

14th Asian Fisheries and Aquaculture Forum

Theme: Greening the Blue Growth in Asia-Pacific

February 12-15, 2025 New Delhi, India

Venue:

ICAR Convention Centre
NASC Complex, New Delhi, India

BOOK OF ABSTRACTS

Organized by:

Asian Fisheries Society (AFS), Kuala Lumpur, Malaysia Indian Council of Agricultural Research (ICAR), New Delhi, India Department of Fisheries (DoF), Government of India, New Delhi, India Asian Fisheries Society Indian Branch (AFSIB), Mangalore, India









14TH ASIAN FISHERIES AND AQUACULTURE FORUM (14AFAF)

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ISBN: 978-81-7164-287-8

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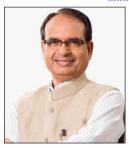
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कृषि एवं किसान कल्याण और ग्रामीण विकास मंत्री भारत सरकार कृषि भवन, नई दिल्ली

Minister of Agriculture & Farmers Welfare and Rural Development Government of India Krishi Bhawan, New Delhi



MESSAGE

I am happy to extend my warmest greetings to all the participants of the 14th Asian Fisheries and Aquaculture Forum (14AFAF), organized by the Asian Fisheries Society (AFS), Kuala Lumpur in collaboration with the Indian Council of Agricultural Research (ICAR), New Delhi; Department of Fisheries (DoF), Government of India, and Asian Fisheries Society Indian Branch (AFSIB), Mangalore, India. It is a privilege for India to co-host this prestigious forum, scheduled to take place during 12-15 February 2025, reflecting the collective commitment of the Asia-Pacific region toward fostering sustainable fisheries and aquaculture.

Fisheries and aquaculture play a pivotal role in millions' livelihoods and food security, particularly in the Asia-Pacific region, the hub of global aquatic production. With its theme, 'Greening the Blue Growth in Asia-Pacific,' the forum brings to light the critical importance of addressing global challenges in fisheries, aquaculture, and Asia-Pacific. As we face mounting challenges such as resource over-exploitation, climate change, and environmental degradation; this forum is an invaluable platform for sharing innovative ideas, research advancements, and practices to strengthen sustainability.

India is proud to co-host this forum as a nation with a rich aquatic heritage and a strong commitment to sustainable fisheries development. The Government of India remains committed to enhancing the production of our fisheries sector through scientific management, environmentally friendly practices, and cooperative efforts. The objectives of this forum align closely with India's vision to integrate blue economy strategies into our broader development goals, ensuring food security, economic growth, and ecological balance.

I appreciate the organizers for fostering networking and cooperation among scientists, researchers, and stakeholders in the fisheries and aquaculture sectors. Such collaborative efforts are essential for addressing global challenges, unlocking the potential of aquatic resources to improve the lives of millions and ensuring equitable benefits for all stakeholders involved in the sector.

As we convene to deliberate on greening blue growth, I encourage all participants to bring forth ideas that inspire innovation and sustainable development, paving the way for a resilient and thriving fisheries and aquaculture sector. Let us work together to make significant strides toward balancing economic growth with environmental preservation, ensuring that fisheries and aquaculture continue to be a source of prosperity, food security, and resilience for the people of this region and beyond. I hope the deliberations during this forum will be insightful and impactful, and the outcomes inspire actionable steps toward realizing the vision of sustainable and inclusive blue growth.



(Shivraj Singh Chouhan)

राजीव रंजन सिंह उर्फ ललन सिंह RAJIV RANJAN SINGH ALIAS LALAN SINGH



पंचायती राज मंत्री एवं मत्स्यपालन, पशुपालन एवं डेयरी मंत्री भारत सरकार

Minister of Panchayati Raj and Minister of Fisheries, Animal Husbandry and Dairying Government of India

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01 Jan 2025



MESSAGE

I am delighted to know that the Asian Fisheries Society, Kuala Lumpur; Indian Council of Agricultural Research, New Delhi; Department of Fisheries, Government of India; and the Asian Fisheries Society Indian Branch, Mangalore are jointly organizing the 14th Asian Fisheries and Aquaculture Forum (14AFAF) during February 12-15, 2025 at New Delhi. This prestigious forum is a landmark event for advancing sustainable fisheries and aquaculture in the Asia-Pacific region.

The theme of this forum "Greening the Blue Growth in Asia-Pacific" resonates deeply with India's commitment to the blue economy by fostering environmentally responsible and economically inclusive fisheries and aquaculture. As a nation with a rich heritage of fisheries and aquaculture practices and diverse aquatic resources, India recognizes the sector's pivotal role in ensuring food security, nutritional well-being, livelihood opportunities, and economic growth, especially for coastal and rural communities. Through the sustainable development of the sector, India also empowers small-scale fishers and fish farmers, whose livelihoods are most vulnerable to climate change and, resource and habitat degradation.

The forum's scope, encompassing sustainable resource management, technological innovation, and socioeconomic development, aligns with India's flagship initiative, the Pradhan Mantri Matsya Sampada Yojana (PMMSY), which aims to drive a Blue Revolution through the promotion of sustainable practices, efficient resource utilization, aquatic biodiversity conservation, and the socio-economic upliftment of fisherfolk and fish farmers.

I am sure, the 14AFAF will provide an invaluable platform for collaboration, knowledge exchange, and sharing of innovative ideas among experts, researchers, policymakers, educators, industry leaders and other stakeholders. The deliberations in the technical sessions, coupled with the participation of global partners, will undoubtedly bring forth new insights and actionable strategies for overcoming challenges and harnessing opportunities in fisheries and aquaculture, not just in India but for the entire region.

As we strive towards achieving the Sustainable Development Goals (SDGs) of the United Nations, forums like this remind us of the indispensable role of global and regional partnerships in addressing pressing issues such as climate change, resource sustainability, and inclusive development. I am confident that the outcomes of this forum will contribute significantly to shaping the policies and practices that ensure a resilient and sustainable future for fisheries and aquaculture in the region and beyond.

I extend my best wishes to the organizers for the success of the 14AFAF.

(Rajiv Ranjan Singh)



भागीरथ चौधरी BHAGIRATH CHOUDHARY





MINISTER OF STATE FOR AGRICULTURE
& FARMERS WELFARE
GOVERNMENT OF INDIA



MESSAGE

I am happy to note that the 14th Asian Fisheries and Aquaculture Forum will be held in New Delhi during 12-15 February 2025 with the theme of "Greening the Blue Growth in Asia-Pacific". I compliment the organizers, the Asian Fisheries Society (AFS), Kuala Lumpur; Indian Council of Agricultural Research (ICAR), New Delhi; Department of Fisheries (DoF), Government of India, New Delhi; and the Asian Fisheries Society Indian Branch (AFSIB), Mangalore, India for organizing this very important event of international importance. It is indeed a very pertinent theme for global fisheries as well as fisheries of the Asia-Pacific region and I take great pleasure to note that India is hosting this important conference.

The fisheries and aquaculture sectors are vital in ensuring global food and nutritional security. Aquaculture is not just the fastest-growing food production system globally, it has become a hope for our future food security. The South Asian region is a powerhouse in global aquaculture production. However, maintaining sustainability has been a bigger challenge for the sector. At this juncture, I would request that researchers from Asia-Pacific countries work on advanced science and technology and also promote the adoption of new technologies. It is necessary to provide platforms for the farmers to connect with extension systems.

I sincerely hope that the scientists and all delegates at the 14th AFAF will deliberate in detail regarding the fisheries and aquaculture sector and a roadmap will be developed for sustainable fisheries and aquaculture development in the Asia-Pacific region.

I wish the 14th AFAF all success.

(Bhagirath Choudhary)







एडवोकेट जार्ज कुरियन ADV. GEORGE KURIAN





राज्य मंत्री मत्स्यपालन, पशुपालन एवं डेयरी और अल्पसंख्यक कार्य मंत्रालय, भारत सरकार MINISTER OF STATE FOR FISHERIES, ANIMAL HUSBANDARY, & DAIRYING AND MINORITY AFFAIRS

GOVERNMENT OF INDIA



MESSAGE

I am very happy to know that the Asian Fisheries Society, Kuala Lumpur; Indian Council of Agricultural Research, New Delhi; Department of Fisheries, Government of India, New Delhi and the Asian Fisheries Society Indian Branch, Mangalore are organizing the 14th Asian Fisheries and Aquaculture Forum (14AFAF) from 12 to 15 February 2025 at New Delhi, India. It is extremely heartening to learn that this triennial event is being organized for the 2nd time in India during the last 35 years. I sincerely believe that this Forum would offer a platform to deliberate upon the ways and means for sustainable development of fisheries and aquaculture in the Asia-Pacific region and also globally. It will certainly provide opportunities to explore ideas for solving multifaceted problems and realizing the dream of "Greening the Blue Growth in Asia-Pacific".

Asia remains the world's largest producer of aquatic foods, derived from both aquaculture and capture fisheries. However, the region faces significant challenges, including the impacts of climate change, which contribute to flooding and salinization in coastal areas and major deltas. Pollution also threatens the marine biodiversity of the region. In recent years, the Indian fisheries sector has made significant progress toward modernization and sustainable growth, thanks to the collaborative efforts of the government and private sectors. The available aquatic resources, having multiple stakeholders, also need robust planning and policy frameworks for their sustainable utilization in fisheries growth. Recognizing the immense potential of this sector, the Government of India has launched the Pradhan Mantri Matsya Sampada Yojana (PMMSY) aimed at the holistic development of the fisheries sector in the country.

I am sure that this Forum will achieve its goal in bringing information, ideas and innovations on a single platform to successfully disseminate among researchers, academicians and industries for the discernible transformation of blue growth into greening of blue growth.

I extend my best wishes to the organizers for the success of the 14th Asian Fisheries and Aquaculture Forum.











डॉ. हिमांशु पाठक Dr. HIMANSHU PATHAK

सचिव (डेयर) एवं महानिदेशक (आईसीएआर) Secretary (DARE) & Director General (ICAR)



भारत सरकार कृषि अनुसंधान और शिक्षा विभाग एवं

भारतीय कृषि अनुसंधान परिषद् कृषि एवं किसान कल्याण मंत्रालयए कृषि भवन, नई दिल्ली-110001 GOVERNMENT OF INDIA

DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION (DARE)

AND

INDIAN COUNCIL OF AGRICULTURAL RESEARCH (ICAR)
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MESSAGE

I am happy to know that the Asian Fisheries Society (AFS), Kuala Lumpur, Malaysia is organizing the 14th Asian Fisheries and Aquaculture Forum (14AFAF) with the theme "**Greening the Blue Growth in Asia-Pacific**" in collaboration with the Indian Council of Agricultural Research (ICAR), New Delhi, India; Department of Fisheries (DoF), Government of India and the Asian Fisheries Society Indian Branch (AFSIB), Mangalore, India during February 12 to 15, 2025 at New Delhi, India. I hope that the Forum will Provide a unique platform for deliberations among the experts and delegates which will help in developing a pragmatic roadmap for Blue Growth in years to come and in achieving the United Nations' Sustainable Development Goals and Blue Transformation objectives.

The Asia-Pacific region, with its diverse aquatic ecosystems and rich tradition of fisheries and aquaculture, plays a pivotal role in global food security and livelihood. This region shares common resources and challenges, from transboundary fish stocks to the impact of warming oceans. Collaboration across nations is crucial to address these shared concerns. Greening the Blue Growth in 'Asia-Pacific' through sustainable fisheries and aquaculture is essential for striking a balance between economic development and environmental sustainability. India is committed to fostering regional partnerships, and therefore, this forum shall provide a unique platform for stakeholders to come together, share knowledge, and collaborate on advancing sustainable practices in this vital sector.

It is a great pleasure that India is hosting the event for the second time after 18 years. I hope that this forum will discuss the Asia-Pacific region across the world aquaculture. Further, I hope that the 14AFAF will raise awareness for the utilization, conservation, sustainable production, and development of aquatic resources in the Asia-Pacific region.

I wish the programme a grand success.

Dated the 3rd January, 2025 New Delhi (Himanshu Pathak)







Dr. Abhilaksh Likhi, IAS Secretary डॉ. अभिलक्ष लिखी, भा.प्र.से. सचिव



भारत सरकार मत्स्यपालन, पशुपालन एवं डेयरी मंत्रालय मत्स्यपालन विभाग कृषि भवन, नई दिल्ली–110001







Government of India Ministry of Fisheries, Animal Husbandry & Dairying Department of Fisheries Krishi Bhawan, New Delhi-110001

MESSAGE

I am truly delighted to learn that the Asian Fisheries Society, Kuala Lumpur in collaboration with the Indian Council of Agricultural Research, New Delhi; Department of Fisheries, Govt of India and the Asian Fisheries Society Indian Branch, Mangalore, is hosting the 14th Asian Fisheries and Aquaculture Forum (AFAF) with the theme "Greening the Blue Growth in Asia-Pacific" in New Delhi, India, from February 12-15, 2025.

Fisheries has emerged as one of the fastest-growing sectors in agriculture and is increasingly recognized as a sunrise industry for the Indian economy. The sector plays a pivotal role in providing livelihoods to millions of fishers and fish farmers at the primary level, as well as provides significant economic opportunities for countless individuals along the value chain, including vulnerable and economically disadvantaged communities. Fisheries also contribute significantly to the availability of high-quality animal protein at affordable prices, ensuring national food and nutritional security, especially for the underprivileged sections of society. The rapid development of the fisheries sector has enhanced food supply, improved nutrition, generated employment, and earned foreign exchange for the nation.

India's fisheries sector is on a path of significant transformation, driven by the country's abundant and diverse marine and inland water resources. With increasing domestic and global demand for fish and seafood, the sector has vast untapped potential. However, challenges related to sustainable growth, biodiversity conservation, and resource management remain. Addressing these challenges requires continued innovation, the application of advanced technologies, and robust policy frameworks to ensure the long-term sustainability of our fisheries resources.

I firmly believe that this forum will provide an invaluable platform for distinguished scientists, researchers, and stakeholders from across the globe to exchange knowledge, present cutting-edge research, and explore innovative solutions to ensure the continued growth and sustainability of the fisheries and aquaculture sectors.

I extend my heartfelt congratulations to the organizers and participants of the 14th AFAF, and I wish the forum every success in its mission to drive global dialogue on sustainable fisheries and aquaculture practices.

(Abhilaksh Likhi)











Prof. Neil LoneraganPresident, Asian Fisheries Society



MESSAGE

Welcome to the 14^{th} Asian Fisheries and Aquaculture Forum (14AFAF) with the theme of "Greening the Blue Growth in the Asia Pacific". It is an honour to join you at the 14AFAF in the thriving, metropolis of New Delhi. The Asian Fisheries Society is very grateful to our co-convenors and the local organisers of the 14AFAF from the Indian Council of Agriculture Research (ICAR), the Department of Fisheries (DoF), Government of India, and the Indian Branch of AFS.

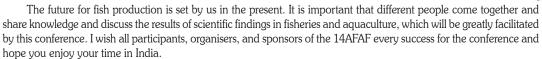
Asia is a powerhouse of global fisheries and aquaculture production, with an estimated over 80% of the world's capture fish production and 86% of its aquaculture production coming from the region. India is a top fisheries and aquaculture producing nation and a leader in research, development and education in these fields. It is very timely that we have the 14AFAF in India and a pleasure to be able to meet in person for the first time in six years following COVID and our inaugural, hybrid 13AFAF at the National Cheng Kung University.

The topics of the 14AFAF cover a wide range of technical sessions and diverse themes such as Production systems in fisheries and aquaculture, Policy and management of these systems, Economics, Gender, and Livelihoods, all of which are central to developing sustainable production systems and are very important for ensuring sustainable global seafood production.

The Asian Fisheries Society is a non-profit scientific society founded in 1984 and currently has two branches (India and the AFS Taiwan Branch), three sections (Asian Fisheries Social Science Research Network, Fish Health Section and Gender in Fisheries and Aquaculture) and a recent students and early career researcher's group. The first AFAF, then known as the Asian Fisheries Forum was held in Manila in 1986 and since then, has been held every three years in seven other locations in the region (https://www.afsconferences.net/category/afaf/). The AFS aims to promote networking and cooperation between scientists, technicians and all stakeholders involved in fisheries and aquaculture production, research and development. A very important component of this is developing students and early career researchers in aquaculture and fisheries. The ultimate objective of AFS is to enhance food security and income-generating opportunities for fisheries and aquaculture workers through promoting sound management practices, and the environmentally sustainable development and use of aquatic resources. The AFAF meetings are an essential component for achieving these objectives.

The 14AFAF brings together scientists, researchers, government, fishers, fish farmers, industry people, and policymakers to discuss the latest scientific research on fisheries and aquaculture. Because of the hard work of the co-convenors and international and local organising committees, we have a very attractive program with distinguished speakers. It also provides an important forum for AFS members to meet and consider the status and future of the Society.





Professor Emeritus Neil Loneragan, BSc (Hons), PhD Murdoch University

President, Asian Fisheries Society (14th Council)

Editor-in-Chief, Asian Fisheries Science

Adjunct Professor, IPB University, Visiting Professor, Universiti Putra, Malaysia









डॉ. जे.के. जेना उप महानिदेशक (मत्स्य विज्ञान) **Dr. J.K. Jena** Deputy Director General (Fisheries Science) and Convener, 14AFAF



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FOREWORD

Asian Fisheries Society (AFS), a non-profit scientific society founded in 1984, has its present Headquarters in Kuala Lumpur, Malaysia. To promote scientific interaction among members and the community in Asian countries, the Society has been organizing triennial events, i.e. the Asian Fisheries and Aquaculture Forum (AFAF) in different countries in Asia. With the 1st Forum organized in the Philippines in 1986, the AFS successfully organized the subsequent 12 triennial events in Japan (1989), Singapore (1992), China (1995), Thailand (1998), Taiwan (2001), Malaysia (2004), India (2007), China (2011), South Korea (2013), Thailand (2016), Philippines (2019), and Taiwan (2022).Now, the 14thAsian Fisheries and Aquaculture Forum (14AFAF) is being organized by the Society in collaboration with the Indian Council of Agricultural Research (ICAR), New Delhi, India; Department of Fisheries, Government of India, New Delhi; and the Asian Fisheries Society Indian Branch (AFSIB), Mangalore, India at the ICAR Convention Centre, New Delhi, India from 12 to 15 February 2025 with the theme "Greening the Blue Growth in Asia-Pacific". The Forum is going to provide a unique platform for researchers, academicians, students, farmers, entrepreneurs, policy makers, and all associated with the value chains from all over the world, particularly from the Asia-Pacific region, to exchange/share their ideas and experiences.

The Technical programme of 14AFAF will include a Keynote, Plenary, and Lead Speaker Presentations by globally acclaimed experts in different subject areas of fisheries and aquaculture. There will be 16 Technical Sessions covering all relevant aspects which would include oral and poster presentations by the delegates. There has been an overwhelming response for this international event and a record number of 805 abstracts have been accepted for oral and poster presentations. The oral presentations under different Technical Sessions will be undertaken through ten parallel sessions. It is expected that the Forum will discuss all issues currently the fisheries and aquaculture sector is encountering and come out with a strategic roadmap for achieving the United Nations' Sustainable Development Goals and Blue Transformation objectives.

The research on aquatic animal health management in recent years has led to the generation of a lot of information on disease diagnosis and reporting, effective vaccines and vaccination strategies, disease and AMR surveillance, quarantine, biosecurity, and alternate therapeutics besides the application of newer technologies to develop resistant varieties of fish using genome editing. Looking at the latest developments in the above areas, a Symposium on 'Aquatic Animal Diseases: Emerging Challenges and Preparedness' will be organized as a parallel event during the 14AFAF.

It is a well-known fact that during the last three decades, coastal shrimp farming has grown significantly due to its high economic impact. Despite being recognized as a money-spinning farming activity, farming today is subjected to several issues and concerns, importantly disease threats and price volatility. A stakeholder interaction, i.e. Academia-







Industry-Government Meet is going to be organized as a Satellite event on the Theme 'De-risking Shrimp Aquaculture Value-Chain for Improved Global Competitiveness' which is expected to discuss emerging Challenges and measures for sustainable farming practices.

A grand exhibition (14AFAF Expo) will also be organized during the 14AFAF involving the scientific and academic organizations, and industries & business houses associated with the fisheries and aquaculture sectors showcasing their achievements and products.

I, on behalf of the organizers, the Indian Council of Agricultural Research; Department of Fisheries, Government of India; and Asian Fisheries Society Indian Branch, sincerely thank the President and Members of the 14th Council of Asian Fisheries Society for the opportunity and faith rendered to host the event in New Delhi, India. I convey my sincere thanks and gratitude to the Patrons of the 14AFAF Dr. Himanshu Pathak, Secretary, DARE and Director General, ICAR; and Dr. Abhilaksh Likhi, Secretary, Department of Fisheries, Govt of India for their guidance and active support. I extend my sincere gratefulness to the Members of the International Advisory Committee; National Advisory Committee; Core organizing committee including Co-Conveners, Organizing Secretaries, Members and Treasurer; Members of the Scientific Committee; and Members of different Sub-Committees for their active involvement and support. The Co-Sponsors of the Events and the participants of the 14AFAF Expo are also thankfully acknowledged for their generous support.

I sincerely thank the Invited speakers and delegates from all across the nations for their kind participation and welcome all of them to the capital city of India, New Delhi, and also to 14AFAF.

New Delhi, India 27 January 2025 Dr. J.K. Jena Convener, 14AFAF Chairman, AFSIB & DDG (Fisheries Science), ICAR

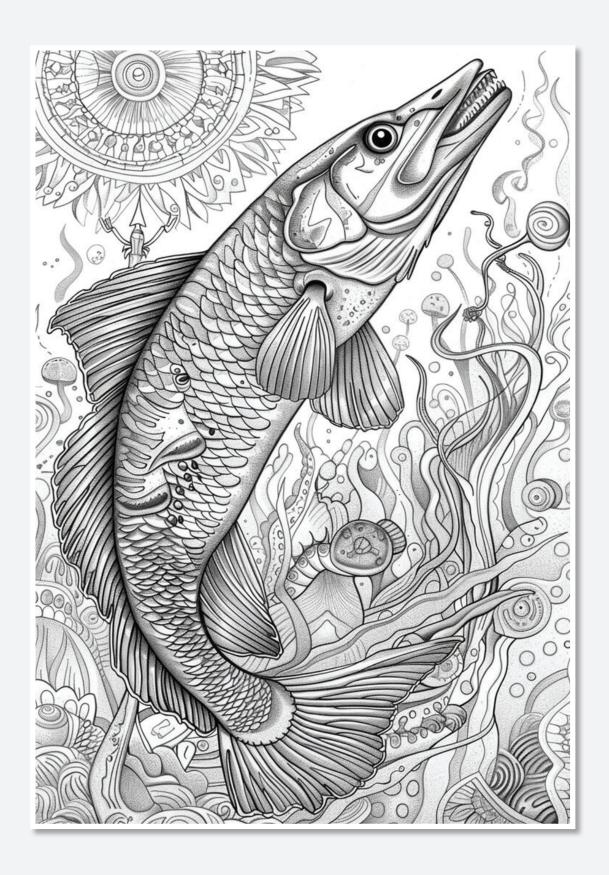




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Invited Papers Keynote, Plenary and Lead Lecture Presentations



IndFish To-2030

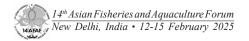
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Indian Fisheries & Aquaculture is a saga of millions of fishers and farmers in a country bestowed with unique aquatic ecosystems ranging from deep sea to mountains. With documented strides for over a century, it is an important component of the Blue Economy as well as the Agriculture & Food Production System, with few parallels. With over 8% of the global aquatic biodiversity of 3,137 finfish species and being the second largest fish producer to the tune of 17.6 mmt annually with aquaculture production of 12 mmt, it contributes 9% to the global fish basket and 4.1% of the market. Providing livelihood to over 25 million people, it comprises 1.24% of the Indian GVA, 7.28% of agri-GVA, and 16% of agri-exports. Also aiding the community nutrition efforts, the domestic fish consumption is over 14.2 mmt, with a CAGR of 5.63%, making fish an important protein supplement and India at the 123rd position in this regard. Blue Revolution is the current focus in the food production system in the country, in view of the potentials of the sector as well as the changing socioeconomic scenario of health concerns, income levels, and lifestyles.

It is contextual that the growth in the global supply of fish for human consumption has outpaced population growth in the past five decades, increasing at an average annual rate of over 3%, double that of population growth, leading to a higher average per capita availability. There however, exists a gap in the consumption between the developing regions (~19 kg), low-income food-deficit countries (LIFDCs; 3.5-7.6 kg) and industrialized nations (~27 kg). Fish has over different periods, accounted for 17% of the global population's intake of animal protein and 7% percent of all protein consumed, providing over three billion people with almost 20% of animal protein intake. In the framework of the Sustainable Development Goals, 2030 agenda, fisheries &aquaculture playa prominent role with regard to world food security.

Indian marine fisheries, with a potential of 5.31 million tonnes annually, is a typical multispecies, multi-fleet fisheries characterized by a heterogeneous fishery management system. With a predominance of pelagic fisheries (1.87 mmt), it comprises 0.9 mmt of demersal fishes, 0.2 mmt of molluscans and 0.4 mmt of crustaceans. Oceanic tunas include Yellowfin tuna, Bigeye tuna and Skipjack tuna, which resources are still to be fully harnessed. Recent assessment of 135 fish stocks in the Indian Ocean showed 91.1% to be healthy, with 86.7% being sustainable, 4.4% subject to overfishing, 8.2% overfished, and 0.7%, rebuilding. To achieve resilient fisheries, the action plan includes: Introduction of a central legislation (Marine Fishery Act) for the regulation of fishing in the Exclusive Economic Zone (EEZ); Institutionalization of periodic stock assessment of major fishery resources;



AI-mediated automated mechanisms for landing estimation, analytics of sub-stock-level information; Assessment and characterization of deep sea and non-conventional fishery resources; Integrated fishery development plans for the two major island ecosystems of Andaman & Nicobar and Lakshadweep; Installation of artificial reefs and mechanisms for impact assessment and improvisation; Concerted efforts for a cleaner environment; Ecolabeling of marine fishery resources; Strengthening fishermen accident insurance, fishing vessel insurance, and coastal immovable asset insurance through technological and policy interventions.

Fish biodiversity in the Inland water bodies covering nearly six percent of India's geographical area including estuaries, rivers, reservoirs, lakes & floodplain wetlands comprises 1,035 fish species of 326 genera, the annual capture fisheries potential being 2.2 mmt. There are, however, several challenges of climate change, shrinking water resources, water extraction for off-stream use, habitat loss and degradation, biodiversity loss and introduction of exotic species, pollution and so on. Along with assessment and remediation activities, several conservation programmes for rejuvenation include the establishment of protected areas, ranching, fish sperm & embryo cryopreservation, tissue banking and live gene banking. Drone-mediated assessment and enhancement measures are a new approach in the restoration of water bodies. A unique feature of Indian Inland fisheries is the Coldwater fisheries along the Himalayas, with several species of mahseers and troutshaving been domesticated.

Mariculture is a fast-emerging sub-sector of India's Blue Economy. While the current mariculture production is less than 0.1 mmt annually, scaling up intensification of the available technologies of seed production and farming of finfishes - Cobia, Pompano, Sea bass, groupers, snappers, breams and ornamental fishes; shellfishes - mussels, oysters, clams, green tiger shrimp, blue swimmer crab; and seaweeds, along with production in Recirculatory Aquaculture Systems (RAS), Integrated Multitrophic Aquaculture Systems (IMTA) and cage farming can enhance the levels to 4.1 mmt. Evaluation ofthe sustainability of offshore mariculture beyond two km from the coast and in water depths of 50 m and above also merits consideration. It is apt that the National Mariculture Policy addresses different aspects of the development of leasing and licensing, mariculture systems and species, environmental sustainability, seed and feed development, health management, certification, insurance, market support as well as the institutional and legal framework.

Of the world's production of farmed shrimp of 5.6 million metric tonnes, India, next only to Ecuador and China, along with Vietnam and Indonesia, contributes over 74%. Of the 1.2 million ha as potential aquaculture area, about 15% has been utilised and the growth of shrimp aquaculture in India has been spectacular, with the present production of farmed shrimp being around 8,00,000 metric tonnes. Public-private partnerships with shrimp farmers & exporters, research institutions, promotional bodies, regulatory framework, as well as technical and policy support from governmental agencies have resulted in an Indian Shrimp farming model. The main drivers of growth have been ready market demand and profits for the produce; employment generation to the tune of 15 million; availability of brackishwater resources for farming and future expansion, as they are considered as a



zero-economic resource not used for other purposes; biodiversity richness that is yet to be fully harnessed, high productivity, negligible footprint on potable water and lower carbon emissions; environmental tolerance & adaptability of farmed species, both finfish (seabass, milkfish, pearl spot, etc.) and shellfish (penaeid shrimps, *viz.*, *L. vannamei, P. monodon,P. indicus*, mud crab and backwater oysters).

Intensification and expansion of Pacific whiteleg shrimp farming as a monospecies practice have also resulted in new challenges and a balanced growth with due species diversification is required. Revival of tiger shrimp farming and harnessing the potential of Indian white shrimp needs emphasis, along with finfishes like seabass, milkfish, mullets, pearl spot, etc. In order to achieve sustainability in production and maintain the growth momentum, focused efforts are needed towards quality seed production and diversification of species including the development of indigenous SPF stocks; sustained farm production and productivity through good management practices and diversified rearing systems; cost-effective quality formulated feeds with new feed mills; upgradation of shrimp processing infrastructure of global standards; and unified marketing approach with due emphasis on domestic markets to reduce dependence on exports and boost domestic consumption.

Freshwater aquaculture has been the mainstay of Indian aquaculture in terms of total quantity as well as catering to the domestic fish basket, presently contributing to over 60% of the total fish production. The potential of tripling fish production has both horizontal expansion with more water including integrated farming areas (0.8 m ha to 1.2 m ha) and enhanced productivity (around 3 t/ha/year). Species diversification is also an important aspect driven by market forces, yield rates, climate change, reduced availability in the wild, disease incidence and so on, that needs to be addressed in terms of richness and evenness. With the practice being mainly carp-based (over 82%), diversification in terms of both habitats and species is the priority. There are almost two dozen species for which seed production and grow-out culture technologies have been standardized and field tested with a considerable increase in the farm income levels. A fifty species-based freshwater aquaculture is projected for the coming decades, as also organic aquaculture. Ornamental fisheries, aqua-tourism and sport fisheries, though in vogue, have been receiving increasing attention with non-traditional investors taking interest in these ventures in recent years.

The key drivers are the resources themselves, both water and the biodiversity, with an imminent need for water budgeting for different culture systems in terms of species of carps, catfish, prawn and so on, as also levels of intensification or integration with other farming systems; quantifying water requirements with due reference to the positive water productivity for fish culture as compared to other practices and emphasis on wastewater recycling; potentials of aqua-systems for carbon sequestration as also low carbon footprints; water use policy, including scientific leasing of water bodies; quality seed enhancement with due hatchery accreditation and seed certification; adequate feed supply, with 20% of the present production being feed-based, to be increased by four-folds, along with intensification in at least 20% farms; farm mechanisation in view of emerging youth migration from rural areas and labour issues; health management, with new generation diagnostics, prophylactics

and therapeutics, including emerging diseases; bio-safety and bio-security measures also addressing introduction of exotic species and internal checks with regard to seed movement in the country; capacities to build value chain and global competitiveness; infrastructure and policy support including export-oriented production and postharvest management; and harnessing ICTs, Spatial Analytics & GIS for aquaculture practices.

India, with its aquatic resources, has a huge opportunity to produce cheap and quality protein, as being envisaged in the 'Blue Economy' and '*Matsya Sampada Yojana*'. The next decade is likely to see major changes in the environment, resources, macroeconomic conditions, international trade rules and tariffs, and market characteristics, with climate change, variability and extreme weather events as compounding threats to sustainable aquaculture. In the years to come, a large unutilised area will be brought into aquaculture, with a number of cultivable varieties and new technologies. Furthermore, as the wealth of the country increases, consumption of fish as health food would also increase, requiring greater research on aquaculture production, harvest and post-harvest technologies.

Institutional mechanisms and Quality Human Resources have been key drivers in the journey of Indian fisheries and Aquaculture for nearly eight decades. With Ministries of Fisheries at the Centre and the States, the sector is accorded due importance in the governance structure of the Country. With over 20 R&D Institutes, primarily under the apex Agency for Agricultural Research, the Indian Council of Agricultural Research (ICAR) & others, and 35 Colleges of Fisheries, as also Institutions like the National Fisheries Development Board, Coastal Aquaculture Authority, National Biodiversity Authority, Marine Products Export Development Authority, Krishi Vigyan Kendras (Farm Science Centres), Federation of Fisheries Cooperatives, National Bank for Agriculture & Rural Development, Food Safety & Standards Authority of Inda, Bureau of Indian Standards, etc. and strong collaborations with a host of governmental and corporate bodies, both promotional and regulatory functions are aunique feature. A new trend is the establishment of Fish Farmer Production Organisations (FFPOs) and Fish-Start Ups, with demonstrated youth vigour and gender equity. It is estimated that over 1,000 researchers and an equal number of academicians in the National Agricultural Research & Education System (NARES), along with around 5,000 Development Officials in the States are associated with the fisheries sector in the country. International bodies like the FAO-NACA, the WorldFish and related organisations also contribute to the country's efforts in domestic growth as well as globalising good practices. Strides in the domain have been amply evidenced by returns on investments and cumulative growth rates over the years.

Based on the analysis of the past data and emerging scenarios, the outlook for farmers in India by 2030, is that farming would be an enterprise; with the 'rurban' migration, the gender mix would change to the greater role of women; mechanised & precision farming would be pronounced; financing mechanisms would become more diverse, with active corporate and private players; and greater partnerships would emerge between governments and farming stakeholders with regard to policy prescriptions, with emphasis on infrastructure and market orientation. Information technology (IT) systems are the core component in the transition from breakthroughs in laboratories to field-scale implementation. Fusion of technologies,



eg. CRISP-R, Big Data Analytics, IoT in Farming, SAG/GIS and Remote Sensing, Image Processing, Digital Farming, Artificial Intelligence, Deep/Machine Learning, Blockchain technology, Sensors & Robotics will help optimize resources. In this context, smart sensors, drones, robots, delivery systems, nutraceuticals and nutrigenomics, high-value compounds from aqua-sources are opening up new avenues, also bringing in new players.

With a target of an annual fish production of 24 mmt by 2030, comprising Capture Fisheries: 6 mmt; Aquaculture: 18 mmt (Freshwater: 15 mmt, Brackishwater: 2 mmt; Mariculture: 1 mmt) and 40 mmt by 2047, comprising Capture Fisheries: 8 mmt; Aquaculture: 32 mmt (Freshwater: 24 mmt, Brackishwater: 3 mmt; Mariculture: 5 mmt), a blend of knowledge base and skill development is required to build the aquapreneurship, that would lead to a large number of aqua-start ups, for both production and profits. Given the trends, it is clear that the fish demand would be largely met by aquaculture in the three major ecosystems of freshwater (both plains and hills), brackishwater and marine, to the extent of 75%, catering to both domestic and export markets. The National Fisheries Policy, 2020, converges several of these aspects, with a combination of technology, policy, investments and partnerships. At a time when a paradigm shift of starch-to-protein is required in the country's food production systems, along with minimal water and carbon footprints, aquaculture offers unique opportunities through 'Looking to the Waters'.

India has been pursuing a 'Blue Revolution', through technologies and investments, though much more diversification and intensification are needed and possible. Along with other edible food species comprising finfish and shellfish (crustaceans - shrimp, crabs; molluscans - mussels, oysters), are the seaweed and algal resources, that could be used in different forms including the production of nutraceuticals and food additives. Aquatic biosecurity and quarantine, disease reporting system, seed certification, feed management, disaster management, customised cold chains for domestic marketing, low-volume high-value species, domestication of more fish and shellfish species, integrated water management, fish as a health food, aqua-tourism and aqua-parks, and aquarian reforms are the aspects to be addressed in this direction. Resource management with due reference to availability, access and international agreements, requires a holistic approach and synergy of efforts of multiple agencies involved. New science and innovations, deployment of new tools, higher investments and convergence of players, in a value chain approach, is the way forward.

Blue Growth in Capture Fisheries: The Significance of Ecosystem, People-Centred and Partnership Approaches

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Asian fisheries and aquaculture contribute an estimated 70% to global seafood production. In contrast to aquaculture production which has been increasing rapidly, marine capture fisheries have plateaued, and most fisheries are fully exploited, with little potential for increase. Typically, fisheries are assessed based on single species stock assessments, which do not consider any interactions between fisheries and other species, the impact of fishing on the marine ecosystems that support them or acknowledge the multi-species nature of fisheries. The multi-species, multi-gear and data-limited nature of fisheries are prominent in Asian waters, which are a hotspot of marine biodiversity. In addition, the livelihoods of coastal communities and millions of people in Asia are dependent on catches from small-scale fisheries, which are notoriously difficult to assess and manage. Incorporating ecosystem approaches and the social dimensions of fisheries provides a means of enhancing the understanding of these fisheries and is fundamental for ecosystem-based fisheries management (EBFM). Ecosystem modelling provides a means of increasing understanding fisheries and their interactions with marine ecosystems to ensure their future sustainability and contribute to EBFM. Ecosystem models also provide a mechanism for communicating across a wide variety of people from different disciplines and backgrounds to understand ecosystem structure and function. Examples from Australia and Indonesia are provided of how conceptual, qualitative, and quantitative models are developed to understand the functioning of marine systems and identify solutions for impacted systems. To understand the current state of a system and assess its health requires transdisciplinary approaches that consider fisheries and their ecosystems within a management system, including the implementation of management decisions. Asian scientists have the capacity and interest to apply these approaches which would be enhanced by establishing networks of practitioners and developing partnerships with a range of organisations across government, universities, NGOs, fishers and the fishing industry.

KEYWORDS: Fisheries and aquaculture, Stock assessment, Ecosystem-based fisheries management, Ecosystem models, Social dimensions, Partnership



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The Function and Application of Interferons in Controlling Viral Diseases in Aquaculture

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Outbreaks of viral diseases cause significant economic losses to the aquaculture industry. Understanding the antiviral responses of fish is vital to the development of effective measures for disease control. Interferons are key immune factors that are produced during viral infection and play central roles in coordinating host antiviral responses. During the last 20 years, significant advances have been made in the characterization of the roles of the interferon system in combating viral infections in fish and in the exploration of the potential of interferons in practical application in aquaculture. In vertebrates, based on their functions, receptors and signaling pathways, interferons are classified into 4 types. Type I, III and IV interferons activate antiviral effector genes, conferring resistance of host cells to viruses, while type II interferon mainly exerts regulatory functions in innate and adaptive immunity. It is now well established that teleost fish possess type I, II and IV interferons, but lack type III. Fish interferons are structurally and functionally conserved. For example, fish type I and IV interferons display typical 6 alpha-helical topology which is stabilized by 1-3 pairs of disulphide bonds, and interact with distinct receptor complexes to elicit cellular responses. They activate JAK/STAT signaling pathways, leading to the induction of antiviral genes and enhancement of resistance to viral infections. This talk will overview recent advances in interferon research and the potential applications in controlling viral diseases in farmed fish.

KEYWORDS: Interferon, Viral disease, Farmed fish

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Implementing International Instruments to Combat IUU Fishing and Achieve Sustainable Fisheries

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Over the past four decades, the international community has developed a comprehensive framework of instruments aimed at safeguarding the sustainable exploitation of living marine resources. Within the broad scope of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) and the context of the 1995 FAO Code of Conduct for Responsible Fisheries (CCRF), this framework has been constantly evolving to set international standards that support sustainable fisheries, as well as to define actions that eradicate unsustainable practices and illicit activities which have detrimental effects on sustainability. Illegal, unreported and unregulated (IUU) fishing undermines efforts to conserve and manage fish stocks in all types of capture fisheries and in all areas. Coordinated and effective implementation at national, regional and global levels of the minimum requirements and standards associated with port, flag, coastal and market State responsibilities, as defined in international instruments, and supported by internationally-agreed tools, is critical to eliminate IUU fishing.

The 2009 FAO Agreement on Port State Measures (PSMA) provides a potent international legal and operational mechanism for verifying the compliance of vessels entering foreign ports with applicable fisheries conservation and management measures, including on the high seas. Commitment to the implementation of the PSMA has continued to rise since it came into force in 2016, with 105 countries, to date, bound to the Agreement. The Parties to the PSMA have developed a Strategy to strengthen the implementation and effectiveness of the Agreement in deterring, preventing and eliminating IUU fishing, including through global exchange of electronic inspection and compliance information. The PSMA also supports cooperation with flag States in ensuring and promoting compliance with applicable regulations and assures market States on the legal and sustainable origin of traded products.

The application of traceability schemes and control of fishery products from the moment of catch, followed by any movements of fish by transshipment and landing operations, and throughout the value chain, are also essential actions in combatting IUU fishing. The international guidelines on the regulation, monitoring and control of transshipment, together with those on catch documentation schemes, adopted by FAO Members in 2022 and 2017 respectively, provide complementary support to States in accomplishing this objective.

The need for improvement of flag State performance has been highlighted in numerous international fora, with calls in recent years for monitoring and strengthening compliance with applicable measures of vessels, particularly those operating on the high seas. The 2014



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FAO Voluntary Guidelines for Flag State Performance constitute a compendium of flag State responsibilities and best practices, defined in binding instruments and other voluntary instruments, concerning the flagging and control of vessels engaged in fishing and fishing-related activities. The Guidelines encourage States to periodically conduct performance assessments against these internationally-agreed requirements, placing them in a better position to take action to strengthen their capacity to ensure compliance by their vessels.

Coastal State responsibilities as described in the CCRF and the 2001 FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) include the monitoring and control of activities in exclusive economic zones (EEZs) by coastal States to ensure sustainable exploitation of the resources within their waters.

Whilst the international momentum and individual commitment of States to combat IUU fishing and to achieve sustainable fisheries has been remarkably growing, challenges remain to fully and effectively implement the minimum requirements defined in international instruments at the global scale. In particular, the requirements of developing States, as duly considered in these instruments, demand continued attention and capacity development support needs to be intensified to attain these goals. Furthermore, the enhancement of interagency coordination at national and international levels would greatly benefit the cohesive implementation of the suite of international instruments to eliminate IUU fishing.

KEYWORDS: IUU Fishing, Sustainable fisheries

The State of Fisheries in Asia Pacific: How to Improve Fisheries Sustainability in Asia Pacific?

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Since 1971, the FAO has provided regular analyses of global fish stock status, published in its flagship report, *The State of World Fisheries and Aquaculture* (SOFIA). These analyses have relied on a fixed list of stocks—representing over 70% of global fish landings—and a standardized methodology that has ensured consistency and comparability over time. However, the fisheries sector has evolved significantly since the 1970s, and the introduction of SDG Indicator 14.4.1 has established complementary monitoring processes. To address these changes, the FAO plans to update its methodology to better align with national SDG reporting, broaden expert participation, enhance transparency, and maintain the historical integrity of its time series. The updated approach will produce stock status indices at the FAO fishing region level, aiming to reduce assessment gaps through continuous improvement.

Comparisons of overfishing estimates demonstrate the new methodology's broader scope, which now covers over 2,500 stocks, a significant expansion from the previous focus on approximately 445 species. This participatory, bottom-up approach better reflects the global state of marine fisheries. Focusing on the Asia-Pacific region, we examine the status of fisheries in FAO Regions 51, 57, 61, and 71, which collectively contribute over 60% of global production. Significant variability in fisheries status across these regions is explored, with an emphasis on the implications for sustainability. Challenges associated with data- and capacity-limited fisheries are discussed, and a roadmap for aligning the region's fisheries with FAO's *Blue Transformation* initiative is introduced.

KEYWORDS: Fisheries, Sustainability, Asia Pacific

Sustainable Intensification of Aquaculture in Asia-Pacific: Pathways to Green Blue Growth Through Regenerative Aquaculture

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The fisheries and aquaculture sector produced 223.2 million tons of aquatic animals and plants valued at USD 472 billion in 2022 (FAO, 2024). Almost 89% (164.6 million tons) of the aquatic animal production of 185.4 million tons was destined for direct human consumption, resulting in a per capita consumption of 20.7 kg (15% of the animal protein supply, and up to 50% in some parts of Asia and Africa). Asian countries accounted for 71% of this consumption. As one of the most traded food commodities, aquatic animal trade generated USD 192 billion in 2022. With the global population expected to reach 9.7 billion by 2050, there is an urgent need to intensify food production sustainably. Aquaculture, as the fastest-growing food production sector, plays a vital role in addressing this demand with the global aquaculture production totalling 130.9 million tons worth USD 313 billion in 2022. The Asia-Pacific region contributes 91.4% (119.7 million tons) of this output. Seven of the top 10 aquaculture-producing countries are in Asia: China, Indonesia, India, Vietnam, Bangladesh, the Philippines, and S. Korea.

The fisheries and aquaculture sector employs 61.8 million people, 36% of which engage in aquaculture operations. Almost 95% of the aquaculture workers are in the Asia-Pacific region where more than 80% of farm production comes from small- to medium-scale enterprises. Therefore, it is necessary to sustain the livelihoods of small-scale farmers to meet the growing demand for nutritious food while ensuring environmental sustainability. Sustainable intensification of aquaculture offers a promising solution to increase food production while minimizing environmental impacts. This approach aims to enhance productivity through more optimized use of resources, environmentally sound practices, and technological innovations, rather than simply increasing inputs. Key pathways for sustainable intensification of aquaculture (Fig. 1) include responsible production, supporting small-scale farmers, adopting innovative technologies, enhancing nutrient recycling, and diversifying aquaculture species and systems to enhance the resilience and nutritional value of blue foods. Intensification of aquaculture becomes sustainable when the production systems are transformed into regenerative models that prioritize environmental concerns and resilience to climate change, conserve species diversity, and prevent pollution. Ensuring the quality and safety of farmed seafood while improving productivity and delivering socioeconomic benefits is key for this development. Regenerative aquaculture (RA) involves those practices that mitigate adverse environmental impacts while actively contributing to the restoration and regeneration of aquatic ecosystems. Regenerative aquaculture promotes



nutrient recycling, habitat restoration, and biodiversity enhancement while facilitating carbon sequestration in aquatic ecosystems used for food production (Fig. 2). Absorption of excess nutrients in accumulated sediments and by freshwater/brackishwater crops, marine macrophytes and bivalves are significant in this context. Multiple crop integration such as that in polyculture and integrated multitrophic aquaculture (IMTA) systems is essential for advancing RA within a viable food system. A key driver supporting the rapid expansion of RA systems is the notable increase in aquatic plant production over the last three decades, which reached 37.8 million tons in 2022.

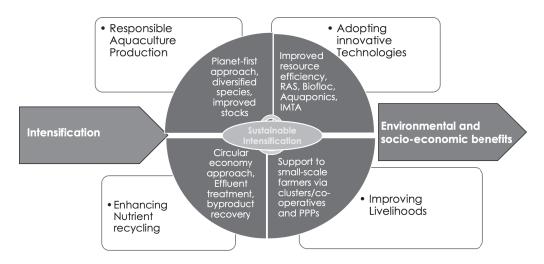


Fig. 1: Key pathways to sustainable aquaculture intensification

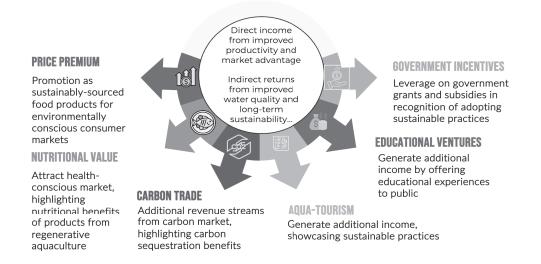


Fig. 2: Economic Benefits from Ecosystem Services by Regenerative Aquaculture



Looking ahead, the future of sustainable aquaculture intensification in Asia-Pacific will depend on continued innovation, collaboration, and policy support to fully capitalize on these advantages. Key areas for development include strengthening biosecurity and animal welfare practices, enhancing climate resilience in aquaculture systems, improving feed sustainability through alternative protein sources and efficient formulations, developing and implementing nature-based solutions and responsible investment strategies via Public-Private-Partnerships (PPPs), and capacity-building and knowledge transfer to level the playing field across the region. Sustainable intensification of aquaculture presents a significant opportunity for green-blue growth in the Asia-Pacific region. By adopting holistic approaches that balance productivity, environmental stewardship, and social responsibility, the sector can play a crucial role in ensuring food security, improving livelihoods, and contributing to sustainable development goals. Continued research, innovation, and multi-stakeholder collaboration will be essential in realizing this potential and addressing the evolving challenges faced by the aquaculture industry.

KEYWORDS: Restorative Aquaculture, Smallholders, SDGs, Certification, Blue Economy

Aquaponics

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Aquaponics represents a significant measure to address the pollution caused by tailwater discharge in traditional aquaculture in China. It is an innovative integrated farming system that combines aquaculture with hydroponics. Through ingenious ecological design, aquaponics achieves an ecological symbiotic effect where fish can be raised without needing to change the water, thus avoiding water quality issues, and vegetables can grow normally without the need for fertilization. During the research and development of the aquaponics system, our team has closely monitored international frontiers, national policy orientations, industry development needs, and the importance of industry-academia-research-application collaborations, leading to breakthroughs in the three aspects. 1) A breakthrough has been achieved in the precise measurement technology for the three nitrogen compounds in aguaponics systems. We have invented a combined technology utilizing Raman spectroscopy. fluorescence, colloidal optics, and nanomaterials. A multi-excitation dual-channel buffered optical measurement structure has been designed, and methods for weak signal extraction and intelligent compensation correction have been established. The detection limit for ammonia nitrogen in aquaculture water has been improved by one order of magnitude, and the detection time has been shortened to one-sixth of the original duration (i.e., 5 minutes). 2) A technology for intelligent collaborative operation of equipment in complex environments has been proposed. Innovations have been made in the digital transformation of traditional aquaculture equipment, the concentration and reuse of fish waste and sewage, and the lateral stripping of carbon dioxide combined with micro-nano bubble aeration technology. The digitalization rate of the equipment has reached 100%, the TSS (Total Suspended Solids) concentration in tailwater has been increased by 70.2 times, energy consumption has been reduced by 30%, and oxygen utilization has been improved by 40%. An intelligent feeding method based on multi-source information fusion of "environment-biomass-feeding behavior-residual bait identification" has been invented, and an intelligent inspection and feeding robot has been created, resulting in a 20% reduction in feed usage. Additionally, a factory-based production system for vertical vegetable cultivation, an intelligent seedling logistics system for vegetables, and a mechanized harvesting system for pot-grown leafy vegetables have been invented, achieving fully unmanned operations from sowing, seedling cultivation, transplanting, to harvesting. 3) A technical system for intelligent aquaponics factories has been established. This system integrates aquaculture systems, circulating water treatment systems, planting systems, measurement and control systems, and cloud platforms, achieving full-process digitization, networking, and intelligence in aquaculture and cultivation. An intelligent aquaponics factory and micro-factory production model have



been created, with a nitrate nitrogen utilization rate of 95%, daily water exchange rate of less than 3%, maximum aquaculture density of up to 80 kilograms per cubic meter, and maximum leafy vegetable yield of up to 36 kilograms per square meter. Currently, aquaponics systems have been successively implemented in various provinces in China, including Beijing, Shandong, Tianjin, Jiangxi, Guangdong, Chongqing, and others, generating significant demonstration and promotion effects.

KEYWORDS: Aquaponics, Aquaculture, Hydroponics

Applying Genetic Technologies to Combat Infectious Diseases in Aquaculture

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Infectious diseases caused by viruses, bacteria, fungi or parasites are major causes of mortality in aquaculture. The disease is often difficult to exclude from aquatic environments and treatments can be costly, require repeated handling of fish, have severe effects on fish welfare and lead to the development of resistance in the disease agent. Fortunately, cultured fish and shellfish species contain genetic variation for resistance against major diseases, and prevention by improving host-resistance has proven effective for avoiding infestation in many cases. There are also sometimes substantial differences in the susceptibility of different closely related species, and if we could discover the mechanisms underlying cross-species variation in host-resistance it might be possible to apply this knowledge using the latest genetic technologies to reduce infectious disease outbreaks and spread. In this presentation I will focus on work we have been doing using single-cell RNA sequencing, spatial transcriptomics and gene editing to understand the genetic mechanisms giving host-resistance to sea lice in different salmon species, some highly resistant (e.g. coho) and some highly susceptible (e.g. Atlantic salmon) to sea lice infection. We have used the latest transcriptomic technologies to map the gene expression response to infection in these species at a cellular level, every 12 hours at and surrounding the precise site of infection in the skin. This has given us a clear picture of the genetic and cellular changes after infection with sea lice, how the genetic response differs between more susceptible and more resistant salmon species, what overall genetic mechanisms and cell types are involved and important knowledge about ways sea lice suppress host immune responses, sea lice attraction to the host and stimulation of lice by the host. We are using CRISPR gene editing to further understand and prove which of these genes could provide keys for suppressing or eliminating the problem of sea lice. There are four main ways we now see this knowledge being applied to combat infectious disease outbreaks in the future. The deep understanding we have gained about the genetic and cellular mechanisms affecting cross-species variation in host-resistance to sea lice, could open possibilities for the creation of vaccines, for the production of effective feed additives, for more effective and directed selective breeding and, if accepted by the authorities and the public, possibilities for creating gene-edited sea lice resistant (and sterile) salmon. We have also modelled the creation and dissemination of fish with host resistance to sea lice in Norway and how this would reduce the need for delousing treatments and what possible effects it could have on the evolution of sea lice.

KEYWORDS: Host-disease resistance, Transcriptomics, CRISPR gene editing



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Nutrigenomic Approaches to Enhance the Feed Efficiency in Fish Vikas Kumar*

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Aquaculture Research Institute at the University of Idaho in collaboration with USDA has genetically selected several lines of rainbow trout (Oncorhynchus mykiss) that show higher growth rates when fed all plant protein diet (PPD) than non-selected lines of trout fed a fishmeal-based diet. So far, no commercial breeding programs have yet started to improve feed utilization efficiency in fish, mainly because of the difficulty in accurately measuring individual feed intake of fish reared in groups. This study aimed to identify trout families with better efficiency in using soybean-based diets through two experiments. In the first experiment, 15 families (CX-118, CX-125, CX-134, CX-135, CX-137, CX-138, CX-141, CX, 143, CX, 144, CX-145, CX-146, CX-147, CX-148, CX-149, and CX-152) of rainbow trout (80 fish/family) with an average initial weight of 32.7±9.4 g (±SD) were PIT tagged and randomly distributed in four tanks (450 l). Fish were reared in this environment for four months and went through two periods of feed deprivation (FD) and two periods of refeeding (RF). During the RF periods, fish were fed at satiation with a soy-based extruded diet. Fish performance was classed as FD-, FD+, RF- and RF+ for fish exhibiting loss (FD) and gain (RF) of weight relatively lower (-) and higher (+) than the population mean (FD-/ RF-, FD+/RF+, FD-/RF+ and FD+/RF-). These four groups were distributed in 800-1 tanks (~45 fish/tank) with three replicates to measure the Feed Conversion Ratio (FCR). In the second experiment, another group of 1200 rainbow trout belonging to the same 15 families were individually PIT tagged and distributed into two groups of 40 fish/tank and fed two diets. Diet 1 was supplemented with lyophilized powder of spirulina whole cells and Diet 2 was supplemented with U-15N labeled spirulina. After 18 days of feeding, 0.4 mm diameter punches were used to take muscle samples from each fish to analyze for ¹⁵N isotopes. Results for the first experiment showed families CX-148, CX-146, and CX-125 with significantly higher weight gain and families CX-138, CX-135, and CX-152 withlower weight loss during RF and FD periods, respectively (p<0.05). FCR and final weight were slightly improved in the best group (FD-/RF+) but results were not significant. Results for the second experiment showed a similar trend for weight gain (p>0.05). Also, families CX-148, CX-146, CX-147, CX-141, and CX-135 showed the highest ¹⁵N isotopein muscle. Overall, the results of the present study, so far, have demonstrated that there are substantial genetic-based variations among different families of rainbow trout in utilizing soybean-based diets. The selected individual fish from both experiments are currently using for the breeding program.

Keywords: Nutrigenomics, Feed efficiency, Rainbow trout



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Comprehensive Monitoring of Animal Health and Developing Oral Therapeutics are Needed for Sustainability of Shrimp Farming Worldwide

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Infectious diseases caused by viruses, bacteria, and fungi continue to pose a threat to the growth, profitability and sustainability of shrimp farming worldwide. As the shrimp industry expands and farming becomes more and more intensive, disease outbreaks will be inevitable and new diseases will continue to emerge. Many diseases like infectious hypodermal and haematopoietic necrosis virus (IHHNV) and Taura syndrome (TS), which shaped shrimp industries in the late 80's and early 90's, no longer pose a serious threat to the industry; while some existing diseases like white spot disease and infectious myonecrosis disease continue to cause major economic losses globally. Additionally, lesser-known pathogens like Enterocytozoon hepatopenaei have emerged as a new threat for its impact on growth, and other associated clinical manifestations like white feces disease. There are other emerging pathogens, like *Penaeus vannamei* Solinyivirus (*PvSV*) that are now widely prevalent in Latin America, although their direct impact on shrimp health is not known yet. It has been speculated that a virus like PvSV might cause synergistic effects on shrimp health when co-infected with other viruses, as seen by infectious myonecrosis outbreaks in Brazil, in 2016-2018. Similarly, the emergence of a new genotype of an existing virus, Decapod hepanhamaparvovirus (DHPV), and its wide prevalence in some countries in Latin America highlight the need to continuously monitor existing viral diseases in shrimp farming.

Today, the health assessment of shrimp primarily relies on polymerase chain reaction (PCR)-based assays and often avoids any microscopy-based diagnosis, especially histopathology-based screening. For viral pathogens like IHHNV, even PCR-based assays are becoming challenging to accurately identify infectious forms of the virus since segments of the viral genome remain integrated into the host genome. This has created a new challenge in disease diagnosis for a need to differentiate infectious virus from genome-integrated forms of the virus, also called endogenous virus element (EVE). It is becoming increasingly evident that progressive overreliance on molecular diagnostics and concurrent neglect of histopathology is creating unforeseeable challenges for shrimp farming worldwide. A recent paper published by the Aquaculture Pathology Laboratory summarized empirical evidence of how overreliance on PCR-based diagnostics can lead to erroneous diagnoses. These findings illustrate the risks of overreliance on a single methodological approach and emphasize the need for a comprehensive health assessment to safeguard the global shrimp farming industry by reducing detection failures of new or rapidly evolving pathogens, improving disease detection and identification, and improving animal health management practices.



Industrial-scale culture and the global expansion of shrimp farming are potential drivers for the emergence of new diseases in shrimp farming. It is now known that crustaceans like shrimp harbor a plethora of microbial pathogens, and new diseases will likely continue to emerge in the foreseeable future. Therefore, early diagnosis and the development of novel diagnostic tools to prevent the spread of disease will remain a cornerstone of shrimp disease management in the foreseeable future. However, prevention alone is unlikely to make the industry profitable and sustainable for the future.

There is an urgent need to develop therapeutics to control shrimp diseases. Over the past two decades, there has been enormous progress in understanding the defense mechanisms in crustaceans and developing antiviral therapeutics. Despite these efforts, delivering antiviral therapeutics via the oral route in a commercially viable way remains a bottleneck. Recent work on developing an oral delivery platform for administering therapeutic RNA using an engineered replication-deficient shrimp virus via a commercial diet has opened a new beginning for disease control in shrimp. Thus, a comprehensive health assessment by combining histopathology and molecular diagnosis and the availability of therapeutics at a commercial level will enable us to minimize the risk of disease outbreaks and enhance the long-term sustainability of shrimp farming globally.

KEYWORDS: Animal health, Oral therapeutics, Shrimp farming

Ecosystem Based Marine Management in the Norwegian Waters Lasse H. Pettersson*

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Norway has one of the longest coastlines in the world, stretching for over 25,000 kilometers (15,534 miles) along the North Atlantic Ocean and the Barents Sea. Narrow and deep fjords meet the open ocean and the Norwegian Coastal Current, setting up complex ocean current systems, which in turn make these waters rich in marine living resources. The Economic development along the coast of Norway is a significant focus for the country due to its extensive coastline, natural resources, potential for various industries, business development and recreation. Norway's marine and coastal regions have seen developments in several sectors, including oil and gas exploration, fishing, aquaculture, shipping, tourism, coastal infrastructure development and renewable energy – to mention some. Pending on natural living resources, and being the second most important export value (after oil and gas), fisheries and aquaculture has a long tradition and is managed in an integrated and holistic marine ecosystems approach.

The Norwegian government started its last assessment report with: "Current and future seabased value creation is dependent on good environmental conditions and a rich natural diversity in Norway's coastal and marine areas, safeguarding the sea as a food dish, and ensuring sustainable use of the sea's resources. Through the previous management plans for each individual sea area, comprehensive frameworks and measures for the sustainable use and conservation of the ecosystems have been laid down. With this notification, the government continues and renews the system of comprehensive and ecosystem-based management plans for the Norwegian marine areas". In this respect, Norway has defined the management plans for our oceans into three geographically district regions of the Exclusive Economic Zone (EEZ) beyond the coastal baseline: Barents Sea and Lofoten, Norwegian Sea and North Sea and Skagerrak

In this presentation, examples will be given on the environmental data, analysis and assessments forming the basis for the evolving Norwegian marine management plans. Also, the European Copernicus Marine Forecasting System of the Arctic Ocean (ARC-MFC) services, hosted by the Nansen Center will be presented. This is a service that covers physical and biological variables, such as sea-level, temperature, phytoplankton phenology and integrates novel in-situ measurements into the Marine Service to extend, the monitoring and forecasting capabilities to coastal hazards such as e.g. harmful algae bloom and marine heat waves.

KEYWORDS: Ecosystem, Marine Management, Norwegian Waters



Enhancing Climate Resilience of Fisheries and Aquaculture Sectors in the Asian Region

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The growing effects of climate change pose significant challenges to fisheries and aquaculture, particularly in Asia, where these sectors are essential for nutrition and food security and livelihoods. The region's high dependence on aquatic food from fisheries (inland and marine) and aquaculture (freshwater, brackish, and marine) makes it vulnerable to climate impacts such as sea level rise, warming waters, and extreme weather events further threatening ecosystems, and livelihoods. To address these challenges, the Food and Agriculture Organization (FAO) is providing comprehensive support to build resilience in the fisheries and aquaculture sector, including through normative work and field projects. The FAO's Adaptation Toolbox offers guidance on institutional and policy support, emphasizing the integration of fisheries and aquaculture into adaptation planning. Additionally, it focuses on enhancing the resilience of fisheries and aquaculture-dependent livelihoods and implementing risk reduction and management strategies. Building on FAO's guidance provided throughout the years on adaptation, mitigation and on fisheries and aquaculture management, FAO is implementing a portfolio of field projects to support developing countries in different regions in making their aquatic food systems more resilient to climate change. This paradigm shift towards climate-resilient fisheries and aquaculture is essential to ensure the long-term sustainability of aquatic food systems in the face of a changing climate.

KEYWORDS: Climate change, Climate resilience, Fisheries and aquaculture, Asian region

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Shrimp Chitooligosaccharide-Polyphenol Conjugates: Novel Additives for Seafoods

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Seafoods are rich in nutrients, however, they are perishable with a short shelflife. Seafoods undergo quality deterioration as induced by microorganisms, enzymes, and chemical reactions. Food additives have been widely used to maintain quality. Nonetheless, some artificial additives can harm the human health. As a consequence, the natural additives, especially from marine- and plant-based origins, have garnered augmenting attention. Chitooligosaccharide (COS) is derived from chitosan via the hydrolysis of glycosidic bonds. COS has been demonstrated to possess both antioxidant and antimicrobial activities. To enhance such activities, plant polyphenols have been successfully grafted to COS through the ascorbic acid/H₂O₂ free radical grafting method. The resulting conjugates (COS-PPN) have increased bioactivities but are governed by the types of polyphenols used. COScatechin (COS-CAT) had higher DPPH and ABTS radical scavenging activities, oxygen radical absorbance capacity (ORAC) and ferric-reducing ability antioxidant power (FRAP) than COS and all other COS-PPN conjugates, e.g. COS grafted with gallic acid, ferulic acid; caffeic acid, and epigallocatechin gallate, etc. When whole Pacific white shrimp treated with COS-CAT with the aid of pulsed electric field (PEF) and vacuum impregnation (VI) and stored at 4 °C for 15 days, a lower melanosis score took place in the samples when pre-treated with PEF, followed by soaking in CHOS-CAT conjugate at 2% (w/v) with VI (CC-PV-2) than other samples at the end of storage (15 days) (p<0.05). Total viable bacteria, psychrotrophic bacteria, presumptive Pseudomonas, Vibrio parahaemolyticus, other Vibrio sp., H₂S-producing bacteria, and Enterobacteriaceae counts of CC-PV-2 were lower than other samples at the end of storage. Polyunsaturated fatty acids were retained at a substantial amount in the CC-PV-2 on day 15. Furthermore, next-generation sequencing revealed a low percentage of spoilage bacteria such as Shewanella and Pseudomonas and pathogenic bacteria, particularly Vibrio sp. in the CC-PV-2. Overall, CC-PV-2 had a shelf-life up to 12 days, whereas the control could be stored only for 3 days. COS-CAT conjugate mainly caused microbial membrane disruptions and damages as witnessed by numerous pores and concaves on the cell surface. Membrane damages were further confirmed by the increases in conductivity, extracellular malondialdehyde content, and the leakage of potassium and magnesium ions. Biofilm formation was also reduced in the presence of COS-CAT. Apart from microbial spoilage, melanosis is an undesirable phenomenon in shrimp and other crustaceans. This discoloration is triggered by a biochemical reaction mediated by tyrosinase or polyphenoloxidase (PPO). When comparing all COS-PPN conjugates, COS-CAT exhibited the lowest IC₅₀ toward Pacific white shrimp PPO. CHOS-CAT showed the



mixed-type inhibition kinetics. CHOS-CAT was linked with various amino acid residues, including Tyr208 or Tyr209 of proPPO via van der Waals, hydrophobic interaction, and hydrogen bonding as elucidated by the molecular docking of proPPO. Therefore, COS-PPN can serve as a promising additive for maintaining the quality and extending the shelf-life of seafood.

KEYWORDS: Shrimp shell, Chitooligosaccharide, Conjugates, Antimicrobial, Antioxidant, Shelflife, Melanosis, Waste utilization

Socio-Economic Dynamics and Extension in Fisheries and Aquaculture

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The topic "Socio-Economic Dynamics and Extension in Fisheries and Aquaculture" lies at the intersection of environmental sustainability, food security, and socio-economic development. Fisheries and aquaculture are not merely economic sectors; they are lifelines for millions of people across the globe. Small-scale fisherfolks, their families, and their communities depend on the health of aquatic ecosystems for their survival. The complex socio-economic dynamics of fisheries and aquaculture will be delved in this presentation, with a focus on how extension services can empower fishing communities to achieve sustainability and resilience.

The fisheries and aquaculture sectors play a critical role in the global economy. Small-scale fisheries provide food for billions, contribute to GDPs, and form the backbone of coastal communities. However, these fishing communities face mounting pressures. Overfishing, climate change, and habitat destruction threaten the resources they depend on. Socioeconomic inequalities further compound the problem, as many small-scale fishers lack access to markets, credit, and technology. Women, who play vital roles in post-harvest activities, often face barriers to participation and decision-making. The "Too Big to Ignore" (TBTI) initiative has highlighted these challenges on a global scale, emphasizing the need for policy and research attention to support small-scale fisheries. This is where extension services come into play. Extension in fisheries and aquaculture refers to programs and initiatives that disseminate knowledge, build capacity, and facilitate access to resources for small-scale operators. It serves as the bridge between innovation and practice, ensuring that fishers and fish farmers are equipped to adapt to changing conditions. While extension services hold immense potential, several challenges must be addressed: 1) resource access inequities; 2) financial barriers; 3) knowledge gaps; and 4) gender inequality. Despite these challenges, the opportunities for positive transformation are immense. By leveraging extension services effectively, we can unlock the potential of fisheries and aquaculture to drive sustainable development. Examples of opportunities are: 1) eco-certification for market access; 2) community-led resource management; 3) digital innovations, and 4) youth engagement.

As we move forward, there are several key actions that we must prioritize: 1) invest in extension services; 2) promote inclusive policies; 3) foster global collaboration; and 4) empower communities. The future of fisheries and aquaculture is not just about sustaining industries; it is about sustaining lives, cultures, and ecosystems. By addressing the socioeconomic dynamics of these sectors and leveraging the power of extension services, we can create a more equitable and sustainable blue economy.

KEYWORDS: Socio-economic dynamics, Fisheries and aquaculture extension



Rethinking Gender Research in the Era of Big Aquaculture and Fisheries Transformations

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With transformations in the aquaculture and fisheries sectors happening at a very fast pace both in terms of technology (efficient, productive and sustainable or green) and policy (for eg: blue economy), it is imperative that gender research also be equally responsive to highlight the importance of gender inclusion and responsiveness in technology development and sensitivity and inclusion in the policy. Mere inclusion of gender as a cross-cutting theme without highlighting the actual needs will only result in further marginalization of women (and other vulnerable groups). This requires enhanced efforts by gender researchers to provide critical evidence and inputs that can integrate gender as a driver just like other dimensions.

Over the past three decades, a rich body of work has documented and established the roles and contributions of women and the patterns of gender inequalities across fish value chains. These have established differential and often invisible roles that women play in making and keeping the value chains efficient. The reasons for the invisibility stem largely from the lack of recognition of women's work as productive for fish value chains to function. Besides highlighting roles, the differential impacts of natural disasters, technology interventions, policies, access to finance, etc. have also been highlighted, often bringing forth the lack of gender sensitivity in responses and gender blindness in development. Interesting and often overlooked human dimensions like contributions and issues with respect to people with disabilities, older people and people who align themselves as other genders have also been studied. Global studies such as the FAO-led *Illuminating Hidden Harvests* study and policy instruments such as the Voluntary Guidelines on Small-Scale Fisheries and the Sustainable Development Goals have highlighted positive impacts of gender inclusion, which should essentially form gender reference points for States to develop policies. Though it is encouraging to observe that gender is today an important and inevitable part of any policy document, and gender monitoring and evaluation an important inclusion in any program, a lot remains in terms of implementation to match the actual intent and outcomes to establish actions as being gender-sensitive, responsive and transformative.

The research approaches and methods have also undergone changes with studies moving away from documentation, which was and continues to be very important, to increasing stress of the use of robust conceptual and theoretical models and methods that establish and explain more emphatically the evidence that is required to drive policy and program.



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Though data gaps remain a critical issue, attempts are seen to generate these, largely at micro and meso levels. Concerted global efforts are required to generate data at the macro level to understand national, regional, and global patterns. Gender inclusion and its impacts are often not immediately visible, like an improved fishing technology intervention or a fish disease diagnostic that will result in cost reduction and improved profits that are easily measurable in the very short term. Gendered impacts are often long-term and may be in the form of improved household nutrition, the enhanced decision-making power of women at household and community levels, improvement in health and education of members of the family, and more participation of women in the labour force, all of which are not easily discernible. Attributing these to gender inclusion, equality and equity will require detailed and time-consuming enquiry.

KEYWORDS: Gender inclusion, Equity, Fisheries, Aquaculture, Blue transformations

Fisheries and Aquaculture Products: Recent Trends, Challenges and Opportunities

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The fisheries and aquaculture sector significantly contributes to food security and livelihoods, supplying millions with sustenance, nutrition, income, and employment while fostering economic development through harvesting, processing, and marketing. Several nations, notably many developing countries, and small island developing states (SIDS), exhibit significant reliance on the sector, which is especially vital for the populations of various coastal, riverine, insular, and inland areas. In 2021, total fisheries and aquaculture production attained a record high of 218 million tonnes, consisting of 182 million tonnes of aquatic animals and 36 million tonnes of algae. This signifies an increase of 2 percent relative to 2020, primarily attributed to the expansion of aquaculture in Asia and catch fisheries in the Americas. China, India, and Indonesia were the leading aquaculture producers, collectively representing over 70 percent of the total production of aquatic animals. In contrast, China, Indonesia, and Peru were the three principal capture producers in 2021. However, they represented less than 30 percent of the entire capture output of aquatic animals, underscoring the lower concentration of capture production compared to aquaculture production.

In 2021, the global trade in aquatic animals, propelled by inflation, reached a historic peak of USD 176 billion, surpassing the prior record of 2018 by over USD 11 billion and reflecting a 16.7 percent increase relative to 2020. The United States of America, China, and Japan were the three principal importers, collectively representing 35 percent of the total value of imports. Conversely, China, Norway, and Vietnam were the three principal exporters, collectively representing 25 percent of the total export value. Therefore, fisheries and aquaculture products are commodities substantially influenced by the three angles of sustainability and international trade. Exports of fisheries and aquaculture products impact global production and distribution patterns. Additionally, the industry is frequently confronted with extended value chains, exacerbating the complexity of exogenous and endogenous influences. The industry has encountered numerous new environmental and social regulations in recent years. Import regulations are in place in multiple significant importing countries to guarantee the legality of imported fish. Furthermore, several private importers have implemented minimal market requirements that address environmental and social issues. The recurring disruptive events that historically occur in producing, distributing, and trading fisheries and aquaculture products in numerous countries have generated new opportunities to sell fish innovatively and access alternative markets. The sector continues to face traditional obstacles, including non-tariff barriers, the necessity of reducing food loss and waste, the expansion of a whole

utilization approach, the fundamental role of small-scale fishers, and the need for more comprehensive dissemination of the nutritional value of fisheries and aquaculture products. The presentation will analyze the most recent developments in producing fisheries and aquaculture products and the corresponding challenges, market innovations, and projections. It will also emphasize the interconnectedness of FAO instruments and the potential for technical assistance from FAO, particularly in sustainability requirements and market access opportunities, to promote a sustainable industry from all three sustainability perspectives.

KEYWORDS: Fisheries and aquaculture products, Challenges and opportunities

Beacons for the Governing of Fisheries: A Reflection

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Governance has become a buzzword with a variety of interpretations. My view of governing is that it is broader than management and has a longer time horizon and a wider scope. It is a process that involves many actors at multiple scale levels. Importantly, it includes governing actors other than the government, such as communities, religious orders, and private parties. The constellation of governing actors and processes is characterized by legal pluralism. Finally, it is good to note that governance is not always 'good', but can also be 'bad' or, hopefully, 'good enough'.

Stream 14 contains a variety of contributions that will hopefully help us to better understand the realities of governing as they take place on the ground in various Asian locations. These realities are frequently different than the ones worded on paper, and I prefer to give them extra weight. After all, it is what is on the ground that matters to fishers and their communities, not what is contained in policy documents. Legal pluralism, as understood by the members of the Commission on Legal Pluralism, brings together people acting according to different bodies of norms, rules and regulations. Their cohabitation can be uneasy or conflictuous, but sometimes also accommodating and mutually supportive. The alternation between these states of cohabitation has interested me and resulted in papers of different sorts, often taking Indian fisheries as a case in point.

The objectives of governance are various. The councils governing the fisheries that I study in Tamil Nadu have as ultimate goal the wellbeing of their communities. Their regulations for fisheries have environmental, economic and social dimensions. The achievement of fairness between community members is one of them. The government often strives to maintain law and order among fishers who are suspected to be especially boisterous and difficult to control. But let us focus on the bigger goals or beacons of capture fisheries governance as they are formulated in the international arena. The first beacon is 'maximum sustainable yield' (MSY). This beacon is important in view of the declining health of marine ecosystems and the prevalence of overfishing. It derives from the disciplines of marine biology and ecology. The second beacon is 'maximum economic yield' (MEY), which looks at fisheries from an economic perspective. It is interested in efficiency and monetary benefit. Many countries focus explicitly on these two objectives.

I would argue that we are overlooking a third dimension: the maximizing of sustainable employment (MSE). In a paper recently published in Fish & Fisheries, the authors argue that the employment benefits of capture fisheries are notable and of great importance for people living along coasts in marine and inland areas. In a long historical series of State



of World Fisheries and Aquaculture reports, FAO has documented the increasing number of people earning a living around capture fishing. It is only recently that FAO argues that employment figures may be going down, at least in some countries. We know, however, that FAO estimates are uncertain and that the trend may actually be different. We also know that in many developing countries, also in Asia, the livelihood opportunities offered in capture fisheries are substantial, attracting people from other rural and urban sectors. In my studies of Indian fisheries, In Tamil Nadu, I therefore regularly come across migrants of non-fishing origin from other parts of the country.

The reason the employment factor is important lies beyond fisheries. It is a consequence of the broader economies in which fisheries are embedded. Many of these broader economies are one-sided and do not show growth where it may be most needed: in the rural domain. For many rural populations, fishing continues to provide a real opportunity for making a living and drives them to seek employment there. For reasons of completeness, I therefore argue that sustainable employment be elevated as a beacon next to 'sustainable' and 'economic' yield. In every country situation, governors must seek the most appropriate balance between these beacons.

The last topic I would like to bring up in this keynote is 'alternative employment'. Many fisheries managers are of the opinion that there are too many fishers in the world and that fishers should be encouraged to look for 'alternative employment'. I do not disagree with this objective because indeed there is an overcapacity problem in many capture fisheries. In my visits to coastal communities in Southern India and Sri Lanka, I have also noted that all, or at least most, parents want their children to leave fishing and attain more 'job satisfaction'. They therefore send them to primary, then to secondary, and then to college education. Why do they do this? My impression – that I cannot expand on here – is that parents and children are responding to the abominable state of fisheries governance in many countries that results in large conflicts and continuously declining catches. Under such conditions, the best option for the future would seem to lie outside the sector. But then comes the realitycheck: many of these now better-educated children are not able to find the jobs they are seeking outside of fishing. They are rebuffed by the larger condition of the economy that cannot offer employment to many job-seekers from fisheries but also from so many other rural sectors. As a result, many youngsters return to the fisheries from which they originate.

KEYWORDS: Fisheries governance, Fisher communities

Regional Response to Emerging Aquatic Animal Diseases Eduardo M. Leaño*

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The continuously growing human population remains to be the main challenge in the sustainable production of animal protein and aquaculture is one of the industries that can sustain such demand for human consumption. The decrease in the traditional food fish supply has led to an increasing reliance on aquaculture, where the bulk of production comes from the Asia-Pacific. Although aquaculture in the region can already be considered as well developed, there are still many challenges and problems that the industry are facing, including transboundary aquatic animal diseases. Aquatic animal disease outbreaks often result to significant economic losses and affect the sustainability of the aquaculture industry as an important food production sector. Over the past three decades, the Asia-Pacific region has been swept with several devastating epizootics, where results were aggravated by the lack of emergency preparedness and response. Some of these diseases include: Infection with *Aphanomyces invadans* (Epizootic Ulcerative Syndrome; EUS) and Infection with koi herpesvirus (KHV) among freshwater fishes; Infection with white spot syndrome virus (WSSV) and Infection with myonecrosis virus (IMNV) among marine shrimps; and White tail disease (WTD) in freshwater prawn.

More recently, emerging diseases of shrimps and finfish again challenged the aquacultureproducing countries in the region in responding to prevent and/or control outbreaks. One of which is the Early Mortality Syndrome (EMS) of cultured marine shrimps, which was later named as Acute Hepatopancreatic Necrosis Disease (AHPND). Despite the availability of advanced molecular diagnostic tools, identification of the causative agent (Vibrio parahaemolyticus) took a significant amount of time while the disease brought havoc in the shrimp industry of the affected countries. The situation clearly showed the lack of preparedness of most countries in dealing with emerging diseases, this is considering the several disease epizootics that have happened in the past. The experience with AHPND taught another lesson on how vulnerable the aquaculture industry is on emerging diseases. Thus, when another emerging shrimp disease was reported (Infection with decapod iridescent virus 1; DIV 1), most of the major shrimp-producing countries immediately undertook disease surveillance and implemented biosecurity measures to prevent the entry of the pathogen (better preparedness and response). For finfish, the Tilapia Lake Virus (TiLV) was detected in the region in 2017, and several countries immediately responded to detect the presence of the virus in their cultured tilapia. Consequently, some national and farm-level biosecurity measures were put into place to prevent and/or properly manage the disease. Overall, regional preparedness and response to disease emergencies significantly improved in recent years, through proper coordination with both regional and international organisations and

collaboration among the different stakeholders especially in major aquaculture-producing countries in the region. With the continuous intensification of aquaculture systems coupled with the transboundary movement of live aquatic animals and aquatic animal products, emerging disease emergencies will still happen in the future. This warrants a better or improved disease preparedness and response at both national and regional levels.

KEYWORDS: Emerging aquatic animal diseases, Epizootics, Regional response

Biosecurity and Quarantine for Disease Prevention in Aquaculture Iddya Karunasagar*

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According to FAO estimates, the contribution of aquaculture to global fish production is likely to increase from 49% in 2022 to 54% in 2032. Aquaculture is expected to cross the 100 million tonnes threshold in 2027 to reach 111 million tonnes in 2032. But there are increasing challenges like wider adoption and enforcement of environmental regulations, reduced availability of water and areas suitable for aquaculture and increasing impact of animal diseases in intensive aquaculture. To achieve sustainable aquaculture production, it is essential to minimize the impact of diseases by adopting preventive approaches like the implementation of biosecurity. According to the WOAH Aquatic Animal Health Code, biosecurity means a set of management and physical measures designed to mitigate the risk of introduction of pathogenic agents into or spread within or release from aquatic populations. Biosecurity needs to be implemented at different levels – aquaculture establishments, zones, or compartments and at the national level.

Aquaculture systems and species cultured are diverse and the disease risks for each species and aquaculture system would be different, hence for each aquaculture establishment or zone or compartment a detailed biosecurity plan needs to be developed. This should be based on the information on the potential pathways for the pathogenic agents to be transmitted into, spread within, and released from aquaculture establishment, zone, or compartment. In addition, risk analysis needs to be undertaken to identify and evaluate disease threats and ensure that the biosecurity plan addresses the risks appropriately and efficiently. Management practices needed to minimize the disease risks should be integrated into the operating procedures within aquaculture establishment, zone, or compartment. Biosecurity measures need to be evaluated for the effectiveness, costs involved, and practicality of implementation. A schedule for reviews and audits of biosecurity practices needs to be incorporated into the plan, but any breach of biosecurity indicated by disease outbreaks or changes in risk profiles may trigger the need for ad hoc review.

Quarantine is defined as maintaining a group of aquatic animals in isolation with no direct or indirect contact with other aquatic animals to undergo observation for a specified length of time. During this period, the animals may undergo testing or treatment. Quarantine is used as a risk management measure in international trade to prevent the transmission of diseases during the transboundary movement of aquatic animals. There may be pre-border quarantine in the exporting country and post-border quarantine in the importing country. There may be quarantine at the farm level when live animals come into the farm to ensure that only healthy animals are released into the farm and in such cases, quarantine becomes part of

the biosecurity operational plan. Quarantine may be used as a risk management measure while moving live animals like fish seeds or crustacean larvae or live feed into a disease-free zone or compartment. Some case studies of biosecurity plan and quarantine regulations in international trade will be discussed.

KEYWORDS: Biosecurity, Quarantine, Disease prevention, Aquaculture

Diagnostics and Vaccines for Aquaculture in India

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The aquaculture sector is poised to play a critical role in meeting the global demand for protein- and nutrient-rich meals by 2040, driven by exponential growth and the adoption of advanced scientific technologies. However, the sector faces significant challenges, including the escalating incidence of fish diseases and associated economic losses. Traditionally, fish disease management has relied heavily on antibiotics and chemical treatments, leading to major concerns such as antimicrobial resistance (AMR), chemical residues in aquatic ecosystems, and adverse environmental impacts. As a result, effective fish health management now hinges on rapid disease diagnosis and robust preventive strategies to minimize losses and ensure sustainable practices.

The integration of automation and artificial intelligence (AI), including machine learning and sensor technologies, into fish disease diagnostics and prediction is revolutionizing aquaculture. These technologies enable a deeper understanding of disease progression and facilitate improved fish health and welfare. Diagnostics serve as an essential tool for detecting infections, enabling timely interventions, managing outbreaks, and implementing robust biosecurity measures. State-of-the-art diagnostic tools, such as polymerase chain reaction (PCR), quantitative PCR (qPCR), digital PCR (dPCR), loop-mediated isothermal amplification (LAMP), LFIA, and CRISPR-based methods, along with traditional serological techniques and microscopy, have become standard practices in aquaculture disease management. ICAR has filed patents for the invention of extremely sensitive and field-deployed CRISPR Cas12-based diagnostic assays for significant diseases like tilapia lake virus and white spot disease virus. Furthermore, emerging technologies such as metagenomics and nanopore sequencing are transforming the field by enabling the rapid identification of unknown pathogens directly at the site of disease occurrence, thereby eliminating the need for sample transportation to distant laboratories.

In India, aquaculture is predominantly small-scale and concentrated in coastal and northeastern regions, where rapid disease progression poses a significant challenge. The development of on-farm or field-based diagnostic tools is crucial for timely disease detection and management. Despite progress in establishing referral and accredited diagnostic laboratories supported by the National Surveillance Programme, access to advanced diagnostic tools in remote and rural areas remains limited. Research institutes in India are now equipped to handle outbreaks and emerging diseases swiftly; however, the lack of affordable, user-friendly

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diagnostic solutions for small-scale farmers remains a pressing issue. Addressing this gap is essential to ensure equitable access to advanced fish health management technologies across all stakeholders in the sector.

Vaccines are an integral component of sustainable aquaculture, offering a viable alternative to antibiotics and chemicals. However, awareness of aquaculture vaccines remains limited, particularly in India. Globally, commercial vaccines for species such as salmonids, tilapia, and catfish have demonstrated significant success. In India, however, commercial vaccine programs for aquaculture are still in their infancy. Recent advancements by ICAR institutes have led to the commercialization of vaccines targeting bacterial pathogens such as *Aeromonas hydrophila*, *Edwardsiella tarda*, and *Flexibacter columnaris*, as well as viral infections caused by betanodavirus. Regulatory guidelines for vaccine development are nearing approval, which is a promising step toward making commercial vaccines widely available in India.

Despite these advancements, several challenges persist. Developing effective vaccines for parasitic organisms remains a significant hurdle. Parasitic infections are becoming increasingly problematic for aquaculture, necessitating a comprehensive and collaborative approach to develop innovative solutions, including vaccines. Moreover, effective vaccine delivery mechanisms tailored for large-scale, cost-effective application to culturable species are urgently needed. Immersion vaccines, in particular, require novel adjuvants to enhance their efficacy and accessibility for small-scale and resource-constrained aquaculture operations.

To overcome these challenges, a comprehensive approach is necessary. This includes the development of novel vaccine candidates that target concealed antigens and consider the roles of innate, trained, and specific immunity. Research must also focus on innovative delivery mechanisms that are scalable and cost-effective, ensuring accessibility for all aquaculture stakeholders. Additionally, the design of advanced adjuvants, particularly for immersion vaccines, is critical for improving vaccine efficacy.

India's aquaculture sector stands at a pivotal juncture. With continued investment in research and development, the integration of cutting-edge diagnostic technologies, and the commercialization of effective vaccines, the sector can achieve significant strides in sustainable disease management. These advancements will not only mitigate economic losses but also ensure the long-term viability and environmental sustainability of aquaculture as a vital source of nutrition for a growing global population.

KEYWORDS: Diagnostics, Disease, Fish, India, Vaccines

Aquatic Animal Disease Surveillance in India

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Globally, about 10% of total aquaculture production is lost due to diseases which are recognized as the most significant constraint to the sustainable growth of aquaculture, and have serious impacts on productivity as well as profitability. Over the last few decades, there has been the emergence of several new diseases, and as per WOAH Aquatic Animal Health Strategy 2021-2025, two new diseases in aquatic animals have been reported to emerge every three years. Besides, there has been the spread of known diseases to new areas. Importantly, about one-third of the aquatic animal products are traded internationally which is an important route for the transboundary spread of diseases. The intensification and diversification of aquaculture are further likely to facilitate the emergence and spread of pathogens.

Early detection is key to minimizing losses due to diseases and can be achieved through a disease surveillance programme, which provides information about the occurrence of important diseases and pathogens to produce meaningful reports on the disease status of the country. Realizing the importance of rapid detection of diseases and meeting international obligations of disease reporting, the Government of India initiated a National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) in the year 2013. In Phase I (2013-22), the programme was implemented in 19 states through 31 centres, including Fisheries Research Institutes, College of Fisheries, other government organizations and colleges. Since 2022, Phase II of NSPAAD (2022-25) has been implemented in pan-India under the Pradhan Mantri Matsya Sampada Yojana (PMMSY). In Phase II of NSPAAD, the State Fisheries Departments (SFDs) and Marine Products Export Development Authority (MPEDA) have also been involved in strengthening the disease surveillance.

In the NSPAAD, a strong network of laboratories working on aquatic animal health has been created. The 'Diagnostic Manual' prepared under the programme contains internationally-agreed protocols for the diagnosis of aquatic animal diseases to be followed uniformly by all the Collaborating Centres that harmonise the testing process. Besides, diagnostic capability for WOAH-listed diseases of finfish, crustaceans and molluscs has been developed, and the capacity for detection of emerging aquatic animal pathogens is continuously being upgraded.

The emphasis of the programme has been to strengthen passive disease surveillance. In this direction, all the NSPAAD Collaborating Centres have been organising awareness



programmes involving fish farmers to create awareness about major aquatic animal diseases, their management, the importance of timely reporting of major incidents of mortality and the methods of transporting diseased fish samples to nearby laboratories. Besides, training programmes are being regularly organized to strengthen the diagnostic capability of officers of SFDs. Further, all the Centres investigate disease cases reported by the fish farmers, and provide scientific advice to them to manage the diseases. The robustness of the passive disease surveillance programme can be reflected in terms of the report of 12 new diseases from the country for the first time which include Goldfish haematopoietic necrosis disease; Koi sleepy disease; Tilapia lake virus disease; Epitheliocystis; Infection with red sea bream iridovirus; Hepatopancreatic microsporidiosis, Infectious myonecrosis, Infection with Rhabdovirus; Infection with Mud crab reovirus, Tilapia parvovirus disease, Infection with Wenzhou shrimp virus 8 and Infection with Macrobrachium rosenbergii golda virus. In addition, infection with *Perkinsus olseni* has been reported in a new host i.e. short-neck yellow clam Paphia malabarica. Importantly, NSPAAD helped to negate unconfirmed reports of Acute Hepatopancreatic Necrosis Disease (AHPND) from the country. In addition, screening of fish samples for spring viremia of carp virus; infectious pancreatic necrosis virus; and viral haemorrhagic septicaemia virus and shrimp samples for yellow head virus genotype 1 and Taura syndrome virus did not reveal any positive case from the country.

Under the NSPAAD, a mechanism has been established for the confirmation of exotic and emerging diseases detected in the country for the first time. Following suspicion of a new disease, the same is reported to the coordinating institute i.e. ICAR-NBFGR and the samples are shared with two national laboratories. Following confirmation of the disease by all three centres, a compiled report is submitted to the Competent Authority i.e. Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, and alerts and advisories are sent to the SFDs. The report of the WOAH-listed diseases detected in the country for the first time is notified to WOAH. The information regarding WOAH-listed and NACA-listed diseases is shared with WOAH and NACA on a quarterly basis. The country has been transparent in disease reporting and the same is being appreciated in several international fora.

To further strengthen farmer-based reporting, an Android-based app named as 'ReportFishDisease' has been developed and launched by the Government of India. The app is available in Hindi, English and 11 regional languages on Google Play Store. Using the App, the farmers can report disease cases in finfish, shrimps and molluscs on their farms to the field-level officers and fish health experts, and get scientific advice for quickly addressing the disease problem on their farms.

The aquatic animal disease surveillance programme in the country has helped to know the diseases that are present, significantly enhance the diagnostic capability, rapidly detect new and emerging diseases, provide scientific advice to the farmers, issuing early warnings for disease emergencies, and reduce losses due to diseases.

KEYWORDS: Aquatic animal disease, Surveillance, Aquaculture



Surveillance of Antimicrobial Resistance in Indian Aquaculture: Recent Updates

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Bacterial diseases are known to cause huge economic losses to the aquaculture industry and farming community. Disease treatment in aquaculture is mostly metaphylactic use of antimicrobials. However, sub-therapeutic levels of antimicrobials exert selection pressure on bacteria promoting the emergence of antimicrobial resistance (AMR) in bacterial populations. The Spread of AMR in aquatic environments is further aided by the horizontal gene transfer of AMR genes within bacterial species of aquatic ecosystems. Globally, AMR in pathogens of human healthcare and animal sector is on the rise due to inappropriate and excessive use of antimicrobials. The AMR not only makes disease treatments ineffective but also increases the severity of the disease, reduces productivity and leads to economic losses. Thus, it was important to quantify the burden of AMR in food-producing animals and aquaculture.

Indian Network of Fisheries and Animal Antimicrobial Resistance (INFAAR) was established to document AMR in different animal production systems, describe the spread of resistant bacterial strains and resistance genes, identify trends in resistance and generate hypotheses about sources and reservoirs of resistant bacteria through a structured national surveillance programme. INFAAR is a technical programme of the Indian Council of Agricultural Research (ICAR), being executed with the cooperation of the Food and Agricultural Organization (FAO). INFAAR is currently operational through 31 centres (11 centres in fisheries and 20 in the livestock sector) spread across the country. The objectives of INFAAR envisions are to (i) undertake surveillance of AMR in target microorganisms isolated from healthy farmed animals and fish/shellfish to quantify its burden and monitor the spatial and temporal trends of AMR in India and (ii) improve awareness and understanding of AMR among the farming community, veterinary and fish health professionals and policy-makers through effective communication, education and training to promote the judicious use of antimicrobials in farmed food animals and fish. The crucial data emerging on the spatial level will be input to formulate strategies and policies to prevent and reduce the spread of AMR in farmed animals and fish and subsequently to humans.

Surveillance of AMR is being carried out in three kinds of aquaculture production systems, namely- freshwater, brackishwater and marine. The freshwater production system comprised of three fish species, *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*, collectively termed as Indian major carps. These three fish species contribute to >75% of the total aquaculture production of India. Brackishwater aquaculture system contributes towards the production of



farmed shrimps predominantly *Penaeus vannamei*, intended mainly for exports, while marine aquaculture comprised of cage cultured fish mainly seabass, *Lates calcarifer*. The priority microorganisms used to assess AMR in freshwater aquaculture are *E. coli*, *Staphylococcus aureus*, other Coagulase-negative *Staphylococcus* species (CONS) and *Aeromonas* species, whereas *E. coli*, *S. aureus*, CONS and *Vibrio* species including *Vibrio parahemolyticus* for shrimps and marine fish. The network partners followed the disc diffusion method for antimicrobial susceptibility testing of the isolates and the results were interpreted as per the CLSI breakpoints using WHONET software.

Altogether, a total of 5447 aquaculture farms located in 42 districts covering 12 states of India were surveyed and sampled for bacterial isolation during 2019-2023. Atotal of 12,067 bacterial isolates were analysed for AMR. The S. aureus and CONS isolates were mostly sensitive to chloramphenicol, gentamicin, tetracycline and linezolid. However, Staphylococcus isolates across all the aquaculture systems showed high resistance against penicillin. Erythromycin resistance was noted in 1/3rd of the Staphylococcus isolates. Ciprofloxacin resistance was also notable in a few freshwater fish isolates. E. coli isolates from freshwater fish were susceptible to most antimicrobials, whereas shrimp isolates exhibited moderate resistance against ampicillin. Marine isolates showed higher resistance to cefotaxime and cefpodoxime as compared to freshwater and shrimp samples. Vibrio isolates from shrimp showed significant resistance observed against ampicillin, whereas marine fish isolates showed high resistance against cefotaxime. The majority of the Aeromonas isolated from freshwater fish were susceptible to amikacin, cefepime, chloramphenicol, imipenem and tetracycline. The obtained surveillance data on AMR is helping the farmers in decision-making on using the right choice of antimicrobials for the treatment and management of fish diseases. The network partners also organised awareness programmes on AMR and disseminated the results of surveillance data to farmers, health professionals and policymakers. INFAAR plans to continue generating sector-specific, commodity-specific and region-specific information on the burden of AMR in aquaculture and monitor yearly trends.

KEYWORDS: Surveillance, Antimicrobial resistance, Indian aquaculture

Therapeutic Intervention in Indian Aquaculture for Improved Aquatic Animal Health Management

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Culture intensification with improved germplasm and better management practices supported by judicious use of chemicals, biologicals and veterinary medicinal products (VMPs) are the key factors driving global aquaculture. The economic and environmental sustainability of the sector depends largely on maintaining the optimal water and soil quality, control and prevention of diseases, and improvement in growth and production. However, the diseases are considered as one of the limiting factors in achieving optimal production in the global seafood production practices. The loss in aquaculture could be due to bacterial, viral and fungal infections, external and internal parasitic infestations and altered environmental parameters. Major bacterial pathogens reported in Indian aquaculture were *Aeromonas hydrophila*, *A. veronii, Edwardsiella tarda*, *E. ictaluri, Flavobacterium collumnare, Vibrio alginolyticus*, *V. vulnificus*, *V. harveyi, Photobacterium damselae*, *Streptococcus agalectiae*, *Aphanomyces invadans*, and *Saprolegnia parasitica* while *Caligus* spp., *Argulus* spp., *Lernanthropsis* spp. and *Lernaea* spp. were the major parasitic infestations.

The direct and indirect losses to the sector are estimated to be between 10-15% of production value. The direct cost of disease includes loss of stock and expenditure towards prophylactic and therapeutic measures, while indirect cost may include loss of employment in upstream (hatcheries, nursery, feed mills, chemical and healthcare manufacture, etc.) and downstream (processing, marketing, exports, etc.) enterprises and the consequent loss to the exchequer. To achieve healthy and sustainable fish production it is essential to use chemicals, biologicals and veterinary medicinal products (VMPs). However, the potential human and environmental health risks need to be assessed for regulating their optimum use. Generally, chemicals, nutritional supplements, probiotics, disinfectants, antimicrobials and antiparasitic agents are applied in aquaculture operations to maintain optimal environmental quality, improved health, growth, production and protection against microbial and parasitic diseases. Nonjudicious use of disinfectants and antiparasitic agents might affect the non-target organisms leading to potential ecological degradation. Similarly, the unmonitored use of antibiotics might augment the emergence of antibiotic resistance.

In general standard guidelines for applying chemicals and VMPs across the aquaculture countries for the safe and effective use of these compounds for sustainable aquaculture. Globally, the organizations like USFDA, European Medical Agency (EMA), Health Canada, South East Asian Fisheries Development Centre (SEAFDEC) regulate and monitor the usage of drugs and chemicals in their respective countries while Codex Alimentarius recommends



internationally accepted codes and standards for food production including aquaculture. To establish similar standards for Indian aquaculture, All India Network Project on Fish Health (AINP_FH) funded by the Indian Council of Agriculture Research (ICAR) has established, biosafety and withdrawal periods for the commercially important fish species of fish. Efficacy against major bacterial and fungal pathogens was evaluated while environmental safety and degradation were established. Antimicrobial agents (Oxytetracycline, Florfenicol, Sulfadimethoxazole with trimethoprim, Sulfadimethoxine with ormetoprime and Oxolinic acid), anti-parasitic agents (formalin, hydrogen peroxide, emamectin benzoate, lufenuron, ivermectin and praziquantel), antifungal agents (formalin, copper sulphate and hydrogen peroxide) and disinfectants (potassium permanganate, dimethyl alkyl benzalkonium chloride, povidone iodine and formalin) has been examined. These substances are known to rapidly degrade in aquaculture environments through photo-degradation, and thermodegradation. The environmental safety of these substances is evaluated using recommended environmental indicator organisms.

The risk of antimicrobials used in food animal production, especially aquaculture needs to be seen in the light of their metabolism in the host and their natural degradation in the aquatic environment. Further, selection based on pharmacokinetic studies in different fish species, appropriate therapeutic regimen design, and required legislation is required to promote the practical and prudent use of antibiotics in aquaculture. Antibiotics need to be effectively used in response to the bacterial disease burden and food and environmental safety.

Generally among Asian countries, freshwater fish farming contributes to bulk of the domestic fish consumption while shrimp farmed in brackishwater systems are destined for international markets. Hence prioritized efforts are required to address disease management across the major fish-producing countries. Reorienting the expenditure on prophylactic and therapeutic agents, promoting training and awareness programs, providing effective diagnostic services, developing guidelines for the scientific use of healthcare products and implementing targeted disease control programs could be suggested for effective management of aquatic animal diseases. Further, efforts to address the identified determinants of the diseases could lead to substantial benefits in terms of increased farm revenue, thus accentuating food security and employment generation.

Higher efforts are required at the national and international levels through enhanced funding for research, capacity building through training and dissemination of scientific health management practices would help in reducing the disease prevalence and the consequent economic loss. Further, institutional strengthening and capacity building, implementation of science-based risk analysis, epidemiology, surveillance, comprehensive disease management strategies, and planning for emergency response need to be emphasized.

KEYWORDS: Therapeutic intervention, Aquaculture, Aquatic animal health

Technical Session-1 Resource Assessment and Management for Sustainable Fisheries



The Fishery Performance Assessment Tool (FPAT): Identifying Key Management Procedures to Sustain Red Snapper Fisheries in the Arafura Sea

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As the world's largest producer of red snapper, Indonesia contributes to 60% of the global trade volume with the estimated monetary around USD 18.86 million in 2023. The Arafura Sea is one of the key sources of red snapper in Indonesia. However, these fisheries face significant challenges, including overfishing, illegal and unregulated fishing, and data limitations, which threaten their sustainability and economic viability. This study aims to address these challenges by assessing the status of red snapper and simulating management procedures to enhance sustainability and performance. To assess the fishery's status, a combination of length-based Spawning Potential Ratio (SPR) using a stochastic approach and Fishery Performance Indicators (FPI) was utilized. The Fishery Performance Assessment Tool (FPAT) was further applied to simulate various fishery management procedures. Data collection was carried out collaboratively by YKAN, ATSEA, and MMAF across nine fishing ports targeting the Arafura Sea between 2016 and 2023. This effort resulted in a comprehensive dataset of 238,102 fish length samples. The SPR for red snapper was estimated to range between 15% and 27%, indicating that the stock is under fully exploited to overexploited condition. Using the FPI framework, the ecological, economic, and community performance of red snapper fisheries in the Arafura Sea was characterized. The FPI scores revealed strengths in ownership and management, post-harvest assets, industry performance, community services, and market institutions. However, critical areas for improvement were identified, including ecological sustainability, stock health, harvest-related dimensions, national environmental performance, management methods, and harvest rights (scores<3). To address these challenges, FPAT was applied to identify effective management procedures (MPs) aiming for equitable and just outcomes across ecological, economic, and community dimensions. Five MPs were simulated: status quo catch-effort, size limits, spatial management, Total Allowable Effort (TAE), and Total Allowable Catch (TAC). The simulation indicated that

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size limits, TAE, and TAC management most likely to succeed in maintaining spawning stock biomass above the limit reference point (0.5) for relative spawning biomass, relative catch, and relative recruitment. These findings highlight the need for targeted interventions and adaptive management to ensure the long-term sustainability and economic viability of red snapper fisheries in the Arafura Sea.

KEYWORDS: Arafura Sea, Adaptive management, FPAT, Management procedures, Red snapper

Match Making Implementation of Tuna Harvest Strategy for Securing Blue Food Equity in Indonesia

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Indonesia's tuna fisheries are among the most significant, diverse, and complex in the world, with over 130,000 vessels ranging from 3 to over 100 meters in length, yielding more than 1 million tons of tuna annually, primarily for export. In response to declining tuna resources within Indonesian archipelagic waters (FMAs 713, 714, 715), the Indonesian government has prioritized the development of harvest strategies as part of the National Tuna Management Plan (NTMP) for tropical and neritic tuna. The implementation of these strategies, formalized in 2023 after seven years of development, requires comprehensive data and robust management instruments. This study documents the extensive process of developing the Tuna Harvest Strategy (HS), which included series of Stock Assessment Workshops and triangulation by Focus Group Discussions since 2014. The HS process begins with assessing fish stocks to determine their status, catch per unit effort, and health, followed by establishing management objectives and developing regulations to achieve these goals. Key management actions to be implemented from 2024 include the regulation and restriction of Fish Aggregation Devices, spatial and seasonal closures in the Banda Sea, and a 10% catch reduction over three years. Our findings highlight the potential of international trade to distribute Indonesian blue food tuna products globally, addressing food needs. However, current global food and trade flows fail to achieve equitable distribution, particularly in low and lower-middle-income communities, as evidenced by high poverty indices in some tuna-producing provinces. The study suggests that while promoting international tuna trade, the government must develop policies to support local industry, ensuring their profitability to meet domestic consumption and nutritional needs. This approach underscores the importance of enhancing the wellbeing of small-scale fishers and their families, enabling them to invest in food security and nutrition. Recommendations for implementing the Tuna Harvest Strategy in Indonesian Archipelagic Waters (IAW) emphasize the need for policies based on Law 7/2016 on the Protection and Empowerment of Fishermen, reducing entry barriers, formalizing the fishing profession, recognizing women's roles, and strengthening value chains.

KEYWORDS: Tuna harvest strategy, Blue food, Food equity, Poverty

Growing Fish Invasions in Inland Waters Call for Immediate Management Measures

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Biological invasions, involving human-mediated introductions, establishment and expansion outside their native range of distribution pose significant adverse impacts on native species and ecosystem services. Many farmed species, both in aquaculture and aquarium trade in India are non-native to the country and their growing numbers pose risks of intentional or accidental release into the wild from captivity or abandoned farms impacting native biological diversity and ecosystem functioning. As many as 626 non-native freshwater fish have been widely introduced to the freshwater ecosystem. This study has identified 16 non-native invasive species that have invaded the inland waters; their invasion pathways and impacts have been assessed to highlight the management concerns. A holistic approach, together with quantitative risk assessment (RA), proposes four major actions: (a) determination of introduction pathways, (b) studying life history characteristics of non-native species in invaded ecosystems, (c) assessment of invasion impacts and their mechanisms, and (d) management action plan. Based on the field studies, interactions between native and non-native species have been understood to have cascading effects, mostly negative, on the entire community and might lead to the imperilment of some native species with a narrow distributional range, threatening their conservation, and economic loss for commercial fishers when the native fish are of economic interest. The outcome of this study, therefore, provides a mechanistic understanding of invasive non-native species impacts in risk assessments. The impact of an invasive species is described as: I = R x A x E where the total impact (I) of the invader is a function of its range (R), abundance (A), and its per capita effect (E). It is important to develop functional response (FR) to predict the ecological impacts of existing, emerging, and future invasive non-native species. If not properly managed, invasive species can spread further in other parts of the rivers and reservoirs. It is imperative to recognize that the rapid development of farmed fish is likely to increase the risks of biological invasions. Therefore, this paper suggests new biosecurity protocols and management strategies to address gaps in our current understanding of biological invasions.

KEYWORDS: Invasive, Introduction pathways, Risk assessment, Impacts, Management



Sustainability Challenges with Spatio-temporal and Biological Dynamics of Moonfish (*Mene maculata*) Fisheries in Southwestern Taiwan Waters

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This study investigates the biological parameters, environmental drivers, and sustainability challenges of moonfish (Mene maculata) fisheries in the southwestern waters of Taiwan from 2013 to 2024. Data from Voyage Data Recorder (VDR) logs, port inspections, and biological sampling were analyzed to evaluate fishing dynamics and resource health. Trawling dominated the fishery, contributing over 98% of catches, with peak yields recorded in March and secondary peaks between December and February. The Linyuan region of Kaohsiung City accounted for 83% of the regional harvest, highlighting its critical role in the fishery. Spatio-temporal factors, particularly sea surface salinity (SSS) and sea surface height (SSH), significantly influenced catch per unit efforts (CPUE). A habitat suitability model incorporating these variables achieved high predictive accuracy ($R^2 = 0.89$). Biological analyses of 1,271 specimens revealed hypo-allometric growth, consistent sex ratios, and a spawning period starting in March-April, peaking after July. Lengths-at-maturity (L_{ms0}) were estimated at 19.7 cm for females and 19.57 cm for males. Resource assessments using Schaefer and Fox models estimated a maximum sustainable yield (MSY) of 2,400.2 metric tons, with signs of overexploitation evident in declining biomass (B/BMSY = 0.9) and high fishing mortality (F/M = 4.39). To mitigate risk, the study recommends size-based harvest limits, seasonal closures, and enhanced stock monitoring. These findings underscore the urgency of adopting ecosystem-based management approaches and further research to elucidate moonfish migration patterns and ecological dependencies for the long-term sustainability of this fishery.

KEYWORDS: Mene maculata, Maximum Sustainable Yield, Environmental drivers, Fisheries management

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Disappearance of Kholsi (*Trichogaster/Colisa* sp.) Fish from Kholsi Beel: Unraveling the Impact of Unscientific Management in a Floodplain Wetland of Ganga Basin

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Kholsi beel, a 65 ha seasonally connected floodplain wetland, has undergone significant human interventions over the past decade aimed at boosting fish production. One key management measure involved is the removal of submerged and floating macrophytes, both manually and chemically, to facilitate fishing operations. This intervention had a noticeable impact on the wetland's overall fish diversity and its associated ecological parameters, including water quality, sediment composition, plankton populations, and benthic communities. A study was conducted between 2014 and 2016 and the presence of 37 fish species was documented, with indigenous small fishes (ISF) being a major component. However, the removal of submerged macrophytes resulted in an increase in plankton turbidity in the water column as revealed during the recent survey in 2024, preventing the reestablishment of key macrophytes such as Hydrilla verticillata, Ceratophyllum demersum, and Vallisneria sp., which had previously occupied a significant ecological niche in the wetland. The survey revealed that as many as eight SIF species have since disappeared from the wetland, despite the presence of seasonal connection of the wetland to the river. Disappeared fish species included Kholsi fish (Trichogaster fasciata, Trichogaster lalia, Trichogaster sota), which accounted for 19.5% of the total indigenous fish production in 2014. Other fish species that have disappeared from the wetland are Nandus nandus, Lepidocephalichthys guntea, Rasbora daniconius, Channa gachua, and Anabas testudineus, suggesting the crucial role of submerged macrophytes in their life cycle. Fishery of *Puntius* sp. has also been significantly impacted, with its contribution to the total indigenous fish catch declining from 56.38% to a mere 5-10%; however, seven different *Puntius* species responded differently, with *P. chola* and P. gelius being the most impacted. The wetland is now almost devoid of its previously diverse and dense benthic molluscan population, with disappearance of species like Gabbia orcula and Gyraulus convexiusculus, indicating their complete dependence on submerged macrophytes. Our present study demonstrated the importance of maintaining ecological integrity to conserve the precious biodiversity of wetland, and hence scientific knowledgedriven management measures should be undertaken to ensure the sustainability of such interventions.

KEYWORDS: Submerged macrophyte, Ecological integrity, Biodiversity, Indigenous fishes



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Holistic Analysis of Ichthyofaunal Diversity, Exploitation Levels, and Production in the Ganges River

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ICAR-Central Inland Fisheries Research Institute under its flagship project "Namami Gange" has been regularly monitoring and assessing fish diversity, stock status, and catch in the river Ganga. The study recorded 199 fish species, including 190 native and 9 exotics, across 144 genera, 65 families, and 25 orders. The IUCN classification showed 15 species as Near Threatened (NT), 2 species as Vulnerable (Vu) and 2 species as Endangered (EN). Around 73.68% of the recorded species were Least Concerned (LC), and can comprehensively be utilized for human consumption. Tehri and Haridwar was confronted with the maximum abundance of T threatened (Vu - 22.22% and 7.49%) and NT (11% and 4%) species. The stock status of 15 key species, including medium carps, catfishes, and small indigenous fishes, was evaluated. Results showed that Mahseer and Cirrhinus mrigala are overexploited (E>0.5), while Labeo rohita, L.catla, and L. calbasu are less exploited (E<0.5). Among small indigenous fishes, Cabdio morar (E=0.62) and Rhinomugil corsula (E=0.60) are more exploited, but most other species are less exploited (E<0.50). Catfish exploitation rates also exceeded optimal levels, indicating a need for caution. The invasion index indicates that Cyprinus carpio var. communis (common carp) is the most widespread exotic species in the middle Ganges River stretch (Haridwar to Buxar), with a distribution index of 54%. Tilapia (Oreochromis niloticus) is the second most common exotic species in this region, with a 38% distribution. Fish catch data showed a range from 1.87 tonnes in Uttarkashi to 7380.79 tonnes in Varanasi, with a total annual catch of 56,387.24 tonnes. The middle and lower river stretches are more productive than the upper stretch. The average catch per unit effort (CPUE) from river Ganga varied from 0.48 kg/fisherman/day to 55.95 kg/fisherman/ day during summer, 0.65 kg/fisherman/day to 48.04 kg/fisherman/day in monsoon, and 0.28 kg/fisherman/day to 53.57 kg/fisherman/day in winter. Increase in the share of IMC in the total landing from 8.50% (2018) to 14.31% (2023), and simultaneous decrease in share of exotic fishes in the Prayagraj stretch indicates positive impact of conservation attempts in IMCs through ranching.

KEYWORDS: Diversity, Stock Assessment, Invasion index, Catch Per Unit Effort, River Ganga

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Breeding Phenology and Population Response to Climate Variability in Asian Leaf Fish (*Nandus nandus*): Insights for Sustainable Management in the Lower Gangetic Floodplains

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The Asian leaf fish (Nandus nandus) is a small yet significant freshwater species, highly valued for its food and conservation importance in inland waters. Despite its importance, this species remains relatively understudied. Our research provides the first comprehensive assessment of how regional climate variability affects the population attributes and breeding phenology of N. nandus, using a General Additive Model (GAM) to predict its vulnerability in a changing climate. Focusing on the lower Gangetic floodplains, we identified the environmental cues, biological thresholds, and preferred climatic conditions for breeding. We found that the female length at first maturity (LM₅₀) in the lower Ganga basin is 10.8 cm, with a Gonado-somatic index (GSI spawn₅₀) threshold of 8.11 units for individuals ready to spawn. Optimal breeding occurs at temperatures above 28°C and rainfall over 200 mm. The narrow temperature range for GSI spawn₅₀ highlights the heightened vulnerability of the species to climate change. Our study also revealed a strong correlation between GSI and both rainfall and temperature in floodplain wetlands, with the population's vulnerability to climate change classified as moderate to high, based on 14 specific attributes. This innovative vulnerability framework is a significant contribution to the Indian subcontinent, offering crucial data to quantify climate-induced risks and guide mitigation efforts. Additionally, our analysis of growth and mortality dynamics in lower Gangetic wetlands indicated positive allometric growth patterns, with an asymptotic length (L ∞) of 18.38 cm and a growth curvature (K) of 1.2/year. The current exploitation rate (Ecur) of 0.19 suggests room for increased fishing efforts, with a maximum exploitation rate (Emax) of 0.41 indicating that the fishery has not yet reached its full economic potential. By optimizing the management of N. nandus resources, we can balance the conservation needs with economic benefits, ensuring the resilience of this crucial freshwater fish species.

KEYWORDS: Climate vulnerability, Breeding phenology, Population parameters, Sustainability



Assessing Species Resilience in Karnataka's Trawl Fishery: An Evaluation of Key Factors

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The trawl fishery along the Karnataka coast, India, plays a crucial role in supporting the livelihoods of coastal communities and contributes significantly to the state's economy, accounting for over 80% of the total fishery landings. With a wide array of species being targeted, ensuring the sustainability and resilience of these species is vital for maintaining both ecological balance and economic growth. This study aims to assess the resilience of key species within Karnataka's trawl fishery to current fishing pressures. To evaluate species resilience, a Productivity-Susceptibility Analysis (PSA) was conducted on 28 major species representing a significant portion of the fishery's catch. The PSA helps identify species that are more resilient or vulnerable based on their biological productivity and susceptibility to fishing practices. In the analysis six species exhibited low vulnerability scores (1.00 to 1.24), demonstrating strong resilience to current fishing efforts These species include mainly shellfishes, which are well-positioned to thrive under existing fishing conditions. An additional 17 species were classified as moderately vulnerable, with vulnerability scores between 1.25 and 1.57, indicating that they could recover with effective management practices. Most of the demersal fishes were in this category. Only five species were found to be highly vulnerable, with scores between 1.62 and 1.90, requiring specific conservation measures to mitigate risks. These findings suggest that Karnataka's trawl fishery has significant potential for sustainability. By focusing on maintaining resilient species populations and implementing targeted strategies to protect more vulnerable species, the fishery can continue to support economic development while conserving marine biodiversity. Ongoing monitoring and data collection will be essential to refine management decisions and ensure the long-term sustainability of this critical resource.

KEYWORDS: Trawl fishery, Species resilience, Vulnerability assessment, Sustainable fishing, Conservation strategies

Navigating Troubled Waters: Indian Ocean Humpback Dolphins at the Intersection of Dolnet Fishing and Coastal Development in Megacity Mumbai, India

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The Indo-Pacific humpback dolphin (*Sousa plumbea*) faces significant threats from human activities, particularly from fishing and coastal infrastructure projects. This study investigates the interactions of these dolphins with fishing methods and the impacts of coastal development on their habitat. The study, conducted from February 2023 to February 2024, utilized surface photo-identification techniques to monitor dolphin populations. Key findings include frequent sightings of dolphins near dolnets, which are likely attracted to the concentration of fish. This attraction often leads to entanglements and conflicts with fisheries. Moreover, the Mumbai Coastal Road Project poses additional risks through habitat destruction, noise, and water pollution, severely affecting dolphin habitats. The presence of dolphins near construction sites and frequent entanglements with fishing gear underscore the urgent need for conservation measures. These should include adopting eco-friendly fishing practices and implementing stringent environmental protections during coastal development. These strategies are crucial to ensuring the sustainability of both dolphin populations and local fisheries, highlighting the critical balance needed between development and marine conservation.

KEYWORDS: Indo-Pacific humpback dolphin, Sousa plumbea, Dolnet fishing



Length-Weight Dynamics and Biology of Wolf Herring from Andhra Pradesh

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Wolf herring (*Chirocentrus dorab*), widely distributed along the east and west coasts of India, are increasingly recognized for their local culinary significance. Despite their economic importance, comprehensive studies on their biology, particularly in Andhra Pradesh, remain scarce. This study investigates the length-weight relationship and biological characteristics of *C. dorab* in the Visakhapatnam region. We recorded a fork length range from 26.9 cm to 58.5 cm, with an average of 39.02±2.38 cm. Total weight varied from 85 g to 932.2 g, averaging 127.38±5.59 g. Our analysis of the length-weight relationship revealed significant correlations for both sexes, with a combined sex ratio of 0.5 and a peak ratio of 1 in November. Notably, mature females were less prevalent throughout the year, except in the first quarter, indicating potential reproductive cycles. Feeding studies highlighted the highly carnivorous nature of this species, revealing that over 50% of individuals had empty stomachs, with a predominant diet of Clupeid finfishes, particularly *Stolephorus*. This research provides essential insights into the reproductive biology and ecological dynamics of *C. dorab*, contributing valuable information for sustainable fisheries management in the region.

KEYWORDS: Wolf herring, Length-weight relationship, Feeding ecology, Reproductive biology

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Fishery, Biology and Population Dynamics of *Metapenaeus monoceros* from Andhra Pradesh, India

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Shrimps represent a vital high-value fishery resource in India. From 2018 to 2023, the landings of Penaeid prawns exhibited fluctuations, ranging from 11,303 tons in 2018 to a low of 8,563 tons in 2023, with a peak landing of 15,615 tons recorded in 2022 in Andhra Pradesh. The average landing of the *Metapenaeus* genus during this period was 7,039 tons and Metapenaeus monoceros contributed 4,397 tons in the state. Notably, the Metapenaeus genus accounted for approximately 60% of the total penaeid trawl catch, with M. monoceros making up 38.5% of the total penaeid trawl catch of the state. To gather comprehensive data, weekly surveys were conducted at Fishing Harbour from January 2018 to December 2024. Detailed biological assessments included measurements of total length (TL in mm), weight (g), stomach fullness, and female maturity quantification. The maturity studies indicated two peaks. Mature individuals first appeared in the size class of 126 to 130 mm, with the highest prevalence observed in the 156 to 165 mm size range, accounting for nearly one-third of mature specimens. Additionally, population growth parameters such as asymptotic length $(L\infty)$, growth coefficient (K), and mortality rates were analyzed to assess exploitation rates and overall stock dynamics. This research provides critical insights into the sustainability of shrimp fisheries and underscores the need for effective management strategies.

KEYWORDS: Metapenaeus monoceros, Fishery, Biology, Population dynamics, Andhra Pradesh

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Apportionment of Pesticide Residues and Risk Assessment in the Cauvery River Ecosystem

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The diverse types of hazardous and toxic substances originating from different sources through anthropogenic activities accumulate in the aquatic environment. Pesticides and other organic contaminants are some of those substances frequently encountered in aquatic bodies like rivers, estuaries, wetlands, reservoirs, etc. The presence of residues of these toxic xenobiotics in water or sediment is detrimental as they exert an adverse effect on the flora and fauna of the aquatic ecosystem. In addition, percolation of the residues and subsequent bioaccumulation and biomagnifications along the food chain to the aquatic animals, more importantly, fishes is a serious concern. Since fish is consumed by human, the presence of any toxic substance is undesirable as there is a chance of serious health hazards to human when consumed. The river Cauvery is one of the major rivers of Peninsular India flowing through the states of Karnataka and Tamilnadu. Different reports point out about pollution of the river with a range of different emerging contaminants. Under this context, monitoring of the river was undertaken to find the pollution of the river with respect to pesticide residues. Water, sediment and fish samples collected at different locations from upstream to downstream of the river were analyzed for residues of organochlorines (OC), organophosphates (OP), and synthetic pyrethroid (SP) pesticides. OCs were detected in 15% water, 8% sediment, and 20% fish samples while for OPs, the corresponding values were 8%, 4%, and 21% respectively. About 8% of water samples were positive with SP residues though in sediment and fish, the SP contamination was 12%. Only in a few instances, the concentration of residues detected in water were higher than the USEPA (United States Environmental Protection Agency) aquatic life criteria, otherwise they were mostly within the threshold value. The dietary risk analysis revealed that the residue concentrations in edible fish tissue were much below the ADI (Acceptable Daily Intake) of respective pesticides. Similarly, hazard quotients were much lower than one, thus indicating that consumption of fishes from the river would not pose any risk to the consumers.

KEYWORDS: Pollution, Pesticide residues, River, Cauvery, Fish

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Diet Characteristics and Seasonal Prey Trophic Guild Structuring in Bombay Duck, *Harpadon nehereus* Off Mumbai Coast, Maharashtra, India

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The Bombay duck, *Harpadon nehereus* (Hamilton, 1822) is a major contributor to the fishery in the northern Arabian Sea. The understanding of the diet characteristics and seasonal trophic guilds by prey item analysis in the stomach is a measure for sustainable fisheries management. For the study, samples were collected during the fishing season (August, 2023-September, 2024) from dol netters operating in the inshore waters and trawlers off Mumbai coast, Maharashtra during fishing season in 2023 to 2024. A total of 738 specimen were sampled, with a size range of 37-316 mm. The sex ratio (male:female) was 1:0.8. It was found that the food types and fullness index differed between the seasons (p<0.001). Based on the Index of relative importance, the diet varied from fishes belonging to diverse taxa i.e. microcrustaceans, penaeid and non-penaeid shrimps, cephalopods and microplastics with the dominance of Acetes spp. during the post-monsoon season. Though, a high diet overlap was observed among the seasons, some species remained in the guild for the whole season while some species such as red goby were observed during certain seasons only. In the inshore areas, the presence of the Bombay duck was negligible from December-March while the presence of Acetes spp. was prominent in the landing during these months, explaining the effect of predator presence on prey abundance and distribution.

KEYWORDS: Predator, Northwest coast, Diet breath

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Status and Trends of the Blue Swimming Crab Fishery in Palk Bay on the Southeast Coast of India

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Portunus pelagicus (Linnaeus, 1758), commonly known as the Blue Swimming Crab, is a high valued marine crab in India. Crabs are mainly caught as by-catch in mechanised bottom trawls (Iral madi) and mini trawls (Thalluvalai), whereas; they are a target in indigenous outboard bottom-set gillnets (Nanduvalai). The estimated fishery landings of *P. pelagicus* in 2023 were 9311 t, with an annual average of 6299±2007 t from 2012 to 2023, contributing 94.2% to the total crab landings in Palk Bay. Gillnets contribute 65.7% of the total P. pelagicus landings from Palk Bay, followed by 29.6% by mechanised trawl. The economic value of this fishery was estimated to be around US\$ 26 million annually (US\$1= 83.7). Between 2012 and 2023, there was a significant difference between blue swimmer crabs and total crab landings in Palk Bay across gears and years. The processed products of P. pelagicus are exported mainly to the USA. The mechanized trawls mostly landed the adults, whereas the outboard gill nets landed a mixture of sub-adults and adults, and the mini trawl net landed only the juveniles. The fishery is mostly supported by a 0-year class of crabs during the observation period. In Palk Bay, the crabs are opportunistic omnivores with a preference for crustaceans in their diets. Their most active spawning is during the premonsoon and post-monsoon, with a minor peak during the monsoon. The assessment of the fishery reveals that catches are declining from 2012 to 2021, and there is an increasing trend from 2022 onwards. However, the population analysis supports the claim that Palk Bay's stock is sustainable. It is recommended that for the sustainable fishery of the Blue Swimming Crab, the minimum legal size of 90 mm CW can be implemented and a further reduction in the harvest of berried females from Palk Bay would create a conducive condition for this fishery to sustain in the future.

KEYWORDS: Catch rate, Crab, Management, Landings, Portunus pelagicus

Enhancing Fisheries Through Waste Water Management—The EKW Perspective

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The East Kolkata Wetlands (EKW) is situated in the eastern part of Kolkata city, covering about 12,500 hectare area. Apart from its ecological importance and a Ramsar site, the EKW sustains the world's largest integrated resource recovery systems based on a combination of aquaculture, and agriculture. Over 260 shallow fish ponds in the EKW receive about 900 MLD pre-settled sewage daily from the Kolkata metropolitan region. The traditionally evolved natural water purification-waste recovery practice saves nearly Rs. 4680 million annually in terms of the generated sewage non-treatment cost. These wetlands also lock-in over 60% of carbon from wastewater, thus reducing harmful greenhouse gas emissions from the region. The EKW system provides subsistence opportunities for a large, economically underprivileged population of 0.15 million, among them 20,000 people are directly involved in fisheries. To understand the current fisheries status of the EKW, a project is under operation at ICAR-Central Inland Fisheries Research Institute, Barrackpore, and a survey was carried out covering 125 bheries covering all the size groups, from January to September 2024. The generated data based on GIS studies revealed that although there is tremendous pressure of urbanization associated with land conversion, the area under fisheries has steadily increased from 4442 ha in the year 2000 to 5212 ha in 2012 and finally to 6073 ha in 2024. The frequently cultured fish species include Labeo rohita, Catla catla, Cirrhinus mrigala, L. bata, Hypophthaimihcthys molitrix, Ctenopharyngodon idella, Cyprinus carpio, Oreochromis mossambicus and O. nilotica. Invasive fish species Pterygoplichthys sp. exists in most of the bheries and shares a significant portion of the available nutrient. The generated data reveals that the average fish production ranges from 1800–2200 kg/ha/annum, and thus, the estimated present production figure is 11,000 to 13,000 tonnes per annum from the wetlands. Under the present scenario of resource crunch, socio-political changes, and environmentassociated awareness, management of this vital ecosystem in a sustainable manner is most challenging but at the same time, necessary for maintaining the present level of production and improving the livelihood of the poor fishers.

KEYWORDS: East Kolkata Wetlands, Wastewater fisheries, Fish production, Invasive species

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Integrating Machine Learning Models for Optimizing Ecosystem Health Assessments Through Prediction of Nitrate-N Concentrations in the Lower Stretch of Ganga River, India

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Nitrate, a highly reactive form of inorganic nitrogen, is commonly found in aquatic environments. Understanding the dynamics of nitrate-N concentration in rivers and its interactions with other water-quality parameters is crucial for effective freshwater ecosystem management. This study uses advanced machine learning models to analyse water quality parameters and predict nitrate-N concentrations in the lower stretch of the Ganga River from the observations of six annual periods (2017 to 2022). The parameters include water temperature, pH, specific conductivity (Sp. Con), dissolved oxygen (DO), nitrate-N, total phosphate (TP), turbidity, biochemical oxygen demand (BOD), silicate, total dissolved solids (TDS), and rainfall. We evaluated the predictive performance of five models-Multiple Polynomial Regression (MPR), Generalized Additive Models (GAMs), Decision Tree Regression, Random Forest (RF), and XGBoost (Extreme Gradient Boosting)-using RMSE, MAE, and R² metrics. XGBoost emerged as the top performer, with an RMSE of 0.024, MAE of 0.018, and R² of 0.85, explaining 85% of the variance in nitrate-N concentrations. RF also demonstrated strong predictive capability, with an RMSE of 0.028, MAE of 0.021, and R² of 0.80. MPR effectively modelled non-linear relationships, explaining 75% of the variance, while Decision Tree Regression and GAMs were less effective, with R² values of 0.60 and 0.48, respectively. Variables viz., BOD, pH, Rainfall, water temperature, and total phosphate were the best predictors of nitrate-N dynamics. Comparative analysis with previous studies confirmed the robustness of XGBoost and RF in environmental data modelling. The findings highlight the importance of advanced machine learning models in accurately predicting water quality parameters and facilitating proactive management strategies.

KEYWORDS: Nitrate-N, Ganga River, Machine learning, Water variability

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Length-Weight Relationship and Reproductive Biology of the Largescale Mullet *Planiliza macrolepis* (Smith, 1846) from the Malabar Coast of India

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Fishes belonging to the family Mugilidae constitute one of the prominent fisheries of India's coastal waters and estuaries. The fish is highly vulnerable to unregulated exploitation due to its delicacy and high local prices. Setting a minimum legal size (MLS) is an essential precursor for the sustainable harvest of resources. In this context, the present study aimed to establish the information on the length-weight relationship and reproductive biology of *Planiliza macrolepis* (Smith, 1846) by examining 1545 individuals collected from the coastal water and estuarine fishery of northern Kerala (Malabar region) coast during 2021-2022. The sampled individuals unveiled total length and weights between 10-50 cm and 12-1570 g, respectively. The exponent value (b = 2.9336) in the study indicated a negative allometric pattern of growth. The sex ratio of males and females was 1:1.67 showing the dominance of females in the population. The size at first maturity (Lm_{50}) of large mullet was estimated at 19.4 cm and 21.3 cm total length for males and females respectively. Significant numbers of fully mature and oozing ovaries occurred in most months and high Gonado-somatic Index values from September to May with a peak in January followed by March indicated that *P. macrolepis* has a prolonged spawning season.

KEYWORDS: Mullet, Length-weight, Sex ratio, Maturity, Spawning

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Bottom Trawl Selectivity of 35 mm Square and Diamond Mesh Cod-Ends for *Loligo duvaucelli* (Orbigny, 1848) from the East Coast of India

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Selectivity of 35 mm square and diamond mesh cod-ends bottom trawl net was undertaken for the squid L. duvaucelli off Kakinada, Andhra Pradesh using the covered cod-end method. The L_{25} , L_{50} , and L_{75} for 35 mm square mesh cod-end were 5.03, 8.66 and 12.32 cm, respectively. Selection ranges (SR), selection factor (SF), and selection ratio (Sr) were 7.29, 2.70, and 2.08, respectively. The L_{25} , L_{50} , and L_{75} for 35 mm diamond mesh cod-end were 4.50, 7.25, and 9.99 cm, respectively while the selection range (SR), selection factor (SF) and selection ratio (Sr) were 5.49, 2.07, and 1.56, and the values were lower when compared to square mesh cod-end. The selectivity parameters L_{25} , L_{50} , and L_{75} of square mesh codend were relatively higher when compared to diamond mesh cod-end. Results revealed that square mesh was more selective and facilitated the escapement of juveniles in comparison to conventional diamond mesh cod-end.

KEYWORDS: Cod-end, Diamond mesh, Selectivity, Square mesh, Trawl net

Economic Efficiency and Characterization of the Small-Scale Jellyfish Fishery in the Northwestern Bay of Bengal: A Case Study from the Odisha Coast

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Globally, jellyfish are gaining recognition as an important marine resource, with increasing demand for their consumption mostly in Southeast Asian countries. In India, the harvesting of edible jellyfish began in 1984, primarily for export. Recently, one of the catostylid jellyfish species, Crambionella annadalei has been contributing to a small-scale seasonal jellyfish fishery along the Odisha coast. This study aimed to characterize the jellyfish fishery. its associated fishing activities, post-harvest handling, and its economic efficiency along the Odisha coast during 2020-21. Jellyfish are typically caught by single-day motorized gillnetters (8.5-9.7 meters overall length, with 9-10 horsepower engines) between December and April. The sizes of the jellyfish sampled ranged from 11 to 27 cm in bell diameter, with an average size of 22.4 ±0.14 cm. Their total body weight ranged from 100 to 1548 g, with an average weight of 879.7±15.8 g. The economic assessment of the jellyfish fishery revealed an average operating cost of Rs. 7,936 per fishing trip, with a catch rate of 577 kg per trip. Gross revenue from each fishing trip averaged Rs. 13,600, resulting in a net operating income of Rs. 5,664 per trip. Capital productivity was estimated at 0.58, while labor productivity was 96.2 kg per crew member per trip. In light of declining global fish stocks, the sustainable exploitation of jellyfish offers an alternative source of income and livelihood for small-scale fishers. The study also found that only the oral arms of the jellyfish are processed using salt and alum before being exported to Southeast Asian countries, primarily China. This baseline data provides crucial information for developing better handling, stabilization, and harvesting techniques while promoting jellyfish as a potential food resource in India.

KEYWORDS: Catostylid jellyfish, Crambionella annandalei, Small-scale fishery, Economics

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Habitat Preferences of Blue Marlin (Makaira nigricans) in the Arabian Sea

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Blue Marlin (Makaira nigricans) are top predators in tropical and subtropical waters and are significantly caught by longline fisheries. Understanding their habitat preference and its influence on vulnerability to capture is critical for effective management. This study examines the relationship between spatio-temporal patterns of blue marlin (M. nigricans) abundance and environmental factors in the eastern Arabian Sea, a region that extends 0.86 million km² from 7° to 23°N latitude and 60° to 74°E longitude. Monthly catch data of *M. nigricans*, were sourced from the Fisheries Resource Assessment Division of Central Marine Fisheries Research Institute, using a multistage stratified random sampling technique. Environmental parameters like Sea Surface Temperature (SST), Sea Surface Salinity (SSS), Sea Surface Height anomalies (SSHa), current speed, and Chlorophyll-a concentration (Chl-a) were obtained from the Copernicus Marine Environment Monitoring Service. These data were analyzed using Generalized Additive Models (GAM) to predict relative abundance. The best GAM with the lowest Akaike's Information Criteria (AIC) was; M. nigricans ~ s(SSS, k = 3) + s(SST, k = 3) + s(SSH, k = 3) + s(current, k = 3) + s(Chl, k = 3). The best-fit GAM included significant covariates such as SSS, SST, SSHa, current speed, and Chl-a, explaining 31.2% of the variance. Results indicated that SSS between 34-36 \infty and SST from 25-29°C positively influenced marlin abundance, with SST above 29°C negatively impacting catch rates. SSHa in the range of 0.2-0.6 m and current speeds over 0.1 m/sec were also associated with higher catches, while lower Chl-a values (0.00-0.2 mg/m³) had a positive effect. M. nigricans contributed an average of 7% to the total billfish landings during the study period, with the significant relationship between catch rates and environmental variables emphasizing the species sensitivity to oceanographic conditions. The results highlight the ecological preferences and spatiotemporal distribution of blue marlin in response to environmental variability in the Arabian Sea. Such understandings are essential for developing area-based management strategies ensuring the sustainable exploitation and conservation of these key marine predators. The study also helps to identify the preferred spawning stock habitat of M. nigricans, and provides a valuable baseline for comparing and analyzing the species environmental preferences in the future, proposing critical perceptions into how these top predators may respond to the ongoing global climatic variations.

KEYWORDS: *Makaira nigricans*, SST, SSHa, SSS, Chlorophyll-a, Current speed, Environmental preferences



Insights into the Reproduction of the Indian Mackerel *Rastrelliger* kanagurta (Cuvier 1833) in the Western Visayan Sea

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Aspects on the reproduction of the Indian mackerel Rastrelliger kanagurta from the Western Visayan Sea were examined from June 2023 to May 2024. Reproductive data were obtained from monthly samples collected from catches of commercial fishers while growth parameter estimates were calculated from monthly length-frequency data. A total of 636 R. kanagurta individuals had standard lengths (SL) ranging from 10.4 cm to 22.6 cm, and a mean size of 15.56 cm. Asymptotic length (L_w) is estimated at 23.1 cm with a growth rate coefficient (K) of 0.34. The length at first maturity (Lm_{s_0}) of the species was found to be at 17.7 cm which is significantly smaller compared to the Lm_{s_0} of 21.2 cm usually observed in Manila Bay of the Philippine waters. However, this falls within the Lm_{so} range of 15.9 cm to 17.7 cm published from other fishing grounds within the Indo west-Pacific. The smallest size of mature males was 15.5 cm while that of females was 15.8 cm. Mature individuals were dominant in June and November coinciding with the high values of the gonadosomatic index during the northeast monsoon as well as the summer season. This is consistent with the results of their recruitment pattern as well. Currently, there is no comprehensive management framework for small pelagic fish species, such as R. kanagurta, in the Visayan Sea aside from closed fishing seasons specifically from November to January. This emphasizes the need for a better understanding of their population and reproductive dynamics which may prove beneficial for future studies, and which may be used as a basis for crafting management policies for commercial fishers within the Visayan Sea.

KEYWORDS: Small pelagics, Growth, Lm50, Reproductive pattern

Stock Assessment of Indian Marine Fishery Resources - Interweaving Methods and Inventing a Path to Sustainable Framework

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Marine fishery resource dynamics have been both a matter of challenge and creativity. All the tools and methods that have been put to use to study, assess, analyse, and forecast the resource dynamics have been borne out of basic presumptions that mostly lead to a computational framework. The best examples are the size-frequency-based assessment and the macro-factor-based modelling. It has always been in the realms of quantitative fish stock assessment's grey area, that when, where and more importantly whether these ever meet at a point of biological prudence. Once we add the economics and value of resources based on either ecosystem gradation or market realization this picture gets much more muddled. It has always been a game of probability breaching the contours of biology leading to a nearly one-sided result. Further, there are always uncertainties involving the type, kind, quantum and frequency of data that are required to arrive at plausible readings of the stock trends. This work aims at the partial and purposive review of the most commonly utilized biological and bioeconomic models and to come out with the areas of concern and cohabitation when they meet the biological formations found in the tropical regions of the Indian Ocean. Three distinct data sets are being put to the test to adequately represent the ecosystem continuum in this analysis viz (1) Hierarchical (2) Highly volatile/ migratory (3) Sparsely Interactive. The analyses would be based on both single-species and multi-species anchored by keystone species. It has been attempted in equal measure to follow the same leads while dealing with value-enriched series too. The focus of this work is not only on the inferential part of the most important reference points but also to enlist and typify the routines, framework and ways and means of an ensemble or integrated assessment of the marine fishery resources in a standard data collection regime and how effective it is in feeding directly into an informed governance setup. On the sidelines, this work also focuses on the quantity of biological learning required in this modeling exercise and also aims to take a pragmatic call on the limitations and overindulgences of Bayesian methods and simulation procedures. To conclude, this work serves as an integrator of stock dynamics assessment approaches and an assimilator of what suits the existing data rigour, thereby leading to what could be a trigger for a robust and responsive paradigm for the assessment of fisheries both targeting biological and economic sustainability.

KEYWORDS: Fish stock assessment, Biological reference points, Management regimes, Management strategy evaluation



Optimizing Maximum Sustainable Yield (MSY): Compensating for Environmental Variability and Impacts

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Maximum sustainable yield (MSY) forms one of the most important management reference points for formulating a management strategy to ensure sustainable fisheries in the region. Higher estimates of MSY can lead to higher permission levels of catch leading to a decline in resource abundance and hence, there is a need to optimize the estimates of MSY. Surplus production models are the most widely used analytical method to arrive at the MSY level and the corresponding fishing effort (F_{MSY}) using time series of catch and effort data, assuming catch rate as a function of effort. It is a well-known fact that the abundance of the resource (catch rates) at a given time not only depends on the historical harvest rate (fishing pressure) but also the variation and trends in the environmental factors. However, most of the studies carried out from the region undermine the incorporation of environmental variables while estimating the potential yield of a given resource. Gujarat is one of the major maritime states of India, contributing to marine capture fisheries of the country. Several resources are key and unique to the region and their abundance is known to vary significantly in response to climate change. The present study selected three major resources of the region viz., croakers, bombayduck and golden anchovies and screened the environmental variables like Chlorophyll-a (Chla) Mixed Layer Depth (MLD), Sea Surface Temperature (SST), Bottom Temperature (BT), salinity, and Sea Surface Height (SSH) for its correlation with the resource abundance. The environmental data are remotely sensed and are sourced from the global data repository. The time series of the most significant environmental parameters for each given resource is used as a covariate in a surplus production model to arrive at the MSY. The model is fitted using a maximum likelihood approach. The estimated MSY was compared with conventional estimates. It was observed that the MSY after incorporation of environmental variables was lower than the conventional estimates, and hence advocates the adoption of more conservative estimates of MSY for formulating management strategies.

KEYWORDS: Gujarat, MSY, Climate change, Surplus production model

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Charting the Course of Capture Fisheries Research in India: An Analysis of Research Presented at the Indian Fisheries Forums

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The first Indian Fisheries Forum (IFF) was held in 1988, and since then it has been held continuously every four years, with the most recent XII Indian Fisheries and Aquaculture Forum (IFAF) held in 2024. Over the years, the IFAF has become the dominant platform to showcase fisheries research in India. Through the participation of fisheries researchers, academicians, students and other stakeholders, the IFAFs enable a broad view of research in Indian fisheries. Hence, in this study, we analyzed the research presented at the past IFAFs (1988-2022) to understand the direction in which Indian fisheries research has moved, with a focus on capture fisheries research. The overall number of researches presented at IFAFs has increased tremendously from 109 in the first IFF to 899 in the Twelfth IFAF. Fishery biology has been a theme from the First IFF and since then, it has been modified to include fishery resources, management, biodiversity, and conservation. The research presentations under this theme increased from 24 in the First IFF to 173 in the XII IFAF showing an increase of nearly 621%. The dominant research titles in terms of number during the First IFF were reproductive biology (21.7%), food and feeding (21.7%), and age and growth (13%). In the most recent IFAF, the dominant research titles pertained to the resource-specific fishery (12.9%), fishery reproductive biology (9.9%), age and growth (9.4%), biodiversity and allied biodiversity research (9.4%) and stock assessments (7.0%). Hence it is evident that the research topics in capture fisheries have remained quite steady over the decades. New research with respect to non-conventional resources, Potential Fishing Zones, GIS and Remote Sensing emerged in recent IFAFs; however, they formed a minor percentage. Some key research areas missing from or, being used meagerly in the Indian scenario were EBFM, especially for marine areas, in-situ (underwater) studies across all aquatic ecosystems, behavioural ecology, ecological mapping, climate change impact, especially on freshwater ecosystems, and impact of fisheries policies/management measures. The results of our study may prove helpful in directing the course of focused future research in Indian capture fisheries.

KEYWORDS: Research trend, Research theme, Marine fisheries, Scientometrics

Integrating Fisheries into Watershed Development: A Pathway to Sustainable Livelihoods in India

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Watershed development has been a cornerstone of India's rural development strategy since the 1980s, with the launch of the National Watershed Development Programme for Rainfed Areas (NWDPRA) in 1986, which aimed to promote sustainable land use, reduce soil erosion, and enhance water availability in rainfed areas. The ICAR-Central Inland Fisheries Research Institute has developed a comprehensive Watershed Development Plan for the micro-watersheds within a 10 km radius of the Warasgaon-Warangi Pumped Storage Project (PSP) in Maharashtra, India, covering an area of 150600 ha, comprising nine interconnected micro-watersheds with varied slopes and stream lengths, and a resident population of 32667 individuals, with a literacy rate of 81.25%. The watersheds have existing soil and water conservation efforts, active extension services, and widespread adoption of field bunds for annual crops, but weaknesses include smaller landholdings, erratic rainfall, soil erosion, and limited fodder accessibility. The plan also considers the fisheries sector, which is a vital component of the watershed ecosystem, with seven family groups representing 19 fish species, highlighting the importance of integrating fisheries into watershed development. By adopting a holistic approach, the plan aims to protect and restore habitats, establish a monitoring program to track changes in biodiversity and ecosystem health and conserve biodiversity through management of natural resources. In the study area, the plan is expected to benefit approximately 3,266 households, with a potential increase in fish production by 10-15%, and a potential increase in income of INR 300-500 per household per month, and a reduction in poverty by 5-10%. Further, conservational measures such as stock enhancement and habitat improvement were suggested. This would contribute significantly to the achievement of the United Nations Sustainable Development Goals, particularly Goal 6 (Clean Water and Sanitation) and Goal 14 (Life Below Water).

KEYWORDS: Watershed development, Fisheries management, Integrated water resource management



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Harmonious Coexistence: Adopting A Natural Agricultural Perspective in Fish Farming

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Fisheries in the Indian sub-continent is inherently natural, with aquaculture being an organic component of rural India. Natural farming involves the judicious exploitation of the biogenic carrying capacity of water bodies without external inputs, other than fish seeds. This approach is reflected in the production and productivity of inland fisheries resources. In India, fish farming is largely organic, with minimal use of synthetic inputs. The Indian government's efforts to promote natural farming have led to a remarkable growth in inland fish production, with a 60-fold increase over the last 72 years, from 0.2 million metric tonnes in 1950-51 to 17.14 million metric tonnes in 2022-23. ICAR-Central Inland Fisheries Research Institute has played a pivotal role in achieving this success, with its research and development efforts focusing on natural farming practices, conservation of aquatic biodiversity, and sustainable management of inland fisheries resources. Integrated Multi-Trophic Aquaculture (IMTA) systems, which cultivate multiple species together, have been shown to enhance nutrient cycling, reduce feed requirements, and increase farm resilience. Studies have demonstrated that IMTA systems can reduce feed conversion ratios by upto 30%, and improve water quality by upto 25% when compared to conventional monoculture systems. Additionally, IMTA systems have been found to increase biodiversity by upto 40% and reduce chemical use by upto 20%. ICAR-CIFRI's research has shown that natural farming practices can increase fish production from reservoirs, with an average yield of 174 kg/ha/y in some small reservoirs. Additionally, ICAR-CIFRI has emphasized the importance of the conservation of aquatic biodiversity, with a focus on maintaining eco-health and preventing eutrophication. By embracing natural agricultural perspectives, the fish farming industry can move towards a more sustainable, equitable, and resilient future. With the global demand for fish and seafood projected to increase by 30% by 2030, adopting natural agricultural perspectives in fish farming is crucial for ensuring the long-term health of our planet and the well-being of both human and aquatic ecosystems.

KEYWORDS: Natural farming, Sustainable aquaculture, Organic fish farming

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Fishery, Biology and Growth Traits of the Narrow-Barred Spanish Mackerel, *Scomberomorus commerson* Off Gulf of Mannar, India

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Scomberomorus commerson, S. guttatus, and S. lineolatus are the three species that comprise the seerfish diversity. Reports indicate an annual landing of 35,326 tonnes of seerfish along the Gulf of Mannar. The narrow-barred Spanish mackerel, Scomberomorus commerson (Lacepede, 1800), is a highly valuable commercial fish in the Gulf of Mannar. Scomberomorus commerson (93.8%) was the main contributor to the landings, followed by S. guttatus (6.1%) and S. lineolatus (0.09%). The growth parameters, feeding biology, and fisheries of Scomberomorus commerson were the focus of a study conducted in the Gulf of Mannar during 2020–2023. Male, female, and undetermined growth rates varied significantly from each other, indicating that the growth was allometric. All year round, mature females have been observed, with a peak in November and February. Peak spawning periods are correlated with higher gonadosomatic index values. Sardines (50.4%) and anchovies (32.4%) were the most preferred prev items according to the Index of Relative Importance (IRI) values. Fish showed a large percentage of empty or trace amounts of food in their stomachs, indicating very low feeding intensity. The estimated asymptotic length is 199.5 cm, and the growth coefficient is 0.37/year. The estimated values of total mortality, fishing mortality, and natural mortality were 0.72/year, 0.56/year, and 0.16/year, respectively. The exploitation ratio (E) was 0.16, while the rate of exploitation (U) was 0.23. The estimated Emax value is 0.421 and the M/K ratio is 1. The estimated yield per recruit is 0.022. The findings of this study highlight the necessity of provincial assessments for fisheries management, which can be applied for managing the stocks of *S. commerson*.

KEYWORDS: Seerfish, Diversity, Allometric, Management, Gulf of Mannar

Molecular Identification and Reproductive Biology of *Salmo Trutta* (Brown Trout) in High Altitude River Tons, Uttarakhand: A First Record

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The Tons River, located in the Govind Wildlife Sanctuary, Uttarakhand, India, at an altitude ranging from 2000 to 3600 meters above sea level, has been the subject of extensive research aimed at understanding the fish assemblages in Himalayan stream. The eastern Himalayas excel in cold-water fish diversity compared to the western Himalayas. During a fish diversity survey conducted along the Tons River from May to August 2019-20, 20 specimens of Salmo trutta, commonly known as brown trout, were captured through experimental cast netting. These findings mark the first-ever record of brown trout at altitudes 1252 meters in the Tons River, identified through morphology, DNA sequencing and phylogenetic analysis. Morphometric identification confirmed that all specimens analyzed were indeed S. trutta. Additionally, their feeding habits were assessed using Relative Gut Length (RGL) and Gastro-somatic Index (GaSI), indicating that brown trout in this region are carnivorous. DNA sequencing of the isolated fish sample confirmed its identity as S. trutta. Phylogenetic analysis revealed that the isolated fish sample was closely related to S. trutta based on its 18S rRNA gene sequence. The reproductive biology of S. trutta in the Tons River was studied in pre-monsoon, monsoon, and post-monsoon. It was observed that brown trout primarily matured during the monsoon season. Fecundity and Gonado-somatic Index (GSI) sharply increased during this season and declined in the post-monsoon period as the water temperature decreased. This research provides crucial insights into the distribution, identification, and reproductive biology of S. trutta in the high-altitude region of the Tons River in Uttarakhand, contributing to conservation and management efforts for this ecologically important species in the region.

KEYWORDS: Salmo trutta, Tons river, DNA sequencing, Gonado-Somatic Index, Gastro-Somatic Index

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Fish Diversity, Assemblage and Seasonal Abundance Structure Along the Tidal Dominated River Matla of Indian Sunderban

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Estuaries rank among the most productive ecosystems globally and serve as nursery habitats for fish species from both marine and freshwater origins. Matla River forms a wide estuary in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal. A study on fish diversity covered three seasons during 2023-24 and recorded 63 species representing 37 families. Gobiidae was observed to be the most diverse piscine family (9.8%), while the Sciaenidae and Engraulidae were the second most with a contribution of 7.8%. Seasonal abundance exhibited a rise in fish species richness during pre-monsoon (n=47), and least during post-monsoon (n=27), indicating that a rise in water salinity allows most of the fish species to migrate inward to the estuary. The estuary comprised primarily marine (49%), brackish water (41%), and freshwater (10%) fishes. Moreover, as per the habitat, the estuary is dominated by demersal (52%), followed by pelagic (24%), benthopelagic (17%), reef-associated (5%), and bathydemarsal (2%) fish species. Compared with other estuaries, the Matla River estuary is marine-dominated, consisting mostly of marine taxa. The present study can provide vital insights to the present status of the river Matla flowing in Sunderbans and their current fish status.

KEYWORDS: River Matla, Estuary, Sunderbans, Icthyofauna

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Assessment of Fisheries and Socio-Economic Profile of the Harike Wetland System

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The present study was conducted in the Harike wetland system, a Ramsar site in Punjab, India. During the study period, a total of 41 fish species from 18 families were observed in catch composition from the fishing areas of this diverse wetland system. The commercial catch was mainly dominated by Cyprinidae, comprising 34.1% of the total catch, followed by Bagridae (9.7%), Channidae, Siluridae (each represented 7.3%), Notopteridae (4.9%) and Sisoridae (2.43%). Miscellaneous catch composition was contributed by different species of the family: Danionidae, Clariidae, Heteropneustidae, Ailiidae, Schilbeidae, Ambassidae, Nandidae, Mastacembelidae, Synbrachidae, Gobiidae, Dorosomatidae and Belonidae. Biometric characterization was conducted for selected commercially important fish species, including carps, catfishes, snakeheads and featherbacks. The ranges of the length-weight varied within and amongst the different species, namely, Labeo rohita (45-68.9 cm, 1-4.7 kg), Sperata seenghala (45.5-95.5 cm, 0.5-4.3 kg), Wallago attu (33.8-115.3 cm, 0.1-14.2 kg) Channa striata (37-97 cm, 0.4-6.9 kg) and Notopterus notopterus (25.6-30.7 cm, 0.1-0.3 kg). The relative condition factor, an important biometric tool, was recorded with a value of ≥ 1 for all the selected species, which indicates the suitability of the habitat for their growth. The socioeconomic conditions of fishing communities around the Harike wetland system were also investigated in this study. Approximately 60 fishermen from Uttar Pradesh, Bihar, West Bengal and Punjab were interviewed for the socio-economic survey. While a few reside in sturdy *Pucca* houses, the majority live in makeshift *Kuccha* houses near the wetland. Their literacy rate was found to be negligible, indicating limited access to education and awareness, thereby, impeding fishermen's access to financial aid and opportunities for skill enhancement. Despite such challenges, they sustain their livelihood using traditional fishing methods utilizing fishing crafts like wooden boats with flattened bottoms and fishing gears such as Fasla (gill net), Ghumav jal (cast nets) and Kundi (hook and line). This study facilitates database generation on fish catch composition and biometric parameters along with the socio-economic profile of fishermen working in the Harike fishing area, which will further lay the groundwork for future research and strategic interventions to conserve and sustain fish production from this wetland system.

KEYWORDS: Biometric, Fishermen, Wetland, Harike, Socio-economic profile

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Assessment of Water Quality of River Sutlej: The Longest Tributary of Indus River System

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This study aimed to assess the water quality of the longest tributary of the Indus River system, river Sutlej. The study was carried out at four designated sites viz., Site-1 (Ropar Headwork), Site-2 (Phillaur before confluence of Buddha Nallah), Site-3 (Wallipur Kalan after confluence of Buddha Nallah) and Site-4 (Harike-Pattan where river Sutlej meets with Beas) from February 2018-August 2019 for determination of water quality of river Sutlei along its course of flow in Punjab. Samples of water, sediment and fish were collected in triplicate at two monthly intervals from the designated sites for water quality and heavy metal analysis. The outcome of the present study revealed that river Sutlej gets heavily polluted after the influx of Buddha Nallah at village Wallipur Kalan as evident from low levels of dissolved oxygen (<5 mg/l), elevated levels of biological oxygen demand (>5 mg/l) and chemical oxygen demand (>10 mg/l). Moreover, heavy metals (Cd, Cr, Cu, Pb, Ni and Zn) were also detected, although within permissible limits in water, sediment and fish (flesh and gills). Besides, Lead (Pb) concentrations were found to be slightly higher than the permissible limits in water (0.05 mg/l) at Site-3, in flesh (0.5 µg/g) of W. attu and in gills of A. seenghala and W. attu. The findings of this study are alarming and warrant constant monitoring of river Sutlej to save its fragile ecosystem from further deterioration. Implementation of stringent legislative measures and formulation of effective management plans are much needed to curb the menace of pollution in river Sutlej and save its floral and faunal biodiversity.

KEYWORDS: Water quality, Sutlej, Buddha Nallah, Heavy metals, Fish

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Conservation and Sustainable Utilization of Floodplain Wetland Fisheries of North-Eastern India Amidst Emerging Issues

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The north-eastern region of India has rich open-water fisheries resources in the form of rivers. floodplain wetlands, reservoirs and lakes. The floodplain wetlands (wetlands associated with floodplains of rivers) are considered as the most potential among these resources considering their large resource size (133,976 ha) and high fish production potential (485 to 2324 kg/ ha/yr). They constitute an important fisheries resource in the states of Assam, Manipur, Meghalaya and Arunachal Pradesh supporting the livelihood and nutritional security of local communities besides contributing to the aquatic food system of the predominantly hilly region. These wetlands vary in size, shape and extent of riverine connection. Besides acting as an important source of capture fisheries, several fisheries enhancement tools (e.g., species enhancement, stock enhancement, enclosure culture, etc.) can be practiced in these wetlands, which result in qualitative and quantitative improvement in their fisheries. Naturally, their fish production ranges widely depending on their ecology management regimes and other factors. Fish stock enhancement has emerged as the most popular fisheries enhancement option practiced in these wetlands. Fish yield rates of 1,500 kg/ha/yr or higher have been recorded in a couple of floodplain wetlands practicing culture-based fisheries. However, these wetlands are sensitive ecosystems and are a repository of high aquatic biodiversity and discharge many other ecological functions. Thus, conservation and sustainable utilization of floodplain wetland fisheries of the region is the need of the hour. The available options for their conservation and sustainable utilization, as well as major/emerging issues (e.g., siltation, encroachment, disruption of riverine connection, pollution, over-fishing, macrophyte infestation, multiple-use conflicts, leasing policy, lack of funds for management, climate change, etc.) affecting their fisheries and ecology, are discussed in the paper.

KEYWORDS: Floodplain wetland fisheries, Northeast India, Conservation, Sustainable utilization

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Inland Openwater Fisheries Resources of Northeast India: Implication for Sustainable Management on Production Enhancement and Conservation

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Northeastern states of India (21°57'-29°30' N; 89°46' -97°30' E) comprise eight landlocked states including Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Mizoram, Tripura, and Sikkim. The predominantly hilly region has vast and varied inland openwater fisheries resources in the form of rivers and canals (20,875 km), floodplain wetlands (1,34,209 ha), ox-bow lake (1766 ha), reservoirs (21,237 ha) and derelict water bodies (1,03,211 ha). There are 58 notable rivers in the region besides numerous rivulets/hill streams. These important fisheries resources in the region support the livelihood and nutritional security of millions of people. More than 90% of the region's population are fish eaters. Openwater fisheries resources are a repository of high aquatic biodiversity and discharge many other ecological functions. The region is considered as one of the hot spots of freshwater fish diversity in the world. A total of 422 fish species belonging to 133 genera and 38 families have been reported from the region. These resources have immense potential for fulfilling the growing demand for animal protein. There is a need to incorporate a sustainable utilization strategy into fisheries management modules of openwaters of the region for enhancing fish production and conservation. The floodplain wetlands (1000-1500 kg/ha/yr) and Reservoirs (100-500 kg/ha/yr) of the region have high fish production potential. Openwater fisheries are amenable to practicing various fisheries enhancement protocols resulting in quantitative and qualitative improvement in fisheries including production enhancement. The Brahmaputra and Barak are the two major river systems in the region. The potential productivity has been estimated at 900 kg/km/yr for the river Brahmaputra and 450 kg/km/yr for its tributaries including the Barak River. Ranching programme in the rivers along with their tributaries can revive the depleted stocks. Strict implementation of the fishing ban period in natural waters is the need of hour for the revival of natural fisheries. Concurrently, the creation of alternative livelihood avenues for dependent fishers of these natural resources also needs specific attention. The policymakers need to prepare region and resource-specific management plans for the sustainable development of these openwater fisheries resources. Efforts are required from all stakeholders of the region to realize the huge fish production potential of these aquatic resources in a sustainable manner.

KEYWORDS: Rivers, Floodplain wetlands, Reservoirs, Derelict waters, Sustainability



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Fine-Tuning of CIFT-Turtle Excluder Device for Selective Shrimp Trawling in India

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Turtles were declared as protected animals under Schedule I of the Indian Wildlife Act 1972. However, there has been a considerable number of incidental mortalities of turtles reported as a result of drowning in trawl nets and also entanglement in gillnets, especially from the east coast of India. ICAR-Central Institute of Fisheries Technology is the nodal organization to develop turtle excluder device (TED) designs suitable to Indian conditions with a focus on reducing catch loss in trawls fitted with TED. The indigenous TED was fine-tuned as per international standards for implementation in India to conserve turtles and facilitate the lifting of the shrimp export ban. Dive evaluation of the TED, to see the performance underwater, revealed excellent sealing of escape opening while towing the trawl at 3 km speed, ensuring no catch loss in TED attached trawls. The specially prepared flap material with proper knot orientation resulted in pushing the flap down by the water column above. Further, the overall transition from trawl belly to TED extension and cod end was smooth for the movement of catch to the cod end. Field trials of a 33 m shrimp trawl fitted with TED and 25 mm square mesh cod end stipulated in the Marine Fishery Regulation Act, revealed that there is no shrimp catch loss from TED attached trawl. Similarly, there was no increase in the trawl drag or fuel consumption in TED-fitted trawls. Remarkably the catch obtained was clean as the TED with two floats lifted the cod end a little above the sea bed, which had a washing effect on the cod end. Large-sized jellyfish and marine debris are likely to be eliminated through TED which is an added advantage of this device. However, fishes with more than 4-inch girth size, which is very rare in shrimp trawl catches, are likely to be excluded from the trawl. A better market price for the shrimps due to the lifting of the export ban coupled with the conservation of endangered turtles can very well compensate for the infrequent and minimum financial loss.

KEYWORDS: Turtle Excluder Device, Shrimp Trawl, Dive-evaluation, MFRA, Catch loss



Population Structure and Biology of Obtuse Barracuda, *Sphyraena obtusata* Cuvier 1829 (Sphyraenidae) in the South-Eastern Arabian Sea

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Barracudas (Sphyraenidae) are major fishery resources in Indian waters contributing 35,129 tonnes to the total marine fish landing in India in 2023. In north Kerala, barracudas account for 1225.8 tonnes, contributing 19.8% to the Kerala fishery. Trawlers were the major gear contributing 69.87% of the barracuda catch. Obtuse barracuda, Sphyraena obtusata is a commercially valuable fish species in the Indian coastal waters. This study investigated the population structure, feeding and reproductive biology of S. obtusata in the southeastern Arabian Sea. Monthly samples of S. obtusata were collected from fishery landing during fortnight sampling along north Kerala and their length, weight, stomach analysis, sex, gonad weight, and maturity status were recorded. The size range in the fishery was 120-297 mm TL, females ranged from 171-297 mm TL while in males, TL varied from 151-275 mm. Large numbers of juvenile specimens were observed during June-August and January. Stomach analysis showed 35.7% to be empty. Fishes, dominantly anchovies formed the major diet component. Females exhibited a distinct seasonal pattern in overy weight, with a peak in April-May and October. Males showed a similar pattern in testis weight, though less pronounced. The sex ratio was 1:1.06 (F:M). The study indicated that S. obtusata is a summer batch spawner, with a short spawning season. These comprehensive findings contribute to a better understanding of the feeding and reproductive biology of S. obtusata from the Arabian Sea for better informed sustainable management practices of this important fishery resource.

KEYWORDS: Population structure, Obtuse barracuda, Arabian sea

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Ontogenetic and Seasonal Shifts in Habitat and Diet of a Deepwater Snapper *Pristipomoides filamentosus* Along the South-West Coast of India

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Pristipomoides filamentosus is an economically important deepwater snapper species belonging to the family Lutjanidae. This study examines the diet, habitat use, and seasonal movements of *P. filamentosus* across different life stages, highlighting significant ontogenetic shifts in feeding ecology. Fish in the 50-65 cm size range, identified as spawning adults, primarily inhabit coral reef regions during reproductive months. Their diet during this period consists predominantly of coral reef-associated organisms, reflecting a specialized feeding strategy linked to spawning. Post-spawning, these fish migrate to deeper waters (150-300 m), where their diet diversifies, and incorporating larger prev organisms. This transition to a broader diet reflects a shift towards a more generalist feeding strategy post-reproduction. Juvenile and sub-adult fish (12.4-25.5 cm), inhabit nearshore waters characterized by lower dietary diversity compared to larger individuals. The adult fish in the 25.5-50.0 cm size range also migrate to deeper waters for foraging, as evidenced by their broader diet, which is predominantly composed of deepwater species. The ontogenetic shift from nearshore habitats to deeper waters and the associated dietary changes highlight the species' adaptive strategies across different life stages. Overall, the findings illustrate the complex life history of *P. filamentosus*, marked by seasonal migrations and significant dietary shifts that optimize reproductive success.

KEYWORDS: Crimson jobfish, Feeding ecology, Habitat use, Spawning adults, Reproductive success

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Growth Traits of Six Deep-Sea Fishes from the Southeastern Arabian Sea: Implications for Database Enhancement and Fisheries Management

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The growth characteristics of fish enable researchers to estimate fish weight based on length, assess biomass, and evaluate the health of the overall environment. Length-weight relationships (LWRs) and condition factors of six deep-sea fish (Pisces: Teleostei) collected from Kerala, southwest coast of India, were analyzed and presented. The specimens were collected from commercial deep-sea shrimp trawlers operating at depths of 250 to 340 m in the southeastern Arabian Sea. The intercept (a) value of LWRs varied from 0.0032 (Chelidoperca occipitalis) to 0.0281 (Lepidotrigla bispinosa). The growth scaling coefficient (slope, b) based on the student's t-test proclaimed hypoallometric growth (b<3, p<0.05) for three species (Aesopia cornuta, L. bispinosa, and Dactyloptena macracantha) and isometric growth (b=3, p>0.05) for two species (Parapercis alboguttata and Trachinocephalus myops). However, only C. occipitalis revealed hyperallometric growth (b>3, p<0.05) indicating that their weight increases more rapidly than their length, which suggests that the species is experiencing optimal growth conditions. The coefficient of determination (r²) was found higher for all the species ($r^2 > 0.97$), suggesting the best-fit model of the relationships. The mean ($\pm SD$) relative condition factor (K_a) value ranged from 0.98±0.04 (*T. myops*) to 1.03±0.06 (*A. cornuta*). The higher Fulton condition factor (K_r) values were observed in D. macracantha and L. bispinosa. The corporeal status based on the allometric condition factor (K_{Λ}) illustrates the highest percentage of plump fish in A. cornuta and L. bispinosa, while, the percentage of lean fish was found higher in T. myops. The present study forms the first report of LWRs of two species and condition factors of all six species from the Indian waters. The provided descriptive statistics will help understand the growth priors of deep-sea species from the studied region. Consequently, it will be a valuable database for managing deep-sea fisheries in this region and for comparing other similar studies in the future.

KEYWORDS: Condition factor, Corporeal status, Deep-sea, Lepidotrigla bispinosa

Diversity Status of Deep-Sea Fishes from Indian Waters Inferred Through Meta-Analysis

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Deep sea constitutes around 90% of the oceanic realm and constitutes valuable aquatic resources. Deep sea exploration in Indian waters began in the late 1950s through exploratory surveys as well as commercial trawlers operating beyond 200 meters. Data were collected from the published sources for the period from 1899 to 2023 consisting of 210 references and synthesized for ascertaining the present status of deep-sea fish species from Indian waters. The data collected covered 22 landing centers and 7 research vessel cruises. The total number of species reported is around 510 belonging to >80 families. Order Perciformes exhibited maximum diversity of species, followed by Myctophiformes, in depth zone from 200 to 3210 m. Analysis showed that the south-west coast represents more species, whereas the Andaman and Nicobar Islands exhibited the least diversity. Among the fish landing centres, Sakthikulangara harbor recorded the highest diversity. Exploratory surveys carried out through FORV Sagar Sampada documented more fish diversity in comparison with landing centres, where deep-sea fishes are caught mostly as by-catch using commercial trawlers. Information generated from this study on the diversity of fish resources in the deeper waters will help fishery managers to implement management strategies for sustainable utilization.

KEYWORDS: Deep sea fish, Secondary resources, Biodiversity, Sustainable utilization, Fisheries management

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Forecasting Fisheries: Time-Series Insights into Landings of Indian Major Carps in Brahmaputra River of India

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Fish landings over time can be analyzed as a time-series process, revealing trends and patterns influenced by underlying factors. Indian major carps (IMC); including Labeo rohita, Catla catla, Cirrhinus mrigala, and L. calbasu form an important fish group of the Brahmaputra River. This study models landings of IMC in the lower Brahmaputra at Guwahati (India) under a time-series framework. For this purpose, quarterly data from 1987 to 2019 were utilized to construct an appropriate model. The average catch and coefficient of variation (CV) for each quarter were: 2.2 tonnes (CV = 118.09%) for the first quarter, 9.9 tonnes (CV = 84.9%) for the second quarter, 13.4 tonnes (CV = 84.9%) for the third quarter, and 4.6 tonnes (CV = 77.5%) for the fourth quarter. Maximum recorded catches were 13.9 tonnes in Q1 (1998), 26.2 tonnes in Q2 (1990), 48.4 tonnes in Q3 (2002), and 14.5 tonnes in Q4 (1990). The data were divided into a training set (Q1 1987 to Q4 2016) for model development and a test set (2017-2019) for validation. An ARIMA model was fitted using the Box-Jenkins methodology, incorporating seasonal differencing to achieve stationarity. Among the SARIMA models tested, SARIMA (1,0,1) (0,1,1), provided the best fit, with the lowest AIC (750.33) and BIC (761.35) values. Parameter estimates for this model were: non-seasonal AR1 = 0.8616 (s.e. = 0.1173, p< 0.001), non-seasonal MA1 = -0.7371 (s.e. = 0.1428, p< 0.001), and seasonal MA1 = -0.6028 (s.e. = 0.0902, p< 0.001). The SARIMA (1,0,1) (0,1,1)model accurately fits the IMC landings data, with diagnostic checks confirming its suitability. Forecasting for the test period (2017–2019) yielded MAE, MAPE, and RMSE values of 0.1703, 13.508, and 0.2244, respectively. Out-of-sample forecasts for Q1 2020 to Q4 2022 suggested that annual IMC landings would stabilize at approximately 5 tonnes per year. The findings can guide policymakers and fisheries managers in formulating sustainable fishery management practices aimed at conserving IMC stocks in the Brahmaputra River.

KEYWORDS: Catch prediction, Fishery management, Seasonal ARIMA model

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Status and Prospects of Scampi Production in Reservoirs in Telangana

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The freshwater prawn (Scampi) production has shown significant potential in Telangana due to the state's abundant water resources, including rivers, ponds, tanks, and reservoirs. The state has been actively promoting scampi farming with a fully funded state scheme of release of prawn juveniles into public water bodies like reservoirs since 2017 and recorded a substantial increase in scampi production from 7,783 t in 2017 to 14,142 t valued at Rs. 465 crore in 2022-23. In the present paper, the results of a survey conducted to collect data on scampi production in reservoirs in Telangana are presented. Data from 12 reservoirs located in five districts (Khammam, Nalgonda, Mahaboobnagar, Janagaon, and Narayanapet) of Telangana were collected. Cooperative societies are managing these reservoirs. The data analysis revealed that 9.759 million scampi juveniles were stocked during 2021-22 in these 12 reservoirs. The stocking density of scampi juveniles (~2 g) ranged from 2 to 30 lakhs. After eight months of stocking, 26.98 t of scampi (20 to 100 g) were harvested. The yield from the reservoirs ranged from 0.80 to 150 t (1.61 to 93.75 kg/ha). The harvested scampi was sold at prices ranging from Rs. 150 to 350 per kg, significantly enhancing the income of the society members. The present study is a first report of a systematic study on scampi production from reservoirs and it revealed the potential of such interventions in enhancing scampi production in the country. Problems faced by the fisherman managing the reservoirs and their suggestions for improvement are also discussed.

KEYWORDS: Freshwater Prawn (Scampi), Reservoirs, Production, Telangana

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Hydrogeochemical and Chemometric Assessment of Water Quality in Bhojtal Wetland, India: A Ramsar Site

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Bhoital wetland, a Ramsar site in Bhopal, India, is essential for maintaining aquatic biodiversity and supplying water for various human activities. This study aimed to assess spatiotemporal variation in surface water quality using chemometric analysis and the trophic state index (TSI), identify hydrogeochemical characteristics, andquantify contamination levels of primary heavy metals. Nine sampling stations representing key pollution sources, including wastewater inlets, recreational activities, and agriculture, were analyzed. The study revealed significant seasonal variations in water quality, with pH, magnesium (Mg²⁺), and dissolved oxygen (DO) exceeding permissible limits. Hydrogeochemical classification shifted from the dominance of alkaline earth metals (Ca²⁺ and Mg²⁺) and strong acids (Cl) during the monsoon to Mg²⁺ and Cl⁻ dominance in post-monsoon. Entropy-based WQI results showed excellent water quality during the monsoon, which declined to good (67% samples) and medium (33% samples) post-monsoon. TSI evaluation indicated hyper-eutrophication, with average values of 81.81 and 82.61 during the monsoon and post-monsoon, respectively. Heavy metal levels were within safe limits during the monsoon, but post-monsoon measurements at Karballa and Hallalpur revealed high cadmium (Cd) and lead (Pb) concentrations. Principal component analysis (PCA) identified four principal components explaining 84% of the total variance, with PC1 highlighting the impact of municipal and urban effluents. Non-metric multidimensional scaling (nMDS) revealed distinct groupings among sampling stations, indicating significant spatial variability in water quality due to varying anthropogenic impacts. These findings underscore the need for targeted land use management and pollution control to safeguard the wetland's water quality, especially during the post-monsoon period.

Keywords: Entropy water quality index, Hydrochemistry, Heavy metal pollution index, Multivariate statistics, Trophic state

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Technological Innovations in Inland Fisheries Harvesting: Advancements in Traps, Lines, Baits and Modern Methods for Sustainable Fishery Practices

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Inland water bodies, such as rivers, lakes, and reservoirs, offer a significant source of fish production, contributing to global food security and local livelihoods. Sustainable and efficient harvesting technologies are essential to optimize yields while minimizing environmental impacts. This paper explores recent advances in fish harvesting technologies in inland fisheries, with a focus on traps, horizontal and vertical lines, foldable traps, and other modern methods. Specific attention is given to bait used for both herbivorous and carnivorous species, and the development of selective harvesting techniques that improve species-specific targeting. Modern innovations like foldable traps and line fishing are also evaluated for their role in improving catch rates while adhering to sustainability standards. Field trials conducted across key inland water bodies in Andhra Pradesh, Odisha, Jharkhand, and Assam provide robust insights into the practical applications of these technologies. Specifically, experimental trials at Meghadri Gedda Reservoir, Visakhapatnam, Andhra Pradesh, demonstrated the efficacy of foldable traps, capturing 0.5 kg of *Puntius* species and other miscellaneous fishes within a 2-hour soaking period. Further results showed these traps yielding 1 to 4 kg of small freshwater prawns (Macrobrachium and Caridina spp.) with immersion durations of 8-12 hours at Chandil reservoir, Ranchi. These technologies enhance productivity and provide insights into responsible fishing practices, offering the potential for scalable implementation in inland fisheries globally.

Keywords: Inland fisheries, Harvest technologies, Traps, Horizontal lines, Vertical lines, Baits, Foldable traps

The Fishery and Trends of Sacred Chank (*Turbinella pyrum*) in the Gulf of Mannar, Southeast Coast of India

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The sacred Chank Turbinella pyrum forms a commercial fishery along the Gulf of Mannar (GoM), southeast coast of India. Its distribution is restricted to the inshore water from 5-30 m depth. From 2013 to 2023, the study documented the sacred Chank fishery in the GoM. Different gears, such as trawl nets (bottom trawls), bottom set-gill nets (crab nets, lobster nets, and chank nets), and diving using mechanised trawlers, vallams, and FRP boats are used for Chank collection. Among the different exploitation methods, *T. pyrum* is a targeted fishery in the diving method, and in other gears it comes as bycatch in the southern Gulf of Mannar, whereas in the northern Gulf of Mannar, it is targeted by gastropod trawling and diving. In the entire GoM region, the average annual landing of T. pyrum was 408 t (2012-2023), and it fluctuated between 249 t in 2020 and 634 t in 2018. Since 2020, there has been an annual increase in the catch trend, with the catch reaching 460 t in 2023. The maximum landing of T. pyrum (141 t) comes from the outboard gill net, which contributed 34.5%, followed by 129 t from the single-day mechanised trawl net (31.5%). The annual landing from the diving method was 91 t (22.2%), while the landing from the multiday trawl net was 39.4 t (9.7%), with the remaining 2.1% from other gears. The overall species composition of gastropods reveals that T. pyrum accounts for 55% in outboard gill nets, 38% in mechanised trawl nets, and 30% in diving and handpicking. In the fishery, the mean size of T. pyrum was high in the diving method (155 mm), followed by outboard gillnet (141 mm) and mechanised trawl net (120 mm). The study shows a high catch rate by diving (14.8 kg/unit and 3 kg/ person), followed by outboard gillnet (6.9 kg/unit) and mechanised trawl net (0.2 kg/hr). T. pyrum shells exploited in the GoM regions are highly valued for the handicrafts and jewelry industry in India and abroad.

KEYWORDS: Chank, Trawl, Diving, Landing, Catch rate

Biometry and Seasonal Size Distribution of Two Medusa *Crambionella annandalei* and *Chrysaora* spp. along the Coast of Andhra Pradesh, Western Bay of Bengal

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Jellyfish are key constituents of coastal and marine ecosystems. Understanding the population dynamics, seasonality and reproductive plasticity of jellyfish medusa requires information about the size structure of populations and temporal changes in size. Although research on jellyfish has increased in recent years, our knowledge of the dynamics and ecosystem role of populations remains scanty in most parts of the oceans, and this precludes an accurate integration of jellyfish into functional ecosystem models. This is especially true in tropical waters, where few studies have been conducted and where field samplings are generally inadequate. Indeed, it could be argued that studies on the life history, biology, population dynamics and ecology of jellyfish are desperately needed in these areas. As a first step to redressing this knowledge gap in the western Bay of Bengal, we developed information on the biometry and seasonal size distribution of two medusa, Crambionella annandalei and Chrysaora spp. caught using gillnets along the coast of Andhra Pradesh between January 2017 and December 2018. Although both taxa exhibited strong seasonal patterns in abundance and growth, being the most common and smallest in summer, C. annandalei were largely absent during the monsoon and post-monsoon seasons. In contrast, Chrysaora spp. were recorded throughout the year across a variety of size groups. There was a strong cohesion in pattern between years, suggesting that the monsoon impacts populations of both species, albeit in slightly different ways. We provided rare, field-based measurements of growth for both species that are in broad agreement with published data for similar taxa. Our length-weight data contribute valuable baseline information.

KEYWORDS: Bay of Bengal, Bell diameter, Growth, Scyphozoa, Von Bertalanffy growth curve

Evaluation of Economic Impacts of Trawl on Juvenile (Finfish and Shellfish) By-Catch Along the Coast of North Andhra Pradesh, India

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By-catch and discards are recognized as major issues in shrimp trawl fisheries. The bycatch issue involves not only juveniles of targeted fishery organisms but also juveniles and spawners of non-targeted fishery organisms and non-fishery organisms that are not the intended catch. Juvenile by-catch may potentially harm adult species recruitment and result in future financial losses due to overfishing. Keeping in view of these aspects, a study was carried out to assess the economic value of juveniles of commercially important species of finfish and shellfish caught as by-catch by multiday commercial trawlers operated off the coast of Visakhapatnam, north Andhra Pradesh. Juveniles of 20 species (four species of cephalopods and sixteen species of finfish) were found to dominate the trawl by-catch. The landed juveniles of these 20 species formed 12,757.16 t and 286.86 million numbers per year, and their contribution to the total landings of these species in trawl by-catch was 55.30% by weight and 57.03% by numbers. Annual average loss due to fishing of juveniles was estimated to be Rs. 209.62 crores. This information will help in deriving policies and formulating appropriate management measures to reduce biological and financial loss occurring due to juvenile finfish and shellfish by-catch in trawls. These results will also help fisheries managers to conduct a management plan aiming to decrease the effects of trawling on local fishery resources and ensure their sustainability.

KEYWORDS: Economic loss, Bio-economic model, Trawl impacts, Mesh size

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Invasion of Exotic Fishes in Natural Water Bodies of Peninsular India

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After the independence of India, to increase fish production from large water bodies, fastgrowing and easily breeding exotic fishes were introduced. Tilapia, Oreochromis mossambicus was first introduced into India in 1952 and thereafter stocked in several reservoirs of south India for augmenting production. Common carp was also introduced into India during this time. Two species, viz., O. mossambicus and O. niloticus are predominantly available in the country, found in almost throughout the country. Later many Chinese carps were introduced for fish production. During the 1990s Malaysian catfish, Pacu and African catfish were introduced clandestinely, but Malaysian catfish and Pacu were legalized in India for aquaculture. Many ornamental fishes got entry into natural water bodies from discarding by hobbyists, and now the sucker catfish, Pterigoplychthys sp. has been established in many water bodies of India. To study the impact of invasive species on native fishes of India, the ICAR-National Bureau of Fish Genetic Resources has taken up studies, under which extensive sampling was done in different water bodies of Kerala and Karnataka. We observed breeding populations of African catfish established in a temple pond in Kozhikode, Periyar Lake, Thekkady, Manathwady River in Wayanad, Anayirangal dam, Mattuppetti dam in Idukki and almost all the stretches of Cauvery River in Karnataka. In Panamaram River, Wayanad, African catfish started appearing in 2014 and after the floods in Kerala in August 2018, fish started appearing in nearby rivers also. Surveys were also conducted in Pampa and Manimala Rivers, in southern Kerala, where we got an adult female specimen with matured ovaries. We observed sucker catfish, *Pterigoplychthys* sp. in many rivers, especially in Amayizhanchan thodu in Trivandrum. In our studies, we observed a well-established population in different stretches of the Cauvery River, starting from Thalakkavery to Tanjavur. In our studies, we also found that Tilapia, mostly *Oreochromis niloticus*, African catfish, and to some extent, sucker catfish were all well established in our natural water bodies and these species will compete with indigenous species. Our study found that tilapia and African catfish are omnivorous, and have high fecundity and capacity to survive in adverse conditions, unlike indigenous fishes. Due to their high plasticity, these species are established in more water bodies, and we need to enforce management practices for the removal of these invasive exotic fishes from our water bodies.

KEYWORDS: Invasive species, Exotics, African catfish, Tilapia, Sucker catfish, Indigenous fishes



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Growth Patterns and Feeding Dynamics of the Critically Endangered *Hemibagrus punctatus* in the Cauvery River, Western Ghats, India

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Hemibagrus punctatus is a critically endangered catfish endemic to the Cauvery river basin (Jerdon, 1849). Commonly known as the Nilgiri mystus, it is found in habitats with deep, flowing water over a predominantly rocky substrate. Earlier this species was also considered extinct from its native range until its rediscovery after a gap of 14 years from the tributaries of Cauvery in Tamil Nadu and Karnataka. The present study was conducted to evaluate the length-weight relationships, relative condition factor and feeding biology of this species from the Cauvery River, Karnataka. The study is based on 130 specimens collected over one and half years with the assistance of local fishermen. The total length of the species ranged from 16.0 to 46.0 cm in males and 16.0 to 42.0 cm in females. The length-weight relationship (LWR) parameters and the correlation coefficient (r) were analyzed. The regression coefficient (b) was estimated as b = 3.03 with r = 0.96 for both males and females, with no significant difference observed between the sex (p>0.05). The regression coefficient indicates isometric growth, meaning the fish grows proportionally in all dimensions relative to its length. The relative condition factor (K) was estimated as 0.73 for males and 0.77 for females, suggesting that the habitat environment was favorable for the well-being of the fish. Gut content analysis revealed that the gastro-somatic index (GaSI) reached its peak value of 9.6 in November and lowest value of 2.58 in June. The result suggests that as the fish grows in size, it consumes a wider variety of food items. Smaller fish primarily feed on insects and larvae, gradually shifting to prawns mainly Macrobrachium sp. However, larger fish predominantly consume small fishes and crabs. The data of the present study provides valuable insights into the species growth patterns and feeding habits, which will contribute to the management and conservation of the species in Indian waters. Further, this study will form a baseline database for future reproductive and stock assessment studies in the Cauvery River.

Keywords: Biology, Conservation, Gastro-somatic index, Length-weight relationship, Nilgiri mystus



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Assessing the Ichthyofaunal Diversity and Seasonal Variation of Fish Assemblages Associated with Trawl Catches of Nagapattinam Fishing Harbour, Southeast Coast of India

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The present study aimed to record the spatio-temporal diversity and seasonal diversity of ichthyofauna from the Nagapattinam Fishing Harbour. The ichthyofaunal individuals were collected fortnightly during the period from August 2022 to September 2023. The recorded ichthyofaunal diversity includes 325 species belonging to 2 classes, 16 orders, 75 families, and 180 genera. The order Perciformes dominates with 156 species followed by Clupeiformes (32 species), Carangiformes (30 species), Tetraodontiformes (20 species), Beloniformes (16), Chaimaeraformes (15), Anguiliformes (12), Laminiformes (10), Orectalobiformes (9) and Sygnathiformes (8). Among the families represented during the study period, the family Carangidae was found to be dominant with 30 species, Lutjanidae with 22 species, Dorosomatidae with 18 species, Nemipteridae with 16 species and Serranidae with 15 species. The spatio-temporal diversity analysis revealed that the maximum species diversity was observed during the post-monsoon (290 species), while the minimum was observed during the summer (210 species) season. The dominant species were found to be *Decapterus russelli*, Sardinella gibbosa and Nemipterus japonicus. The present study also gives information on the IUCN status, frequency of occurrence, season-wise diversity, bycatch species landings and size ranges of juvenile fish that are encountered in trawl catch along the Nagapattinam coast. The results on the species diversity, richness, evenness and phylogenetic diversity were calculated by using PRIMER (v7.0) software and were elucidated in the paper. The outcome of the study gives baseline information on the trawl diversity which paves the way for sustainable exploitation and also the management of exploited fisheries resources in this region.

KEYWORDS: Biodiversity indices, Spatio-temporal, Distribution, Occurrence, Trawlers

Impact of Non-Selective Dolnet Fishing on Juvenile Fish Populations in Coastal Maharashtra

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The study was conducted in the coastal regions of Madh Island, Mumbai Suburban, Maharashtra, a key hub for Dolnets, a type of non-selective bag net. Using the research vessel M.F.V. NARMADA (IV), eight experimental fishing trips were conducted between December 2022 and May 2023 in water depths of 10-14 meters. Fish and shellfish caught were identified at the species level using taxonomic methods, including online databases like WORMS and FishBase. Special attention was given to the sexual maturity of each species. The experimental catches yielded a total of 120.33 kg, with juveniles constituting 66% (57.6 kg) across eight fishing trips, which included species like Cynoglossus arel, Metapenaeus brevicornis, Coilia dussumieri, and several others. Juvenile species were predominantly caught in the net. Out of the 78 species identified during the study, 38 (48.71%) were juveniles, making up a significant portion of the catch. This highlights the vulnerability of young fish to non-selective fishing gear, which can have long-term ecological consequences. Among the juveniles, notable species included Alepes djedaba, Ilisha melastoma, Johnius borneensis, and Pampus chinensis. The capture of juvenile species is a matter of concern as it impacts their ability to mature and reproduce, potentially leading to a decline in fish populations over time. By catching fish before they reach sexual maturity, the sustainability of fisheries is compromised. This underscores the importance of developing more selective fishing practices to minimize the capture of juveniles and ensure the health and longevity of fish populations in the region.

KEYWORDS: Dolnet, Juvenile, Bag net, Maharashtra

Assessment of Biomass Indices for Managing Small-Scale Dolnet Fisheries Along the Mumbai Coast

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The marine capture fisheries of Mumbai, Maharashtra is uniquely contributed by Dolnet fishery, which is traditionally evolved as set bagnet. The expansion of Dolnet operations to deeper waters made most of the coastal fishes vulnerable to overfishing and it calls for an urgent attempt to evaluate the biomass and stock status of the major resources caught by these set bagnets. Therefore, a Length-Based Bayesian Biomass (LBB) estimation method was adopted to develop Length Based Indicator (LBI) for understanding the status and health of two predominant fish resources, Goldspotted grenadier anchovy, Coilia dussumieri, and White Sardine, Esculaosa thoracta exploited in Mumbai waters by the Dol netters. The estimated parameters of C. dussumieri were asymptotic length, $L_{\infty} = 18.4$ cm, length at first capture $L_{cs0} = 13$ cm, and relative natural mortality, M/K = 1.51; while for *E. thoracata*, L_{∞} was 11.7 cm, $L_{c50} = 5.85$ cm, and M/K = 0.87. The estimation of the length at first capture that would maximize catch and biomass for the given fishing effort (L_{c ont}) was 10 cm and 6.4 cm for C. dussumieri and E. thoracata respectively. The current state of biomass B/B₀ was 0.49 for C. dussumieri and 0.83 for E. thoracata, while the biomass capable of producing maximum sustainable yield (B/B_{MSY}) of C. dussumieri was found to be 1.3 and 2.1 for E. thoracata. A healthy stock status can be assigned for these two species (B/B_{MSY}> 1); however, relative stock size B/B₀ is smaller than 1, which is figured out as an indicator to reduce the catch. The LBIs estimated suggest the size selection is happening at the Dolnet fishing grounds as L_{c50} (5.85 cm) is smaller than L_{c_opt} (6.4 cm), in the case of white sardine along with lower M/K (0.87) which indicates that \overline{F} is at the edge of growth overfishing. To retain the sustainability of the multi-species Dolnet fishery, cod end selectivity is recommended to ensure optimum harvesting of size classes ensuring MSY and biomass in a healthy state.

KEYWORDS: Coilia dussumieri, Esculaosa thoracta, LBB, LBI, MSY

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Marine Mammal Strandings and Bycatch in Fishing Gears along the North-Eastern Coast of India

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Marine mammals are protected under various conservation agreements such as CITES, IUCN-Red list, CMS, WPA etc. For developing conservation measures information on the distribution and abundance of resources is highly necessary. North-east coast of India covers Northern Andhra Pradesh, Odisha and West Bengal from Kakinada to Sundarbans. Incidents of marine mammals stranding and bycatch of mammals along the north-east coast of India were collected and analysed. Stranding events from 1852 consisted of 12 different species of marine mammals including incidents of bycatch from gillnet, shore seine and trawl. There was no seasonality of strandings and it was random. Out of 12 correctly identified marine mammals, three falls under IUCN-Red list category Vulnerable (VU), three under Data Deficient (DD), three under Endangered (EN) and three under Least Concern (LC). Under CITES, six each was placed in Appendix I and II. 4 species were placed under Appendix II, two under Appendix I and two species were placed under Appendix I and II of CMS. All the marine mammals in India, were protected by Schedule I (Part I) of Wildlife (Protection) Act, 1972. Only 5 species of marine mammals have been caught in fishing gears. Gillnet accounted for a high proportion of bycatch along the north-east coast. Preparation of a checklist on marine mammal strandings and bycatch on the north-east coast of India provides a deep insight into the stranding events, gear wise contribution to by catch and helps to validate the distribution of marine mammals and in the conservation of marine mammals. This will also help in developing marine mammal rescue response operations and identification of hotspot which would probably help in the future plans.

KEYWORDS: Marine mammals, Stranding, Conservation, Checklist

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Case Study on Jellyfish Bloom Biomass Quantification and its Impact Analysis in the Commercial Trawl Fishing Ground of Daman Coast, Arabian Sea, India

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Jellyfish bloom biomass was quantified using shrimp trawlers during an experimental survey on the Daman coast in 2024. The jellyfish specimen collected in the bloom was identified as Rhopilema hispidum. R. hispidum blooms occurred in two main seasons: October-December and March-May, at depths of 10-40 m. The estimated biomass of R. hispidum bloom was found to be in the range of 1190.47 - 1257.65 kg/km². The mean estimated biomass is 1223.45 kg/km². The mean ratio of fish catch to jellyfish in the total catch was 3:2. Each R. hispidum individual weighed between 1.45 - 7.89 kg. The water quality parameters observed in the bloom waters were as follows: atmospheric temperature, 30°C; sea surface temperature (SST), 27.8°C; pH., 8.0; salinity, 33 %; total dissolved solids (TDS), 50.1 g/l; dissolved oxygen, 5.45 ppm; and turbidity, 6.31 NTU. Microbial analysis showed that the total viable count (TVC) was 1 x 10⁴ cfu/ml and the Escherichia coli count was Nil in the jellyfish bloom waters. R. hispidum bloom is found to impact the commercial trawl fishing operations of Daman coast negatively in terms of reduced fish catch, increased fuel cost, increased catch sorting time, decreased fish catch quality, and painful stings to fishermen while handling the jellyfish blooms, and discards of the fish catch along with the jellyfish caught at the cod end was found to be 30% of the total catch during the blooming period. This study records baseline data on jellyfish bloom biomass quantification and its negative impacts on commercial fishing operations on the Daman coast.

KEYWORDS: Rhopilema hispidum, Gujarat, Northwest coast, Jellyfish, Gelatinous bloom

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Length-Weight Relationship, Condition Factor and Feeding Biology of the Shrimp Scad, *Alepes djedaba* (Forsskal, 1775) Along the Uttara Kannada Coast of Karnataka

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The Shrimp scad, Alepes djedaba (Forsskal, 1775) is a member of the Carangidae family found mostly in the marine waters of the Indian and Pacific oceans. It is found mostly in the inshore reefs. The body with the dorsal and ventral profiles are almost evenly convex. The important identification characteristics are that the posterior part of the eye is covered with an adipose membrane, and the anterior part is naked. There is a blotch on the operculum which is dark on the lower portion and shiny silver on the upper portion. The last ray of the anal fin is slightly detached from the previous ray. The lateral line is 'U' shaped, curved anteriorly and gets straightened from the point equal to the first ray of the 2nd dorsal fin. The lateral line is with 39-51 scales of which 0-3 scales are on the straight part and 31-36 scales are on the curved part. The vernacular name of this species is 'Gondlu'. The present study was conducted along the Uttara Kannada coast of Karnataka for one year from Oct 2023 to Sept 2024 (excluding the monsoon mechanized fishing ban period of June and July). A total of 756 specimens were examined in the present study of which 336 were males and 420 were females and the overall length ranged from 12-32 cm. The length-weight relationship of the males and females was W=0.007807L^{3.1684} and W=0.01653L^{3.019229} indicating that both the sexes show positive allometric growth. The average relative condition factor (Kn) values for males and females were 0.9053 and 0.9366 respectively. The diet of Alepes djedaba consisted maximum of fishes (38.3%) followed by crustaceans (25.8%), cephalopods (20.6%), digested matter (12.5%) and fish scales (2.8%) which indicated its carnivorous nature of feeding.

KEYWORDS: Scad, Length-weight, Condition factor, Feeding

Assessment of Spawning Seasonality of the Shrimp Scad, *Alepes djedaba* (Forsskal, 1775) Off the Coast of Karnataka, India

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Carangids are important pelagic resources that contributed 8% (2,84,665 t) to the Indian marine fish landings, of which scads contributed 43% (1,23,758 t) to the carangid's landings in 2023. The Shrimp scad, Alepes diedaba found mostly in the marine waters of the Indian and Pacific oceans is a dominant species among the scads and has local as well as export value. Hence setting a minimum legal size (MLS) is an essential precursor for the sustainable harvest of resources. In this context, the present study aimed to establish the information on the size at maturity and breeding seasonality of Alepes diedaba off Uttara Kannada coast, Karnataka for one year from Oct 2023 to Sept 2024 (excluding the monsoon mechanized fishing ban period of June and July). A total of 756 specimens with lengths ranging from 12-32 cm were examined for biological observation of which 336 were males and 420 were females. Length at first maturity of males and females was 19.5 cm and 18.3 cm respectively. indicating that females mature earlier than males. The sex ratio for males and females was 1:1.2. The Gonado-somatic index (GSI) values ranged from 0.34 to 5.39 in males and 0.37 to 5.61 in females. Fecundity ranged from 26,888 to 3,50,644 eggs with an average of 2,00,281 eggs per individual. The ova diameter of fully matured and oozing gonads ranged from 0.37 mm to 0.68 mm. The spawning period of the Alepes djedaba was found from June to November with the peak in September and October.

KEYWORDS: Scad, Sex ratio, Maturity, Spawning, Fecundity

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Sperm Whales in Indian EEZ: Distribution, Abundance and Habitat Suitability

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Sperm whales are the largest of toothed cetaceans and the only living member of the genus *Physeter* with distribution in all world oceans. A study was conducted to map the distribution, assess the abundance, identify the hot spots, and predict the habitat range of *Physeter macrocephalus* in the Indian EEZ. The abundance estimate was made by undertaking vessel-based surveys following the line transect methodology. A total of 4547 animals were estimated from the Indian EEZ with the highest densities recorded from the southwest coast of India. An ensemble approach was employed to create a species distribution model for *Physeter macrocephalus*. Our findings indicate that sperm whales strongly prefer deep-sea environments, particularly around continental slopes. Sea surface temperature (mean and minimum SST) was identified as a crucial factor in habitat suitability. Notably, areas around the Andaman and Nicobar Islands, southern Sri Lanka, and the southwestern coast of India were highlighted as important suitable habitats. The study conducted was the first of its kind and an important step towards marine mammal research and conservation in the country. Information on the distribution, abundance, and habitat preferences of sperm whales is crucial for its effective conservation and management.

KEYWORDS: Sperm whale, Distribution, Population, Hot spot, Habitat preference

Mapping of Salt Affected Lands Using Google Earth Engine and Machine Learning Techniques in Ramanathapuram District, Tamil Nadu, India

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Soil salinization is a major environmental issue and the extent of salt-affected land is expected to increase due to climate change. The assessment of salt-affected lands is still not a common process globally, particularly in developing nations due to the non-availability of data sources and infrastructure. The conventional approach of a collection of soil samples and the analysis for electrical Conductivity (EC) is labour oriented and takes a long time for larger areas. Remote sensing digital satellite images of different spectral bands and combinations of their various spectral indices are well capable of monitoring land salt content characteristics based on the reflection of the various bands in different wavelengths and spectral indices. The saltaffected lands have been assessed using spectral indices of vegetation, and salinity integrated with field EC values using the Random Forest model for Ramanathapuram District of Tamil Nadu, India. Sentinel-2 satellite images of 2022 from March to May month from Google Earth Engine (GEE) data catalogue were used for the calculation of various vegetation indices such as Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Soil Adjusted Vegetation Index (SAVI), Generalized Difference Vegetation Index (GDVI); soil salinity indices such as Normalized Difference Salinity Index (NDVI), Canopy Response Salinity Index (CSRI), Salinity Index (SI), SI1, SI2, SI3, Salinity index I (S-I), S-II, S-III, S-IV, S-IV, S-V along with the spectral bands of Sentinel-2 such as B2, B3, B4 and B8. A total of 30% independent variables along with soil samples EC values were used to predict salt-affected land. Prediction shows 0.97% of the total study area as saltaffected land with 87% validation accuracy. This study demonstrates the ability of machine learning tools coupled with Google Earth engine capacity in forecasting salt-affected lands.

KEYWORDS: Mapping, Salt affected lands, Machine Learning

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Predator-Prey Size Relationships among Marine Finfishes: Interspecific Variations in Selected Finfish Species from Southeastern Arabian Sea

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Size-based feeding habits of four species of finfishes namely Saurida tumbil, S. undosquamis, Nemipterus randalli and N. japonicus from the southeastern Arabian Sea were assessed through the preferred predator-prey mass ratio (PPMR) and frequency distribution of relative prey sizes eaten, and were related to species-specific predator feeding habits and gape sizes. Maximum prey size and slopes of prey size with predator size varied significantly among predator taxa. The preference for food of a predator is determined by individual weight combined with a species preference. The preference for prey weight is described by the log-normal selection model and was estimated using direct observations of the size of prey in predator stomach content and calculated using the appropriate function in Rsoftware. The estimated preferred predator-prey mass ratio (β) ranged from 29 for S. undosquamis to 234 for N. japonicus with a mean value of 122 for these four species along the study area. The width of the selection curve (σ) values ranged from 0.7 for *S. undosquamis* to 2.5 for N. randalli with a mean value of 1.4 for all four species. Though the preferred PPMR was higher for N. japonicus, the sigma values were lower than that of N. randalli, which indicates that the formerhas higher size accommodation in preferences than the latter. The values were compared with the β and σ values of the large pelagic shark *Carcharhinus falciformis*. Gape sizes and allometric relationships with various body sizes were also varied among predators. The study on the feeding preferences based on predator-prey mass ratio is highly relevant as these form mandatory inputs for many size-based ecosystem fisheries models.

Keywords: Size based models, Feeding preference, Fish diet analysis, Predator-prey interaction

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Gametogenesis, Spawning and Spatfall of the Brown Mussel *Perna indica* (Kuriakose and Nair, 1976) from South Kerala

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The brown mussel, *Perna indica*, is an important sea mussel species supporting the livelihood of 252 families of skilled mussel-picking divers in South Kerala. Unlike the widely distributed Indian peacock mussel, *Perna viridis*, the *P. indica* has a restricted distribution from Tuticorin to Cape Comorin along the east coast and Cape Comorin to Alleppey along the west coast. This study, conducted from 2017 to 2023, involved monthly fisheries and mussel bed sample collections to analyse the species' reproductive cycle. The gonadal development stages were categorized as indeterminate (ID), early maturing (EM), late maturing (LM), ripe (R), partially spawned (PS), and spent (SP). Spats collected from the beds during this period were also examined. The study identified the peak spawning season as occurring primarily in April, May, and June, based on observations of ripe, and partially spawned mussels. This research provides detailed insights into the monthly sex ratio, gonadal development stages through morphological and histological analysis, and the spawning season and spatfall patterns of *P. indica* from the Vizhinjam-Kovalam bed along the Thiruvananthapuram coast.

KEYWORDS: Brown mussel, Perna indica, Gametogenesis, Spawning season, Maturity stages

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Microplastic Ingestion and Feeding Strategies in Fishes from the Creeks of Northeastern Arabian Sea

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In this study, we evaluated the diet composition and microplastic ingestion of fish species collected from a selected creek area in the northeastern Arabian Sea. An investigation was made on the feeding preferences and microplastic uptake of six dominant fish species using the Vacuity Index (VI), Diet Breadth (Bi), Trophic Level (TrL), Index of Preponderance (%IOP) of prey, and the number of microplastics in their guts. A total of 900 fish samples were collected monthly from November 2021 to September 2022 for gut content analysis. The results indicated that the most preferred prey items were shrimps (26.23%), followed by algae (12%), fish (11.39%), and zooplankton (10.23%), while microplastics accounted for 4.83% of the total diet composition. The mean abundance of microplastics in individual fish guts ranged from 5.82±1.26 to 7.35±2.37. Omnivorous fish were found to have a higher microplastic load compared to carnivorous fish. The microplastics identified were predominantly black fragments within the 100-250 µm size range and composed mainly of polypropylene. The highest levels of microplastic ingestion were observed during the postmonsoon months. No significant correlation was found between trophic level, body length, and microplastic ingestion. Our study underscores the significant presence of microplastics in fish from this area, which may pose potential health risks to humans.

KEYWORDS: Feeding habits, Microplastics, Pollution, Fibre, Trophic level

Mass-Balance Model of a Small Young Sub-Tropical Reservoir: An Implication for Sustainable Fisheries Management using Ecopath with Ecosim

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Ecosystem-based fisheries management has been gaining popularity for sustainable fisheries management in recent years. The small reservoir ecosystem is known to be the most productive ecosystem, but due to a gap in understanding its ecological functioning and potential throughput, these ecosystems were underutilized. A mass-balance model of trophic interactions of Maphou Reservoir was constructed using the Ecopath model using Ecopath with Ecosim, to evaluate the trophic structure, energy flow, maturity, stability and ecosystem functioning of the reservoir. The present study was conducted between June 2021 to May 2022. All the primary data were collected from the four designated sampling sites, and secondary data were sourced from published literature. Ten functional groups were considered, and the findings revealed that the ecosystem has three trophic levels (TL - I, II, III). Most organisms were confined in trophic level II (Low order primary consumer). Exotic fish groups were found to be the most exploited group (EE = 0.782) because of fishing pressure, followed by herbivorous fish (EE = 0.623). Carnivorous fish, being the top predator, was the keystone species based on the keystone index (Keystone index = 1.35). Mix trophic index (MTI) suggested lower trophic level functional groups (detritus and phytoplankton) have a positive impact on most of the higher trophic level functional groups, manifesting "bottom-up" control of the ecosystem. The ecosystem is characterised by grazing food as the transfer efficiency from the primary producer (TE = 4.864%) is higher than that of detritus (TE = 4.024%). The ecosystem is immature (TPP/TR = 3.628) and in the developing stage (TPP/TB=70.70) with strong resilience capacity against the external perturbation (overhead = 63.27%). The food web is moderate (connectance index = 0.463) in nature. The study suggested detritivores and phyto-planktivorous fish species for future augmentation programmes as they were positively impacted in most of the higher functional groups. The finding will be instrumental for the sustainable ecosystem-based fisheries management for the small tropical reservoirs.

KEYWORDS: Maphou Reservoir, Upland hills, Keystone species, Food web

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Effect of Long-Term Exposure of Cypermethrin During Breeding Season of *Cyprinus carpio* in Captivity

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Cyprinus carpio (common carp) is a widespread freshwater fish found in eutrophic waters such as lakes and large rivers in Europe and Asia. The fish is the fifth most farmed species in the world and has been introduced in many countries for aquaculture. In the present study, the sublethal effects of cypermethrin for 30 days on the reproductive performances, biochemical and hormonal changes of common carp have been investigated during the breeding season using three sublethal concentrations of cypermethrin, i.e. 0.0025µl/l, 0.0030ul/l, and 0.0035ul/l. The investigation shows a significant reduction (p<0.01) in GSI, the number of eggs spawned, fertilization rate, hatching percentage, and survival of hatchlings than control females, however, the decrease was observed in other groups for all of the parameters mentioned above. Total sperm cell count/ml (92633.8) was observed to be significantly (p<0.05) reduced at 0.0035 μl/l cypermethrin-treated males compared to control group males. The trend of total sperm cell count /ml was increased as the concentration of cypermethrin exposure decreased and the range of sperm cells varied from 92633.8 to 123934.8 cells/ml. Out of total sperm cells/ml (92633.8) at 0.0035 µl/l cypermethrin treated males, motile sperms were 57144.0, and immotile sperms were 35489.7 cells/ml. Further, blood hemoglobin and hematocrit levels decreased significantly with increasing cypermethrin concentrations exposure, and blood hemoglobin was found significantly the highest (4.3±0.54%) in 0.0035 µl/l concentration of cypermethrin-treated groups. On the other hand, the total protein contents and blood glucose level were increased significantly (p<0.05) with increasing cypermethrin concentrations exposure. Similarly, blood glucose and cortisol levels were also found significantly higher in the maximum cypermethrin (0.0035 ul/l) concentration treated groups compared to control group. Increased activity of SGPT and SGOT was observed at low concentrations of cypermethrin-treated and control groups. The plasma testosterone in males and 17β-estradiol in females after 30 days of exposure to cypermethrin, in the 0.0035 µl/l treated group resulted in significantly (p<0.05) lowest (29.10; 881.45 pg/ml) values, compared to control groups. The findings revealed that the use of cypermethrin during breeding season may harm the reproductive performance of Cyprinus carpio.

KEYWORDS: Breeding, Cyprinus carpio, Cypermethrin, Reproduction, Biochemical, Hormonal parameters



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Insights from Experimental Trawling: Species Composition and Spatio-Temporal Dynamics of Fisheries Resources Off the Mumbai Coast

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Experimental trawl fishing was conducted biweekly, between latitudes 18°57'N to 19°12'N and longitudes 72°40'E to 72°43'E, within a depth range of 6 to 21 meters, using the M.F.V. Narmada (IV), operated by ICAR-Central Institute of Fisheries Education, Mumbai. A 35-meter bottom shrimp trawl net with a cod end mesh size of 35 mm was employed for the operations. The analysis of trawl catch composition showed a predominance of bycatch (79.43%) compared to commercial catch (20.12%), with marine debris accounting for 0.45%. Estimated bycatch ranged between 3.44 to 61.34 kg/h, while commercial catch varied from 3.80 to 57.25 kg/h. A total of 93 species were identified from the catch, which were categorized into groups: finfishes (53 species), shrimps (13), gastropods (11), crabs (4), cephalopods (4), stomatopods (3), elasmobranchs (3), a single lobster species, and one hermit crab species. The commercial catch was primarily composed of sciaenids (37%), shrimps (21%), and coilia (17%), while bycatch was dominated by squilla (28%), juvenile sciaenids (13%), and juvenile shrimps (11%). Spatial analysis indicated that species richness was highest at the 12-15 m depth range, where a maximum of 69 species were recorded.

KEYWORDS: Trawl fisheries, Bycatch composition, Species diversity, Depth stratification

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Multi-Model Approach to Compute Potential Yield (PY) for the Marine Fishery Resources of Gujarat

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Gujarat holds the largest share of India's mechanized fishing fleet, contributing 780,000 tonnes to the country's total landings. Scientific monitoring of this sector is essential for ensuring its sustainability. Accurate estimates of the potential yield of marine fishery resources provide critical inputs for effective management and sustainable harvesting of fish stocks. Implementing harvest limits based on potential yield is crucial for maintaining both economic viability and biological sustainability. CMSY and Bayesian Surplus Production Models were employed to compute potential yield for the commercially important fishery groups using time series catch and standardized fishing effort data (1994 to 2018). The CMSY was run using R-script CMSY O 7q.R. Data-intensive food web model (Ecopath with Ecosim) was applied to the fishery ecosystem of Gujarat using catch, effort, biomass, and diet composition for the selected 45 functional groups. The FMSY and relative catch corresponding to them were estimated using the FMSY module in the Ecosim. The pooled MSY estimates for different functional groups using EwE was 11.70 lakh t, but estimates were lower for the BSM (9.05 lakh t) and CMSY models (8.73 lakh t), but comparatively higher than the recent catch (7.49 lakh t in 2019). The difference in the potential yield between the three approaches was noticed mainly in non-penaeid prawns, perches, clupeids, and Bombayduck functional groups. The computed potential yield for the commercially exploited fishery resources could be taken as Biological Reference Points, BRPs/Fishery Harvest Limits, and FHLs in the region. The Potential Yield estimated in the present study could be used to compute the optimum fishing fleet for different fishing crafts. To achieve sustainable management of fishery resources, it is essential to conduct regular stock assessment studies and develop comprehensive fishery management plans (FMPs). This study recommends reducing fishing efforts on the continental shelf while extending fishing activities to deeper oceanic regions to better exploit these resources. This transition should be supported by improved infrastructure and the implementation of appropriate policy interventions.

KEYWORDS: Catch-based model, Fishing effort, EwE model, Potential yield, Gujarat

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Assessment of Water Quality of River Sutlej: The longest tributary of Indus River System

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This study aimed to assess the water quality of the longest tributary of the Indus River system i.e. river Sutlej. The study was carried out at four designated sites viz., Site-1 (Ropar Headwork), Site-2 (Phillaur before confluence of Buddha Nallah), Site-3 (Wallipur Kalan after confluence of Buddha Nallah) and Site-4 (Harike-Pattan where river Sutlej meets with Beas) from February 2018 to August 2019 for determination of water quality for river Sutlei along its course of flow in Punjab. Samples of water, sediment and fish were collected in triplicate at two monthly intervals from the designated sites for water quality and heavy metal analysis. The outcome of the present study revealed that river Sutlei gets heavily polluted after the influx of Buddha Nallah at village Wallipur Kalan as evident from low levels of dissolved oxygen (<5 mg/l), elevated levels of biological oxygen demand (>5 mg/l) and chemical oxygen demand (>10 mg/l). Moreover, heavy metals (Cd, Cr, Cu, Pb, Ni and Zn) were also detected, although within permissible limits in water, sediment and fish (flesh and gills). Besides, Lead (Pb) concentrations were found to be slightly higher than the permissible limits in water (0.05 mg/l) at Site-3, in flesh (0.5 µg/g) of Wallago attu and in gills of Aorichthys seenghala and Wallago attu. The findings of this study are alarming and warrant for constant monitoring of river Sutlej to save its fragile ecosystem from further deterioration. Implementation of stringent legislative measures and formulation of effective management plans are much needed to curb the menace of pollution in river Sutlej and save its floral and faunal biodiversity.

KEYWORDS: Water quality, Sutlej, Buddha Nallah, Heavy metal, Fish

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Understanding the Sustainability and Exploitation Pattern of Data-Limited Small-Scale Wetland Fisheries, Brahmaputra Basin, India

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This study investigated the growth, mortality, and exploitation patterns of four small indigenous fish (SIF) species viz., Gudusia chapra, Puntius sophore, Mystus bleekeri, and Heteropneustes fossilis inhabiting Deepor Beel, a Ramsar-listed wetland in the Brahmaputra Basin, northeastern India. Monthly samplings over a one-year period (June 2023-May 2024) was conducted, yielding data on over 13129 fish specimens. The analysis using FiSAT-II software revealed species-specific insights into population dynamics, such as length-weight relationships, growth coefficients, and mortality rates. Notably, *P. sophore* displayed positive allometric growth, indicating body weight increase at a faster rate than length, while the other species exhibited negative allometric growth, with length increase surpassing weight. Exploitation rates were calculated for each species, revealing G. chapra to be moderately exploited (E = 0.48) and P. sophore facing slightly higher exploitation (E = 0.57). However, M. bleekeri and H. fossilis demonstrated higher exploitation rates of 0.63 and 0.61, respectively, suggesting they are nearing overexploitation thresholds. Seasonal recruitment patterns varied across species, with spawning peaks aligning with post-monsoon and winter seasons, suggesting distinct breeding adaptations and resilience. The study underscores the ecological role of these SIFs, essential for nutrient cycling and food web stability in the wetland ecosystem, while also highlighting their socioeconomic value to local communities reliant on SIFs for protein and income. By offering essential baseline data on life-history traits and exploitation levels, this research provides critical insights into balancing fishery practices with conservation needs, supporting the dual goals of biodiversity preservation and community livelihoods. The findings thus serve as a reference point for policymakers working to enhance conservation efforts and ensure the sustainable use of Deepor Beel's fishery resources.

KEYWORDS: Small indigenous fish, Growth, Mortality, Exploitation, Conservation

New Approaches to Assessing and Managing the Multispecies Fishery in Thai Waters of the Gulf of Thailand

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Marine fisheries in Thailand are multispecies/multigear fisheries. The Multispecies Maximum Sustainable Yield (MMSY) has been used as the reference point for fisheries management, with an equilibrium surplus production model used to estimate MMSY of three groups: demersal fish, pelagic fish and anchovy. Additionally, single species assessments are conducted for 15 economically important species using length frequency data to monitor the status of individual species. Thailand is attempting to increasingly apply ecosystembased management concepts that consider the broader ecosystem rather than focusing solely on individual species. Unlike traditional fisheries management, which often emphasizes maximizing the yield of specific target species or species groups, ecosystem-based approaches better account for complex interactions within marine ecosystems, including predator-prey relationships, habitat requirements, and the effects of environmental changes on marine life. The research discussed here applies the recently developed Lenfest tools for ecosystem-based fisheries management to fisheries in the Thai waters of the Gulf of Thailand. A new draft harvest strategy that highlights how single species, multispecies and ecosystem considerations can be combined in a single strategy is being developed. This uses multiple data sources, including statistical catch and fishing effort, species composition and catch per unit effort from research vessels, and port sampling data for major fishing gears covering both artisanal and commercial vessels. The project has resulted in the MMSY reestimated using dynamic models, with results presented by using Kobe plots that describe changes in biomass and fishing effort over time. Recent single species assessment results have also been updated. Principle component analysis (PCA) and heatmaps are used to describe changes in catch composition over time, with implications for MMSY. Finally, we present ecosystem indicators of topology, resiliency, and distortive pressures, which are combined in an Ecosystem Traits Index (ETI) score that describes the trajectory of the health of the Gulf of Thailand ecosystem. All of this information will be integrated and used to further develop and deliver harvest strategies that enhance the sustainability of Thai fisheries and support ecosystem health.

KEYWORDS: Ecosystem-based fisheries management, Marine ecosystem, Ecosystem indicator, Maximum sustainable yield, Harvest strategy



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Informing Sustainable Management of Multi-Species Fisheries Using Fish Biology, Population Genomics and Fishery Policies

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Fisheries management across the globe has been largely based on the political jurisdictions of nation states and their provinces. Such management often leads to a mismatch between the population boundaries of fish and the management boundaries of fisheries. Resolving this mismatch to attain sustainability and ecological integrity is particularly difficult in multispecies tropical fisheries. We propose an intuitive heuristic tool Biology – Transboundary Management Vulnerability Matrix (BTM-matrix) for multi-species vulnerability assessment and management that improves PSA by incorporating information about 1) the spatial distribution of genetically-distinct individual populations, 2) the possibility of multiple fisheries (management regimes) fishing same population and 3) the biological relevance of the individual management instrument to the species. As a case study, we conducted a BTM vulnerability assessment for nine fish species harvested along the west coast of India. We first used population genomic tools (ddRADseq) to identify the spatial distribution of individual populations of nine species. For management analysis, we then examined the policies and regulations of all provinces along the study area. The BMVM matrix demonstrated that different populations of the same species differ greatly in terms of how they are managed by respective fisheries, which in turn influences their vulnerability. Moreover, the disparity between different fisheries harvesting the same population also impacts the vulnerability of that population. The matrix was also observed to be sensitive to periodic changes in the management. The BTM approach has significance for much of the Global South, where achieving social justice and maintaining ecological integrity are equally critical.

KEYWORDS: Multi-species fisheries, Fish biology, Population genomics, Fishery policies

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Assessment of Low Value Trash Fishes Landing and Utilisation from Major Fish Landing Centres in Coromandel Coasts of India

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Trawl fisheries accounted for 40% of the marine fish production (1.43 million tonnes) in India during 2017-2019. It contributes more than 75% of the marine fisheries exported from India. The practice of bottom trawl fishing was critically analysed from a sustainable manner, particularly the trash fish landing (non-commercial species, juvenile fishes with commercial values). A portion of trash fish landing which does not have market demand value known as low-value trash (LVT) continues to be a matter of concern from an ecological and economic perspective. This study discusses the overall trash fish landing and utilisation from five major fishing harbours in the Coromandel coasts of India (Tamil Nadu, Pondicherry). Both qualitative and quantitative assessment survey was used to assess the trash fish in five landing centres (Kasimedu, Cuddalore OT, Nagapattinam, Karaikal, and Palaiyar) in the east coasts of India. This study explores the possibility of converting fish waste and investigates alternative measures for sustainable use. This study investigates the possible measures from various agencies involved in fisheries (Government, Private) to reduce juvenile fishing and landing through legal and sustainable perspectives. This study is based on the data collection along the Coromandel coasts of India during the period 2023-2024. The estimated landing of low-value trash fish by bottom trawlers increased, which is reflected in as reduction of waste by the users. Assessment of trash fishes from different fishing harbours of India showed that as many as 67 species/groups of marine fauna with juveniles of commercially important fishes were landed as LVT (Low-Value Trash). Increase in trash landing and utilisation from bottom trawlers as well as SSF (Small - Scale Fisheries), market-driven trend, and how this impact on marine ecosystem / marine fishery production is discussed in this paper. This study concludes that the trash fish landing was found to be more in Cuddalore OT, Nagapattinam, Karaikal, and Palaiyar. Fishing of juveniles affects the wild fishery resources which need to be regulated through increases of net mesh size for sustainable conservation of marine resources in Coromandel coasts. The trash fishes that are not commercially important can be converted into value-added fish-meal products and marketed for the sustainable livelihood of fishers.

KEYWORDS: Bottom trawler, Coromandel coasts, Low-value trash, Juvenile fishes

Enhancing Local Community's Participation in Coastal Resource Management through Ecotourism Development in Northern Luzon, Philippines

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This research explores the potential of ecotourism as a tool for enhancing local community participation in coastal resource management in Northern Luzon, Philippines. The study examines the relationship of ecotourism development and the emancipation of local communities to engage in resource management along the coastal areas. The research looks into the socio-economic background and local governance mechanism in the study sites through household surveys and key informant interviews. The findings suggest that ecotourism, when properly integrated into local resource management strategies, can serve as a catalyst for both environmental conservation and socio-economic development. However, challenges such as inadequate infrastructure and limited capacity for sustainable tourism management need to be addressed to ensure long-term sustainability and equitable development in the coastal areas. This research highlights the importance of viable economic activity such as ecotourism in fostering a more inclusive and effective approach to coastal resource management in the Philippines.

KEYWORDS: Economic viability, Socio-economic, Sustainability

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Sardines Fishery in the Coastal Waters of San Vicente, Northern Samar

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The municipal waters of San Vicente, Northern Samar have an estimated area of 739.44 sq. km and are part of the Fisheries Management Area 8 where sardine is the common species among the regions composing the management area. The study aimed to identify the species composition of the sardines' fishery, the number of local and transient fishers, the current size structure and the estimated production. The study was conducted in the two islands, Tarnate and San Vicente from August 2022 to February 2023. The study used purposive sampling for intensive catch monitoring. Thirty boat owners were randomly chosen for the data on catch trends. Gill net was the current fishing gear used. Sixty-eight percent of the 419 recorded fishermen were transient. The actual number of fishers operating in the area is greater in number than the records from the treasurer's office. Two fish species were identified under the family Clupeidae in this study. The species caught through gillnet fishing are Sardinella lemuru and Amblygaster sirm. The dominant size (total length) of S. lemuru in the catch falls on the class interval of 14.3-15.0 cm and 15.2-16.0 cm. Amblygaster sirm had a total length of 18.0-20.4 cm and forked length of 16.0-18.0 cm. In San Vicente, larger size individuals of Sardinella lemuru were recorded, while 25.77% of the catch of the fishers in the island barangay of Tarnate, ranges from 14.4-15.0 cm which is smaller than those caught by fishers in the Poblacion. The larger individual was only 0.58% of the total cumulative catch. The majority (87.78%) of S. lemuru of the dominant size in the catch were sexually matured. The trend on the most abundant catch being recorded for the species S. lemuru fall under the class size of 14.3-15.1 cm and 15.2-16.0 cm for both fishing areas monitored. The actual total catch of the three fishermen monitored for four months was 11,106 kg with the highest catch in August. Based on the responses of the interviewed fishers, the estimated catch in 2022 per fisher is lower than the catch from five years ago.

KEYWORDS: Species composition, Size structure, Estimated catch

Recruitment Pattern and Exploitation Rate of Mangrove Crabs (*Scylla serrata*, Forskal, 1775) in the Coastal Waters of Northern Samar, Philippines

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Northern Samar is one of the major sources of mangrove crabs in the Philippines and collection of all sizes in the wild is rampant. This study determines the recruitment pattern and exploitation rate of mangrove crabs $Scylla\ serrata$ in the province. The data were analyzed using the ELEFAN routines of the software on FiSAT II. The results of this one-year study showed that the $S.\ serrata$ can grow more than 18.12 cm in carapace width (CW), with a fast growth rate (k) of 0.41 per year. The fishing mortality (F) contributed about 65% of the total. The recruitment pattern exhibited a bimodal distribution and the estimated exploitation rate was 65%, which exceeded the 50% optimum exploitation threshold; therefore, the current level of fishing mortality is unsustainable, putting the population's health and the sustainability of the resource at risk. The computed length at first capture (Lc_{50}) was 5.1 cm indicating that 50% of the crabs were caught at this size, and were fully recruited by the fishery at a size of 5.98 cm CW, while still at a juvenile stage. The use of push/scissor's net or 'sidsid' should be prohibited. The establishment of crab sanctuaries and the implementation of the closed season will help in the conservation of the wild population.

KEYWORDS: Growth, Mortality, Population parameters, Scylla serrata

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Morphological Plasticity in *Garra mullya* (Sykes, 1839): A Case Study from the Rivers of Maharashtra

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A total of 573 Garra specimens were collected from various rivers in Maharashtra which includes Ulhas, Tansa, Koyna, Patalganga, Kundalika, and Bhatsa. An integrated taxonomic approach was applied to identify all samples as belonging to a single species, Garra mullya (Sykes, 1839), which exhibited three distinct snout morphologies: G. mullya Type-R, characterized by numerous unicuspid tubercles, a transverse lobe, and a bilobed proboscis; G. mullya Type-MR, with fewer tubercles and a weakly developed proboscis; and G. mullya Type-S, featuring a smooth snout with no tubercles. All three types shared the common feature of a transverse groove. About 28 morphometric and 11 meristic characteristics were measured and analyzed to distinguish these morphotypes. Body proportions such as maxillary barbel length, head depth, head length, and pectoral fin length relative to standard length, were found to be key differentiating proportions, and was evident that body morphology is not completely different through Linear Discriminant Analysis, Also, Principal Component Analysis did not reveal clear distinctions among the types. Kruskal-Wallis test followed by post-hoc Dunn's test showed significant differences in certain meristic traits (lateral line scales, dorsal fin rays, pelvic fin rays, pectoral fin rays, transverse scale rows). Further efforts to differentiate the types included analyzing otoliths, scales, and X-ray images, along with DNA barcodes of mitochondrial COI gene also showed the plasticity. Intraspecific distances ranged from 0.0001 to 0.0205 between the types. A Maximum Likelihood tree based on genetic divergence clarified the phylogenetic relationships. Overall, the study highlights the morphological plasticity of G. mullya in the Western Ghats of Maharashtra.

KEYWORDS: Snout morphology, Unicuspid tubercles, Proboscis, Transverse groove

Feeding Guild Structure of Fish Community in the Middle Stretch of the Ulhas River, Maharashtra

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This study investigates the trophic guild structure of the fish community in the middle stretch of the Ulhas River, a vital ecosystem along the Western Ghats of India. The research focuses on the dietary patterns of 22 fish species from 12 families, based on the gut content analysis of 1,015 individuals sampled from two stations, Karjat and Neral, along the riverbank. Trophic levels (TrL) of the studied species ranged from 2.0 to 3.9, reflecting their respective positions within the river's food chain. The dietary analysis revealed 33 distinct food types, highlighting niche partitioning among the species. Most fish were mid-level carnivores, crucial for sustaining the ecosystem's energy flow and trophic equilibrium. Seven trophic guilds were identified using the SIMPROF test, and a cluster dendrogram was constructed based on their dietary components. The carnivore guild, with 7 species, was the most specious, followed by insectivores with 5 species, while five other guilds piscivore, detritivores, periphhyton feeder, omnivore and planktivore comprised two species each. Analysis of diet breadth (Bi) values, ranging from 0.25 to 0.92, showed that some species exhibited generalist feeding behaviors, whereas others were more specialized, reflecting the adaptability and resilience of the ecosystem. The vacuity index for most species was low to moderate. Bacillariophyceae (50%) was the dominant diet component for planktivorous fish, followed by Chlorophyceae (46.1%) and Cyanophyceae (15.3%). Diet overlap analysis revealed significant competition for food resources within and across guilds, especially among species with high dietary overlap. The findings offer valuable insights into the trophic structure and food web of the Ulhas River, emphasizing the importance of species and habitat conservation to ensure ecosystem stability. The study also calls for stringent conservation efforts to combat pollution and overfishing of juveniles, which threaten the river's ecological health and resilience.

KEYWORDS: Western Ghat, Trophic levels, Vacuity index, Diet overlap

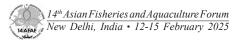
Comparative Study of Fuel Use, Environmental Burden and Global Warming Potential of Constructional and Operational Inventories in Mechanized and Small-Scale Fishing Systems Along Indian Coast Using Life Cycle Assessment Approach

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Fossil fuel, which generates large volumes of CO₂ and other greenhouse gases, is the main energy source for different fishing methods, including trawling, gillnetting, purse seining, longlining, etc. Using more than 40 billion litres of fossil fuel, the world's fishing fleet emitted 179 million tons of CO, equivalent and other greenhouse gases into the atmosphere (Parker et al., 2018). The emission due to fossil fuel consumption in Indian marine fisheries contributes less than 1%, however, it plays a significant role in environmental deterioration. Systematic evaluation of a product, process, service and its environmental components at each stage of its life can be assessed by a tool known as life cycle assessment. The present study was conducted from ten different harbors and landing centers covering seven Indian coastal states. The detailed data of representative sample was generated on constructional and operational inventories of fishing systems from net makers, boat builders, fishermen, boat operators, and crew on-board fishing vessels. The personal interview was adopted with the help of pre-tested questionnaires and templates. Three major mechanized fishing systems viz. trawl, purse seine and longline-cum-gillnet fishing systems along with small-scale fishing systems were considered in the present study. The different length classes of smallscale fishing vessels, made of wood and FRP were analyzed by the life cycle assessment tool using SimaPro software, followed by a comparison between them. The findings of the study revealed that the specific consumption of fossil fuel and potential to contribute towards global warming, per kilogram of live fish landed was maximum for trawlers followed by purse seiners and longliner-cum-gillnetters. In the case of small-scale fishing systems, wooden vessels had less environmental impact than fishing vessels made of FRP. However, in the long run, the result was reversed. Hotspot analysis of constructional inventories indicated that epoxy resin contributed maximum to global warming potential among other inputs in small-scale fishing vessels. However, for fishing operations, fuel was the primary operational input that contributed maximum to the global warming potential and the ensuing environmental effects in both mechanized and small-scale sectors. The detailed inventory analysis of different hotspots in each fishing system will be discussed in the paper.

KEYWORDS: Life Cycle Assessment, Environmental burden, Global warming, Mechanized fishing, Small-scale fishing



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Evaluating Ecosystem Stability of Gayatri Reservoir in Karnataka, India Using a Steady State Trophic Model for Culture-Based Fisheries

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The trophic models play a decisive role in determining the interactions in an ecosystem and are useful in many ecological studies. The trophic models act as a tool to quantify the ecological interactions in the ecosystem and the extent of impact by various processes or stressors. A steady state trophic model of the Gayatri reservoir ecosystem was constructed and parametrized using Ecopath with Ecosim software. Gayatri reservoir (N 13º 47' 47.06" E 76° 48' 05.08") constructed across River Suvarnamukhi in Chitradurga District of Karnataka has a water spread area of 784 ha at Full Reservoir Level. The present fish yield ranged from 78 to 158 kg/ha/yr which is much lesser than the production potential of 800 kg/ha/yr. However, there is scope to enhance the production through culture-based fisheries (CBF). CBF is an effective way to increase fish production and also provide additional income to fishers. The model consisted of 14 functional groups based on the information that was mainly collected from the field sampling. The aquatic birds, herons and cormorants classified as top predators were found to feed on murrels, gobids, Indian major carps, Nile tilapia, cichlids and catfishes. Macrophytes and phytoplankton are the major groups at the lower trophic level. The reservoir has a detritus-based food chain, where almost all the biomass is concentrated in the first two trophic levels (the producers level and the herbivore/detritivore level), with rather low transfer efficiencies. A number of indices that describe an ecosystem as a whole in the Ecopath model were used to assess the status of the ecosystem in terms of stability. Finns Cycling Index was estimated at 1.99 % of the total system throughput. The ecological stability indices, such as total primary productivity to total respiration (6.12), total primary production/ total biomass (28.42) and total biomass/total system throughput (0.02) and net system production (2328.74 t/km²/yr) indicated that the Gayatri reservoir ecosystem is in the developmental phase.

KEYWORDS: Reservoir ecosystem, Trophic levels, Transfer efficiency, Finns cycling index

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Stock Structure Analysis and Reproductive Biology of *Rita rita* (Hamilton, 1822) Along the Middle Stretch of Brahmaputra River System Using Truss Network Analysis

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Rita rita, a freshwater bagrid catfish popularly known as 'Rita' is a commercially important food fish all along the Brahmaputra basin and its tributaries. A truss network was constructed by interconnecting 14 landmarks to form a total of 30 truss measurements, based on 300 samples collected from three populations representing the Brahmaputra River, Jamuna River and Kopili River. The factor analysis (FA) of the truss network that body depth-related traits were heavily loaded on the first factor, while shape-related traits of the caudal portion were associated with the second factor. The first principal component (PC1) explained 82.14% of the total variation, whereas PC2 accounted for 3.56%. Discriminant function analysis classified 74% of the original groups correctly, with 26% misclassified, suggesting the possible existence of two stocks of *Rita rita*: a single stock in the Brahmaputra River, while the Jamuna and Kopili Rivers contain the same stock. In the present study, data on reproductive biology containing sex ratio, condition factor, fecundity, hepatosomatic index and Gonado-somatic index (GSI) of Rita rita were assessed. Samples were collected from the landing centres located on the bank of river Brahmaputra at Tezpur, river Jamuna at Jamunamukh and River Kopili at Dharamtul from August 2022 to July 2023. An overall sex ratio (M/F) of 1:2.70 observed was statistically non-significant. The gonadosomatic index ranged from 0.22-3.81 in males and 0.65-11.45 in females, both showing peaks in the month of July. The hepatosomatic index (HSI) varied from 0.88-1.35 in males, 1.34-2.14 in females and 1.09-1.59 for the pooled sample; the value of the HSI index gradually decreased with the increase of GSI in both males and females. The fish was highly fecund and the fecundity ranged from 10445.88 to 26262.52 with an average of 16,865.89. The fecundity was found to increase with the increase of total length, body weight and ovary weight and the relationship was linear and significant among them. However, the relative condition factor >1 suggested the species to be in good condition throughout the year in both the males and females.

KEYWORDS: Stock structure, Truss morphometrics, Reproductive biology, Rita rita

Status of Ichthyofaunal Diversity and Seasonal Physico-Chemical Variations of Charipunia Beel of Morigaon District, Assam

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The present study was conducted to evaluate the ichthyofaunal diversity and habitat ecology of Charipunia beel (7.0 ha), Morigaon district of Assam, for a period of one year from May 2022 to April 2023. A total of 26 fish species belonging to 18 genera, 11 families and 4 orders were recorded from the beel. The order Cypriniformes comprised 1 family (9.09%), 7 genera (38.89%) and 10 species (38.47%). Five families (45.45%), 5 genera (27.77%) and 7 species (26.92%) made up the order Perciformes. With 2 families (18.19%), 3 genera (16.67%) and 6 species (23.08%), the order Siluriformes contributed a significant portion to the total number and percentage composition of the beel, followed by Clupeiformes with 3 families (27.27%), 3 genera (16.67%) and 3 species (11.53%). Fisheries of Charipunia beel was mainly dominated by Amblypharyngodon mola, Puntius sophore, Mystus tengara, Mystus vittatus, Cirrhinus mrigala, Labeo rohita and other miscellaneous species. As per IUCN Conservation status (2023), the highest species were recorded under Least Concern (LC) category with a total number of 20 and a contribution of 58.80%, majority of the species belonged to the family *Cyprinidae* with 8 (23.52%) followed by *Bagridae* with 4 (12.48%), Channidae with 3 (8.82%) and Clupeidae, Heteropneustidae, Ambassidae, Gobiidae, Nandidae with 1 species contributing 2.94%. Under the Near Threatened (NT) category, Siluridae contributed 2 (6.24%) and Cyprinidae with 1 (2.94%) species, respectively. Under the Data Deficient (DD) category, only *Anabantidae* contributed 1 species (2.94%). Under the vulnerable (VU) category, *Bagridae* contributed 2 (6.24%) species and *Cyprinidae*, Heteropneustidae, Claridae, Channidae and Anabantidae each contributed 1 species (2.94%). Margalef's Richness Index (d), Pielou's Evenness Index (J), Shannon-Weiner Index (H') and Simpson Index $(1-\lambda)$ indicated high fish diversity in the beel, with a more or less even distribution of fish genera indicating that the beel was in good condition for fish production. During the study period, a total of 26 genera of phytoplankton and 11 genera of zooplankton were recorded in the beel. Chlorophyceae was found to be dominated among the phytoplankton and rotifera were dominated among the zooplankton group. The majority of physico-chemical parameters were found to be in a favourable range for aquatic species growth and reproduction. Although the condition of the beel was found to be favourable for fish production, there is an urgent need for strict imposition and monitoring of fisheries regulations during the banned season.

KEYWORDS: Ichthyofauna, Physico-chemical variations, Beel



Composition of Fish Catch by Fisheries Co-operative Society Dari Bhari, Gobind Sagar Reservoir, Himachal Pradesh, India

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Gobind Sagar Reservoir was created by damming River Sutlei at the village Bhakra in 1963. Fishermen working in this reservoir have been organized in the form of fisheries cooperative societies. Fisheries co-operative society Dari Bhari is one of these fisheries cooperative societies. Catch composition data of fishes by fisheries co-operative society Dari Bhari during the years 2014, 2015 and 2016 was compiled and analyzed. The state fisheries department of the Himachal Pradesh Govt. has maintained the fisheries data. Fishing activities have been performed by licensed fishermen in the presence of officials of the state fisheries department. Conservation measures were also adopted. Among the exotic carps Hypophthalmichthys molitrix, Ctenopharyngodon idella and Cyprinus carpio are dominating in this reservoir. Indigenous fishes are Catla catla, Labeo rohita, Labeo calbasu, Sperata seenghala, Cirrhinus mrigala, and Tor putitora. In the area of the reservoir where fisheries co-operative Dari Bhari performed its fishing activities, seasonal fluctuations in the water level were observed. During the monsoon season, lentic water conditions were observed, and during the summer season, lotic water conditions were found. No fishing was done for two months during monsoon season, due to conservation reasons. Seed stocking was done from time to time by the state fisheries department. Gillnets having dimensions, 80 meters x 5 meters were applied during the afternoon hours and the caught fish was retrieved the next day morning. Only those fish that have attained minimum harvestable size were caught. Fish caught by Dari Bhari co-operative ranged from 447.5 kg to 545 kg during the April and May months of the year 2014. In the same year, the catch during August remained 7276.5 kg. This monthly catch was maximum during the year 2014. During winter months only 857.5 kg of fish catch was recorded in November, in the year 2014. An increase in fish catch to 2086.5 kg in March month during the summer of year 2015 was recorded. Fisheries management was done scientifically.

KEYWORDS: Gillnets, Fishermen, Seed stocking, Conservation

Enhancing Seaweed Monitoring Along the North-West Coast of India Using Remote Sensing Indices: A Preliminary Image Processing-Based Approach

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Seaweeds play a vital role in marine ecosystems, providing critical services such as habitat for marine life, nutrient cycling, and carbon sequestration. They are also increasingly valued for their economic contributions to industries like food, pharmaceuticals, and biofuels. However, accurate mapping and monitoring of seaweed distribution remains a challenge due to their complex and dynamic nature. Enhanced monitoring techniques are essential for sustainable management and conservation efforts, particularly in regions with significant seaweed diversity. This study focuses on improving the accuracy of seaweed monitoring along the North-West coast of India by standardizing three remote sensing indices: the Normalized Difference Vegetation Index (NDVI), Floating Algae Index (FAI), and the Seaweed Enhancing Index (SEI). Using high-resolution Landsat-8 satellite imagery from 2018 to 2022, we assessed seaweed distribution across three key sites: Veraval, Kelwa, and Porbandar. To validate the effectiveness of these indices, ground-truth surveys were conducted across 1,197 grid cells (100 m x 100 m) during low-tide conditions, allowing for accurate visual assessment and density mapping of seaweed habitats. The results showed strong correlations between the remote sensing data and field observations, with the SEI demonstrating the highest accuracy in identifying seaweed, particularly in submerged or sparsely vegetated areas. Veraval recorded the highest seaweed density, followed by Kelwa and Porbandar. Our findings highlight the SEI as a particularly effective tool for seaweed mapping, outperforming NDVI and FAI in specific scenarios. By integrating remote sensing with ground-truth validation, this study presents a robust methodology for enhancing the precision of seaweed monitoring, which is critical for sustainable marine resource management.

Keywords: Seaweed monitoring, Remote sensing, Satellite imagery, Seaweed indices



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Assessment of Different Maturity Stages Through Gonadal Histology and Biochemical Constituents in Goldlined Seabream, *Rhabdosargus sarba*

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The goldlined seabream *Rhabdosargus sarba* is a brackish water candidate species known for its adaptability to varying salinity, high market value, and rapid growth in controlled environments. This study examines the biochemical composition of tissues and histological changes across maturity stages in R. sarba. The study reveals significant shifts during reproductive development. The high lipid content in immature male tissue (9.10%) and liver (17.09%) supports growth, while maturing females exhibit even higher lipid levels (30.72%) to facilitate vitellogenesis. Lipid levels lowered in immature male gonads (1.09%) and spent female gonads (2.03%). Protein peaked in maturing males (18.90%), with gonadal protein being highest in the matured stage (17.50%). Female liver protein peaked at maturation (12.77%) to support metabolic activity. Gonadal protein reached the maximum in the matured stage (17.96%), while protein was reduced in the spent stages. Carbohydrates peaked in the spent stage (19.04%) of the male liver as energy reserves, while gonadal carbohydrates peaked during maturation (18.43%) for gametogenesis. Histological analysis in females showed that the perinucleolar stage (102±2 µm) occurs in early maturity (February-August) in fish (164±38 g). The yolk vesicle stage (163±5 μm) appears in September-October in fish weighing 1019±153 g, while primary (347±32 μm), secondary (390±14 μm), and tertiary yolk sac stages (477±13 μm) occur in November-December, followed by the spent stage with atretic oocytes (122±3 um) in January. In males (120±32 g), the immature stage is seen from January to March. Early development (spermatocytes) occurs from April to September (245±64 g), with late development (spermatocytes and spermatids) observed in October (450±120 g). Mature and ripe stages (mature spermatozoa) are found from November to January (582±44 g), followed by the spent stage in January. This study provides crucial insights into the biochemical and histological changes associated with maturation and reproduction in R. sarba, highlighting the species' distinct nutrient allocation patterns during different maturity stages.

KEYWORDS: Proximate analysis, Biochemical analysis, Broodstock, Reproductive development

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Brackishwater Seaweed Farming Site Selection in Thiruvallur District Coastal Sub-Watershed Using MCDM Method for Coastal Farmers' Livelihood Development

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Seaweed farming, recognized as a promising avenue for sustainable development and coastal community empowerment, hinges on the selection of optimal cultivation sites. This study introduces a refined model for site selection specifically tailored to brackishwater ecosystems. The model integrates multi-criteria decision-making techniques and the fuzzy Analytic Hierarchy Process (FAHP), allowing for the nuanced evaluation of diverse factors critical to the success of seaweed cultivation. This methodology was applied to the coastal sub-watershed of Thiruvallur district, India, encompassing 19 sub-watersheds. This region has significant brackishwater aquaculture potential. The factors considered in the model are water quality, environmental factors, accessibility and existing constraints. Geographic Information System (GIS) and Remote Sensing (RS) technology were leveraged to create detailed spatial maps, culminating in a comprehensive suitability map for seaweed farming. The total area encompassed by river/brackishwater within the study area is about 37,242 ha. The result indicates that 2,040.29 ha were classified as highly suitable, while an additional 277 ha were deemed moderately suitable. This robust model offers invaluable decision support for policymakers, aquaculture planners and coastal communities, promoting sustainable seaweed farming practices. By identifying prime cultivation locations, the model can contribute to economic growth, livelihood diversification and environmental conservation in coastal regions.

KEYWORDS: FAHP, Seaweed cultivation, Sustainable development, Remote sensing

Diving Fisheries in West Central Philippines: Species Composition, Seasonal Patterns and Economic Value

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This study investigated the diving fisheries along the northeast coast of Panay Island, west central Philippines, focusing on catch composition, fishing effort, and seasonal variations. Fishers in the area use diving to collect mollusks from deeper waters (3-10 m) that are inaccessible by gleaning. Data from compressor diving (hookah) were collected daily from the Gigantes group of islands and Concepcion Bay from June 2018 to May 2020. Meanwhile, daily records from freediving (locally known as "mano-mano") were collected from the adjacent waters of Ajuy Bay from February 2021 to March 2022. Diving activities in all areas typically lasted 3 to 6 hours per day, with a fishing effort of 11-31 days per month, depending on sea and weather conditions. Compressor diving in the Gigantes Islands was dominated by the spiny oyster Spondylus variegatus and the scallops Mimachlamys sanguinea and Bractechlamys vexillum, accounting for over 50% of the catch. In Concepcion Bay, the comb pen shell Atrina pectinata comprised 86% of the catch. Freediving in Ajuy Bay primarily yielded the common razor clam *Pinna bicolor*, magnificent venus clam *Antigona magnifica*, brown mussel Modiolus modulaides, and saddle oyster Placuna ephippium, making up more than 60% of the total catch. Monthly catch patterns were similar across sites, with higher yields during the NE monsoon (November–March) and lower catches in July and August, likely due to the SW monsoon disrupting diving. Annual compressor diving catch in the Gigantes Islands ranged from 2,015 to 7,230 tonnes, valued at Php 60-220 million, with 90-120 divers. In Concepcion Bay, 25 divers yielded 190-315 tonnes annually, worth Php 5.4-9.5 million. Freediving catch in Ajuy Bay was smaller, ranging from 4.5 to 59.6 tonnes, valued from Php 0.3-4.5 million, with 5-18 divers. This study emphasizes the economic significance of the diving fishery in west central Philippines and the need for sustainable management to protect both the fishery and local livelihoods. Further research on the biology of the species caught is essential to address sustainability concerns and preserve mollusk diversity in these coastal areas.

KEYWORDS: Molluscs, Catch, Fishing effort, Annual value

Fishery, Morphometrics, Length-Weight Relationships and Size at Maturity in *Charybdis* (*Charybdis*) *lucifer* (Fabricius, 1798) from Southeastern Arabian Sea

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Portunid crab Charybdis (Charybdis) lucifer (Fabricius, 1798) commonly known as 'Yellow Brown Crab' is distributed along both coasts of India and forms a minor fishery in Kerala. During 2007-2023 around 1817 tonnes of the species were recorded from Kerala, constituting 3% of the total crab landings in the state. The landings fluctuated during the period and showed an increasing trend in recent years. The bulk of the landings are contributed by trawlers (Single day-58%; Multiday-19%) and outboard trawls (20%), and fishery comprising of 33-98 mm carapace width (CW) crabs. In males, 61-65 mm CW and in females, 56-60 mm CW size crabs dominated the landings. In some coastal areas, the species is considered a non-conventional resource, however, in Kerala, it is consumed and fetches around Rs.50/kg. Knowledge of the body weight-length/width relationships and interrelationships of various morphometric parameters in populations is important for estimating the population size of a stock and its exploitation. Hence, the carapace width/length-weight of the species was estimated (1031 male and 701 female crabs) and the 'b' values for carapace width-weight in males (38-98 mm/CW), females (33-88 mm/CW), and pooled were 3.037, 2.847, and 3.043 respectively. The 'b' values for carapace length-weight in males (24-61 mm/CL), females (17-51 mm/ CL), and pooled were 3.028, 2.748, and 2.992 respectively. The results show an isometric growth pattern for males and pooled whereas, females showed considerable deviation from isometric growth in both cases. An analysis of covariance indicates a significant difference between sexes ($p \le 0.01$) concerning the carapace width/length-weight relationship. Similarly, morphometric relationships between various characters, viz., carapace width (CW)/ length (CL) and chelar propodus length (CPL) and height (CPH) in males, as well as carapace width/length and abdominal width (AW) and length (AL) in females were estimated. The allometric relationships between the characters of this set suggest that most relationships are positive and highly significant (p≤0.01). Size at maturity (LM50) in females was estimated at 44.7 mm CW, and all females were mature above 66 mm CW, and mature females below 40 mm CW were not recorded in the landed crabs.

KEYWORDS: Charybdis (Charybdis) lucifer, Length-weight relationships, Morphometry, Size at maturity, Arabian Sea



Revolutionizing Marine Fisheries Data Access: An AI-Powered Natural Language Interface

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This paper introduces an innovative application designed to revolutionize data access within the marine fisheries scientific community by utilizing an AI-powered natural language interface. Leveraging the capabilities of the Generative AI Model Gemini Pro, the application allows users to retrieve marine fisheries landing data from the National Marine Fishery Data Centre through simple natural language queries, eliminating the need for technical expertise in SQL. Developed using Python, Django, and Streamlit, the platform offers a user-friendly interface where researchers can input queries in plain languages, such as English or Hindi. The AI model interprets these queries, translates them into the necessary SQL commands, and retrieves the relevant data, which is presented in a clear, analyzable format. This approach democratizes access to fisheries data, removing technical barriers and making data exploration more accessible to a broader audience. By enhancing the ease of data retrieval and interpretation, the application has the potential to significantly boost research productivity, facilitate collaboration, and support evidence-based decision-making in marine fisheries science.

KEYWORDS: AI-powered interface, Marine fisheries, Natural language processing, SQL automation

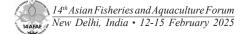
On an Approach to Moderate, Augment and Synthesise Estimates of Commercial Fish Production from Multiple Sources

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The survey of commercially landed fishery resources needs a highly nuanced approach, both at the survey design level as well as execution level. The FAO acknowledged Multistage Stratified Random Sampling Design has always been evocative of these two critical components of estimating marine fish landing dynamics, by assuming gear-based categorisations as the bases for defining populations. CMFRI methodology has stood the test of time since its inception. Though the Alagaraja method (1984) thankfully handled the second-stage unit selection in terms of ease at the field, it has certain diachronic deficiencyrelated issues which need immediate attention when it concerns the first-stage units. Also, the type of complexities that arise out of considering gear-wise population is palpable. To address these challenges effectively a hybrid approach towards the entire process will be the most appropriate course to be charted. This work attempts to develop strategies to possible synthetic/combined approaches in the estimation of commercial marine fisheries landings. The main challenge faced in the formulation of synthetic estimators has been that of incongruence triggered in-consistence. Insights onto combating such heterogeneity of estimated figures always indicate two things, viz., the one relevant to spatio-temporal granularity and the other based on enumerator bias. This study has taken two cases wherein the same spatio-temporal frame has been sampled over a period of one year each. One pertains to Tamil Nadu landings 2018-19 and the other relates to Maharashtra 2023-24. In both these cases enumerator-wise, landing centre-wise, and gear-wise resource comparisons were made. It was found that significant influence was triggered by a couple of field-level factors, which were attributable to the number of units of a particular gear craft combination seen in action in a session and the quantity of unit-wise resource-wise landings, unusually. This is being recorded as unusual because the most predominant differentiating factor between the enumerators is commonly perceived to be species/resource identification. One of the possible solutions to counter this incongruence is to have informed trend-based plugin moderators. Such moderators could be either weights or functionals of recorded data. This attempt to study the extent of what's incognizant has its focus on detection rather than moderation. Both these studies have highlighted the major leads to follow while dealing with such mismatches at varying granularities. Evolved into a full-fledged algorithm, this approach can show the way to integrate comparable estimates related to a spaciotemporal agglomeration more effectively. This has immense potential in making data reconciliation assignments easier and more objective. With multiple agencies vying for acceptability for their estimates/statistics a moderator-based synthesis of marine fish production figures will be the best way forward.

KEYWORDS: Multistage Stratified Random Sampling, Diachronic deficiency, Plugin moderators, Granularity, Reconciliation of aggregated data



Fish Community Structure in Accordance with Environmental Signatures in Tropical River Ecosystem, Eastern Himalayan Eco-Region

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Environmental characteristics can influence the distribution of fish communities in aquatic habitats. The study of fish communities in Dhansiri River aimed to reveal the relation between fish community structure and environmental characteristics. Sampling was carried out across three seasons (pre-monsoon, monsoon, and post-monsoon) in four stations, representative of the whole river stretch flowing through Nagaland. The highest number of species was recorded along the upper stretch S1 (54), followed by S2 (45), S3 (41 species), and the least in S4 (37). Seasonal analysis showed that the highest number of species was recorded during monsoon (64), followed by post-monsoon (59) and pre-monsoon (54). Shannon index (H') ranged from 3.327 to 3.750, with higher values along the upper stretch with a gradual decline downstream. Diversity was found to be lower in S4, which may be due to poor environmental parameters and high anthropogenic pressure. Relative abundance of fish families was found to range from 0-5.63% with cyprinids being the most abundant. Nonmetric dimensional scaling reflected that S4 samples were distinctively separated as compared to S1, S2, and S3. Analysis of water quality parameters revealed a pristine nature in S1 and gradual deterioration downstream. A significant relationship was observed for most water quality variables. PCA showed that pH (20.96%), total alkalinity (13.80%), specific conductivity (9.92%), NO₃ (12.19%), and TDS (6.22%) contributed significantly to the observed variation in Dim1 and NO₃ (53.43%) and water temperature (6.05%) to Dim2. BIO-ENV module reflected that variables such as NH, NO, CO, TDS, total alkalinity, pH, specific conductivity, DO and water temperature were significantly correlated with fish abundance and composition. The present study provides insights into the role of the environment in fish community structure in an important and less-explored tropical Himalayan river and can help in the sustainable management of riverine fish diversity.

KEYWORDS: Fish assemblage, Ecology, Spatio-temporal fish diversity, Himalayan river, Sustainable fisheries

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Studies on Gut Content Analysis of Spineless Cuttlefish, Sepiella inermis (Van Hasselt, 1835) in Mangaluru, Southwest Coast of India

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In this study, we investigated the dietary habits of the spineless cuttlefish (*Sepiella inermis*), a commercially important cephalopod species distributed along the southwest coast of India. The stomach contents of 624 specimens, comprising 305 females and 319 males, were analysed from May 2023 to April 2024 using detailed anatomical techniques. The size of the cuttlefish specimens examined ranged from 2.87 to 10.06 cm in Dorsal mantle length (DML). The fullness index (FUI) indicated varying degrees of stomach fullness among the individuals sampled. The empty stomachs were recorded in 74.98%, ¼ fullness in 13.36%, ½ fullness in 3.37%, ¾ fullness in 3.50% and fullness in 4.78%. The occurrence index (OI), revealed that the spineless cuttlefish primarily feeds on crustaceans, constituting 38.26%, followed by fishes (10.45%) and cephalopods (3.84%). A considerable part of the stomach content comprised of digested matter, 47.45%. Fullness weight index (FWI) was 11.32% and 26.7% for males and females, respectively. Our results unveiled that the spineless cuttlefish predominantly preys on crustaceans. This study provides valuable insights into the foraging behaviour and ecological significance of the spineless cuttlefish, contributing to a comprehensive understanding of their role in marine ecosystems.

KEYWORDS: Sepiella inermis, Dorsal mantle length, Fullness index and Fullness weight index

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Emerging Importance of Leatherjackets, Triggers and Surgeon Fish in the Fishery Along North Tamil Nadu Coast

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Until recently, fishes like leatherjackets, triggerfishes, and surgeonfishes had the least importance in the fishery along the north Tamil Nadu coast. These fishes in general are called "Seruppumeen" in Tamil due to their highly compressed body, rough and thick sandpaperlike skin, and human footwear-like appearance. But from 2023 onwards, we observed a significant change in the scenario. During August-September 2023, an unusually heavy landing of Aluteros monoceros (unicorn leatherjacket) was observed in the Kasimedu landing centre. On an average, each trawler brought 4-5 tonnes of leatherjacket every day which amounted to a total of 150 to 180 tonnes per day. The fishes were exported and about one lakh tonnes were obtained from 700 trawlers fetching an export value of Rs. 30 crores. With a sudden rise in export demand, the locals also have started buying this fish @ Rs. 250 to 280 per kg. During July 2024, triggerfishes viz., Odunus niger (red-toothed triggerfish) and Sufflamen fraenatum (masked triggerfish) were observed in considerable quantities in the landings at Kasimedu. These fishes now command local demand and are priced at Rs. 100 to 150 per kg. From the middle of August 2024 to the first week of September 2024, fishermen at Kasimedu caught around 300 tonnes of Naso reticulates (reticulate unicornfish). These fishes are now marketed locally @ Rs. 230 to 250 per kg. The emerging importance of these resources indicates a possible wave of change in the future which can help ease the pressure on the more common food fishes that currently sustain the fisheries along the north Tamil Nadu coast.

KEYWORDS: Leatherjacket, Triggerfish, Unicornfish, Export value, Delicacy

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Biometric Characterization and Stock Status of *Pila globosa* from Kanwar Lake – A Ramsar Site in Bihar, India

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This study, conducted at Kanwar Lake from September 2022 to August 2023, aimed to assess the biometric characteristics and stock status of the freshwater snail species *Pila globosa*, a key molluscan species in the region. The biometric measurements of *Pila globosa* specimens from Kanwar Lake revealed the mean values for shell length (SL) of 440.35±3.68 mm, shell width (SW) of 58.72±31.94 mm, spire length (SPL) of 15.80±3.98 mm, base length (BL) of 37.27±7.32 mm, aperture length (AL) of 30.88±5.45 mm, aperture width (AW) of 23.62±5.67 mm, and shell weight (WT) of 52.62±41.35 g. Mortality analysis revealed a natural mortality (M) rate of 0.92 per year, fishing mortality (F) of 0.66 per year, total mortality (Z) of 1.58 per year, and an exploitation level (E) of 0.42 per year. The relatively low exploitation level indicates that the *Pila globosa* population in Kanwar Lake is not currently overexploited, suggesting a sustainable population under the present fishing pressure. This study provides crucial baseline data on the growth patterns, mortality rates, and exploitation levels of *Pila globosa* in Kanwar Lake. These findings are essential for effective resource management and conservation strategies, particularly for species in ecologically significant areas like Ramsar sites.

KEYWORDS: Pila globosa, Kanwar Lake, Exploitation level, Stock status, Conservation

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Morphology of Statoliths in Cephalopods (Mollusca) from the Indian Waters as a Tool for Species Identification

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Cephalopods play an important role in marine food webs, particularly serving as prey for top marine predators like sharks and dolphins. While their soft tissues are rapidly digested inside the stomachs of predators, their hard parts, such as statoliths, chitinized beaks, and arm suckers, will typically remain as evidence of their consumption. The morphological characteristics of these hard parts are species-specific allowing taxonomic identification of the cephalopod prey from the stomach contents of their predators. However, there are no species-specific keys for species-level taxonomic identification of the cephalopod hard parts. including the statoliths. To address this gap, this study investigates the statolith structure of all three taxa of cephalopods, namely squid, cuttlefish, and octopus. Cephalopod statoliths are paired calcareous structures associated with sensory epithelia, which are involved in the detection of linear and angular acceleration. Adult individuals of 30 species of cephalopods (20 species of squids, 5 species of octopus, and 5 species of cuttlefish) were examined for their statolith. The sampled individuals were collected from trawls operated in the southeastern Arabian Sea. The cephalopod specimens were measured, weighed and the statolith pair was extracted and measured, according to standard protocol. The allometric growth of the statolith when fitted against the dorsal mantle length of the cephalopods showed negative relationships. Results showed differences in statolith shape among squids, cuttlefishes, and octopus groups and among species. The analysis of the morphology and size of the statolith enabled the successful identification of the cephalopod genus and species. This can be used as an input for the automated identification of statolith images and offers a novel approach for identifying and quantifying predator-prey interactions in marine ecosystems.

KEYWORDS: Cephalopoda, Statolith, Arabian Sea, Squid, Cuttlefish, Octopus

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Diet Composition of Pharaoh Cuttlefish *Acanthosepion pharaonis* (Cephalopoda: Sepiidae) Along the Eastern Arabian Sea

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Pharaoh cuttlefish, Acantosepion pharaonis (Sepia pharaonis) (Ehrenberg, 1831) is a commercially important species, which contributes more than half to the cuttlefish production in India. It is widely distributed in the Indo-Pacific region in shallow waters to a depth of 100 m. Besides its importance in regional fishery, this species holds potential as a candidate species in aquaculture, where efforts are directed to develop a commercial farming protocol, over the last few years, which requires an understanding of the species biology including the diet preferences. Random samples of A. pharaonis were collected from commercial trawls operated along the Karnataka coast, eastern Arabian Sea. The dorsal mantle length (DML mm), body weight (g), sex, maturity stage and stomach fullness were recorded, and the gut was dissected and preserved in 10% formaldehyde for further analysis. The diet components were estimated using a frequency of occurrence and proportion in stomach contents. A total of 584 stomachs of A. pharaonis (339 females and 245 males) ranging in DML from 55 to 385 mm, were examined for food and feeding habits. 48 (8.2%) of the stomachs were empty while 536 (91.8) contained food items. The degree of stomach fullness varied, with the majority (54.1%) of were only moderately full with a fullness score of 1-2, 26.2% had a fullness score of 3, and 11.5% had a fullness score of 4-5. Analysis of diet composition showed that the species is carnivorous and preys on teleosts, crustaceans, and cephalopods. Crustaceans were dominant in the smaller individuals (<100 mm DML), while larger individuals (> 100 DML) consumed a more diverse diet including crustaceans, teleost, and cephalopods. The major food items were fish and crustaceans. Seasonal variations were also observed, with crustaceans dominating the pre-monsoon period and teleost and cephalopods dominating the post-monsoon period. Cannibalism was observed during the post-monsoon months. These findings contribute to our understanding of the feeding ecology of A. pharaonis.

KEYWORDS: Pharaoh cuttlefish, Food and feeding, Karnataka

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Unveiling the Life History Traits and Feeding Habits of the Bottlenose Guitarfish, *Rhynchobatus australiae* Whitley, 1939 in the Arabian Sea

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This study investigates the reproductive biology of Rhynchobatus australiae, a benthic coastal inshore batoid species, in Indian waters, where life history data is limited. A total of 230 specimens, collected as by catch from shrimp trawls and gillnets operating up to 100 m depth off Karnataka, southwest coast of India between 2016 and 2022, were analyzed. Specimens ranged from 50.6 to 283.0 cm total length (TL) and 0.4 to 230 kg total weight (TW). The length-weight relationship for combined sexes was W = $0.002613 \text{ TL}^{3.2312}$ (r² = 0.972). For females, the coefficients 'a' and 'b' were 0.001343 and 3.405986 ($r^2 = 0.981$), and for males, 0.004606 and 3.081451 ($r^2 = 0.990$), respectively. Length-at-maturity ($Lm_{50\%}$) was estimated at 175 cm TL for females and 130 cm TL for males. Rhynchobatus australiae has two functional ovaries, with simultaneous ovarian and gestation cycles. Pregnant females were found year-round, indicating a non-seasonal reproductive cycle. Litter sizes ranged from 2 to 11 pups, with birth sizes between 45.0 and 50.0 cm TL. Breeding peaks occurred in October–December and February–May, with the highest abundance in post-monsoon. Stomach content analysis showed a diverse diet, with teleosts comprising 73.3% by the index of relative importance (IRI), crustaceans 23.4%, and cephalopods 3.3%. Depth-wise landing patterns were mapped to aid spatial marine planning. This study provides critical baseline data for the fisheries management and conservation of the bottlenose wedgefish in the eastern Arabian Sea.

KEYWORDS: Rhynchobatus australiae, Diet, Length at maturity, Northern Indian Ocean

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Assessment of Fish Length Variations and Mean Size Changes in *Bregmaceros mcclellandi* (Unicorn Cod) in Stationary Bagnet Catches Along the Northwest Coast of India

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This study examines the variation in fish length across six locations, three in Maharashtra (Alibaug, Arnala, and Madh) and three in Gujarat (Rajpara, Jafrabad, and Navabandar), to understand the regional differences in fish sizes captured in bagnet fisheries. Fish length data were collected at each location and analyzed to assess the variability in length between the locations. The mean fish lengths varied significantly across the locations, with Rajpara in Gujarat exhibiting the highest mean length of 73.5 mm (SD=1.70), while Alibaug in Maharashtra had the lowest mean length of 36.9 mm (SD=2.77). A one-way ANOVA confirmed that the differences in fish length across locations were statistically significant (F=1616, p<0.001). Post-hoc Tukey tests further identified significant pairwise differences in fish lengths between most locations. Notably, Rajpara had significantly larger fish compared to all other locations (p<0.001). Conversely, locations such as Alibaug and Navabandar recorded the smallest fish sizes, with a mean difference of 31.29 mm between Rajpara and Navabandar. These findings suggest strong regional variations in fish size, likely influenced by local environmental conditions and fishing practices. The study provides valuable insights for fisheries management, emphasizing the need for location-specific strategies to ensure sustainable fish stocks in these regions.

KEYWORDS: Fish length, Stationary bagnet, Gujarat, Maharashtra

Exploring Micro-Phytoplankton Diversity and Size Composition: Linking Phytoplankton Ecology to Fish Abundance in the Coastal Waters of Gujarat

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Gujarat is India's leading maritime state for seafood production, primarily from capture fisheries. The coastal waters of Gujarat exhibit unique ecological characteristics, particularly winter convective mixing, which enhances productivity and extends into the post-monsoon period. Phytoplankton composition plays a critical role in biogeochemical processes and significantly impacts marine fishery resources. This study examines the diversity, abundance, and size composition of phytoplankton, specifically diatoms and dinoflagellates in the coastal waters of Gujarat. Key physicochemical parameters, including temperature, pH, dissolved oxygen, salinity, and nitrates, were analyzed to assess their influence on phytoplankton abundance. Results indicate that diatoms accounted for nearly 90% of micro-phytoplankton abundance at depths of less than 50 meters, with *Chaetoceros* and *Coscinodiscus* being the most dominant species. Dinoflagellates were primarily represented by *Ceratium* and *Dinophysis*. The study found that the 30-meter depth exhibited the highest chlorophyll-a content and diatom density, while the 20-meter depth had the maximum nutrient load. Furthermore, catch per unit effort (CPUE) analysis suggests that both visual predators and fish at lower trophic levels favored areas with a higher presence of smaller phytoplankton.

Keywords: Phytoplankton diversity, Coastal productivity, Diatoms, Dinoflagellates, Trophic interactions

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Leveraging Local Ecological Knowledge for Adaptive Fisheries Management in Maharashtra and Gujarat

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This study investigates the importance of local ecological knowledge (LEK) in stationary bagnet fisheries along the northwest coast of India, specifically in the states of Maharashtra and Gujarat. Fishermen from three locations in Maharashtra (Alibaug, Arnala, and Madh) and three locations in Gujarat (Rajpara, Jafrabad, and Navabandar) provided insights into how they used their deep understanding of the environment to adapt to their fishing practices. LEK was found to play a crucial role in managing fishing activities, as fishermen rely on their knowledge of seasonal patterns, fish behavior, and habitat changes to optimize their catch. By observing environmental cues and past experiences, they adjust their nets, shift fishing grounds, and modify their methods to improve fishing efficiency. This approach helps them to adapt to spatial and temporal changes in the marine ecosystem, ensuring better catches despite fluctuating conditions. The findings of this study emphasize the value of incorporating LEK into fisheries management, as it allows for more adaptive and responsive fishing practices. Recognizing the importance of local knowledge alongside scientific approaches could promote sustainable fishing practices, supporting both the livelihoods of coastal communities and the long-term health of fish stocks.

KEYWORDS: Local ecological knowledge (LEK), Stationary bagnet fisheries, Traditional knowledge



Redefining the Occurrence of the Pelagic Stingray, *Pteroplatytrygon violacea* (Boneparte, 1832) in Indian Waters

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The pelagic sting ray, *Pteroplatytrygon violacea* (Boneparte, 1832) is a lone stingray, known to inhabit deep oceanic waters of temperate and tropical regions. While the Atlantic and Pacific oceans are confirmed to be aggregation realms of this species, its occurrence in the Indian Ocean is rare and confined to the Southern Indian Ocean, south of the equator. However, sporadic reports have confirmed the occurrence of this species in northern Indian Ocean as well. P. violacea is easily identified from its conspicuous wedge shape disc which is unique to this species. This species is of low utilization interest and does not command any market demand. Local fishermen in Tamil Nadu report that catch of this species is not uncommon along this coast. However, because of its poisonous sting and its low commercial value, it is usually discarded at sea and therefore it is seldom seen in the landed catch. This is probably the case all along the Indian coast. Published literature indicates that regular hooking of this species has been observed in the Indian EEZ; however, when caught onboard commercial longliners, the fishermen fearing possible stinging while removing the hook, kill the fish and throw it back into the sea since it is not consumed locally. Absence of the fish in commercial fish landings along the Indian coast is not an indicator of the extent of its availability in Indian waters, and the common definition of its occurrence as "rare" appears erroneous. In this study, we review the various reports of the occurrence of this species at different locations along the Indian coast and in deeper waters of the Indian EEZ since conflicting conclusions regarding the distribution of the species in Indian waters warrants the need to reassess its spatio-temporal availability in the region. Although it is classified as a species of "Least Concern" in the IUCN redlist, being a top predatory fish with preferential and selective feeding habits tending towards a predominantly crustacean diet, it is necessary to ascertain the abundance and distribution of P. violaceae in Indian waters as it may have a larger role to play in the ecosystem than what is perceived currently.

KEYWORDS: Pelagic Stingray, Indian waters

Empowering Marine Fishery Research through an Innovative Database Solution

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MARLIN@CMFRI, an innovative android-based application is designed to create an extensive marine fish database within the Indian Exclusive Economic Zone (EEZ). This user-friendly platform allows contributors to easily upload high-quality images of marine fish species, accompanied by metadata such as species details, contributing to accurate identification. The application features geolocation integration, enabling users to geotag fish landing locations, thus improving the spatial precision of the data. By promoting collaboration, MARLIN@CMFRI connects individuals interested in marine conservation, allowing them to become contributors to an expanding repository of marine biodiversity data. Beyond its role as a photo-sharing tool, the application serves as a powerful resource for researchers, supporting the analysis of fish distribution patterns and providing valuable insights for sustainable fisheries management. Through the collection and sharing of real-time data, MARLIN@CMFRI plays a critical role in enhancing research capabilities and facilitating informed decision-making in marine conservation and resource management efforts within the Indian EEZ.

KEYWORDS: Database solution, Android application, Geolocation integration, Citizen science, Resource management



A Decadal Overview of Large Pelagic Fisheries Resources in Karnataka

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The large pelagic fishes comprising various groups and species, have a wide range of distribution and migration patterns. The high demand and lucrative market prices for these fishes both in domestic and export markets make them a targeted species for fishing. Large pelagic fishes play a crucial role in the marine ecosystem, functioning as predators of most of the small and medium-sized fishes. The major large pelagic groups comprised tunas, billfish, seerfish, dolphinfish, cobia, barracuda, queenfish, needlefish, and rainbow runner. The estimated landings of large pelagic fishes in Karnataka over the decade varied from 9139 t in 2014 to 48.362 t in 2022 and it contributed 1.9% in 2014 to 9.5% in 2020 of total marine fish landings of the state. The recent development by the purse seine fishery of adopting a big-sized mesh (more than 45 mm) and pelagic/columnar trawling practice with the speed engines by trawl boats increased the landings of large pelagic fishes in the state. These two gears together landed more than 90% of the large pelagic fishes during the study period. Among, the large pelagic fishes studied, tunas, seerfish, and barracudas were the major groups landed in the state and contributed (%) from 15.6 (2013)-46.0 (2016), 12.2 (2023)-40.8 (2014) and 13.8 (2016)-42.4 (2019), respectively. Continuous monitoring of the landings of large pelagic fishes is essential for recommending suitable management plans for the optimal and sustainable exploitation of the available large pelagic resources in Karnataka. This paper attempts to provide an overview of the large pelagic fisheries of Karnataka, based on the analysis of the landings for a period from 2013 to 2023.

KEYWORDS: Large pelagic fishes, Tunas, Seerfish, Barracudas, Management plans, Sustainable exploitation

Catch and Length-Based Stock Analysis of the Penaeid Shrimp Metapenaeus dobsoni from the Southeastern Arabian Sea, India

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Fishery management is crucial ecologically and socio-economically for regions that exploit fishery resources on a commercial scale. In most fisheries worldwide with commercial dimensions, assessment of the fishery and resulting management advisories are becoming indispensable from an ecological, socio-economical, eco-labelling, and certification outlook. Penaeid shrimp are a sought-after delicacy with a significant market presence in various countries. Metapenaeus dobsoni is a predominant species harvested along the peninsular coast of India. It contributes significantly to the fishery of the coast and has immense export value. The stock of M. dobsoni, off the southeastern Arabian Sea, India, is assessed by the catch and effort-based Bayesian Schaefer Model (BSM) and Length-based Bayesian Biomass (LBB) methods. The BSM in the R environment primarily uses catch and abundance data; the latter model uses length frequency data. Catch and abundance data from 2009 to 2022 gave a terminal B/B_{msv} of 1 and F/F_{msv} of 0.75 indicating fully exploited biomass and low fishing pressure. The Kobe plot from the analysis depicts a probability of 45.1% in the healthy zone, 43% undergoing reduced fishing pressure with low stock biomass, and 11.6% overfished and undergoing overfishing. Length frequency data from commercial landings from January 2017 to December 2022 were used in the LBB analysis which provided F/M=0.65 and B/ B_0 =0.46 signifying that the stock was in good condition with B/B_{msv} =1.2 (healthy stock). The results imply that the biomass of the shrimp stock has a high probability of increasing if the current level of fishing pressure is maintained. The species supports the livelihood of fishers and other stakeholders associated with its trade along the coast. Besides, it is one of the shrimp species going through the certification process, a label prescribed based on responsible fishing practices and compliance with sustainability.

KEYWORDS: Bayesian Shaefer model, Length based bayesian biomass, Stock biomass

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A Statistical Platform for Enhanced Fisheries Stock Assessment

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Understanding the status of marine fish stocks is crucial for formulating strategies that ensure sustainable harvests of marine resources. Despite the availability of various stock assessment methods, user-friendly platforms that simplify this process remain limited. To bridge this gap, a cutting-edge web application has been developed using the Shiny App package of R, aimed at streamlining stock assessments for fishery biologists. This intuitive platform integrates multiple statistical models and analytical techniques, offering a seamless interface that removes the complexity of traditional statistical analysis and R programming. With just a single click, users can perform comprehensive stock assessments, estimate biological parameters such as growth, mortality, and the length-weight relationship, and fit yield-perrecruit models to evaluate sustainable exploitation rates. By enhancing both accuracy and accessibility, this tool empowers researchers and fisheries managers to make informed, datadriven decisions for sustainable marine resource management.

KEYWORDS: Stock assessment, Shiny App, Sustainable fisheries, Yield-per-recruit models

A Simplified Framework for Fishery Stock Assessment Using Landing Data, Ecological and Environmental Indicators

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Effective fisheries management relies on accurate stock assessments, particularly in datalimited contexts where traditional methods, which require extensive datasets, are often impractical. To address this limitation, an R package called *SSplots* has been developed, offering a simplified yet robust framework for evaluating fish stock exploitation status using only time series data on landings. *SSplots* generate bivariate stock status plots, enabling visualization of multispecies fisheries and their exploitation trends across ecosystems over time. Complementing this tool, ICAR-Central Marine Fisheries Research Institute has introduced the Environmental Performance Index (EPI) for fisheries, which integrates ecological and environmental indicators to assess sustainability. EPI's major advantage is its ease of calculation, making it accessible for fisheries even with limited data, while providing valuable insights into both stock health and environmental impacts.

KEYWORDS: SSplots, Stock assessment, Environmental performance index, Fisheries management

The Ocean Sunfish, *Mola mola*: Advances in Understanding Biology, Ecology and Conservation Implications

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The ocean sunfish (Mola mola), a member of the Molidae family, holds the distinction of being the largest and most prolific species among teleosts, while also playing a vital role in maintaining marine ecosystem balance. This species exhibits a global distribution across temperate and tropical waters, making it an essential component of various marine environments. The present study aims to enhance our understanding of the distribution and abundance patterns of *Mola mola*, with a particular focus on habitat preferences, population trends, feeding habits, and ecological interactions with other marine species, especially jellyfish. Through a comprehensive analysis, we investigate the habitat utilization of ocean sunfish and identify key areas of abundance. Our findings reveal significant patterns in their distribution, which correlate with the availability of prey and suitable environmental conditions. Additionally, we explore the feeding behavior of Mola mola, highlighting its role as a predator of jellyfish, and the implications of these interactions for marine food webs. In 2022, the International Union for Conservation of Nature (IUCN) updated the conservation status of *Mola mola* from "Least Concern" to "Vulnerable." This change reflects increasing concerns regarding threats to its population, including bycatch and entanglement in fishing gear, habitat degradation, and the impacts of climate change on its food sources. The study underscores the need for enhanced conservation efforts to mitigate these threats and protect the ocean sunfish and its habitat. Overall, this research contributes to the growing body of knowledge surrounding Mola mola and emphasizes the importance of understanding its ecological role and conservation needs. As marine ecosystems continue to face various anthropogenic pressures, protecting this unique species is vital for maintaining the balance and health of oceanic environments. Our findings advocate for more sustainable fishing practices and habitat conservation measures to ensure the survival of the ocean sunfish and its ecological partners.

KEYWORDS: Ocean sunfish, Mola mola, Feeding behaviour, Jellyfish interaction, By-catch

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Foundational Insights into the Biological Traits of a Vulnerable Whipray from India's Northeastern Coast

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The northeastern coast of India is home to a diverse array of marine life, including several species of sharks, rays and skates, many of which remain understudied. Among these, is the whipray Brevitrygon heterura, a small, vulnerable species belonging to the family Dasyatidae. Despite its ecological and economic importance, there is a lack of biological information on this species from Indian waters. The present study examined the general biological profile of the lesser-studied dwarf ray, Brevitrygon heterura, from Odisha. 74 specimens were collected from small-scale fisheries in the coastal waters of Puri during 2023. Species identification was confirmed, and the specimens were analyzed for their biological characteristics. The sample comprised 33 females and 41 males, resulting in a sex ratio of 0.80:1 (F:M). Length frequency distributions for both sexes indicated that the mean and modal lengths of the exploited whiprays were 16.88 cm and 17 cm DW. The average sizes observed were 16.66±0.37 cm DW for females and 17.06±0.25 cm DW for males. The length-weight relationship (LWR) for pooled data was estimated as W=0.016 DW^{3.2} (R²=0.91). Males and females were found to mature at 16.4 cm and 17.5 cm (DW), respectively, aligning closely with the predominant landed length group in the fishery. Although large, ripe ova were present alongside smaller developing ova throughout the year, a significant increase ($p \le 0.01$) in mean ova diameter was observed during December and January, indicating the peak reproductive period for this species. One pup was recorded from a pregnant female measuring 20.6 cm DW (maximum recorded size) and weighing 289 g. There was no significant difference in the dietary composition between males and females, with stomach contents revealing a strong preference for crustaceans (shrimps, IRI=67%, followed by crabs, IRI=23%). The species has been recently assessed as "Vulnerable" (IUCN, 2021). Given its lesser-known status, further research into its reproductive behavior, population dynamics, and ecological interactions is essential for a more comprehensive understanding of its biology, which would aid in the sustainable management of this resource.

KEYWORDS: Dasyatidae, Odisha, Coastal fisheries, Sustainable management

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Delineating Stock Structure in Mangrove Red Snapper, *Lutjanus* argentimaculatus (Lutjanidae: Perciformes) from Indian Waters Using Geometric Morphometric Analysis of Body Shape

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Defining stock structure is a prerequisite for stock assessments to ensure effective management. In this study, we attempted to define the stock structure of the mangrove red snapper, *Lutjanus argentimaculatus*, in Indian seas using Geometric Morphometric Analysis (GMA). Principal Component Analysis on body shape revealed two distinct *L. argentimaculatus* populations: the Bay of Bengal (east coast of India) and the Arabian Sea (west coast of India). The major morphological variations between eastern and western populations were in the relative sizes of the head, eyes, dorsal fins, mouth position, and pectoral fins. The west population was characterized by large heads, bigger eyes, more inferior mouths, posteriorly occupied pectoral fins, and large dorsal fins. These results indicate that local adaptations have resulted in phenotypic structuring in the mangrove red snapper population in the Indian seas. Hence, two separate phenotypic stocks may be considered: one for the western Bay of Bengal and one for the eastern Arabian Sea. The present study provides a pioneering application of GMA to identify geographical variation in morphological characters and phenotypic stock of a marine finfish in India, providing valuable insights for fisheries management.

KEYWORDS: Phenotypes, PCA, Multivariate analysis, Body shape, Plasticity

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Catch Trends and Dynamics of Crab Fisheries Along the Karnataka Coast

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The swimming marine crab fishery accounts for up to two percent of total landings along the Indian coast and one percent of total landings along the Karnataka coast, primarily targeting three species namely *Portunus pelagicus, Portunus sanguinolentus* and *Charybdis feriatus*. Marine crabs are a delicacy and have shown significant growth in exports over the years, contributing to the country's seafood trade. The study analyzed the catch trend, fishing effort, and catch rate for crab resources from 2016 to 2023, and also examined catch-based MSY plots for these resources. Trawl net dominates crab landings of Karnataka, accounting for 78%, followed by gill net at 14%. Notably, multi-day trawls occasionally capture *Charybdis lucifera* and *C. smithii* from December to February. The average landings of crab resources from trawl nets along the Karnataka coast is 2729 tonnes, of which *P. sanguinolentus* contributes 42% to the fishery. The catch per unit effort peaked during April and May at 1.5 kg/hr. Average crab landings were found to peak during March due to higher fishing effort in units and hours. The average catch per unit effort for crab fishery along the Karnataka coast was estimated at 0.9 kg/hr. Furthermore, data indicate an irregular cyclic trend in both landings and species composition within the crab fisheries.

KEYWORDS: Marine crabs, Catch trend, CMSY

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Research Approaches to Monitor and Track the Algal Bloom Along the North-Eastern Arabian Sea

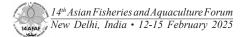
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Algal blooms primarily consist of autotrophic algae, with occasional contributions from heterotrophic species. The frequency of these occurrences in coastal waters worldwide has been increasing. Algal blooms are influenced by various environmental conditions, including nutrient levels (particularly nitrogen and phosphorus), water temperature, and sunlight, which create optimal conditions for algal growth. Between 1916 and 2019, a total of 75 bloom events were recorded along the west coast of India. Among these, dinoflagellates were the predominant group responsible for blooms, accounting for 52 occurrences, followed by diatoms (29), cyanobacteria (24), rhodophytes (4), and haptophytes (1). Algal blooms are composed of major groups i.e., 62% dinoflagellates, 15% diatoms, 15% cyanobacteria, 7% raphidophytes, and 1% haptophytes. Monitoring and tracking algal blooms represent a crucial area of research for understanding ecological patterns, assessing climate change indicators, and evaluating potential impacts on food webs, particularly concerning fishery resources and toxic management. Furthermore, this research aids in the development of predictive models regarding the occurrence and behavior of blooms. Remote sensing technology plays a vital role in the monitoring and tracking of algal blooms by capturing spectral data, especially in the visible and near-infrared bands, which detect chlorophyll-a, a key indicator of algal presence. This technology facilitates the estimation of bloom size, movement, and intensity by regularly imaging water bodies and measuring water quality parameters such as temperature and turbidity. Generally, three main approaches are employed for monitoring algal blooms: a) Field Sampling: This involves collecting water samples to assess physico-chemical parameters (such as sea surface temperature, pH, and dissolved oxygen), nutrient levels (nitrogen and phosphorus), and productivity metrics (chlorophyll-a and primary productivity); b) Remote Sensing Techniques: These techniques utilize ocean color data to detect and monitor algal blooms; c) Citizen Science Initiatives: Involving local fishermen in bloom reporting and sample collection enhances community engagement and data collection efforts. A comprehensive sampling approach that integrates these methods will enable reliable reporting, real-time monitoring, and the provision of timely advisories to fishers and the public who frequent coastal waters.

KEYWORDS: Algal blooms, North-Eastern Arabian Sea, Remote sensing, Dinoflagellates



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Distribution Dynamics of Sciaenids along the Gujarat Coastal Ecosystem: A Spatio-Temporal Analysis

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India stands as a leading fishing nation in the Indian Ocean, contributing nearly 60% of the region's sciaenid fisheries. The north-west coast, including the state of Gujarat, is recognized as a prime fishing ground for croakers in the Indian Ocean. Croakers are divided into two broad categories: larger sciaenids and lesser sciaenids. Along the Gujarat coast, lesser sciaenids constitute the majority of the croaker catch, with several key species contributing significantly. Their distribution, however, varies spatially and temporally, making the study of their spatio-temporal patterns essential for effective harvest management. This study utilizes haul-wise data from bottom trawlers operating along the Gujarat coast to analyze lesser sciaenid catches. By employing geo-tagged catch rates and applying interpolation techniques (ordinary kriging), thematic maps were created to illustrate seasonal variations in the abundance of lesser sciaenids in Gujarat's coastal waters. Semi-variogram modelling was adopted for spatial analysis. Spherical, Gaussian and polynomial models were compared for their performance based on R² and RMSE values. The spherical model gave the best fit to the spatial data. The generated thematic maps indicated Central Gujarat as the most productive area for croaker fisheries along the coast. High abundance zones are identified off Mangrol and Porbandar in shallow waters (<50 m) during the post-monsoon season, with notable catches also reported off northern Gujarat. In winter, catch rates generally decline, with high abundance zones moving to deeper waters. As summer-monsoon approaches, productive zones shift back to shallower depths, with northern Gujarat experiencing peak catch rates during this period. Further, the probability of recording higher catch rates (CPUE) was much higher during post-monsoon, followed by winter and summer-monsoon. This study provides critical insights for the sustainable management of croaker resources and supports Marine Spatial Planning within India's marine fisheries sector.

KEYWORDS: Gujarat, Spatial modelling, GIS, Thematic maps

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Status of Non-Penaeid Fishery Along Maharashtra Coast, Arabian Sea

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Non-penaeid fishery plays a vital role in supporting small-scale fisheries contributing to both the livelihood and nutritional security of coastal communities especially along the north-west coast of India. The monitoring of catch and effort is crucial for the sustainable management of fishery resources. Major non-penaeid resources are supported by three species viz., Acetes sp., Nematopalaemon tenuipes, and Exhippolysmata ensirotris. Off the major gears employed along the Maharashtra coast, dol net contributed the maximum in total non-penaeid catch. This group constituted 12.20 % of the total marine landings of the state and played an important role in the food chain for many fishes. A detailed study on the catch trend of nonpenaeid shrimp was carried out during 2017-2023. During this period, the average landing of non-penaeid resources from the dol and trawl net was 25,025 tonnes and 1,435 tonnes respectively. The group constitutes 49.53% of the dol net fishery and 1.53% of the trawl net. Among the total non-penaeid landings, nearly 94.6% of the catches was formed by dol nets. Peak landings were observed during November-December and March-April. During March-April, this resource is mainly targeted for the dry fish market. Acetes sp. dominated the non-penaeid landings forming 55.2%, followed by Nematopalaemon tenuipes 41.6 % and Exhippolysmata ensirotris 3.1%, with E. styliferus forming only 0.1%. They are consumed fresh as well as dried form. They are also used for making paste for adding flavor to various traditional dishes. The CMSY analysis showed that the group is exploited sustainably along the Maharashtra coast. However, there is a need for resource management of the stocks and implementation of minimum legal size (MLS) for the sustainable exploitation of these resources.

KEYWORDS: CMSY, Catch trend, Species composition, Non-penaeids, Maharashtra

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Spatial Variations in Biometric Parameters of *Cirrhinus reba* Along the River Ganga

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The biometric assessment of a freshwater fish species *Cirrhinus reba* (minor carp) was conducted at four different sampling stations along the River Ganga. A total of 224 fish specimens were sampled, and various biometric parameters were measured and analyzed. The study revealed strong correlations in length-length relationships (LLRs) and length-weight relationships (LWRs) (p<0.001) with R² values close to 1. Significant variations in growth trends and condition factors of the selected fish species were noted across different sampling sites. The b values were 2.909, 2.911, 2.890 and 1.941 from the Narora, Kanpur, Varanasi and Bhagalpur sites, respectively. Condition factor values were below 1 from the Kanpur and Bhagalpur sites. The findings of the study provide valuable insights into the growth patterns and health status of the selected fish populations which are essential for its fisheries management, conservation efforts, and ecosystem sustainability. The study highlights the significance of biometric assessments in comprehending fish population dynamics and informing effective conservation strategies.

KEYWORDS: Biometric assessment, Length-weight relationship, Condition factor, Growth

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Phenotypic Variability in Otoliths as a Tool for Stock Identification of *Mystus vittatus* in the River Ganga

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Stock identification is essential for understanding the connectivity and structure of fish populations across broad geographic regions, contributing to sustainable fisheries management. Otolith shape and structure have proven as an important tool in analyzing fish populations. The present study aims to investigate the phenotypic variability in otoliths of Mystus vittatus along the River Ganga, through detailed otolith shape and morphometric analysis to delineate spatial stock structure. A total of 269 fish samples were collected from four distinct locations on the river viz., Narora, Kanpur, Varanasi, and Bhagalpur. Spatial differences in otolith shape were evaluated using wavelet coefficients, and otolith morphometric parameters including size and shape indices. The statistical assessments, including ANOVA-like permutation test (PERMANOVA) and canonical analysis of principal coordinates (CAP), revealed significant differences in otolith shapes among the four populations. The Kruskal-Wallis and Dunn's tests further confirmed significant differences in most morphometric parameters across the populations. Principal component analysis (PCA) accounted for 39.2% and 23.4% of the total variance in the PC1 and PC2, respectively for the otolith morphometric parameters. The cross-validation classification using the random forest method showed a classification accuracy of 64.68% based on otolith shape and 59.11% based on morphometry. The findings of this study demonstrate the phenotypic variations among four populations of Mystus vittatus. Both otolith shape and morphometric analysis showed that the Narora population had the highest allocation success. These findings offer critical insight for effective fisheries management and conservation strategies of the target fish species in the River Ganga.

KEYWORDS: Otolith shape, Otolith morphometry, Stock structure, Mystus vittatus, River Ganga

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Fishery and Stock Assessment of Whitefin Wolf-Herring, *Chirocentrus nudus* (Swainson, 1839) from the North-Eastern Arabian Sea

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The whitefin wolf-herring, *Chirocentrus nudus* (Teleostei: Clupeiformes: Chirocentridae) is widely distributed throughout the Indo-Pacific region and has wide distribution in Indian waters along both the east and west coasts. The two species, Chirocentrus dorab and C. nudus are recorded from the Indian coast, but along the Maharashtra coast, the commercial fishery is formed by C. nudus. Locally referred to as "Karali" or "Datali", it constitutes a significant fishery resource in the states of Maharashtra and Gujarat along the northwest coast of India. It possesses a good local demand for food fish, mostly among the tribal community in Maharashtra. C. nudus is generally caught as a bycatch in trawlers but also forms a targeted fishery in Maharashtra. The species is caught mainly in gill net (59%), trawl (31%), and dol net (4%) in Maharashtra waters. During the 2017-2023 period, the estimated average landing of wolf-herring was around 927 tonnes, and it contributed about 0.33% to 2.33% of the total pelagic fish landing in Maharashtra. The landing of C. nudus in Maharashtra exhibited significant variability, with an average annual landing of approximately 2,342 tonnes reported between 1991 and 2007, and around 1,329 tonnes between 2008 and 2023. The historical maximum landing recorded in Maharashtra was 3,529 tonnes in 2015. Studies on the stock assessment of *C. nudus* on the management of the resource are scarce. Stock assessment parameters were estimated using Electronic Length Frequency Analysis (ELEFAN) as included in the R package TropfishR. The length-converted catch curve and the length-based yield per recruit model were employed. Based on assessments of the relative stock size (B/Bmsy) and exploitation (F/Fmsy), the C. nudus population is reported to be in a healthy condition. However, it is necessary to implement management intervention to maintain the stock at a sustainable level.

KEYWORDS: Arabian Sea, Bycatch, Wolf-herring, Stock assessment, Targeted fishery

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Reef Fish Diversity in North Kerala Coastal Waters: A Baseline Assessment and Insight from Fish Landing Observations

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The northern Kerala coast along India's west coast is known for its rich marine ecosystems, including coral reefs, rocky patches, and scattered reefs. Despite this ecological richness, a comprehensive assessment of reef fish diversity in this region has been lacking. This study aimed to document the diversity and species composition of reef fishes along the northern Kerala coast, establishing a baseline for future conservation efforts. Field surveys were conducted at multiple reef sites, and small-scale gillnet landing centers operating near these habitats were monitored. Fish species were identified using visual surveys and underwater photography. A total of 146 reef fish species were recorded, representing 44 families and 16 orders. The family Ballistidae dominated (40%) across all sites, followed by Lutjanidae, and Serranidae. Lutjanidae (13%), Mullidae (11%), and Serranidae (7%) were the primary contributors to species richness. Additionally, a new report of several rare species was observed, extending the known distribution of some reef fishes in the region. This study provides an essential baseline assessment of reef fish diversity in northern Kerala and underscores the importance of implementing effective management and conservation measures to safeguard these fragile marine ecosystems from growing anthropogenic pressures and climate change impacts.

KEYWORDS: Reef fish diversity, North Kerala coast, Species composition, Conservation

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Assessing Land Use and Land Cover Dynamics in the Harike Wetland System Through Landsat Imagery

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The critical role of wetlands in preserving ecosystem health and biodiversity is increasingly threatened by their rapid decline, highlighting the need for localized studies. In the present study, the region of interest (ROI) extended from the Harike wetland, a Ramsar site in Punjab, India, to its adjoining fishing grounds, covering a total area of approximately 7401 hectares (ha). Changes in land use and land cover (LULC) were analyzed from 1995 to 2023 using Landsat imagery to explore the impact on the wetland and its surrounding areas. The images were classified into various categories, including agricultural land, water bodies, sandy areas, and aquatic weeds, among others. The dynamics of the spectral indices such as the Normalized Difference Water Index, Modified Normalized Difference Water Index and Normalized Difference Vegetation Index played an important role in the image classification for this study. Alarmingly, in 2023, approximately 42% of the ROI was infested with aquatic weeds, which adversely affected the wetland's hydrological system. Furthermore, the extent of agricultural land surged from a mere 12.1% in 1995 to 39% by 2023. This alarming increase in agricultural practices, combined with declining groundwater levels, is exacerbating the degradation of the wetland. Additionally, the surface water area decreased from 15.2% in 1995 to 10% in 2023 during the pre-monsoon period, thereby impacting the wetland ecosystem. These changes underscore the urgent need for continuous monitoring and a comprehensive conservation strategy for the Harike wetland, emphasizing participatory management to safeguard its ecological integrity.

KEYWORDS: Land Use Land Cover, Wetland, Ramsar, Indices

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Catch Per Unit Efforts and Impact of Gears on Fish Abundance in Oxbow Lake, Manika, Bihar

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Manika Oxbow Lake (abandoned, fractioned and derived from river Burhi Gandak) is located at Mushari Block Muzaffarpur district, Bihar, India. The study was conducted from 16th January to 18th July 2023 to analyse the catch composition of fish at selected sampling sites of River Burhi Gandak and its Oxbow Lake Manika. In order to meet the research goals, four sample sites of Burhi Gandak River Mushahri, Pilkhi, Dholi, and Pusa and one sampling site, Oxbow Lake Manika, were chosen. Gillnets operated in the river Burhi Gandak are categorized into 5 types that vary from 20-56 mm based on the size of the mesh. Webbing material and hanging coefficient for gillnets, which are polyamide monofilament and 0.7 in the River Burhi Gandak. The mesh size of the gillnet operated in Oxbow Lake Manika was found to be varied from 20 mm and 30 mm. In case of design features of gillnets, webbing material and hanging co-efficient were found to be the same i.e. Polyamide monofilament and 0.7 respectively. Catch per Unit effort (CPUE) was found for gillnet (20 mm), i.e. 999.88g or approx. 1 kg. A total of 33 species belonging to 7 orders, 11 families, and 18 genera were recorded from Manika Oxbow Lake, where the maximum contribution was from order Perciformes, i.e. 37% followed by Siluriformes (30%). The least contribution was from Tetradontiformes i.e. 0.1%. The gillnet design is crucial when determining fishing efficiency and level of selectivity. The soaking duration of gillnet (20 mm) in Manika Oxbow lake is 10-11 hours. The present study showed that unchecked growth in gear volume at various portions of Manika Oxbow Lake has an adverse effect on fish capture.

KEYWORDS: Gillnet, Hanging coefficient, CPUE, Fishing efficiency

Biometric traits of *Nemipterus japonicus* (Bloch, 1791) from Northeastern Arabian Sea

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The Japanese Threadfin Bream, *Nemipterus japonicus* is a non-migratory marine benthic species found in the Indo-Pacific region. The present investigation examines the morphomeristic traits, length-frequency distribution, length-weight relationships, and condition factors of N. japonicus collected from Veraval Fishing Harbour, Gujarat, Northeastern Arabian Sea from September 2022 to August 2023. Discriminant analysis following univariate ANOVA test revealed no significant (p>0.01) difference between males and females for all the morphometric characters except anal fin base length and caudal fin length. The coefficient of variation (CV) was found high in most of the morphometric characters (CV>20%). Based on range differences, seven characters in standard length (SL) and six characters in head length were found in the intermediate category (10-15%). Meristic characters depict constancy in all specimens except for pectoral and ventral fin rays and the number of gill rakers. Length frequency distribution reveals that the maximum proportion of fishes were recorded in the 13-14 cm SL size group. The covariance analysis reveals a significant difference (p<0.05) in length-weight relationships (LWRs) between males and females. The average relative condition factor (K₂) was estimated as 1.0066 for males and 1.0055 for females. The Fulton condition factor (K_p) showed a pronounced value for both sexes ($K_p > 2.50$). The highest proportion of plump fish was recorded in May in females and September in males. The present study proclaims high intra-population variations and inconsistent morphometric characters. Further, a higher number of specimens landed in small-size groups suggests restrictions in the harvesting of smaller individuals. The LWRs of both sexes identify that fish become slimmer with increasing length. The provided biometric parameters of Japanese Threadfin Bream will help in the formulation of conservation and management plans in the study area.

KEYWORDS: Coefficient of variation, Demersal, Japanese Threadfin Bream, Negative allometric

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Analyzing Marine Fish Production in Odisha—Trends, Growth, Instability and Forecast

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The marine fish production sector of Odisha plays a significant role in India's fisheries sector, providing for the nutritional needs of 5.96 lakh people and accounting for 4.80% of the nation's marine fish output in 2022–2023. This study aims to investigate the trends. growth patterns, and instability of marine fish production in Odisha from 1990-91 to 2022-23 and also forecasts production for upcoming years. The annual time series data of marine fish production in Odisha was obtained for these years. Initially, the study examines growth trends over the decades, revealing fluctuations influenced by factors like natural calamities (cyclones) and government regulations. Marine fish production exhibited a gradual increase with a recent surge, but the overall compound Growth Rate (CGR) remained modest (1.56%). The exponential Trend method was used to fit the historical production data, where the R2 value for the entire period was found 0.56. Later, the study employs Autoregressive Integrated Moving Average (ARIMA) and Holt's Linear Trend (HLT) methods to project future productions. The ARIMA model selection was based on the Akaike Information Criterion (AIC) to ensure optimal model fit. HLT model captures both the trend (linear increase or decrease) and the random fluctuations in production data. While ARIMA (0,1,0) and HLT both were suitable for forecasting, comparing their predictive accuracies, Holt's Linear Trend model achieved higher accuracy (93%) for the next five years. The study further investigates district-wise growth patterns and instabilities, identifying Kendrapara district as exhibiting significant instability in recent years. The analysis highlights the disparities in production among coastal districts, with Balasore, Jagatsinghpur, and Puri emerging as major contributors. Instability analysis using Coefficient of Variation (C.V.), Coppock's Instability Index (CII), Cuddy-Delle Valle Index (CDVI) revealed Kendrapara's instability in marine fish production. The CDVI offers a more comprehensive measure, considering both the frequency and magnitude of production changes. This combination of indices provided quantitative measures of production fluctuations. Kendrapara stands out for its notable instability, attributed to a combination of environmental, socio-economical, and government regulation-related factors such as cyclones, limited infrastructures, and fishing restrictions. Challenges such as underreporting and market constraints pose significant barriers to fully harnessing the potential of marine fisheries in Odisha. Despite all the hurdles, the study identifies a gradual increase in production in recent years. The study highlights the need for improved production strategies in Odisha's marine fisheries sector. Additionally, it emphasizes determining the factors that affect the state's marine fish landings.

KEYWORDS: Odisha, Marine fish production, Growth trend, Time Series analysis, Instability analysis



The Effect of Organic Food on the Length and Weight Relationship of *Labeo rohita* and *Catla catla* from Paithan, Maharashtra

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The effect of organic food on the growth of freshwater fishes *Labeo rohita* and *Catla catla* was studied. The growth pattern i.e., length and weight relationships of *L. rohita* and *C. catla* were comparatively studied. Organic food can potentially enhance growth performance i.e. both length and weight. These findings suggest that the nutritional requirements of *L. rohita* and *C. catla* differ, and optimizing feed composition can enhance growth and digestibility in these species. Organic feeds also affect the biochemical composition of these fishes. Studies were conducted to investigate the effectiveness of various organic foods (plant-based ingredients) on fish growth when applied individually and/or when combined with supplementary feed. Results revealed that organic manure, and soybean-based food is better for an increase in the length and weight of the fishes compared with other organic foods tested. It appears that *L. rohita* and *C. catla* have different growth trends when fed different organic feeds with varying protein levels. Organic food is also helpful for better survival rate, better Feed Conversion Ratio (FCR), and Specific Growth Rate (SGR) for both species.

KEYWORDS: Organic food, Supplementary feed, Biochemical composition

FCSA 2.0: An Advanced Online Platform for Marine Fisheries Catch Data Collection and Processing

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The Fish Catch Survey and Analysis (FCSA) is an online application developed by ICAR-Central Marine Fisheries Research Institute to collect and process real-time data from fish landing centres using electronic devices since 2018. FCSA comprises different segments, including online data entry via tablets, tools for data scrutiny, analysis, estimation, and report generation. FCSA software has undergone significant enhancements from Version 1 to Version 2, aimed at improving the efficiency, accuracy, and user experience of marine fisheries data collection. Version 2 of FCSA (FCSA 2.0) features critical upgrades in areas such as realtime monitoring, scalability and modularity, functionality, and technological improvements in data entry and collection. FCSA 2.0 has a redesigned user interface that is more intuitive and user-friendly, with enhanced navigation features and customizable dashboards, allowing users to tailor the experience to their specific needs. For technical enhancements, the FCSA 2.0 mobile app was developed using Flutter SDK with Java, making it compatible with Android devices running version 10 or above. This transition to a mobile-centric platform significantly mitigates reliance on dedicated tablets, as most users possess devices capable of supporting the application. Consequently, this advancement has led to a marked reduction in the financial overhead associated with tablet procurement and maintenance. Its serverside module combines a user-friendly front end with a PostgreSQL database, allowing for more robust data collation, verification, estimation, and summarization of landings and effort estimates. The expanded features in version 2 include advanced analytics tools, customizable report templates, and the ability to quantify the proportion of low-quality catches per species, providing insights into juvenile catches as well. Further, an updated functionality was added that incorporates an advanced Android API for accurate geo-location mapping to ensure accurate data collection in specified locations. This allows for real-time monitoring of field observers, ensuring data is collected at the right time and place which enhances data integrity and provides immediate feedback to users. FCSA 2.0 features a modular structure that supports easy scalability, allowing for the addition of new functionalities without disrupting existing operations. Moreover, it is designed to evolve with future technological advancements by integrating AI technologies. This integration will help to identify patterns, trends, and relationships with catch and effort data through data mining, scenario analysis and predictive modelling. Overall, FCSA 2.0 represents a substantial upgrade from Version 1, introducing critical enhancements that improve overall system performance.

KEYWORDS: Online platform, Marine fisheries, Catch data



Morphometric and Allometric Relationships of *Pethia ticto* from the River Ganga: Insights into Growth Dynamics and Ecological Assessment

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Pethia ticto is a small indigenous fish species (SIS) abundant in South Asian countries, recognized for its ability to adapt to a wide range of freshwater habitats. It's vivid colours and calm disposition have also made it popular in the aquarium trade. This study investigates the length-length (LL), length-weight (LW) relationships, and condition factor (K) of P. ticto. A total of 183 specimens were collected from different sampling stations along the upper, middle, and lower stretches of the River Ganga from September 2022 to December 2023, covering a wide size range. Standard length (SL), total length (TL), and body weight (W) were measured for each individual to establish LL and LW relationships. The lowest R² values for the LL and LW relationships were 0.330, 0.452, and 0.538 for specimens from Kanpur, Bhagalpur, and Varanasi, respectively, while the highest value, 0.823, was recorded at Narora. The b-values were 2.742, 1.612, 1.072, and 0.388 across the selected sampling sites, reflecting varied growth patterns. Condition factor (K) values were 1.420, 1.883, 2.026, and 1.595, providing insights into the well-being of the populations. These findings offer crucial baseline data for the biological and ecological management of Pethia ticto, shedding light on the species growth dynamics and overall condition in natural habitats.

KEYWORDS: Length-length relationship, Length-weight relationship, Condition factor, Freshwater, Ecological restoration



Occurrence and Abundance of Microplastics in Dried Fish and Prawn Samples along the Karnataka Coast

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The extensive use of plastics has led to the widespread distribution of non-degradable and hazardous solid waste in aquatic ecosystems, significantly increasing the accumulation of microplastics (MPs) over the past few decades. This contamination is becoming an alarming phenomenon, as MPs can transfer from marine organisms to the human body, posing potential health risks. The present study aimed to assess the occurrence, abundance, and morphometry of microplastics in selected commercially important dried fish and prawn samples sold in markets along coastal Karnataka. The fish samples included soles, anchovies, false trevally (Lactarius lactarius), and Acetes spp. All fish and prawn samples contained microplastics, with the highest quantities found in anchovies from Udupi and the lowest in false trevally from Karwar. Notably, the microplastic content was higher in unwashed samples compared to washed samples. Washing the samples significantly reduced microplastic content, emphasizing the importance of proper cleaning before consumption. Three shape variants of microplastics were identified: fragments, fibres, and films, with fragments being the most prevalent, followed by fibres and films. The colours of the microplastics included black, red, orange, transparent, blue, brown, pink, green, sky blue, and yellow, with black materials being the most common. Microplastics were categorized by size into five groups: <100 μm, 101-250 μm, 251-500 μm, 501-1000 μm, and >1000 μm. Most microplastics measured less than 100 µm, followed by the 101-250 µm range. The polymer composition of the microplastics included polyethylene, polypropylene, and rubber.

KEYWORDS: Microplastics, Dried fish, Prawn

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Feeding and Prey Preference of Cobia *Rachycentron canadum* (Linnaeus, 1766) Caught off Chennai Coast

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Diverse predatory characteristics of fishes play a pivotal role in regulating the biomass of prey species in the lower trophic level of the marine ecosystem. Understanding this preypredator relationship at different trophic levels is significant for effective ecosystem-based fishery management. In tropical pelagic ecosystems, cobia is an apex predator, foraging across water columns in different habitats and thereby predating on a wide range of prey. The habitat selection of cobia is highly linked to prey abundance and thus, the diet composition differs geographically. Cobia contributes 0.1% of the total marine fish landings in Chennai. Dietary details of cobia are sparsely studied on the southeast coast. To bridge this gap, the diet composition and prey preference of cobia were studied. Between 2017 and 2024, cobia of different size groups ranging from 305 to 754 mm were collected from commercial landings by trawlers off Chennai and adjacent coasts. The guts of collected samples were subjected to dietary analysis. Data on feeding intensity, composition, and qualitative and quantitative details were collected for calculating the Index of Relative Importance (IRI) and Prey specific Abundance (PSA). Guts were mostly observed as either full or half full and indicated high feeding intensity throughout the year. The diet was dominated by pelagic and benthic fishes of 12 genera followed by molluscs. Dominant teleost prey indicated the foraging behavior of cobia in epipelagic and mesopelagic regions. Crustacean prev seemed secondary in prey preference. Pups of *Brevitrygon imbricata*, previously unreported as prey of cobia in Indian waters, were found in a few guts. In contrast to Cobia's affinity for the crustacean diet reported elsewhere, the dietary pattern of cobia in the present study indicated a preference for fishes over crustaceans. Thus, cobia appears to be piscivorous in Indian waters. Diet variation with season was not evident in the present study.

KEYWORDS: Dietary composition, Index of Relative Importance, Prey, Predator, Prey-specific Abundance

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Spatio-temporal Distribution of Jellyfish Bloom (*Rhopilema hispidum*) Along the Coast of Maharashtra, India

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Rhopilema hispidum (Vanhoffen, 1888) is a prominent species of scyphozoan jellyfish with significant ecological and economic effects on coastal fisheries. It supports commercial fisheries in countries like China, Vietnam, Indonesia and Pakistan, as well as along the coast of Gujarat, Andhra Pradesh and Kerala, in India, However, blooms of this species are known to disrupt fisheries in Maharashtra by reducing fish catches, damaging fishing gear, and stinging fishers. The current study investigates the spatiotemporal distribution of R. hispidum along the coast of Maharashtra, India. Field surveys were conducted across eight sites in five coastal districts of Maharashtra, namely Palghar (Satpati, Arnala), Mumbai Suburban (Marve, Versova), Raigad (Karanja, Alibag), Ratnagiri (Mirkawada), and Sindhudurg (Malvan). Jellyfish samples were collected through fisher-assisted onboard sampling and from bycatch at landing centers during the study period from October 2023 to September 2024. The species was confirmed using morphological assessment and molecular analysis based on the partial sequence of Cytochrome C Oxidase I (COI) gene, which has been submitted to the NCBI database. R. hispidum was found to be distributed in three districts namely Palghar, Mumbai Suburban and Palghar. The species were recorded during February, March and April. Hence, the season of occurrence was identified as pre-monsoon. The distribution pattern was mapped along the coast of Maharashtra, revealing that it has a wider range of distribution from 10 to 60 meters in depth. This study concludes that R. hispidum which is a commercially harvested jellyfish is also distributed in three coastal districts of Maharashtra and has the potential to support commercial fisheries if its distribution pattern is further monitored.

Keywords: Scyphozoan jellyfish, Molecular identification, Commercial fisheries, Bloom impact, Arabian sea

Deformities in *Heteropneustes fossilis* Collected from Kishanganj Fish Market, Bihar, India: Observations and Implications

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The Asian stinging catfish, Heteropneustes fossilis, holds significant economic value across Asia, notably in India, where it is widely farmed for its high market demand and nutritional value. H. fossilis is a popular fish among consumers as it has very less intramuscular bones. However, recent studies, including observations from fish markets in Kishangani, Bihar, India have reported a concerning prevalence of deformities in this species, manifesting as spinal malformations and curved backbones. The potential causes of these deformities can be multifaceted. Deformities appear to result from a combination of environmental stressors and suboptimal aquaculture practices, including poor water quality, high stocking density, and possibly genetic factors affecting their overall health and survivability. The economic implications of these deformities are significant, as consumers prefer visually healthy fish and don't want to purchase deformed fish even at a much lower price than the actual. Deformities impact market demand, thus affecting the livelihoods of local fish farmers and vendors. Effective management and improved rearing conditions are essential to mitigate deformities and support sustainable aquaculture. Implementing sustainable aquaculture practices, along with potential circular economy strategies, may enhance market stability, reduce financial losses, and support the continued economic viability of *H. fossilis* farming.

KEYWORDS: Heteropneustes fossilis, Deformities, Aquaculture, Economic impact, Sustainability

Fishing Mortality and Natural Mortality of *Lates calcarifer* in Chilka Lagoon, East Coast of India

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The fishing mortality and natural mortality of *Lates calcarifer* in Chilka lagoon has been studied using FiSAT software package. A total of 600 numbers of *L. calcarifer* from different size groups ranging between 12.00 cm and 51.00 cm in total length and 87.0 g and 2200 g in total weight were collected from different landing centers of Chilika lagoon during the year 2023. The growth co-efficient (K) was found to be 0.53/yr. The M/K values lie within the range of 1.0 to 2.5 suggesting reasonability in the study of natural mortality. The value of Z/K is found to be 2.91 indicating that the stock was mortality dominated during the sampling period.

KEYWORDS: Fishing mortality, Natural mortality, Growth co-efficient

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Establishing a DNA Barcode Database for Fish Species in the Sardar Sarovar Reservoir

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The Sardar Sarovar Reservoir, located on the Narmada River is a multipurpose river valley project, stretching 214 km upstream from the Sardar Sarovar Dam. The reservoir has its submerged area spread across three states including Madhya Pradesh, Maharashtra, and Guiarat. The present study was designed to generate DNA barcodes for the identification of species using cytochrome oxidase I (COI). Cytochrome Oxidase I (COI) DNA barcodes were generated for 17 species and the obtained barcodes differentiated all the species with sufficient barcode gap. The order Cypriniformes represented the highest diversity with 9 species followed by Siluriformes with 4 species. The majority share in terms of species richness was attributed to family Cyprinidae (8 species). In addition to barcode-based species identification using COI, phylogenetic relationships among the species have also been attempted. The average genetic distance was reported to be 11.87% at the genus level, 15.05% between the genus, 9.51% between family and 24.42% between the order. Neighbourjoining tree was generated based on DNA barcodes and all the specimens clustered in agreement with their taxonomic classification at the species level. The generated barcodes provide a baseline reference for the ichthyofaunal biodiversity of the region which is crucial for sustaining the ichthyofaunal diversity and promoting appropriate conservation strategies and management planning of fisheries in the Sardar Sarovar Reservoir.

KEYWORDS: Sardar Sarovar Reservoir, DNA barcoding, Cytochrome Oxidase I, Fish biodiversity, Cyprinidae, Phylogenetics

Exploring Environmental Patterns Influencing *Coscinodiscus* **Blooms in Tropical Estuarine Ecosystems**

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A phytoplankton bloom is defined by the rapid and dense proliferation of microscopic algae within aquatic systems. This study focused on the occurrence of such blooms, particularly those dominated by the genus *Coscinodiscus*, within the tropical Patalganga River estuary, aiming to assess the environmental factors influencing Coscinodiscus bloom development in this complex ecosystem. A total of three Coscinodiscus species, along with 22 species from other genera, were documented during the bloom period. The class Coscinodiscophyceae contributed 24%, followed by Bacillariophyceae (32%), Mediophyceae (20%), Dinophyceae (20%), and Cyanophyceae (4%). Coscinodiscus cell densities ranged from 6.25 x 10³ to 5.43 x 10³ cells/l. The Shannon-Weiner diversity index (H') ranged from 0.30 to 0.54, reflecting reduced diversity towards the upper estuary at station S6. Diversity indices indicated low species diversity during the bloom, with Coscinodiscus dominating the phytoplankton community. Cluster analysis and nMDS showed distinct groupings of sampling stations based on species composition. BIO-ENV analysis identified pH, dissolved oxygen, alkalinity, and silicate as key factors influencing bloom formation and the abundance of associated species. Canonical correspondence analysis (CCA) showed that the bloom of Coscinodiscus radiatus was positively associated with salinity, transparency, and alkalinity, while Coscinodiscus wailesii and Coscinodiscus centralis were positively linked to pH, temperature, nitrate, nitrite, and chlorophyll-a. The study underscores the significance of monitoring phytoplankton blooms and their environmental drivers in the Patalganga River estuary, as understanding these dynamics is essential for sustainable management and conservation of aquatic ecosystems under increasing anthropogenic pressures.

KEYWORDS: Environmental pattern, Coscinodiscus bloom, Estuarine ecosystem

Exploring Remotely Sensed Biophysical Links of Tuna Catch Rate Using Machine Learning Models: A Pathway to Sustainable Exploitation of Tuna in Indian Waters

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The sustainable exploitation of oceanic resources such as tuna is essential for fostering blue economy. This study presents a modelling of spatio-temporal distribution of tuna along the north-west coast of India, offering key insights into potential strategies for enhancing the blue economy through responsible resource utilization. One of the major challenges to achieving sustainability in tuna fisheries has been the lack of detailed spatial information on fishing grounds. To address this knowledge gap, spatially explicit data were collected from tuna gillnetters' fishing grounds between 2011 and 2024, along with remotely sensed environmental factors. Machine learning models were applied to integrate fishery and environmental data, identifying potential fishing grounds at a spatio-temporal scale. The study demonstrated that remotely sensed factors such as Sea Surface Temperature (SST), Sea Surface Height (SSH), Chlorophyll-a (CHL), Mixed Layer Depth (MLD), Oxygen (OXG), and Eddy Kinetic Energy (EKE) with machine learning approaches significantly improved the efficiency of prediction. These findings enhance our understanding of the spatial extent of tuna distribution in the region by correlating environmental factors with fishery catch rates. The study also examined spatial and temporal variations in tuna catches, shedding light on their distribution patterns. This study could be adapted to nearby countries in the Arabian Sea region for an effective and useful tool to monitor and manage the fishery resources. Furthermore, it could aid in decision-making for policymakers and resource managers to formulate strategies for holistic marine fishery management and sustainable resource exploitation.

Keywords: Tuna fisheries, Yellowfin tuna, Species Distribution Modelling, Blue economy, Arabian Sea

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Enhancing Energy Efficiency in Trawling: Success Story of CIFT-VSOB

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Trawling, contributing approximately 52% of India's total marine fish production, remains one of the most fuel-intensive fishing techniques, posing significant environmental and economic challenges. With growing concerns over greenhouse gas emissions and global warming, innovations in gear design are imperative to enhance fuel efficiency and sustainability in the trawling sector. Among the key components of trawl systems, otter boards contribute nearly 20% of the total trawl drag. To address this issue, the ICAR-Central Institute of Fisheries Technology (ICAR-CIFT) developed the V-form Double Slotted Otter Board (CIFT-VSOB), an advanced hydrodynamic design incorporating strategically positioned slots in the front section. Extensive field trials using fuel consumption meters demonstrated that the CIFT-VSOB significantly reduced diesel consumption by 2–3 liters per hour compared to conventional otter boards, while maintaining optimal horizontal spread and catch efficiency. Adoption of the CIFT-VSOB at scale could have profound environmental benefits; if implemented in at least 50% of India's trawler fleet, it is estimated to save approximately 9 million liters of diesel annually, preventing 18 million kilograms of CO, emissions. Moreover, the use of marinegrade steel in its construction enhances durability, doubling the lifespan of the otter boards and improving cost-effectiveness. Currently, about 10% of trawlers in Kerala, Karnataka, and Tamil Nadu have integrated this technology, facilitated by financial support from the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and the National Fisheries Development Board (NFDB). This study highlights the potential of integrating hydrodynamic engineering into fisheries operations to simultaneously address environmental sustainability and economic efficiency. Widespread adoption of such innovations could significantly reduce the carbon footprint of trawl fisheries, contributing to global efforts to mitigate climate change while ensuring the economic viability of fishing communities.

KEYWORDS: Sustainability, Carbon footprint, Greenhouse gases, Fisheries, Otterboard

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SEM Analysis, Statistical Validation and Environmental Degradation Studies of Rayon-based Biodegradable Fishing Materials

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Marine litter, particularly from synthetic fishing gear, has become a significant environmental concern. This study explores the potential of rayon-based biodegradable fishing nets as eco-friendly alternatives by integrating Scanning Electron Microscopy (SEM) imaging, fortnightly underwater degradation tests, and statistical analysis. The study examined the effects of temperature, salinity, and pH on degradation patterns under controlled freshwater conditions, with three test conditions (T) and replicates (R) for robust evaluation. SEM imaging provided detailed visualization of the material's degradation progression. Initial micrographs of untreated samples revealed smooth, dense fiber surfaces with consistent alignment. Postexposure images showed progressive fiber fragmentation, surface roughness, and pore development, with degradation varying across conditions. After 14 days, samples exposed to high salinity (35%) exhibited a 42% increase in surface porosity and a 37% reduction in fiber thickness compared to untreated samples. Low pH (6.0) accelerated hydrolytic degradation, resulting in a 28% increase in fibril separation, while higher temperatures (32°C) intensified molecular breakdown, causing a 45% loss in structural integrity. The underwater degradation study revealed significant differences in the material's biodegradation rates. Statistical analysis using ANOVA confirmed the effects of salinity and pH (p<0.01) on degradation, with salinity emerging as the most influential factor. Multivariate analysis highlighted interactive effects, with high salinity and acidic pH conditions resulting in a 52% tensile strength reduction. Tensile strength decreased from 85N to 41N under combined high salinity and acidic conditions, demonstrating the material's potential for biodegradation in diverse marine environments. These findings suggest that rayon-based biodegradable fishing nets could reduce marine litter by degrading within weeks under typical marine conditions. The integration of SEM imaging and statistical validation underscores the potential for scaling production and optimizing these materials for real-world applications. Future research will focus on field trials and life cycle assessments to promote the adoption of sustainable fishing gear.

KEYWORDS: Ghost Nets, Biodegradable Fishing Nets, Environmental Degradation, SEM Analysis



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Evaluating the Stock Health Status of the Crucifix Crab, *Charybdis feriata* (Linnaeus, 1758) in the Indian Waters: A Regional Analysis

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Charybdis feriata (Linnaeus, 1758), also known as the crucifix crab, is a large portunid species found in tropical and subtropical Indo-Pacific waters. In India, it is a commercially important species due to its size and meat quality, contributing around 3,821 tonnes (0.11%) to the nation's total marine landings. The Northwest (NW) region contributes the most, with 1,830.3 tonnes (48%), followed by the Southwest (SW) region with 1,369.43 tonnes (36%). The Northeast (NE) and Southeast (SE) regions contribute 442.83 tonnes (12%) and 178.40 tonnes (5%), respectively. The resource is primarily exploited by trawlers (94.8%), followed by gill netters (1.6%) and dol netters (1.3%). Given its fisheries importance, the stock health of C. feriata was assessed using the Bayesian state-space implementation (BSM) of the Schaefer surplus production model (Schaefer, 1954), following the approach suggested by Froese et al. (2017) using the CMSY++ R package. This analysis provided initial estimates of fisheries reference points such as maximum sustainable yield (MSY), F_{MSY} , B_{MSY} , and the relative stock size (B/B_{MSY}) and exploitation (F/F_{MSY}). Long-term catch and abundance (catch per unit hour) time-series data from different regions, covering the period 2007 to 2021, were used for the analysis. The resilience of the species was found to be high (r = 0.98), likely due to its faster growth rate and reproduction. The total MSY for all regions was estimated at 6,031.2 tonnes. The relative biomass (B/B₀) was highest in the SE region (0.79), followed by the NE and SW regions, each with a B/B₀ of 0.67. The lowest B/B₀ was observed in the NW region (0.45). Depletion was most pronounced in the NW region, where catches declined continuously from 2,985.7 tonnes in 2016 to 355 tonnes in 2021. Similarly, B/B_{MSV} was above 1 for all the regions except the NW region, where it was at 0.91. The relative fishing mortality (F/F_{MSY}) was lower than 1 in all regions, indicating the potential for an increase in exploitation to obtain MSY. A comparison of B/B_{MSY} and F/F_{MSY} using a Kobe plot suggests that the resource is in a healthy and sustainable state in all regions of India except the NW region, where it is recovering rapidly. Given the low targeted exploitation (F/F_{MSV}) for the species in the NW region, the resource is expected to be abundant and in a healthy sustainable state in the coming years.

KEYWORDS: BSM, Crab, Stock health status, Sustainable, Data-limited method, India

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Technical Session-2 Sustainable Aquaculture Intensification and Diversification



Development of Sustainable Bioflocculation Technology Using Diatoms and Their Secretions

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Bioflocculation technology offers significant economic and environmental benefits in aquaculture, including improved water quality stabilization, reduced feed consumption, and minimized water change frequency. Chemical flocculants have traditionally been used to accelerate floc formation; however, concerns have arisen regarding their environmental and biosafety risks. Meanwhile, the widespread adoption of modern intensive aquaculture has increased the incidence of infectious diseases in aquatic animals, complicating the stable maintenance of bioflocs. This work aims to develop a natural biofloc system using diatoms and their secreted molecules as a sustainable alternative to chemical flocculants. Sterile kaolin served as a model suspended particle to simulate aquaculture conditions and evaluate the flocculation activity of the tested samples. Compared to chemical flocculants, the stress-induced diatoms combined with *Bacillus* sp. demonstrated comparable flocculation efficiency. Under the optimal algal cell-to-bacteria ratio, a similar level of flocculation effect was achieved. Using diatom secretions, such as polyamines, as flocculants demonstrated that spermidine and nor-spermine exhibit excellent flocculation effects, even at nanomolar concentrations. Fucose-containing sulfated polysaccharides produced by diatoms have been shown to enhance biofloc formation more effectively than fucoidan from brown algae. The results highlight the potential of a natural flocculation system centered on diatoms and their secretions to replace chemical flocculants, offering valuable applications for efficient and safe aquaculture management. Research efforts will focus on optimizing the production, scalability, and stability of diatom-derived secretions under diverse environmental conditions to improve their applicability in real-world aquaculture settings.

KEYWORDS: Polyamines, Biofloc, Diatom secretions, Aquaculture management

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Aquaculture Spatial Planning: A Tool for the Expansion of Responsible Aquaculture

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Shrimp aquaculture initially developed without comprehensive spatial planning, leading to a sudden collapse of the sector in many countries. The imbalance due to unplanned growth of the sector on one side and vast brackishwater areas available on the other side has been observed in many countries. Comprehensive planning for aquaculture is still uncommon, and the fact that many farms are abandoned or are suffering significant disease problems demonstrates the need for such improvement in planning. The guidelines have been framed for the development of aquaculture in shrimp-growing nations. In India too, Coastal Aquaculture Authority (CAA) regulations ban the use of mangroves, agricultural lands, and common water bodies for shrimp aquaculture and impose a buffer zone between different resources and aquaculture. However, the area under shrimp aquaculture has stagnated in India since the last two decades. The aquaculture expansion needs to be responsible as land is a major limiting factor and multiple users share the coastal region. For aquaculture spatial planning tools, land use land cover, water availability, water quality, soil characteristics, and carrying capacity of water bodies, CAA guidelines have been used for expanding responsible aquaculture. The existing aquaculture maps and high tide lines of the sea have been drawn to quantify the aquaculture farms within CAA limits. The unused lands with supporting brackishwater creeks have been delineated, and the mudflats suitable for mangrove regeneration have been drawn. The model spatial analysis has been carried out using ArcGIS Pro. The carrying capacity of waterbodies has been delineated to assess assimilation capacity for further possible expansion. The spatial model was evaluated in the selected districts of Tamil Nadu, Andhra Pradesh and Puducherry. Aquaculture spatial planning (ASP) needs to be done for all coastal states, which will surely bring down the potential area due to spatial restrictions and sharing of the resources for other uses.

KEYWORDS: Coastal aquaculture, CAA act, ASP, Spatial analysis, Aquaculture zones

BioflocTechnology Enhances Growth Performance, Antioxidative Activity and Intestinal Health of Immature Metamorphic Froglet (Hoplobatrachus rugulosus)

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Traditional tadpole farming methods, such as continuous flow systems, significantly contribute to environmental pollution by discharging nutrient-rich effluents that exacerbate water contamination. Biofloc technology (BFT) represents an eco-friendly aquaculture approach that enhances water quality management and nutrient recycling through microbial aggregates. The study aims to assess the potential of BFT on the growth performance, antioxidant defenses, intestinal morphology, and gut microbiota of Hoplobatrachus rugulosus tadpoles' culture during metamorphosis. The results indicate that the biofloc group achieved significantly higher cumulative metamorphic rates, body weight, and body length compared to the control group (p<0.05). Enhanced antioxidant enzyme activities, including superoxide dismutase (SOD) and catalase (CAT), were observed in the biofloc group, accompanied by reduced malondialdehyde (MDA) levels (p<0.05). Furthermore, improved intestinal villus structure increased lipase and protease activities, and decreased amylase activity suggested enhanced nutrient absorption. Microbiota analysis revealed a significant enrichment of Proteobacteria and genera such as Citrobacter and Klebsiella in the biofloc group (p<0.05). Functional predictions further indicated increased thyroid hormone synthesis pathways, correlating with improved cumulative metamorphic rates. In conclusion, these findings highlight the potential of BFT to improve growth performance and physiological adaptations in amphibian aquaculture, providing a sustainable and innovative strategy for rearing tadpoles.

Keywords: Biofloc technology, *Hoplobatrachus rugulosus*, Digestive enzyme, Intestinal microbiota, antioxidant enzyme

Measuring the Site Suitability for Aquaculture in a Small Tropical Indian Estuary using PCA Based Multi-Criteria Decision Making of Bio-Physico-Chemical-Operational Data Frame

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The wild-caught fish production is stagnating globally and the need for fish from domestic and export markets is on the rise. Aquaculture is a solution to the growing demand for fish and is an important provisioning ecosystem service rendered by estuaries and backwaters in the coastal region. Choosing the right site for aquaculture is essential to provide optimal conditions for fish to feed and grow to marketable sizes, even while avoiding negative environmental impacts. We assessed the site suitability of a small tropical estuary - Chettuva, along the southwest coast of India for aquaculture activities using Principal Component Analysis (PCA) based Multi-Criteria-Decision-Making (MCDM) protocol and spatial analysis. The selected variables included physico-chemical (temperature, dissolved oxygen, depth, pH, chlorophyll-a, turbidity, ammonia, bio-chemical oxygen demand, nitrite, nitrate, phosphate) and operational [channel width, distances to -1) mouth, 2) navigation route, 3) freshwater discharge, 4) sewage disposal sites, 5) agricultural fields, and 6) harbours] types. The variables were spatially mapped and the sites suitable for aquaculture were delineated using the water quality index mapping based on the selected variables. The spatial analysis indicated 12.4% of the area as very good, 6.5% area as good, and 29.9% of the area as moderately suitable for aquaculture activities. The most critical factor is the depth of the estuary which is a matter of concern due to the deposition of silt in the last two decades, ravaging flood events and the challenges in the management of Groyne in the bar mouth. The study, thus showed how the spatial analysis and PCA-based MCDM can facilitate site selection for aquaculture, aiding stakeholders in the efficient utilization of water resources for fish culture.

KEYWORDS: Tropical estuary, Aquaculture, Site selection, MCDM, PCA, Water quality index

Effect of Vitamin C and CIFA M-CheckTM on Growth and Survival of Implanted Pearl Mussel, *Lamellidens marginalis*

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Survival of implanted mussel is one of the major concerns in the freshwater pearl farming sector. In this backdrop, a 120-day culture trial was conducted to evaluate the efficacy of the supplementation of Vitamin C and CIFA M-Check to improve the growth and survival of implanted mussels. A total of two hundred twenty-five healthy mussels (avg. size: 8.31 cm; avg. wt 48.88 g) were distributed in five treatment groups including control in 15 aquaria, each tank having 30 litres of water. The CIFA M-Check was applied for the first seven days after implantation and Vitamin C (T1: C0, T2: C20, T3: C40, T4: C 80 mg/l) was applied regularly. The control group was devoid of disinfectant and vitamin C supplementation. Live *Chlorella* was provided as feed to all the mussels throughout the experimental period. A statistically significant (p<0.05) variation was noted between the experimental and control groups in terms of final weight, specific growth rate (SGR), weight gain percentage, percent length gain, and survival. But across all the treatments, including control, there was no discernible difference (p>0.05) in Fulton's condition factor. Further, the highest survival and SGR were observed in T2 (20 mg/l Vitamin C) as compared to the control. These findings indicate that using CIFA M-CheckTM in the critical post-implantation phase, combined with regular Vitamin C supplementation at 20 mg/l, can effectively enhance the growth and survival of implanted mussels. This approach could improve management practices in pearl aquaculture, aiding farmers in increasing yields and reducing losses due to implantation stress and related factors.

Keywords: Implanted mussel, CIFA M-Check™, Vitamin C, Growth, Survival

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Amelioration Measures to Reduce Total Alkalinity in Inland Saline Aquaculture Ponds

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In recent times, salinization has been a major concern that has affected over 380 million ha of land spreading over 20 countries worldwide. In India, nearly 8.62 million ha of land area is affected by soil salinity and about 40% is clustered in the north-western, semiarid/ arid states of Haryana, Punjab, Uttar Pradesh, and Rajasthan. This type of wasteland cannot be used for agriculture and is instead being used for farming of brackishwater species. The primary candidate shrimp species suitable for inland saline water is the Pacific white shrimp, Penaeus vannamei. Generally inland saline waters are characterized by high alkalinity and pH, imbalanced ions, and complex chemical composition. High total alkalinity (TA) affects survival, moulting and reduces immunity. To reduce TA and utilize the inland areas effectively, different chemicals and organics were screened. Among the chemicals, sodium-bisulphate (NaHSO₄) was the most effective, about 1.3 and 1.6 ppm reduces 1 ppm of TA under 2 and 25 % salinity, respectively. Sodium-bisulphate significantly reduced the TA in the first hour, and almost stabilized thereafter. A yard experiment was conducted on P. vannamei with a stocking density of 80/m² to study the effect of NaHSO₄ on animal survival, change in TA, growth rate, biochemical parameters and other water quality parameters. A total alkalinity experiment was conducted for a month under six different treatments viz., control (T₁), 600 ppm (T_2) , TA reduced from 600 to 300 (T_3) , 600 to 200 (T_4) , 300 (T_5) , and 300 to 200 (T_6) under two salinities 2 and 25 %. Animal survival was good and the growth rate increase was 25.6 and 31.3% at high salinity, and 70.4 and 68.9% at low salinity in T_3 and T_4 respectively compared to T₂. pH numerically decreased on NaHSO₄ application and returned to normal within a day. The addition of NaHSO₄ did not cause any significant changes in dissolved oxygen and other water quality parameters and protein, ash and fat content in the animals. Total haemocyte count was low under high TA and increased with NaHSO, addition. To conclude, NaHSO₄ may be recommended to remediate high alkalinity issues.

KEYWORDS: Penaeus vannamei, Alkalinity, Sodium bisulphate, Growth

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CIFA-Brood-Vac Enhances the Breeding Performance of the Striped Catfish, *Pangasianodon hypophthalmus* (Sauvage, 1878)

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A study was conducted to determine the efficacy of the "CIFA-Brood-Vac" on the breeding performance of the striped catfish, *Pangasianodon hypophthalmus* (Sauvage, 1878). In this study, the control group of broad fishes was injected with a commercially available inducing agent only, and in the treatment group, female brood fishes were injected with the "CIFAbrood-vac" (0.5 ml/fish) along with the commercially available inducing agent. In both groups, the dose of the commercially available inducing agent was 0.2 ml/kg body weight in males, and 0.4 ml/kg body weight in females. The results revealed that in the treatment group, the fecundity was significantly higher (1.22±0.12 lakh eggs/kg body weight) than in the control group (0.75±0.15 lakh eggs/kg body weight). Likewise, the fertilisation rate was higher in the treatment group (99.18±0.52%) in comparison to the control group (80.6±1.56%), and the hatching percentage in the treatment group was ~89.56±1.33 which was quite higher than the control group (68.5±1.22). Further, "CIFA-brood-vac" also helped in enhancing the survivability of the spawn as ~98 % of the spawn were recovered from the treatment group, whereas only 88% of spawn were recovered from the experimental group. These results together highlight the important function of the "CIFA-brood-vac" in enhancing the breeding performance of the striped catfish.

KEYWORDS: Striped catfish, CIFA-brood-vac, Breeding performance, Fish vaccine

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Biofloc Aquaculture in India, What More is Needed to Achieve Sustainability and Commercial Viability

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Traditional land-based aquaculture in India has little scope for expansion due to the nonavailability of suitable land and water resources. To further increase production from aquaculture, the requirement for robust technologies is the need of the hour that requires less space and utilization per drop of water for more production in a sustainable manner. Landbased aquaculture production affects the environment, and state-of-the-art Biofloc Aquaculture System (BAS) offers a promising solution for intensification, better utilization of feed, yield improvement and economic performance. Despite its numerous advantages, BAS presents several challenges, such as high energy demand, high initial/running costs, waste (effluent, suspended solids, and sludge) management, opportunistic pathogens (Vibrio) spread, and a lack of understanding of operational/aquatic/microbial dynamics. Managing these issues requires sound scientific knowledge and practical/field skills besides the selection of suitable species that can effectively cope with the system, and system logistic requirements. In view of the above, the Government of India emphasized on introduction of BAS to the farming community in India during the COVID-19 pandemic to provide immediate monetary relief to the suffering community with small land holdings in a short span. In the last 4 years, a total of over 4000 biofloc units have been approved under the PMMSY scheme of the Government of India, and a good number under the state government plans. To evaluate the performance of biofloc units at the farmer's level, 200 units of biofloc in 16 districts of Kerala, Odisha, and Uttar Pradesh were selected for the study. The study was focused on the fish species used, species combinations, productivity, cost analysis, and the type of beneficiaries (age, gender, education, experience). The study provided an overview of the advantages and the challenges of BAS and highlighted the key technical, biological, and economic considerations to optimize its application and for further promotion/ adoption by overcoming the current challenges. Based on the farmers' perception, the desired interventions have been proposed that need to be solved through future research, extension, and policy planning.

KEYWORDS: Biofloc, Species selection, Productivity, Technical issues, Policy

Optimizing Stocking Density for Growth Enhancement and Survival of Amur Carp in Inland Floating Cages in Large Tropical Reservoir of India

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The study aimed to evaluate the growth performance and survival of Amur carp at different stocking densities in inland floating cages at Maithon reservoir, Jharkhand, India, over a 180day period. Fingerlings of Amur carp (12.27±0.31 cm and 35.6±3.16 g) were stocked in three different densities: 10 fish/m³ (SD 10), 20 fish/m³ (SD 20), and 30 fish/m³ (SD 30), each in duplicate in galvanized iron (GI) cages. The fish were fed a commercial floating pellet diet (28% crude protein and 4% crude fat) twice daily (9:00 and 16:00) at 5-3% of their body weight. Water quality parameters were measured monthly from inside the cages, 50 m and 100 m away from the cages. The results showed that stocking density significantly affected the growth and survival of Amur carp. The lowest density of 10 fish/m³ (SD 10) achieved significantly higher (p<0.05) weight gain (358.64 \pm 10.05 g), absolute growth rate (2.00 \pm 0.05), and specific growth rate (1.34±0.02) compared to the higher densities (SD 20 and SD 30). Better feed utilization and efficiency were observed in the lower density (SD 10), while a poorer survival rate was reported in the highest density (SD 30). Condition factor (K) ranged from 1.88±0.01 (SD 10) to 1.91±0.03 (SD 30) with no significant differences among treatments. The benefit-cost ratio was highest in SD 10 (1.18), indicating better economic returns. The findings suggest that rearing Amur carp at a lower density of 10 fish/m³ may be considered optimal for grow-out culture in inland open-water cages for better growth and survival.

KEYWORDS: Stocking density, Amur carp, Cage culture, Growth, Species diversification

Comparative Analysis of Gonadal Maturity and Haematological Parameters in Hormone Pellet Implanted Streaked Spine Foot Rabbit Fish Siganus javus

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Commercial cultivation of lower trophic level fishes is gaining importance to meet human nutritional requirements and sustainability of coastal farming. Captive maturation and breeding of streaked spinefoot rabbit fish Siganus javus, a commercially important lower trophic level brackishwater foodfish, has been constrained by limited information on its reproductive biology. To understand the gonadal maturity of S. javus in relation to their length, weight and different seasons, wild-caught fishes (average length of 41.10±2.0 cm and weight 892.0±15.20 g) were conditioned in 10t indoor FRP tanks and fed ad libitum twice daily with formulated pellet feeds. Seasonal ovarian development was monitored from April to August 2024, to understand the endocrine regulation of gonadal development and the optimal time for induction of spawning. Further, the effect of sex hormones on gonad development was also examined by implanting female and male fish with LHRH and 17a methyl testosterone (MT) hormone pellets, respectively, at a dose of 50 µg/kg body weight. Serum samples from both hormone-implanted and non-implanted fish were analysed for 17β-estradiol and testosterone levels using ELISA. The results indicated that implanted fish had larger oocyte diameter (120-328 µm) compared to the non-implanted fish (120-214 μm). Progress of oocyte maturation in wild-caught fishes was recorded as 95 μm to 140 um from April to August. Estradiol levels were higher in females, while testosterone levels were elevated in males, supporting the stimulatory role of sex steroids on fish maturation. No significant differences were observed between hormone-implanted and non-implanted males. Further research is needed to optimize hormone dosage for final oocyte maturation in captive broodstock.

KEYWORDS: Vitellogenic oocytes, Estradiol, Gonadal maturity

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Antifouling Strategies in Aquaculture Cage Nets through Surface Modification of Polyalkene Using Polyaniline and Nano Carbon Dot-Graphene Biocide

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Marine biofouling is a challenge to aquaculture farmers, as it consumes 25% of the project cost for its management. It begins with the adsorption of organic molecules, leading to microbial adhesion, biofilm formation, and eventually the attachment of larger organisms like barnacles and mussels. In aquaculture cages, biofouling clogs the lumens of cage nets, causing feed accumulation, microbial growth, algal blooms, and poor crop yields, necessitating early intervention in biofilm formation. Polyethylene's non-polar and hydrophobic nature not only facilitates the accumulation of organic matter, leading to biofouling but also makes it difficult to incorporate biocides. Strategies are already in place to modify the non-polar polyethylene surface to a polar one using polyaniline, successfully embedding biocides like copper. The use of inorganic biocides against biofouling has low interest among fishers, highlighting the need to develop sustainable biocides. The present study aimed to synthesize a carbon-based biocide, nano carbon dot-graphene composite (CD-Gr), and to evaluate its application against marine biofoulers. The polyethylene aquaculture cage net surface was modified using polyaniline, a conducting polymer, and the CD-Gr composite was coated over the net and exposed to the estuarine environment for 8 months. The optimum ratio for better CD-Gr was 1:3 (CD: Gr) with a particle size of 21 nm. The nano CD-Gr composite formed with a few unorganized layers and exhibited an amorphous nature. The carbon dot interacted with graphene through its conjugated C=C double bonds, OH and N-H functional groups. Varied concentrations of CD-Gr coated over an aquaculture cage net and its exposure in an estuarine environment revealed 0.02% as the optimum concentration for maximum biofouling inhibition. The study related the biocidal mechanism of the composites to the synergistic activity of CDs and graphene under sunlight to generate ROS and free radical species, thereby interfering with the microbial biofilm formation on the cage net resulting in enhanced biofouling resistance.

KEYWORDS: Carbon dots, Fish eye, CD-graphene composite, Marine biofouling, Hydrothermal synthesis, Polyaniline surface modification

Salinity Resilience of Marine Ornamental Clownfish Varieties, Revealed by Gill Histopathology

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The fish gill is the core target organ for acute chemical and physical changes in their living aquatic environment. The study was aimed to examine the histopathological alterations in the gills of hatchery-produced juveniles of *Amphiprion percula* and *Amphiprion frenatus*, which were exposed to five levels of low salinity (24‰, 18‰, 12‰, 6‰, and 0‰) for a period of 120 hours to test their salinity resilience. Microscopic examinations of low salinity exposed fish gill architecture were assessed with the control groups, which exhibited a normal architecture. Histopathological examination showed a positive correlation between increasing degrees of gill damage and the lowering of salinity. The main vicissitudes on the gill observed in both the species were alteration of the arrangement of the epithelium, vacuolation, hypertrophy and hyperaemia of the epithelium of the primary lamella and hydropic degeneration in the secondary lamella. Histopathological changes observed in fish gills of *Amphiprion percula* and *A. frenatus* revealed their resilience to low salinity.

KEYWORDS: Clownfish, Salinity resilience, Histopathology, Gills, Alterations

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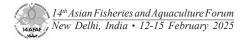
Gonadal Maturity Stage Identification and Oocyte Size Measurement using Deep Learning Ultrasound Tool in Pearlspot, *Etroplus suratensis*

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Ultrasonography is an imaging technology that allows the visualization and evaluation of internal structures of organs of animals without the need for invasive procedures like surgery, biopsy, or euthanasia which is stressful and even lethal. This technology is increasingly being used in fish reproduction across various species to determine gonadal development where sexual dimorphism is absent. The information obtained through ultrasonography can be used in hatcheries for decision-making on reproductive efficiency, benefiting research, management of culture fisheries and the conservation of endangered species. However, a limitation of ultrasound imaging is the lack of trained personnel capable of interpreting images, particularly from immature to mature gonadal stages in specific fish species. The present study aims to explore the potential of using both machine learning and deep learning techniques to classify ultrasound images quickly and automatically. A SonoSite Edge II ultrasound imaging system with a linear array transducer (6 to 13 MHz) was used to image adult pearspot Etroplus suratensis. Following the capture of gonadal sonograms, gonadal tissues were processed for conventional reproductive parameter studies. The gonadosomatic index (GSI) and ovarian follicle diameter were also measured throughout the entire reproductive cycle. Additionally, parameters such as gonad length, weight, width, GSI, and histological gonadal stages were aligned with ultrasound-measured parameters and gonadal stages to evaluate the efficiency of ultrasonography. The dataset was with labels for the images provided from ultrasonography and histological studies. Support vector machine, VGG16 and DenseNet have been used to classify the images. While SVM is a machine learning model, VGG16 and DenseNet are based on transfer learning. By using transfer learning, we combine the benefit of having already learned several image features from a pre-existing dataset along with the ability to adjust the weights in the last layer for our specific application. This is beneficial because the present dataset is comparatively small and cannot be used to train large models. Results indicate that transfer learning provides better performance than SVM. It is also demonstrated in this work that minimum and maximum oocyte diameter can be predicted by performing regression on the images with an average absolute error of 21 microns with 93% accuracy.

KEYWORDS: Gonadal maturity, Ultrasound, Pearlspot, Deep learning



Exploring Age-Dependent Fertility Traits in Male Golden Mahseer Brooders for Improved Hatchery Efficiency

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Despite recent technological advancements in female broodstock management of golden mahseer, the reproductive efficiency of male brooders, especially under captive conditions, remains underexplored. This study addresses the gap by investigating age-dependent fertility traits in male golden mahseer to optimize hatchery output. Three experimental groups of male brooders, based on age (2⁺, 3⁺ and 5⁺ year), were reared in 10001 circular tanks with gravelbed substratum and photo-thermal manipulations. The fish were maintained under a 12h:12h photoperiod, with light intensity ranging from 1200-1400 lux, and fed a broodstock diet ad libitum. Water quality parameters were closely monitored, including temperature, dissolved oxygen, pH, nitrite, ammonia, and hardness. Milt samples from each group were collected. Sperm count and morphology were assessed to determine age-dependent fertility. In vivo milt quality was evaluated by fertilizing eggs, followed by examining fertilization success, hatching rates, survival, and growth of fry. Additionally, we also assessed phenotypic traits such as fry thermal tolerance (CTmax and CTmin), antioxidant enzyme activity (superoxide dismutase, catalase), TBARS, total antioxidant potential, and glucose levels in seminal plasma. Testosterone and 11-keto testosterone concentrations were also analyzed across the different age groups. Results showed comparatively higher reproductive efficiency in terms of sperm count, spermatocrit, morphology, viability, biochemical indices, and environmental fitness (of fry) among the age group. In a nutshell, the study provides critical insights into optimizing male golden mahseer broodstock management for enhancing breeding success and hatchery output.

KEYWORDS: Golden mahseer, Hatchery output, Fertility traits, Larval fitness, Milt quality

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Optimizing the Nursery Rearing of *Scylla olivacea* Through Culture System Modification and Feeding Strategies

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Mud crabs (genus Scylla) are crucial to Indian aquaculture due to their high value, rapid growth, adaptability, and taste. However, wild populations are declining due to overharvesting of the stock. Commercial hatchery production of mud crab is still insufficient, particularly in the case of Scylla olivacea, a regionally important species. The production of stockable juveniles of this species is challenging particularly from megalopa to stockable juvenile crab. In order to address the issues in nursery rearing of this species, several indoor and outdoor experiments were carried out. The effect of various hideout/substratum (seaweed bed, ST1; seaweed bed + vertical seaweed ropes, ST2 and seaweed bed + black shade net, ST3), colour of the tank (white, CT1; black, CT2; light blue, CT3; yellow, CT4; orange, CT5 and red, CT6), and feed (clam meat, FT; artificial feed, FT2 and clam meat + artificial feed, FT3) on survival and weight/size was evaluated. No significant difference was found between the substratum treatments in the case of the weight and survival of S. olivacea megalopa. The carapace width was significantly higher in ST1 (13.8±2.31 mm) compared to ST2 (11.65±2.64 mm) and ST3 (12.85±2.11 mm). The survival was found to be significantly higher in treatment reared in orange colour tanks, (CT5; 87±2.65 %) and there was no significant difference in treatments fed with artificial feed (FT2: 44±4.6%) and clam meat + artificial feed (FT3; 52±3%). The current study provides valuable data into the improvement of survival in the nursery phase of mud crabs for the future of the mud crab hatchery industry.

KEYWORDS: Mud crab, Scylla, Seed production, Megalopa, Instar

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Integration of Brackishwater Seaweed, *Gracillaria salicornia* with Pond-Based Shrimp, *Penaeus vannamei* Culture System for Enhancing the Productivity

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Brackishwater seaweed plays a crucial role in shrimp farming within confined systems, offering improvements in water quality, nutrient recycling, and reducing environmental impact. Integrating seaweed into shrimp aquaculture supports sustainability and opens up additional income streams for stakeholders by diversifying products and creating new market opportunities. In a research experiment conducted by ICAR-Central Institute of Brackishwater Aquaculture, the potential of integrating G. salicornia seaweed with P. vannamei shrimp farming was explored in a lined pond. Shrimp post-larvae were stocked at a density of 40 individuals/m³ over a period of 42 days. A floating raft (3×3m) equipped with horizontal rope with 3 m length (15 nos) and vertical ropes with 1m length (16 nos), initially holding 1.5 kg and 0.5 kg of seaweed biomass respectively, was installed at the centre of the pond. Water quality parameters such as pH, temperature, ammonia, and nitrate showed no significant difference between the control pond and the pond integrated with seaweed. For comparison, the control pond had shrimp stocked at the same density but without the seaweed integration. After 41 days, the seaweed-integrated pond produced 260±15.2 kg of shrimp with an 87±2.1% survival rate, while the control pond yielded 220±9.8 kg of shrimp with a 77±1.8% survival rate. Additionally, the integrated pond generated 170±8.6 kg of seaweed biomass, representing a fivefold increase and a productivity of 3.4 tonnes/ ha. This result not only demonstrated enhanced productivity but also provided farmers with an additional income source. The study underscores the potential advantages of integrating seaweed with shrimp farming in aquaculture systems.

KEYWORDS: Integration, Seaweed, Gracillaria salicornia, Brackishwater, Raft

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Development of a Cost-Effective Alternative Biofilter Media for Recirculating Aquaculture Systems (RAS) Utilizing Locally Sourced Materials

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Recirculating Aquaculture Systems (RAS), a sustainable fish farming method, is revolutionizing the aquaculture industry with its efficient and eco-friendly approach. However, the high cost of RAS's conventional biofilters, like bio balls and MBBR hinders the accessibility of this technology for small-scale aquaculture farmers. This research explores the potential of locally sourced materials such as zeolite, coconut shell, terracotta, and broken glass pieces as viable and affordable alternatives that can effectively replace conventional RAS biofilters. The experiment was conducted under controlled conditions in a 3001 mini-RAS, where ammonium chloride, sodium nitrate, and glucose were added to stimulate microbial growth and evaluate biofilter performance. The key role of each biofilter media in nitrogen cycling and ammonia removal was assessed by studying, the formation of distinct ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB) microbial communities and their ability to foster specific microbial consortia on each biofilter material. Water quality parameters were closely monitored, while the physiochemical properties of the biofilter materials were analysed by evaluating the surface area, porosity, density, leaching, and longevity. Biofilm samples from different biofilter materials were collected for microbiological analysis, focusing colony-forming unit (CFU) counts during four stages of bacterial succession. Metagenomic sequencing of the 16S rRNA gene identified the characterization of microbial communities. DNA sequencing was followed by bioinformatic analysis of the raw reads to evaluate microbial diversity and functional potential in each biofilter material. Additionally, hydrogen peroxide decomposition was measured to determine the oxidative stress tolerance of the microbial communities. Preliminary results reveal that each biofilter material exhibited considerable variations in microbial biofilm formation and bacterial succession, with significant differences in the AOB and NOB diversity and community structure. These distinctions directly influenced water quality parameters, especially ammonia, nitrite, and nitrate levels, which fluctuated according to the microbial consortia supported by each material. The biofilters that fostered more diverse and efficient bacterial communities demonstrated greater efficiency in nitrogen cycling. These findingsindicate that identifying and selecting the right biofilter material based on microbial consortia will make RAS technology more affordable for small-scale fish farmers, promoting broader adoption of sustainable aquaculture practices.

KEYWORDS: Biofilm, Microbial consortia, Ammonia, Sustainable aquaculture



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Year Round Breeding and Seed Production of Maze Rabbitfish, Siganus vermiculatus in a Recirculatory Aquaculture System

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Maze rabbitfish, Siganus vermiculatus has very good aquaculture potential due to its fast growth rate, herbivore feeding habit and tolerance to adverse environmental conditions. Despite the availability of breeding and seed production technology for Siganus vermiculatus, the commercial farming of this species is hindered by the lack of a steady year-round supply of fry for aquaculture. There is no information available on extended round the year breeding and seed production of S. vermiculatus in captive condition. The study aimed to evaluate the reproductive efficiency of S. vermicualtus brooders maintained in recirculatory system for a period of 15 months during March 2023 to May 2024. A total of 110 nos of S. vermculatus, 61 nos females (24.60±0.58 cm; 291.81±18.66 g) and 49 nos males (24.89±0.30 cm; 264.76±11.32 g) were maintained in 10 tonne capacity recirculatory system. Brooders were fed with feed containing (40 % crude protein and 10% fat) enriched with cod liver oil and vitamin E at 5% body weight. For induce breeding trials, S. vermiculatus females with oocytes size ranging from (370-470 µm) and running males were selected. The first dose of LHRH hormone at 200 µg for female fish and 100 µg for male fish was administered intramuscularly. A second dose was administered to the females after 24 hrs interval. A total of 35 induced breeding trials were conducted during the study period. The results revealed that 29 breeding trials were successful, and spawning occurred round the year in all the months and lunar phases. The estimated number of eggs spawned per female varied from 80,000 to 350,000; the average for 29 spawning was 217,843 eggs/female. Females induced with oocyte size 410-470 μm had higher mean fertilization rate and hatching rate 95.05±7.08 % and 87.05±11.05% respectively. Larval rearing of S. vermiculatus was carried out in a 1 tonne capacity FRP tanks with yellow inner background colour placed in semi-outdoor facility with solar illumination, provided with Parvocalanus crassirostris and Brachionus rotundiformis as first feed and this enhanced the survival rate to 12-14%. The present study demonstrates the year-round breeding of S. vermiculatus through hormonal induction by maintaining brooders in controlled recirculatory system and by selection of females with oocyte size > 400 μm for induced breeding for higher fertilization, hatching and larval survival rates, offering reliable method for steady supply of seeds for aquaculture.

KEYWORDS: Year-round breeding, Maze rabbitfish, Oocyte size, Recirculatory system



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Environmental Enrichment for Spiny Eels in Captivity: Effects of Lighting, Shelters, and Substrates

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The study assessed the impact of environmental enrichment on the development and spawning of broodstock, as well as the growth and welfare of two species of spiny eels, Macrognathus pancalus, and Macrognathus aral, in captive conditions. For M. pancalus, the study examined growth, stress response, and gonadal development in reinforced plastic tanks with varying light intensities (127 to 1185 lux) and periodicities (0 to 16 hours of light), with the provision of bottom shelters, while being fed *Tubifex* worms. Additionally, the spawning performance of M. pancalus and M. aral was evaluated using floating and submerged weeds as spawning substrates, whereas the rearing of M. pancalus fry and sub-adults was conducted using different substrate-shelter combinations. The findings indicated that a low light intensity of 243 lux led to significantly higher values (p<0.05) for ovary diameter, gonadalsomatic index, and fecundity. Furthermore, the study revealed a preference for natural light hours for the gonadal development and maturation of M. pancalus. Organosomatic indices and reproductive parameters indicated feeding intensity and ovarian development-related changes in liver stress biomarkers and antioxidant levels. For spawning, the floating weed was identified as the best egg substratum. The study also emphasized the importance of habitat enrichment, in combination of soil substrate and shelter, and only shelter for the growth, survival, and welfare of fry and sub-adults, respectively, as well as the effects on stress biomarkers and digestive enzyme activities. Overall, the study provides valuable insights into the broodstock development, spawning, and rearing of spiny eels under captivity, which can be useful for future aquaculture and conservation programs.

KEYWORDS: Macrognathus, Light intensity, Photoperiod, Ovarian development, Spawning

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Comparative Study on Two Fish Rearing Methods for Production of Stunted Fingerlings of Silver Pompano, *Trachinotus blochii*

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Production of stunted fingerlings has been recognized as a viable option to ensure prolonged seed availability during off seasons and also to supply healthy and hardy stocking material for farming, besides their ability to exhibit compensatory growth. The present study compared two different methods of fish rearing for the production of stunted fingerlings through crowding and feed deprivation. In the first method, fishes in the treatment group with an average weight of 2 g were stocked @100 nos/m³ in FRP tanks of 2-tonne capacity filled with clean filtered seawater of 35% salinity. The feeding was done using commercially available pellet feed @ 3% of the biomass. In the control tanks, the stocking density was 20 nos/m³, and feed @ 10% of biomass was provided. In both the tanks, 100% water was exchanged daily. In the second method, the fishes were reared in a tank fitted with a simple water recirculation arrangement. Here the two FRP tanks of 7-tonnes capacity were filled with 5-tonnes water. Both the tanks were connected separately to a simple Recirculatory Aquaculture System (RAS). Fishes were stocked at 200 nos/m³ in the stunting tanks whereas in the control tank, stocking was at 40 nos/m³. Feeding was done in a similar pattern as that of the first method. Water quality parameters such as dissolved oxygen, pH, salinity, and ammonia were monitored from day 1 to 7. It was observed that from day 5 onwards the water quality started to deteriorate and on day 7 few fishes died in both tanks. So, it was decided to give a complete water exchange once in 5 days, and by following this protocol, no mortality was observed. Growth was assessed by random sampling (n=30) from both tanks. The results of the study revealed that stunting could be achieved in the second method also which revealed the scope for using this technique for stunting of fish where seawater availability is a limitation and also for a reduction in manpower requirement.

KEYWORDS: Stunting, Silver pompano, RAS, Compensatory growth

Nursery Rearing of Spiny Lobster (*Panulirus ornatus*) in Marine Floating Cage to Assess its Growth and Survival

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In some areas of the Philippines, particularly Surigao, Zamboanga, and Davao Oriental, many lobster species are prevalent, but there is a widespread lack of cost-effective hatchery and nursery technology for lobsters. Most of the spiny lobster production comes from wild fisheries, while aquaculture production accounts for only a small portion of the total production. This study investigates the feasibility of nursery culture of lobster in 1 m x 1 m x 1 m marine floating cages in Panabo Mariculture Park in Davao del Norte, Philippines. Two stocking densities were tested in a Complete Randomized Block Design (CRBD) – 80 and 130 per m³ and the growth and survival rate of juvenile spiny lobsters after 120 days of culture were evaluated in three independent experiments. The results showed that growth and survival rates correlated positively with stocking density. Lobster cultured at a stocking density of 80 per m³ showed significantly higher growth (15.18 g, 24.98 mm) and survival rates (35%) than those cultured at a high stocking density of 130 per m³ (11.39 g, 23.03 mm, 30%). The data collected in this pioneering study will be useful to refine and further develop nursery culture technology for spiny lobsters in the Philippines.

KEYWORDS: Lobster pueruli, Growth, Survival rate, Stocking densities, Cost-effective

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Biofloc: A Sustainable Approach for Growth and Survival in *Cyprinus carpio* (Linnaeus, 1758)

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Biofloc is an emerging technology in fish culture systems that is moving towards ensuring sustainable aquaculture. In contrast to Re-circulatory aquaculture systems (RAS), where water treatment is done outside the culture column, biofloc technology is an in-situ water treatment method. A 90-day study was conducted to evaluate the effects of biofloc on the growth performance, digestive enzyme activity, and immune response of the koi carp. The experimental fishes were cultured under biofloc-enriched conditions and compared to the control group reared in traditional aquaculture systems. Koi carp reared under biofloc condition attained significantly better (p<0.05) performance in terms of weight gain (WG) (46.5±4.8g), specific growth rate (SGR) (0.87±0.03%), feed conversion ratio (FCR) (1.7±0.09), and feed conversion efficiency (FCE) (55.9%) when compared to the control group. The biofloc groups demonstrated elevated levels of digestive enzymes (amylose, lipase and protease), pointing to enhanced nutrient assimilation and digestion. Fish in the biofloc system showed improved immune status characterized by higher white blood cell counts and haemoglobin concentrations. These findings suggest that biofloc environments may bolster fish health and disease resilience. The results of this study demonstrated that the biofloc-based culture system worked well for koi carpbecause it improved growth performance, digestive enzyme activity, and immune status and lowered stress response, suggesting that its adoption could lead to reduced environmental impact, higher productivity, and cost-effective and sustainability in aquaculture.

KEYWORDS: Sustainable aquaculture, Digestive enzyme, Immune response

Evaluation of *Penaeus vannamei* Culture in Inland Saline Water-Based Semi-Biofloc Culture System

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The study was conducted to evaluate the effect of the usage of mineral and bioflocculating agent in biofloc system for the rearing of P. vannamei in inland saline water. The various concentration of mineral: Chitosan: Cationic starch (C1-1g/l:0ppm:0ppm, T1-1g:30 ppm:30 ppm, T2-1g/l:50ppm:50ppm, C2-2g/l:0ppm:0ppm, T3-2g/l:30 ppm:30 ppm, T4-2g/1:50ppm:50ppm) were chosen. The shrimp was stocked at the rate of 100/m³. The highest survival rate was observed in T3 (91%), followed by T1 (89%), T2 (85%), T4 (81%), C2 (76%), and C1 (72%). The growth indices such as weight gain percentage (WG%) and Specific growth rate (SGR) were significantly higher in T3 (144.4±5.69, 1.48±0.03) and lower in C1 (83.69±2.05, 1.01±0.02). Digestive enzyme activities, specifically protease and amylase, were significantly elevated in T3 (2.35±0.16, 6.60±0.16). The optimal formulation identified was 30 ppm each of chitosan and cationic starch with 2 g/l of mineral supplementation into the biofloc media for better growth and physiological well-being of shrimp. A subsequent study was conducted to optimize rearing conditions for inland saline water-based biofloc systems. Shrimp with an average weight of 2.2 g were stocked at 60 shrimp/m³ in biofloc systems and 40 shrimp/m³ in control systems, in triplicate, across six 200 m² polylined ponds for 120 days. The biofloc ponds were maintained as zero water discharge systems and control was with limited exchange. Biofloc consortia produced in a bioreactor at 15% was used. Survival was comparatively higher in biofloc system (82%) than control (57%). The sludge was not removed throughout the culture period in biofloc ponds, due to lack of bottom drains in those ponds. Floc volume was maintained at 3 mg/l throughout using limited addition of biofloc consortia (50 mg fermented with 200 g molasses in 3001 water) every 4th day. The ammonia, nitrite and nitrate were within optimum without any water exchange or sludge removal. The fatty acid profile indicates that biofloc enhances HUFA, while it was not detected in control shrimp. Hence the results indicate value addition when the shrimp is cultured in biofloc compared to a clean water system which, however, needs further studies. The microbiological analysis of Vibrio showed that control ponds had higher Vibrio loads compared to biofloc. Biofloc ponds had an increase in Vibrio load towards harvest but did not lead to mortality. Metagenomic analysis of shrimp gut showed that the gut microbiome of shrimp from control indicated less diversity compared to those from biofloc. Dominant families were Rhdobacteracea, Corynobacteriacea, Bacillacea, and Acidomicrobiacea.

KEYWORDS: Penaeus vannamei, Inland saline water, Biofloc culture system



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Enhanced Breeding and Seed Production of Pearlspot (*Etroplus suratensis*) in Temperature Controlled Indoor RAS System

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Pearlspot, Etroplus suratensis (Bloch, 1790) belongs to the family Cichlidae, is distributed in peninsular India and Sri Lanka, and is declared as the state fish of Kerala. Pearlspot is one of the most preferred species for brackishwater aquaculture for its wider salinity tolerance, omnivorous nature, excellent meat quality and ornamental value. In natural pond conditions, pearlspot breeds most of the months and peak season varies from place to place. However, bottlenecks of pond-based breeding are difficulties in the collection of seed, acclimatization, and inbreeding issues. To come across these issues, the ICAR-Central Institute of Brackishwater Aquaculturehas standardized pair breeding of pearlspot in the tank-based system for continuous seed production. As the water temperature falls to 25°C in normal tank-based system, poor spawning is noticed from November to January. To overcome these challenges, a pilot study was attempted at MES-CIBA to enhance the breeding and seed production of pearlspot in a temperature-controlled prototype indoor RAS system with a photo-thermal control facility. In each tank, eight brooders were stocked in equal sex ratio having body weights of 150-220 g for females, and 78-140 g for males respectively, and a water temperature of 32-33°C was continuously maintained with a photo-period of 14 L:10 D. In control, fishes were maintained in four hapa placed in pond water where water temperature ranged from 25-27°C with average photo-period 12 L:12 D. No spawning was observed in control. In a temperature-controlled RAS setup, paired females laid the eggs. A total of thirty-six spawning were observed in four tanks during the said period @ three spawning/tank/month with an average fecundity of 2500 eggs, and average hatching of 82%. Attached eggs/wrigglers were separated early (within 3 days) from breeding tanks to curtail the parental care and placed in separate 100-lit larval rearing tanks maintaining the same temperature (32-33°C). Larvae were reared in a green-water system and fed with Artemia nauplii, and larval feed for fry production. This photo-thermal control facility can help to achieve tank-based year-round seed production of pearlspot.

KEYWORDS: Pearlspot, Temperature control, RAS system, Breeding, Seed production

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Supplementation of Fish Waste Hydrolysate on Fingerling Production of Milkfish, *Chanos chanos* in Enhanced Culture System

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The processing of fish, shrimp, and crab generates significant waste, accounting for 30-50%, 50-60%, and 40-60% of their total mass, respectively. Improper disposal of untreated fish waste poses major environmental risks worldwide. This study examines the effects of fish waste hydrolysate (FWH) on the nursery rearing of milkfish, Chanos chanos, within an enhanced culture system. FWH, a nutrient-rich hydrolysate produced from fish waste through an innovative process, was applied at varying concentrations (20, 40, and 80 ppm), both with and without weekly supplementation of zooplankton (copepods and rotifers). The control group received neither FWH nor zooplankton. Advanced larvae of C. chanos (15 days post-hatch) were stocked in 500 l FRP tanks, with 30 fish per tank. After a 42-day feeding trial, C. chanos showed significantly (p<0.01) improved growth parameters and survival rates in treatments with 80 ppm FWH, both with and without zooplankton, compared to other treatments. Growth metrics such as final body weight, specific growth rate, average daily gain, and weight gain percentage were significantly higher (p<0.01) in the 80 ppm FWH treatments, irrespective of zooplankton addition, compared to the control. The average body weight increased by 36% in the treatment that included both FWH and zooplankton. Moreover, FWH supplementation led to significantly higher floc densities (p<0.01), with densities rising in proportion to FWH concentration. Nutritional profiling of the harvested floc biomass supported these findings. Additionally, the abundance of phytoplankton and zooplankton was significantly higher in FWH-treated groups, correlating with increased FWH doses. This enhanced plankton abundance likely contributed to better floc formation and improved growth of C. chanos. The study concluded that FWH supplementation enhances the growth and survival of *C. chanos* and reduces production costs in nursery rearing.

KEYWORDS: Fish waste, Milkfish, Circular economy, Plankton

Surface Charge Characteristics of Cyprinid Milt Constituents: A New Vista in Aquaculture and Fisheries

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Surface charge of milt constituents was analysed using Electrophoretic Light Scattering (ELS) method in ten commercially important cyprinids. At pH 7.0, the mean surface charge was lowest in *Cirrhinus mrigala* and highest in *Systomus sarana*. Cyprinids being an externally fertilizing group, the effect of pH on charge and size dynamics of milt constituents were evaluated. In addition, changes in functional properties such as sperm viability and fertilization rate after a brief exposure to sub-lethal pH extremes were investigated. While low pH (4.0) resulted in reduced surface charge (p<0.05), high pH (10.0) had the opposite effect. Though differences in pattern for particle size distribution are observed at different pH, both low and high pH resulted in aggregation of milt constituents. Neither of the pH treatments affected the viability of sperm, but the fertilization rate was significantly reduced at pH 4.0 (p<0.05). The present study is the first report on the surface charge characteristics of milt constituents and the influence of pH on the physical and functional characteristics of milt. Further studies on charge characteristics of milt will be instrumental in addressing puzzling questions of ecology, reproductive physiology and migratory behaviour of fishes.

KEYWORDS: Cyprinid, Milt constituents, Aquaculture

Degradation of Oxolinic Acid in Aquaculture Pond Environment Under Tropical Conditions

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Oxolinic acid is a quinolone antibiotic that is extensively used in aquaculture against bacterial infections. To understand the influence of abiotic factors (pH, temperature, salinity, sunlight exposure and soil texture) on the degradation of oxolinic acid in water and soil, an experiment was conducted following the guidelines of the Organization for Economic Cooperation and Development (OECD). A known quantity (100 ppm) of oxolinic acid was added to water under varying pH (5,7 and 9) and salinities (0.5, 15 and 25‰) and was maintained under sunlight and dark conditions throughout the study. Similarly, oxolinic acid was spiked in loamy sand and clay soil textures and field capacity was maintained throughout the experiment. During the experiment, the temperature and light intensity varied from 30 to 36°C and 3,156 to 121,300 lux (mean 36,973 lux). The photoperiod averaged 12 hours and 13 minutes throughout the study, sampling was done at periodic intervals and oxolinic acid was estimated using Liquid Chromatography Mass Spectrometry (LC-MS/MS). Data were fit into a kinetics model and for further analysis, Computer Assisted Kinetic Evaluation (CAKE) software was used. The degradation of oxolinic acid in water under sunlight followed the first-order kinetics, with a half-life of 1.9, 2.3 and 2.4 days for pH 9, 7 and 5 respectively. Lower salinity exhibited a higher rate of degradation, with a half-life of 0.904, 2.09 and 3.75 days for 0.5, 15 and 25%, respectively. Oxolinic acid degradation was significantly slower under dark conditions. In soil, clay exhibited slightly faster degradation with a halflife of 8.62 days compared to loamy sand (10.3 days), attributed to higher organic matter content and more active molecular interactions in clay. To summarise, the degradation rate was higher under low salinity and high pH in the presence of sunlight. In tropical countries like India, aquaculture ponds are exposed to ample light intensity throughout the year, which helps accelerate the degradation of oxolinic acid.

KEYWORDS: Abiotic factors, Pond soil, Degradation, Kinetics, Oxolinic acid, Water

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Effect of Stocking Densities on the Growth Performance of Jayanti Rohu in Floating Cage Environment of a Flood Plain Wetland

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Cage culture is an emerging technology through which fishes are reared from fry to fingerling. fingerling to table size and marketable size in the restricted water area of cages surrounded on all sides by mesh net made of synthetic material that resists decomposition in water over long periods. The production of farmed aquatic organisms in caged enclosures has been a relatively recent aquaculture innovation in India. Wetlands play an extremely important role in fish production, and livelihood security besides many other direct or indirect values. The floodplain wetlands of Assam can be considered an ideal system to convert them into culturebased fisheries resources. For cage culture, the selection of species is very much important since all species are not suitable for all culture systems. An experiment was conducted to determine the optimum stocking density of Jayanti rohu (genetically improved Labeo rohita fingerlings) reared in 12 number modular cages of size 48 m³ (6m x 4m x 2m) at Thekera beel, Morigaon, Assam for three months. Four treatments T1 (15 fish/m³), T2 (20 fish/m³), T3 (25 fish/m³) and T4 (30 fish/m³) in triplicates were used by feeding the reared fishes once daily in the morning with 28.01% crude protein @ 5% of the body weight. Weight gain percent (WG %), specific growth rate (SGR) and survivability % were found to be the highest at the lowest stocking density (T1) and lowest at the highest stocking density (T4) with significant (p<0.05) difference among the treatments. The water quality parameters in the different treatments were found to be within the favourable range for fish culture. Plankton density was found to be the highest in the cage site and lowest at the outside cage area (50 m away). The study revealed that though the average final body weight gain was highest in the lowest stocking density at T1 (15 fish/m³), the gross yield was maximum in treatment T3 (25 fish/m³), hence, Treatment T3 was the best stocking density of Jayanti rohu fingerlings for production of table fish in modular cages installed in a seasonally open beel of Assam.

KEYWORDS: Modular cages, Beel, Genetically improved Labeo rohita, Plankton

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Successful Breeding and Seed Production of Giant Trevally (*Caranx ignobilis*): A Major Milestone in Indian Mariculture

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Caranx ignobilis, commonly known as giant trevally, is a high-value foodfish and a popular species in the oceanariums worldwide. This species has been popularly recognized as an ideal fish for farming in the sea and brackishwater areas. Despite its significance, captive rearing, breeding, and successful larval rearing remain challenging due to its complex reproductive characteristics and species-specific nutritional and environmental needs. This study outlines effective strategies for the induced breeding and larval rearing of C. ignobilis in aquaculture, focusing on optimizing reproductive conditions, improving larval survival rates, and promoting sustainable seed production practices. Juveniles measuring 11-18 cm in total length (TL) and weighing 12-58 g in total weight (TW) were collected during March-April 2022 from Kollam, Kerala (8°55'43"N 76°34'33"E), and stocked in open-water floating cages of ICAR-Central Marine Fisheries Research Institute. The fishes were tagged and fed with pellets and fresh, low-value fishes. The maturity stages were monitored by cannulation biopsy from May 2023 onwards. Once the oocyte size reached 300 µm, broodstocks (1 female: 2 males) were transferred to the spawning facility (10-tonne RAS) at the Vizhinjam Regional Centre of ICAR-Central Marine Fisheries Research Institute. Commercial-grade GnRH analogue was used for induction, and successful spawning occurred 24–36 hours post-induction. Fertilization rates ranged from 65% to 94%. The eggs were spherical, 726 um in diameter (n=40), and the hatching rate was 91%. Hatchlings measured between 1780– 1864 µm and mouth opening was observed between 63–66 hours. Larvae were fed calanoid copepod *Parvocalanus crassirostris*, and gut content analysis confirmed successful feeding. Metamorphosis was completed 28–33 days post-hatching (dph); weaning onto pellet feeds (100–150 µm) began at 30 dph, and was completed by 35 dph. This study demonstrated that with controlled environmental conditions and optimized feeding strategies, the successful seed production of C. ignobilis in captivity is feasible, which can contribute significantly to mariculture production.

KEYWORDS: Caranx ignobilis, High-value finfish, Aquaculture, Fish breeding, Larval rearing, Copepod

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Reproductive Physiology and Spawning of Indian White Shrimp, *Penaeus indicus* Broodstocks in Captive Systems

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A year-round broodstock development trial was carried out in tank systems to investigate the reproductive physiology of Indian white shrimp, Penaeus indicus in captivity. The broodstock development was carried out using Post larvae (PL) of Indian white shrimp for 365 days under indoor and outdoor units (5000 l). A wider range of salinity (16-32‰) and temperature (25-30°C) was recorded in outdoor tanks, whereas the indoor system recorded a narrow range of salinity (23-32‰) and temperature (28-30°C). The outdoor units were subjected to a natural photoperiod, while the photoperiod was maintained at 12L:12D in indoor units. A significant variation (p<0.05) in growth performance, water quality, and microbial and microalgae were recorded among the rearing systems. Higher sperm count (8.84±1.35×10⁶) and percentage of normal sperm were noticed in males reared in the outdoor units compared with indoor-reared broodstocks. The levels of sex steroids (17-aOH progesterone and 17-B estradiol), total cholesterol, triglycerides, and digestive enzymes varied among the units. Similarly, histological analysis revealed cellular level variation in spermatophore and ovarian developmental stages under different units. At the end of the trial, female broodstock reared in outdoor tanks recorded an average weight of 35-42 g with 25.6% brooders recording community captive spawning in tanks even without eye stalk ablation, while gonad development was nil in indoor units. The study explores the importance of natural environmental cues on the successful spawning of closed thelycum shrimp under captivity.

KEYWORDS: Reproductive physiology, Spawning, Indian white shrimp, Broodstock

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Density Optimization of Seabass Fry and Fingerlings for Live Transportation

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Asian seabass, Lates calcarifer is a potential candidate finfish for diversification in brackishwater farming. Live seabass fry and fingerlings are transported from hatcheries to culture sites for farming in closed and open systems under varying salinity. However, there is no scientific protocol evolved for optimization of densities according to duration for live transportation of different sizes seabass fry and fingerlings. In this present investigation, optimum densities for seabass fry and fingerling (1-3 inch size) live transportation for varying transit durations of 6, 12, 18 and 24 hrs were studied in 30 l capacity polythene bags filled with oxygenated 5 l of 15% brackishwater. In trial-1, seabass fry (2.5-2.7 cm) were packed at density of 100, 200, 300, 400 and 500 nos. in 5 l water, respectively. In trial-2, seabass advanced fry (5.0-5.5 cm) were packed at density of 100, 200 and 300 nos. in 51 water, respectively. In third trial, seabass fingerlings (7.3-7.9 cm) were packed at density of 50, 100 and 150 nos, in 5 l water, respectively. Control bag was with only oxygenated 15% brackishwater. All packed polythene bags with seabass fry and fingerlings were kept in thermocol boxes for transportation for duration of 6, 12, 18 and 24 hrs periods. Survival rate and water quality parameters such as water temperature (°C), pH, dissolved oxygen (ppm), salinity (ppt), ammonia (ppm) and nitrite (ppm) were assessed before packing and after respective transportation duration time. Results revealed 100% survival of seabass fry (2.5-2.7 cm) at packing density of 200, 300 and 400 nos. in 5 lof 15% oxygenated water for 24, 18 and 6-12 hrs duration of live transportation, respectively. For seabass advanced fry (5.0-5.5 cm), 100 % survival was observed at packing density of 100, 200 and 300 nos. in 51 of 15% oxygenated water for 18-24, 12 and 6 hrs duration of live transportation respectively. Seabass fingerlings (7.3-7.9 cm) packed at density of 50 nos. in 5 l of 15‰ oxygenated brackishwater water for 6 hrs live transportation exhibited 100% survival. Present study suggests optimal packing densities for short and long-distance transportation of seabass seed, which is useful for the farmers.

KEYWORDS: Seabass seeds, Live transport, Density, Transit time, Water quality, Survival

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Enhancing Small-Scale Fisheries Production and Conservation Through Pen Aquaculture in an Indian Floodplain Wetland

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The present study deals with stakeholder-driven implementation of pen culture for raising of fish seed for culture-based fisheries in Chamta, a floodplain wetland, in Gangetic plains through polyculture of Indian major carps (IMCs) Labeo catla, Labeo rohita and Cirrhinus mrigala with small indigenous fishes (SIFs) Labeo bata, Systomus sarana and grass carp, Ctenopharyngodon idella in co-management mode. The approach involved polyculture of Indian major carps (Labeo catla, Labeo rohita, and Cirrhinus mrigala) along with small indigenous fish species (Labeo bata and Systomus sarana) and grass carp (Ctenopharyngodon idella). Two trials were conducted using high-density polyethylene (HDPE) pens. In the first trial, a mix of IMCs and SIFs was cultured for 90 days, achieving a net yield of 682.3±20.6 kg per pen. In the second trial, IMCs were cultured with grass carp in the same stocking density and yielded 413.9±21.7 kg per pen over 90 days. Survival rates ranged from 77% to 85%. The economic viability of the polyculture system was evident with a benefit-cost (BC) ratio of 1.92, and all seeds produced in the pens were released back into the wetland to enhance culture-based fisheries. Grass carp showed significant growth potential in macrophyte-rich wetlands, reaching 1.5-2 kg in six months and 3-3.5 kg in one year. The SIF species, S. sarana and L. bata matured within the wetland environment. Pen culture proved to be a costeffective and sustainable technology to enhance fish production in wetlands while supporting species conservation. The production of SIFs in wetlands in pens will aid in their production enhancement and conservation if they successfully breed in the wetland, especially in closed wetlands. Integrating pen culture using diversified species will promote sustainable fisheries management in these floodplain wetlands.

Keywords: Wetland, Culture-based fisheries, Small indigenous fishes, Production, Conservation

Present Status and Way Forward for Dissemination of Genetically Improved Carps from ICAR-Central Institute of Freshwater Aquaculture Nucleus Breeding Centre

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ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA) initiated selective breeding of rohu in the year 1992 in collaboration with the Institute of Aquaculture Research (AKVAFORSK), Norway due to its high consumer preference, poor growth performance in carp polyculture system and susceptibility to diseases. In the year 1997 during the 50th anniversary of Indian Independence (Swarn Jayanti), the improved rohu was first released to the nation and is therefore popularly known as "Jayanti". Later from the year 2004, disease resistance against Aeromonas hydrophila was added as a second trait for selection and is therefore, presently known as AhR Jayanti rohu. Further, the selective breeding programme on Catla (Labeo catla) was initiated to improve the body weight at harvest in 2010. By 2024, the 14th generation of AhR Jayanti rohu and the 4th generation of improved catla have been produced. ICAR-CIFA is the nucleus breeding centre (NBC) for AhR Jayanti rohu and CIFA-Amrit catla. Demonstrations through the field trials conducted in different geographical locations in India have shown higher growth potential of both genetically improved carps, thereby having a positive impact on farmers' income. Effective dissemination of improved strains of fish among the farmers is crucial to harness the benefits of the investments made in genetic improvement programs. A decentralized model of dissemination was followed for the dissemination of both technologies among various stakeholders, ICAR-CIFA signed Memorandum of Understandings (MoUs) with different stakeholders which include commercial hatcheries/institutions and developmental agencies. ICAR-CIFA has disseminated more than 256 million spawn of AhR Jayanti rohu to 18 different states/union territories during 2010-2024, and more than 21 million spawn of CIFA-Amrit catla to 11 different states/ union territories during 2014-2024. To create awareness regarding the superiority of the genetically improved carps over the local strain and the importance of "quality seed" among the farmers, hatchery owners and entrepreneurs; ICAR-CIFA conducted several workshops and Farmer-Scientist interaction meets throughout India. Genetic improvement programs can immensely contribute to sustainable aquaculture production. The present study explains the dissemination strategies followed by ICAR-CIFA, constraints encountered and the way forward to effectively disseminate the improved carps "AhR Jayanti rohu and CIFA-Amrit catla" across the nation.

KEYWORDS: Genetic improvement, Dissemination, Selection, Growth trait



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Broodstock Development, Breeding and Larval Rearing of Golden Trevally, *Gnathanodon speciosus* (Forsskal, 1775): A Promising Mariculture Species for India

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The present study describes the first trials on broodstock development, breeding and larval rearing of golden trevally, Gnathanodon speciosus (Forsskal, 1775). Fingerlings (100 g) were collected from the wild and raised to adults having an average size of 3.75±0.10 kg weight and 47.6±1.43 cm length. These adult fishes were stocked @ 1 kg/m³ in ratio of 1:2 (female and male) in a circular concrete tank of 35 m³ capacity connected with a recirculatory aquaculture system. The fishes were fed with fresh squid, clam meat and crab at a 2:1:1 ratio fortified with squid oil, and vitamin-mineral pre-mix for a day till satiation. The brooders matured within 2 months, with ova size of 400-450 um. Spawning was obtained naturally by manipulating the water quality. The number of eggs spawned by golden trevally ranged from 0.8 to 1.5 lakhs per spawning per female. The eggs were collected and treated with 15 ppm iodine solution for 10 minutes with strong aeration. Treated eggs were stocked in 100 1 aquarium tanks @ 200 nos per liter. The size of the fertilized eggs ranged between 820-870 µm. The eggs hatched out after 12-14 hrs of incubation at a temperature of 29±1°C. The overall fertilization and hatching rate were found to be 79±1.55% and 83.67±0.81%, respectively. Subsequent spawning of golden trevally was achieved at an interval of 7-9 days in RAS. The larval rearing was carried out in 2 t capacity FRP tanks. The newly hatched larvae measure 1.70-1.80 mm in total length. The mouth opening formed at 38-44 h posthatch. The newly hatched larvae were collected from the water surface of the hatching tank and stocked in larval rearing tanks @ 10 no/ml. A systematic and overlapping regime of livefood supply, beginning with copepod nauplii, rotifer, Artemia nauplii and artificial pellets was used as feeds during larval rearing. Weaning of larvae to an inert diet started from the 18th day post-hatching (DPH) onwards. Larvae started metamorphosis by the 22nd DPH and were completed by the 33rd DPH, when the larvae reached a size of 20.21±0.10 mm. The larval rearing protocol resulted in an average survival rate of 2.71±0.45% till complete metamorphosis. The present study showed golden trevally to mature and spawn in captive conditions, as well as initial success in larval rearing in captive conditions, makes the golden trevally a candidate for mariculture, as it is a fish in good demand and is understood to grow faster. The results of this study would facilitate developing technology for mass-scale seed production of golden trevally in captivity, which is likely to emerge as a promising mariculture candidate species in India.

KEYWORDS: Golden trevally, Broodstock, Breeding, Larval rearing, Seed production



Effect of Ionic Composition of Water on Egg Fertilization, Hatching and Larval Survival in Magur (*Clarias magur*)

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The ionic composition of water has a pivotal role in the osmoregulatory process and maintenance of membrane potentials of cells. During egg incubation, if water has a lower ionic concentration, then the egg absorbs water, causing it to swell quickly and potentially burst during embryo development. Conversely, if the medium has a hypertonic ionic concentration, a white layer develops around the egg cell hampering its hatching process. This study assessed the impact of calcium (Ca^{2+}) and magnesium (Mg^{2+}) concentrations (i.e., total water hardness) on egg fertilization and hatching in magur (Clarias magur). Five water hardness levels (50, 100, 200, 400, and 800 mg/l as CaCO₂) were used during the study and the eggs were suspended in sieves with a continuous water flow, mimicking standard hatchery conditions. The results showed a decline in fertilization rates as water hardness increased, ranging from 81.04% at 50 ppm to 46.75% at 800 ppm. A similar trend was observed in the hatching rate as well. Further, during larval rearing, lower water hardness (50 ppm) led to higher larval survival (71.3%), while more increase in hardness reduced survival, with 32.0% survival at 800 mg/l as CaCO₃. The findings indicate that maintaining water hardness below 200 mg/l as CaCO3 is critical for maximizing magur fertilization, hatching, and larval survival. A similar experiment was conducted to examine the impact of different concentrations of HCO₃² and CO₃² i.e., total alkalinity (TA) viz., 100, 200, 400, and 800 mg/l as CaCO, on egg fertilization, hatching rates, and larval survival in magur. The results indicated that as TA increased, a slight decline in fertilization and hatching rates was observed, with optimal rates occurring at 100 mg/l as CaCO₃ (74.0% fertilization, 67.0% hatching). The lowest rates of fertilization (68.0%) and hatching (62.0%) were recorded at 800 mg/l as CaCO₂, indicating a negative effect of higher alkalinity. During larval rearing, the highest survival rates were observed at 100 (71.3%) and 200 mg/l as CaCO₂ (72%). However, as TA reached 400 mg/l as CaCO,, survival dropped to 66.7%, and a significant decrease was noted at 800 ppm (48.7%). Overall, moderate alkalinity (100-400 mg/l as CaCO₃) had minimal effects on survival, but excessively high levels (800 mg/l as CaCO₃) severely reduced larval survival in magur.

KEYWORDS: Hardness, Alkalinity, Clarias magur, Egg Fertilization, Hatching, Larval survival

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Dietary Effect of Polychaete Worms on Maturation of *Macrobrachium rosenbergii*

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In recent years, the pursuit of sustainable aquaculture practices has focused on alternatives to fisheries-derived ingredients, to avoid economic and environmental unsustainability. The inclusion of low-trophic organisms, such as polychaetes is considered to be suitable for achieving effective and enhanced reproductive performances in finfishes and shellfishes due to high protein and lipid content. The present study aimed to investigate the inclusion level of polychaete as part of fresh food combination in the maturity stages of *Macrobrachium rosenbergii* brood stocks. The two treatments were fed with a combination of chicken liver, squid, and polychaete at 5% inclusion level (T1) and 10% inclusion level (T2) in the feeding regime. In contrast, the control group was fed only a diet combination of chicken liver and squid. Our results indicated that brood stocks in T1 showed elevated levels of serum vitellogenin (p=0.001) and cholesterol (p<0.005) as compared to C and T2. The ovarian histomorphology revealed a larger number of advanced-stage oocytes in the same group. Therefore, 5% inclusion of polychaete in a combination diet is sufficient to improve reproductive performance and promote the synthesis of serum steroid hormones in females thereby facilitating ovarian development.

KEYWORDS: Polychaete, Macrobrachium rosenbergii, Maturation, Steroid hormones

Growth and Survival of Tilapia and IMC Seed During Fry Rearing in Biofloc System

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The experiment aimed to assess the effect of indigenous biofloc on the growth performance of Indian major carps (IMC) and tilapia seeds. The biofloc consortium consisted of both Gram-positive and Gram-negative bacteria (Priesta aryabhattai, Bacillus cereus, Exiguo bacterium indicum, Acinetobacter indicus, Mixta calida, and Bacillus altitudinus) with good probiotic characteristics. The spawn of IMC (Labeo rohita and Cirrhinus mrigala) was initially fed with egg albumin and custard ad libitum for five days before the commencement of the experiment. The prefed IMC larvae and 5-days old tilapia larvae were stocked in circular 20,000 litre biofloc tanks for evaluation. With a stocking density of 15 nos./l, IMC and tilapia seeds were each stocked in triplicate for two cycles (21 days culture). The floc in the experiment was maintained by adding jaggery as a carbon source and a floc level of 5 -10 ml/1000 ml was maintained throughout the experimental period. No water exchange was made during this period (except filling due to evaporation loss). A powdered feed containing 30% CP was provided ad libitum to the reared larvae of both species. The water quality parameters were monitored weekly. The IMC fry grew to 26±2.0 mm whereas tilapia grew to 15±2.0 mm. Fry survival rates of 43% in IMC seed and 86% in tilapia seed were achieved from biofloc tanks. This study implies that the fry production of IMC and tilapia seed can be undertaken in biofloc systems, and this may reduce dependency on nursery fry production in earthen ponds in the future. This method of rearing has the potential to reduce drudgery in the seed rearing business and overcome environmental uncertainties.

KEYWORDS: Biofloc, Bacteria, Indian major carps, Tilapia

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Growth Performances and Economic Feasibility of Amur Carp and Jayanti Rohu Reared Under Integrated Rice-Fish Farming in High Altitude Terraced Rice Fields

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Cultivation of rice in high-altitude sloppy hills is often carried out in terraced fields. These fields are reservoirs of nutrient-rich soil, water, and microorganisms. Integrated rice-fish farming (IRFF) using existing terraced fields is an important means of food production, especially for mountain dwellers. The present study experimented with Cyprinus carpio and Labeo rohita vis-à-vis their improved strains, Amur carp and Jayanti rohu, respectively, in terraced rice fields to establish the most suitable species for rearing in such an integrated system in the high-altitude region without compromising growth and survival of the fish, while at the same time being economically viable. The study was carried out at Tungjoy village of Manipur State in India, following the traditional rice farming method of manual composting and puddling of soil and without supplementary farm inputs and fish feed. The experimental carp fingerlings (6.95±0.67 g) were introduced in the fields thirty days after paddy-transplantation at a stocking density of 6000 nos./ha, keeping rice fields (without fish) as C(control), T₁ (common carp), T₂(rohu), T₃(Amur carp), T₄(Jayanti rohu) under monoculture, whereas T₄ (common carp+ rohu) and T_s (Amur carp+Jayanti rohu) under polyculture system. After 120 days of cultivation, Amur carp (T₂) had the highest weight gain and survival rate, followed by common carp (T_1) . Overall biomass gain was highest in T_3 and T_1 of the monoculture system. Fish production ranges from 243.2 to 350.0 kg/ha based on species/strains. Single-cropping rice cultivation in hilly terraced fields is economically unprofitable. Rice production in treatment groups was enhanced by 7.4% as compared to control. IRFF enhances productivity and profit to a tune of Rs. 12,677 to Rs. 39,467/ha from the sale of fish and additional rice yields. The study also identified 37 genera of phytoplankton from the experimental fields, belonging to 25 families and 18 orders, indicating that terraced rice fields harbor wide consortiums of plankton that served as natural fish feed to the rearing fish. Common carp and Amur carp were found to be the most promising carp species/strain for rearing under IRFF in high-altitude terraced rice fields.

KEYWORDS: Conservation, Sustainable, Terrace farming

Biofloc Technology — A Highly Efficient System for Intensive Fry Production of *Cirrhinus mrigala* (Ham. 1822)

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Intensive fry rearing of mrigal was studied for four weeks in a set of indoor biofloc tanks (5 m diameter) filled up to 20,000 litre of dechlorinated pond water. Mrigal spawn (6.04 \pm 0.01 mm; 2.4 mg) stocked after due acclimatisation at four densities- 4,000 (T1), 6,000 (T2), 8,000 (T3), and 10,000 spawn per m³ (T4), each with three replicates was used. Floc development was achieved with the regular addition of molasses (carbon supplement) and CIBA FLOCTM (probiotic). Commercial powdered feed (38% CP) was provided @ 300 g/ lakh spawn on 1st day, split into two meals, and was continued with 30 g/day increment. Higher fry survival (70.4-84.2%) was recorded after 28 days rearing in all treatments, attributed to the continuous availability of flocs and its nutritional support in addition to the supplementary feed. But, survival, harvested lengths and body weights of fry decreased with increased rearing density from T1 to T4 (p<0.05). Fry in T1 reached 18.3±0.2 mm (60 mg), outperforming those in T2 (17.1±0.5 mm, 50 mg), T3 (15.3±0.3 mm, 40 mg) and T4 (12.3±0.3 mm, 37 mg). T1 also recorded the highest SGR in terms of length (3.96%/ day), while T4 had the lowest value (2.54%/day). Since no water exchange was given in the tanks during the rearing phase, an increased number of fry harvested with increased rearing density led to an increase in water productivity from T1 to T4. Fry size of 17-20 mm has been reported in major carps with 40-60% survival after 20 days of high-density rearing (2,000/m) in concrete tank nurseries. Since the number of fry harvested is more important than the size attained in the nursery phase; with high fry survival in all treatments, the observed fry size of 15-17 mm (T2 and T3) can be considered as an acceptable size range, unlike the size in T4. Moreover, the calculated net profit and cost-benefit ratio were higher in T2 and T3 than those of T1 and T4. Therefore, the study recommended 6,000-8,000 spawn/m³ density to be the ideal range for nursery rearing of *C. mrigala* in the biofloc system.

KEYWORDS: Biofloc, Nursery, Mrigal, Stock density, Cost-benefit ratio

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Effect of Different Stocking Densities on Survival, Growth and Non-Specific Immune Parameters of Giant Murrel (*Channa marulius*) Fry Under Indoor System

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A study was conducted to assess the effects of different stocking densities on the growth performance, survival, and non-specific immune parameters of giant murrel (Channa marulius) fry in fiber-reinforced plastic (FRP) tanks. Fry (0.13 g) were reared for four weeks at different stocking densities of 200, 400, 600, and 800 fry/m³, designated as T1, T2, T3, and T4, respectively, with three replicates per treatment. The fry were fed on live feed mostly consisting of mixed copepods and rotifers. At the end of the study, no significant difference in survival rates was observed among treatments, but a relatively higher level of 97.33% was noted in T2. The highest average body weight gain (ABW%) was observed in T1 ($556.57\pm31.51\%$), which was significantly greater (p<0.05) than in T2 ($385.47\pm17.29\%$), T3 (297.31±9.32%), and T4 (230.82±11.02%). The weight gain % tends to decrease with an increase in stocking densities. The specific growth rate (SGR%) followed a similar trend, with the highest value in T1, and a significant decline with increasing stocking density. Significantly higher (p<0.05) myeloperoxidase (MPO) activity was noted in T2 and T3 in comparison to T1 and T4, while significantly elevated nitroblue tetrazolium (NBT) activity was observed in T3. Water quality parameters remained within acceptable limits throughout the study. Considering the seed survival to be the most crucial factor in the nursery phase, similar survival in T2 and T3 indicated T3 to be an ideal density during fry rearing. Moreover, T3 also showed significantly higher MPO and NBT activity among the experimental groups.

KEYWORDS: Stocking density, Channa marulius, Growth, Survival, Non-specific immunity

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Scope of High Value Freshwater Fish, Pabda (*Ompok bimaculatus*) and Striped Murrel (*Channa striata*) Culture in Inland Saline Water

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The present study was conducted at Bathinda, Punjab to optimise the rearing of high-value freshwater fishes i.e. Ompok bimaculatus (pabda) and Channa striata (striped murrel) in low salinity inland saline water. The fry of both the species was reared in 500 litre tanks in triplicate with four treatments i.e. 2 ‰, 4 ‰, 6‰ and 8 ‰ and control (freshwater with zero ‰), with stocking density of 50 nos/tank for 90 days. The different salinities were prepared by dilution of 10 % inland saline water. Salinity acclimatisation of 9 days was done before starting the experiment. In O. bimaculatus the highest weight (17.49±1.36 g) was recorded in 6 ‰, whereas the lowest weight (15.02±1.68 g) was recorded in 8 ‰ which was not significantly different among treatments and control. In C. striata also, the highest weight (8.72±0.124 g) was recorded in treatment with 6 \ salinity at the end of sampling and it was not significantly different from other treatment groups and control. The lowest mean weight was recorded in 8 \%. In both species, although survival was not significantly different among treatment groups and control, the highest survival of Pabda (90%) was recorded in 4 %, whereas in C. striata (63%) was recorded in 6 \(\). We concluded that both pabda and striped murrel has great scope for culture in low saline waters (upto 6 %), without compromising survival and growth performance compared to freshwater and can be an alternative to shrimp farming under low-risk fish farming category.

KEYWORDS: Freshwater fish, Ompok bimaculatus, Channa striata, Inland saline water

Reviving a Rare Species: Captive Breeding of the Endemic Western Ghats Catfish, *Ompok malabaricus*

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The Malabar butter catfish (*Ompok malabaricus*), locally known as Thonnivala/ Chottavala is a rare silurid catfish endemic to the rivers of the Western Ghats, and is important for small-scale fisheries. Its population is rapidly declining due to habitat degradation, overfishing, pollution, and destructive practices such as dynamiting. Despite being classified as Least Concern by the IUCN (2011), urgent conservation efforts are needed. This study documents the first successful captive breeding, broodstock development, and larval rearing of O. malabaricus. Adult fish (15-25 cm, 25-55 g) were collected from the Chalakudy River in Kerala using gill nets. Broodstock development was conducted in earthen pond cages (4x4x1m), where the fish were fed with a commercial pellet (40% crude protein). Six breeding trials were carried out using females (avg. 17.3 cm, 35 g) and males (avg. 16.8 cm, 33 g) at a sex ratio of 1:1. Hormonal stimulation with WOVA-FH (1 ml/kg) led to spontaneous spawning in half the trials after a latency of 11.2±0.44 hours. The naturally ovulated, demersal, adhesive eggs (fecundity: 1,500-2,000 per female) were olive green in colour. Embryonic and larval development of O. malabaricus, covering the period from fertilization to metamorphosis has been documented. Fertilization rates were 90-95% and hatching occurred 24-28 hours post-fertilization with 85-90% success. Yolk sac absorption was completed within 66-78 hours, and fry were fed Artemia nauplii four times daily from the third-day post-hatch. Size variation became evident by day 10 post-hatch, with survival dropping to less than 5% due to cannibalism between days 15 and 45. Subsequent trials aimed at improving survival through varied tank backgrounds and substrates showed promise. This study demonstrates the first successful induced breeding and nursery rearing of O. malabaricus in captivity, providing critical insights into its conservation.

KEYWORDS: Broodstock, Canabalism, Conservation, Embryology, Fertilization, Hatching

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Co-Culture System of *Penaeus vannamei* and *Gracilaria*: Enhanced Nutrient Uptake and Sustainability in Aquaculture

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Addressing the rising global demand for seafood and omega-3 fatty acids (EPA and DHA) presents a significant challenge. With aquaculture now supplying half of the world's seafood, intensifying this industry is essential to meet future needs while ensuring sustainability. Issues related to scarce resources, adverse environmental effects of feed supplementation, and intensive stocking densities are rising. Aquaculture effluent discharge is composed of dissolved and settleable nutrients from uneaten feed and waste from farmed species and their treatment is a major concern. Improper management of the release of nutrients, such as nitrogen, phosphorus, and solid organic matter, into the environment can lead to algal blooms, eutrophication, hypoxic events, and water acidification. A system of evaluation that incorporates social, economic, environmental, and resource standards is necessary to maximize aquaculture systems holistically. Using seaweed as a bioremediation agent is one of the potential approaches that can be used to enhance the water quality of shrimp ponds with the least amount of water exchange and to lessen the negative impact on the environment caused by the effluents. A co-culture experiment was carried out where Penaeus vannamei at different stocking densities was a fed species, and *Gracilaria* at constant density was an inorganic extractive species in a tank system to estimate the nutrient uptake efficiency and post-uptake elemental profile of seaweeds. The result showed enhanced growth of P. vannamei and Gracilaria than its respective monoculture. Further, the integration of Gracilaria improved the water quality by reducing Total Ammoniacal Nitrogen by 98% and Phosphorus by 75-80%. In addition, it also absorbs and stores important macro and microelements into the thalli from the environment. The study indicates that optimum stocking density and coculture of shrimp P. vannamei with Gracilaria can be a sustainable practice in intensified aquaculture systems, owing to the less nutrient release into the system.

KEYWORDS: Seaweed, Shrimp aquaculture, Intensification, Elemental composition

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Resolving Livefeed Issues in Marine Ornamental Fish Seed Production

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Commercial hatchery production of marine ornamental fishes is still not developed worldwide. One of the major issues in the larval rearing of marine ornamental fish is poor larval survival due to issues related to live feeds. Most of the marine ornamental fishes have altricial type of larvae that are very small and with mouth size at initial feeding stages of generally 150-200 µm. Popular live feeds like Artemia and rotifers are insufficient because of their larger size and inadequate nutritional profiles. Recently, copepods have emerged as an essential live feed for utilization in marine finfish larval rearing. Here, the investigating team has developed 12 species of marine copepods suitable for larval rearing of marine fishes. By using these copepods as larval feeds, successful seed production was achieved for popular ornamental fishes like damsels, anthias, dottyback and gobies and also, and significantly higher survival was recorded in clowns and other ornamental fishes. Large-scale production of copepods viz., Acartia bilobata, A. southwelli, A. tropica, Bestiolina coreana, B. similis, Dioithona oculata, Euterpina acutifrons, Oithona brevicornis, Parvocalanus crassirostris, Pseudodiaptomus annandalei and P. serricaudatus are being carried out in the hatchery. Successful seed production of marine ornamental fishes like cloudy damsel (Dacyllus carneus), Maldives damselfish (Amblyglyphidodon indicus), Lemon damselfish (Pomacentrus moluccensis), Caerulean damsel (Pomacentrus caeruleus), Black-bar chromis (Pycnochromis retrofasciatus), Two-tone chromis (Pycnochromis fieldi), Azure demoiselle (Chrysiptera hemicyanea), Dottyback (Pseudochromis sp.), Wide-barred shrimpgoby (Amblyeleotris latifasciata) Ornate goby (Istiogobius ornatus) and Lemon coral goby (Gobiodon citrinus) has been achieved using these copepod species. Additionally, copepods could improve large-scale seed production of 8 species of clown fishes. Few species of copepods can be utilized in the co-culture system with fish larvae. In a few cases, selective feeding was ideal. In some cases, copepods and rotifer co-feeding were better, and in many cases, ornamental fish were reared exclusively using copepods.

KEYWORDS: Livefeed, Marine ornamental fish, Seed production

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Enhancing the Pigmentation, Growth and Survival of Koi Carp, *Cyprinus carpio* var. Koi Carp Through Dietary Astaxanthin

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This study aimed to evaluate the effect of astaxanthin supplementation on the growth, survival and pigmentation of koi carp, *Cyprinus carpio* juveniles. Four diets enriched with astaxanthin at different levels in practical feed were fed for a trial of eight weeks to evaluate its influence on the colour, growth and survival of koi carp. Accordingly, four experimental groups of Koi carp juveniles were reared with astaxanthin of 0 mg/kg (T1), 50 mg/kg (T2), 100 mg/kg (T3) and 150 mg/kg (T4) for 56 days to examine the growth performance, pigmentation and survival. An increase in growth parameters was obtained in fish fed with astaxanthin enriched diet compared to the control. All treatments with astaxanthin-enriched feeds also provided higher carotenoid content and pigmentation than that in the control group of the fish. The survival rates were also better in astaxanthin-treated experimental koi carp juveniles. It can be concluded that the inclusion of astaxanthin in the practical fish feed can serve as an alternative carotenoid source in the diets of Koi carp *Cyprinus carpio* var. koi carp to ensure better pigmentation, improvement of the skin colour for increased attraction and subsequently increased value of the highly demanded, commercially important ornamental fish.

KEYWORDS: Astaxanthin, Koi carp, Pigmentation, Growth, Survival

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Growth and Nutritional Profile of Marine Microalgae, *Chaetoceros calcitrans* Under Different Water pH Conditions in Indoor Experiments

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An indoor experiment was conducted to assess the growth and nutritive profile of marine microalgae, Chaetoceros calcitrans under different water pH conditions in the indoor research facility. The study pH was maintained at four different levels viz., 5, 6.5, 8 and 9.5, in the carboy cans by providing different dosage periods of CO, at a temperature of 28°C. The pH 5, 6.5 and 8 were maintained cyclically by 12 h (3 h CO₂ addition and 3 h rest), 8 h (2 h addition and 4 h rest) and 4 h (1 h addition and 5 h rest) addition of CO₂ respectively, in a day, and pH 9.5 was maintained without the addition of CO₂. The culture showed better growth at pH 8 than at any other pH conditions. The reduced growth was witnessed at a lower pH of 5 during the 10 days of the culture experiment. The cell count was comparatively lower at pH 5 (7.36 million cells/ml) than at the other pH conditions (13.76 million cells/ml at pH 9.5; 14.63 million cells/ml at pH 6.5; 16.97 million cells/ml at pH 8). Among the different pH conditions, biomass (0.039±0.001 gDW/l), specific growth rate $(0.23\pm0.002~\mu_{max}/day)$ and doubling time $(2.95\pm0.03~days)$ were higher and better at the pH 8. The algal biomass from each treatment was lyophilized for further nutritional analysis. The crude protein and crude lipid contents were found higher at pH 8 (48.1±0.23%) and pH 9.5 (18.56±0.089%) respectively. The fatty acid composition in terms of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) increased with an increase in the pH levels. The EPA content increased from 0.75% at pH 5.0 to 2.43% at pH 9.5. However, the α-linolenic acid (~3) composition was found higher (4.12%) at pH 6.5 followed by pH 8.0 (3.58%) group. The study revealed that pH 8.0 is the most optimal for better and higher cell density, biomass and specific growth rate and the lower doubling time among all the pH treatments.

KEYWORDS: Chaetoceros calcitrans, Carbon dioxide, Nutritional value, Algal biomass, Unsaturated fatty acids

Techno-Economic Viability of Asian Seabass (*Lates calcarifer*) Nursery Rearing Systems

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Asian Seabass is considered one of the most suitable candidate finfish species for brackishwater aquaculture since it can withstand a wide range of salinity. In India, seabass farming is growing steadily for the past two decades due to the availability of hatchery seed, costeffective formulated feed and ready market. However, the availability of fingerling size seed in adequate quantity is a major constraint for adopting large-scale farming practice. Although seabass fingerlings are produced in different rearing systems such as earthen ponds, hapa and tanks, the information on the techno-economic viability is not reported. In this study, the stocking density, rearing protocols, survival rate, capital and operational cost were analyzed and compared among these three rearing systems. In the pond-based rearing system, an extensive approach is used, relying on naturally available plankton for feeding. Harvesting is done after 45 to 60 days of rearing to produce 3 to 4 inch size fingerlings. In contrast, in tanks and hapas, seeds are reared in an organized manner using formulated feed to produce uniform-sized fingerlings (4 to 5 inches) through regular grading, achieving a survival rate of 70 to 80%. In the tank system, higher productivity can be achieved by providing Recirculating Aquaculture System (RAS) and following biosafety measures. The hapa-based system is more suitable for small-scale farmers/self-help groups for the enhancement of livelihood, as it is less capital intensive. Although the pond-based nursery system is an easily manageable production method, the percentage of survival and uniformity in seed harvest depends on the availability of natural feed during different seasons. However, in the hapa and tank production systems, weaned seabass fingerlings can be produced with uniform size and a higher survival rate. The details of the cost-benefit ratio analysed are discussed.

KEYWORDS: Seabass, Fingerlings, Nursery, Production, Livelihood

Exogenous GTHS Administration to Elucidate Environmental-Endocrine Relation on Gonadal Maturation in *Clarias magur* (Hamilton, 1822)

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A 60-day experiment was conducted to study the effect of exogenous FSH administration to elucidate the environmental-endocrine relation on gonadal maturation in Clarias magur. This present study uncovers the maturation in captivity by using a specific inducing agent (rFSH) using two different substrates i.e., Dypsis lutescens (Substrate 1) and Eichhornia crassipes (Substrate 2). The present experiment was conducted for 60 days in a 2×2 factorial design and the experimental setup consists of four different treatments Substrate 1 without hormone (S1H0), Substrate 1 with hormone (S1H1), Substrate 2 without hormone (S2H0), and Substrate 2 with hormone (S2H1) in FRP tanks (1 ton capacity) in duplicates. The fish weighing 88.9±3.71g were randomly stocked at 1.3 kg per m³ in all the treatments. The hormone was administered based on the oocyte progression after the ovarian biopsy and ultrasonography. Initial and final serum sampling was done to study the reproduction dynamics and stress parameters influencing reproduction. Histology was done on the initial and final day of the experiment to know the different stages of oocytes. At the end of the 60 days, S2H1 i.e., E. crassipes with GTHs showed increased fecundity of 11,797±281 no's, fertilization rate of 86±3.2% and a hatching rate of 89±2.1% followed by Substrate 1 with hormone, Substrate 2 without hormone and Substrate 1 without hormone. The overall best performance regarding fecundity, fertilization percentage, and hatching rate was S2H1. This study will help in optimising conditions for captive maturation and subsequent breeding of C. magur.

KEYWORDS: Exogenous Hormone, Substrate, Clarias magur, Previtellogenic oocyte

Captive Maturation and Induced Breeding of Peacock Eel, *Macrognathus aral* for Conservation and Aquaculture Diversification

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Two separate experiments were conducted to develop the seed production technology of Macrognathus aral. The first experiment was conducted to evaluate the effect of different substrate on ovarian sexual maturation. Around 90 sub-adult fish (mean length, 14.5±1.85 cm and mean weight, 13.60±2.50 g) in the sex ratio of 2:1 (male: female) were randomly distributed in the eight tanks (2000 l) having different bottom substratum viz., Dead coral (T1), River sand (T2), and Soil (T3) in duplicate and reared for three months (April to June 2024). During the experiment, all the fish were fed with fresh chicken liver @10% of average body weight. At the end of the experiment, female fish were sampled. Results of the study showed that significantly (p<0.05) higher values of serum estradiol (43.88±0.18 pg/ml), vitellogenin (70.19±0.03 µg/ml), ovarian aromatase (102.94±1.20 ng/ml), mean oocyte diameter (1145±5.00 μm) and gonado-somatic index (GSI, 12.56±2.50%) in the T3 group than the T1 and T2 groups. Histological observation revealed the asynchronous type of ovarian development. In the second experiment, different doses of commercial hormone viz., 50, 100, 150 and 200 μl/mature female fish (mean oocyte diameter, 1145±5.00μm) and half the dose to oozing male was administered for induced breeding of M. aral (n=6). Maximum spawning percentage (80±2.00) was recorded in 200 µl dose. The latency period was inversely related to the dose of hormone and it was around 20 h in a higher dose of 200 μl. The significantly (p<0.05) highest functional fecundity (2700 eggs/female), fertilization rate (45±5.60%), hatching rate (35±7.20%) and larval survival (5±1.50%) were recorded in 200 µl dose. It is concluded that the presence of soil substrate induces captive maturation and the commercial hormone @ 200 is the optimal dose for induced breeding of M. aral.

KEYWORDS: Soil, Substrate, Sex steroids, Histology, Oocyte

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Development of Culture Method for the Wild Polychaete Worm, *Perinereis nuntia* collected from the Mandapam Sea Shore Area

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The marine polychaete worms, *Perinereis nuntia* (6 to 15cm in size), were collected from the seashore area of Maraikkayar Pattinam, Mandapam area. The DNA was extracted for identification by using the COI gene (700 bp), with the help of primers polyLCO and HCO. The worms were screened by using OIE protocols for the presence of shrimp pathogens. Most of the worms screened were negative for six shrimp pathogens, viz., WSSV, EHP, AHPND, TSV, DIV, and IHHNV, respectively. The worms were analyzed for their biochemical composition, particularly protein, fat, and fibre (8.07, 3.15%, and 0.09% (WWB) respectively. The parameters like pH, electrical conductivity, organic carbon, total available phosphorous, and available nitrogen contents of the soil substrate of the area of the collection were also reported as 8.3, 3.408, 0.164, 0.67, 29.12, and 3.75 respectively, and compared with the CAA standards. P. nuntia showed saturated fatty acid (0.60%), polyunsaturated fatty acid (0.30%), and monounsaturated (0.18%) respectively. A total of around 425 juveniles of *P. nuntia* (0.28 g of 7.1 cm size) were stocked into 17 rectangular tubs of 2.4 sq m area (40 cm × 60 cm area, 25 numbers stocked per tub). They were fed 50 ml of algae Chaetoceros calcitron (106/cfu/ ml) with 5 g of powdered CIBA shrimp larval feed (No:1) alternatively in the morning and evening. The worms were grown for 120 days and they reached the size of 1.1 g on average, with a total harvest of 374 g and 80% survival. The present study revealed that growing polychaete worms in a controlled condition is advantageous, compared to collection from the wild.

KEYWORDS: Identification, Perinereis nuntia, Proximate composition, Culture

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Impact of Organic and Inorganic Fertilizers on Biomass Production, Proximate Composition, Bioactive Compounds, and Antioxidant Activities of Watermeal (Wolffia globosa)

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An experiment was conducted to evaluate the effect of organic and inorganic fertilizers on the biomass production, biochemical composition, and antioxidant potential of Wolffia globosa (wolffia). Six treatments were applied in a randomized complete block design, including T0 (control; inorganic fertilizer), T1 (10 g/l cow dung), T2 (20 g/l cow dung), T3 (30 g/l cow dung), T4 (40 g/l cow dung), and T5 (50 g/l cow dung), each with three replications. Results showed a significant impact of both fertilizer types on biomass production and biochemical properties. Total biomass was highest in T0 (287.83±5.78 g) and T4 (271.23±5.79 g). Crude protein content was notably higher in T4 (30.40%) and T0 (29.31%), while crude lipid was significantly higher in T4 (5.09%) and T0 (4.91%). The highest total phenolic content (TPC, 350.04 mg GAE/g), total flavonoid content (TFC, 159.35 mg QE/g), and vitamin C (99.05 mg/100 g) were observed in T5. Total carotenoid content (TCC, 2286.90 μg/g) and chlorophyll-b (Chl-b, 11.82 µg/g) were significantly higher in T0. Antioxidant activities, measured through DPPH scavenging activity, ABTS, and FRAP, were highest in T5 (57.42%) DPPH and 65.65% ABTS) and T1 (180.64 µmol Fe/g FRAP). This study suggests that organic fertilizers, particularly cow dung, significantly enhance the bioactive compounds and antioxidant activities of wolffia.

KEYWORDS: Wolffia, Cow dung, TPC, TFC, Vit C, Antioxidant activities

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Early Life-History Traits of Upside-Down Jellyfish Cassiopea xamachana: Insights from Experimental and Field Studies

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Upside-down jellyfish, Cassiopea spp., display a meta-genetic life cycle with medusoid, polyp and intermediate ephyra stages. The present study describes the morphological development and morphogenesis of planuloid, polyp, ephyra, and young medusa Cassiopea xamachana in captivity for the first time in Indian waters. Asexual planuloid buds of C. xamachana (4±2 nos) develop from the hypostome or stalk of the budding polyp and become ciliated free-swimming planuloid in 3±2 days, which further undergo anterior-posterior axis changes in 4±2 days to become young, settled polyps. The polyp is elongated in the forward end and undergoes a series of development: four pre-radial, radial, and inter-radial tentacles in 5±2 days. The fully mature polyp (8±2 days) had a perisac, stolen, calyx, hypostome, and tentacles, (16 to 32 nos) and these polyps either strobilated or produced buds depending on the ambient environmental conditions. The newly released ephyra (1.9±0.8 mm bell diameter) are phototactic with long manubrium length, 16 yelar lappets, 32 rhopalial lappets, and zooxanthellae in the mesoglea. As the ephyra grew, the first four gastric filaments developed from the manubrium, with four oral arms and bifurcated into eight arms. Furthermore, vesicles develop in the arms and disc center; in this stage, ephyra is geotactic and found at the bottom as young medusae in 4±2 days. The study revealed that the young medusae readily accepted live feed in laboratory conditions, and morphogenesis continued under laboratory conditions, which is essential to unravel its swarming behavior in the wild.

KEYWORDS: Medusa, Marine Invertebrates, Rhizostomeae, Scyphozoa, Indian waters

Cellular and Molecular Insight to the Vitellogenesis of Black Tiger Shrimp, *Penaeus monodon*

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The black tiger shrimp, *Penaeus monodon*, was the most widely farmed penaeid shrimp species, and global aquaculture production was dominated by this species until early 2000. Owing to the frequent crop losses due to highly contagious infectious diseases such as white spot disease, many Asian countries including India introduced specific pathogen-free (SPF) stock of *P. vannamei*, and currently almost 83% of the global farmed shrimp production is contributed by this species. P. monodon is, however, considered the second culture option in the crustacean aquaculture sector, and there is a renewed interest in P. monodon due to its high and stable market price. Although SPF P. monodon was developed by a few breeding companies, the management of reproduction under captivity of this species has still been an enigma. The current research work aimed to evaluate the cellular and molecular mechanism of P. monodon reproduction under captive conditions. Progressive changes of female germ cells during the oogenesis were characterized by light and transmission electron microscopy: The germ cells in the adult shrimp were divided into oogonia, pre-vitellogenic oocytes (Oc1 and Oc2), early vitellogenic oocytes (Oc3 and Oc4), late vitellogenic oocytes (Oc5) and mature oocyte (Oc6). The ovarian cycle of naturally reproducing and eyestalk ablated broodstock was characterized using histological and macroscopic tools and was classified into five welldefined ovarian stages: immature/spent, pre vitellogenic, early vitellogenic, late vitellogenic and ripe stages. After one month of the hatchery cycle, in eyestalk ablated shrimps none of the shrimps were found to be immature indicating that eyestalk ablation leads to a minimum level of stimulation in all the animals, although only 30-40% of animals spawned successfully. To further our understanding of the molecular mechanism of vitellogenesis, the dynamics of Vg mRNA expression were examined in naturally reproducing and endocrinologically induced P. monodon brooders. A partial sequence of Vg cDNA was amplified and cloned. Vg mRNA expression was found only in the hepatopancreas and ovary of females. In the ovary of naturally reproducing shrimp, Vg mRNA expression levels were found lowest in the immature stage and the ripe stage with a peak in the vitellogenic stage, whereas in ovarian tissues of eyestalk ablated brooders, there were two peaks in the expression levels: in the vitellogenic and ripe stages. The Vg mRNA level in the hepatopancreas was found to be lower than in the ovarian tissues, and its level peaked only in the pre-vitellogenic ovary of naturally reproducing females. The present study also indicates that there were two forms of population, with high and low fertility rates.

KEYWORDS: *Penaeus monodon*, Vitellogenesis, Vg mRNA, oogenesis, Reproductive maturation, Transmission electron microscopy



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Standardization of an Intermittent Flow-Through Respirometer for Assessing Aerobic Performance in Fish

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Global warming and climate change are disrupting aquatic ecosystems, affecting wild fish populations, and causing stressful husbandry conditions in aquaculture. The ability of fish to cope with these challenges is closely tied to their aerobic performance, measured as their capacity to deliver oxygen to tissues for energy production, which supports maintenance, growth, and reproduction. This performance is quantified by assessing two key metabolic rates: the maximum metabolic rate and standard metabolic rate, with the difference between them defined as the aerobic scope. Accurate measurement of these parameters requires specialized equipment like intermittent flow-through respirometers. In this study, we customdesigned, developed and standardized a cost-effective intermittent flow-through respirometry system to reliably measure aerobic scope in *Oncorhynchus mykiss* (rainbow trout). The system employs time-controlled submersible pumps and optical dissolved oxygen sensors. During the flush cycle, the pump replaces the water in the respirometer chamber, while in the measurement phase, the pump is turned off, and oxygen consumption is monitored through a recirculation loop equipped with dissolved oxygen sensors. To check the functionality of the respirometer, we investigated the aerobic performance of rainbow trout under various conditions, including different dietary compositions, nutritional levels and environmental conditions. The results revealed that aerobic performance varied significantly across these conditions, with the highest performance observed when the fish were maintained in their most optimal nutritional and environmental conditions. The standardized custom-built respirometer could serve as a reliable and efficient tool for assessing aerobic performance in different fish species, providing critical insights into their physiological responses to varying environmental conditions. Eventually, these findings are critical for improving aquaculture management practices and understanding the impacts of climate change on fish species in their natural habitat.

KEYWORDS: Flow-through respirometer, Fish, Oxygen consumption, Aerobic scope

Induced Breeding and Nursery Rearing of Organic Silver Barb, *Puntius gonionotus*, (Bleeker 1850) in Cement Tank

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The study focuses on the induced breeding and nursery rearing of organic Silver Barb (Puntius gonionotus), utilizing cement tanks as a controlled environment. Induced breeding was achieved by administering the pituitary gland extract, which stimulated the spawning process in broodstock. The use of pituitary extract ensured successful ovulation and increased the fecundity rate, significantly enhancing the hatchability of the eggs. The nursery-rearing phase involved feeding the larvae with a specialized diet comprising egg yolk, milk, and yeast powder, which provided essential nutrients for optimal growth and survival. The cement tanks offered a cost-effective and manageable alternative to traditional earthen ponds, allowing for better water quality control and easier fish health monitoring. By adopting organic farming practices, this research aligns with sustainable aquaculture methods, minimizing the use of synthetic chemicals and promoting environmentally friendly fish farming. The results demonstrated a high survival rate of the larvae, suggesting the feasibility of cement tanks for both breeding and nursery rearing. This study provides insights into the potential of using cement tanks for induced breeding and nursery rearing of Silver Barb, offering a sustainable and scalable approach for aquaculture practitioners aiming to produce organic fish in controlled environments.

KEYWORDS: Organic nursery rearing, Silver Barb, Puntius gonionotus, Cement tank

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Effect of Chronic Crowding Stress on Growth, Haematology and Serum Biochemistry of *Pangasianodon hypophthalmus* (Sauvage, 1878) Fingerlings

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A 60-day experiment was conducted to study the effect of chronic crowding stress on the hemato-biochemical parameters of *Pangasianodon hypophthalmus* (Sauvage, 1878) fingerlings. The fish (n= 324 fish, 12.02±0.47 g) were randomly distributed into three distinct experimental groups with four replicates each in twelve fiberglass tanks with different stocking densities, viz., stocking density 1, SD1 (9 fish/100 l), stocking density 2, SD2 (27 fish/100 l) and stocking density 3, SD3 (45 fish/100 l) and were subjected to crowding stress for 2-month period. Fish feeding was done using a commercially purchased well-balanced diet three times per day with a feeding rate of 3% of the wet fish weight. Results revealed a significant decline in the growth of fish when the stocking density increased. With increasing stocking density, the haematological parameters viz., total erythrocyte count (TEC), and packed cell volume (PCV) was significantly (p<0.05) decreased, while the total leukocyte count (TLC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) levels were significantly (p<0.05) higher. The serum biochemical profiles were also significantly altered in the higher stocking density groups compared to the control. Under crowding conditions, the level of stress biomarkers (glucose, serum cortisol), metabolic enzyme activities (alkaline phosphatase, aspartate aminotransferase, and alanine aminotransferase), cholesterol, urea, uric acid, and creatinine were significantly increased (p<0.05), while serum protein, albumin, and calcium ion were significantly (p<0.05) decreased. From the results of the present study, it may be concluded that a stocking density of 9 fish/1001 (SD1) is ideal for overall individual growth, better health, and stress responses of striped catfish.

KEYWORDS: Chronic stress, Crowding, Pangasianodon hypophthalmus, Cortisol

Redefining Seaweed Farming with Custom Designed Rafts Engineered for High-Tidal Amplitude Zones: A Case Study on Production Assessment along Indo-Pak Border Marine Sites with Validation

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The emerging interest in seaweed farming along the Indian coast necessitates the development and adaption of region-specific structural designs and farming technologies to ensure sustainable sector growth. This study introduces an indigenous innovation of High-Density Polyethylene (HDPE) floating rafts, custom-designed mooring technologies specifically tailored for high tidal amplitude zones along the sensitive Indo-Pak border marine waters. The selected sites were assessed with preliminary site suitability criteria and were spatially demarcated. Subsequently, for structural, production and productivity assessments in areas experiencing one of the highest tidal amplitude ranges (8-12 meters) in India along the Kutch coast of Gujarat, we engineered a grid-based mooring system. HDPE raft frames (3 x 3m) insulated with Polyurethane foam (PUF) were deployed at a depth range of 6-8 meters. The mooring assembly was optimized using two designs; a multigonal grid mooring and an umbrella mooring design, and its assemblies were tested separately. The performance evaluations indicated that the umbrella mooring, utilizing four 100 kg RCC blocks with a cumulative anchorage of 400 kg, demonstrated seaworthiness, superior structural integrity, and stability under turbulent sea conditions during the 75-day culture period observations. In a grid consisting of 4 rafts, 2 rafts were integrated with 10 net tubes and another 2 rafts with 10 monolines, each stocked with 30 kg of seaweed (Kappaphycus alvarezii) seedlings. The study resulted in average harvests of 412 kg (Monoline) and 338 kg (Net tube) respectively from the integrated rafts. The custom-designed raft systems showed significant production improvements with enhanced yields when compared with traditional bamboo rafts operated in the region. Further, the monoline-integrated rafts performed significantly better in growth and biomass yield, affirming the efficacy of the indigenously developed HDPE seaweed raft structures and their adaptability. This study represents a technological and biological validation approach, marking the first-time development of a customized seaweed raft assembly system. Our findings suggest that a grid configuration of four HDPE rafts with umbrella mooring can effectively support seaweed cultivation and enhance the expansion of the seaweed sector along the Kutch coast. Current assessment could serve as a valuable case study for other maritime states, offering insights for refining and improving custom designs, mooring assemblies, and seaweed culture protocols. Furthermore, this innovative approach not only enhances production capacities and biomass yields but also supports the broader goals of the seaweed mission, promoting farming practices that are adaptable to diverse marine environments along the Indian coast.

KEYWORDS: Seaweed, Mariculture, Sustainable practices, HDPE, Grid Mooring Systems



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ICAR-CIBA Initiatives to Popularize Brackishwater Finfish Farming Towards Species Diversification

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Brackishwater aquaculture is one of the most dynamic and fast-growing food-producing sectors, contributing substantially to the economy and sustainability of coastal communities worldwide. India achieved an all-time high marine export earning of Rs. 63,969 crores in the year 2022-23 due to technological advancements and the adoption of sustainable practices. However, the sector is facing challenges presently in terms of disease-related issues, increased cost of production and unstable prices in the international markets. The changes witnessed have imparted crucial lessons on the need for diversification of species, especially finfishes for a holistic and sustainable aquaculture development in India. Finfish species can capitalize on the new opportunities through diversified farming practices in brackishwater bodies to achieve long-term growth and success. ICAR-Central Institute of Brackishwater Aquaculture (CIBA) has initiated research and developmental activities to develop comprehensive technology packages for candidate finfish species such as seabass. milkfish, pearlspot, catfish, scat, and silver moony, and for upscaling the seed production of grey mullet and mangrove red snapper. Seabass farming in India is witnessing increasing trends that are shaping its future and growth with hatchery-produced seed, fish vaccine and formulated feed now available for the stakeholders. CIBA is partnering with Govt. departments and entrepreneurs to establish fish hatcheries, customized feed mills, vaccine development for health management and hand-holding approach with farmers for nursery production and grow-out culture establishments through MoUs, field-level demonstrations, farmers' interactions meets, etc. CIBA encourages to establishment of satellite fish seed rearing in different places by providing inputs such as fish spawns/larvae/fry, live food organisms, larval diets, technical know-how and training to the private farmers/entrepreneurs. The institute supports the supply of healthy seabass brooders to jump-start the seed production for the newly started private seabass hatcheries till the development of their own broodstock. As brackishwater finfishes can be farmed in varying salinity regimes and diversified rearing systems such as earthen ponds, open sea cages, brackishwater low-volume cages, tankbased re-circulatory systems and pens in open water bodies; a wide range of farmers can be involved to enhance the fish production

KEYWORDS: Diversification, Finfish farming, Brackishwater aquaculture, Seed production

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Induced Breeding and Larval Rearing of Striped Murrel, *Channa striata* in Different Refuge Systems

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Channa striata commonly known as striped murrel is a popular high-valued indigenous food fish of the Indian sub-continent with considerable medicinal values. Although the breeding and seed production technique is available for C. striata, consistent production of good quality seed is still a major problem due to poor survival during fry rearing, particularly due to heavy cannibalism. To address the issue, trials on induced breeding and larval rearing were conducted during July of 2023 and 2024. FRP tanks with *Eichhornia* sp. were used for induced breeding trials. Fish were injected with synthetic hormone ovatide @ 1 ml /kg to the female fish, whereas males were given @ 0.8 ml/kg body weight. Male to female ratio was kept at 2:1. After a latency period of 20-25 hours, about 80-85% fertilization of eggs was achieved. After yolk sac absorption, larvae were reared in different refuge systems for a period of 21 days to estimate the survival percentage of fry. During this, larvae were reared in four treatment groups T₁ (Water with medium-sized stone bed), T₂ (Water with mediumsized stone and 2-inch sand bed), T₃ (Water with Eichhornia plants), and T₄ (Water with the combination of all i.e. stones, sand bed and Eichhornia plant). One hundred individuals of four days old larvae produced from induced breeding were introduced to all the treatment groups. Larvae were fed with mixed zooplankton six times per day. Continuous aeration was given in all the treatments with 30% water exchange every 3rd day to keep the water quality parameters under optimum level. The highest survival was recorded in the T₂ group (56%), and was significantly higher than other treatments, followed by T4 (32%), T1 (27%), and the lowest was observed in T3 (18%). The present findings suggest that a sand bed having medium-sized stones may prove a better substratum and habitat for achieving higher survival of fry in C. striata. The study suggests the need for more trials in different agro-eco regions.

KEYWORDS: Channa striata, Induced breeding, Refuge systems, Larval survival

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Site Suitability Assessment of Inland Saline Groundwater Resources Based on Farm Productivity and Ionic Parameters

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Commercial shrimp farming using inland saline groundwater is practiced in an area of roughly 3500 acres in north-western India. A deeper understanding of the ionic parameters of inland saline groundwater is essential for determining the site's suitability and evaluating the underlying reasons for unexplained mortality, and recurring low productivity. A survey was conducted to determine the relationship between farm productivity and ionic variables of saline groundwater. Saline groundwater samples were collected from operational shrimp farms in major farming clusters of north-western India (n=120) and were analysed for salinity; pH; total alkalinity; total hardness; aqueous Na⁺, K⁺, Ca²⁺, Mg²⁺ levels; relative hardness (RH: observed hardness/hardness of reconstituted seawater of same salinity); Mg²⁺/Ca²⁺ ratio and calcium equivalence [Ca²⁺(%)= observed aqueous Ca²⁺ levels/aqueous Ca²⁺ levels in reconstituted seawater of same salinity x 100). Based on the historical farm productivity data, the saline groundwater samples were grouped into three classes viz., high (H; yield: > 3000 kg/acre; n=79), medium (M; yield:1500-3000 kg/acre; n=37) and low productivity (L; yield: <1500 kg/acre; n=8). The three sample classes were clearly distinguished by significantly different (p<0.05) RH, Mg²⁺/Ca²⁺ratio, and Ca²⁺(%). Samples from least productive farms (L) had significantly lower (p<0.05) RH of 0.93±0.07, whereas highly productive farm samples displayed a mean RH of 1.53±0.03. Samples from farms that reported medium productivity demonstrated an RH of 1.79±0.07 indicating a reduction in growth as hardness approaches values twice (RH=2) as that of seawater of the same salinity. Similarly, samples that resulted in higher productivity exhibited a significantly higher Mg²⁺/Ca²⁺ ratio of 1.48±0.04 over medium-productive farms (1.20±0.06). Calcium equivalence values of 300% resulted in high productivity whereas values exceeding 400% resulted in medium productivity. The study indicates that Whiteleg shrimp, *Penaeus vannamei* demonstrates high productivity when reared in inland saline groundwater of intermediately higher hardness levels whereas productivity decreases as RH approaches 2.0. Moreover, under a high Ca²⁺ equivalence scenario (>100%), low total hardness (RH<1) results in poor productivity due to reduced aqueous Mg²⁺ levels despite favourable Mg²⁺/Ca²⁺ ratio. Overall, the study provides deeper insights into the understanding of different ionic parameters to develop new site suitability.

KEYWORDS: Inland saline groundwater, Relative hardness, Penaeus vannamei, Mg2+/Ca2+ ratio



3P3C Model: ANovel Intensive Aquaculture Approach for Maximized Productivity and Profitability

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Achieving financial sustainability in aquaculture depends on production and profitability from culture systems. In the current era, declining profit margins in agriculture and the reduced per capita land availability driven by rapid population growth demands a shift toward resource-specific and species-specific aquaculture practices to maximize the potential of the aquaculture sector. Various models exploring production efficiencies in different culture systems, techniques, and species are crucial for enhancing income and cost-effectiveness in aquafarming. An innovative model known as "3 Phase 3 Cycle" (3P3C) is such a model developed by the Regional Research and Training Centre of ICAR-Central Institute of Fisheries Education (CIFE), Mumbai to address better profitability out of a production system. The model integrates different aquaculture techniques, resources, and trophic levels within an intensive farming framework. It consists of three distinct phases executed over three annual cycles which start with nursery rearing conducted in specialized nursery ponds followed by transition or "phase-out" culture, where seeds grow to a stocking size under intensive biofloc systems, and finally mixed grow-out farming of carps and catfish in ponds. This model has shown an ability to boost production by three to five times per unit of land and water, making it highly efficient and adaptive. The 3P3C model is notably resilient in both flood and drought conditions, providing stable outputs across varying environmental scenarios. Additionally, it supports overwintering practices under low temperatures, which improves the quality and survivability of fish stock. The 3P3C model demonstrates that integrating multi-phased intensive practices not only increases productivity but also provides a pathway to sustainable, resource-efficient aquaculture. This approach could be pivotal in meeting future demands while ensuring economic and ecological stability in aquaculture systems.

KEYWORDS: 3P3C Culture Model, Mixed farming, Production efficiency, Cost-effective, Aquaculture

Airlift-Based Recirculating Aquaculture System Design for Energy Efficient Small-Scale Fish Farming: A Multi-Species Validation

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Recirculating aquaculture system (RAS) is gaining global prominence as a sustainable solution for fish farming due to its potential to support high productivity and efficient use of water and land. However, RAS adoption by small-scale farmers is limited by high capital and operational costs, energy requirements and system complexity. Considering these constraints, a simplified RAS model was designed and developed to reduce system complexity and operational costs. The components of this RAS prototype were a 0.2 m³ culture tank with dual drains, a solid removal system, a moving bed biological filter, and an airlift-based pump and aeration system. In this system, three separate growth trials were conducted using juvenile rainbow trout (Oncorhynchus mykiss), mono-sex tilapia (Oreochromis niloticus), and striped catfish (Pangasius hypophthalmus), and the trials lasted 93, 84, and 31 days, respectively. Following a 15-day biological filter maturation period, fish were stocked at initial densities of 10.5 kg/m³ for rainbow trout (mean weight: 67.4 g); 21.5 kg/m³ for tilapia (mean weight: 85.8 g); and 22.8 kg/m³ for pangasius (mean weight: 142 g). The water temperature during the trial ranged 9.5-17.3°C, 22.6-29.4°C and 26-28.9°C for rainbow trout, tilapia and pangasius, respectively. Other water quality parameters such as dissolved oxygen, ammonia, nitrite, nitrate, pH and alkalinity were maintained within the acceptable limits for these fish. Results showed that the airlift-based RAS could support the production of 29.5 and 42.6 kg/m³ of rainbow trout and tilapia, respectively. Beyond this density, the growth rates were found to decline. In case of pangasius, 32.7 kg/m³ standing biomass could be cultured in a short period, and there is potential to increase productivity further given their facultative air-breathing ability and high dissolved oxygen concentration in the culture tank. During these trials, feed conversion ratio was estimated to be 0.96, 1.16 and 0.95; and energy consumption was estimated to be 16.8, 7 and 12.5 kWh/kg for rainbow trout, tilapia and pangasius, respectively. In conclusion, we validated that the simplified airlift based RAS design was suitable for small-scale farming of different fish species, without sophisticated filtration systems and electric water pumps.

KEYWORDS: Sustainable aquaculture, RAS, Air-lift mechanism, Energy efficiency, Productivity



Macrobrachium dayanum (Henderson, 1893)—APotential Candidate Species for Freshwater Aquaculture

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Macrobrachium dayanum (Henderson, 1893) is a truly freshwater small-sized species of palaemonid prawn inhabitant of rivers. In the rivers of Bihar, its fishery is negligible, but it fetches good market price. Keeping in view the scarce availability of this coveted prawn in rivers, research for its propagation under captivity was undertaken in pre-prepared college ponds. Juveniles of the size of 6.2 mm to 8.00 mm having weight of 1.150 mg to 1.280 mg were collected from river Budhi Gandak, the nearby available wild source and stocked in the pond. They were initially fed with zooplankton and then provided with supplementary feed. Maturity was attained by the prawns within 120-130 days of stocking and berried females were observed bearing lush green colored eggs among its pleopods, which changed gradually to forest green and finally olive to muddy green at the time of their release into the ambient water The shape of the eggs was elliptical, measuring 2.15-2.20 mm in length and 1.50-1.57 mm in width. The incubation period was observed to be 29-30 days when hatchlings came out resembling their parent except for their tail and hence called post larvae. The hatchlings were observed regularly throughout the year in the pond, indicating the prolific breeding behavior of the prawn. Berried females were observed around the year with two peak breeding periods, one during March and another in June to September. Fecundity varied from 70 to 148 eggs. The maximum weight of the female recorded was 2.85 g including the weight of the egg cluster of 0.550 g. The sex ratio varied from 1:18 to 1:11.5; females dominated the stocked population. Berried females were observed during winter months also, but males preferred hideouts in those months. The survival percentage recorded was not very good, being only 42%. The present study revealed that M. dayanum accepts artificial feed, and grows and breeds well under captive conditions. Due to added attributes like its complete adaptation to freshwater, abbreviated larval development without a hatchery phase, and lucrative market value, this prawn can be promoted as a potential candidate species for aquaculture especially for income generation of rural people

KEYWORDS: Palaemonid prawn, Hatchlings, Abbreviated larval development

Stable Isotopic Evidence on Natural Diet of Giant Freshwater Prawns Utilized for Stock Enhancement in Agrarian Reservoirs of Sri Lanka

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Sri Lanka is full of agrarian reservoirs built throughout the past 2500 years or so, for stormwater harvesting targeting paddy farming. Potential of those reservoirs for the development of culture-based fisheries (CBF) utilizing exotic finfish species, has been well documented. Giant freshwater prawn (GFP) Macrobrachium rosenbergii is an indigenous riverine species identified recently as a candidate for CBF, boosting income generation of associated rural communities. National Aquaculture Development Authority, Sri Lanka (NAQDA) stocks millions of GFP post-larvae annually in many reservoirs without relating environmental conditions to the yield from those reservoirs. Since GFP naturally grows in the riverine environment and migrates to the ocean for reproduction, aim of this paper is to assess their natural food consumption in reservoirs using ¹³C and ¹⁵N stable isotope (SI) ratios in body tissues. GFP specimens along with potential basal food resources and cooccurring consumer species were collected from six reservoirs, time to time within the 2023-2024 period. Muscle tissues were subjected to lipid removal, oven drying and powdering following standard procedures prior to SI analyses, which were carried out at James Cook University, Australia. Results showed that δ^{13} C values of GFP ranged from 35.89 ‰ to 21.52 ‰ with the variety of food sources while δ^{15} N values ranged from 7.93 ‰ to 13.04 ‰ showing trophic shifts based on their habitat. δ^{13} C and δ^{15} N values of GFP from six reservoirs were significantly different (p<0.001; Kruskal-Wallis) confirming the variety of food sources for GFP in different agrarian reservoirs. In the stable isotope space considering all reservoirs together, GFP diet in terms of C source was closer to other co-occurring omnivorous Indian carps, Cirrhinus mrigala and Catla catla, but trophically above them in terms of N source evidencing carnivory. This information provides insight to the dietary adaptability of GFP supporting proper management of stock enhancement practices in agrarian reservoirs.

KEYWORDS: Culture-based fisheries, Macrobrachium rosenbergii, Stock enhancement

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Impact of Sub-Lethal Iron Exposure on Physiological Responses in Labeo robita and the Protective Role of Antioxidant Diet

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Elevated iron (Fe) concentrations in aquatic environments present a significant challenge, particularly in Northeast India, due to their toxic effects on fish species and the consequent impact on aquaculture sustainability. This study evaluated the physiological responses of Labeo rohita, an economically important freshwater species, to sub-lethal ferric iron exposures at $1/16^{th}$, $1/8^{th}$, and $1/4^{th}$ of the 96-hour LC₅₀ concentrations. Fish were sampled at 0, 7, 15, and 30 days for hematological, immunological, and biochemical analyses to elucidate Fe-induced stress responses. Results revealed that hematological parameters, including erythrocyte count and hematocrit levels, increased proportionally with Fe exposure duration and concentration, while serum protein, albumin, and globulin concentrations declined, indicating potential protein catabolism under Fe stress. Biochemical analyses indicated hyperglycemia and decreased serum bactericidal activity, highlighting a compromised immune response in Fe-treated groups compared to controls. Immunological markers and enzyme assays showed reduced activity in key antioxidant enzymes, with catalase (CAT) and superoxide dismutase (SOD) activities dropping markedly at the 7-day mark, signaling oxidative stress induction. Additionally, Fe bioaccumulation in gill and hepatic tissues correlated positively with exposure levels, accompanied by elevated alkaline phosphatase activity, further indicating tissue-specific toxicity. To mitigate oxidative stress, an antioxidantenhanced diet incorporating 2% bamboo shoot was formulated, which significantly restored antioxidant enzyme levels and reduced Fe-induced oxidative damage in Labeo rohita. These findings suggest that dietary interventions with antioxidant properties, such as bamboo shoot supplementation, offer a viable strategy to counteract the physiological stress imposed by high Fe concentrations in aquaculture systems.

KEYWORDS: Labeo rohita, Iron toxicity, Oxidative stress, Hematological parameters, Immunological response, Antioxidant diet

Leveraging Nature-based Solutions to Green the Blue Growth in Asia-Pacific: Lessons from AQUADAPT, a Collaborative Aquaculture Research Program

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In response to growing environmental and climate challenges, aquaculture actors are exploring nature-based solutions (NbS) to enhance resilience and sustainability. Naturebased solutions are defined as actions to protect, conserve, restore, and sustainably manage natural or modified aquatic ecosystems while supporting the cultivation of species for food security and livelihoods. Examples include aquaculture-silviculture, integrated multitrophic aquaculture, low-input seaweed and bivalve farming, natural alternatives to antimicrobials, and sustainable fish feeds. While such interventions hold great potential to "green the blue growth," their effectiveness, scalability, socioeconomic benefits, and potential risks require further research and evaluation. Barriers also impede the uptake of nature-based solutions, particularly for marginalized and/or small-scale aquafarmers. This presentation discusses how researchers can help to catalyze a transition to socially inclusive nature-based aquaculture, drawing on early experiences from AQUADAPT. AQUADAPT is a CA\$24 million 4-year (2023-2027) collaborative research program that aims to advance nature-based solutions in aquaculture in Asia-Pacific. The initiative is co-funded by the International Development Research Centre (IDRC) and Global Affairs Canada. In this presentation, we provide an overview of AQUADAPT. We will then discuss emergent lessons from our experiences managing a multidisciplinary cohort of 11 projects in 10 Asia-Pacific countries. Concrete practical examples will illustrate each lesson. Three key lessons to date are: a) Many existing practices might be considered "nature-based," but in the aquatic foods sector, this term is inconsistently applied and poorly understood. Clear jargon-free definitions and standards can help integrate NbS in policy and catalyze investment, including through climate finance. Such standards must include gender and social equity criteria; b) Nature-based solutions' implementation and assessment integrates diverse disciplines and forms of knowledge. Interactions between knowledge producers are shaped by unequal relationships of power. Promoting effective and equitable research collaboration for NbS therefore requires peerlearning and reflexivity. Game-based methodologies are one way to promote transdisciplinary dialogue and knowledge coproduction; and c) Partnerships between researchers and private sector actors can help scale socially inclusive business models for NbS, especially when researchers engage private sector actors early in the research process. Research-private sector collaboration is best conceptualized as a means to social and environmental outcomes, rather than an end in itself.

KEYWORDS: Climate change, Regenerative aquaculture, Ecosystems, Resilience, Participatory action research (PAR)



Growth and Reproductive Performance of Swordtail (Xiphophorus helleri) Raised in Inland Saline Waters

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This study investigates the reproductive performance and salinity tolerance of swordtails (Xiphophorus helleri) in inland saline waters, aiming to evaluate the feasibility of ornamental fish farming as a sustainable alternative for small farmers in salt-affected and waterlogged regions of Puniab. The experiment was conducted at the College of Fisheries, GADVASU, Ludhiana, utilizing inland saline water collected from Village Birewala, District Mansa. Glass aquaria with a capacity of 50 litres were set up to test varying salinities (0, 2, 4, 6, 8, 10, and 12 %) in triplicate, with continuous aeration being provided. Swordtail fry were obtained from the college's seed production unit and stocked at a density of 12 fish per aguarium. The fry were fed commercially available feed twice daily, while water quality and ionic composition were monitored using standard protocols. Growth assessment was performed through measurements of total body length (TBL) and body weight (BW) over a 90-day period. Results indicated significantly higher growth parameters (TBLG, NWG, SGR) in salinity groups of 2-12% compared to the control group (0%). However, growth declined substantially at higher salinities (10-12‰). Survival rates were high at lower salinities (94.44% in 0-8 %) but diminished at elevated levels, with survival rates recorded at 88.89% in 10% and 80.55% in 12%. Additionally, fish behaviour and reproductive metrics, including gonadosomatic index, fecundity, and fry survival rate were notably affected by salinity, showcasing optimal reproductive performance at 8%. The findings suggest that freshwater ornamental swordtails can thrive in inland saline water, with a maximum salinity of 8 % recommended for optimal growth and reproduction. This study highlights the potential of ornamental fish farming in transforming the socio-economic landscape of Punjab by utilizing otherwise unproductive saline agricultural lands.

Keywords: Inland saline water, Salinity tolerance, Swordtail, Physiological responses, Colouration

Ecosystem Dynamics and Mariculture: Unveiling and Mitigating Environmental Impacts and Sustainability Challenges in Indian Coastal Sea Cage Farming

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Mariculture is emerging as a key solution to global challenges such as surging fish demand, shrinking land resources, and the depletion of wild fish stocks. The rapid expansion of opensea farming presents immense economic potential, but also heightens the risk of nutrient runoff, accelerating eutrophication and threatening marine ecosystems. India's ambition to double farmers' income through large-scale mariculture along its vast coastline is promising, yet fraught with environmental concerns if inadequately managed. Our study on spiny lobster (Panulirus polyphagus) farming along Gujarat's Saurashtra coast, where 12,557.74 km² (52%) coastal sea space has been identified as suitable for sea cage farming, highlights these critical dynamics. Throughout a one-year study, excluding two months of the northwest monsoon season, sampling was conducted fortnightly to assess environmental parameters, phytoplankton diversity, lobster growth performance, feed supply, and remote sensing data on water currents at both the cage culture and reference sites. The study was structured into three phases: Before culture, During culture, and After culture. Results indicated negligible environmental impacts, however, phytoplankton diversity decreased during the culture phase and increased in the after-culture phase. Total suspended solids (TSS) were identified as a key factor affecting phytoplankton diversity and ecosystem health, underscoring the complexity of these interactions. The increased dominance of specific phytoplankton species during farming (D=0.05438) compared to the reference site (D=0.0405) highlighted potential ecological imbalances and the urgent need for effective mitigation strategies as mariculture expands. The Generalized Additive Model (GAM) validated that total suspended solids levels above 300 mg/l negatively impacted phytoplankton diversity. It also illustrated that total suspended solids and ammonia along with other nutrients exerted significant predictive influence on phytoplankton diversity, revealing complex interactions between total suspended solids, nutrients, and phytoplankton. As open-sea cage farming expands, the study stresses the need for an ecosystem-based approach and policies with strict environmental standards, continuous monitoring, and enforcement to balance industry growth with ecological sustainability in coastal waters.

KEYWORDS: Mariculture, Sea Cage Farming, Sustainability, Ecosystem Approach to Aquaculture (EAA), Generalized Additive Model (GAM)



Impact of Salinity on Microalgae Culture (*Thalassiosira* spp.) and Application of Harvested Concentrate on Rotifer Culture

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Microalgae are the major food source for many aquatic organisms and the main live feed used in marine hatchery operations. The value of microalgae as a food source depends on some characteristics such as cell size and biochemical composition. The diatom Thalassiosira weissflogii (Fryxell & Hasle, 1977) has been widely used as live feed in aquaculture. Salinity affects the growth and chemical composition of T. weissflogii. Information related to the effect of salinity on the growth and the quantity of harvested biomass is not yet available. Thus, it is important to know the optimal salinity at which T. weissflogii has to be cultured for aquacultural purposes. In our study, the culture media used was f/2 (Guillard, 1975). The salinity concentrations used were 5, 10, 15, 20, 25, 30 and 34%. Each treatment was performed in triplicate. Room temperature was maintained at 20±1°C with a continuous light intensity of 3000 lux. The pH was measured daily with a pH meter. Cell counts were performed daily, in triplicate, with a Neubauer chamber (0.1 mm depth) to determine the maximum cell density. The maximum cell density (6.2x106 cells/ml) was obtained at 25%, followed by 20% with 5.7x106 cells/ml after 7 days of culture. The microalgal concentrate was produced by harvesting the culture by flocculation with 1N NaOH (pH 9.5) resulting in 80% harvesting efficiency with viable cells. The concentrate produced at each salinity was used for rotifer culture to assess its potential for rotifer multiplication. The *Thalssiosira* culture on 25% showed a higher multiplication rate compared to other salinities. It might be due to the higher cell count produced at that salinity. Hence it is concluded that 25% is the ideal salinity for the mass culture of *Thalassiosira* for aquaculture applications.

KEYWORDS: Microalgae, Thalassiosira, Rotifer, Salinity, Concentrate

Captive Spawning and Juvenile Production of Designer Domino Clownfish (Amphipriono cellaris)

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Marine ornamental fishes have enormous potential in the global market owing to their attractive colour and behaviour. The lack of sustainable hatchery production and the overexploitation from the wild could lead to severe threats to their natural ecosystem. Owing to their export and import value, it is generally being collected from the wild only. Domino Clownfish is a designer fish developed through selective breeding of Black and white Darwin Ocellaris Clownfish Amphipriono cellaris. Darwin Ocellaris Clownfish has a beautiful color morph with jet black and three contrast white stripes. Even though the Darwin Ocellaris looks very different than the regular Ocellaris, their behavior and feeding habits are very similar. This study envisaged courtship behaviour, captive broodstock development, selective breeding, embryonic and larval developments, larval rearing of designer Domino clownfish (Amphipriono cellaris) and its rearing with a suitable live feed. Different age groups (60– 100 mm Tl) were stocked (glass aquaria, 500 l) in outdoor transparent roofed hatchery at a water temperature 29±1°C for pair formation. After 6 - months of rearing, 5 pairs were formed. The size of the females ranged from 90 to 100 mm and males from 50 to 70 mm. Each pair was then stocked in 250 l perspex breeding tanks in the indoor breeding unit with a photoperiod of 14 L:10 D by a 40-W bulb suspended at 20 cm above the water surface. The environmental parameters such as temperature, salinity, dissolved oxygen and pH, NO₂, NO₃ and NH, were maintained at suitable levels and monitored once in 24 h. The pairs were daily fed with cooked meat of squid, shrimp, green mussel, and raw fish egg mass at 10% of their body weight in four split doses and live adult Artemia (10-15/day). The pairs began to spawn 300 to 400 eggs after 6 months of acquisition in the breeding tanks. The incubation period lasted for 44 h at a water temperature of 28±1°C, and most of the time, males guarded the eggs more than females. The size of the newly hatched larva was 1.5±0.1 mm long and the mouth gape varied between 90 and 110 µm, and its behaviour was also documented. Larval rearing was carried out in 250-l rectangular tanks using phytoplanktons Nannochloropsis oculata and Chlorella salina (1:1 proportion at 1-5 × 10⁶ cells/ml), along with different combinations of live micro-zooplanktons. The larvae metamorphosed to juveniles within 25-30 days of post-hatch (dph). The metamorphosed juvenile showed different banding patterns with 50% having no bar. 25% had one opercular white dots. 20% had two dots (cheeks and lateral side). 5% were with broken bands. The metamorphosed juveniles after 45 days attained an average of 28.82 mm in total length with a weight of 0.360 g.

KEYWORDS: Captive Spawning, Juvenile production, Domino clownfish



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Captive Breeding and Seed Production of Lemon Damsel (*Pomacentrus moluccensis* (Bleeker, 1853)

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The global marine ornamental fish trading industry has grown into a multibillion-dollar enterprise. Almost 98% of the marine ornamental fishes traded are wild collected from coral reefs of tropical countries posing a threat to the ecosystem. Effective captive breeding and seed production methods are essential to the sustainability of the aquarium trade. The marine ornamental fishes of the Pomacentridae family are the most dominant group accounting for 43% of all fish traded. This study aims to investigate the broodstock development, spawning, embryogenesis and larval ontogeny of the yellow damsel. *Pomacentrus moluccensis* which possesses great potential for the aquarium trade due to its vibrant body coloration. Subadults were collected from the coastal waters of Cape Comorin, east-coast of India and reared in captivity. The fishes (3-6 cm) were kept in 3001 aquarium tanks equipped with biofilter in controlled conditions of temperature (27.5±0.7°C), salinity 34±1 g/l and a 12:12 h photoperiod. The fishes were fed 2 times a day with pellet feed and once a day with a special broodstock diet. The onset of spawning was noted after 3 months in captivity. Each spawning event yielded around 600-1200 eggs. The eggs were capsule-shaped, demersal and adhered to the substrate, and the size varied between 1026-1097 µm in length. The incubation period was around 84 h and the egg hatched after the sunset. Newly hatched larvae lacked eye pigments with an average total length of 2.78±0.42 mm. Larval mouth opening occurred at 23-25 h, and yolk absorption was complete by the third-day post-hatch. The larvae were fed with the nauplii of calanoid copepod Parvocalanus crassirostris. The spawning interval varied between 3-7 days. The larval metamorphosis was completed by 35-40 days with an average survival of 5.2±0.8%. This study provides insightful information on standardizing broodstock development, and attempted detailed documentation of embryogenesis and larval ontogeny of P. moluccensis.

KEYWORDS: Marine ornamentals, Breeding, Embryogenesis, Pomacentrids, Lemon damsel, Seed production

Impact of Salinity Variations on the Embryonic and Larval Development of Mangrove Red Snapper, *Lutjanus argentimaculatus*

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Salinity is a crucial environmental factor that influences the early life stages of fish species. Lack of technical knowledge on the maintenance of optimal water quality parameters can lead to undesired results in fish larviculture during the hatchery phase. Therefore, determining the optimal salinity range for early development is essential for standardizing hatchery production techniques. The mangrove red snapper (Lutjanus argentimaculatus) is of significant commercial value in aquaculture as it can be farmed both in ponds and cages. Production of an adequate quantity of fish seed in the hatcheries would help to expand farming activities. However, one of the most critical aspects is to understand the developmental biology of larval fish under captive conditions. As such, studying its salinity tolerance during embryonic and larval development could help to establish standard breeding and rearing protocols. This study investigated the effects of different salinity levels on the development of L. argentimaculatus during the embryonic and larval phases. Specifically, the study examined: a) the impact of various salinity levels (0, 5,10, 15, 20, 25, 30, 35 and 40%) on egg buoyancy, hatching, and survival rates; and b) the survival rate and growth profile of larvae from 0 to 5 days post-hatch (dph) under salinity gradients (10 to 40%). The results showed that neutral egg buoyancy occurred at 25-30% salinity regime, and the first hatching was observed 18-20 hours after fertilization in salinity levels from 15 to 40%. The highest hatching rate (75-85%) and growth rates were observed at salinities of 25 to 40%, while the highest survival rates of up to 5 dph larvae (>70%) were found at 20 to 35%. The study suggests that a higher salinity range (30-35%) is optimal for the embryonic development and larval development of this species.

KEYWORDS: Lutjanus argentimaculatus, Salinity, Egg buoyancy, Larval growth, Larval survival

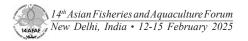
Reproduction and Population Growth of Brackishwater Cladocera *Diaphanosoma celebensis* Stingelin, 1900 at Different Salinities: An Alternative to *Artemia* Nauplii for Larval Rearing of Marine Fishes

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Diaphanosoma celebenis is a brackish water cladoceran species found in the brackishwater ecosystem. Cladocera are crucial components of zooplankton communities, serving as key primary consumers in a variety of aquatic environments, including freshwater, marine, and brackishwater. Their ability to tolerate a wide range of salinity and temperature makes them one of the most abundant groups in these ecosystems, contributing significantly to nutrient cycling and energy transfer within food webs. Due to their ease of cultivation and minimal space requirements, Cladocera are relatively inexpensive to produce, making them an economical choice for aquaculture. However, they remain one of the least explored groups of crustacean zooplankton compared to other aquatic live feeds, presenting opportunities for further research and utilization in aquaculture practices. To optimize the mass culture of Cladocera in marine hatcheries, it's essential to fine-tune culture conditions, with salinity being a key parameter that significantly affects their life history. Adjusting salinity levels can influence growth, reproduction, and overall health, making it crucial for successful cultivation in aquaculture settings. Therefore, the study investigated the influence of different salinity rages (18, 20, 22, 24, 26, 28, 30, 32, 34‰) on population growth and reproductive parameters viz., the number of reproductions, age at first reproduction (days), clutch size, longevity (days), number of offspring, etc. of a brackishwater cladocera, D. celebensis. The experiments were carried out at 28-29°C in a 10 h L:14 h D photoperiod in the laboratory. Isochrysis galbana + Chaetoceros gracilis (1:1) at a concentration of 10⁵ cells/ml was used as the microalgal diet. The result of the study revealed that *Diaphanosoma* showed maximum no. of neonate production at 22% salinity, followed by 20% and 18%%. Population growth rate was also highest at 22% salinity with an average of ~10 nos/ml. Longevity was observed to be highest at the lowest salinity and the age at first reproduction was observed to be similar in all the treatments. Based on the above observations, it was concluded that the optimum salinity range to achieve the highest population growth was 22‰. The findings of this study suggest that D. celebensis could be used as a potential live feed if cultured at a salinity range of 18-24‰. The study also revealed that elevated culture salinities will decrease its reproductive potential and thereby, decrease the population growth rate of D. celebensis. The biochemical profiling of D. celebensis also revealed that they are rich in DHA and protein. The use of D. celebesis was found suitable for larval rearing of clownfishes from 8th DPH onwards with complete replacement of artemia nauplii.

KEYWORDS: Cladocera, *Diaphanosoma celebenis*, Zooplankton, Population growth, Larval rearing, Marine ornamental fishes



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Comparative Analysis of Fermented Microbial Consortia Fortified in Biofloc Systems: Impacts on Growth, Survival, Immune Response and Gene Expression in *Penaeus vannamei*

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Biofloc-based farming is an innovative, intensive culture system that can yield higher productivity with a sustainable approach. Solid-state fermentation (SSF) enhances the nutritional quality of feed by fortifying and increasing the availability of simpler carbohydrates for easy digestibility in cultured animals. A 45-day experiment was carried out to evaluate the effect of microbial consortium fermented by a solid-state fermentor and its effect on the growth, survival, immunological parameters, and gene expression of immune and digestiverelated genes of P. vannamei. The C:N ratio was maintained at 12:1 by the addition of different carbon sources such as rice bran, molasses, and wheat flour. The treatments were categorized into two different culture systems: Biofloc (B) and Clear Water (CW). Each system included two treatments and a control, as follows: fermented feed (FB, FCW) and unfermented feed (UFB, UFCW), with the control being Commercial feed + Biofloc (CB) and Commercial feed + Clearwater (CCW), respectively. The treatment groups had 27% crude protein, and the control groups had 37% crude protein. The experiment was carried out in triplicate in fiber-reinforced plastic (FRP) tanks of 500l capacity at a stocking density of 60 nos/m³ $(4.0\pm0.5 \text{ g})$. The result showed a significantly (p<0.05) higher growth in the FB (9.7±1.6 g) treated group, followed by CB (9.5±1.42 g), UFB (9.21±0.98 g), FCW (9.15±1.79 g), CCW (8.70±1.44 g) and least in UFCW (7.992±1.47 g). A similar trend was observed in survival rate (97.2±2.5%) when compared to control (81.6±1.66%). Further results on immunological parameters such as prophenoloxidase, lysozyme and superoxide dismutase activity in the FB group showed a significant difference (p<0.05) compared to the control. The relative gene expression of digestive and immune genes (trypsin, chymotrypsin, amylase, cathepsin B, cathepsin L, lysozyme, and myostatin) also showed upregulation in the FB group compared to other treatments. In conclusion, the fermented biofloc group showed improved growth, serum immunity, and immunomodulation in P. vannamei.

KEYWORDS: Biofortification, Solid state fermentation, FCR

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Growth of *Magallana bilineata* (Röding, 1798): A Comparison of Hatchery Produced Cultched and Cultchless Spat in Grow-Out Culture

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Edible oysters are the most widely cultivated bivalves in the world and proved as one of the profitable ventures in the coastal belts of southern India. Though the complete package of seed production and oyster farming technology has been developed, oyster culture has not yet become popular in India. Throughout the world, the source of seed (spat) is changing from natural spat collection which formed the basis of most oyster culture industries in the past to hatchery-produced spat. The cost of hatchery-produced seed is more expensive than wild-collected ones. But natural spat-fall is unpredictable and low in quality and quantity. The advantage of hatchery production of the oyster seed is that the desirable stage and the required number and quality of larvae throughout the year can be guaranteed. This study was conducted to compare the growth of hatchery-bred cultched and cultchless spat of Indian backwater oyster. The culture was carried out using the raft and ren method for cultched spat, and the raft and tray method for cultchless spat in the Palghar district of Maharashtra. Growth rates, in terms of shell length, both for cultched and cultchless spat did not differ significantly. The average growth rate of cultchless spats was 1.23 cm per month, while it was 1.16 cm per month for cultched spats. Growth rates, in terms of shell length, showed a positive correlation with salinity. The results of the present study ensured the potential of hatchery-bred oyster spat as seeds for grow-out culture to address the declining number of spat falls in the area where there is failure or unpredictability in spat falls.

KEYWORDS: Oyster farming, Spat, Growth rate, Maharashtra

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Sustainable Seafood and Blue Economy: Unlocking India's Mariculture Potential

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As the blue economy gains momentum globally, India must leverage its vast marine resources to ensure a sustainable and prosperous seafood future. India's seafood demand is projected to reach 9 million tonnes by 2030 and 12 million tonnes by 2050, assuming the current demand trends persist. With the marine capture fishery potential estimated at 5.3 million tonnes, around 4 million tonnes by 2030 and 7 million tonnes by 2050 must be sourced from mariculture to meet this demand. Despite a mariculture production potential of 4-8 million tonnes annually, India's current output is less than 0.1 million tonnes. To narrow the production gap and meet the high demand, the mariculture sector should aim for a 10% growth rate by introducing high-value species, enhancing hatchery outputs, fish health, nutrition and feeds, and upscaling sustainable farming practices for finfishes, molluscs, crustaceans, echinoderms, and seaweeds. The existing sea-cage farming technologies achieve a productivity of ≈25 kg/m³/year. Potential expansion areas along India's 8,000 km coastline cover 46.000 hectares, which could support an additional 2 million tonnes annually. Current bivalve production is just 0.01 million tonnes from about 120 hectares, while the global market for bivalves is projected to reach \$6 billion by 2030. The expected global pearl jewellery market is projected to reach \$34 billion, while the ornamental fish market is expected to grow to \$12 billion by 2030; both of which should be strategically tapped. Opportunities for seaweed farming cover 23,000 hectares, with a potential production of 9 million tonnes (wet weight), though current output is only around 0.07 million tonnes, and domestic demand is expected to exceed 1 million tonnes by 2030. A sustainable growth strategy is vital to unlocking India's mariculture potential, including central and state-level policies for leasing marine areas, resolving stakeholder conflicts, establishing critical infrastructure, and encouraging private investment. Coastal state governments need to align leasing policies with national goals to secure operational environments. Engaging local communities and industry players through transparent communication will help mitigate conflicts. Identifying new offshore areas for large-scale mariculture beyond the territorial waters up to the EEZ will provide long-term growth opportunities. Significant investments are required for brood banks, hatcheries, nurseries, seaweed production units, and processing facilities. Research and technology efforts should focus on assessing carrying capacities, selective breeding for productivity enhancement and disease resistance, and improving food utilization. Exploring market opportunities through branding, quality standards, and traceability in domestic and international markets is also crucial besides implementing entrepreneurship-focused education and training to harness the potential of India's mariculture blue economy, ensuring sustainable seafood production and enhanced coastal community development.

KEYWORDS: Mariculture, Sustainable Seafood, Blue Economy, Marine Resources



Evaluation of Individual Rearing of CIFA-GI Scampi® Broodstock as an Alternate Approach to Group Rearing During the Post-Selection Rearing Phase in its Selective Breeding Program

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CIFA-GI Scampi[®] is a genetically improved and fast-growing strain of giant prawn, Macrobrachium rosenbergii developed by ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA) in collaboration with WorldFish, Malaysia. Every year selected broodstock of new generations of CIFA-GI Scampi® are reared family-wise in nylon hapas till their possible use as parents of the next generation. However, during this post-selection rearing phase which lasts around 3-4 months, there is a loss of good candidate parents especially the male parent due to aggressive social interactions and cannibalism. Therefore, the present study was undertaken to evaluate individual rearing of selected broodstock as an alternate strategy to group rearing. The control group in the present study was the group rearing (GR) of male and female broodstocks separately in six closed nylon hapas of 2 m³ each. The treatment group was the individual rearing (IR) of male and female broodstocks in 36 hard plastic meshboxes (30 x 20 x 20 cm) placed in ponds (18 boxes each for male and female broodstock). In each box, one adult broodstock was stocked. The initial weight in GR of males and females was 24.39±4.78 g and 25±2.95 g respectively and the initial weight of males and females in IR was 21.5±3.13 g and 21.39±3.24 g respectively. The stocked prawns were fed at 2% of their body weight with commercial shrimp feed with 36% crude protein once daily in the forenoon. The study was conducted for 70 days. The average daily weight gain of males and females under GR was higher (0.48 g and 0.31 g respectively) than the IR group (0.31 g and 0.16 g respectively). There was a cent percent survival of males and females in IR while the same in GR was 50% and 77.8% only respectively. The maturity status of females and the male morphotypes showed no significant difference between IR and GR. Considering the significantly higher survival in IR compared to GR, individual rearing of broodstock can be considered as an alternate strategy for the post-selection rearing phase of CIFA-GI Scampi® as it will help to avoid the loss of good candidate parents in the selective breeding program.

KEYWORDS: Broodstock, *Macrobrachium rosenbergii*, Selective breeding, Individual rearing, Group rearing, Growth, Maturity

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Breaking Thermal Stratification Using an Airlift Aeration System Enhances the Oxygen Profile in Shallow Earthen Ponds

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Limited availability of dissolved oxygen (DO) in aquaculture can significantly impact fish behavior and health. Further, the diurnal variation of DO at different depths of water is an important parameter to be considered for fish growth. To solve this problem, an experiment was conducted at the Kalvani Field Station, ICAR-Central Institute of Freshwater Aquaculture, using two ponds each measuring 1000 m² with 1.2-meter water depth. The study carried out between March and May 2024, involved stocking Indian major carps (IMC) at a density of 2000 nos./acre. Oxygen and temperature sensors were installed at depths of 45 cm and 90 cm. Airlift aerators were operated for 6 hours either during the night (23:00-05:00 hrs) or during the day (11:00-17:00 hrs) to enhance DO. At low wind speed, stratification occurred, resulting in noticeable differences in oxygen and temperature between the 45 cm and 90 cm depths. Oxygen levels at 45 cm exhibited a delayed response of approximately 3 hours to the peak solar radiation, with concentrations rising in the evening. Meanwhile, the 90 cm layer often became depleted of oxygen during the day and late evening, falling below the critical threshold of 2 mg/l for IMC. At night, oxygen concentrations at 45 cm declined while they rose sharply at 90 cm. Over time, the oxygen levels throughout the water column equilibrated and then decreased. After sunrise, oxygen levels at 45 cm increased again, while the 90 cm layer continued to drop. Temperature data showed that, before sunrise, temperatures at both depths were nearly identical. The study revealed that breaking the thermal stratification through airlifting the bottom water column at day time can improve the total oxygen content of the pond and also the bottom layer of water saturated with much higher oxygen.

KEYWORDS: Airlift, Aeration, Hypoxia, Indian major carps, Dissolved oxygen

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Egg Production in Calanoid Copepod *Acartia tropica* **Under Various Rearing Conditions**

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Copepod productivity under culture conditions is dependent on several variables such as salinity, food quality, stocking density, etc. It is necessary to standardise the optimum culture conditions for the maximum hatchery production of different copepod species. Mean daily egg production (eggs/female/day) of the calanoid copepod species Acartia tropica of the same age group under different experimental salinity levels, dietary treatments and stocking densities was studied. Actively swimming adult pairs were stocked in four replicate 50 ml beakers for respective salinity treatment (5, 10, 15, 20, 25 and 30 ‰). The number of eggs produced over 24 h duration was enumerated under a compound microscope. Every day, each copepod pairs were replaced with new adult pairs and daily egg production per female was determined for four consecutive days. For studying the effect of algal diets, actively swimming adult pairs were stocked in four replicate 50 ml beakers for respective seven dietary treatments (3 microalgae species and their combinations at 1000 µg C/l concentration). The number of eggs produced in 24 hours was counted daily and each copepod pairs were replaced with new adult pairs for eight consecutive days. The effect of stocking densities was evaluated by stocking adult copepods of the same age group in three replicate 250 ml containers kept floated in 11 beakers at different densities viz., 125, 250, 500, 1000 and 2000 adults/l per each treatment. At every 24 h, each 250 ml container with adults was shifted to a new 11 beaker and the eggs and nauplii collected in 11 beaker were counted. The mean daily egg production of A. tropica differed significantly between the salinity treatments (p<0.05). The highest mean daily egg production per female was recorded at 15 % (33.42±5.88 eggs/ female/day) and the lowest mean daily egg production per female was recorded at 30 % salinity (12.83±1.95 eggs/female/day). The egg production of A. tropica over 8 days in response to feeding different algal diets showed significant differences among the treatments (p<0.05). Copepods fed with *Dicrateria inornata* recorded the maximum number of days (7 days) with egg production of more than 30 eggs/female/day. The highest mean daily egg production was recorded when fed with D. inornata (39.96±1.36). The stocking density treatment of 125 adults/l produced a significantly higher mean number of eggs per female daily (62.37±10.32 eggs/female) over 8 days followed by 250 and 500 adults/l respectively.

KEYWORDS: Calanoid copepod, Egg Production, Rearing Conditions

Effect of Different Carbon Supplements on Growth Performance and Digestive Enzyme Activities of Butter Catfish (*Ompok bimaculatus* Bloch, 1794) in Biofloc System

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Effect of three carbon supplements, i.e. molasses, rice flour and finger millets on the growth performance and digestive enzyme activities in *Ompok bimaculatus* (Pabda) were studied through 90 days of rearing in the BFT system. A set of 12 circular 200-litre FRP tanks filled with 150-litre dechlorinated water and provided with aeration were used. The tanks, each stocked with 50 fingerlings of pabda (1.620±0.03 g), were grouped into three treatments (T1-molasses; T2-pre-boiled rice flour; T3-pre-boiled finger millets); and a control, each maintained in triplicates. Probiotics (CIBAFLOCTM, Chennai, India) were added in treatment tanks at 10% of carbon sources and a C:N ratio at 15:1 was maintained. Fish were fed commercial floating feed (CP 32%; CL 5%) at 5% body weight. The study revealed the addition of carbon sources to promote microbial flocs and the floc-mediated water quality was within the optimum range for growth of the catfish. It also demonstrated all the carbon sources to improve profiles of digestive enzymes (amylase, protease and lipase) in fish leading to improved feed utilization and growth performance. The treatment groups also supported significantly higher total bacterial counts than the control. Among the carbon sources, finger millet demonstrated superior survival, growth attributes and nutritional indices in the juveniles compared to molasses and rice flour. Additionally, its cheaper cost and easy availability provide an edge to its use as a promising carbon supplement in BFT to rear O. bimaculatus. However, further studies are required to test its efficacy in more intensive rearing in the biofloc system.

KEYWORDS: Biofloc, pabda, Carbon sources, Growth, Survival, Digestive enzyme

Growth Performance and Physiological Response of Butter Catfish (*Ompok bimaculatus* Bloch, 1794) During Juvenile Rearing at Varied Densities in Finger Millet Based Biofloc System

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A 60 days juvenile rearing study of butter catfish (Ompok bimaculatus) was carried out in biofloc system (BFS) with finger millet flour as a carbon supplement to evaluate the growth performance, survival and physiological responses of the fish reared at varied densities. Fingerlings (6.54±0.02 g) were stocked at 100 (Control), 200 (T1), 300 (T2) and 400 nos/ m³ (T3) in an indoor set of 1000 l FRP tanks, each filled up to 800 l with dechlorinated pond water. Three replications maintained for each treatment including control. Fingerlings were fed a commercial diet (32% protein). Finger millet flour was used as a carbon supplement in treatments at an estimated C/N ratio of 15:1, while CIBA FLOCTM (Chennai, India) was used as a probiotic source. Among the treatments, T2 (300/m³) showed significantly higher (p<0.05) activities of digestive enzymes; amylase, protease and lipase, compared to others. Rearing density also significantly influenced serum biochemical parameters and blood profile. Total protein and albumin-globulin ratio decreased with increasing rearing densities among treatments. Whereas, concentrations of RBC, WBC, HGB, HCT and MCHC were either reduced or varied minimally in T1 and T2 than control, but all these parameters were significantly higher in T3 (p<0.05). Additionally, serum glucose and activities of liver function enzymes (SGOT and SGPT) also significantly increased with rising densities (p<0.05). Similarly, antioxidant stress enzyme responses (serum superoxide dismutase and catalase activities) increased with significantly higher (p<0.05) activities in T3. All these observations were indicative of the rising stress level in juveniles, attributed mostly to the increasing crowding stress in treatments. There was no significant variation in juvenile growth performance (length, weight, SGR, and FCR) among the treatments except for the significantly reduced survival in T3 (92.9%, p<0.05). However, T2 (300/m³) showed higher survival (97.5%, p<0.05) and relatively higher growth (final length and body weight), SGR, condition factor and efficient feed utilization (lower FCR) as compared to T3. Based on this result, the study recommended 300 fingerling/m³ (T2) as the ideal density for juvenile rearing of butter catfish in such a finger millet-based biofloc system.

KEYWORDS: *Ompok bimaculatus*, Biofloc, Finger millet, Stock density, Growth, Digestive enzyme, Haematology



Characterization of Bacterial Consortium as Biofloc Inoculum and Assessment of Growth and Disease Resistance of Fish

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Integration of probiotics into aquaculture practices has multifaceted benefits viz., improved animal health, better growth, enhanced water quality and reduced environmental impact. Here we addressed the importance of the collaboration of probiotics bacteria and biofloc technology for better growth and disease resistance. In this study, six potential probiotic bacteria were isolated and characterized i.e. Priesta aryabhattai, Bacillus cereus, Exiguobacterium indicum, Acinetobacter indicus, Mixta calida, and Bacillus altitudinus from autochthonous sources using biochemical reactions and 16s rDNA PCR and sequencing. The probiotic potential of bacterial isolates was assessed using an array of *in vitro* tests along with safety analyses. All the isolates and their combination showed antimicrobial potency against important fish pathogens and were resistant to a wide range of pH (2-9) and bile concentrations (10 %). The isolates have denoted/exhibited good adhesion properties in vitro (high auto, co-aggregation and biofilm formation capacity, and cell surface hydrophobicity). All the isolates were nonhaemolytic, and non-pathogenic to fish when intraperitoneally injected with high dose of (5x10°) bacteria, able to produce extracellular enzymes, viz., lipase, amylase, and cellulase, and displayed significant free radical scavenging activity. Further, all the isolates were found to be tolerant to viz., ammonia, nitrite and nitrate in vitro and able to grow on tilapia and rohu mucus. Rearing and grow-out experiments were carried out using the newly developed biofloc bacterial consortium for rohu and tilapia using jaggery as a carbon source. In each tank, 1000 numbers of rohu fry (length: 20-25 mm) were stocked @1/lit and reared for 90 days. Similarly, tilapia fry (length: 30-35 mm) were also stocked in a similar system in triplicate. No water exchange was made during this period and feed containing 30% CP was provided ad libitum. After 90 days of culture, 80% and 99% of survivability were recorded for rohu (weight 60-70 mm) and tilapia (weight 50-60 mm) respectively. Tilapia raised under biofloc were challenged with pathogenic Enterobacter cloacae and the relative percentage survival (RPS) was found to be 30%. The present study highlights the effective utilization of bacterial consortium as biofloc inoculum

KEYWORDS: Biofloc, Bacterial consortium, Tilapia, Rohu, Growth, Disease resistance

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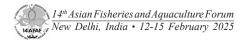
Green Synthesis of High-Performance Bioflocculant from Insect Waste: A Circular Economy Approach in Biofloc Aquaculture

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This study investigates the potential of chitosan nanoparticles, derived from Black Soldier Fly (BSF) larvae shells, as a sustainable bioflocculant for enhancing floc formation and wastewater treatment in biofloc aquaculture systems. Chitosan was extracted from BSF larvae shells using a three-step process: demineralization, deproteinization, and deacetylation. The extracted chitin yield was 29.4%, with a high degree of deacetylation (84.1%), confirming successful chitosan production. Chitosan nanoparticles were synthesized using an ionic gelation method with sodium tripolyphosphate. Characterization techniques, including Fourier-transform infrared spectroscopy, X-ray diffraction, and thermogravimetric analysis, confirmed the successful synthesis and nanoscale properties of the chitosan nanoparticles. Scanning electron microscopy revealed the morphology of both extracted chitosan and chitosan nanoparticles. The particle size analysis of the synthesized nanoparticles revealed an average diameter of 74 nm, while zeta potential measurements indicated a positive surface charge of 32 mV. The flocculation efficiency of the chitosan nanoparticles was evaluated using the kaolin clay method. Remarkably, the nanoparticles achieved over 90% total suspended solid removal at concentrations as low as 10-15 ppm. To assess their practical application, a 60day biofloc experiment was conducted using chitosan nanoparticle concentrations of 10, 15 and 20 mg/l. Over the 60-day experimental period, water quality parameters including TAN, nitrite-N, nitrate-N, temperature, DO, pH, alkalinity, TSS, and floc volume were analysed. The 10 and 15 mg/l groups exhibited the lowest TAN and nitrite-N levels and the highest nitrate-N levels. Significant fluctuations in alkalinity and pH were noted in the control group compared to treated groups. DO levels remained optimal across all groups. The highest TSS level (354 mg/l) was observed in the chitosan @20 mg/l group, while floc volume was significantly higher in the chitosan @10 and 15 mg/l groups compared to the control (p<0.05). Overall, better water quality was observed in the 10 and 15 mg/l groups. Further, antimicrobial activity tests at the selected doses demonstrated no adverse effects on bacterial growth, ensuring the nanoparticles' compatibility with the biofloc ecosystem. These findings highlight the significant potential of BSF larvae shell-derived chitosan nanoparticles as a sustainable and effective bioflocculant for biofloc aquaculture. This innovative approach promotes waste valorization, improves water quality, and contributes to the development of environmentally friendly aquaculture practices.

KEYWORDS: Biofloc, Black Soldier Fly, Nano-chitosan, Flocculating activity, Water quality



Comparative Evaluation of Production Performance of Pangas Catfish and Mint in an Automated Aquaponic System and Traditional Culture System

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The present study was undertaken to compare the production performance of pangas catfish and mint in an automated aquaponics system (AAS) and traditional culture system (TCS) in triplicate for 120 days. Healthy fingerlings of pangas (9.29-9.36 cm) were randomly stocked @ 40 per m³ in circular cemented tanks (10 m³) in AAS and @ 4 per m³ in cemented rectangular tanks (10 m³) in TCS. Mint was planted in the hydroponics unit (HM) at a 12 cm gap between two plants in AAS and a 40 cm gap between two plants in the soil bed traditional system (SM) by following the Completely Randomized Design (CRD). The findings of the study revealed that the water quality parameters remained in an optimum range for fish culture in both systems. The fish survival (%) was insignificantly different in TCS (95.83%) and AAS tanks (95.08%). Although, the results in terms of average final body length (23.53 cm), average total length gain (14.24 cm), average final body weight (148.90 g), net weight gain (142.53 g) and SGR (2.63) of pangas were significantly higher (p≤0.05) in control with an improved FCR (1.75); however, the average yield of pangas (3.52 kg/m³) was significantly (6.17 times) higher in AAS tanks as compared to control, with improved metabolic profile and intestine and liver histomorphology. The mint yield (109.54 Qt/acre) increased by 1.25 times as compared to the control, with significant improvements in final plant height (65.61 cm), plant height increase (13.17%), final root length (26.58 cm) and root length increase (5.05%). The overall results indicated the potential of aquaponics technology to higher pangas productivity (6.17 times) and mint biomass (1.25 times) in an integrated system.

KEYWORDS: Aquaponics, Pangas, Mint, Hydroponics, Fish

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Study on the Feeding Habits of Three Sizes of *Scylla paramamosain* with Four Types of Shellfish

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This study investigates the feeding preferences of mud crab Scylla paramamosain when presented with shellfish from various ecological niches. Three sizes of Scylla paramamosain (carapace widths of 5.8±0.6 cm, 8.1±0.6 cm, and 11.5±1.8 cm) were tested with four types of shellfish. The shellfish species and sizes included: Meretrix taiwanica (2.4±0.7 g, 5.2±1.6 g, 16.3±3.4 g per piece), *Perna viridis* (3.9±0.6 g, 7.5±0.7 g, 22.9±1.3 g per piece), *Mytilopsis* sallei (0.6±0.2 g per piece), and Mytella strigata (3.0±0.5 g per piece). After a 48-hour experiment, results indicated that the largest mud crabs (11.5±1.8 cm) consumed significantly more large Meretrix taiwanica (16.3±3.4 g per piece) compared to the smaller crabs (8.1±0.6 cm and 5.8±0.6 cm), suggesting a body-size preference in clam feeding. Additionally, crabs with carapace widths of 5.8±0.6 cm were unable to consume clams with a shell length of 3.9±0.3 cm. Another experiment showed that mud crabs with a carapace width of 8.1±0.6 cm displayed the highest intake of *Mytella strigata*, consuming 6.6±1.1 pieces (19.8±3.4 g), followed by smaller *Meretrix taiwanica* clams at 4.8±1.0 pieces (12.0±2.4 g), likely due to the similar sizes of these shellfish. When offered both Perna viridis and Meretrix taiwanica of varying sizes, crabs preferred smaller clams (2.4±0.7 g per piece) and smaller green mussels (3.9±0.6 g per piece). When Meretrix taiwanica and Mytilopsis sallei of similar size were introduced, the blue crabs preferred to feed on Mytilopsis sallei. These findings suggest that co-cultivating crabs with clams of varying sizes can leverage crab feeding preferences to help control invasive mussel species (e.g., Mytella strigata, Perna viridis, and Mytilopsis sallei) and improve the survival rates of cultured clams.

KEYWORDS: Scylla paramamosain, Meretrix taiwanica, Polyculture

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Stocking Density Effects on Larval Development and Survival Rates in Mud Crab (*Scylla serrata*) Rearing

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This study investigated the influence of stocking density on the survival and development of *Scylla serrata* larvae from the zoeal 1to the zoeal 3. Three stocking densities were: 80,000 nos./ton (Treatment A), 50,000 nos./ton (Treatment B), and 10,000 nos./ton (Treatment C), each with three replicates. Larvae were cultured in 0.5-ton tanks and fed a diet of *Brachionus plicatilis*, brine shrimp nauplii, and *Nannochloropsis oculata*. Results indicated that the survival rate of larvae in Treatment C (25±10.7%) was significantly higher than that in Treatment A (12±6.4%). In terms of the Larval Stage Index (LSI), Treatment C exhibited higher values for Z1, Z2, and Z3 stages compared to Treatment A and B. Additionally, the Megalopa Occurrence Index (MOI) revealed a faster molting time and emergence rate of megalopa larvae in Treatment C. These findings suggest that lower stocking densities (10,000 nos./ton) promote higher survival rates and accelerated development of *S. serrata* larvae during the early zoeal stages.

KEYWORDS: Scylla serrata, Survival rate, Megalopa Occurrence Index (MOI)

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Influence of Water Temperature on the Development of Mud Crab Larvae (Scylla serrata)

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This study investigated the impact of water temperature on the rearing of *Scylla serrata* larvae from the zoeal 4 to the megalopa stage. Two water temperature treatments were employed: $26\pm0.3^{\circ}\text{C}$ and $30\pm1.1^{\circ}\text{C}$, each with three replicates. Larvae were cultured in 0.5-ton tanks at a density of 200 nos./ton and fed a diet of brine shrimp nauplii and artificial powdered feed. Results indicated that the survival rate of larvae in the 26°C treatment (19±5.2%) was slightly higher than that in the 30°C treatment (16±5.7%), although the difference was not statistically significant (p>0.05). In terms of the Larval Stage Index (LSI), the 26°C group exhibited lower values for Z4, Z5, and megalopa stages compared to the 30°C group. Conversely, the Megalopa Occurrence Index (MOI) revealed a faster molting time and emergence rate of megalopa larvae in the 30°C treatment. These findings suggest that elevated water temperature accelerates the developmental rate and metabolic processes of *S. serrata* larvae, leading to a shorter nursery period. While the final survival rate was not significantly affected, the increased molting frequency in the 30°C treatment could potentially enhance nursery yields.

KEYWORDS: Scylla serrata, Survival rate, Larval Stage Index (LSI))

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Spore Liberation, Germination and Sporeling Development in *Gracilaria corticata* under Laboratory Settings: A Pilot Study

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Seaweeds are emerging as valuable resources owing to their fast growth, short cultivation period and sustainability, positioning them as a promising solution to future resource challenges. Global seaweed production has increased significantly to meet rising demand. Currently, vegetative propagation, involving the labour-intensive planting of thallus fragments is the primary farming method. However, this approach, especially when cultivated plants stem from a single clone, leads to issues like reduced productivity, seasonality, lower product quality, and vulnerability to diseases. Strain improvement typically relies on selecting vigorous phenotypes, but traditional hybridization techniques are challenging. Efforts are underway to enhance strains through in vitro techniques, including micropropagation, callus culture, and spore germination, which explore the vegetative and reproductive structures of seaweeds. Though vegetative propagation helps scale up production more rapidly, spore culture encourages genetic diversity. Controlled spore culture in lab settings enables to study the growth, reproduction, and physiology in detail, which is vital for understanding the macroalgal responses to environmental stressors, aiding in the development of more resilient strains. In this study, we attempted spore liberation, germination and sporeling development in the red alga *Gracilaria corticata*, in a controlled laboratory aquarium setting. Successful spore-based cultivation of *Gracilaria* species requires an understanding of their complex life cycle, which involves a Polysiphonia-type three-phase cycle with isomorphic alternation between diploid tetrasporophytes and haploid gametophytes. After fertilization, a diploid carposporophyte forms on the female gametophyte, producing diploid carpospores. These carpospores grow into diploid tetrasporophytes, which undergo meiosis to yield haploid tetraspores, thus completing the cycle. We assessed key parameters, including water temperature (20-30°C), light intensity (10-40 μmol photons/m²/s), salinity (25-35‰), photoperiod, and nutrient supplementation. Sporeling development was observed at 24±2°C, 35% salinity, light intensity of 30 µmol photons/m²/s, a 16:8 light-dark photoperiod, and nutrient-enriched seawater. Further research is needed to optimize sporeling production under controlled conditions. Utilising tetraspores or carpospores as a source of genetic variability for agar-yielding red algae could be a suitable strategy for strain improvement. This could potentially benefit the seaweed industry by addressing the genetic limitations associated with clonal propagation in traditional seaweed farming.

Keywords: Carpospores, Light intensity, Nutrient supplementation, Seaweed production, Tetraspores



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Effect of Stocking Density on Cannibalism, Survival and Growth Performance in Silver Pompano, *Trachinotus blochii* Larviculture

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Experiment was aimed to evaluate the survival, growth performance and cannibalism with respect to stocking density in larviculture of Trachinotus blochi for 21 days. T. blochii larvae (14 dph) with mean total length 7.83±0.16 mm and body weight 2.33±0.33 mg were stocked in 300 l FRP tanks in triplicates with four different stocking densities i.e. 2 nos/l (T1), 4 nos/I (T2), 6 nos /I (T3) and 8 nos/I (T4). During the experiment, larvae were fed with newly hatched Artemia nauplii (5 nos/ml) and commercial larval feed containing 59% crude protein and 14% lipid, fed three times a day. Daily observations were made during early morning and evening hours, before and after feeding to study the behavior of cannibalism in silver pompano larvae (whether it attacks and engulfs from the head side or tail side) by counting cannibalized dead fishes which were identified by injuries on body parts (head, dorsal fin and caudal fin) observed under a microscope and photos were taken and recorded. Results revealed that the mean total length of T. blochii larvae was significantly higher at a lower stocking density of 2 larvae/l (23.70±0.35 mm) (p<0.05). The highest mean body weight was observed in 2 larvae/l (292.90±5.58 mg) (p<0.05) and the lowest was recorded in 8 larvae/l (129.47±5.79 mg). The specific growth rate and percent weight gain were found highest in 2 larvae and 4 larvae/l (p<0.05) respectively. The survival rate had a significant difference (p<0.05) among the treatments. The mean survival rate was found higher in 2 larvae/l (74.08±4.712%) and 4 larvae/l (69.91±3.29%). In the present experiment, cannibalism was prevalent from 16 dph onwards and continued till 24 dph; the larvae were aggressive during the initiation of metamorphosis. In lower stocking density, T. blochii exhibited type -1 cannibalism (damages to body parts and caudal fin). Type-2 cannibalism (predator attack and engulf from head side) was observed in higher stocking densities 6 and 8 larvae/l. The percentage of cannibalism loss was highest in 8 larvae/l (23.14±1.03%) and lowest was recorded in 2 larvae/l (8.0±0.57%) and 4 larvae/l (11.33±0.66%). No cannibalism was observed after the completion of the metamorphosis. From the overall results, it is concluded that 4 larvae/l is the ideal density for the larval rearing of *T. blochii* in FRP tanks.

KEYWORDS: Stocking density, Survival, Growth, Cannibalism, Trachinotus blochii

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Effect of Normal Saline Diluted Wova-FH on Sex Hormones and Haematological Parameters of Indian Major Carps

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The present investigation was carried out to delineate the effect of diluted Wova-FH hormone on the blood chemistry of three Indian major carps viz., Catla catla, Labeo rohita and Cirrhinus mrigala during breeding. The experiment was conducted in five experimental groups, T0 (Control, 100% Wova-FH), T1 (25% diluted Wova-FH with normal saline), T2 (50% diluted Wova-FH with normal saline), T3 (75% diluted Wova-FH with normal saline) and T4 (100% normal saline) in triplicate. The experiment was carried out for three consecutive years (2016, 2017 and 2018) and the data obtained were pooled at the end of the third year, separately, species-wise. In the present study, the females of all three species showed lower levels of plasma estradiol in the control, T1 and T2 than in the other two treatments. Time-wise estimation of estradiol revealed a significant increase in the estradiol level in all the treatments upto 6 hrs of sampling, then the value decreased in C. catla, L. rohita and C. mrigala. Significantly higher values of plasma testosterone levels were observed in males of C. catla, L. rohita and C. mrigala in T0, T1 and T2 as compared to other treatments T3 and T4, whereas in females significantly higher values of testosterone were observed in T3 and T4. Time-wise analysis of testosterone in males showed significantly increasing values upto 6 hrs or 8 hrs of sampling but in females, it first decreases upto 8 hrs in C. catla and 4 hrs in L. rohita and C. mrigala and then increases. The plasma cortisol level significantly increases as the dilution of hormone increases and the lowest value was observed in T4, where only normal saline was administered. The hematological parameters such as hemoglobin (Hb), total erythrocyte count (TEC), total leucocyte count (TLC), packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) showed variation among male and female of the three species under study indicating the effect of sex on hematology. From the result, it can be inferred that the farmers can use 25% normal saline diluted Wova-FH in the induced breeding of Indian major carps without affecting their blood chemistry.

KEYWORD: Wova-FH, Normal saline, Estradiol, Haematology, Indian major carp

Strategies for Reducing Microplastic Accumulation in Shrimp Culture: Lessons from Indian Coastal Aquaculture

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Shrimp aquaculture is crucial for global food security, yet microplastic (MP) contamination presents challenges to food safety and industry sustainability. This study examined MP contamination in *Litopenaeus vannamei* over a 120-day culture period across 12 shrimp ponds on India's east and west coasts. MP abundance, characteristics, and trends were analyzed in shrimp tissue and environmental matrices, including feed, water, and sediment. MPs were present in 93.7% of shrimp samples, with the highest levels in coastal ponds, averaging 4.075 items per shrimp or 1.24 items per gram of tissue. MPs ranged from 8 µm to 4.22 mm, predominantly fragments and fibers, with polyethylene (PE) and polypropylene (PP) being the most common polymers. Feed was identified as the primary MP source, highlighting the need for strategies targeting feed quality. To assess the effectiveness of various processing interventions, shrimp were treated as headless (HL), peeled and undeveined (PUD), and peeled and deveined (PD). MP levels decreased from 4.8 items per shrimp on day 15 to 2.3 items on day 120, with the PD treatment showing the most significant reduction, lowering MP presence to 0.09 items per shrimp. These findings indicate a strong inverse relationship between intervention intensity and MP contamination levels in shrimp tissue. Additional strategies for MP reduction include comprehensive water filtration, sediment management to prevent resuspension, controlled water exchange to reduce external MP introduction, and selecting low-MP feeds. Biological filtration systems, such as natural filters, combined with regular monitoring of MP levels in shrimp, water, and feed, further support contamination control. Addressing MP contamination at multiple intervention points, this study provides a model for sustainable shrimp farming that can be adapted to various global aquaculture systems, promoting safer products for consumers and greater environmental stewardship.

KEYWORDS: Food safety, Food security, Sustainability, Litopenaeus vannamei, Seafood trade

Effect of Stocking Densities on Growth Performance of Indian Major Carps Under Short Duration Culture

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The present study was conducted to compare the growth performance of the three Indian major carps (IMC) at different stocking densities under a short-duration fish culture technique. The experiment was carried out in equal size (5.64 m×3.75 m×1.2 m) rectangular cement cisterns in the fish farm of the College of Fisheries, Raha for 90 days. All the cisterns were cleaned and dried in the sunlight and provided with 6 inches of soil bed. Lime was applied @500 kg/ha and the cisterns were filled with filtered groundwater to a depth of 1.0 m±5 cm. After 5 days of lime application, all the experimental cisterns were fertilized with a mixture of raw cow dung (RCD), mustard oil cake (MOC), single super phosphate (SSP) and vitamin-mineral @100 kg/ha, 350 kg/ha, 25 kg/ha, and 200 kg/ha respectively. The liming and fertilization were repeated at every 10 days interval during the experimental period. For the experiment, three treatments with stocking densities @4 fish/m³, 5 fish/m³ and 6 fish/m³ were taken as T1, T2 and T3 respectively. The Tc with stocking density @1 fish/m³ was considered as a reference treatment to compare with the growth performances under different stocking densities. Each treatment was conducted in triplicate. The cisterns were stocked with yearlings of IMC and the stocking ratio in all the cisterns was 40%, 50% and 10% of catla, rohu and mrigal respectively. During the experimental period, the fishes were fed with a mixture of rice polish, mustard oil cake (MOC) and premixed vitamin-mineral containing 24% crude protein @3% of body weight twice daily. The study showed that the growth performances of IMC under short-duration culture varied significantly (p<0.05) at different stocking densities. Though the net weight gain, average daily growth rate, SGR and feed utilization of all three species decreased with increasing stocking densities, the net yield and economic performances increased at higher stocking densities. The results indicated that the T2 treatment with stocking density @5 fish/m³ showed the highest yield and benefitcost ratio and hence considered to be economically more profitable. The physico-chemical parameters of water like temperature, pH, dissolved oxygen, free carbon dioxide, hardness, alkalinity and nitrogenous wastes were examined at every 10 days intervals. Though the values differed with stocking densities, they were observed to be within the tolerance limit for IMC in all the treatments throughout the experimental period.

KEYWORDS: Stocking density, Growth, Indian major carps



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Effects of Different Carbon Sources on Growth of Freshwater Zooplankton *Moina micrura* in Biofloc System

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Biofloc is a high stocking-density fish culture system that produces a complex natural food associated with heterotrophic bacteria. To enrich the biofloc with zooplankton, a 30-day study was conducted to evaluate the effects of different carbon sources like sugarcane jaggery (SG), and rice bran powder (RB) on the multiplication of freshwater zooplankton Moina micrura in biofloc system in 100 l volume of plastic tank. Four treatments were taken: freshwater without biofloc (C); Biofloc with rice bran (BFRB), Biofloc with sugarcane jaggery (BFSJ), and Biofloc with a mixture of RB and SJ (BFRB+SJ) in triplicate. Adult Moina micrura was inoculated into each treatment @ 10 nos/l. In control tanks yeast was given as food and for other treatments, biofloc inoculum was prepared with ammonium sulphate as a nitrogen source and different carbon sources as per respective treatments. The floc volume, TAN, turbidity, TPC, TSS, pH, and alkalinity parameters were measured in each treatment. The study found that BFRB treatment showed a significant increase of Moina micrura (120±5) nos/l) than BFSJ (16±3 nos/l), BFSJ+RB (30±5 nos/l) and control (40±6 nos/l). In BFRB treatment, the peak number of *Moina* sp reached on 21 days, and then the number decreased, whereas in other treatments and control, the peak number was reached on 15 days and then decreased. The microscopic images of floc revealed that there is more diversity in flocs of BFRB treatments than in others. The study indicates that the multiplication of Moina *micrura* was more in complex carbon-based biofloc systems than in simpler carbon.

KEYWORDS: Biofloc, Rice bran, Sugarcane jaggery, TAN, Moina micrura

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Evaluation of Ideal Conditions for the Optimal Production of *Hypnea musciformis* in the Brackishwater Ecosystem

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Hypnea musciformis holds significant ecological value, furthermore, its economic potential is increasingly recognized due to its substantial carrageenan content. However, its commercial cultivation remains in its infancy. This study aims to establish optimal culture practices for H. musciformis within the brackishwater ecosystem. Three experimental trials were conducted to investigate the effects of salinity (Trial 1), biomass density (Trial 2), and water depth (Trial 3) on the growth and yield of *H. musciformis*. The growth response of *H. musciformis* was assessed under different salinity levels (20, 25, and 30%). Seaweeds cultivated at a salinity of 25% exhibited a significantly higher specific growth rate, highlighting the species' preference for moderate salinity conditions. A Completely Randomized Design (CRD) experiment evaluated the impact of varying initial biomass densities (25, 50, 75, 100, and 125 g) on the specific growth rate of *H. musciformis*. The highest specific growth rates were observed at biomass densities of 50, 75 and 100 g, indicating an optimal range for cultivation initiation. Various water depths (0.25 m to 1 m) were tested to identify the optimal depth range for H. musciformis cultivation. The depth zone of 0.25 to 0.5 m proved most conducive to growth, suggesting that the species thrives in shallower waters with increased light availability. This study provides valuable insights into the cultivation potential of H. musciformis in brackishwater ponds. An optimum culture environment provides higher yields and improved growth rates. Findings suggest H. musciformis is a promising candidate for commercial cultivation, offering a sustainable carrageenan source.

KEYWORDS: Brackishwater, Carrageenan, H. musciformis, Seaweeds, Sustainable

A Comparative Life Cycle Assessment of Whiteleg Shrimp (*Penaeus vannamei*), Cultured in an Earthen Pond and HDPE Pond Farming System — A Case Study from the West Coasts of India

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Aquaculture, particularly the farming of whiteleg shrimp (*Penaeus vannamei*), has experienced rapid global expansion, with this species being one of the most widely cultivated. However, conventional shrimp farming systems pose considerable environmental challenges, including greenhouse gas emissions, eutrophication, and resource depletion. These environmental concerns are particularly pressing in India, a major global shrimp exporter. Life cycle assessment (LCA) is increasingly applied in shrimp aquaculture as a valuable tool for comparing different production systems. To evaluate the environmental performance of intensive and semi-intensive shrimp farming systems on the west coast of India, we conducted surveys of one hatchery and 20 farms, completing a cradle-to-farm-gate LCA. Field surveys were carried out from February to July 2024 across 15 normal earthen ponds (semi-intensive) and 5 HDPE (intensive) ponds. Data were analyzed using SimaPro 9.6.0, applying the ReCiPe 2016 Midpoint (H) characterization method to assess environmental impacts across various categories. The environmental impact categories included global warming, acidification, eutrophication, and ecotoxicity. Our results indicated that intensive farming had significantly higher environmental impacts per unit of production compared to semi-intensive farming in all impact categories. Specifically, for every ton of shrimp produced, HDPE ponds generated higher emissions than normal earthen ponds: 369.04 and 268.06 kg CO₂ equivalent, 1.1987 and 0.9355 kg SO₂ equivalent, and 0.0333 and 0.0538 kg nitrogen equivalent, respectively. Key contributors to emissions included seed production, electricity use, and feed inputs. The study also revealed that Indian shrimp farming systems exhibit a significantly lower Global Warming Potential (GWP) compared to other major shrimp-producing nations. To mitigate environmental impacts, the study recommends transitioning to normal earthen ponds where feasible, integrating solar-powered aeration systems, and replacing fishmeal in feed with plant-based alternatives. Enhancements proposed for Indian shrimp aquaculture include modifications in feed composition, improvements in farm management practices, and the adoption of alternative electricity generation methods. These findings can guide the optimization of market-oriented shrimp supply chains and support the advancement of more sustainable shrimp production and consumption. This research provides a comprehensive cradle-to-farm-gate life cycle inventory for shrimp farming in India, offering valuable insights to support the development of sustainable aquaculture practices and policies.

KEYWORDS: Aquaculture, Life cycle assessment, Environmental assessment, West coast India



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Transforming Waste to Value: Harnessing Organic Fertilizer Extracts to Supplement Mineral Nutrients in Aquaculture Wastewater for Sustainable Production of *Channa striata* (Bloch, 1793) and *Lactuca sativa L*. in Aquaponics

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A 90-day trial explored the feasibility of using organic fertilizer extracts as supplemental nutrient sources in Channa striata-lettuce aquaponics. Four different organic fertilizers vermicompost, cow manure, chicken manure, and black soldier fly larvae frass (BSFL) were applied weekly, and their effects on water quality, lettuce yield, and fish physiology were evaluated. The results showed that water quality remained within acceptable limits for aquaponics. Lettuce yield was significantly higher in the vermicompost treatment (1111.88±4.90 g) compared to the other treatments. Total lettuce yield followed the order: vermicompost (1111.88±4.90 g) > cow manure (865.87±4.95 g) > BSFL (778.63±5.34 g) > chicken manure (768.67±3.30 g) > control (729.83±7.18 g). Proximate analysis revealed a significant increase in crude protein (1.59±0.12%) in the vermicompost treatment, and nutrient content was higher in treated lettuce compared to the control. While the supplementation did not significantly affect fish growth performance, it did alter some physiological responses, including serum glucose, cortisol, and liver enzymes. The antioxidant stress enzymes, superoxide dismutase (SOD), and catalase, exhibited significant differences in the liver of fish treated with chicken manure. Overall, the results suggest that all organic fertilizer extract supplementations performed optimally, but vermicompost outperformed the others in terms of lettuce yield, proximate and mineral composition, and fish physiology. Therefore, vermicompost is recommended as the best feasible option for aquaponics.

KEYWORDS: Aquaponics, Organic fertilizer extracts, Vermicompost, Chicken and cow manure

Environmental Manipulation and Dietary Supplementation for Round-the-Year Breeding of Three Indigenous Species of Snow Trout in Captive Condition

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Snow trout belongs to the family Cyprinidae and subfamily Schizothoracinae and forms an important natural fishery in uplands. This is a preferable fish species in the Himalayan region to the consumers having rich nutritive value, but is not under the aquaculture practice due to slow growth and non-availability of seed. The wild population of this group of fish is fragmented due to hydroelectric projects and anthropogenic activities. Gonadal maturity in females under captive conditions is the major constraint for seed production. Hence, breeding, seed production, and conservation are priorities for this commercially important indigenous food fish. Breeding protocol has been developed for three species of this fish i.e., Schizothorax richardsonii, S. progastus, and S. plagiostomus. During the experimentation, gonadal maturity was achieved in 88% of female brooders keeping at an optimal thermal regime of 16-18°C for 15-18 days having less diurnal fluctuation and using dietary supplementation of the blend of herbs @ of 1% of the diet. Ashwagandha (Withania somnifera) root powder, dried powder of garlic (Allium sativum), and hing (Ferula asafoetida) was included in the diet of females and Ashwagandha (Withania somnifera) root powder, flower powder of Butea monosperma, seed powder of Mucuna pruriens and dried powder of Jaiphal (Myristica fragrans) in the diet of males. A field study was conducted with 3 years old captive-reared stock. Gonadosomatic index (GSI) and Hepatosomatic index (HSI) were recorded for the annual breeding cycle coupled with breeding indices and regular monitoring of water quality parameters. Voluntary spawning was achieved successfully by inducing hormones, environmental manipulation, and providing a gravel bed covered with muslin cloth. As this group of fish is batch spawner, breeding in captive conditions is feasible for all three species round the year. Findings would be helpful for the regular seed production and aquaculture of snow trout in hills.

KEYWORDS: Snow trout, Gonadal maturity, Gonadosomatic index, Voluntary spawning, Blend of herbs

Growth and Nutrient Uptake of *Gracilaria corticata* Under Different Nutrient Conditions for Sustainable Land Based Production

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Gracilaria corticata is a red macroalgae found in the lower mid-littoral zone and intertidal pools of coastal water, also found in brackish water estuaries towards the high tide water mark. G. coricata are harvested from wild stocks and used for preparing food-grade agar in India. The species is a potential source of agar, PUFA, carotenoids, proteins, and minerals, and is among the seaweed species that have shown potential in IMTA in estuarine as well as in coastal waters. Although some efforts are being made to cultivate the species on a large scale, the potential for land-based production of this red macroalgae has yet to be evaluated. This study evaluated the optimum nitrate and phosphate requirement of G. corticata in two different salinities (20 \infty and 35 \infty). Under different nutrient conditions varying growth rates (DGR ranging from 1.67 to 6.19%), pigments quantity (PE ranging from 480 to 1331µg/g, PC ranging from 155 to 507 μg/g, total chl 134 to 230 μg/g) and nutrient uptake was obtained for both salinities. In both salinity, 80 µM nitrate and 4 µM phosphate nutrient addition showed better biomass, whereas the increase in phosphate concentration more than 8 µM resulted in deterioration of biomass. Further, the cultures with the optimized nutrient combination were found to have healthy red thallus with reduced or no incidences of deterioration of biomass. The findings reported in this study would be useful for the sustainable production of *G. corticata* in land-based systems.

KEYWORDS: Growth, Nutrient uptake, Gracilaria corticata

Assessment of Unused Land Soil Characteristics for Brackishwater Aquaculture Planning: A Case Study in Raigad District of Maharashtra

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Brackishwater aquaculture offers a promising way to utilise unused lands that are unsuitable for other productive purposes, contributing to the development of coastal livelihoods. However, careful planning is essential to avoid multi-user conflicts and to preserve agricultural lands. This study focused on evaluating the soil characteristics of unused lands in three coastal taluks of Raigad District, Maharashtra. The unused lands have been mapped from Sentinel data for the year 2023 using ArcGIS Pro. Soil samples of unused lands were collected from 20 stations and analysed for pH, electrical conductivity (EC), and organic carbon (OC) following standard procedures, while soil texture data was sourced from the ICAR-National Bureau of Soil Survey and Land Use Planning, India. Based on the electrical conductivity values, the lands have been classified as saline or non-saline. The electrical conductivity in saline regions ranged from 5.25-59.16 dS/m. Most of the land was salt-affected, with 83% having salinity levels above 4 dS/m, making it unsuitable for agriculture. The range of organic carbon and pH in saline and non-saline regions varied from 0.09% to 3.68% and 4.48 to 8.34 respectively. Based on the optimum values for brackishwater aquaculture (pH: 6.5-7.5; EC: >4 dS/m; OC: 0.5-1.5%), the lands were identified as most suitable, suitable, less suitable and not suitable in terms of pH, electrical conductivity, organic carbon and texture. Of the unused lands assessed, 73% of lands were found to have potential for aquaculture. Moreover, the distance from the source water bodies and the quality of the source water will also play a key role in developing aquaculture. Overall, the results indicate that the attributes of the unused lands are appropriate for expanding shrimp farming areas.

KEYWORDS: Unused lands, Raigad, Soil characteristics, Mapping, Geospatial

Present Status of Fry Production Technology for Marine Finfish in India

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The present status of hatchery technology for the breeding and fry production of marine finfish in India, including species such as Indian pompano (Trachinotus mookalee), silver pompano (Trachinotus blochii), cobia (Rachycentron canadum), orange spotted grouper (Epinephelus coioides), John's snapper (Lutjanus johnii), pink ear emperor bream (Lethrinus lentjan), goldsilk seabream (Acanthopagrus berda), fanged seabream (Sparidentex jamalensis), spangled emperor (Lethrinus nebulosus), vermiculated spinefoot (Siganus vermiculatus), banded grunter (Pomadasys furcatus) and golden trevally (Gnathanodon speciosus), based primarily on the work carried out in ICAR-Central Marine Fisheries Research Institute, has been described. To date, more than two dozen species have been evaluated for their larval rearing potential in India, with initial success achieved for nearly a dozen of them. Notably, the life cycle has been fully closed in captivity for five species: Indian pompano, orangespotted grouper, John's snapper, cobia, and silver pompano. Currently, approximately 2 million juveniles are produced annually, with pompano being the most significant species. Broodstocks are maintained in recirculating aquaculture systems with capacities ranging from 30 to 100 tonnes. Fertilized eggs are obtained primarily through natural spawning, though induced breeding is also utilized. Broodstocks are fed a mixed diet of fresh squid, clam, and crab meat. Instead of stocking hatched larvae, eggs are typically placed directly into larval rearing tanks. An overlapping feeding regimen is employed, starting with copepod nauplii and rotifers, followed by Artemia nauplii and artificial diets in later stages. The highest survival rate of 23% during the larval rearing period is observed in Indian pompano. Nursery rearing protocols for fry of the different species have been standardized across different systems, including flow-through tanks, recirculating aquaculture systems, and hapas in ponds and cages. Survival rates during nursery rearing exceed 80-95%, depending on the system used. Grow-out farming for Indian pompano, silver pompano, and cobia is well-accepted by farmers in coastal and marine cages and coastal ponds. Further refinement of fry production technology is focussed on generating biological information on larvae and juveniles, developing complete microparticulated diets, enhancing the design and structure of larval rearing tanks for intensive feeding, and establishing health protocols.

KEYWORDS: Fry production technology, Marine finfish



Effect on Different Water Sources on Embryonic Stages and Larval Development of Striped Catfish, *Pangasianodon hypophthalmus* (Sauvage, 1878)

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Striped catfish, Pangasianodon hypophthalmus (Sauvage, 1878) is the second largest fish species widely cultured in freshwater aquaculture after Indian major carps in the country. Seed availability is the major constraint in most of the states in India due to different environmental factors and water resources. To address the problem, an experiment was conducted to study on embryonic developmental stages and larval survival of striped catfish with different water sources. Fish breeding was conducted using borewell, canal and pond water to observe the developmental stages of the embryo and post-hatching of larvae. All the water quality parameters were assessed viz., pH (7.3-8.1), alkalinity (100-130 mg/l), dissolved oxygen (5.2-7.4 mg/l) and temperature (27-30°C), and were observed optimum during the breeding cycle. The Hardness levels of bore, canal and pond water were observed to be 220 to 260 mg/l, 105 to 140 mg/l and 130 to 160 mg/l, respectively. Significant differences (p<0.05) in fertilization, hatching and survival rate were observed among the water sources. The incubation period was maximum (18-22 hrs) in bore water and minimum (16-18 hrs) in canal water. Embryonic development (Morula, Blastula, Gastrula stages) was faster in pond water than in borewell water. Yolk sac absorbed earlier (2.5 dph) in pond water than in canal and borewell waters (3.2 dph). The average total length of newly hatched larvae was recorded as 6.46±0.15 mm, 5.83±0.18 mm, and 4.92±0.20 mm in pond, canal and borewell water, respectively. Larval survival was recorded the highest (90%) in pond water, followed by canal water (82.5%) and borewell water (66.94%). It was concluded that canal and pond waters are ideal for the breeding of *Pangasius* and better hatching and survival of larvae.

KEYWORDS: Pangasius, Breeding, Water quality, Embryonic development, Larval survival

Management Strategies to Combat Issues in Seaweed Farming in India

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Seaweeds are a vital coastal resource that benefits both the environment and society. Seaweeds are valued commercially for their bioactive metabolites, manure, and fodder, as well as for their cell wall polysaccharides, which include agar, algin, and carrageenan. In India, seaweed farming is one of the effective, diversified livelihood options for marine fishers. Seaweed farming has four major issues and its management is essential to increase production. This paper deliberates the constraints and their management strategies. One of the constraints is epiphytism, which is the attachment of undesirable seaweeds to the cultured species, which usually occurs at the onset of monsoon brought by changes in water temperature, trade wind and water current. Drifted seaweeds compete for space, nutrients, and sunlight with the cultured species. Other seaweeds attached to the cultured species have to be removed periodically. "Ice-ice" is the only disease reported in seaweed farming. It is caused due to abiotic stress like low salinity, high temperature, and light intensity. The branches show symptoms of whitening and eventually disintegrate which may result in crop loss. If disease is observed, the entire crop has to be harvested and farming has to be restarted with new seedlings. Natural calamities like heavy storms and cyclone causes complete damage to the Kappaphycus alvarezii farming. Based on the early warnings, premature harvest can be done. A portion of seaweed seeds can be placed in a net bag and kept in deeper waters for the subsequent cycle of culture. Grazing by herbivorous fish is one of the major issues in seaweed farming. To address this issue ICAR-Central Marine Fisheries Research Institute, Mandapam Regional Centre has initiated an innovative biological approach to prevent the grazing of seaweed. A total of 20 monoline units were enclosed by a pen of 125 x 25 feet in dimension and 10 nos. of Asian Seabass, a highly carnivorous fish weighing an average of 500 g size were introduced inside the pen. The seabass could control the grazers like rabbitfish, small-scale Terapon, etc. This approach is very effective and an increase in yield by 30% was observed.

KEYWORDS: Seaweed, Farming, Grazing, Epiphytism, Ice-ice disease, Management

Optimizing Hatchery Production: The Impact of Stocking Density, Salinity and Aggression on Growth and Survival in Juvenile Black Seabream (*Acantopagrus berda*) during Nursery Rearing Practices

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Nursery management is one of the major prerequisites for a continuous supply of goodquality seeds for aquaculture. Experiments for optimising the stocking density and salinity requirement for nursery rearing of Acanthopagrus berda were conducted with various treatments in triplicates in 0.5 m³ tanks filled with 0.3 m³ of filtered and chlorine-treated saline water. A commercial pelleted fish feed (42 % Crude protein; 8% Crude Fat; 5 % Fibre; 11 % Moisture) was provided daily at 10% of the total fish biomass. Natural light provided a 12-hour light/dark cycle with a surface water light intensity ranging from 1000-2000 lux. The optimum stocking density for nursery rearing was standardised as 500 numbers/m³ among various treatments (150, 500 and 1000 numbers/m³) and the optimum salinity as 30% among various treatments (10, 20 and 30%). Aggression and its impact on juveniles during nursery rearing also were evaluated. Experiments assessed the effects of stocking density (10, 20, and 30 fish/aquarium) and size segregation on aggressive interactions, mortality, and growth in aguaria with 100 litre seawater. No significant differences (p<0.05) in final length or growth percentage were observed among stocking densities. However, size segregation significantly affected survival and growth. Unsegregated groups exhibited higher final length, growth percentage, and survival compared to segregated groups. Cumulative mortality analysis revealed significantly higher mortality rates in segregated groups, suggesting increased aggression. Mortality was positively correlated with growth, possibly due to compensatory growth among surviving fish. This study highlights the detrimental effects of aggression on juvenile black seabream in nursery rearing and underscores the importance of managing social interactions to optimize hatchery production.

KEYWORDS: Sparidae, Agonistic behaviour, Transportation, Crowding, Mortality

Optimisation of Stocking Density for Grow-Out Culture of Indian Pompano in Marine Cage—Towards Development of an Ideal Production System

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Indian pompano (Trachinotus mookalee), is one of the emerging marine fish species for sea cage farming, with excellent culture traits. A 10-month grow-out culture experiment was performed in floating marine cages to evaluate the effect of different stocking densities on various production traits such as growth, physiology, nutritional quality and economic returns. A complete randomized design (CRD) consisting of four treatments and three replications of each treatment was followed throughout the trials: SD1 (15 numbers/m³), SD2 (20 numbers/m³), SD3 (25 numbers/m³), and SD4 (30 numbers/m³). Fish behaviour and feeding habits were similar among stocking densities and maximum mortality was recorded at the high density (SD4). Cumulative fish growth (848.0±25.57 g) and AGR (2.75±0.08%) were significantly (p<0.05) high, and FCR was low (1.98±0.15) for low stocking density (SD1). Stress indicators such as serum glucose (104.46±3.14), cortisol (102.72±37.19) and HSP-70 (3.21±0.99) concentrations were significantly high in SD4 during the end phase of the grow-out culture, and showed an increasing trend with increasing stocking densities. The enzymatic markers, AST and ALT significantly varied among treatments, indicating crowding stress. Changes in other physiological attributes such as serum protein, albumin and globulin, did not vary with stocking density and are not good indicators for crowding stress studies. Edible muscle nutritional quality was influenced by the stocking density, with significantly low fat (3.44 \pm 0.26) and low energy providing fatty acid, Palmitic acid observed at high stocking density (SD4). High profitability was observed in SD3, indicated by high economic performance indicators (low operating ratio of 0.67). Overall, high stocking density was a chronic stressor for the fish; and had a negative impact on growth, FCR, animal welfare, and certain nutritional parameters, but within the acceptable limit. The study recommends for sea cage culture of Indian pompano at 25 nos./m³, with a carrying capacity of 18 kg/ m³ for better fish welfare and profitability.

KEYWORDS: Indian pompano, Stocking density, Stress, Cage, Growth, Profitability

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High-Density Fingerling and Juvenile Production of *Osteobrama belangeri* (Val. 1844) in Biofloc Systems

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Studies were conducted to evaluate the impact of varied stock densities on the growth performance of pengba (Osteobrama belangeri) in the biofloc system for two developmental stages; fingerling rearing and juvenile raising. In both studies, the fish were reared in 20,000liter circular biofloc tanks over 84 and 210 days, respectively. Biofloc concentration of 10-12 ml/lwas maintained, achieved through addition of molasses as carbon supplement and CIBAFLOC™ as probiotic source, maintaining a C/N ratio of 10:1. In fingerling raising, fry (2.14±0.04 g) were stocked at three densities- 50, 75 and 100 fry/m³ as the three treatments Tf-1, Tf-2 and Tf-3, respectively, and evaluated in triplicates. After 84 days rearing, survival ranged from 97.58-98.44%, showing no significant variation among treatments. However, Tf-1 exhibited the highest final weight (11.86±0.27 g) and specific growth rate (2.06±0.03%/ day), while Tf-3 had the lowest values (8.14±0.24 g; 1.66±0.04%/day). Feed conversion efficiency (FCE) and protein efficiency ratio (PER) and FCR were significantly higher in Tf-1. Similarly, feed conversion ratio (FCR) was the least in Tf-1 (2.67) followed by Tf-2 (3.05) and Tf-3 (3.11). In juvenile rearing, fingerlings (6.34±0.82 g) were stocked in three treatments Tj-1, Tj-2 and Tj-3 with 20, 35 and 50 fingerling per m³ densities, respectively, and evaluated in the same set up of tanks in triplicates. Survival remained consistent across treatments, ranging from $94.7\pm0.4\%$ in Tj-3 to $97.7\pm0.8\%$ in Tj-1 (p>0.05). The final body weight of juveniles relatively decreased from Tj-1(60.7 ± 1.5 g) to Tj-3 (56.1 ± 1.3 g) (p>0.05). The FCR in Tj-1 was 2.04±0.08, which increased to 2.22±0.06 and 2.12±0.08 in Tj-2 and Tj-3, respectively. However, the biomass yield was the highest in Tj-3. Overall, the results indicated lower stock density to improve growth and FCR in both studies. But based on the greater number of fingerlings produced in Tf-3 and higher biomass produced in Tj-3, the higher stock density is preferably recommended for both fingerling and juvenile rearing phases in such biofloc system for more profit realisation.

KEYWORDS: Biofloc, Osteobrama belangeri, Stocking density

Standardizing the Eradication Method for Jellyfish in Shrimp Culture Ponds

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The study focuses on standardizing methods to eradicate jellyfish from shrimp culture ponds, a crucial aspect of maintaining a healthy farming environment. The research aimed to identify effective treatments to control or eliminate jellyfish in shrimp culture ponds. The experiment was conducted initially using in-vivo trials in a 20-liter aquarium tank containing 30 nos. of *Penaeus vannamei* post larvae (PL-18), along with small-sized jellyfish (20 individuals) and box-type jellyfish (12 individuals.) collected from the same culture pond. Different concentrations of potassium permanganate, copper sulphate (0.50 ppm (T1), 0.75 ppm (T2), 1.00 ppm (T3) and 1.50 ppm (T4)) and tea seed cake (1.50 ppm (T1), 2.50 ppm (T2), 3.50 ppm (T3) and 4.50 ppm (T4)) were applied to the experimental tanks in triplicate. Water quality parameters remained stable across all tanks after 24 hours of treatment, including salinity, pH, ammonia, nitrite, nitrate, total alkalinity, temperature, and dissolved oxygen. Mortality of jellyfish was observed in the treatment tanks after 18 hrs, with no mortality in control tanks. Potassium permanganate treatments resulted in 100% mortality of small-type jellyfish at both low and high concentrations, with no effect on box-type jellyfish. Copper sulfate treatments showed 100% mortality of small-type jellyfish and 70 to 100% mortality of box-type jellyfish at higher concentrations. Tea seed cake treatments led to 100% mortality of small-type jellyfish, 7 to 20% of box-type jellyfish and 3 to 7% mortality of shrimp post larvae at higher concentrations (3.50 and 4.50 ppm). For on-farm demonstration, a dose of 1.0 ppm of copper sulfate was applied to a large earthen pond (1.20 ha) contaminated with jellyfish. Significant (p<0.05) mortality of jellyfish groups (small and box type) was observed in the surrounding areas of the pond after 24 hrs of application. The shrimp PLs were alive with no mortality in the side and center of the pond bottom. After 36 hrs, a large number of molting shells were observed but no dead shrimp. Based on the experimental results and extended pond-based evaluation, copper sulfate at an optimum concentration of 1.00 ppm was found to be an effective method for eradicating jellyfish in shrimp culture ponds with no effect on the culture shrimp.

KEYWORDS: Penaeus vannamei, Potassium permanganate, Copper sulfate, Tea seed cake

Intensive Production Sequence of Marine Calanoid Copepod, *Parvocalanus crassirostris* (f. Dahl, 1894) as Live Feed for Marine Fish Hatcheries

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This study aimed to investigate the effect of different adult stocking densities on the survival and population growth of Parvocalanus crassirostris (F. Dahl, 1894) in intensive continuous and batch production. The grow-out experiment was conducted to assess the adult copepod density-dependent nauplii production and survival at different stocking densities of (T1) 500, (T2) 1000, (T3) 1500, (T4) 2000 and (T5) 2500 adult copepods/l. The rearing water quality parameters like salinity, temperature, photoperiod, pH, dissolved oxygen and algal concentration were optimal in all the experiments. The copepods were fed with mixed microalgae of Nannochloropsis salina, Isochrysis galbana and Paylova lutheri at 1:2:1, a concentration of 40,000 cells/ml/day. The result shows that enhanced nauplii (N1) production per individual female on the first day in adult stocking densities of 2500, 2000, and 1500 nos, per litre, however, a sharp decline in the experimental tanks was observed on the 6th, 7th, and 8th days. The life span observed was 8-12 days for males and 18-21 days for females in captivity. The sex ratio during healthy culture conditions was 1:10. The daily egg production varied between 42±15 eggs/female/day. Spherical eggs with a transparent and smooth surface (60±2.0 µm) are broadcasted in water and the eggs are collected from the bottom of culture tanks with a sieve of mesh size 50 um. The newly hatched nauplii (N-I size 65μ) develop into egg-laying adult stage (N-I to N-VI; C-I to C-V) within a 5-6 days period. The adult stocking density of T2 and T3 was higher in mean nauplii production from the 1st, 2nd, 3rd, 4th and 5th day. The average nauplii production recorded from T3 and T4 were 12 nos. and 18 nos./ml/day. Total mean nauplii production per individual female over the seventh day differed significantly across the stocking densities (p<0.05). The study concluded that the moderate stocking density of *P. crassirostris* (1500-2000 adults/l) in the intensive batch production method and the mixed microalgae concentration of 40,000 cells/ml/day are ideal for the intensive mass production of nauplii.

KEYWORDS: Calanoid, Intensive production, Isochrysis spp, Parvocalanus spp, Nauplii

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Appraisal of Biofloc and Semi Floc with Periphytic Substrates-Based Shrimp Farming in Terms of Productivity, Nutritional Benefit, Immune Protective Responses and Economic Analysis of *Penaeus vannamei* (Boone, 1931)

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A 120-day trial was conducted in HDPE polyethylene-lined ponds with three treatments: semi-floc (SF=vertical periphytic substrate and lower carbon addition), biofloc (BF=CN ratio with periphytic substrate), and a conventional system (Control=without biofloc and periphyton). The experiment was conducted at commercial farms located in the Nagapattinam district, Tamil Nadu, India. Stocking densities of post-larvae were 58, 72, and 116 post-larvae per square meter (Initial ABW=0.086±0.001 g) in the control, semi-floc, and biofloc ponds, respectively. Significantly (p<0.01) higher growth was observed in biofloc ponds, followed by the SF treatment with periphytic substrate, compared to conventional farming. The heterotrophic bacterial community was significantly higher, whereas Vibrio load was lower in the BF culture medium than in the control. The cumulative mortality rate was significantly (p<0.05) lower in the BF groups, followed by the SF groups. The total hemocyte count was significantly (p<0.05) higher in BF shrimp, followed by SF shrimp, compared to the control. Similarly, DHC was higher in terms of hyaline, semigranular, and granular hemocytes. Moreover, the percentage of phagocytotic hemocytes was significantly higher in BF treatment shrimp (p<0.05) compared to other treatments. The prophenoloxidase enzyme activity was higher in BF shrimp serum samples, followed by SF treatments, whereas the positive control showed lower activity. The percentage inhibition of SOD levels was significantly (p<0.05) higher in BF treatment groups (41.21-61.75%), followed by the SF group, whereas the positive control (39.23±1.99) recorded a lower percentage. When challenged with the pathogen V. parahaemolyticus, the cellular and humoral immune responses were significantly enhanced in BF groups compared to other treatments. Economic analysis revealed that the net return and the percentage of return on investment were significantly (p<0.05) lower in BF, followed by SF treatment, compared to the control groups. Hence, the present study concludes that semi-floc and biofloc with periphyton-based shrimp farming are significantly better farming practices in terms of productivity, water quality, protective immune responses, economic viability, and sustainability.

KEYWORDS: Periphyton, Production, Water quality, Disease, Cost analysis



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Optimization of Co-Feeding with Fresh *Wolffia globosa* in Artificial Feed-Based Polyculture of Pabda (*Ompok bimaculatus*) and Pengba (*Osteobrama belangeri*)

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In our previous work, we observed that co-feeding with fresh Wolffia @100% (wet weight basis, moisture content 96%) was a superior feeding strategy over co-feeding with a low protein diet (CP 26%) in pabda (Ompok bimaculatus) – pengba (Osteobrama belangeri) polyculture system. The present study was conducted to optimize the feeding rate of fresh Wolffia globosa in a semi-intensive polyculture of pengba (stocking density: 40000/ha) and pabda (stocking density: 70000/ha). Five feed regimes viz., T1- exclusive feeding with a high protein diet (CP: 32% @ 4-6% of the pabda biomass), T2- pabda feed + pengba feed (CP: 26%; 4% of pengba biomass), T3- pabda feed + fresh Wolffia (50% of pengba biomass; on wet weight basis), T4- pabda feed + fresh Wolffia (75% of pengba biomass; on fresh biomass basis) and T5- pabda feed + fresh Wolffia (100% of pengba biomass; on fresh weight basis) were tried. Pabda feed was offered at 7-8 pm, while pengba feed or fresh Wolffia at 9-10 am. The trials were conducted in triplicates in 15 outdoor cement tanks (3m x 1m x 1m) provided with soil base (8-12 cm) and mechanical aeration. T4 and T5 resulted in significantly (p<0.05) higher final mean weight, net weight gain and daily growth index for pengba, However, for pabda, T2, T4 and T5 resulted in significantly higher final mean weight, net weight gain and daily growth index. For the system as a whole T4 and T5 showed significantly high (p<0.05) combined final and net biomass gain and yield. The overall feed efficiency was higher for T4 compared to the rest of the treatments. The majority of the physiological and haemato-immunological parameters showed no significant differences (p<0.05). However, serum glucose level was significantly low in T4 and T5 for both the species. Among the digestive enzymes, lipase and protease showed no differences (p<0.05) in pabda. In pengba, the highest lipase and protease activities were observed in T4 and T2 and the lowest in T5. The net profit for T4 was approximately 76% higher than T1, 60% higher than T2, 56.03% higher than T3, and 29.44% higher than T5.

KEYWORDS: Commercial feed, Wolffia, Feeding rate, Pabda, Pengba, Polyculture

Decadal Trends in Finfish and Shellfish Seed Production Status, Innovations, and Challenges in Inland and Maritime States in India

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India is a global leader in fish and shellfish production, with a robust seed production system supporting its aquaculture sector. The country's annual fish seed production exceeds 50 billion fry and fingerlings, driven by major producing states. As the largest producer of freshwater fish seed, West Bengal contributes around 40% to the national output. It specializes in Indian major carps like rohu, catla, and mrigal. Innovations in broodstock management and hatchery technology have enhanced seed quality and availability. Renowned for its aquaculture advancements, Andhra Pradesh is a leader in both freshwater and brackishwater seed production. It accounts for over 60% of India's shrimp seed production, focusing on species like *Penaeus vannamei*. Orissa has significantly increased its freshwater fish seed production through government initiatives and investments in hatchery infrastructure. The introduction of improved breeding techniques has bolstered carp seed output. Assam, known for its diverse aquatic resources, plays a crucial role in freshwater fish seed production. The state is enhancing its hatchery systems to meet the rising demand and improve seed quality. Tamil Nadu is another significant contributor to shrimp seed production, focusing on modern hatchery practices and selective breeding programs to enhance production efficiency. The decadal trends in seed production in the inland and maritime states of India exhibit notable variability influenced by factors such as water resources, infrastructure, and policy interventions. In inland states like Jharkhand, there has been substantial growth in fish seed production, driven by improved hatchery infrastructure and reservoir stocking. Karnataka saw a 92% increase in inland fish production post-2020, largely due to enhanced seed production and stocking efforts in reservoirs. In 2022-23, West Bengal produced 27 billion fish seeds and achieved a total fish production of 20.45 lakh metric tonnes, supported by its extensive water resources, including ponds, tanks, and coastal areas. Quality control issues with seed quality, stemming from inbreeding and inadequate broodstock management, persist across states. Many states still rely on outdated hatchery facilities. Climate change and water scarcity are increasingly affecting natural ecosystems vital for seed production. Innovative practices, improved infrastructure, and training of personnel are essential for overcoming these challenges and enhancing India's fish and shellfish seed production capacity.

KEYWORDS: Finfish, Shellfish, Seed production, Innovations, Challenges

Precision Breeding and Management of Koi Carp: A Pathway to Self-Reliance and Global Market Leadership

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Among the 600 ornamental fish species worldwide, Nishikigoi, or Koi carp (Cyprinus rubrofuscus Lacepède, 1803), is the most popular in the aquarium industry. Koi have more than 100 attractive varieties and exhibit great variation in value or demand in the market depending on their shape, colour patterns and intensities. India, the third-largest Koi importer primarily sources from Thailand, Indonesia, and Malaysia. The established conventional breeding of ornamental Koi carp, however, rarely focuses on refining traits for market value, resulting in mixed-quality stocks that raise production costs. In this milieu, the ICAR-National Bureau of Fish Genetic Resources has established a germplasm resource centre of highvalue Koi to maintain good quality, certified stock of different varieties, such as Kohaku, Hi Utsuri, Ki Utsuri, Shiro Utsuri, Tanchoshowa, Yamabukiogon, Orangi ogon, Platinum ogonand Shushui for the precision breeding. For this purpose, inheritance study of Shiro Utsuri and Kohaku variety (ornamental koi carp white body with black spot) have been made and constituted mainly with 3 phenotypes; Kohaku (white body with red spots), Platinum ogon (silvery white) and Shiro Utsuri (white body with black spots) in the F1 progeny. The results of the inheritance study would benefit Koi breeders so that targeted production can be accurately anticipated. Thus, the efforts for the development of a germplasm resource centre for high-quality ornamental Koi carp through precision breeding and management could help us towards making India self-reliant, and to emerge as one of the major Asian countries in the global ornamental trade.

KEYWORDS: Koi carp, Precision breeding, Inheritance study, Germplasm resource centre

Study on Biomineralization and Pearl Formation in Comparison to Different Temperatures in Freshwater Mussel, *Lamellidens marginalis* (Lamarck, 1819)

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Lamellidens marginalis is one of the important candidate species in freshwater pearl culture. Temperature is one of the crucial factors in the pearl formation process, so the experiment on the evaluation of the effect of different thermal regimes on nacre secretion in *Lamellidens* marginalis during indoor rearing was done in the wet laboratory. Different temperatures, viz., 24°C (T1), 26°C (T2), 28°C (T3), 30°C (T4), 32°C (T5), and 34°C (T6) maintained throughout the culture period, with each temperature representing a different treatment group. The mussels were sampled at regular intervals to observe the nacre secretion and samples were kept for further analysis. Stress enzymes, other enzymes and histology of the tissue were examined. A sensor was kept to monitor the temperatures. Using a hemocytometer (Neubauer's Chamber), the freshwater mussels' hemolymph (0.1 ml) was measured for each treatment and found, that when the temperature increased, T1 had the lowest number of cells per milliliter (0.12±0.045 x 10⁶ cells/ml) and T6 had the highest number of cells per milliliter (0.35±0.20 x 106 cells/ml). Immune measures such as NBT and MPO were examined, and no significant alterations were identified for a longer duration. The collected samples were examined histologically to observe the effects of various treatments on the formation of the pearl sac, including the epithelial cell and the deposition of CaCO, crystals. The amount of glycogen in the tissues i.e., visceral mass, foot, and gills was estimated. It was found that the visceral mass had a higher concentration of glycogen than the tissue in the foot and gills. During this period, survival and growth were also observed. The biomineralization process in response to the temperatures was observed during the experiment.

KEYWORDS: Lamellidens marginalis, Temperature, Biomineralization, Immune response

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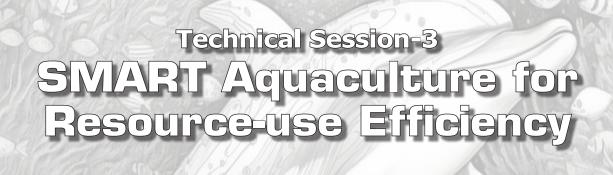
Growth Performance and Water Quality of Indian Major Carps Reared at Different Stocking Density, in an *In-situ* and Externally Produced Biofloc System

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Biofloc Technology has been gaining significant attention, especially in aquaculture, as a sustainable and cost-effective method to maintain water quality while simultaneously producing protein-rich feed. The present study was conducted to compare the effects of in-situ produced biofloc and externally added biofloc on water quality and growth of IMC (Catla, Rohu and Mrigal) under different stocking densities. Experiments were carried out in FRP tanks (1000 l each) for a period of 90 days. The experimental design included in-situ biofloc, externally added biofloc and control treatments conducted at three different stocking densities (STD): 25, 50 and 75 no. fish per m² of surface area of tank respectively, with each experiment replicated thrice. IMC of individual average weight 15±1.6 g was reared in all treatments. In in-situ biofloc treatment, low protein (20%) commercial fish feed was added initially. Further, organic carbon in the form of wheat flour was added daily to maintain the C:N ratio at 10. 60% extra carbohydrate was applied in a typical *in-situ* biofloc tank. In externally added biofloc treatment, 50% of fish feed and 50% wet floc was added. The biofloc was produced in a 25 m³ cemented tank using aquaculture effluent from a nearby carp culture pond and maintaining the best C:N ratio of 10. In control treatment, high protein (30%) commercial fish feed was added. The harvested weights of fish in all treatments with different STD were found to be significantly different among each other (p<0.05). Fish survival was 100% in all the treatments. The FCR values in *in-situ* biofloc treatment and externally added biofloc treatment were less compared to control treatment. Frequency of water exchange was significantly less in externally added biofloc treatment compared to insitu biofloc treatments and control treatments.

KEYWORDS: In-situ biofloc, Externally added biofloc, Indian major carp, Growth, Water quality





Field Colorimetric Determination of Critical Parameters in Aquaculture Pond Waters of Varying Salinity

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Regularly monitoring Dissolved Oxygen (DO), pH, ammonia and nitrite in aquaculture pond waters is essential, as these parameters cause stress and affect the overall health of aquatic organisms. A majority of farmers send water samples to the laboratory for the analysis of water parameters. Generally, these parameters are measured by following the standard methods in the laboratory or by portable meters/kits in the field. ICAR-CIBA developed portable kits for DO, pH, ammonia as Total Ammonia Nitrogen (TAN), and nitrite as nitrite N. A limitation of these kits is the quality of the indicator for DO, and only range values and inability to distinguish between similar colour shades for pH, TAN and nitrite. To improve the accuracy of these parameters, colorimetric methods were developed and standardised in waters with varying salinity. The modified winkler method was used for DO where the intensity of colour was measured using a portable colorimeter at 470 nm ($R^2 = 0.990, 0.990, 0.991$ for 0, 5, and 30%). DO levels up to 1 ppm were able to be measured using the indicator, whereas the levels above 1 ppm was determined even without the use of the indicator, which is an advantage as the indicator degrades more rapidly during storage. pH was measured at 610 nm within a range of 6.5 to 10 ($R^2 = 0.996$, 0.993, 0.990 for 0, 5, and 30%); TAN at 630 nm within a range of 0 to 2 ppm ($R^2 = 0.994, 0.992, 0.995$ for 0, 5, and 30%); nitrite N at 540 nm within a range of 0 to 1.2 ppm ($R^2 = 0.992, 0.997, 0.995$ for 0, 5, and 30%). The results of all these parameters were validated with a UV-visible spectrophotometer and were found to be accurate. The usage of portable kits and hand-held colorimeter provides quantitative, precise and accurate results that benefit the farmers due to their simplicity, rapid analysis, and costeffectiveness. Agua farmers can quickly assess the water quality at the pond site and make necessary decisions such as enhancing aeration, correcting pH, and mitigating metabolites to ensure a favorable environment for cultured aquatic organisms.

Keywords: Ammonia, Dissolved oxygen, pH, Nitrite, Portable colorimeter, Portable water kits.

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Integrated Farming of *Lates calcarifer* and *Macrobrachium rosenbergii* in Aquaponics System: A Sustainable Water Utilization Approach

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Aquaponics, the bio-integration of recirculating aquaculture system (RAS) and hydroponic system is an eco-friendly crop production system. It offers a solution to the scarcity of land and water and simultaneously produces quality aquacrops. Asian seabass *Lates calcarifer* larvae (0.453±0.001 g) and post-larvae of giant freshwater prawn Macrobrachium rosenbergii (0.035±0.001 g) were cultured in two sets of Aquaponics Systems - Set I and Set II with an inlet flow rate of 2.0 l/min and 3.0 l/min, respectively. The static water culture system Set III served as control. Fish and prawns were fed with pelleted diets (protein 40%) ad libitum twice a day. After 90 days of culture, the average final weights of seabass and prawn were significantly (p<0.05) higher in set II compared to set I and set III. Specific growth rates showed similar trends. Total crude protein, lipid, and ash contents were significantly (p<0.05) higher in set II compared to the fish and prawn cultured in the other two systems. All ten essential amino acids and twenty non-essential amino acids were present in the cultured seabass. Lysine and glutamic acid were the most dominant essential and non-essential amino acids, respectively in seabass. In prawns, all ten essential amino acids were recorded. Leucine and glutamic acid were the most abundant essential non-essential amino acids, respectively in prawns. In seabass, a total of eight saturated fatty (SFA), four mono-unsaturated (MUFA), four n-6 polyunsaturated (n-6 PUFA), and five n-3 polyunsaturated fatty acids (n-3 PUFA) were recorded. In prawns, a total of eight saturated fatty (SFA), three mono-unsaturated (MUFA), three n-6 polyunsaturated (n-6 PUFA), and three n-3 polyunsaturated fatty acids (n-3 PUFA) were recorded. The culture of fish and prawns in Aquaponics Systems reduces the requirements of water compared to the static water system

KEYWORDS: Aquaponics System, Asian seabass, Prawn, Amino acids, Fatty acids

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Next-Generation Climate-Smart Precision Farming System for Sustainable Shrimp Production

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In the face of evolving climate challenges, the aquaculture sector must embrace innovation and technology to ensure resilience and sustainability. Present-day shrimp aquaculture faces many challenges, including increased input costs, declining international markets, and disease risks. The solution lies in optimizing inputs, creating a suitable environment, and enhancing system efficiency to boost productivity without harming the environment. A sustainable approach gaining attention involves enhancing shrimp productivity by utilizing co-cultured microbes, algae, copepods, planktonic organisms, and associated biofloc (microcosm). In line with this vision, ICAR-CIBA developed a pioneering next-generation farming system, with high stocking density and precise use of input resources such as water, feed and energy. Key features include smart feeding, intelligent aeration systems, stringent biosecurity, in-situ natural feed production, minimal water exchange and energy consumption. Monthly stocking and harvesting ensure year-round production, which is an added advantage of such a compact farming system. We did several cycles of farming with stocking density ranging from 100-240 shrimps/m³. Between November 2023 and August 2024, we completed seven cycles of shrimp production trials with hatchery-produced selectively bred, SPF *Penaeus vannamei* seeds. Each farming cycle ranged between 90 to 104 days. We achieved a productivity of 3.47-4.97 kg per m³, which is equivalent to 34.7-49.7 tonnes/ha. The highlights of this farming system were the minimal use of inputs such as feed, aeration, and water, resulting in a better feed conversion ratio (FCR) between 0.97-1.16 and survival between 86.5%-97.8%. By adopting the design and way of operation, farmers can get 3-4 cycles of farming in such kind of engineeringly designed system. This success indicates that the system could serve as a scalable model for monthly shrimp stocking and harvesting, promoting domestic market growth and offering fresh shrimp to consumers at affordable prices under the direct "farm to fork" concept. On the farmers' side, it will reduce reliance on export markets. In this win-win model, farmers benefit from increased revenue and consumers enjoy access to fresh, highquality shrimp.

KEYWORDS: Shrimp, Penaeus vannamei, Climate-smart, Precision, High density, Productivity

Rapid Micropropagation of *Anubias barteri* var. Glabra: A High Value Aquarium Plant of Slow Growth and Propagation and its Value Addition

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Aquarium plants play an important role in the structure and function of the aquarium ecosystem by increasing the transparency of water bodies, absorbing nutrients such as nitrogen and phosphorus from fish waste, and reducing the eutrophication level. The tissue culture technology enhances the proliferation rate of plants rapidly in a short time and facilitates a new way to asexually propagate high-quality seedlings of commercially important aquarium plants and meet the demand of the aquarium plant industry. A rapid in vitro propagation protocol for true-to-type plants has been established from the mature shoot tip of high-value aquarium plants of slow growth and propagation viz. Anubias barteri var. Glabra as the natural propagation of this species is limited due to the production of a small number of plants with a long cultivation period, pathogen attack, and requirement of a large space for propagation. The young shoot tips were surface sterilized using 0.5% (w/v) mercuric chloride solution containing 2 drops of Tween-20 emulsifier per 100 ml solution for 3 minutes followed by 5% sodium hypochlorite solution for 10 minutes. The explants were cultured on Murashige and Skoog Medium augmented with different concentrations and combinations of plant growth regulators for shoot bud initiation and multiplication. The highest frequency of shoot bud proliferation (8.6±0.38 shoots) was observed in MS medium augmented with 3.0 mg/l of 6-Benzyl Amino Purine. But when a combination of 3.0 mg/l of Benzyl Amino Purine (BA), 1.0 mg/l of Naphthalene Acetic Acid (NAA), and 0.5 mg/l of Thidiazuron (TDZ) was used, the multiplication rate was enhanced to (23.38±0.42). For the differentiation of plantlets, half-strength Murashige and Skkog Medium supplemented with 1 mg/l BA was found to be the best. Half-strength Murashige and Skoog medium supplemented with 2 mg/l Indole Butyric Acid (IBA) was the best for root initiation (5.4±0.28). Almost 100% acclimatization and recovery of the plants were observed while hardening. These plants were ideally suited for high-value products like aquascaped aquariums, terrariums, and paludariums compared to other aquarium plants.

KEYWORDS: High-frequency propagation, Aquascaping, Terrariums, Paludariums

Developing IoT Based System for Real-Time Monitoring and Management of Dissolved Oxygen (DO) in Culture Fishery

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Monitoring and management of fish and shellfish culture, especially in inland fisheries is of much importance for attaining its production potentials to meet the ever-increasing demand. The growth and survival of aqua products are very much dependent on the ambient environment. In culture fishery, fluctuations of DO level may severely impact the survival of aquatic life like fishes, leading to a high level of mortality. This event can happen very quickly and at any time which may be critical for sensitive fishes where water is recirculated, where fish stocking levels are high. However, in recent years, advancements in automation technology, ICT and sensors have the potential to automate the monitoring and management of the water quality of the fish farm, thus leading to increased fish production. The present study aimed to develop an integrated IoT-based system that will act as a smart system to monitor the DO level of the waterbody, identify stress situations and automatically start the aerator in real time. The system is equipped with a cloud-based monitoring system for remote and real-time monitoring of DO status via the Internet. The system can function with electric power as well as solar power. The invention helps to continuously record and store the DO and temperature data in the cloud server. It can automate the DO management system in a highly intensive culture fishery system which subsequently reduces the power consumption due to on-demand aerator operation, manpower requirement and most importantly high fish mortality induced by DO deficiency. The technology can complement in attaining SDG14 goals for sustainably managing and protecting the ecosystem in life below water. The developed IoT-based automated DO monitoring system can be deployed in any cultured fisheries system to improve the water quality for fish survival.

KEYWORDS: IoT, DO, Culture fishery, Aerator, Automatic system

Farmers' Friendly Portable Fibre Reinforced Plastic (FRP) Scampi Hatchery to Boost Seed Production in India

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The Giant River Prawn (Macrobrachium rosenbergii), commonly called 'scampi', is a native Indian freshwater species found in rivers, canals, and estuaries. Valued for its size, rapid growth, delicious flavour, and strong export demand, it ranks as one of the most significant species for freshwater aquaculture. The natural seed availability of this species from Indian rivers and estuaries has significantly reduced due to various anthropogenic activities. Although the captive breeding and seed production of this species is standardised, the wider availability of seeds has been a constraint. The existing scampi seed production system is technology-intensive, which requires a larger infrastructure and space. Further, the hiring of technical personnel and adequate manpower for hatchery operations increases the operational cost. This is debarring many interested farmers to take up scampi seed production. The All-India Co-ordinated Research Project functional at ICAR-Central Institute of Freshwater Aquaculture has designed and developed a farmers'-friendly Fibre Reinforced Plastic (FRP) portable scampi seed production unit with seed production capacity of one lakh per cycle. This is a simple technology-friendly model of scampi hatchery. This model requires less space and can be easily managed by one to two persons only. The cost of the developed FRP hatchery unit is much less than the concrete tank-based hatchery. The hatchery unit consists of five one-tonne capacity larval rearing tanks, two seawater storage tanks of 5-tonne capacity each, two Artemia hatching tanks, one freshwater overhead tank, aeration system, and other accessories. As scampi hatchery during larval rearing requires seawater, FRP materials being non-toxic and corrosion-free are found to be better. The on-station trials revealed that the total larval media and the freshwater requirement to complete one cycle are about 10 tonnes and 5 tonnes, respectively for the production of one lakh seeds per cycle.

KEYWORDS: Freshwater prawn, Scampi, FRP, Portable hatchery, Seed production

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Investigation into the Performance of an Indigenous Automatic Fish Feeder

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Automated feeders, which are programmable devices designed to dispense feed at specific intervals and quantities, offer several benefits over manual techniques. These include precise feeding schedules, portion control, and reduced labour costs. Additionally, automated feeders ensure consistent feeding practices, potentially leading to better growth rates and improved feed conversion efficiency (FCE). An indigenous automatic fish feeder has been designed and developed for continuous feeding in fish production systems like RAS, large aguariums, ponds, tanks, and cages. The system allows users to set the time intervals for feed delivery and adjust the feed volume, with the ability to estimate the reservoir's feed level for future planning. The release volume is controlled by adjusting the valve's open duration. Key components of the feeder include a feeding mechanism, an electronic control system, and a display unit. The system's efficiency was tested by installing the feeder in 5-ton FRP fish production tanks. All tanks were equipped with biological filters to maintain optimal water quality. Juveniles of marine finfishes collected from the hatchery were stocked at a uniform stocking density across three replicate tanks. In manual feeding tanks (control) the fish were stocked at the same stocking density. Fishes in the control tanks were fed twice daily (10 am and 4 pm), while auto-feeding was programmed four times daily (6 am, 10 am, 2 pm, and 6 pm). A commercial feed containing 40% protein was used for both methods, with a feeding rate of 5% of the total biomass and a feed size of 0.8 mm. The study results suggest that in tank-based fish production systems, increasing feeding frequency through automatic feeders can significantly enhance growth and reduce labour requirements. Feeders improve feed distribution within the tanks leading to reduced feed waste and improved FCE. The use of automatic feeder technology improved weight and length gains, feed utilization, survival rates, and overall production, while also decreasing labour dependency compared to manual feeding methods. This newly developed feeding device has wider application in large-scale culture systems like offshore cages and other fish culture systems for production enhancement.

KEYWORDS: Automated feeders, Feed efficiency, Growth parameters, Feeding frequency, Labour reduction

Advanced Methods for Mass Seed Production of Akoya Pearl Oyster, *Pinctada fucata* (a. Gould, 1850)

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Captive breeding and hatchery seed production of the Akoya pearl oyster (*Pinctada fucata*, A. Gould, 1850) was first achieved by the Central Marine Fisheries Research Institute in 1983. Although the seed production technique was standardised decades ago, subsequent technological improvements have not kept pace with advancements in science. Challenges such as the mass-scale production of pure microalgae cultures and inadequate nursery rearing methods have hindered higher survival rates and large-scale commercial production. To address these issues, the ICAR-Vizhiniam Regional Centre of Central Marine Fisheries Research Institute developed a high-density larval rearing system and innovative nursery systems like the micronursery and field upweller system. Adult oysters collected from culture rafts were strip-spawned in the hatchery, and the larvae were reared in high-density bivalve rearing systems using cylindroconical tanks with a 500-litre capacity. In these systems, larvae can be stocked at densities of 15-100 larvae/ml, compared to 1-10 larvae/ml in conventional methods. Once the larvae reached the settlement (eyespots) stage, they were transferred to a micro-nursery system comprising both downwelling and upwelling systems. The larvae were grown to spat size (10 mm) before being transferred to a field upweller system for further rearing.

KEYWORDS: Akoya pearl oyster, *Pinctada fucata*, Seed, Spat production, Micro nursery system, Field upweller system

Habitat Refurbishment in Aquaculture: Role of Seaweeds in Open Water Cage Farm Sites (IMTA)

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Cage fish farming in the open waters has considerably boomed in the last decade throughout Kerala and habitat restoration is the immediate requirement. In cage farming, fish are grown in their natural habitats while enclosed in net cages with ad-libitum feeding. Therefore, the inorganic and organic loads from these cages through feed waste, fish excreta, etc. are discharged into the water increasing the nutrient loads, resulting in water quality deterioration and eutrophication. In this study, the seaweed, Gracilaria corticata, was integrated with the cage culture of seabass, Lates calcarifer, at the site, Moothakunnam, Ernakulam, Kerala, The study determined the water quality parameters and assessed the seaweed's role in biofiltering and removing the dissolved nutrients from the water. Water samples were collected from five sites: reference site; cage site (fish); integrated sites (seaweed + mussel + fish), (mussel + fish), and monoculture site of seaweed. The values of ammonia (0.003±0.0071 mg/l), nitrate (0.0553±0.108 mg/l), nitrite (0.004±0.009 mg/l), and orthophosphate (0.0097±0.018 mg/l) were found lower in the integrated site than other sites, except for seaweed monoculture site. The present study revealed good prospects for seaweed farming and cage farming to reduce the pollution from cage farming. Seaweed farming with fish farming in cages reduces nutrient loads and improves water flow through the fish net.

KEYWORDS: Cage farming, Seaweeds, Mussels, Water quality

Assessing the Impact of Carbohydrate-Based Biofloc Systems on Koi Carp Growth and Survival

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Biofloc technology is an innovative and environmentally sustainable approach to aquaculture that focuses on maintaining a microbial community within the culture water to enhance water quality and support the growth of aquatic organisms. This study evaluated the effects of different carbohydrate-based biofloc systems on the survival and growth of koi carp (*Cyprinus carpio* var. koi) fry over a 60-day period, using four carbon sources. A total of 450 fry, with a mean weight of (1.55±0.12 g), were randomly distributed into 15 tanks (n=30 per tank). Experimental groups were set up in triplicate: T0 (clear water/control), T1 (finger millet), T2 (wheat), T3 (molasses), and T4 (rice flour). Biofloc was developed and added to 300 l FRP tanks to maintain a 15:1 C/N ratio. Periodic proximate analysis of carbohydrates and the effects on physicochemical parameters of water, growth parameters, and survivability were recorded. The results showed that the physicochemical parameters remained within normal ranges. The final observations indicated that the finger millet-based biofloc system provided the best specific growth rate (5.75±0.02%) and survivability (79.97±3.36%) among the different carbohydrate-based biofloc systems. The study concludes that BFT is a promising technology for koi carp production, enhancing growth and survivability.

KEYWORDS: Biofloc technology, Cyprinus carpio var. koi, Growth, Carbohydrate source

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Enhancing Aquaponics Efficiency: Insights from *Labeo rohita* and *Ipomoea* sp. in Floating Raft and NFT Systems

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Aguaponics is an innovative aquaculture practice aimed at achieving sustainable production. The present study examines the performance of *Labeo robita* and *Ipomoea* sp. in floating raft and NFT aquaponics systems, focusing on the impact of optimal stocking density on biomass production and nutrient budgeting over a 90-day period. Floating rafts (Polystyrene) with dimensions of 1.5 m x 0.8 m and a thickness of 3.76 mm, each containing 28 planting holes, were constructed. Six treatments were conducted in triplicate. In the first three treatments (T1, T2, T3), fish densities were 50, 100, and 150 respectively, with a constant plant density of 28. In the subsequent three treatments (T4, T5, T6), plant densities were 14, 28, and 42, while fish density was maintained at 100. Results indicated the highest overall fish biomass gain in the NFT system (T3) ranged from 11.97±0.70 g to 39.36±0.36 g in 45 days, with the highest plant biomass in NFT (T6) at 411.33±6.89 g. Nutrient budgeting revealed superior growth rates for both fish and plants in the NFT system compared to the floating raft system. In the floating raft system, the highest fish biomass gain was observed in T3 (26.27±0.62 g to 49.30±1.41 g) and the highest plant biomass in T6 (366.33±3.76 g). Notably, individual plant growth peaked in T5 due to optimal nutrient availability. This study underscores the potential of floating raft aquaponics and highlights the significance of optimal stocking density for sustainable aquaponics production, benefiting marginal farmers through techno-economic analysis.

KEYWORDS: Aquaponics, Floating raft, NFT, Labeo rohita, Nutrient budgeting

Computer Vision and Machine Learning Approach for Predicting Shrimp Disease Occurrence Based on Growth Dynamics and Behaviour Analysis

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India ranks among the top five seafood exporters globally, exporting 1.36 million metric tons of seafood valued at \$7.76 billion in 2021-22, marking the highest value to date. Frozen shrimp is the most significant export, accounting for over 53.18% of the quantity and 75.11% of the export value. Despite the success of shrimp farming, the industry faces numerous challenges, particularly diseases, which hinder growth and cause substantial economic losses. Infectious diseases in shrimp are caused by viruses, bacteria, and microsporidia, with the White Spot Syndrome Virus (WSSV) being one of the most pathogenic shrimp viruses worldwide. Due to its high infectivity and mortality rate, WSSV has become a significant challenge for the global shrimp farming sector. To address this, an early WSSV detection model was developed, incorporating important indicators such as growth dynamics, behaviour, and morphological signs using Computer Vision and Deep Learning. The model non-invasively revealed that WSSV-infected shrimp showed no growth compared to healthy shrimp, which displayed an average growth of 1.9 grams over a 7-day period. Additionally, the DeepSORT Tracking model showed that WSSV-infected shrimp exhibited prolonged flaccid movement and immobility for over 50 hours before succumbing to mortality. The severity of WSSV disease incidence was analyzed through Ordinal Regression and various Machine Learning (ML) models to predict disease severity based on observed signs and symptoms. The indicators such as antennae cuts, exoskeleton dryness, carapace displacement, hyperactivity with convulsions, scratching of the carapace with mandibles, and the presence of a white gut with no feeding were identified as significant predictors of WSSV severity. The decision tree classifier emerged as the most accurate and effective model, achieving an 89% accuracy score. The image-based classification was also conducted using Computer Vision and the YOLOv8 model, achieving 81% accuracy in predicting WSSV disease severity. These findings underscore the potential of these technologies to reduce mortality rates and production losses, thus supporting improved farm management and sustainability in the shrimp aquaculture industry.

KEYWORDS: WSSV, Shrimp farming, YOLOv8, Computer Vision, Deep Learning



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In-Silico Screening and Identification of Neem Bioactive Compounds Against White Spot Syndrome Virus (WSSV) Proteins VP26 and VP28

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White Spot Syndrome Virus (WSSV) is a major pathogen responsible for significant losses in penaeid shrimp aquaculture. The virus utilizes structural proteins VP26 and VP28 for host invasion, with VP26 facilitating the entry of the nucleocapsid into the host nucleus and VP28 serving as a viral adhesion protein that binds to the *Penaeus* Rab7 protein. This study aims to identify potential inhibitors of these proteins using an *in-silico* approach. The 3D structures of VP26 (PDB ID: 2EDM) and VP28 (PDB ID: 2ED6) were retrieved from the PDB database for structure-based drug design. Docking studies were conducted using PyRx software, with neem-derived phytochemicals selected as potential inhibitors retrieved from the PubChem database. Seventeen neem compounds were chosen for docking studies based on the literature. Among these, Azadirachtin and Meliantriol demonstrated strong binding affinities to VP26 (2EDM), with binding energies of -10.6 and -7.2 kcal/ mol, respectively. Azadirachtin also exhibited significant binding affinity to VP28 (2ED6), with a binding energy of -10.7 kcal/mol. Beyond its antiviral properties, Azadirachtin has been explored for its anticancer potential, particularly in treating cervical and oral cancers, highlighting its promise as a multifunctional compound for drug development. Meliantriol, known for its antifeedant properties, adds another layer of potential value, especially in pest management within aquaculture systems. These findings suggest that neem-derived compounds, particularly Azadirachtin and Meliantriol, could serve as promising candidates for the development of novel antiviral drugs and offer broader therapeutic applications, including the treatment of key aquatic diseases.

KEYWORDS: White spot syndrome virus, In-silico, Rab7, Neem, Docking

Deep Learning in Aquaculture: Understanding Spatial Relationships in Fish Behavior

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Monitoring fish behavior is essential for maintaining their health. Among the various behaviors, feeding patterns are crucial as they directly reflect fish well-being. This study introduces a novel approach for analyzing feeding behavior using a custom-trained YOLOv10s model, combined with Delaunay Triangulation and Byte tracking to track group dynamics and assess feeding status. The model was trained on a custom dataset containing 3,000 images, achieving an impressive accuracy of 95.07%, outperforming the 94.35% accuracy observed on a larger 10,000-image dataset from Kaggle. Key metrics such as the flocking index, average triangle area, and edge length helped distinguish significant behavior patterns. Fish that were well-fed displayed a higher flocking index and smaller triangular areas, indicating closer grouping compared to starved fish, which exhibited larger, more dispersed formations. By analyzing these behavioral shifts, the system accurately predicts fish hunger, allowing for more tailored feeding schedules. This results in better resource management and less feed wastage. Furthermore, this technique enhances fish welfare by ensuring healthier living conditions and supports sustainable aquaculture by minimizing environmental impacts. The integration of deep learning models with advanced tracking and geometric algorithms showcases the potential to revolutionize fish behavior monitoring, delivering both economic advantages and environmental sustainability.

KEYWORDS: Behavior analysis, YOLOv10, Deep learning, Aquaculture, Feeding patterns

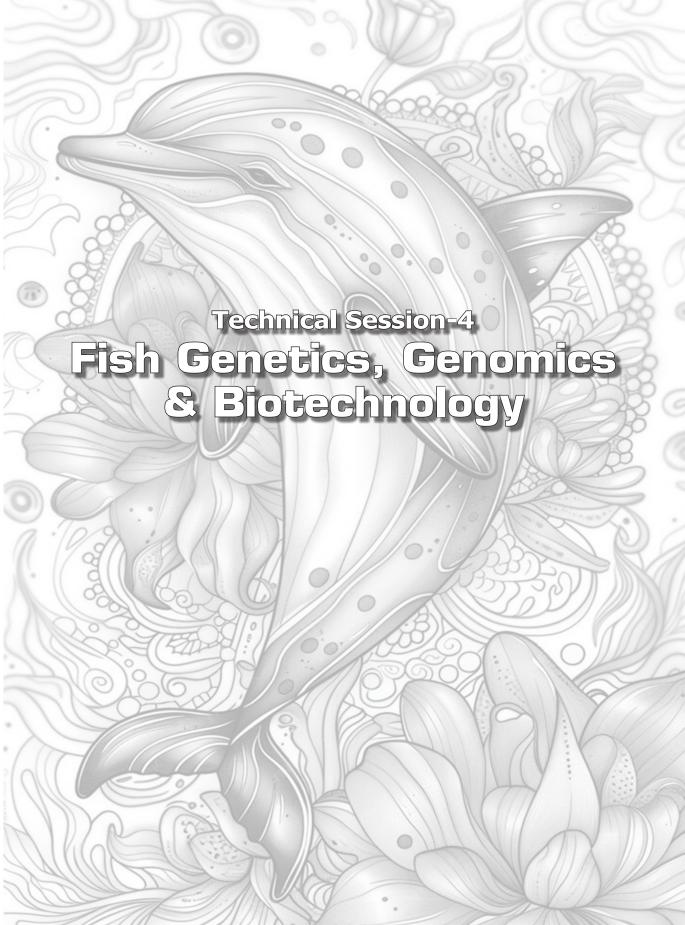
Smart Aquaculture Practices through IMTA and Hydroponics Integration

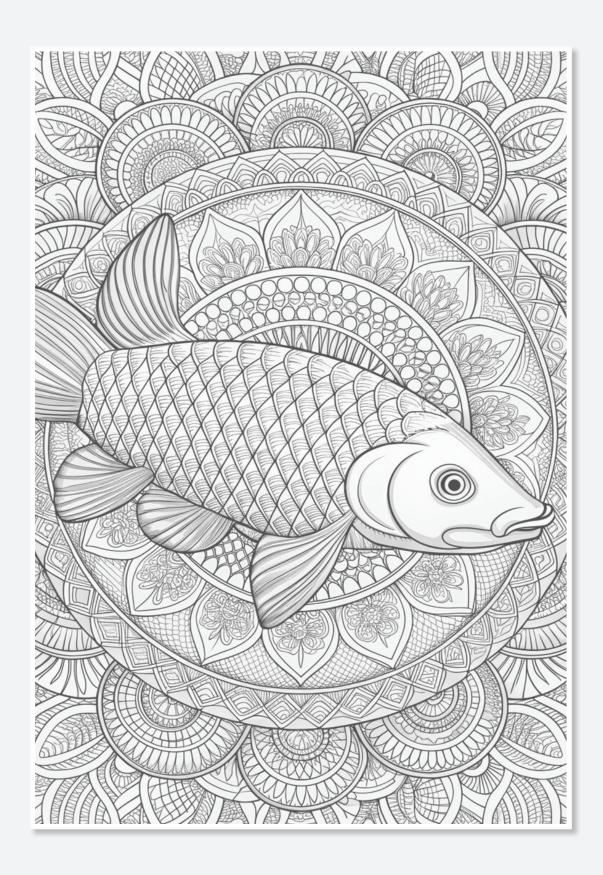
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With the global increase in food demand, aquaculture production has intensified, leading to rapid growth in the industry. However, this intensification, coupled with a shortage of space, has resulted in increased aquaculture waste and environmental pollution. Consequently, effective waste management in minimized space is essential. Zero-exchange recirculating integrated multitrophic aquaculture (IMTA) with hydroponics presents a symbiotic, self-sustaining solution. Unlike the traditional monospecies aquaculture systems that experience nutrient and organic matter losses, Recirculating Aquaculture Systems (RAS) produce nutrients beneficial for plant growth. The advantages of this integrated setup include optimized growth rates, increased crop diversity, proper waste management, sustainable resource utilization, and a balanced food diet. However, the main challenge lies in effective pest and disease control. IMTA with hydroponics enables the cultivation of multiple aquaculture products and agricultural crops simultaneously within the same space, thus improving resource efficiency. The mutual ecological relationships among various biotas involved play a crucial role in maintaining a balanced food chain within this system. This study underscores the potential of IMTA combined with hydroponics as an effective and sustainable aquaculture practice that not only enhances production but also addresses environmental concerns related to waste management.

KEYWORDS: IMTA, Hydroponics, RAS, Zero-water exchange aquaculture





Insights on Unique Genes and Pathways of Cultured Shrimp Species Identified through Pangenome Analysis

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Availability of whole genome data and advanced bioinformatics methods made it possible to compare large numbers of genomes and study similarities and differences among them. Pan-genome analysis is gaining significance in genomics research as it results in core and variable regions of the genome. Core genes are the set of genes shared by all the genomes, while variable genes consist of unique genes of a species and shared genes between a few species. To understand these genic variations, pan-genome set was constructed with five whole genomes of different shrimp species viz., Penaeus indicus, P. monodon, P. vannamei, P. japonicus, and P. chinensis. Annotated protein fasta files pertaining to these species were downloaded from Genbank. The number of annotated genes for these species ranged from 31477 to 39224. Good protein files were generated by filtering the sequences having less than 50 amino acid lengths and changing the headers of fasta sequences. Gene clusters identified using the OrthoMCL v2.0.9 tool revealed a total of 18031 clusters. A total of 10543 gene clusters were common to all the five species of the study in which 6922 were found to be single copy orthologous gene clusters. This single copy orthologous gene clusters could be used to study the evolutionary relationships between the species. In addition, a total of 190, 245, 279, 197 and 108 unique gene clusters were identified for *P. indicus*, *P. monodon*, P. vannamei, P. japonicus, and P. chinensis respectively. Sequences from these unique gene clusters were subjected to annotation using OmicsBox software. Functional analysis revealed species-specific nature of certain metabolism and stress regulation mechanisms. Notably, some unique gene variants of chymotrypsin and trypsin were found to be present in P. vannamei. The Computational analysis of Gene Family Evolution (CAFE 5) tool was used to analyse gene family expansions and contractions across the shrimp species. The phylogenetic tree built based on gene expansions and contractions revealed a close proximity of P. indicus with P. chinensis and P. vannamei with P. japonicus. The methodology followed in this study results in core and variable gene clusters associated with cultured shrimp species which could be used for deciphering similarities and uniqueness of each species along with their evolutionary relationships.

KEYWORDS: Shrimp, Pan-genome, Orthologous genes, Core genes, Unique genes

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Preliminary Studies on Selective Breeding in Pearlspot (*Etroplus suratensis*)

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To sustain and prosper in aquaculture, the development of genetically improved fish species is considered of paramount importance. Pearlspot is known for its tender flesh, delectable taste and recognized for its culinary tourism. The fish has a high-yielding market value in Kerala and few other states of India. It is euryhaline, omnivorous, has a shorter generation interval (8-10 months) and can be bred easily in captive conditions. However, since the fish is a slow grower we implemented selective breeding on body weight to estimate the genetic gain. In this study, adult pearlspot fishes from our farm (Muttukkadu near Chennai) weighing around 100 gm were selected. These fishes were obtained out of random mating between the stocks collected from Chennai and Kerala. We established six pealspot full-sib families (F0) from the adult base population. The culture and feeding standards were maintained the same for both generations to minimise environmental error. The first 45 days post-hatch (dph) is larval rearing in indoor FRP tanks, followed by the next 60 days and rest of the period reared in hapas and meshed cages (2x1x1m) in an open pond at a density of 80-100 fishes per cage. The mean body weight for the F0 fishes for dph 90, 120, 150, 180 and 240 were 4.4±1.7, 10.7±4.0, 18.3±7.6, 29.7±9.2 and 44.8±6.4 grams, respectively. Within the family, selection was carried out based on 240th day body weight. The fishes with the body weight above mean ±2S.D. were selected. Inter-family crossing of F0 families was carried out to generate F1. Three full-sib families were generated. The mean body weight for the F1 fishes for days 90, 120, 150, 180 and 240 were 4.9 ± 1.0 , 11.3 ± 1.7 , 19.5 ± 4.5 , 32.5 ± 6.7 and 48.8 ± 7.1 grams. The coefficient of variation reduced significantly after one generation of selection (F0: 14.3 to 41.6; F1: 13.6 to 23.1). The estimated genetic gain was found to be 8.9% at 240 dph. The experiment indicated that the selective breeding in pearlspot fishes is highly effective and if implemented on a large scale, the growth rate of the fish can be improved significantly.

KEYWORDS: Family selection, Genetic gain, Growth rate, Pearlspot

Development of Asian Seabass (*Lates calcarifer*) Muscle Cell Line for Production of Cultured Fish Meat

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Cell culture technology recently has given hope for the production of laboratory-grown meat. In-vitro meat production is promising due to the reasons that the demand for meat is increasing rapidly and it is not practically possible to meet this demand through conventional means as it requires critical inputs such as land, water and energy which are finite and competed by many sectors. Further, the production of animal and fish meat through conventional techniques has many disadvantages such as ethical issues of slaughtering and animal welfare, the spread of zoonotic diseases, greenhouse gas emission, use of fossil fuels for farm operations, antibiotic and pesticide residues, loss of genetic diversity due to over-exploitation of wild population, etc. With the recent development of in-vitro meat production technology, these disadvantages can be overcome and there is a possibility of increased acceptance of meat by the general public. The technology has the potential to provide sustainability and nutritional security to the growing population. Asian seabass, Lates calcarifer, weighing about 15 g was euthanized and muscle tissue was collected aseptically from the lateral side below the dorsal fin. Muscle tissue explant culture was made and seeded in a 25 cm² flask in a growth medium consisting of L-15 medium supplemented with 20% FBS, fibroblast Growth Factor, and nonessential amino acids and seeded in 25 cm² flasks. The cells were observed periodically and subcultured 1:2 upon reaching more than 90% confluency. The cells were mostly fibroblast in nature with some cells appearing long and filamentous. The cell concentration varied from 9x10³ to 3.9x10⁴ cells/cm². The cells were cryopreserved after 20 passages, and subsequently after every 10th passage. The cells have undergone 52 passages and were characterized for the expression of myoblast-specific marker, myoblast determination protein, MyoD, and species identification. This cell line has the potential to be used for the production of Asian seabass cultured meat in the laboratory.

KEYWORDS: Asian seabass, Lates calcarifer, Muscle cell line, Cultured meat

Deciphering the Effect of Functional Diet Containing Single and Multiple Strain Probiotic on the Gut Microbiome Signatures in the Pacific White Leg Shrimp, *Penaeus vannamei* by Amplicon Sequencing

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Aquaculture production is inextricably connected to health, and the gut microbiome is quickly becoming an indispensable marker for shrimp health. Hence, gut microbiome modification is a viable alternative to broad-spectrum antibiotics in aquaculture disease management. The present objective was to analyze the gut microbiome of the shrimp after dietary supplementation probiotic. Six basal diets with probiotic functional feed viz., P. pentosaceus 109 and 1011 CFU/kg of feed (PP9 & PP11); L. plantarum 109 and 1011 CFU/ kg of feed (LP9 & LP11); Multiple strain probiotics (P. pentosaceus, L. plantarum, L. lactis, E. faecium, E. durans, E. hirae) 109 and 1011 CFU/kg of feed (MSP 9 & MSP11); and control (CON) diet prepared and experiment was conducted in P. vannamei. At the end of the experiment (60 days), the gut of shrimp (n=3) was collected from each group, and microbiome analysis was carried out using Illumina Miseq sequencing of 16S RNA V3-V4 hypervariable regions. A total of 2912608 high-quality reads, sequencing depth 138695.61 (n=21), and 5602 OTUs (Operational Taxonomic Units) were detected. Proteobacteria have been demonstrated to be the most prevalent phylum in the gut microbiome with LP11 depicting a relative abundance of 71.71%. Further, Firmicutes is predominant in the LP9 (14.07%), and Actinobacteria in the PP9 (17.08%). Alpha diversity indices observed OTUs (1452.33 ± 220.80) and Fisher alpha (281.43 ± 52.38) were significantly high $(p\le0.05)$ in the multiple strain probiotic with high dose. Beta diversity indices and principal coordinate analysis depicted distinct bacterial community profile in PP11 & MSP11. The beneficial core microbiome families Oxalobacteraceae, Flavobacteriaceae, Cellulomonadaceae, Rhodobacteraceae, Pseudomonadaceae and Bacillaceae were predominant in the probiotic diet supplementation treatments. Ralstonia, Tenacibaculum, Demequina and Paracoccus were unique and prevalent genus in probiotic diet-supplemented treatments. The probiotic supplementation @ 10⁹ & 10¹¹ CFU/kg of feed showed the number of OTUs at species level specific to be 40 & 42, 51 & 63, 89 & 38 and 39 & 29 in PP9, LP9, MSP9 and CON, respectively. It was found that probiotic supplementation resulted in the modulation, alteration and enrichment of the gut microbiome signatures with relative abundance of healthy beneficial bacterial communities in *P. vannamei*.

KEYWORDS: Gut microbiome, Single strain probiotic, Multiple strain probiotic, *Penaeus vannamei*, Amplicon sequencing



Cytokine Modulation by Sulfated Rhamnoglycan from *Ulva lactuca*: A Novel Approach to Immune Regulation and Anti-inflammatory Therapy

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Green seaweeds, particularly *Ulva lactuca* (sea lettuce), are a major part of the global edible seaweed population. This species, part of the *Ulvaceae* family, is widely consumed and rich in pharmacologically active polysaccharides, showcasing potential for various therapeutic applications. The study explores the nutritional and immunomodulatory potential of a sulfated xylated rhamnoglycan (ULP-2) isolated from the edible green seaweed *Ulva lactuca*, focusing on its ability to regulate cytokine expression in lipopolysaccharide (LPS)-induced CALU-1 non-small-cell lung cancer cells. Through a comprehensive structural characterization (FTIR, 1D and 2D NMR) spectroscopy and high-resolution mass spectrometry (HRMS), ULP-2 was determined to possess a $(1\rightarrow 4)$ -linked polysaccharide backbone consisting predominantly of xylose, rhamnose, and glucuronic acid residues. *In vitro* assays demonstrated that ULP-2 exhibited potent immunomodulatory effects. At a concentration of 125 µg/ml, ULP-2 significantly attenuated the expression of pro-inflammatory cytokines in LPS-induced CALU-1 cells. Specifically, the expression of TNF- α was reduced to 0.82%, and IL-1 β to 1.81%, compared to the elevated levels in LPS-treated control cells (29.28% and 94.89%, respectively). Furthermore, ULP-2 effectively downregulated IFN-y expression by 63%, while promoting a substantial 1.3-fold increase in IFN- α , indicating its potential to modulate both pro-inflammatory and antiviral responses. Enzyme inhibition assays further revealed the selective inhibitory activity of ULP-2 against cyclooxygenase-2 (COX-2) with an IC₅₀ value of 1.21 mg/ml, significantly higher than its inhibition of COX-1, underscoring its antiinflammatory properties. ULP-2 also demonstrated effective inhibition of 5-lipoxygenase (5-LOX), adding to its broad-spectrum anti-inflammatory potential. Nutritional analysis revealed that U. lactuca claims an impressive composition, containing approximately 2.65% lipids, 5.09% protein, and 58.06% carbohydrates, along with a cholesterol content of 2.53%. Its amino acid profile is noteworthy, featuring 57.32 g of essential amino acids, including high levels of phenylalanine and threonine, underscoring its balanced nutritional value. Structure-activity relationship studies highlighted the importance of the $(1 \rightarrow 4)$ -linked sulphated backbone and the presence of sulphate groups, which are crucial for binding interactions with cellular receptors. These interactions influence molecular orientation and initiate intracellular signalling pathways critical for modulating immune responses. Collectively, the findings suggest that LP-2 shows potential as a natural therapeutic agent for chronic inflammation and immune-related disorders due to its unique properties.

KEYWORDS: *Ulva lactuca*, Nutritional profile, Immunomodulatory, Inflammation, Therapeutic applications



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Current Status and The Way Forward for 'CIFA-GI Scampi®'— The Fast-Growing Strain of Giant River Prawn *Macrobrachium* rosenbergii Developed Through Selective Breeding in India

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A family-based selective breeding program of the giant prawn (Macrobrachium rosenbergii) to improve the growth rate was started in 2007 by ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneswar, India, in collaboration with WorldFish, Penang, Malaysia. After the completion of the partnership in 2013, ICAR-CIFA continued the selection program as an in-house project until 2021. Subsequently, the Department of Fisheries, Govt. of India supported the project under the Central Sector Scheme of Prime Minister Matsya Sampada Yojana from 2021 to 2024. The base population for selection was created using a full three-by-three diallel cross among three geographically distinct populations from Odisha, Kerala, and Gujarat in India. Selection for live weight at harvest was conducted for the first three generations using the BLUP (Best Linear Unbiased Prediction) methodology. From the fourth generation onward, the within-family selection was implemented. To date, 16 generations of selection have been completed, with selection responses ranging from 3.6% to 6.0% per generation. The improved strain was registered as 'CIFA-GI Scampi[®]' in 2020. Multi-location testing of 'CIFA-GI Scampi®' was conducted in Andhra Pradesh, Odisha, West Bengal (2021-2022 and 2022-2023), Telangana (2022-2023) and Assam (2023-24). In all locations, polyculture of Indian major carp and 'CIFA-GI Scampi[®]' was practised. In the South 24 Parganas district of West Bengal, 'CIFA-GI Scampi®' yields ranged from 1,012 to 1,200 kg/ha in seven months, with live weights ranging from 75 to 94 g after 216 days. In the Jagatsinghpur district of Odisha, yields ranged from 765 to 780 kg/ha, with live weights ranging from 75.5 to 76 g after 250 days. In the Kamrup district of Assam, the GI scampi yield ranged from 464 to 680 kg/ha with live weight ranging from 58 to 80 g in 185 days. These results demonstrate that 'CIFA-GI Scampi®' performs well across various agroclimatic regions. During 2021-22, ICAR-CIFA selected five multiplier scampi hatcheries and provided them with brood seeds of the latest generation for nationwide dissemination of 'CIFA-GI Scampi[®]. During 2023-24, these hatcheries produced 34 million seeds of CIFA-GI Scampi® that were distributed to farmers across India. The way forward for 'CIFA-GI Scampi[®] is the continuation (and strengthening if necessary) of the selection program and the inclusion of more traits such as survival and resilience. For greater impact, the establishment of more multiplier hatcheries for scaling up seed production and creating awareness about the potential of this improved strain in enhancing the farmers' income from freshwater fish in India will be essential.

KEYWORDS: Selective breeding, Genetic improvement, Giant prawn, CIFA-GI Scampi®



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Chromosome-Scale Genome Assembly for Siganus javus

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Siganus javus belonging to the family Siganidae, commonly known as java rabbit fish is found throughout the Indo-Pacific region. The java rabbit fish is one of the candidate brackishwater species where captive breeding is being standardized towards species diversification. The availability of genomic resources would facilitate a better understanding of complex biology which ultimately leads to the improvement of species. In this regard, it is planned to generate genomic and transcriptomic resources for Java rabbitfish. A specimen of S. javus was collected from the institute experimental station and the species identity was confirmed by using the sequence of the barcoding gene, Cytochrome c oxidase I. The genome size was estimated to be 587 Mb based on the flow cytometry principle and 471 Mb based on the k-mer analysis using short DNA sequence reads. Though both the methods provided varying estimates probably because of differences in the principle on which they operate, the estimates did indicate the sequence data requirements. About 147 Gb of long reads sequence data with N50 of 29 Kb was generated on the PacBio Sequel sequencer. Then wtdbg2 was used to generate a contig-level assembly which is of 563.9 Mb in 332 contigs with N50 of 12 Mb. For scaffolding, 495 million pairs of OmniC linked reads data were generated. The final assembly scaffolds derived using YaHS scaffolder with the evidence of OmniC reads have a length of 563.9 Mb in 210 scaffolds with N50 length of 23.94 Mb. Thereafter, de novo modelling of repeats using Repeat Modeler indicated that the genome has 16.63% repeat elements. About 98.62% of the assembly length is accounted in 24 scaffolds indicating the chromosome-scale nature of the genome assembly. The genome assembly was assessed to be 96.6% complete upon benchmarking with the BUSCO Actinopterygii odb10 dataset. The genome has also shown good synteny with the Siganus canaliculatus genome already available in the public domain. The genome would be annotated for protein-coding genes when RNA sequence data is available. The high-quality genome generated for Siganus javus would help in deciphering the phylogenetic relations and implementation of genetic improvement programs.

KEYWORDS: Chromosome, Genome assembly, Siganus javus



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Metagenomic Analysis Reveals Xenobiotic Degraders in Trans-Himalayan Brahmaputra River Sediments

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Xenobiotic pollutants are substantially increasing in riverine systems due to rapid urbanization and population expansion along the rivers having a severe impact on the ecosystem and human health. These pollutants are recalcitrant having toxic effects, and accumulate in the aquatic environment. Microbes possess the capacity to break down hazardous xenobiotics and transform into non-toxic or less hazardous substances. However, an efficient biodegradation process requires an in-depth knowledge of the microbial community and their metabolismrelated genes in the polluted niches. Functional metagenomics is a powerful approach for the identification of novel gene functions from uncultured microbial populations, serving as a complement to sequence-based metagenomics. In the present study, we employed whole metagenome sequencing to comprehend the xenobiotic degrading genes and their pathways from sediments of the trans-Himalayan River Brahmaputra, India. A large number of catabolic genes were mapped for xenobiotic degradation from 18 metagenome samples of the River across three seasons. The most prevalent xenobiotic degrading genes identified from all the sites were Caprolactam degradation, Geraniol degradation, polycyclic aromatic hydrocarbon degradation, Chlorocyclohexane and chlorobenzene degradation, toluene degradation, aminobenzoate and drug metabolism, respectively. Based on the functional analysis, different xenobiotic degrading enzymes and composite degradation pathways for aromatic compounds were identified in the riverine system. The taxonomic-based analysis identified maximum degrading genes to be related to the bacteria Pseudomonadota phylum. Seasonal variations among the xenobiotics degrading genes were observed at different sites, showing the highest abundance during the pre-monsoon season than in the monsoon and post-monsoon seasons. Moreover, the diversity indices for the pollutant degrading enzymes suggested little variations between the city and non-city riverine stretch indicating the impact of urbanization in the non-city stretch as well. This is the first report on the identification of xenobiotics degraders from the sediment metagenome of the Brahmaputra River, India. Overall, the study provides baseline information for carrying out further work on bioremediation applications and sustainable management of aquatic ecosystems.

KEYWORDS: Xenobiotics, Pollutant, Metagenomics, Microbial community, River ecosystem



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Modulation of Gut Metagenomics in *Labeo rohita* Fingerlings by Dietary *Terminalia arjuna* Bark Powder

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This study investigated the impact of *Terminalia arjuna* bark powder (TABP) on the gut metagenomics of Labeo rohita fingerlings. Four experimental diets with varying levels of TABP (0.0-CT, 5.00-T1, 10.00-T2, and 15.0-T3 g/kg feed) were formulated and fed to the fish in the pond and indoor feed trial. Gut metagenomics analysis using 16S rRNA gene sequencing (V3-V4 region) revealed a dominant presence of Aeromonadaceae (45-65% area) across all treatments. A comparative analysis of the bacterial community structure showed different patterns compared to individual analyses. However, a combined stacked diagram revealed a consistent pattern of variation in both the pond and feed trials. Notably, the T2 treatment showed a higher area of Aeromonadaceae in the pond trial compared to the feed trial. A dendrogram analysis revealed two main clusters in both the pond and feed trials, with the feed trial showing two sub-clusters within cluster two. The bootstrap values for the pond trial were 0.22 and 0.23, while the feed trial showed values of 0.24, 0.25, and 0.27 for the control (CT), T1, T2, and T3 treatments, respectively. The metagenomics data showed that TABP supplementation modulated the gut microbiota, increasing the relative abundance of beneficial bacteria such as *Lactobacillus* and *Bifidobacterium*, while reducing the abundance of pathogenic bacteria such as Vibrio and Pseudomonas. The alpha diversity metrics revealed a significant increase in microbial richness and evenness in the TABPsupplemented groups, indicating a more diverse and resilient gut microbiome. These findings suggest that TABP has a positive impact on the gut health of L. rohita fingerlings, potentially leading to improved growth performance, immune function, and disease resistance. Further studies are needed to elucidate the mechanisms underlying the effects of TABP on the gut microbiome and to explore its potential applications in aquaculture.

KEYWORDS: Terminalia arjuna bark powder, Gut metagenomics, Labeo rohita fingerlings

NRFC: An Authenticated Fish Cell Bank for Research, Resource Conservation and Cellular Agriculture

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Cellular agriculture has emerged as a promising technology to supplement and increase the production of agricultural products through in vitro techniques, like cell culture. Fish cell lines can potentially help in reducing fishing pressure on certain fish stocks, and create a safe and sustainable food industry through cell-based meat initiatives. Employing cell lines from endangered fish species for research can help replace its use in experiments where the specimen has to be disturbed or sacrificed, thereby, indirectly aiding in its conservation efforts. Characterized fish cell lines, especially muscle cell lines, are important resources for evaluating cell-based meat. One of the constraints for cell-based meat manufacturing is the availability of well-characterized cell lines for use in the production process. Even though over 950 fish cell lines have been reported globally, only a few can be accessed by researchers through depositories. National Repository of Fish Cell Lines (NRFC), a fish cell line bank, established in 2010 at ICAR-National Bureau of Fish Genetic Resources, has the world's largest collection of fish cell lines with 83 accessions, representing 39 fish species and 1 insect-shrimp hybrid cell line. Tissue-wise collection includes fin tissues (28 nos.), gill tissues (10), heart (7), eye (6), spleen (5), caudal peduncle (4), kidney (4), muscle (4), brain (4), thymus (4), liver (2), testes (1), peritoneal (1), blood lymphocytes (1), barbels (1) and lymphoid tissue (1). NRFC has provided significant input to several programs, like India's National Surveillance Programme on Aquatic Animal Disease (NSPAAD), to tackle the threat of aquatic diseases. It also enabled the first report of Cyprinid herpes virus-2 in goldfish in India. Cell lines from NRFC have been used to study viral susceptibility of several viruses, like viral nervous necrosis virus, cyprinid herpes viral haematopoietic necrosis virus, tilapia lake virus, red sea bream iridovirus, etc. and to assess cytotoxic effects of numerous heavy metals and pesticides. Cell line depositories, like NRFC, can support various in vitro research and applications like disease diagnosis, cellular agriculture, toxicity, etc.

KEYWORDS: Biobanking, Cell line, Cell-based meat, Fish, NRFC, Toxicity, Virology

Whole Genome Sequencing of Selectively Bred Giant Freshwater Prawn, *Macrobrachium rosenbergii*

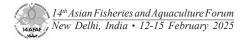
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The freshwater prawn Macrobrachium rosenbergii, commonly known as Giant Prawn (GP) is widely cultured in several tropical and subtropical countries. Worldwide production value of M. rosenbergii in 2022 is over US\$ 2.456 billion. Apart from China (the top producer); Bangladesh, Thailand, Myanmar, and India are the other major producers of this species. However, the production of GP in India declined after 2005 till 2012. Slow growth rate, disease outbreak and mortality during grow out culture are the important factors for poor production causing loss to the farming community. Seed being the single most important input for culture, selective breeding program of M. rosenbergii was initiated in 2007 at ICAR-Central Institute Freshwater Aquaculture, Bhubaneswar in collaboration with WorldFish, Malaysia. The present selection program is based on the conventional breeding protocol. Integration of genomic resources in the form of genome wide marker panel, linkage map, OTL and high throughput genotyping platforms increases the speed and accuracy of genetic gain through marker assisted selection and genomic selection. To accelerate development of genomic resources, the genome of selectively bred M. rosenbergii was sequenced. Multiplatform sequencing of a female M. rosenbergii taken from the 14th generation of ongoing selective breeding program resulted in 352 GB of Illumina short read (16 different libraries) and 170 GB of PacBio HiFi reads (6 SMRT cells) sequence data. Removal of adaptor contamination and other QC filtering resulted in 15,495,729 of clean HiFi reads. The program WTDBG assembler (V 2.5) was used to assemble the clean HiFi reads generating 23010 contigs. The N₅₀ value, largest contig size and GC% were observed to be 1.03 Mb, 14.246 Mb and 36.49%, respectively. The genome size was derived to be 4.63 Gb which is larger than the size reported in other studies. Evaluation of completeness of the assembled genome using BUSCO revealed 94.5% complete and single copy, 0.8% complete and duplicated, 2.1% fragmented and 2.6% missing genes. Assembling the genome using other long read assemblers is in progress. The draft genome of M. rosenbergii will accelerate development of a strain with commercially important traits through marker assisted selection and/or genomic selection.

KEYWORDS: Macrobrachium rosenbergii, Genome sequencing, Draft genome, Prawn



De Novo Transcriptome Profiling of Indian Oil Sardine, *Sardinella longiceps* Using Next Generation Sequencing Technology to Identify Genes Involved in PUFA Biosynthesis

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Indian oil sardine, Sardinella longiceps is an important fishery resource of the Indian subcontinent. They are also ecologically important as they function as an important link in the trophic chain as a planktivore is being preyed upon by larger predators. Indian oil sardine is an important model organism to investigate specific gene repertoire responding to climatic and environmental fluctuations as they respond to environmental fluctuations with localized extinction and recolonization. We performed the De novo transcriptome analysis of different tissues of S. longiceps to develop genomic resources for further investigations on climatic resilience and PUFA biosynthesis. Muscle, gonad, gill and heart tissues of S. longiceps were dissected out and total RNA from each tissue was extracted using Trizol reagent (Invitrogen) and treated with DNase I to remove genomic DNA. The integrity of the sample was confirmed with a Bioanalyzer (Agilent 2100) and RNA extracted from all tissues was pooled in equimolar concentration. RNA library preparation was performed with NEBNext Poly(A)mRNA magnetic isolation module kit (NEB) and NEBNext Ultra RNA library preparation kit (NEB) following the manufacturer's protocol and sequenced using Illumina HiSeq 2500 paired-end 150 base pair cycle. A total of 21Gb data was generated and used for subsequent annotation of transcripts and genome. The total number of assembled transcripts was 95,426, and 75,933 of them were retained after CD-HIT-EST clustering (removing redundant transcripts). The contig N50 was 1937 bp and the longest transcript consisted of 20695. The GC % of the transcripts was 46.76%. 3519 transcripts were assigned with biological processes, 1859 transcripts with molecular function and 751 transcripts with cellular components. The core genes for omega-3 PUFA biosynthesis, such as Elovl 1a and 1b, Elovl 2, Elovl 4a and 4b, Elovl 8a and 8b, and Fads 2, were observed in Sardinella longiceps. The presence of these genes may indicate the PUFA biosynthetic capability of Indian oil sardine, which needs to be confirmed functionally.

KEYWORDS: Indian oil sardine, Sardinella longiceps, PUFA biosynthesis, Transcriptome profiling

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Effect of Genetic and Non-Genetic Factors on Growth and Carcass Quality Trait in Jayanti Rohu Strain

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The Jayanti rohu is a genetically improved strain of rohu developed through selective breeding by the ICAR-Central Institute of Freshwater Aquaculture in India. The information on factors affecting growth and carcass quality traits is important for the accurate estimation of genetic parameters in any selection program. The current study is about the effect of genetic and non-genetic factors on the growth and carcass quality trait of Jayanti rohu from 994 animals belonging to 35 full-sib families of 2020 year class (12th generation) after twelve months of communal pond rearing. The fish growth traits such as body weight at tagging (BW1), body weight at sampling (BW2) and body weight at harvest (BW3), total length at tagging (TL1), total length at sampling (TL2) and total length at harvest (TL3), were recorded from 994 animals; and 368 animals from all families were sacrificed at harvest to measure the carcass weight (CW), head weight (HW), fin weight (FW), scale weight (SW) and viscera weight (VW). The Javanti rohu attained an average body weight of 1010±176 g and 42.8±2.6 cm TL at harvest. The effect of the family for both growth and carcass quality traits at the time of tagging, sampling and harvest was significant (p<0.01), with between family variation higher compared to within family variation. The sex has no significant effect on BW1, TL1 and FW (p>0.01), but it has a significant effect on BW2, BW3, TL2, TL3, CW, HW, SW, and VW. The females have 9.6% higher body weight and 10% higher carcass weight at harvest compared to male. The effect of pond and interaction of pond by sex was not significant on all traits measured at sampling and final harvest (p>0.01). The BW3 and CW showed a coefficient of variation (CV) of 17.48 and 17.70 respectively. The CV for HW, VW, SV, FW and TL3 was 16.69, 23.73, 21.19, 20.34 and 6.18 respectively. The phenotypic correlation of BW3 with TL3 (0.86), and CW (0.99) was very high and significant (p<0.01). The findings of the present study demonstrate the family-wise and sex-wise variation in growth and carcass traits of Jayanti rohu and show potential for further genetic improvement in the traits studied.

KEYWORDS: Jayanti rohu, Genetic and non-genetic factors, Growth and carcass trait

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Gene Editing of Myostatin and Gonadotropin-Inhibitory Hormone in Model Zebrafish and Farmed Rohu Carp, *Labeo rohita*

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Understanding the molecular mechanisms linked with growth, disease resistance and reproduction is essential in farmed rohu carp, Labeo rohita. Myostatin, being a member of a large TGF-beta family, acts as a negative regulator of muscle growth. The information on the negative regulators, such as gonadotropin-inhibitory hormone (GnIH), in the process of gonadal development and maturation in teleosts, is limited. It is expected that GnIH inhibition by gene editing may lead to early gonadal maturation. We intend to develop myostatin and GnIH edited (CRISPR/Cas9) rohu and zebrafish to understand their essential physiological functions. A gRNA of 20 bases targeting exon I of zebrafish GnIH gene successfully enforced mutagenesis (about 90%), and mutated F1 was raised. The mutation in F1 was validated through bidirectional sequencing. The findings indicated a deletion of 7 base pairs (bp) leading to a frameshift mutation, as well as an in-frame mutation comprising 21 bp lacking 7 aa in the signal peptide motif. The same gRNA was employed to create founder stock in farmed rohu (F0) due to their shared homology. Further HRM analysis revealed a successful incorporation of mutations in 90% of embryos. To delineate the independent roles of myostatin a and myostatin b, several gRNA constructs of myostatin a or myostatin b were microinjected in zebrafish and rohu. The founder stocks displaying about 90% mutant zebrafish and rohu carp were successfully raised. The detailed editing data and implications will be presented.

KEYWORDS: Myostatin a, Myostatin b, GnIH, CRISPR/CAS9, Muscle Growth

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Conotoxin Discovery in *Conus inscriptus* Reeve, 1843 (Engraved Cone) Through Transcriptome Profiling

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Cone snails are candidate organisms for biomedical applications due to the presence of conotoxins. The vermivorous Conus inscriptus (engraved cone) is commonly distributed in Indian waters. Despite the potential for biomedical applications, no study has been done so far in C. inscriptus to identify conotoxin through a transcriptomic approach. Here, the present study generated the first transcriptomic datasets for C. inscriptus to address the knowledge gap. The transcriptomes of venom ducts and venom bulbs from C. inscriptus in triplicate were sequenced using next-generation sequencing technology using the Illumina Novaseq 6000 platform. A total of 105.6 million 150 bp paired-end reads were generated. After removing adapter sequences and low-quality reads, transcriptome assembly was constructed using Trinity. A total of 259,828 contigs were generated with a total transcriptome size of 297.2 million bp, average transcript length of 1143.95 bp and transcript N50 of 1604 bp. The transcripts were further processed for unigenes prediction using the CD-HIT package. CDS prediction using Transdecoder yielded 75366 transcripts, and identified 33702, 13327, 21706 and 14637 positive BLASTP matches against four different databases NCBI -NR, Pfam, Uniprot and KOG, respectively. Orthologue assignment and mapping of CDS to the biological pathways were performed using the KEGG automatic annotation server (KAAS). SSR were identified in CDS sequences of each sample with the MISA Perl script. Further analysis with Conodictor 2.0 yielded a total of 6066 unigenes of which 1046 are unknown conotoxins and the rest belongs to 23 superfamilies. This study will greatly improve our understanding of the diversity of conotoxins. The novel conotoxins identified in this research present valuable opportunities for the development of pharmacological applications and marine peptide therapeutics.

KEYWORDS: Conus inscriptus, Venom duct, Venom bulb, Conotoxins

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RNA-Guided Recombinase (RGR) Platform-Mediated Targeted Transgenesis of EGFP Reporter Gene in Zebrafish

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Pathway activity reporter animals harbor multiple permissive loci and allow the generalized and regulated expressions of several reporter genes which are essential for the studies of complex biological phenomena. The present study was conducted to carry out RNA-guided recombinase (RGR) platform, a platform carrying out targeted transgenesis-mediated targeted transgenesis of EGFP reporter gene into one of such putative 'permissive locus', zebrafish Enah-Srp9 intergenic regions. For this, RGR platform components were microinjected into the cytoplasm of two to eight-cell stage zebrafish embryos with 10 - 15 nl microinjection solution containing 60 pg of RGR expression plasmid, 20 pg of donor DNA, and 20 pg of gRNA expression plasmid per 10 nl microinjection solution. This microinjection resulted in post-microinjection embryo hatchability of 47.5% and larval survival of 65%. Further, subsequently developed zebrafish larvae were screened for specific EGFP reporter gene expression. Through this, an efficient level of transgenesis of 46.8% was obtained. Variegated, however consistent transgene expression pattern of caudal fin > trunk > caudal peduncle, abdomen > head was observed in this, which suggested that transgene integration happened at the same locus throughout the microinjections while expression of the transgene had some position effect. Further characterization of the recombination junctions with targeted PCR, however, resulted in weak or no amplifications. This may be attributed to the nonavailability of a specific template for PCR assays because of reasons including, but not limited to, the presence of mosaicism. Overall results of the study revealed efficient RGR platform-mediated targeted transgenesis at the Enah-Srp9-1 site of the zebrafish genome, and the transgene expression there had some position effect. However, the characterization of recombination junctions formed through this and an understanding of the detailed basis of the observed position effect on transgene expression need further studies.

KEYWORDS: RNA-Guided recombinase, Reporter gene, Zebrafish

Profiling of DNA Methylation Patterns in Genetically Selected *Clarias magur* (Hamilton, 1822)

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Clarias magur, a valuable food fish with high market demand, faces challenges in aquaculture due to slow growth, limited seed availability, and low survival rates. To address these issues, a selective breeding program at ICAR-CIFE, Mumbai, aims to enhance growth traits and provide better broodstock for sustainable and profitable farming. This study explores the role of DNA methylation, an epigenetic factor, in shaping growth traits, potentially influencing the success of breeding efforts. Using reduced representation bisulfite sequencing (RRBS), the study analyzed DNA methylation patterns in genetically selected Clarias magur stocks. RRBS produced 249.22 million reads, identifying an average of 490,120 methylation sites across exonic, intronic, and intergenic regions. A total of 896 differentially methylated regions (DMRs) were found, with 356 hyper-methylated and 540 hypo-methylated regions. The DMRs were associated with overlapping genes in 205 exonic, 210 intronic, and 480 intergenic regions. The study further revealed that the genes linked to these DMRs are enriched in biological processes such as response to growth factors, nervous system development, neurogenesis, and anatomical structure morphogenesis. These findings highlight key epigenetic mechanisms that may regulate growth performance in Clarias magur. This provides valuable epigenetic data that could be integrated into breeding programs to select high-performing individuals, contributing to improved seed production and sustainable magur aquaculture.

KEYWORDS: Epigenetics, Reduced representation bisulfite sequencing (RRBS), Differentially methylated regions (DMRs)

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Development of Primary Cell Cultures from the Fin, Brain and Heart of Whiptail Silver Biddy, *Gerres filamentosus* (Cuvier, 1892)

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Primary cell cultures and cell lines are essential and indispensable tools for applications like virus isolation and propagation and toxicological studies. Whiptail silver biddy, Gerres filamentosus is one of the important minor commercial fish species which contributes to local fisheries. In the present study primary cell cultures were developed from the fin and heart by explant culture method and from the brain by enzymatic dissociation method using collagenase type IV. The primary cell cultures of the fin, brain and heart were sub-cultured for 16, 14 and 13 times respectively, in Leibovitz L-15 medium with 20% Fetal Bovine Serum (FBS) containing 2% NaCl at 28°C. All three primary cultures required a minimum NaCl concentration of 2% for optimal growth, while slow or no growth was observed at 0% and 4% NaCl concentrations. The primary cultures were cryopreserved in LN, at different subcultures for different periods and recovered with 70-85%. The authentication of the origin of the primary cell cultures was done by PCR using primer pairs specific to the mitochondrial COI of the species. The primary cell cultures of the G. filamentosus fin, brain and heart were designated as Gerres filamentosus fin (GFF), Gerres filamentosus brain (GFB) and Gerres filamentosus heart (GFH). In conclusion, this is the first study which develops primary cell cultures from G. filamentosus fish species and these three primary cultures could be useful for viral propagation and toxicological studies on microplastics.

KEYWORDS: Explant, Enzymatic dissociation, Primary cell culture

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Expression Profiling of *GnIH* and Its Receptors after Hormone Injections in *Clarias magur*

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Gonadotropin-inhibitory hormone (GnIH) is the hypothalamic decapeptide whose main function is to inhibit the secretion of gonadotropin secreted from the pituitary with the help of GnIH receptor (GnIHR). The role of GnIH and its receptor in the reproduction of various vertebrates is known but in teleosts, it is still a controversy. To demonstrate the presence of this system, a study was conducted in the *Clarias magur*. In this study, a brain tissue sample was used to characterize GnIH and GnIHR. A full GnIH sequence of ORF region 615 bp and a partial GnIHR sequence length of 881 bp were amplified. Three putative peptides of GnIH i.e. GnIH I, GnIH II, and GnIH III, and five transmembranes of G couple receptor i.e. TMD, TMD, TMD, TMD, and TMD, respectively were predicted from the sequence. The synthetic hormone sGnRH (ovatide) initially downregulates the expression of GnIH after 8 hours post-injection. However, after 16 hours, there is an upregulation, suggesting a possible role in the stimulation of reproductive hormones. In both male and female gonads, GnIH expression gradually decreases over time. In contrast, in the pituitary, there is an upregulation of the precursor after 32 hours, while GnIHR exhibits an opposite expression pattern. Thus the presence of GnIH and GnIHR in the gonads gives an idea that both play a major role in the negative and positive regulation of reproduction in C. magur. The expression of both suggests that GnIH might control the secretion of GnRH negatively but in the gonad, GnIH and GnIHR were involved in the autocrine and paracrine regulation of steroid production, germ cell differentiation, and steroidogenesis. More robust and detailed studies on these aspects will be necessary to clarify the role of this neuropeptide in the gonads.

KEYWORDS: Gnih, GnIHR, Transmembranes, Putative peptides, Signal peptide, *Clarias magur*, **Reproduction**

Influence of Temperature on Expression Profile of Sex-Differentiation Related Genes at Early Developmental Stages of an Endangered Cyprinid *Tor putitora* (Hamilton, 1822)

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The golden mahseer, Tor putitora, is an important food and sports fish species of the Himalayan region. It is also distributed in the Southeast Asian region. The species is vulnerable to diverse pressures and therefore declared endangered. It is also reported with a skewed sex ratio in the wild that might be a response to environmental stress, as temperature plays an important role in sex determination and is also identified as an important factor in determining sex ratios in many other species of fishes, amphibians, and reptiles. Therefore, to understand the effect of temperature on the expression profile of different sex-differentiation-related genes such as amh, cyp19a and cyp19b during the early developmental stages in this species, the larvae of golden mahseer at 25 dph (days posthatching) were initially acclimatized at 22°C (control group). Three temperature treatments (T₁=26°C; T₂=30°C; and T3=34°C) were given up to 100 dph. Expression profiles of amh, cyp19a and cyp19b were determined by qRT-PCR in the age group of 50dph and 100 dph. No significant differences (p>0.05) were found in the expression level of amh between different temperature treatment groups at examined age groups that indicated no testicular development. The mRNA expression profile of cyp19a and cyp19b showed no significant difference (p>0.05) between different temperature treatments in the age group of 50 dph; however, a significant difference was observed at T, and T, compared to the control (22°C) in the age group of 100 dph that indicated initiation of ovarian differentiation. The expression pattern of these genes provided important clues of sex differentiation in this species. Nondetection of amh indicated undifferentiated gonads that usually show low levels of amh expression in both prospective sexes of teleost fish. However, the relationship between amh expression and gonad development in teleost fish is still unclear. Early detection of cy19a and cvp19b indicated the onset of ovarian differentiation. In a few of the teleost, the gonad first differentiates into a female sex organ and then transforms either into a male or continues to be a female organ. In the present study, it was found that temperature influences the developmental stages, which was elucidated by the expression of cyp19a and cyp19b genes. However, further study is required to ascertain the fact at higher developmental stages. The present study provides insight into the sex differentiation in this species and the role of temperature which are highly relevant under the climate change scenario.

KEYWORDS: Temperature, Expression Profile, Sex-Differentiation, *Tor putitora*



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Draft Genome Assembly and Comparative Phylogenomics of *Labeo* fimbriatus

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This study aims to generate a high-quality draft genome and develop associated genomic resources for *Labeo fimbriatus*. The estimated genome size is approximately 625 Mb, with sequencing carried out using Illumina NovaSeq short-read technology. To ensure comprehensive coverage and reduce bias, three DNA libraries were prepared using distinct methodologies: mechanical shearing (Illumina TruSeq PCR-Free) and enzymatic shearing (QIAseq FX DNA Library Kit and Illumina DNA Prep Kit). Sequencing yielded 94.58 million reads from the enzymatic shearing and PCR amplification (Illumina DNA Prep), 37.3 million reads from mechanical shearing (Illumina TruSeq PCR-Free), and 71.98 million reads from enzymatic shearing (QIAseq FX). These combined results generated a total of 50.97 Gb of sequence data, achieving an 81.54x coverage for the 625 Mb genome. The lower read count in the TruSeq libraries is attributed to the absence of PCR amplification and the mechanical shearing process, which, while providing high accuracy, typically results in fewer reads. The average sequence quality was high, with Phred scores clustering around Q35–Q36, indicating a very low error probability (1 in 3,162 to 1 in 3,981 bases). The genome assembly produced a total length of 961.59 million base pairs, with an N50 value of 17,255 bp. The assembly included 142,903 contigs, one of which represents the complete mitochondrial genome, spanning 16,451 bp and encoding 13 genes, 2 rRNAs, and 22 tRNAs. Phylogenetic analysis confirmed a close relationship between Labeo fimbriatus and Labeo rohita. This study further explores genome annotation, marker distribution, and the comparative phylogenetics within the genus *Labeo*.

KEYWORDS: Minor carp, Genomics, Markers, Phylogenetics, Genome annotation

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Omics in Fisheries - A Story About Epigenomics and Metagenomics in Aquatic Species and Ecosystem Health Management

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Omics technology is an umbrella term used for modern techniques that have the potential to unravel novel mechanisms in biological science. Different omics platforms have been used in several applications in the fisheries and aquaculture sector, such as growth, reproduction, disease, and health management. Epigenomics studies epigenetic changes, or modifications to a cell's genetic material that do not alter the DNA sequence. While metagenomics is used to determine communities of microbial organisms and their genomes directly in their natural environments and offers tremendous potential to explore microbial community dynamics in aquatic ecosystems. The study highlighted the role of epigenomics and metagenomics in fisheries and aquaculture management. In the first experiment, brine shrimp exposed to different stimuli, such as pathogens (viable or inactivated Vibrios) or heat shock proteininducing immune elicitor phloroglucinol, exhibited a faster and enhanced response, which might lead to protection against pathogens and abiotic stress. Most interestingly, the induced resistance phenotype could even be passed on to the next generation of progenies, a phenomenon broadly called transgenerational transfer of an acquired phenotype (TTAP). Furthermore, the incidence of TTAP was validated in economically important species of giant freshwater prawn, Macrobrachium rosenbergii. This has great relevance in aquaculture for shrimp health management and tremendous practical application as a novel strategy for preventing infectious diseases in shrimps/prawns. Epigenetic reprogramming (DNA methylation and histone modifications) and cellular metabolism were found to be involved as the mechanistic bases for the heritability of the phenotype of robust resistance and immune gene transcription. In another experiment, the microbiome was studied using metagenomic characterization in the east Kolkata wetland, natural wastewater treatment, and a Ramsar site of international importance. The study unveiled the microbiome landscape regarding taxonomic abundance, bioremediation potential of beneficial microbes, antibiotic resistance genes, and potential plastic-degrading microbes/enzymes, providing the microbial functional role in the aquatic system. In conclusion, this study proves that omics technology could be vital for aquatic species and ecosystem health management.

KEYWORDS: OMICs, Epigenomics, Metagenomics, Brine shrimp, Giant freshwater prawn, East-Kolkata wetland



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CpG Methylation Alteration in Selected Genes and Its Effect on Colouration in Zebra Fish Response to Natural DNMT Inhibitor Curcumin and Grape Seed Extract

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The present study aimed to identify the role of DNA methylation at CpG island of selected colouration genes (tyr, sox9, pax3 and dct) in the pigmentation of model zebrafish. Curcumin, a natural DNMT inhibitor and Grape seed extract (GSE, a dietary supplement for pigmentation) were incorporated into the control diet at different levels and combinations. Fishes were fed with treatments and a control diet for 45 days and its effect on methylation at CpG island of the selected genes and colouration were recorded quantitively. The same attributes were re-recorded after all the groups were fed over the control diet for 25 days. Our results showed that curcumin affects methylation at CpG island differently in different genes and a more profound effect was observed when supplemented along with GSE. Changes in methylation at CpG of the colouration genes were corroborated with changes in colouration. The study also depicts, methylation changes at CpG island brought by curcumin (at 2% level) and the same as colouration, retained for a long time after the withdrawal of treatment diets. This study depicts that DNA methylation significantly alters colouration and suggests that combinatorial supplementation of dietary DNMT inhibitors and pigment enhancers can potentially enhance pigmentation and retain the acquired pigmentation for considerably longer. Such knowledge about the underlying mechanisms that collectively govern the vivid display of colours in fishes is fascinating and encouraging for the ornamental fish industry since it would provide new gateways for introducing modifications in this trait.

KEYWORDS: CpG island, Curcumin, DNA methylation, Ornamental fish, Pigmentation

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Deciphering Biomineralization Genes and Associated Markers through Transcriptome Analysis of the Freshwater Pearl Mussel Lamellidens marginalis

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India is home to approximately 50 native freshwater mussel species, with Lamellidens marginalis playing a pivotal role in pearl production. Despite its economic and medicinal significance, efforts to enhance pearl quality through selective breeding or genomic studies in L. marginalis have been limited. This study addresses this gap by identifying key biomineralization genes and genetic markers that can facilitate selective breeding for improved pearl quality. A total of 250 L. marginalis individuals were reared at a freshwater farm, with 200 mussels implanted with nuclei in the mantle and 50 in the gonadal region. Two RNA-seq datasets were generated: RNA-Seq1 from nacre-secreting mantle tissue after six months, and RNA-Seq2 from mantle tissue after 12 months of pearl formation. RNA-Seq1 was used to identify unigenes and key genes involved in the biomineralization process, while RNA-Seq2 helped to uncover differentially expressed genes (DEGs) and single nucleotide polymorphisms (SNPs) associated with pearl quality. Several important biomineralizationrelated genes, such as *calreticulin*, *calmodulin*, *chitin synthase*, and *Pif*, were identified, highlighting their roles in calcium biosynthesis, chitin biosynthesis, and nacre formation critical processes for pearl development. High-quality pearl-producing individuals exhibited significant upregulation of genes such as silkmaxin, perlucin, and tyrosinase, while SNP mining revealed 52,743 SNPs, with 3,161 located in DEGs. Key SNPs in biomineralizationrelated genes such as silkmaxin, tyrosinase, and carbonic anhydrase were validated using High-Resolution Melting (HRM) analysis and Sanger sequencing, confirming their roles in pearl formation and gene regulation. Functional annotation of the RNA-seq data identified crucial domains, including the immunoglobulin-like and zinc-finger domains, suggesting important roles in protein binding and signal transduction. Gene ontology (GO) analysis further highlighted essential cellular processes such as metal ion regulation, chitin binding, and calcium ion regulation, all of which contribute to high-quality pearl formation. This study establishes a genetic framework for improving pearl quality in L. marginalis.

KEYWORDS: Pearl quality, RNA-seq, SNP analysis, Nacre formation



Global Gene Expression Profiles of *Catla catla* Brain Induced by Low Temperature

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Indian major carps are crucial to freshwater aquaculture in India, with Catla catla (Hamilton) being one of the fastest-growing species and experiencing increasing market demand. Temperature plays a significant role in various biological processes, including growth, disease resistance, metabolism, reproduction etc. Catla is a eurythermic species growing best between 25 and 32°C. In this study, the gene expression profiles of C. catla brain tissues at two different temperatures, 20°C (experimental) and 30°C (control), over a 45days period, after acclimatization, were investigated. Comparative transcriptomic analysis revealed 8,607 differentially expressed genes (DEGs), with 5,664 upregulated and 2,943 downregulated at 20°C, as compared to 30°C. Functional characterization of DEGs identified a total of 172 Gene Ontology (GO) terms, out of which 58 were under biological processes with chromatin remodelling (GO:0006338), chromatin organization (GO:0006325), lipid metabolic process (GO:0006629). Under cellular components, 29 terms (FDR<0.25) with the cytoplasm (GO:0005737), cytoskeleton (GO:0005856), synapse (GO:0045202) were most significant. A total of 47 terms (FDR<0.25) were under molecular function, most significant ones were kinase activity GO:0016301, transferase activity GO:0016740, nucleotide binding GO:0000166. Further, molecular pathway analysis of these DEGs were categorized into several functional areas. The most significant pathways observed were the Phosphatidylinositol signalling system, ErbB signalling pathway, and Mitogen-activated protein kinase (MAPK) signalling pathways. The phosphatidylinositol signalling system plays a critical role in brain function, including neuronal growth, development, and connectivity, while the ErbB signalling pathway, which involves the binding of ErbB members to signal transducers, plays a key role in brain function. MAPK signalling pathways are intracellular signalling pathways that regulate a variety of physiological processes in the brain, including neurodevelopment and regulate blood-brain barrier integrity and neuroinflammation. Thus, these results provide valuable insights into the molecular mechanisms and pathways regulating temperature responses in *C. catla* brain and strategies to cope with cold stress.

KEYWORDS: RNA-seq, Gene expression, Low temperature, Signalling pathways

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Nano Conjugated Kisspeptin for Enhancing Reproductive Output in Labeo catla

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Kisspeptins, a member of the RFamide peptide family, have emerged as potent upstream regulators of the reproductive Hybothalamic-Pituitary-Gonad (HPG) axis of vertebrates, including teleosts. Kisspeptin acts through the Kisspeptin receptor (G protein-coupled receptor GPR54), primarily expressed by preoptic and hypothalamic GnRH neurons. These GnRH neurons regulate the synthesis and secretion of pituitary gonadotropins (GtHs), follicle stimulating hormone (FSH) and luteinizing hormone (LH). Pituitary GtHs, in turn, stimulate the production of sex steroids, which are responsible for the progression of gonadal growth and maturation. This makes Kisspeptin a key modulator that helps maintain reproductive function. Because of possessing such roles, Kisspeptin was used for enhancing gonadal development in Labeo catla. L. catla is a commercially important species but matures late compared to other IMCs which costs hatchery managers more for broodstock development of the species. To address this issue, inducing spawning in captivity using maturation-inducing neuropeptides/hormones could offer a promising solution. These compounds stimulate the release of crucial gonadotropic hormones (GtHs), facilitating gonad development, vitellogenesis, final oocyte maturation in females, and spermiation in males. So in this study, Kisspeptin was used for enhancing gonadal development for reducing age at sexual maturity. Kisspeptin was administered after conjugating with nanoparticles which resulted in enhanced gonadal growth compared to the control group. Further, there was a significant increase in the reproductive output of fish when administered GnRH along with nanoconjugated Kisspeptin. This is due to nanoparticle-based conjugation which protects the peptide from degradation, facilitates controlled release and sustained hormonal surge in the body. This innovative approach holds promise for improving broodstock management and breeding success in aquaculture.

KEYWORDS: Kisspeptin, Nanoparticle, Gonadal development, Reproduction, Labeo catla

Purification of HSP70 from Rohu, *Labeo rohita* and Development of Rabbit Polyclonal Antibody for its Detection

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Fish are exposed to many biotic and abiotic stressors in the wild as well as in captivity. One of the most common features of the stress response in fish is the production of heat shock proteins (HSPs), which help in maintaining the protein integrity and function. The 70 kD heat shock proteins (HSP70s) are a protein family known as molecular chaperones that bind to the protein substrates and stabilize them against denaturation or aggregation. The level of HSP70 increases in fish tissues in response to a variety of environmental and biological stressors. Hence, the detection and quantification of HSP70 have been indicated as markers of stress exposure. In the present study, attempts were made to purify HSP70 from rohu, Labeo rohita using affinity chromatography on ADP-agarose. Rohu juveniles were exposed to heat stress at a temperature of 36°C for 5 h and skin tissue samples were collected. The samples were homogenized in the presence of protease inhibitors, filtered through a 0.45 um filter and passed through an ADP-agarose column. After thorough washing, the bound HSP70 was eluted from the column with a buffer containing ADP. The eluted protein sample was concentrated by freeze-drying. The sample was run in an SDS-PAGE gel that showed a single band of 70 kD size. Further, the protein was transferred to nitrocellulose paper in western blot and developed with a mouse monoclonal anti-HSP70 (bovine) antibody that showed a single band of approximately 70 kD. The purified HSP70 was then used to immunize a rabbit for the development of polyclonal antibody. The developed antibody also showed its specific reactivity with HSP70 in the western blot of tissue samples. Thus, this antibody may find applications in detecting the HSP70 protein in blood and various tissues concerning stressors on rohu.

KEYWORDS: Labeo rohita, HSP70, ADP-agarose

Gene Delivery into Fish Cells via Polymer-Based Nanoparticles

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The delivery of nucleic acids or genes into cells through non-viral methods has emerged as a crucial technique in various domains of cell and molecular biology since its inception. Notably, the transfection of cells with plasmids that harbor a gene of interest alongside a reporter gene, such as green fluorescent protein (GFP), has become an essential approach for exploring gene expression, as well as the dynamics of protein trafficking and localization within the cellular environment. However, delivering genes into fish cells poses considerable challenges in comparison to mammalian cells, primarily due to the rigidity of their cell membranes. In this investigation, we evaluated the gene delivery efficacy of a polymer, hexadimethrine bromide, in fish cells. Initially, we examined the interaction between the polymer and DNA to identify the optimal polymer-to-plasmid DNA (pDNA) ratio for in vitro transfection. The results indicated that the cationic polymer effectively interacted with plasmid DNA at a ratio of 1:2 (plasmid: polymer, w/w) and above. Furthermore, the polymer was shown to form nanoparticles with pDNA, as demonstrated by electron microscopy. Subsequent transfection experiments using the polymer alongside the GFP gene confirmed the polymer's ability to transport the GFP gene, as evidenced by the expression of green fluorescent protein inside fish cells.

KEYWORDS: Transfection, GFP gene, Fish cells

Comparative Profiling of Intestinal Bacterial Communities in Indian Major Carp (*Labeo catla*) and Stripped Murrel (*Channa striata*) Under Rearing Conditions: A Case Study

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Intestinal microbial communities play a fundamental role in the health, growth, and metabolism of fish, making their composition critical for aquaculture practices. While extensive research has been conducted on the gut microbiota of Indian major carp (IMC, Labeo catla) and snakehead mudfish (SMF, Channa striata) in artificial culture systems, comparative analyses between these species remain underexplored. Channa striata, commonly known as striped murrel, is prized for its nutritional benefits, including antimicrobial, antioxidant, anti-obesity, and anti-inflammatory properties, primarily due to its rich fatty acid content. On the other hand, Labeo catla plays a significant role in Indian poly-culture systems, owing to its rapid growth, substantial size, excellent meat quality, and high market demand. In this study, we aimed to characterize and compare the gut bacterial diversity, abundance, and functional profiles of IMC and SMF using high-throughput 16S rRNA gene amplicon sequencing. Our results indicated that IMC exhibited significantly higher species richness compared to SMF, while SMF showed higher Shannon and Simpson diversity indices, reflecting greater microbial evenness. The gut microbiota of SMF was predominantly composed of *Proteobacteria*, followed by *Firmicutes* and *Cyanobacteria*, whereas IMC's microbiota was dominated by Firmicutes, Fusobacteria, and Bacteroidetes. At the species level, Fusobacterium mortiferum, Clostridium botulinum, Paeniclostridium sordellii, and Microcystis aeruginosa were abundant in IMC; while Cetobacterium somerae, Photobacterium damselae, Prevotella copri, Clostridium perfringens, Methylobacterium organophilum, and Pseudomonas stutzeri were dominant in SMF. These findings highlight significant differences in the gut bacterial communities between Labeo catla and Channa striata, with specific taxa linked to nutrient metabolism, immune function, and gut health. This study provides valuable insights into species-specific gut microbiota, offering opportunities to develop tailored dietary and management strategies to enhance fish health and optimize aquaculture productivity in freshwater aquaculture. Understanding these microbial dynamics is essential for improving sustainable aquaculture practices.

Keywords: Gut microbiome, Labeo catla, Channa striata, High-throughput sequencing, Aquaculture



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Effect of GABAergic Modulation on the Key Reproductive Genes of the Brain and Gonads in *Clarias magur* (Hamilton, 1822)

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The Indian catfish, Clarias magur struggles with captive breeding due to unsuccessful spontaneous milt release in males. Recent transcriptome analysis by Fish Genetics and Biotechnology Division, Central Institute of Fisheries Education, revealed that despite the LH surge post-GnRH inducement, neuro-endocrine factors like GABA, altered T:11-KT ratio, testicular bile acids, and sevatocin-neurophysin inhibit milt release. This study examined the effects of GABAergic modulation on reproductive enzymes and hormones in Clarias magur. The GABAergic modulators, bicuculine, and muscimol, have shown different effects (agonistic/ antagonistic) in different fish species. To determine the effects of these molecules in magur, three treatment groups comprising of three males and three females each were injected with bicuculine and GONOPRO-FHTM (commercial GnRH formulation: T1), muscimol and GONOPRO-FHTM (T2) and only GONOPRO-FHTM (Control). Blood and tissue samples were collected at 16 h.p.i. The hormones and neuroactive molecules, FSH, LH, testosterone, 11-KT, 17-β-estradiol, cortisol, GABA, and cholic acid were estimated in the blood serum. Gene expression studies of seven key genes related to GABA synthesis and the reproductive pathway, Gad65, Gad67, 3βHsd, FSH, LH, sevatocin, and Cyp11b1 were carried out by real-time PCR in brain and gonad tissues. In T1, the mRNA levels of LH and FSH were significantly upregulated in the brain, 8- and 4-fold, respectively, as were the steroidogenic genes Cyp11b1 and 3β-HSD (10-fold) in the gonads, in both sexes, compared to the control. No regulation of Gad65, Gad67 and sevatocin mRNAs was seen in T1. On the other hand, in T2, Gad65 and Gad67 mRNAs were highly expressed (8-fold) in the brain, as was sevatocin (12-fold). Although LH and steroidogenic genes were upregulated (3- & 4-fold, respectively) in T2 too, compared to controls, these levels were lower than T1. The assay results were similar. The release of key reproductive hormones, LH, FSH, testosterone, and 11-KT was higher in T1. Histological studies of the gonads revealed more spermatids and a greater proportion of oocytes in the vitellogenic phase in T1 compared to T2. Thus, the results confirmed the inhibitory role of GABA in regulating reproductive hormones in magur, and established that bicuculine acts as GABA antagonist and muscimol acts as GABA agonist in *Clarias magur*.

KEYWORDS: GABA receptors, Relative gene expression, Hormone assays, Histology

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Performance Evaluation of Early Growth Traits of *Labeo rohita* (Hamilton, 1822) in a Cohort Breeding Programme

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Labeo rohita is a popular fish and the most cultured carp in the Indian sub-continent. The culture of fish is majorly dependent on seeds produced from unselected varieties. To sustain the demand and improve productivity, it is imperative to have breeding programs for growthrelated traits and those that generate pedigree seeds. In this context, a cohort breeding program was initiated at ICAR-Central Institute of Fisheries Education, Powarkheda Centre. Six different stocks of Labeo rohita assembled from different geographic locations were evaluated for body weight (BW) and total length (TL) at 330, 360, and 390 days of pond age. Stock 5 exhibited significantly the highest growth performance with average body weight after 390 days of pond age (487.79±6.21 g). The phenotypic selection was performed in each stock. A cohort mating plan was designed to produce 3 cohorts consisting of 37 cohort families. Each cohort family was reared separately in hapas installed in the pond and evaluated for early growth traits viz., BW1, TL1 (Body Weight and Total Length at day 1 i.e. 30 days of culture age) and BW2, TL2 (Body Weight and Total Length at day 15 i.e. 45 days of culture age). The BW2, TL2 obtained were 1.88±0.03 g and 5.47±0.04 cm respectively. Among cohorts, cohort 1 had the highest BW2 compared to other cohorts. The broad sense heritability estimated for BW1, BW2, TL1 and TL2 were found to be 0.15±0.04, 0.17±0.046, 0.35±0.07 and 0.49±0.09, respectively. This study provides estimates for early growth performance and genetic parameters which need to be correlated with later growth traits to be utilized in ongoing cohort breeding programme.

KEYWORDS: Cohort, Early growth traits, Phenotypic selection

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Genetic (Co)variance of Common Carp (*Cyprinus carpio*) Body Weight in Inland Saline Production Environment

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Inland salinization and rising groundwater salinity are growing global concerns, making inland saline aquaculture a viable solution for utilizing degraded lands sustainably. Selective breeding can lead to the development of more resilient and faster-growing fish strains that could thrive in saline environments. The common carp, a species of global importance, is particularly well-suited for aquaculture utilizing inland saline groundwater (ISGW). The present study reports the estimates of the heritability of Body Weight (BW) at seven months of pond age. A total of 85 families were generated based on BLUP selection in the base population. About 1,800 fish were PIT tagged randomly and stocked in four ponds at two salinities (2-4‰ and 6-8‰). The average BW at tagging and seven months pond age were 23.24 g and 512.54 g respectively. The CV (%) for BW at 2-4‰ and 6-8‰ was found to be 38.88 and 48.29 respectively. The variance components were estimated employing an animal model in ASReml 4.0. The BW at tagging is considered as covariate; the stock combination, salinity, sex, and pond were considered as the fixed effect; and the animal was considered as random effect. The mean BW for females and males was 584.36±10.62 g and 417.74±7.26 g respectively. The heritability was found to be 0.43±0.07. The BW exhibited high heritability and this estimate further needs to be correlated with harvest size to determine the appropriate age of genetic selection in common carp.

KEYWORDS: Inland saline, Heritability, Common carp

Identifying the Best Age for the Genetic Selection of Growth in Maha-Magur

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Clarias magur, an Indian freshwater catfish species, is a promising candidate for large-scale aquaculture. The ICAR-Central Institute of Fisheries Education initiated a genetic selection programme in 2013 to improve harvest body weight of magur. In the present study, the best age for genetic selection was identified to increase the genetic gain of the Maha-magur. Early and precise genetic selection can minimise the time and resources needed to generate high-quality stock. The Probability Density Function (PDF) showed that the body weight did not increase steadily with age, and the daily weight gain decreased after 400 days. The spline regression showed that the daily weight gain started declining between 420 and 450 days. It has also been observed that the average gain in body weight between the stocking to 180 days of the culture period was higher than the average daily gain between 180-360 days. The heritability of body weight at 180 and 360 days of culture was similar (0.61 \pm 0.05). The heritability of daily weight gain was higher from stocking to 180 (0.52±0.06) days than from 180-360 days (0.32±0.05). The genetic and phenotypic correlations for body weight between different sampling points (Weight at stocking, 180 and 360 days) were inconsistent. Considering the declining daily weight gain from 180 days of the culture period, the high heritability of body weight at 180 days, and the high genetic and phenotypic correlations between body weight at 180 and 360 days, it may be concluded that the genetic selection of Maha-magur can be carried out based on the body weight at 180 days.

KEYWORDS: Magur, Probability Density Function, Spline regression

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Selective Breeding Program of *Cyprinus carpio* (Common Carp) in India: Status and Scope in Inland Saline Production System

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The extent of groundwater salinisation in India is more than 2 lakh km² and is expected to only increase in the future. This water is unfit for traditional agriculture but offers an avenue for aquaculture of saline and saline-tolerant fish species. Cyprinus carpio (Common carp) is the fourth most produced fish globally and is known for salinity and cold tolerance. This is an ideal species for aquaculture in the northwest agro-climatic region of India, which is suffering from inland salinisation. A selective breeding program is initiated at ICAR-Central Institute of Fisheries Education, India, to develop faster-growing common carp in the inland saline production system (0-8%). An Open Nucleus Breeding Scheme (ONBS) involving the main Nucleus Breeding Centre (NBC) at Rohtak (Haryana) and two Satellite Breeding Centres (SBC) (Powarkheda-Madhya Pradesh and Motipur-Bihar) has been adopted. About 15 geographical stocks of common carp have been assembled at these breeding centres. Two generations of selective breeding for body weight are performed. About 606 families were produced, and 15,500 fish were PIT tagged for evaluation of growth-related traits (Body weight, Body length, and Body height) at various salinities (0, 0-2%, and 6-8%). The genetic parameters, viz., heritability and genetic correlation at various pond ages were estimated employing a multivariate animal model using ASReml-R. The growth-related traits exhibited moderate to high heritability (0.29-0.68) and a very high positive genetic correlation (0.84-0.96). The genotype by environment interaction was assessed, and there was no significant reranking of families grown at two salinities, as evidenced by a high genetic correlation (0.91). The results demonstrate sufficient additive genetic variation for growth-related traits in the breeding population that can be utilised for the genetic improvement of common carp in the inland saline production system.

KEYWORDS: Heritability, Genetic correlation, Growth related traits, GxE interaction

Monthly Variation in Milt Quality Parameters of *Labeo rohita* and Effect of Cryopreserved Milt on Hatching

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In Indian freshwater aquaculture, Labeo rohita is one of the most commercially important fish. India's aquaculture sector has benefited from its increased demand, both locally and abroad, which has helped rural people grow economically. For sustainable aquaculture, highquality seed production is essential for enhancing the profitability of farmers. Commercial hatcheries are the main source of seeds and their quality is deteriorating due to lost genetic diversity in hatchery stock. Loss in genetic diversity is being caused by rampant inbreeding and lack of genetic management in the hatchery. Cryopreserved milt from riverine stocks allows us to restore lost genetic diversity in hatchery stock. The current study examines the monthly fluctuation in milt quality parameters of the same individuals during the breeding season. It focuses on milt quality and the hatching success using cryopreserved milt. Milt samples were tested monthly to detect any significant changes in quality parameters, such as motility, rapid progress, velocity (VCL, VAP), and wobbling. Data show no clear seasonal fluctuations within the study period, seeing the highest motility (0.9570±0.5431) in July and the lowest (0.8773±0.1134) in August, the highest VCL (109.3233±20.826921) in June, and the lowest (91.7233±18.51672) in August, and the highest rapid progressive was 0.7605±0.23277 and the lowest was 0.5375±0.25204. Hatching results show no significant differences (p<0.05) during the breeding season. Although there were differences in milt quality parameters during various months of the breeding season, it did not significantly affect the hatching success. These results indicate that the same individuals can be used multiple times for milt cryopreservation during the breeding season without affecting the hatching success. For the establishment of a commercial cryobank, the multiple use of milters will be beneficial.

KEYWORDS: Season variation, CASA, Milt Quality Parameters, Labeo robita

Investigating Temperature-Driven mtDNA Methylation and Growth Dynamics in Nile Tilapia using Nanopore Sequencing

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Thermal plasticity, an organism's capacity to adapt to temperature fluctuations, plays a critical role in regulating fish growth, with epigenetic mechanisms such as DNA methylation emerging as key modulators in this adaptive response. In this context, mitochondrial DNA (mtDNA) methylation serves as an essential epigenetic modification, potentially influencing mitochondrial function and energy production to support growth under varying thermal conditions. The present study explored the role of mtDNA methylation in temperature-dependent growth of Nile tilapia (Oreochromis niloticus), with implications for thermal plasticity. Temperature variation affects growth by altering metabolic rates and energy distribution, potentially impacting mitochondrial structure and function. This study investigated these effects by analyzing mtDNA methylation at different incubation temperatures (24°C, 28°C, and 32°C) through nanopore sequencing, an approach that detects diverse DNA modifications. The O. niloticus embryos were incubated initially at 24°C, 28°C, and 32°C temperatures and later transferred to a common environment at 28°C, and fast muscle tissues were sampled for mtDNA analysis. Using nanopore sequencing with adaptive sampling, we analyzed three epigenetic marks (5mC, 5hmC, and 6mA) to observe methylation variations across temperature treatments. Results indicated minimal mtDNA methylation, predominantly in non-CpG contexts, with temperature-specific trends. The 5mC and 5hmC methylation levels varied between strands, while 6mA was more prominent on the H-strand. Methylation was highest at 24°C, suggesting enhanced epigenetic regulation at lower temperatures. This research highlights mtDNA methylation as a mechanism for thermal adaptation, informing aquaculture strategies for temperature-sensitive species. Future research could explore mtDNA epigenetic modifications across broader environmental contexts to advance sustainable aquaculture practices and selective breeding programs.

Keywords: Nile tilapia, N4-methylcytosine, 5-methylcytosine, N6-methyladenine, Thermal plasticity



Prototype Development of Marine Black Pearl Through *In Vitro* Mantle Epithelial Cell Culture Technology in Black-Lip Pearl Oyster *Pinctada margaritifera*

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Nacre is a model of biomineralization process in molluscs comprising aragonite platelets and organic material. Mantle epithelial cells control nacre formation. Epithelial cells from the mantle tissue of *P. margaritifera* were cultured *in vitro* using seawater as the culture medium. Periodic sub-culturing of mantle cells was carried out to establish primary cultures comprising of granulated epithelial cells. Nuclear beads were placed in culture wells containing semisolid agar medium and incubated in vitro with cultured granulated epithelial cells in order to evaluate the nacre secretion. On visual observation, a brown coloration was observed on the surface of the bead after 7-10 days. Evaluation of the surface of the nuclear beads by scanning electron microscopy (SEM) after 60 days of incubation revealed a good brick and mortar pattern, characteristic of nacreous layer formation. A bright intense lustrous hue was also seen to develop on bead surfaces after this stage. SEM images of a cross-section of the nacre-coated bead showed a pattern of arrangement of aragonite tablets similar to that seen in cross-sections of the nacre layer of the shell of molluscs. The refinement on the bright reflections of the lustrous nacre resulted in the development of an *in vitro* marine black pearl prototype with increased intensity around the circumference of the nucleus owing to the thickness of nacre biomineralization. TEM analysis revealed 0.30 mm thickness of lustrous nacre, falling under good category gradation. The repeatability of the experiment to form a lustrous nacre is 71%. The functional ability of cultured granulated epithelial cells was further confirmed by detecting gene expression of matrix proteins, namely nacrein, lustrin, molluscan shell framework protein, and amorphous calcium carbonate binding proteins which play an important role in the formation of the nacreous layer in both cultured cells and in native mantle tissue. There was a very high positive correlation between the expression patterns of the genes both in in-vitro cultured cells and native mantle tissue, signifying that the in vitro cultured mantle epithelial cells retain their functional characteristics of biomineralization.

KEYWORDS: Aragonite, Biomineralization, Epithelial cells, Mantle, Nacre, Prototype

The Indian Pompano (*Trachinotus mookalee*), A Candidate Species for Genetic Improvement to Augment Mariculture Production in India

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India ranks second in the world in aquaculture and third in fisheries production. The fisheries sector contributes 1.07% to the national GDP and 5.30% to the agricultural GDP. The fisheries and aquaculture sector in India provides employment to millions of people and contributes to the food security of the country. Trachinotus mookalee (T. mookalee), commonly known as the Indian pompano, is a cultivable, high-value and much sought-after marine fish species. The low and unpredictable wild harvest of this species has continually kept the demand for this fish higher than its supply. ICAR-CMFRI recognized its potential for aquaculture and developed technologies for seed production and farming of Indian pompano. To meet the increasing demand; the growth, disease resistance and other economically important traits of T. mookalee need to be improved. The culture technology for this species was standardized and disseminated, and is currently being practiced in marine and coastal cages as well as coastal ponds in various coastal states of India. Myostatin gene expression was found to be relatively lower in *T. mookalee* compared to *T. blochii*, suggesting that the former has higher growth potential. Preliminary genetic studies have demonstrated the presence of significant genetic variation in T. mookalee for growth traits and exhibited moderate to high heritability, indicating the potential for genetic improvement through selective breeding. Genetic selection provides an effective approach to speed up the breeding process and improve the overall performance of farmed species. Due to its high market value, year-round breeding and seed production, availability of three generations in captivity, standardized cultivation techniques, easy acceptance of formulated feed, wide range of salinity tolerance and availability of genomic data, T. mookalee was identified as the most suitable marine fish species for genetic improvement under Indian conditions. A genome-wide association study (GWAS) to elucidate genotype-phenotype correlations is the first step to move on with genomic selection and genetic improvement in this species. The selection goals would be to increase the growth rate (aiming for 800 g in 5 months from the existing 9 months of culture) and thereby reduce feed costs and culture duration. Genetic improvement of the germplasm of this candidate species can lead to the development of superior strains optimized for aquaculture production, thereby contributing to food security, economic development and environmental sustainability in India and beyond.

KEYWORDS: Indian pompano, Mariculture, Genetic improvement, Trachinotus mookalee



Identification of *Clarias magur* miRNAs From NGS Data with Reference to Growth

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The freshwater catfish species, *Clarias magur* is a highly promising aquaculture candidate species in India, ranking just behind carps in importance. Despite being reared under identical conditions, this species exhibits notable variations in growth rates even within the same age groups, ultimately affecting overall biomass yield. At the molecular level, growth regulation is influenced by various growth-related genes, with non-coding RNAs, particularly miRNAs, playing a significant role in the regulation of gene expression. Our study aims to identify and analyse the potential role of miRNAs generated from NGS data and to predict which miRNAs are responsible for regulating growth-related genes between two groups (fast- and slow-grown) of C. magur. In the study, a substantial number of miRNAs were identified, which spanned 102 miRNA families. Differential expression analysis revealed that the expression of around 90 miRNAs was significantly different between the groups, with around 50 miRNAs being down-regulated and remaining up-regulated. To understand their regulatory impact, target gene prediction was conducted in zebrafish, resulting in the identification of around 19,500 zebrafish genes as potential targets of these differentially expressed miRNAs (DEmiRNAs). Among these, about 6,250 genes were found to be present in the C. magur genome, indicating their potential target genes in magur. Further, the gene ontology analysis and pathway studies would reveal the growth-related genes in C. magur that may be regulated by miRNA. This study provided a baseline profile of miRNAs in C. magur, which may have a pivotal role in regulating growth-related genes, thus, may shed light on the molecular mechanisms behind growth variability in this species.

KEYWORDS: Aquaculture, DEmiRNAs, Differential-growth, GO analysis, Clarias magur

Development of Cell Lines from Two State Fishes of India: A Resource for *In Vitro* Applications and Conservation

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Fish cell lines are important bioresources frequently utilized to study key biological processes, such as immunology, toxicology, virology, developmental biology, gene expression studies, biobanking, cryopreservation, etc. With the advent of the cellular agriculture concept, cellbased meat technology has promising prospects to boost the production and consumption of fish. Twenty-three states of India have declared 21 fish species as 'State Fishes'. The classification of state fish species was done using various parameters, like commercial importance, conservation status, local preference, popularity, etc. Chitala chitala and Osteobrama belangeri are the State Fish of Uttar Pradesh and Manipur, respectively. Both fishes have good market demand and aquaculture potential, but their supply is irregular. The explant method was used to develop primary cultures and cell lines from the above two species. Briefly, muscle tissues were aseptically removed using a sterile scalpel, minced into small pieces, washed multiple times with PBS and transferred to a T25 flask containing Leibovitz's L-15 medium supplemented with 20% FBS and 100 μl of antibiotic-antimycotic solution. Cell radiation from explant tissues was observed in 7 and 10 days and monolayer formation took 15 and 30 days in C. chitala and O. belangeri, respectively. Both the muscle cell lines were passaged multiple times using trypsin-EDTA. Further evaluation of the cell lines for cell-based meat is in progress. The muscle cell lines have been named CcM-1 and ObM-1 for C. chitala and O. belangeri, respectively, and have been submitted for deposition in the National Repository of Cell Lines (NRFC) at ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow, for long-term storage. Development of cell lines from these two species will accelerate research, especially related to toxicity and disease diagnosis, and boost cell-based meat prospects.

KEYWORDS: Chitala chitala, Osteobrama belangeri, Cellular agriculture, Toxicity

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Identification and Characterization of a Cyclophilin Gene in the Protozoan Parasite, *Perkinsus olseni*

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Cyclophilins (CYPs) are a highly conserved group of proteins belonging to the immunophilin superfamily. They are primarily known for their peptidyl-prolyl cis-trans isomerase (PPIase) activity. CYPs are ubiquitous proteins involved in diverse cellular processes, including protein folding, signalling, and immune responses. Due to their roles in the life cycles of various pathogens, they have garnered attention as potential drug targets. This study aims to characterize a CYP gene in *Perkinsus olseni*, a protozoan parasite infecting bivalve. Using transcriptome sequencing data, we identified and analyzed a cDNA, encoding a *P. olseni* CYP. The gene contains a 519 base pair open reading frame (ORF) translating to a 172 amino acid protein. Bioinformatic analysis predicted a molecular weight of 18.97 kDa, an isoelectric point of 8.20, and the presence of a Pfam domain and a transmembrane domain. No signal peptide was detected. Phylogenetic analysis confirmed the evolutionary relationship of this CYP with homologs from other species. This is the first characterization of a CYP gene in *P. olseni*. Further research is needed to elucidate its function and assess its potential as a therapeutic target against *Perkinsus* infections.

KEYWORDS: Perkinsus olseni, Cyclophilin, Phylogeny, Transmembrane domain, Drug target

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Genome-wide Single Nucleotide Polymorphism Marker Identification in Giant Freshwater Prawn, *Macrobrachium rosenbergii*

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Macrobrachium rosenbergii is the sixth largest aquacultured species and is widely cultured in tropical and subtropical countries. In addition to China, the other major producers of this species are Bangladesh, Thailand, Myanmar, and India. A selective breeding program of this species at ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneswar in collaboration with WorldFish, Malaysia was initiated in 2007 to overcome the challenges faced by the farming community. A clear understanding of the genetic basis of economically important traits such as growth in aquaculture species is essential for formulating appropriate genetic improvement programme and developing targeted trait improvement. In this study, single nucleotide polymorphism (SNP) identification analysis was performed in M. rosenbergii to identify genome-wide SNP markers. Out of 1000 prawns sampled from the ongoing breeding program, 300 individuals were selected based on the harvest weight (150 with high body weight and 150 with low body weight). Genomic DNA was isolated and genotyping-by-sequencing (GBS) was conducted on the Illumina NovaSeq600 platform, generating ~266 Gb of paired-end sequence data. This sequencing effort generated an average of 2.8 million reads per sample, with an average read length of 159 bp with QC >30. Based on the results of the coverage analysis, 159 samples with coverage of >28% were selected for downstream analysis. Reads were aligned to the reference genome using the BWA MEM algorithm, and the resulting alignments were converted to sorted BAM files (SAMtool V1.19). SNP discovery was conducted using the gstack module of the Stacks pipeline (v2.66), identifying a total of 584,936 SNPs. To ensure quality and reliability, SNPs were filtered with the following parameters in VCFTool -r 0.70, MAF > 0.02 resulting in 14,110 high-quality SNPs. The identified SNPs will act as a valuable resource to identify quantitative trait loci (QTL) associated with growth trait through genome-wide association studies in *M. rosenbergii*.

KEYWORDS: Genome-wide association studies, Genotype-By-Sequencing, QTL

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Deciphering the Distinct Functions of Myostatin A and Myostatin B through CRISPR-Cas9 Gene Editing

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Myostatin, a growth and differentiation factor 8 (GDF8), mainly function as a negative regulator of skeletal muscle growth in fish as well as in higher organisms. Two isoforms of myostatin, myostatin a and myostatin b, have been identified till now. The myostatin b gene is highly conserved across fish species and uniquely functions to reduce muscle size; animals lacking this gene exhibit a condition known as double muscling (DBM), characterized by increased skeletal muscle mass. Myostatin b participates in regulating muscle growth during the early stages of embryonic development, including muscle precursor proliferation and myoblast differentiation. Disrupting the myostatin b gene could enhance muscle growth, which would be beneficial for farmed animals. Myostatin a is a paralogue of the myostatin gene which is found to be present in many teleosts and higher organisms. Myostatin b and myostatin a are differentially regulated throughout the embryogenesis in zebrafish. Furthermore, myostatin is thought to significantly contribute to neurogenesis and immunogenesis during the early stages of development. Nevertheless, the precise function and regulatory mechanisms of myostatin remain elusive. Gene editings of myostatin a and myostatin b were conducted in both zebrafish and rohu carp, Labeo rohita. The gRNAs were synthesized for both isoforms, targeting homologous regions in zebrafish and rohu. A double knockout was performed to eliminate the entire region between exon 1 and exon 3 for both myostatin a and myostatin b. In zebrafish, CRISPR/Cas9 achieved approximately 90% indels for myostatin a and over 95% for myostatin b, as demonstrated by HRM (High Resolution Melting) assays. Additionally, founder stocks of myostatin b-edited rohu fish were generated and are being reared. The comprehensive results and the significance of this myostatin a and myostatin b editing endeavours will be highlighted and discussed.

KEYWORDS: Myostatin a, Myostatin b, CRISPR/CAS9, Muscle Growth

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Understanding the Role of Phoenixin in the Reproduction of Seasonal Breeder Carp Species *Labeo rohita*

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In fishes, the onset of puberty and reproductive function are controlled by coordinated actions of regulators involving the brain-pituitary-gonadal (BPG) axis. During the past decade, numerous known and novel neuropeptides have been implicated in the control of GnRH and gonadotropes in the pituitary. Phoenixin (PNX), a novel peptide recently identified, is widely expressed at various tissue levels and confirmed to be the ligand for the orphan receptor GPR173. Its mature peptide PNX20 has emerged as a novel regulator for reproductive, appetite control, memory retention, and cardiovascular protection. However, little is known about the comparative aspects of PNX, especially in lower vertebrates, and its functional role in the regulation of the BPG axis for controlling reproductive function is largely unclear. As a first step to determine the involvement of phoenixin in the reproduction of farmed carp, we have generated partial cDNA sequences of phoenixin farmed rohu carp (*Labeo rohita*), indicating their existence. A partial cDNA sequence of phoenix in (200bp) was obtained from the brain cDNA of *Labeo rohita*. The quantitative real-time PCR (qRT-PCR) assay indicated that PNX mRNA was expressed in different reproductive tissues (brain, pituitary, and gonad) and non-reproductive tissues (liver, muscle, kidney, heart, blood, spleen, gill, and intestine) of adult male and female rohu. These studies have opened a new impetus to study the roles of PNX at the molecular level as a regulator in the reproductive function of a seasonal breeder carp.

KEYWORDS: Phoenixin, Reproduction, Rohu

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Molecular Characterization of Gonadotropin-Releasing Hormone (GnRH) and its Expression Analysis in Striped Murrel, *Channa striata* (Bloch, 1793)

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The gonadotropin-releasing hormone (GnRH) neuropeptide is often regarded as the master regulator of reproduction. It is secreted in the hypothalamus and is considered essential for activating the pituitary to release gonadotropins such as luteinising hormone (LH) and follicle-stimulating hormone (FSH) to stimulate reproduction. In the present work, molecular characterization of the GnRH gene of snakehead murrel, Channa striata was carried out. The full-length cDNA of the GnRH 275 bp identified by RACE-PCR encoded 99 amino acids comprising 7.26 kDa peptide and an isoelectric point of 6.82. Molecular docking revealed that GnRH binds to the N-terminal region of GnRHR. The obtained GnRH sequence comprises a putative signal peptide, decapeptide, proteolytic processing site, and a GnRH-associated peptide (GAP). Comparative structural analysis and phylogenetic comparison revealed that cloned sequence shares relatively high homology with other piscine vertebrates. aPCR assay demonstrated the expression of GnRH in the brain and gonad tissue during different reproductive stages. These results showed that GnRH is highly expressed in the brain tissues and showed significantly (> 8-fold) higher expression in the male and female brains at 16 hours post-injection of synthetic analogue. The findings from this study can enhance our understanding of GnRH and offer valuable insights for designing more potent molecules for use in induced breeding.

Keywords: Channa striata, RACE-PCR, Real-time PCR, GnRH

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Study of Genotoxicity and Gene Expression Modulation Associated with Selected Antiparasitic Drug Used in Aquaculture on *Danio rerio* (Hamilton, 1822)

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Parasites are one of the major threats to aquaculture, and the application of various antiparasitic chemicals is a widely practised strategy by aquafarmers. Many such antiparasitic drugs are toxic to hosts at higher concentrations and may induce genotoxicity. Our research aimed to study one of the antiparasitic chemicals, Dichlorvos, for its genotoxic effect on zebrafish along with its effect on the expression of p53, Cyp450 and Bcl2 genes. The 96 h LC50 and LC25 were estimated in adult zebrafish based on a sub-lethal toxicity experiment, and it was found to be 10.6 and 6.78 ppm, respectively. The in vivo experiment was conducted with four different test concentrations (2.5 ppm, 5 ppm, 7.5 ppm, 10 ppm) of dichlorvos, and blood samples were analysed by micronucleus and comet assays. A significant increase in micronucleus frequency, by 5.5-fold, was observed between T1 (2.5 ppm) and T4 (10 ppm) after 24 h. The frequency of micronucleus (p<0.01) increased significantly from 24 to 96 h in all corresponding treatments. The zebrafish exposed to different concentrations of Dichlorvos exhibited significantly higher DNA damage (p<0.01) in T4, followed by T3, T2, T1 and control. The lowest DNA damage was observed at 24 h, and there was a gradual nonlinear increase in the DNA damage in erythrocytes with exposure duration, and the highest DNA damage was observed after 96 h in all treatments. The p53 gene expression in gill was found to be 9.25 and 6.5-fold upregulated in T4 and T3, respectively, as compared to control. The Cyp450 gene expression was found to be 8.66- and 2.96-fold upregulated in T4 and T3 gill, respectively, as compared to the control. The expression of the Bcl2 gene was found to be upregulated by 19.1 and 10.45-fold in the gill of T4 and T3, respectively, as compared to control, and the change was more than p53 and Cyp450.

KEYWORDS: Genotoxicity, Gene expression, Aquaculture, Antiparasitic drug, Gene, DDVP

Molecular Characterization of Follicle Stimulating Hormone and its Expression Profiling in Response to HCG Stimulation in Striped Murrel, *Channa striata* (Bloch, 1793)

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Striped murrel (snakehead) Channa striata (Bloch, 1793), an air-breathing fish, is one of the most important food fish in India, Thailand, Vietnam, Malaysia, and the Philippines. One of the key limitations in aquaculture is the lack of availability of quality fish seeds. Induced breeding and the use of synthetic hormone analogues enable seed production technology. as shown in various aquaculture species. Follicle-stimulating hormone (FSH) known as gonadotropin plays an important role in stimulating the ovaries in females and the testis in males through the hypothalamic-pituitary-gonadal (HPG) axis. Pituitary gonadotropins, including Luteinizing hormone (LH) and Follicle-stimulating hormone (FSH), have a key role in reproduction in fishes. In this study, partial ORF with 1-40 bp 5' UTR and 185 bp CDS were identified. Further, 3' RACE PCR resulted in a sequence of 150 bp and formed a complete CDS of the FSH gene of C. striata. The partial and identified 3' sequences of FSH were aligned to obtain a full-length cDNA sequence. The full-length cDNA consisted of 363 bp. The open reading frame (ORF) analysis revealed an ORF encoding a putative protein of 121 amino acids (aa). Online BLASTp analysis of the C. striata FSH deduced amino acid sequence showed 93.33% similarity with FSH of C. argus and 91.6 % with C. maculata (99% coverage area), followed by Anabas testudineus (80.34%), Siniperca chautsi (82.05), Scatophagus argus (80.00%). The obtained sequence of FSH was subjected to the Conserved Domain (CD) search. Gene expression studies in response to HCG stimulation showed FSH was upregulated > 2-fold at 16 hpi in male and > 5-fold level expression in female brain samples after 16 hpi as compared to matured groups. The obtained gene sequence and functional insights from expression studies offer insights into its potential roles in maturation and spawning.

KEYWORDS: FSH, RACE, Stripped murrel

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Cellular and Molecular Level Interactions of COOH-MWCNTs in Zebrafish (*Danio rerio*)

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Recently, the use of carbon nanotubes (CNT) in aquaculture has increased significantly in various applications such as nutrition, water treatment, breeding and disease management. However, employing carbon nanotubes in aquaculture raises questions about their potential toxicity. The primary determinants of carbon nanotube toxicity are their size, zeta potential, and surface-attached functional group. Therefore, the present study examined the distribution and toxicity of multi-walled carbon nanotubes in zebrafish. In the present study, Pristine-MWCNTs were synthesised using the chemical vapor deposition method and functionalised with carboxyl groups to create COOH-MWCNTs. Subsequently, DLS, HR-TEM, and FTIR spectroscopy were used to characterize MWCNTs. Histological investigation revealed the distribution of COOH-MWCNTs in the intestine and gill. It also observed minimal disturbances like erosion of the epithelial layer, necrosis of villi in the intestine, inflammatory focus and aneurysm in gills. Comet assay results showed that zebrafish exposed to COOH-MWCNTs exhibited genotoxic effects. Hence this study suggests that COOH-MWCNTs were not biocompatible as they showed more cellular and molecular damage. As a result, care must be taken while using COOH-MWCNTs in aquatic applications due to their toxicity.

KEYWORDS: Genotoxicity, COOH-MWCNTs, Zebrafish, LC50, Comet assay, HR-TEM

Expression Profiling of Genes for Iridophore and Xanthophore Development Through Guanine and Carotenoid Fortified Diet in Colisa Ialia

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Ornamental fish are small, live and beautifully coloured fish kept in home or public aquaria or in garden pools for recreation. Skin colouration is one of the most important factors that decide the aesthetic value and, therefore the market value of ornamental fishes. Skin colouration in fish is due to the presence of pigment cells such as melanophores, erythrophores, xanthophores, cyanophores, leucophores, and iridophores. Iridophore cells are responsible for the metallic silvery bluish colour and carotenoids play a significant role in the regulation of yellow coloration in fish. In the present study, an attempt was made to study the expression profiling of important genes responsible for iridophore and xanthophore pigmentation in fish. Under this experiment, fishes were fed with two different components viz., guanine and marigold powder for blue colour and yellow colour development in the fish respectively. The fishes were fed with four different types of diet viz. diet 1 (Control), diet 2 (T1), diet 3 (T2) and diet 4 (T3). The diet 1 (C) was prepared without the fortification of guanine and carotenoid, T1 with guanine (4 mg per 100 g), T2 with guanine and carotenoid and T3 with carotenoid (40 mg per 100 g). Fishes were stocked in 12 tanks, each treatment with three replicates. After 90 days of feeding, genes responsible for iridophore development like Alk, Ltk, Tfec and foxD3 were expressed more in T1 fed with a guanine-rich diet and genes responsible for xanthophore pigmentation like Sox10, Sox9b, mitfa, Pax3 and csf1r were expressed more in T3 with a carotenoid-rich diet. Thus, molecular studies demonstrated that guanine and carotenoid-fortified feed in T1 and T3 respectively could enhance skin colouration and pigmentation.

KEYWORDS: Iridophore, Xanthophore, Guanine, Carotenoid, Fortified diet, Colisa lalia

Identification of Differentially Expressed Immune Related Genes and Associated SSRs From Kidney Transcriptome of *Cyprinus* carpio, Exposed to Two Different Temperature Conditions

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Common carp is a worldwide farmed and economically important freshwater fish species, reported to have a cold tolerance range, and thus has tolerance to thermal stress. In the present study, high-throughput transcriptome sequencing generated a total of 67.44 gb Gb reads highquality paired-end reads, which were assembled and clustered into 1275165 transcripts with GC 41.62%. Simple sequence repeats (SSR) were identified in 11447 genes, with maximum number of dinucleotide repeats (71.08%), followed by tri-nucleotides (22.32%), tetra and pentanucleotide, 5.50% and 0.49%, respectively. The differential gene expression profiles were estimated at two water temperatures, 30°C (control) and 20°C as experimental. In the present study, out of 1539 differentially expressed genes (DEGs), 33 were immune genes, of which 26 were under the innate immune category. There were 3 genes under chemokine, 5 complement system, 1 cytokine, 5 interferon, 7 lectin family members and 6 tumour necrosis factors. Under immune adaptive immune category, 6 were under immunoglobulin and 1 under MHC class were found. Molecular pathway analyses of these DEGs identified 8 genes under cytokine-cytokine receptor interaction, 5 genes under complement and coagulation cascades and 4 genes under chemokine signalling pathway. Nine DEG's of immune-related response contain SSRs and seven contain dinucleotide repeats, while two have trinucleotide repeats. The generated data provides valuable genetic resources for the investigation of immune mechanisms, conservation of germplasm, and molecular marker-assisted breeding of Cyprinus carpio.

Keywords: RNA-seq, Transcriptomic analysis, Gene expression, Low temperature, Immune response, SSR markers

Transcriptome Analysis Reveals Differential Gene Regulation in Ovarian Tissues of *Anabas testudineus* (Bloch, 1793) in Response to Monocrotophos

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The widespread and indiscriminate use of agrochemicals, particularly insecticides and pesticides, has led to significant contamination of soil and water environments, posing a threat to aquatic species. Monocrotophos (MCP), an organophosphate insecticide commonly used in agriculture, has raised concerns due to its runoff into aquatic ecosystems and potential adverse effects on fish. The present study envisaged the understanding of the impact of MCP on the ovarian tissues of *Anabas testudineus* (climbing perch), an air-breathing food fish often found close to agricultural fields. Thus, transcriptome profiling of ovarian tissues in response to 45 days of MCP exposure at sub-lethal concentrations was performed. Using Illumina sequencing, a total of 144.51 million reads were generated. After filtering and trimming, 138.82 million high-quality reads were obtained, with 96% successfully mapped to the Anabas reference genome. Differential expression analysis revealed a total of 13,782 differentially expressed genes (DEGs), including 1,077 upregulated genes, 812 downregulated genes, and 11,893 neutrally regulated genes (Log2FC > 1, p<0.05) compared to the control group. Gene enrichment analysis of the DEGs revealed associations with molecular, biological, and cellular functions. Key detoxification genes, such as glutathione S-transferase (GST) and UDP-glucuronosyltransferase (UGT), were upregulated, indicating an enhanced detoxification response to MCP. In contrast, cytochrome P450 family 1 subfamily A (cvp1A1), a gene critical for steroid hormone metabolism, was downregulated, suggesting disruptions in hormone regulation. Functional enrichment analysis highlighted several affected processes, including steroid hormone biosynthesis, oocyte meiosis, apoptosis, and progesterone-mediated oocyte maturation, etc. The randomly selected eight DEGs using RTqPCR confirmed consistent expression patterns in line with the RNA-seq data. This study offers valuable insights into the molecular mechanisms by which MCP affects reproductive processes in A. testudineus. The identified DEGs could serve as potential biomarkers for environmental monitoring and contribute to the development of safer agrochemical practices aimed at protecting aquatic biodiversity and maintaining ecological balance.

KEYWORDS: Transcriptome, DEGs, Monocrotophos (MCP), Anabas testudineus



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Protein Hydrolysates from Fish Wastes of Rohu (*Labeo rohita*): Evaluation of Antioxidant, Anti-Hypertensive and Antibacterial Properties

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The expansion of the aquaculture industry has simultaneously witnessed an increase in waste accumulation. This has become a key issue as mismanagement of waste leads to public health hazards and environmental pollution. However, these waste by-products could serve as a potential source of raw material for pharmaceutical, food and cosmetic industries. Hence, the valorization of these by-products provides mitigation solutions of waste accumulation for sustainable development of the aquaculture industry. These waste by-products are a rich source of protein and the breakdown of these proteins by enzymes into amino acids and small peptides are called fish protein hydrolysates (FPHs). These FPHs make the peptides more bioavailable with certain bioactive properties such as antioxidant, anti-hypertensive, anti-diabetic, antimicrobial, antiviral and anticancer, etc. In the present study, FPHs were prepared from different tissues of rohu (Labeo rohita). Visceral, gill and fin tissues were homogenized, centrifuged and supernatants were collected. The protein concentration of each sample was determined and hydrolyzed with trypsin at a ratio of 1:50 to the protein concentration at 37°C for 24 h. The reaction was deactivated at 100°C for 10 min. The hydrolysates obtained were subjected to sequential separation using centrifugal filters of molecular weight cutoffs of 10, 3 and 1 kDa respectively. Each fraction obtained was examined for its antioxidant (FRAP assay, CUPRAC assay, phosphomolybdate assay, ABTS assay, DPPH assay, FTC assay and TBA assay), anti-hypertensive (angiotensin-converting enzyme inhibition assay) and antibacterial (tested against Gram-positive Bacillus cereus and Staphylococcus aureus and, Gram-negative Aeromonas sobria and Escherichia coli) properties. The various antioxidant assays revealed that the 3 kDa fraction of the viscera, gill and fin tissues of rohu possessed the highest antioxidant properties. The 3 kDa fraction of the gill and fin tissues also possessed anti-hypertensive properties. All three tissues, however, lacked antibacterial properties. The above findings suggest the availability of bioactivities in the FPHs of rohu that can be studied further to find suitable applications.

KEYWORDS: Fish protein hydrolysate, Trypsin, Antioxidant, Angiotensin-converting enzyme

miRNA Profiling from the Muscle Transcriptome of Catla and their Association with Growth Related Genes at Three Growth Stages

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Catla (Catla catla), the fast-growing Indian major carp species, holds a significant economic importance in freshwater aquaculture systems, across the Indian sub-continent. MicroRNAs (miRNAs) are crucial small, non-coding RNAs that play pivotal roles in nearly all biological functions in eukaryotes. Despite their widespread importance, information regarding miRNAs specific to C. catla is not available, and thus, a study was conducted to explore growth-related miRNAs in this species. For miRNA profiling, miRNAs were generated from muscle tissue at four growth stages: Stage 1 (pre-winter, 35-70 g), Stage 2 (post-winter, 37-70 g), Stage 3 (post-winter table fish, 237-320 g) and Stage 4 (mature, 1.45-1.47 kg), resulting in the identification of 468 known and 206 novel miRNAs. The comparative study showed differential expression of 49 miRNAs across three pairwise comparisons of growth stages. Further analysis to study the pattern of expression of miRNAs with that of growth (target) genes revealed that five miRNA expressions are correlated with that of seven growth genes. A high correlation (R²>0.98) was found for two differentially expressed growth genes, while a moderate correlation was observed for 5 genes. Thus, miRNA in Catla at the growth stages may regulate the expression of muscle growth genes, by repressing the death and inflammation of smooth muscle cells and activating muscle hypertrophy. This research provides the first comprehensive miRNA expression profiles linked to growth in C. catla, expanding our understanding of miRNA-mediated mechanisms influencing fish growth.

KEYWORDS: Catla catla, Differentially expressed miRNAs, Pre-winter and post-winter fingerling, Genes associated with growth

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Isolation, Characterisation and De Novo Whole Genome Sequencing of Phcf1.2: A Novel Lytic Bacteriophage Targeting *Photobacterium ganghwense*

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This study details the discovery and characterization of a novel bacteriophage PhCF1.2, which targets and lyses *Photobacterium ganghwense* strain CF1.2 (GenBank Acc. No. MZ489219). Both the host bacterium and its lytic phage were isolated from seawater collected at Cochin Fisheries Harbour in Kerala, South India. PhCF1.2 was purified through three rounds of single-plaque isolation and high-titre stocks were prepared by ultracentrifugation. The phage produced clear, large plaques of approximately 5 mm diameter in soft agar overlay assay. Host range analysis confirmed the specificity of the phage for P. ganghwense, marking the first report of a phage capable of lysing this bacterium. Temperature and pH tolerance assays showed that PhCF1.2 remains viable up to 70°C and across a pH range of 3-11. TEM analysis revealed that the phage has an icosahedral capsid with a diameter of 55±5 nm. Nucleic acid extracted from the high-titre purified phage stock was found susceptible to DNAse but resistant to RNAse and S1nuclease, confirming a dsDNA genome. From the isolated DNA, libraries were prepared using the NEBNext Ultra DNA Library Prep Kit, for sequencing on the Illumina NovoSeq platform. Low-quality reads were removed based on an average Q30 (Phred score) cutoff, and adapter contamination was trimmed using Cutadapt (v3.7). Pre-processed reads were assembled with De Novo assembler SPAdes (v3.15.5), and genome completeness was evaluated using BUSCO (v5.4.6). Paired-end sequencing yielded 959.83 Mb of raw data with a read length of 151 bp. Gene prediction using Prodigal (v2.6.3) identified 62 ORFs. The predicted protein sequences were annotated via BLASTp against the 'nr' database using DIAMOND (v2.1.6). The final assembly produced 49.6 Kb genome for PhCF1.2 and the complete genome sequence is available under NCBI GenBank Acc. No. PQ521129. Based on TEM imaging, genomic features, and phylogenetic analysis, PhCF1.2 was classified as a novel phage in the Realm Duplodnavria; Kingdom Heunggongvirae; Phylum *Uroviricota* and Class *Caudoviricetes*. The discovery of PhCF1.2 marks a significant addition to our understanding of phage diversity and offers new insights into phage-host interactions in the marine environment.

KEYWORDS: dsDNA genome, Genome annotation, Icosahedral capsid, Illumina NovoSeq, Phylogenetic analysis, TEM imaging



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Effect of PUFA-Rich Fish Oil on Induced Arthritis in Rats: A Proteomics Approach

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Rheumatoid arthritis (RA) is an unremitting inflammatory disease of bones and joints. Consumption of fish high in polyunsaturated fatty acid has been linked with a decline in production of pro-inflammatory cytokines involved in pathogenesis of arthritis. The aim of this study was to determine the therapeutic potential of PUFA-enriched oil in an in vivo rat model of rheumatoid arthritis induced by Complete Freund's Adjuvant (CFA). Among the three groups of albino rats taken for the study, two groups were induced with RA by using CFA while one group was the control. Among the two RA-induced groups, one was untreated and taken as positive control, the second was treated with PUFA-enriched fish oil. Morphological changes, and pro-inflammatory and anti-inflammatory cytokines were determined following the completion of the experimental duration of 30 days. Morphological observation revealed that PUFA-enriched fish oil demonstrated effective activity in lowering the progress and acuteness of arthritic disease in CFA rats. Following treatment with PUFA-enriched fish oil, plasma levels of the pro-inflammatory cytokines; interleukin -1\beta, IL-6 and tumor necrosis factor α (TNF α) were markedly lower when compared to CFA-untreated rats. Results also revealed an increase in anti-inflammatory cytokines IL-2 and IL-10 in PUFA-enriched fish oil treated arthritic rats in comparison to untreated arthritic rats. Lowered levels of proinflammatory cytokines and raised levels of anti-inflammatory cytokines in arthritis induced rats treated with PUFA-enriched fish oil correlated with a reduced expression of TNFa, Il-1β and IL-6 and enhanced expression of IL-2 and IL-10 in paw and joint homogenates of treated rats.

KEYWORDS: Rheumatoid arthritis, Inflammatory disease, Freund's adjuvant, Fish oil, Cytokines, Interleukins

Cryopreservation and Biomineralization of *In-vitro* Cultured Mantle Epithelial Cells of Black Lip Pearl Oyster, *Pinctada margaritifera*

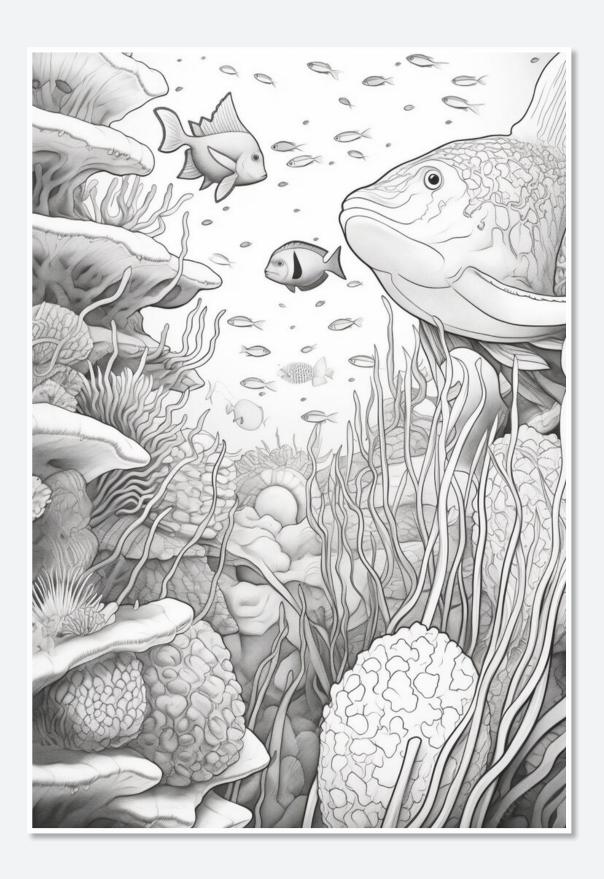
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Nacre is composed of aragonite platelets and organic material, formed by molluscs as an inner shell layer through biomineralization process, and mantle epithelial cells control nacre formation. Primary culture of granulated epithelial cells was established from mantle tissue of Pinctada margaritifera, through a process of continuous sub-culturing at 28°C in yeast-supplemented sterile seawater culture medium. The cryoprotective effects of glycerol, dimethyl sulfoxide, and a mixture of the two on long-term preservation were studied. The mature granulated epithelial cells were mixed with 10% concentrations of the cryoprotective agent, initially stored overnight at -85°C, and then subsequently transferred to -196°C. Viability and metabolic activity were equally better in both glycerol, dimethyl sulfoxide treated cells and comparable to that of unfrozen cells. The optimum post-thaw cell viability after cryoprotection was 98% and 95% with glycerol and dimethyl sulfoxide in comparison to unfrozen cells (87%). The combination of the cryoprotectants and the control (frozen without cryoprotectants) was found to be significantly lower in terms of post-thaw viability of the cells. The cells were further used to induce nacre on nuclear beads in a semi-solid substrate. A nacreous layer, composed of calcium carbonate in the form of aragonite platelets was noticed after 60 days of incubation. The platelets were separated by sheets of elastic biopolymers in the form of an organic matrix, sort of brick-and-mortar work arrangement. The cross-section of the coated bead revealed a pattern of aragonite tablets arrangement similar to that seen in the nacre layer of molluscan shell. Energy dispersive X-ray analysis revealed higher levels of calcium and were found to be 89.30% and 63.72% on the nuclear bead and its cross-section. The major elements were found to be calcium, carbon and oxygen in all the stages. The study shows that mantle epithelial cells cultured in-vitro are amenable for cryopreservation and retain the original functional potential to secrete nacre, representing the survival and recovery of activities even after freeze-thawing.

KEYWORDS: Biomineralization, Cryprotectant, Epithelial cells, Mantle, Nacre

Technical Session-5 Aquatic Animal Nutrition, Feed Technology and Alternate Feed Resources



Effect of Complete Replacement of Fish Meal/Fish Oil on Growth, Digestive Enzymes, Fatty Acids and Metabolic Pathways in Milkfish, *Chanos chanos*

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The aquafeed sector relies on fish meal and fish oil to meet the quality protein and lipid requirements. Though the aquafeed sector constitutes only 4% of the industrial animal feed sector, it consumes more than 70-80% of global available fish meal and fish oil resources. Any further growth of aquaculture depends on the utilization of alternative resources for these two finite resources. Keeping in view of this, three experimental grow-out milkfish, Chanos chanos iso-nitrogenous, and iso-lipidic diets were prepared by totally replacing fishmeal or fish oil. A 60-day feeding experiment was conducted in an indoor RAS system with the hatchery-produced juveniles of milkfish. The effect of replacement was assessed based on the analyses of digestive enzyme profiles (digestive parts), fatty acid profiles (muscle and liver), and transcriptome profiles (liver). The fish fed with a total fish meal replacement diet were observed to record significantly (p<0.05) lower body weight (180.8±3.67%) compared to control (223.1±5.16%). Similarly, pepsin secretion is observed to be significantly lower in the pyloric caeca and stomach of the juveniles fed with zero fishmeal diet (1.53±0.04, 2.39±0.12 & 1.25±0.03 U/mg protein) compared to control (1.76±0.04, 2.53±0.08 & 1.46±0.03 U/mg protein). Pancreatic digestive enzymes were found to be significantly (p<0.05) reduced in juveniles fed with zero fish meal diet. Though the quantity of essential fatty acid profiles was lower in the muscle and liver of milkfish fed with a zero fishmeal diet, it did not reflect the dietary fatty acid profiles. In total, 281 DEGs were found in fish meal replacement samples and 315 genes were found to be differentially expressed in fish oil replacement samples. The differential gene expression analysis based on the liver RNAseq data indicated the influence of fish meal or fish oil replacement on fatty acid metabolism pathways (down-regulated) and amino acid metabolism pathways (up-regulated). Protein digestion and absorption and fat digestion were significantly downregulated in fish meal and fish oil replaced samples, respectively. Overall, the data indicated that milkfish can modify their metabolic pathways to ameliorate nutritional stress and retain essential fatty acids like alpha-linolenic acid, arachidonic, eicosapentaenoic, and docosahexaenoic acids.

KEYWORDS: Chanos chanos, Fish meal, Fish oil, Substitution, Transcriptome

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Physiological, Metabolic, and Body Compositional Responses of All-male Giant Freshwater Prawn (*Macrobrachium rosenbergii*) to Dietary L-tryptophan Supplementation during Nursery Rearing

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L-tryptophan (Trp) is an essential amino acid that plays a crucial role in protein synthesis, serotonin production, and various physiological processes in aquatic organisms. In aquaculture, dietary amino acid supplementation has gained attention as a strategy to enhance growth, stress resistance, and overall health of cultured species. The giant freshwater prawn (GFP), Macrobrachium rosenbergii, is an economically important farmed species, and optimizing its nutrition during the nursery phase is critical for successful production. This study investigated the effects of dietary L-tryptophan (Trp) supplementation on the body composition, physiological parameters, and metabolic response of GFP during nursery culture. The experiment was laid out in a completely randomized design with five experimental groups in triplicates: a control group without Trp and four treatment groups supplemented with crystalline Trp at 1, 2, 3, and 4 g/kg. Post-larvae (PLs) were stocked at 100 ind/l-ton circular tank and fed thrice daily at 5% body weight for 60 days. Proximate composition analysis revealed that higher Trp levels significantly increased crude protein content, with the 3 g/kg group achieving the highest protein level at 66.96± 0.81 g/kg diet. Conversely, crude fiber levels decreased as Trp supplementation increased, while crude lipid content rose, indicating a complex relationship between Trp intake and nutrient composition. These findings align with the known role of Trp in protein synthesis and its potential influence on lipid metabolism. Physiological assessments showed variations in total protein and globulin levels, with some values exceeding optimal ranges, suggesting enhanced protein synthesis and immune function. Notably, phosphorus levels remained below optimal thresholds, indicating potential dietary deficiencies. Metabolic evaluations indicated elevated enzyme levels associated with hepatic stress, while low urea and amylase levels suggested efficient nitrogen retention and limited carbohydrate digestion. Correlation analyses revealed significant relationships between proximate components and blood parameters, particularly a strong negative correlation between moisture and crude lipid, highlighting the impact of hydration on fat storage. Overall, these findings illustrate the complex interplay between dietary Trp supplementation and GFP health metrics, offering valuable insights for optimizing its feeding strategies in aquaculture.

Keywords: Amino acid supplementation, Giant freshwater prawn, Nursery rearing, Proximate composition, Physiological responses, Metabolic response



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Carbohydrate-Based Prebiotics Augment Gut Eubiosis in Fish Madhulika Tripathi, Banu Dharshini, M. Tincy Verghese, Aparna Chaudhari and Subodh Gupta*

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A balanced gut microbiota, known as "eubiosis," is vital for the health of aquatic organisms, influenced by diet, environment, host genetics, and developmental stage. In this context, prebiotics are crucial for modulating gut microbiota by promoting beneficial bacteria and suppressing pathogens, thus fostering a resilient microbial community. To further investigate this, two independent feeding trials were conducted to assess the eubiotic effects of selected carbohydrate-based prebiotics on the growth performance, and physiological, metabolic and immune responses of Labeo rohita fingerlings. The first trial evaluated the efficacy of 0.5% and 1.0% mannan oligosaccharides (MOS), either alone or combined with potassium diformate. The second trial examined the effects of fructooligosaccharides (FOS) and the probiotic Bacillus subtilis (BS), both individually and as synbiotics. Results showed that adding 0.5% of these oligosaccharides significantly enhanced growth performance (p<0.05) and digestive enzyme activity. Notable improvements included increases in red blood cell counts, hemoglobin levels, total protein, and globulin concentrations. Both oligosaccharides elevated white blood cell counts and various immune responses, such as respiratory burst activity, lysozyme activity, albumin ratio, and survival rates after challenges. Additionally, 16S metagenomics studies by next-generation sequencing revealed a significant increase in beneficial gut microbiota populations in groups fed the selected oligosaccharides. In conclusion, MOS and FOS at lower doses are effective eubiotic feed additives that promote gut health by enhancing growth, feed utilization, immune functions, and disease resistance. Their application supports the long-term sustainability of aquaculture practices.

KEYWORDS: Carbohydrate-based prebiotics, MOS, FOS, Metagenomics, Gut eubiosis

Dietary Effect of Ashoka Tree (Saraca asoca) Bark on Gonadal Development of Female Climbing Perch (Anabas testudineus)

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Antioxidant and immuno-modulatory properties of medicinal herbs have been extensively studied in humans and other animals for health purposes, whereas their use as a dietary supplement for gonadal development is relatively rare. Ashoka tree (Saraca asoca) bark known for its bioactive compounds such as alkaloids, glycosides, saponins, steroids, tannins and carbohydrates has been traditionally used to address female reproductive issues in human beings and recorded enhanced fertility and tone-up of the womb for conception. Consequently, a 90-day feeding trial was conducted to study the effect of Ashoka bark powder (ABP) on the reproductive performance of female fish, climbing perch (*Anabas testudineusi*). Two hundred twenty-five fingerlings (average weight 9.0±0.60 g) were distributed randomly into five treatment groups in triplicate. Five iso-nitrogenous (35%) and iso-lipidic (8%) diets were prepared with varying levels of ABP, viz. ABP0 (0%), ABP1 (1%), ABP2 (2%), ABP3 (3%) and ABP6 (6%). At the end of the study, reproductive performance in terms of fecundity, egg size, histological analysis of ovaries and liver, and levels of selected female sex hormones were assessed. Gonado-somatic index and fecundity were significantly (p<0.05) higher in female climbing perch fed with 3% ABP, compared to 1%, 2%, & 6%. Serum levels of vitellogenins and estradiol were also elevated in the ABP3 group, alongside a higher number of vitellogenic stages (Vtg3) observed in 6u tissue sections (p<0.05). Conversely, the ABP6 group experienced increased follicular atresia and yolk material leakage. Liver histology indicated that the ABP3 group has the highest nutrient and lipid accumulation in hepatocytes, which is required to provide nutrients for gonad (Vtg3 stage). The study concluded that dietary incorporation of 3% Ashoka bark powder had a superior stimulatory effect on reproductive performance, however, the higher dose of 6% ABP impaired reproductive function and led to an increased number of atretic follicles, ultimately causing failure in the development of female gonad in climbing perch.

KEYWORDS: Ashoka tree bark, Anabas testudineus, Ovarian histology, Vitellogenin, Estradiol

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Comparative Performance Evaluation of Microalgae Incorporated Prepared Feed and a Commercial Feed for the Growth, Survival and Colouration of the Goldfish, *Crassius aurtatus* and Albino Buenos Tetra, *Hyphessobrycon anisitsi* in Two Commercial Ornamental Fish Farms of Mumbai, India

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An experiment of 5 weeks duration was conducted to compare the performance of microalgaeincorporated experimental fish feed (crude protein 32.0%, crude lipid 6.0% and gross energy 3.90 kcal/g) and a commercial ornamental fish feed (crude protein 34.0%, crude lipid 6.0% and gross energy 4.1 kcal/g) for the growth, survival and coloration of the goldfish, Crassius aurtatus and albino Buenos tetra, Hyphessobrycon anisitsi at Bhandup and Ambernath Ornamental Fish Farms, Mumbai, India, respectively. The experimental feed was prepared by using fish meal, Acetes meal, groundnut oil cake, soybean meal, wheat flour, de-oiled rice bran, microalgae, cod liver oil, baking powder, vitamin-mineral premix, binder, and antioxidants. In both farms, the fish were stocked in triplicate tanks with 20 fish/tank and were fed ad libitum for the whole experiment period. The water quality parameters of the fish-rearing tanks were analysed in every 7 days and maintained in the optimum ranges of fish growth. In the Bhandup Fish Farm, significantly (p<0.05) higher weight gain (%) and specific growth rate of goldfish were found in the microalgae-based experimental feed as compared to commercial feed. The carotenoid deposition in the body of goldfish was also found to be significantly higher (p<0.05) in microalgae-based feed (46% higher carotenoid deposition; 1.6 µg/wet weight tissue in goldfish than the commercial feed 0.9 µg/wet weight tissue). However, the survival was 100% in both microalgae-incorporated experimental feed and commercial feed. The feeding time of goldfish fed with microalgae-incorporated feed and commercial feed was compared, and significantly less time was taken to consume microalgae-incorporated feed than that of commercial one. In the Ambernath Ornamental Fish Farm, significantly (p<0.05) higher weight gain (%) and specific growth rate of albino Buenos tetra was found in the microalgae incorporated feed than the commercial feed. The carotenoid deposition in the body of albino Buenos tetra species was higher (p<0.05) in microalgae-incorporated feed (18 % higher carotenoid deposition; 1.7 µg/wet weight tissue) as compared to the commercial feed (1.4 µg/wet weight tissue). However, the survival was 100% in both microalgae-incorporated feed and commercial feed. It is concluded that the feed intake, growth, and colouration of goldfish and albino Buenos tetra were better in the algal incorporated prepared experimental feed when compared to the commercial ornamental fish feed.

KEYWORDS: Growth, Survival, Feeding time, Carotenoid



Dietary Pineapple Peel Ethanolic Extract Reduces Crowding Stress with Improvement of Growth, Metabolism and Biochemical Status of *Labeo rohita* (Ham.1822)

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Effect of dietary pineapple peel ethanolic extract (PPEE) on crowding stress of rohu, Labeo rohita fingerlings was evaluated through 60 days trial in relation to growth, feed and nutrient utilization, metabolism, and biochemical status. 405 rohu fingerlings (4.2±0.01 g) were stocked in 9 groups viz., $SD_{10}PE_0$ (10 fish/75 litre, 1 + 0% dietary PPEE), $SD_{10}PE_{0.5}$ ($SD_{10}PE_0$ +0.5% PPEE), $SD_{10}PE_1(SD_{10}PE_0+1\%$ PPEE), $SD_{15}PE_0(15 \text{ fish/}75 \text{ l}+0\%$ PPEE), $SD_{15}PE_{0.5}$ (SD₁₅PE₀ + 0.5% PPEE), SD₁₅PE₁ (SD₁₅PE₀ + 1% PPEE), SD₂₀PE₀ (20 fish/75 l + 0% PPEE), $SD_{20}PE_{0.5}$ ($SD_{20}PE_0 + 0.5\%$ PPEE) and $SD_{20}PE_1$ ($SD_{20}PE_0 + 1\%$ PPEE) in triplicates using 3×3 factorial design. 3 iso-nitrogenous, iso-lipidic, and iso-caloric diets were used for feeding fish at satiation level twice a day. Body weight gain, thermal growth coefficient, feed, protein, and lipid efficiency ratio, activity of hepatic G_cPDH, and glycogen contents in liver and muscle reduced with an enhancement of fish stocking density, and the lowest values were observed in SD₂₀ group. However, supplemented PPEE enhanced these parameters with the highest values in the 1% supplemented group. In contrast, the activities of AST, ALT, LDH, and MDH in liver and muscle, and glucose concentration in serum level significantly increased in relation to enhancing stocking density of fish with the highest values in the SD₂₀ group, but dietary PPEE reduced these parameters and 1% PPEE fed group showed the lowest values. In conclusion, 1% dietary PPEE could reduce crowding stress with enhanced growth performance, thus long-term use of PPEE can sustain intensified carp culture.

KEYWORDS: Pineapple peel, Ethanolic extract, Stress, Growth, Waste recycling

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Developmental Ontogeny of Genes Associated with Long-Chain Polyunsaturated Fatty Acids (LC-PUFA) Biosynthesis in Asian Seabass *Lates calcarifer*

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Fish are primary sources of the healthy n-3 long-chain polyunsaturated fatty acids (LC-PUFA) in human diets. The capacity of teleosts to biosynthesise LC-PUFA depends upon the function of key enzymes viz., fatty acyl desaturases and elongases which convert the C18 polyunsaturated fatty acids (PUFAs); linolenic acid and linoleic acid to LC-PUFA, including docosahexenoic acid, eicosapentaenoic acid and arachidonic acid. Preliminary studies were conducted to examine the expression of genes involved in fatty acid synthesis, elongation and desaturation of LC-PUFA biosynthetic pathway viz., fatty acid desaturase ($\Delta 6$ fatty acyl desaturase, fad2), elongation of very long chain fatty acid proteins (elovl5) and fatty acid synthase (fas) in Asian seabass from hatching to juvenile stage. Samples of seabass at different feeding stages of larval development and age groups (volk stage, mouth opening stage, rotifer feeding stage, rotifer, and artemia co-fed stage, Artemia feeding stage, larvae at 20 days post-hatch (dph) and juvenile stage) were collected for ontogeny studies. Tissue samples including brain, liver, muscle, gills, gonads, and spleen were collected for tissue distribution studies. Quantitative real-time PCR analysis of the ontogenic expression of these genes during larval development indicated a distinct expression pattern during early ontogenesis, with peak transcript levels coinciding with the onset of exogenous feeding. The levels of *fads* increased with progress in larval development, with significantly higher transcript levels at the juvenile stage. On the other hand, the expression levels of elov15 and fas were lower in the juvenile stage. Tissue-specific expression of fad showed significantly higher transcript levels in the brain. The present study provides insights into the changes in LC-PUFA biosynthesis during embryogenesis and early larval development in Asian seabass and could aid in the development of nutritional programmes.

KEYWORDS: Asian seabass, Ontogeny, Gene, PUFA, Biosynthesis

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Broodstock Nutrition Improves Reproductive Performance and Larval Quality Traits of *Tor putitora*

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Endangered golden mahseer, a flagship species in Indian coldwater fisheries, needs rehabilitation and conservation measures for its sustainability. For this, mass-scale seed production using captive broodstock is imperative. However, the breeding performance and hatchery output of captive-raised brooders were relatively lower. It is well known that broodstock nutrition is crucial for ensuring successful reproduction and healthy offspring production in fish. In this milieu, a mahseer brooder feed has been developed and validated for captive maturation and higher reproductive performance through repeated trials over a period of three years. The said brooder feed facilitates year-round multiple breeding of golden mahseer with a higher spawning response, fecundity (10-15%), fertilization (12-18%), and hatching rates (4-5%). The immunity of brooders was also enhanced. The broodstock diet improved egg quality (egg size 2.54 mm vs 2.73 mm, carotenoid content, etc.), sperm quality and quantity (spermatocrit and sperm count by 5-10% and sperm viability by 10%), while reducing abnormalities in the sperm by 3%. Further, significantly higher growth (20-22%), survival (7-10%), and fitness (CT_{max} by 0.8 to 1.0 °C) were noticed in offspring/ fry obtained from brooders fed on the broodstock diet. The brooder feed enables the production of robust and healthy mahseer stocking material (seed) for replenishing its population in the natural water bodies through ranching and rehabilitation/conservation.

KEYWORDS: Brooder feed, Gamete quality, Reproduction, Fertilization, Survival

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ICAR-CIBA's Initiatives on Farm-Based Indigenous Aqua-Feeds: Cost Effective Option for Small and Medium Scale Farmers

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Feed being a critical input in aqua farming, not only determines the growth performance of the shrimp and fish but is also a key factor related to cost of production and sustainability. While farmers are already facing several challenges due to emerging diseases, decreased price of final produce, increasing energy cost, etc. increasing feed cost is a double blow for medium and small-scale farmers. Visualizing this as a critical obstacle, ICAR-Central Institute of Brackishwater Aquaculture, developed a cost-effective shrimp feed using indigenous feed processing technology. The feed has been tested in a series of trials in various systems under laboratory, on-farm field testing, followed by validation in farmers' ponds with sufficient replications and commercial feed as control. The cost of the commercial feed available to the farmer is about Rs. 85-95/kg, while the cost of the indigenous shrimp feed is only Rs. 65-75/kg. The use of locally available ingredients and the novel concept of factory-to-farm resulted in making affordable feed and available at ease. Indigenous shrimp feed has good attractability, and palatability and performed on par with the top performed commercial brands in terms of growth, survival, and feed utilization, as revealed by the farmers. We demonstrated that, while the feed cost to produce 1 kg of shrimp can be restricted to Rs. 100 to 110 by using indigenous shrimp feed, it goes up to Rs.150 with branded commercial feeds. The feed showed impressive performance and the farmers could reduce the cost of production of shrimp (P. vannamei) from Rs. 260-270/kg to Rs. 200-220/kg. Thus, the developed feed played a crucial role in improving the profitability of small and medium shrimp farmers.

KEYWORDS: Indigenous feeds, Farmers

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Effect of Salinity on Carapace Mineralization of Whiteleg Shrimp, Penaeus vannamei Reared at Different Water Salinities

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Penaeus vannamei regulates osmotic pressure and ionic balance through hyper-osmosis in low salinity and hypo-osmosis in high salinity, enhancing its survival. This adaptability has made it a leading species in shrimp farming. However, certain unresolved challenges remain, particularly regarding fluctuations in the salinity with respect to the carapace mineralization, nutritional value and mineral profile in P. vannamei. A 42-day feeding trial was conducted to evaluate the effect of salinity on mineralization of the carapace of P. vannamei reared at 3% and 20% salinity. Juveniles of P. vannamei were acclimatized to the experimental salinity levels using freshwater at the rate of 2‰ per day from the original salinity of 20‰. The juveniles were randomly stocked in experimental tanks (500 l) at the rate of 15 per tank and each treatment was carried out in triplicate. During the experimental period, shrimps were fed thrice daily, with a feeding rate equivalent to 6% of their biomass. At the end of the experimental period, significantly (p<0.05) lower weight gain (94.46±5.44 %) and survival (75.56±3.85 %) were registered in shrimp reared at 3% salinity compared to shrimps reared at 20% salinity (140.37±15.13% and 93.33±6.67% respectively). Shrimps were dissected to remove the muscle and carapace. The muscle was analyzed for its nutritional value in terms of proximate composition, fatty acids, amino acids and minerals, while the carapace was subjected to mineral analysis and Scanning Electron Microscopy (SEM). No significant variation in muscle nutritional value was observed in shrimp reared at different salinity levels while the mineral profiles of the carapace revealed elevated calcium content in 3\% $(81.64\pm0.29 \text{ g/kg})$ when compared to 20% $(75.47\pm0.30 \text{ g/kg})$, while magnesium values were recorded to be 3.27±0.29 g/kg and 4.18±0.12 g/kg in 3‰ and 20‰ respectively. The deposition of phosphorus increased proportionally with rising salinity levels from 15.09±0.51 to 16.13±0.10 g/kg, whereas the reverse trend was noticed in the case of sodium and potassium. The SEM images revealed uneven mineral deposition on the carapace of shrimp reared in 3% suggesting a non-uniform hardening of the exoskeleton, which may impact the moulting process.

KEYWORDS: Low salinity, Mineral profile, Mineral deposition, ICP-OES, Scanning Electron Microscope

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Effects of Varied Protein and Lipid Level on Growth, Survival, Antioxidant Status, and Metabolic Responses of *Channa striata* Larvae

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Commercial-scale farming of *Channa striata* (striped murrel) is constrained by the limited availability of seed, primarily due to high mortality rates attributed to a lack of an appropriate larval diet and effective feeding strategies. The present study aimed to develop an optimal strategy to enhance larval survival by optimizing dietary protein and lipid levels. A 22-day feeding experiment was conducted to elucidate the effect of dietary protein and lipid levels on growth, digestive enzyme activity, antioxidant status, and survival of *Channa striata* larvae. For this, six diets were formulated with three different protein levels (50%, 55%, and 60%) and two lipid levels (8% and 12%), designated as P50L8, P55L8, P60L8, P50L12, P55L12, and P60L12. A total of 300 larvae (0.12±0.003 g; 18-day-post-hatch) were randomly distributed to each FRP tank and fed their respective diets. Both protein and lipid levels had a significant effect (p<0.05) on the weight gain and specific growth rate (SGR) of the larvae. Dietary protein levels had no influence on survival percentage, but dietary lipid levels significantly affected survival. The higher weight gain, SGR, and survival were recorded in fish fed the diet P55L12. Dietary protein levels significantly affected trypsin, pepsin, total protease, and amylase activity, except lipase activity; whereas dietary lipid levels affected pepsin, amylase, and lipase activities, except trypsin and total protease. Dietary treatments had a significant impact on the activities of aspartate aminotransferase (AST), lipoprotein lipase (LPL), and fatty acid synthetase (FAS) (p<0.05), whereas the activity of alanine aminotransferase (ALT) remained consistent across all treatments (p>0.05). Super oxide dismutase (SOD), catalase, glutathione peroxidase (GPx), and malonaldehyde (MDA) were not affected by either dietary lipid or dietary protein levels. In conclusion, a diet containing 55% protein and 12% lipid is optimal for larval growth and survival.

KEYWORDS: Channa striata, Protein, Lipid, Nutrient Utilization, Survival

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Impact of *Lemna minor* Incorporated Diets on *Labeo rohita* Larvae

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Freshwater macrophytes are gaining importance as nutritious ingredients for the formulation of fish feed. The inclusion of combinations of various macrophytes in fish feed may help to replace the costly fishmeal from the feeds of aquacrops. Four experimental and two control diets were formulated using computerized software IFFD with a twin screw extruder. In experimental diets, LM-30, LM-40, LM-50 and LM-60, Lemna minor were included at 30, 40, 50 and 60% levels along with fishmeal. *Ipomoea aquatica* (3%) and *Pistia stratiotes* (2%) were incorporated in these diets. The diet without any macrophytes served as control diet 1, LM-0; in the control diet -2 (LM-0-IA-PS), Ipomoea aquatica (3%) and Pistia stratiotes (2%) were included. Rohu Labeo rohita larvae (0.66±0.01 g) were fed one of the six diets at the rate of 5% of the body weight. After 90 days of culture, fish were harvested. Significantly (p<0.05) higher average weight was found in LM-50 diet-fed rohu compared to others. The crude lipid and crude protein levels were maximum in LM-50 diet-fed fish. Amylase, protease and lipase activities were significantly (p<0.05) higher in LM-50 diet-fed fish, whereas trypsin and chymotrypsin activities were maximum in LM-40 treatment. Total essential and non-essential amino acids content were higher in the L. minor incorporated diet-fed fish compared to the control groups. Omega-3 and Omega-6 polyunsaturated fatty acids (PUFA) content were lower in LM-0 diet-fed fish compared to others. Significantly (p<0.05) higher calorific value was found in LM-50 diet-fed fish compared to other diets-fed rohu. The incorporation of L. minor in the diet improved the growth and nutritional value of cultured rohu.

KEYWORDS: Ipomoea aquatica, Pistia stratiotes, Lipase, Trypsin, Fatty acids

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Evaluation of Impact of Linseed *Linum usitatissimum* Oil Incorporated Diets on the Performance of Snow Trout *Schyzothrox richardsonii* Larvae

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The impact of linseed (Linum usitatissimum) oil on snow trout Schizothorax richardsonii was evaluated in the present study. Five iso-nitrogenous and iso-lipidic diets were formulated supplementing different levels of linseed oil in the diets of snow trout. The formulated diets were FLO-0, FLO-25, FLO-50, FLO-75 and FLO-100, containing 0, 25, 50, 75 and 100 ml of linseed oil/kg of feed, respectively. Linoleic acid and α-linolic contents were significantly higher in FLO-0 and FLO-100 diets, respectively. The survival rate of snow trout ranged from 87-91%. The final average weight and specific growth rate were significantly higher in FLO-100 diet-fed fish compared to others. A direct relationship was found between the amount of linseed oil in the diet and the average weight of fish. Significantly higher amylase, total protease and trypsin activities were found in FLO-0, FLO-25 and FLO-75 diets fed snow trout, respectively compared to others. The chymotrypsin and lipase activities were significantly higher in the FLO-100 treatment compared to others. There were no significant difference in the protein, lipid and ash contents among five different diets fed fish. Total saturated and mono-unsaturated fatty acids contents were significantly higher in FLO-75 diet-fed snow trout compared to others. Similarly, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and total n-3 polyunsaturated fatty acids (PUFA) contents were significantly higher in the FLO-75 treatment compared to others. Relative expression of delta-6 desaturase (fads2d6), fatty acid synthase (fas), elongase of very long chain fatty acid 5 (elov15) and elongase of very long chain fatty acids 2 (elov12) were significantly higher in linseed oil incorporated diet fed snow trout compared to the control one. The incorporation of linseed oil in the diet enhanced the n-3 content in snow trout.

KEYWORDS: Schizothorax richardsonii, Linum usitatissimum oil, Eicosapentaenoic acid, Docosahexaenoic acid, Delta-6 desaturase

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Assessment of Co-feeding Strategies with Artificial Diets and Fresh Wolffia globosa on Growth Performance, Physiological Health, and Economic Efficiency in Semi-Intensive Polyculture of Osteobrama belangeri and Ompok bimaculatus

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The present study evaluated the effects of co-feeding artificial feed and fresh Wolffia globosa in a semi-intensive polyculture system involving Osteobrama belangeri (pengba) and Ompok bimaculatus (pabda). The experiment was conducted using three feeding regimes: T1, where only artificial feed was provided targeting pabda (crude protein: 32%, feeding rate: 2-5% of pabda biomass, feeding time: 7-8 p.m.); T2, which co-fed two artificial feeds targeting both pabda (same as T1) and pengba (crude protein: 25%, feeding rate: 2-5% of pengba biomass, feeding time: 9-10 a.m.); and T3, where the pabda-targeting artificial feed (same as T1) was supplemented with fresh Wolffia globosa at 50-125% of pengba biomass (feeding time: 10 a.m.). The trials were conducted in triplicate in nine cement tanks (4m x 3m x 1m) with a soil base. Results showed that the single-feed regime (T1) produced significantly lower growth performance in both pengba and pabda compared to co-feeding regimes (T2 and T3). Pengba displayed superior growth in the T3 regime, with no significant difference in pabda growth between T2 and T3. Feed efficiency (AFCR, APER, APCE) was notably better in T1 and T3 compared to T2. Haemato-immunological parameters, including total erythrocyte count (TEC), total leukocyte count (TLC), packed cell volume (PCV), nitroblue tetrazolium (NBT), and lysozyme activity, indicated improved fish health in T3. Pengba's relative gut length (RGL) was significantly higher in T3. Sensory evaluation revealed better overall acceptability of both pabda and pengba in T2 and T3. Water quality in terms of total ammoniacal nitrogen and nitrate nitrogen was significantly better in T3, while T2 had the highest concentrations. Economically, T3 yielded 56% more profit than T1 and 26% more than T2, demonstrating the advantage of co-feeding Wolffia globosa for enhancing growth, health, and profitability in polyculture systems.

KEYWORDS: Polyculture, Pabda, Pengba, Artificial feed, Fresh Wolffia

Biofloc Meal as A Replacement for Fish Meal in The Diet Could Enhance Growth Performance, Health Status and Muscle Quality of Striped Catfish (*Pangasianodon hypophthalmus*)

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The increased market prices and irregular availability of fish meal are the burning issues in the aquafeed industry and biofloc meal has been gaining popularity in the sector as one of the most nutritious components in aquafeed. The study investigated the influence of the dietary replacement of fish meal with biofloc meal (BFM) on the overall growth performance, health status and muscle quality of striped catfish (Pangasianodon hypophthalmus). The fish (7.71±0.01 g initial body weight) was fed for 120 days with six iso-protenous (31.66±0.06 %) and isoenergetic (21.93±0.02 MJ/kg) floating diets which were formulated to replace 0% (BFM0- control diet), 10% (BFM10), 20% (BFM20), 30% (BFM30), 40% (BFM40) and 50% (BFM50) of fish meal with BFM. The fish were randomly distributed in six treatments with triplicate at the stocking density of 30 nos/m³ in indoor 10001 experimental fiberreinforced plastic tanks. During the culture, no significant difference was observed in water quality parameters among the treatments. The crude protein and lipid contents of BFM diets were 47.45% and 5.13% (dry weight), respectively. The amino acid and fatty acid content were almost similar to fish meal. Among the treatments, fish fed with BFM40 showed significantly (p<0.05) higher growth performance (14.57-76.88% body weight gain, 5.35-25.47% SGR, 1.48-15.20% PER, 2.68-21.34% ANPU), somatic indices (4.98-28.47% VSI and 3.45-37.27% HSI), digestive enzymes activity (11.44-55.88% amylase, 3.29-46.44% protease, 12-133.33% lipase) with improved 11.70-13.22% FCR, enhanced flesh quality and hardness. Also, fish fed with BFM40 showed improved haematological (7.88-80.95% TEC, 4.59-33.22% TLC, 1.32-16.67% Hb, 5.91-26.13% Ht), immunological (2.63-21.03% TSP, 4.50-38.10% albumin, 1.88-15.21% globulin, 10.90-48.13% RBA, 4.02-76.21% lysozyme), antioxidant responses (13.44-74.32% SOD and 8.14-89.96% catalase) and lower metabolic stress enzyme responses (13.79-46.35% ALT, 6.90-19.98% AST and 0.92-19.92% glucose). Moreover, fish fed with BFM40 showed enhanced intestinal villi surface area and height with a certain extent of liver vacuolation. Overall, fish showed significantly (p<0.05) enhanced growth performance and improved health status with increasing dietary inclusion of biofloc meal upto BFM40. Based on the experiment's findings, partial dietary replacement of fish meal (40%) with biofloc meal could be beneficial as a cost-effective alternative ingredient in the striped catfish diet which directs the future sustainability in aquaculture production.

KEYWORDS: Biofloc meal, Fish meal, Striped catfish diet, Growth, Health status

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Dietary Lemon Peel Extract Alleviates Cold Stress in *Labeo rohita* (Hamilton, 1822) Fingerlings

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An 8-week study was conducted to evaluate the impact of dietary lemon peel extract on feed intake and growth of *Labeo rohita* (rohu) fingerlings reared at low temperatures (18±1°C). As part of the preliminary investigation, the antioxidant properties of lemon peel extract (LPE) in water and ethanol were assessed using DPPH (2,2-diphenyl-1-picrylhydrazyl), TPC (Total Phenolic Content), and FRAP (Ferric Reducing Antioxidant Power) assays. The results revealed that ethanol extract (25 mg/l) exhibited higher antioxidant activity across all assays. Five isonitrogenous (300.0 g/kg) and isocaloric (16.10 MJ/kg) diets were formulated with varying levels of ethanol-based lemon peel extract: control (0.0 g/kg), LPE2.5 (2.5 g/ kg), LPE5.0 (5.0 g/kg), LPE10 (10.0 g/kg), and LPE20 (20.0 g/kg). The average initial body weight of the fingerlings was 10.30±0.5 g, and the experiment was carried out in a lowtemperature recirculating aquaculture system (RAS) with a flow rate of 1.5 l/min. The findings indicated that dietary lemon peel extract supplementation significantly improved feed intake and growth performance in rohu fingerlings (p<0.05). Fish fed with 5.0 g/kg LPE showed the highest growth rates, thermal growth coefficient (TGC), and feed conversion (p<0.05), although TGC was similar between the LPE5.0 and LPE10 groups (p>0.05). Growth rates were positively correlated with protease and aminotransferase enzyme activities (p<0.05). Additionally, LPE supplementation significantly enhanced hepatic malate dehydrogenase, citrate synthase, superoxide dismutase, and catalase activities (p<0.05). Based on these results, it can be concluded that dietary lemon peel extract at a 5-10 g/kg level positively influences feed intake and metabolic activity in rohu reared at low temperatures.

KEYWORDS: Winter rearing, Feed utilization, Metabolic changes, Antioxidant properties, Labeo rohita

Effective Utilization of Valorized Non-Mulberry Silkworm Spent Pupae in Catfish Diet for Bioconversion

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The growth and health status of striped catfish (*Pangasianodon hypophthalmus* S.) fingerling was studied using dietary non-deoiled tasar silkworm pupae (*Antheraea mylitta* D.). At 90 days, the 25% replaced diet demonstrated the best growth with a 152.60±3.56% biomass growth rate, 1.54±0.04 feed conversion ratio, and 2.33±0.06 protein efficiency ratio equivalent to the control diet (fishmeal-based). The liver alkaline phosphatase activity displayed a decreasing trend (p<0.05). The serum superoxide dismutase activity increased from 0% upto 50% and eventually decreased (p<0.05). Lower levels of hemoglobin, hematocrit, serum total protein, albumin, globulin, and triglyceride content were recorded among the treatments at 25% replacement onward (p<0.05). Exceeding 25% replacement, a hepatocyte alteration was also evident. Thus, full-fat tasar pupae (65% protein) could be an alternative to substitute at least 25% dietary fishmeal optimally without detrimental effects to improve the overall return under waste-to-wealth bioconversion.

KEYWORDS: Pupae meal, Pangasianodon hypophthalmus, Protein replacement, Growth

Substituting Soybean Meal with Winged Bean Meal and Evaluation of Growth and Physiology of *Ompok bimaculatus* (Bloch, 1794)

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The major ingredients that contribute to protein concentration in feed are fish meal and soybean meal. In search of a new potential protein source, the winged bean was found to have a protein concentration of 28 to 45%. Winged bean has good quality protein and a similar amino acid profile as soybean meal which makes it more suitable to substitute soybean meal. Growth was evaluated after a culture period of 70 days. The research was done with 4 treatments and control in triplicates and fed with 35% protein content formulated feed twice daily with a stocking density of 25 nos, per tank of 150 l water volume. The average weight of the fish was 1.24±0.23 g. Survivality had no significant difference (p>0.05) though better performance was seen in 25%. Growth had better performance at the 25% inclusion level of winged bean but had no significant difference with the 50% inclusion level. FCR was seen best in 25% substitution. This study did not observe any substantial alterations in the activity levels of protease, amylase, and lipase. When compared to the control, there was a notable rise in the WBC values. The PCV dropped with increasing replacement levels of soybean meal, but the blood Hb level was also raised similarly. The levels of GOT and GPT values were observed to be lowest in the group with a 25% replacement. From the overall performance shown, we can consider that 25 % had the best result though the 50% inclusion level of winged bean didn't have a significant difference (p>0.05) in so many aspects. Thus, with proper treatment of winged beans, for example, heat treatment which is one of the easiest ways to reduce the ANFs, can be applied for better growth performance.

KEYWORDS: Soybean meal, Winged bean, Growth, Physiology

Defatted Hermetia illucens Larvae Meal in The Diet of Pangasianodon hypophthalmus: Effects on Growth, Digestibility and Nutrient Retention

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This study evaluated the potential of (Hermetia illucens, IM) larvae meal on growth, digestibility and nutrient utilization of striped catfish, Pangasianodon hypophthalmus. Four diets (crude protein: 32%) were formulated to contain 0 (control; fishmeal-based diet), 4 (IM 4), 8 (IM 8), and 12 percent (IM 12) of insect meal, corresponding to 0, 37.5, 75, and 100% replacement of fishmeal, respectively. Healthy and uniform-sized 180 fingerlings (initial average weight: 20.3±0.16 g) were randomly distributed into 12 individual tanks with 15 fingerlings in each tank, and fed two times daily till visual satiety for 10 weeks. Thermal growth coefficient (TGE), and net protein utilization (NPU) were similar in fish consumed control, IM4, and IM8 diets (p>0.05). However, reduced TGE and, NPU were recorded when inclusion levels exceeded 8%. Dietary composition did not influence intestinal trypsin, aminopeptidase, or alkaline phosphatase activities (p>0.05). Lower levels of pepsin were observed in fish fed IM 12 diet compared to other groups. The crude protein digestibility was significantly reduced at 12% inclusion levels of insect meal. However, the lipid digestibility was unaffected by the dietary composition (p>0.05). Nitrogen retention decreased with increased inclusion levels of dietary defatted insect meal. Based on growth performance, it is recommended that upto 8% of defatted Hermetia illucens larvae meal (75% replacement of fish meal) is the optimum inclusion level for *Pangasianpdon hypophthalmus*.

KEYWORDS: Pangasius, Hermetia illucens, Black soldier fly, Fishmeal, Growth, Apparent digestibility

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Age-Specific Changes in the Serum Proteome, Amino Acids and Antioxidant in Anadromous Fish, Hilsa (*Tenualosa ilisha*): Their Implications for Aquaculture Conservation

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This study aimed to analyse the amino acid, antioxidant and proteomics of Hilsa (*Tenualosa* ilisha) serum. The biochemical and physiological parameters and serum proteome levels of different weight groups and sex groups ranging from 50-400 g were analysed. The profile of amino acids was influenced by maturity, and essential amino acids (EAA) were significantly higher in Hilsa muscle than non-essential amino acids (NEAA). In mature male Hilsa (300-400 g), the amino acids were higher than in females, but there were no such differences in the lower weight group. The antioxidants were studied based on the scavenging of commercially available free radicals viz; 2, 2'-azinobis- [3-ethyl-benzothiazoline-6-sulfonic acid] and ferric reducing antioxidant potential. Antioxidant assay values were higher in females (93.79%) than males (84.50%) and were more than 70% in all the organs and serum of Hilsa. Applying advanced LC-MS/MS base proteomics including bioinformatics, analysis of serum proteome levels show different proteins associated with GO terms, and the genes and associated enriched KEGG pathways (e.g., phagosome, mTOR, Apelin signaling pathways, herpes simplex virus) that implicated in immune responses. In this study, we annotated 952, 494, 415 and 282 proteins in the year class IV to class I and analysed their PPI networks with respect to their functional characteristics. This study will help understand the various changes that occur in the different age groups during the process of breeding and migration for developing a high-value species for conservation aquaculture.

KEYWORDS: Proteome, Amino Acids, Antioxidants, Hilsa, LC-MS/MS

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Effects of Dietary Lipid Levels on Gonadal Maturation and Egg Quality of *Anabas testudineus*

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An experiment was carried out to determine the optimum lipid requirement of Anabas broodstock and its effect on gonadal maturation, reproductive performance, egg, and larval quality. Five isonitrogenous (CP 40%) diets with varying levels of dietary lipids (6-14%) were formulated and fed for 90 days. For this, 90 males (23±5 g) and females (33±5 g) of uniform size (sex ratio of 1:1) were randomly distributed into five distinct experimental groups (T1: dietary lipid level of 6%; T2: dietary lipid level of 8%; T3: dietary lipid level of 10%; T4: dietary lipid level of 12%; T5: dietary lipid level of 14%). The results revealed that higher weight gain was observed in fish who consumed a diet with 10% lipid. Similarly, the gonado-somatic index (GSI), fecundity, and relative fecundity (%) were significantly higher in the lipid level of 10 and 12% in comparison to the 6, 8, and 14% lipid levels. The egg size was significantly higher at 10, 12, and 14% lipid levels compared to 6 and 8%. The fertilization and hatching rates were non-significant (p>0.05) among all groups. Notably, the survival percentage of larvae was significantly increased with dietary lipid levels up to 10%. However, survival of larvae was similar in fish fed 10, 12, and 14%. Based on all observed responses, it is recommended that the dietary lipid of 10% is optimal for improving reproductive performance and larval survival of *Anabas testudineus*.

KEYWORDS: Anabas testudineus, Dietary lipid, Gonadal maturation, Reproduction, Larval survival

Guanine and Carotenoid Fortified Diet Improves Coloration of *Colisa lalia* in Captive Condition

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Skin coloration is one of the most important factors which decide the aesthetic as well as the market value of ornamental fishes. Coloration in fish is due to the presence of pigment cells such as melanophores, erythrophores, xanthophores, and cyanophores, leucophores, and iridophores. In the present study, increase in iridophore and xanthophore pigmentation through incorporation of guanine and carotenoid (marigold powder), respectively, was studied in Colisa lalia. Under this experiment, the effect of a guanine rich diet and a carotenoid rich diet on coloration was studied. The fishes were fed with four different types of diet in triplicate viz., diet 1 (C), diet 2 (T1), diet 3 (T2) and diet 4 (T3). The diet 1 (C) was prepared without the fortification of guanine and marigold powder, T1 with guanine (0.4 g/100 g of diet), T2 with guanine 0.4 g/100 g of diet and marigold powder 4.0 g/100 g of diet) and T3 with marigold powder (4.0 g/100 g of diet). Experiment was conducted in 12 tanks of 50 l capacity with 10 fishes/tank. Feeding was done twice a day. After 90 days of feeding, the results were evaluated for the organoleptic tests and colorimetric analysis. In organoleptic test, overall body colour was seen best in T3 with increased yellowness. During colorimetric analysis, it was found to have increased bluish coloration for T1 fish fed with guanine and increased yellow coloration for T3 fish fed with carotenoid diet. This was due to the enhancement effect of guanine and carotenoid components in T1 and T3, respectively. Thus, the present study concludes that Colisa lalia exposed to different feeding components and compositions responded to colouration for pigmentation of both iridophore and xanthophores providing pronounced silvery bluish and yellowish colours, respectively.

KEYWORDS: Colisa lalia, Guanine, Iridophores, Carotenoid, Xanthophore

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Histopathological, Biochemical and Molecular Changes Observed During Visceral Fat Deposition in *Labeo catla* Females due to Improper Dietary Protein to Carbohydrate Ratio

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Abnormal visceral fat deposition severely impairing reproductive performances in catla females was recently reported in high protein and carbohydrate diets. The present study investigated the histological, biochemical and molecular changes leading to this physiological phenomenon of visceral fat deposition during oogenesis in catla brood stock. The feeding trial was conducted in three equal-sized (0.04 ha) earthen ponds for four months (120 days) to evaluate the effect of different protein-to-carbohydrate ratios on visceral fat deposition. The broodstock (100 fish per group, ~200 kg biomass) was fed with three experimental diets: Feed-II and Feed-III, formulated with varying ratios of groundnut oil cake and rice bran (2:1, 1:1, and 1:2, respectively). The highest VSI and HSI were recorded in the F-III followed by F-I, and least in the F-II diet treatment. Histological examination of liver tissues revealed swollen hepatocytes and distorted cell structures in fish fed with F-I and F-III diets. At the same time, the F-II maintained normal/healthier hepatic architecture. Accumulation of oil droplets in hepatic tissues was visible under the microscope more in F-III, lesser in F-I and not recognisable in the F-II group. Histological observations showed inflammatory and degenerative changes in the hepatic and adipose tissue in F-I and F-III treatments but normal appearance in the F-II group. Biochemical analysis showed increased serum levels of glucose, glycogen, leptin, insulin, ALT, AST, ALP, triglycerides, cholesterol, HDL, and VLDL in the F-I and F-III treatments. Molecular analysis revealed significant upregulation (2-3.5-fold) of fatty acid synthase (FAS) and acetyl-CoA carboxylase alpha (ACCα) mRNA in the liver of fish fed with F-I and F-III diets. At the same time, reproductive genes GnRH and GtH were upregulated (1.8-2.5-fold) in the brain and pituitary tissues of the F-II group. Vitellogenin (Vtg) expression was also higher (~2-fold) in the liver and gonads of the F-II group. The elevated mRNA levels of FAS and ACCα in the F-III and F-I groups in previtellogenic females suggested enhanced visceral fat synthesis. Conversely, the upregulation of GnRH, GtH, and Vtg in the F-II group indicated normal functioning of the BPGL axis. All these indicated efficient synthesis and mobilization of visceral fat, normal endocrine function and vitellogenesis in the F-II group, while these physiological processes were disrupted in the other two treatments.

KEYWORDS: Catla, Visceral fat, Gene expression, Vitellogenesis

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Relative Efficacy of Fresh Wolffia (Wolffia globosa) Based Feeding Strategies in Polyculture System of Indian Major Carps

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Fingerlings of Indian major carps namely, Catla catla (catla; 59-67g), Labeo rohita (rohu, 98-118 g), and Cirrhinus mrigala (mrigal, 36-52 g) were stocked at a combined density of 15,000 fish/ha in 15 outdoor cement tanks (4 m x 3 m x 1 m) provided with a 6-8 cm soil bed. They were fed in 12-week grow-out trial with different diets in triplicates; a commercial floating diet (CP:27%; T1), 1:1 (dw/dw) mustard oil cake and rice bran (T2), 1:3 (dw/dw) fresh Wolffia and rice bran (T3), 1:1 (dw/dw) fresh Wolffia and rice bran and T5- only fresh Wolffia at 4% BW/d on dry weight basis). Feeding was done once a day. The feed ration was adjusted fortnightly after fish sampling. Catla showed significantly high (p<0.05) weights in T1 and T5 compared to T2, while rohu in T4 and T5 and mrigal in T4 compared to the rest of the other treatments. The overall yield $(g/m^2/d)$ was significantly high in T5 (2.2 ± 0.105) , followed by T4 (2.06±0.137), and the lowest in T2 (0.581±0.269). There were no significant differences in AFCR. However, APER was significantly high for T3 and T4 compared to the rest of the treatments (values ranged from 1.14±0.24 to 1.99±0.0967). The antioxidant properties of the flesh measured in DPPH% values, showed significant differences in mrigal, with higher values observed in Wolffia-involved treatments (T3, T4, T5). However, in catla and rohu, no significant differences were observed across the treatments. Feeding with the combination of fresh Wolffia and rice bran (1:1; T4) yielded significantly improved net farm return. Considering that Wolffia can easily be grown by farmers, the present study demonstrates that feeding with fresh Wolffia + rice bran fish (1:1) in a semi-intensive polyculture system of Indian major carp can be a cost-effective, superior and resilient alternative feed strategy.

KEYWORDS: Indian Major Carps, Wolffia globosa, Rice Bran, Mustard oil cake, Alternative feed strategy, Cost-effective, Resilient feed strategy

Causes of Variation in Tastes of Hilsa Between the Meghna and Tetulia River Systems

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Hilsa shad (*Tenualosa ilisha*) is one of the most important anadromous fishes (ascending rivers from the Bay of Bengal) that migrate into the Meghna and Tetulia River systems in Bangladesh. Hilsa is the national fish of this country and is famous for its taste and delicacies, especially among the vast majority of the Bengali population, living in Bangladesh and the seven sister states of India. There is a wide complaint among consumers of all ages about the variations in tastes of hilsa fish captured from different river systems. However, information on the differences in tastes of hilsa among different river systems in this region is scarce. An effort was made to observe the causes of differences in tastes of hilsa between the Meghna and Tetulia River systems closely by nutritional profiling (amino and fatty acids analysis). The nutritional composition revealed that higher myristic and lauric acid contents were found in the Meghna hilsa whereas myristic, oleic, and lauric acid contents were higher in the Tetulia hilsa. The taste-active components such as nonessential amino acids (glutamic acid> glutamine> aspartic acid> alanine> glycine) and essential amino acids (lysine> methionine> isoleucine phenylalanine) were higher in hilsa fish of the Tetulia River estuary compared to that of the Meghna River estuary. Higher contents of taste-active components such as amino acids viz., glutamine, glutamic acid, alanine, aspartic acid, lysine, methionine, isoleucine, lysine; and fatty acids viz., myristic acid, lauric acid, and oleic acid along with higher n3:n6 fatty acid is attributed to the superior taste of hilsa from the Tetulia. To support the reasons for better amino acid performance in Tentulia hilsa, both plankton and hilsa fish samples were collected from the Meghna and Tetulia estuaries at a similar time. Chlorophyta (green algae) was the dominant phytoplankton group in Meghna's hilsa gut (40%) compared to Tetulia (30%), whereas bacillariophyta (diatoms) were the dominating group in Tetulia's hilsa gut (60%) compared to Meghna's (25%). The study suggests conducting a thorough investigation to determine whether the hilsa stocks in the two river systems differ genetically.

Keywords: Hilsa, Amino acid, Fatty acid, Plankton

Understanding the Growth Patterns of Thraustochytrids for Potential Fish Oil Replacement in Marine Aquafeeds

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This study highlights the potential of Thraustochytrids, specifically *Schizochytrium* sp. and *Aurantiochytrium* spp., as sustainable and promising alternatives to traditional fish oil in marine aquafeeds. Due to their ability to produce substantial amounts of docosahexaenoic acid (DHA), thraustochytrids have the potential to replace the inclusion of fish oil in marine aquafeeds. Therefore, the focus of this study was to assess the growth rates, biomass production, and the detailed amino acid composition and fatty acid profiles, particularly DHA content, of three different Thraustochytrid strains; one strain of *Schizochytrium* and two strains of *Aurantiochytrium*. Through a series of experiments, the study found that the growth of these microorganisms was significantly influenced by the presence of methyl donors in the culture media and the DHA content observed in these strains was found to be comparable to that present in traditional fish oil sources. These findings confirm that Thraustochytrids could serve as a sustainable and efficient alternative source of fish oil in aquafeeds, addressing the critical need for environmentally friendly and cost-effective omega-3 sources in mariculture.

KEYWORDS: Growth, Thraustochytrids, Fish Oil, Aquafeeds

Pre and Post-Challenge Immuno-Haematological Changes in *Anabas testudineus* Juveniles Fed Rice Distillers' Dried Grains Soluble with Exogenous Non-Starch Polysaccharidases

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A feeding trial was conducted for 60 days to delineate the combined effect of dietary rice distiller's dried grains Soluble (DDGS) blended with exogenous non-starch polysaccharidases (NSPase) on pre- and post-challenge hemato-immunological responses in climbing perch, Anabas testudineus juveniles. Five hundred and forty juveniles (avg. wt. 5.00±0.2 g) were randomly distributed into 12 treatment groups executed in triplicates. Twelve iso-proteinous (40% crude protein) and iso-lipidic (8%) semi-purified diets with either 0, 10, 20, or 30% of rice DDGS in place of fish meal were prepared with different NSPase (Cellulase: Xylanase: Arabinoxylanase: Glucanase:: 1:1:1:1 w/w) concentrations (0, 0.1 or 0.2%). During the prechallenge period, significantly higher (p<0.05) total erythrocyte count (TEC), hemoglobin, serum total protein, albumin, and globulin content was recorded in the group fed with 20% rice DDGS. Irrespective of the level of rice DDGS, NSPase supplementation had no effect (p>0.05) on the TEC, hemoglobin, serum total protein, albumin, and globulin content. The A:G ratio, SGOT, SGPT, and serum glucose content were significantly higher (p<0.05) in the 30% rice DDGS fed group both in the pre- and post-challenge phase. The supplementation of NSPase at either 0 or 0.1% had significantly raised (p<0.05) the SGOT and SGPT in both pre- and post-challenge periods. NSPase supplementation at any level had no significant effects (p>0.05) on A:G ratio and serum glucose content in the post-challenge phase. Significantly highest (p<0.05) mortality was observed in the group fed with either control or a diet containing 30% rice DDGS, however irrespective of the level of rice DDGS, NSPase supplementation (0.1 or 0.2%) had significantly enhanced (p<0.05) the survival (%). This study concludes that dietary inclusion of 30% rice DDGS leads to immune suppression and increases susceptibility to Aeromonasis whereas, the opposite stands true for dietary inclusion upto 20% rice DDGS. Further supplementation of this diet with 0.1% intensifies the immune status of the A. testudineus. Dietary rice DDGS and exogenous NSPase interactions are effective in stimulating the disease resistance to Aeromonas infection.

KEYWORDS: Rice distiller's dried grains Soluble, *Anabas testudineus*, Challenge study, Hematoimmunological parameters, Survival

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Development Profile of Digestive Enzymes and Intestinal Nutrient Transporters During the Early Ontogeny of Himalayan Snow Trout, Schizothorax richardsonii

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Knowledge of the ontogeny of the digestive system is a critical prerequisite for the development of appropriate larval feeding regimes for any fish species of aquaculture interest. Therefore, this study characterized the ontogenic profile of key digestive enzymes and intestinal nutrient transporters in the Himalayan snow trout (Schizothorax richardsonii) larvae, from 0 to 21 days post-hatch. Wild snow trout brooders were collected and bred in captivity at 20-22°C, at ICAR-DCFR flow-through hatchery, Uttarakhand, India. Posthatching, the digestive physiology of snow trout larvae was studied using biochemical (enzyme activity) and molecular (mRNA expression) approaches. The larvae exhibited an exclusive lecithotrophic phase until 8 dph; followed by an endogenous-exogenous transition phase until 15 dph (fed Artemia nauplii and larval diet); and complete exogenous feeding with larval diet during 15-21 dph. With respect to larval growth, gain in weight (478%) was higher than length (114%). Activity and mRNA levels of the proteolytic enzymes (trypsin, chymotrypsin, carboxypeptidase and leucine aminopeptidase) and peptide transporter (pept1) significantly increased only after the onset of exogenous feeding and peaked on or after 12 dph. Similarly, the expression of lipase (bal, lipc), maltase and lipid-glucose transporters (mttp, sglt1, glut2) increased on or after 9 dph and peaked at 21 dph. The activity and mRNA abundance of amylase coincided with the onset of complete exogenous feeding (on or after 15 dph). The higher expression of apolipoprotein B (apob) and lap during the lecithotrophic phase (before 8 dph) indicates their potential role in utilizing yolk nutrients. Concerning the multifunctional brush border enzyme alkaline phosphatase, mRNA levels were high during 7-9 dph and activity increased after 12 dph and peaked at 21 dph, indicating gut maturation and its role in aiding alkaline digestion. Overall, the development profile of digestive enzymes and intestinal nutrient transporters clearly indicates dietary stimulation and regulation, which is relevant for the weaning and hatchery management of this agastric teleost.

KEYWORDS: Fish, Larval development, Digestive enzyme activity, Intestinal nutrient transport, Gene expression, Weaning



Effect of Meal Timing on Growth Performance, Physiological Traits and Postprandial Kinetics of Digestive and Metabolic Indices in Rainbow Trout (*Oncorhynchus mykiss*)

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Globally, cost of feeding is a major challenge in salmonid aquaculture. Optimizing feeding strategies such as meal timing could substantially reduce operational expenses. In this context, we carried out an 8-week feeding trial to evaluate the effect of meal timing on growth, feed utilization, carcass composition, tissue metrics, metabolic oxygen consumption rates, thermal tolerance limits, and postprandial kinetics of digestive enzymes and plasma metabolites in juvenile rainbow trout. Six replicate tanks of 12 fish were randomly assigned to a morning (fed at 9 am) or evening (fed at 5 pm) feeding group. At the end of the trial, evening feeding resulted in significantly improved growth and feed efficiency; whereas, morning-fed fish exhibited higher feed intake. Protein retention and nitrogen gain were significantly higher in the evening-fed group, concurring with the growth indices. Likewise, postprandial kinetics of digestive enzymes, namely chymotrypsin, trypsin, leucine aminopeptidase, alkaline phosphatase, amylase, and lipase exhibited significant peaks in the evening-fed group, indicating the possible role of enhanced digestion behind the growth difference. Routine and maximum metabolic oxygen consumption rates showed no significant differences between the treatments. Nevertheless, the morning-fed fish exhibited a higher critical thermal maximum indicating an improved welfare state. Corroborating this, postprandial kinetics of plasma metabolites revealed elevated levels of albumin, globulin, total protein, total antioxidant and aspartate transaminase activities in morning-fed fish. Also, morning-fed fish showed significantly higher plasma triglycerides, carcass lipid content and intraperitoneal fat, suggesting increased fat deposition. In summary, evening feeding was found to promote growth, feed utilization and digestion in juvenile rainbow trout; while morning feeding favoured fat deposition and physiological welfare. Overall, our findings provide valuable insights for optimizing meal timing to achieve tailored benefits in rainbow trout production.

KEYWORDS: Aquaculture, Rainbow trout, Meal timing, Growth, Metabolism, Digestion

Effect of Diet Composition and Feeding Ration on Growth, Feed Use, Carcass Nutrient Estimates and Thermal Tolerance of *Pangasianodon hypophthalmus* at Low Rearing Temperature

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A 10-week feeding trial was conducted in juvenile pangasius catfish at sub-optimal (24±1°C) temperature to evaluate the effects of dietary macronutrient composition and ration size on growth performance, feed utilisation, whole body composition, carcass nutrient retention/ gain estimates, tissue metrics and critical thermal tolerance limits. In this 2×2 factorial study design, the fish were fed diets with either high or low protein and lipid (HPL: 40/10 vs. LPL: 28/4 percent) content, at two different feeding rations (1 or 2% of the body weight; 1R vs. 2R). At the end of the feeding period, weight gain, specific growth rate, thermal growth coefficient and nitrogen gain estimate were significantly higher in the HPL and 2R dietary treatments. Particularly, fish fed HPL diet at 2R showed the maximum growth and nitrogen gain, with significant diet and ration interaction. Besides, as compared to the LPL group, HPL fish showed significantly higher feed efficiency, protein retention, whole-body protein content and dressed weight, regardless of the ration size. Concurrently, the nitrogen loss estimate was found to be marginally higher in the HPL group, corresponding to the higher dietary protein intake. Whole body phosphorus content was however significantly lower in the HPL dietary group than the LPL fish. With respect to thermal tolerance, the upper critical thermal tolerance limit (CTmax) and thermal scope were higher in the HPL dietary group, indicating improved fitness traits. Interestingly, the highest CTmax was observed in the HPL group fed 2R, and inferior CTmin values were observed in the LPL dietary group fed 1R. With regard to the effect of feed ration, 2R feeding was associated with an increase in the viscerosomatic index of the fish and substantially higher nitrogen loss. Apparent routine metabolic oxygen consumption (aquatic state) showed no significant differences due to diet or ration. Overall, both diet composition and ration size were found to be critical determinants of the performance and welfare of pangasius catfish at low-temperature conditions, with significant interactional effects.

KEYWORDS: Striped catfish, Low temperature, Macronutrient composition, Feeding ration

Unlocking the Rice Straw Menace: Investigating Pre-Treatment Methods and Insect Bioconversion as Waste Management Strategy

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Rice straw, a globally abundant agricultural byproduct, presents significant waste management challenges. Insect bioconversion offers a promising valorisation strategy, transforming this waste into valuable protein for animal feed. This study investigated the effects of four rice straw pre-treatment methods viz., chemical (C), biological (B), biochemical (BC), and a control (N) on substrate nutritional composition, black soldier fly (*Hermetia illucens*) larval growth, and the resulting larval nutritional profile. Biochemical pre-treatment significantly enhanced crude protein (9.11±0.32%) and crude lipid (2.08±0.02%) content in the treated straw (p≤0.05). While the control (N) exhibited higher lignin and hemicellulose levels, BC maximized cellulose content (44.4±0.26%). Larvae reared on BC-treated straw demonstrated superior growth performance, exhibiting significantly higher crude protein (43.60±0.27%) and lipid (9.75±0.03%) levels (p≤0.05), along with improved survival, waste reduction index, and feed conversion efficiency. These findings highlight the efficacy of biochemical pre-treatment in enhancing rice straw as a substrate for BSF larval production, offering a sustainable solution for both agricultural waste management and high-quality protein production for aquatic animal feed.

KEYWORDS: Rice straw, Black soldier Fly, Waste reduction, Lignocellulose

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Research on the Efficiency and Influencing Factors of Feed Utilization of Aquatic Products in China — From the Perspective of Farmers

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The rapid expansion of aquaculture has catalyzed the evolution of China's aquatic feed industry, intensifying production pressures, particularly regarding the scarcity of protein sources for feed. Addressing the challenge of enhancing feed utilization efficiency holds substantial theoretical and practical implications for the sustainable development of China's aquaculture sector. Drawing on field surveys conducted by the project team, this paper presents findings from interviews with 382 Penaeus vannamei producers across the provinces of Shandong, Hebei, Jiangsu, and Guangdong from 2017 to 2023. The feed coefficient is employed as a key metric for assessing the feed utilization efficiency. Our research has revealed that: (1) Over the years, the feed coefficient of *Penaeus vannamei* exhibits a slight downward trend, although the decrease is not significant. (2) Among farming modes, the feed costs associated with factory farming are higher than those for pond farming; however, the difference in feed utilization efficiency between these two is relatively minor. (3) Multiple regression models indicate factors such as educational level, years of farming experience, scale of operations, and the quality of technical services received by farmers, all have significant negative impacts on the feed coefficient. Moreover, while the breeding mode has a positive effect, the choice of feed brand and overall feed utilization efficiency negatively influences feed utilization efficiency. (4) The heterogeneity analysis reveals that, within the factory farming model, factors such as gender, educational level, farming density, and the level of technical services significantly negatively impact farmers' feed utilization efficiency. In contrast, within the pond aquaculture model, factors such as years of farming experience, feed brand selection, breeding density, and the level of technical services also demonstrate significant negative effects on feed utilization efficiency. Regional differences significantly influence both factory and pond farming methods. Based on research findings, this paper advocates; prioritizing the development of feed-related technologies, enhancing research on alternative protein sources, and ensuring that technology users and breeders (enterprises) fully understand, master, and effectively utilize new feeding technologies. Secondly, fostering interprovincial technological exchanges can stimulate innovation within the aquaculture sector. Enhanced training in aquaculture techniques is essential to elevate the professional capabilities of practitioners. Finally, bolstering government policy incentives and increasing financial investment and support for aquaculture is crucial to achieving highlevel sustainable development in China's aquaculture industry.

KEYWORDS: Aquatic products, Feed utilization efficiency, Influencing factors, Multiple regression analysis



Growth and Health of Juvenile Snubnose Pompano in Response to Various Dietary Insect Meal Combo as a Fishmeal Replacer

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A 90-day experiment was conducted for the replacement of fishmeal content using various insect meal combo in the diet for juveniles of Trachinotus blochii to assess the growth performance, feed utilization and nutritive profile. Five treatments each in triplicates were performed to replace fishmeal protein content using two different combo of insect meal [silkworm pupae meal (SWP)-black soldier fly meal (BSF) 3:1 ratio and krill meal (KM)green bottle fly meal (GBF) 3:1 ratio] at two different replacement levels (50 and 100%). Five iso-nitrogenous (40% crude protein) and iso-caloric (6% crude lipid) experimental diets were prepared. The diets and treatments were named as follows: SBP, 50% replacement of FM protein using SWP-BSF; SBF, 100% replacement of FM protein using SWP-BSF; KGP, 50% replacement of FM protein using KM-GBF; KGF, 100% replacement of FM protein using KM-GBF; and one fishmeal-based control diet (FM) group. The juvenile snubnose pompano with an average size of 8.25±0.25 g was stocked in the treatments. The study revealed that growth performance in terms of body gain percentage, specific growth rate, and average daily growth showed significant differences (p<0.05) among the treatments and higher values were observed in the KGP group. The feed utilization in terms of feed conversion ratio, feed efficiency and protein efficiency ratio showed significant difference (p<0.05) among the treatments and better response was witnessed in the KGP group followed by the FM group. The crude protein content of the KGP and SBP groups were higher than other groups and the crude lipid contents were significantly different among the treatments and higher value was witnessed in KGF followed by the SBF group. The protease activity was found higher in the KGP group whereas the amylase and lipase activity were higher in the SBF group. The histological observation of the liver section revealed that the hepatocytes of the KGP group were found normal without any changes in cytoplasm and nucleus. The study revealed that FM protein can be replaced using KM and GBF (3:1) upto 50%, followed by SWP and BSF (3:1) at 50% level for higher growth, gut health and feed utilization.

KEYWORDS: Insect meal, Feed conversion ratio, Krill meal, Black soldier fly meal, Waste valorization, Gut health

Protein-Sparing Effects of Carbohydrates in the Diet of Cultured Fish with Special Emphasis on Carnivorous Fish Species

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The expanding aquaculture business is leading to an increase in the production, consumption and cost of commercial fish feed. The primary cause of the fish feed price increase is fish meal which is used as a primary source of protein. Although protein is a crucial part of the diets of aquatic species, it is also the most expensive nutrient. Therefore, reducing the amount of protein in feed has become a crucial tactic in the ongoing growth of intensive aquaculture to reduce expenses. On the other hand, carbohydrates are the least expensive dietary energy source that can replace costlier protein as an energy source, decrease nitrogen loss and act as feed binders. Therefore, the ratio of protein (P) to carbohydrate (CHO) is one of the most important parameters to be considered when manipulating dietary nutrients to maintain the growth of aquaculture production. This literature review is written to summarize the earlier research findings on the protein-sparing effects of carbohydrates to provide compiled and relevant information, with a focus on carnivorous fish species that are poor consumers of carbohydrates. According to reviewed articles, protein sparing with carbohydrates reduces feed costs while simultaneously improving fish feed intakes and growth, boosting immune and oxidative stress defense mechanisms, and enhancing water quality. The feeding habits of fish species, source of dietary carbohydrates and inclusion levels are determining factors in partial substitution of protein with carbohydrate in the diet of carnivorous fish species. Although optimal inclusion of carbohydrates is beneficial to carnivorous fish species in their diet, excessive consumption of starch can hinder growth and often lead to poor feed utilization; it can also increase the likelihood of disease. Therefore, the maximum degree of dietary carbohydrate inclusion is typically determined by taking into account its ability to sparingly affect protein without negatively impacting the fish's physiology or growth.

KEYWORDS: Carbohydrate, Carnivorous fish, Fish meal, Protein

Assessment of Apparent Digestibility of Novel Feed Ingredients for Barramundi *Lates calcarifer* under the Red Sea Conditions

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The use of Black Soldier Fly larvae and Unibio microbial protein in aquaculture feed offers a sustainable alternative to traditional fishmeal, as both ingredients can be derived from organic waste or industrial byproducts, thereby reducing environmental impact, supporting circular economy practices, and alleviating pressure on wild fish stocks. This study aimed to evaluate the apparent digestibility coefficients for nutrients and energy of Black Soldier Fly meal sourced from China and locally produced varieties, alongside Unibio microbial meal, when fed to Barramundi (Lates calcarifer). A reference diet (RF) was formulated to meet the fish's nutritional requirements, with test diets created by combining 70% RF and 30% of the test ingredients. Barramundi averaging 338±44 g were acclimated on a basal diet for seven days, followed by another seven days on the experimental diets in triplicate groups, after which fecal matter was collected by stripping. Results indicated that Black Soldier Fly larvae from China had the highest dry matter digestibility at 64.4%, suggesting it is more efficiently utilized compared to other ingredients, while Unibio had the lowest dry matter digestibility at 36.3%, indicating potential inefficiency or a need for further processing. However, Unibio excelled in protein digestibility, achieving 88.2%, significantly higher than the Black Soldier Fly from China at 47.6% and the locally produced Black Soldier Fly at 9.7%, which indicates limited protein bioavailability and may require dietary adjustments. For energy digestibility, the Black Soldier Fly from China also led with 79.1%, followed by the locally produced Black Soldier Fly at 72.9%, while Unibio recorded the lowest energy digestibility at 45.7%, limiting its contribution as an energy source. These findings underscore the potential of these alternative protein sources in aquaculture, though the variability in digestibility emphasizes the need for further research to optimize their incorporation into commercial feed formulations.

KEYWORDS: Sustainability, Black soldier fly, Microbial protein, Aquaculture feeds

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Enhancing Pigmentation, Growth, and Survival of Koi Carp (Cyprinus carpio var. Koi) through Dietary Astaxanthin

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Cyprinus carpio var. Koi is highly sought after in the ornamental fish market, with pigmentation playing a crucial role in their sustainable trade with high commercial value. Astaxanthin, a carotenoid known for its pigmentation-enhancing properties, has been shown to benefit aquatic species. This study investigates the impact of astaxanthin supplementation on the pigmentation growth and survival of juvenile koi carp. During 56 days of rearing, four experimental groups were fed diets enriched with astaxanthin at levels of 0 mg/kg (T1), 50 mg/kg (T2), 100 mg/kg (T3), and 150 mg/kg (T4). Results indicated higher carotenoid levels in all astaxanthin-treated groups, leading to more vibrant skin coloration. Particularly, the fishes of the T3 group possessed significantly (p<0.05) higher pigmentation than other groups. Further, fishes receiving astaxanthin-enriched diets demonstrated improved growth metrics with insignificantly (p>0.05) higher SGR in the T3 group of fishes. Survival percentages were also insignificantly (p>0.05) higher in groups supplemented with astaxanthin compared to the control group. These findings suggest that Astaxanthin supplementation in koi carp diets effectively enhances pigmentation, growth and survival. This research supports the use of astaxanthin as an alternative carotenoid source in koi carp nutrition, ultimately increasing their market value.

KEYWORDS: Astaxanthin, Koi carp, Pigmentation, Growth, Survival

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Effects of Dietary Bile Acid and L-Carnitine on Growth Performance and Antioxidant Enzymes Activities of Gift Tilapia Juveniles Reared in Inland Saline Water

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Agriculturally unfit huge salt-affected ground areas can be converted to aquaculture resources for enhancing aquaculture production. Among euryhaline species, GIFT tilapia could be the most suitable one for culture in inland saline water (ISW) due to their hardy nature and tolerant efficacy of adverse environments. Moreover, the use of a low protein and high lipid or energy (LPHL or LPHE) diet supplemented with lipid-utilizing nutraceuticals could be an effective strategy for economic and sustainable aquaculture production. Therefore, a 60day experiment was conducted with the random distribution of 540 acclimated fish in 12 experimental groups in triplicate with the stocking density of 15 fish/circular tank (200 l water volume) and 12 hetero-nitrogenous (40-30% CP), hetero-lipidic (9-13%) and heterocaloric (413-434 kcal DE/100 g) experimental diets viz. T1 (40% CP and 9% lipid), T1B (T1 +0.05% bile acid), T1C (T1 + 0.05% L-carnitine), T1BC (T1 + 0.025% bile acid and 0.025% L-carnitine), T2 (35% CP and 11% lipid), T2B (T2 + 0.05% bile acid), T2C (T2 + 0.05% L-carnitine), T2BC (T2 + 0.025% bile acid and 0.025% L-carnitine), T3 (30% CP and 13% lipid), T3B (T3 \pm 0.05% bile acid), T3C (T3 \pm 0.05% L-carnitine) and T3BC (T3 \pm 0.025% bile acid and 0.025% L-carnitine) were prepared for feeding the fish of respective groups on satiation basis thrice daily. The highest (p < 0.05) weight gain percentage and specific growth rate and the lowest (p<0.05) feed conversion ratio were found in the T1B and T2B groups, while the fish of the T3C group exhibited the highest (p<0.05) protein efficiency ratio. The highest (p<0.05) activities of liver and gill superoxide dismutase and catalase were found in higher lipid (11% and 13%) fed groups, but dietary nutraceuticals reduced the activities with the highest reduction in the bile acid fed group followed by bile acid plus carnitine fed group. Therefore, it can be concluded that the T2B diet (35% CP and 11% lipid-containing diet supplemented with 0.05% bile acid) could register the best growth performance and antioxidant status of GIFT tilapia reared in ISW of 15% salinity. This information will be helpful in eco-friendly feed formulation for sustainable GIFT culture in ISW.

KEYWORDS: GIFT tilapia, Inland saline water, Lipid utilizing nutraceuticals, Growth response, Antioxidant status



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Assessment of Black Soldier Fly (*Hermetia illucens*) Larval Meal in the Diets of Indian Pompano (*Trachinotus mookalee*, Cuvier, 1832)

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This study assessed the use of black soldier fly larvae meal (BSFLM), derived from fish processing waste, as a fishmeal replacement in the diets of juvenile Indian pompano (Trachinotus mookalee). Juveniles, averaging 2.08±0.05 g, were randomly assigned to 18 tanks (10 fish per tank) in a recirculating aquaculture system. The feeding trial included nine different diets with varying levels of fishmeal (FM), BSFL meal, and taurine (T): Control (100% FM, 0% BSFLM, 0% T), Treatment 2 (100% FM, 0% BSFLM, 1% T), Treatment 3 (100% FM, 0% BSFLM, 2% T), Treatment 4 (10% FM, 90% BSFLM, 0% T), Treatment 5 (10% FM, 90% BSFLM, 1% T), Treatment 6 (10% FM, 90% BSFLM, 2% T), Treatment 7 (0% FM, 100% BSFLM, 0% T), Treatment 8 (0% FM, 100% BSFLM, 1% T), and Treatment 9 (0% FM, 100% BSFLM, 2% T). After 9 weeks feeding period; growth, biochemical markers, and histological outcomes were evaluated. The best weight gain and feed efficiency (p<0.05) were observed in Treatment 8 (0% FM, 100% BSFLM, 1% T). Digestive enzyme activities (amylase, lipase, protease) in BSFLM-fed groups were comparable to the control. However, antioxidant enzyme superoxide dismutase activity in the liver and gills was significantly higher (p<0.05) in the control group. No histopathological changes were detected in the liver, stomach, or intestines of any treatment group. The study concludes that BSFLM can fully replace fishmeal in the diets of Indian pompano juveniles, provided 1% L-taurine is included, without adverse effects on growth or overall health.

KEYWORDS: Alternative feed ingredients, Fish meal, Marine fish, Taurine

Effect of Marine Algal Oil Supplementation on Egg Quality in Clarias magur

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Clarias magur is a commercially and economically important freshwater catfish with high market demand. However, reproductive performance is hindered by the low quality of the eggs, which affects overall seed production. The study determines the effect of marine algal oil supplemented feed on egg quality based on the Gonadosomatic index (GSI), egg size, and histological changes. There were four treatments, including the control and commercial feed (Growel with 6% crude fat and 40% protein), used for marine algal oil supplementation. In control, 3% of cod liver oil supplementation was used, followed by marine algal oil supplemented at different percentages (T1-3%, T2-4%, and T3-5%) in other treatments. C. magur at 100-120 g weight, stocked at 5 nos/m³ for around 90 days was fed at 5% of body weight. At the final sampling, females developed oocytes with germinal vesicle migration and high GSI was observed in 4% of marine algal oil supplementation (T2), followed by T1 and T3. Egg size varied significantly (p<0.05) between all the treatments. Histological observations showed the increased egg size with high yolk molecules in T2. The study results indicated that it would be more useful for farmers to produce good quality seed using 4% algal oil supplementation instead of fish oil.

KEYWORDS: Clarias magur, Marine algal oil, Gonadosomatic index, Gonad Histology

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Growth and Expression of Crustin and Prophenoloxidase in Pacific White Shrimp (*Peneaus vannamei*) Post Larvae Fed with Methanotrophic Bacteria Meal and Extract

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Methanotrophs are bacteria that can utilize methane and ammonia as sources of energy and are rich in nutritional quality. It is also abundant in several nitrogenous non-protein molecules with nutraceutical properties. To evaluate the effect of methanotrophic bacteria meal extract (BME) or a hydrolysate (BHM) on growth and immune related gene expression in Pacific white shrimp, *Peneaus vannamei* post larvae, a 60-day feeding trial was conducted. The diets used in the study were isonitrogenous (crude protein 35%) and isolipidic (6%), and the treatments were viz., control (Basal diet), TE0.1, TE0.5 and TE2.0 (basal diet supplemented with 0.1, 0.5 and 2.0% BME, respectively) and TM0.1, TM0.5, and TM2.0 (basal diet supplemented with 0.1, 0.5 and 2.0% BHM). The results showed that feeding with 0.5% methanotrophic bacteria meal extract enhanced (p<0.05) survival, growth, protein utilization, and total antioxidant status in P. vannamei. Among the hydrolysed meal fed groups, shrimp fed 2.0% hydrolysed meal showed higher growth rate and nutrient utilization. Crustin gene expression was significantly higher in the 0.5% BME fed group followed by 2.0% BHM fed group. However, the dietary inclusion of methanotrophic bacteria meal extract or hydrolysate led to the downregulation of heat shock protein (HSP70). Hence, from this study, it can be concluded that feeding with 0.5% dietary inclusion of methanotrophic bacteria meal extract and a 2% inclusion level of methanotrophic bacteria hydrolysed meal led to improved growth and immunity in the post-larvae of Pacific white shrimp.

KEYWORDS: Crustacea, Nucleotide, Hydrolysed protein, Functional feed, Immunity

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Synergistic Effects of Selected Dietary Additives on Growth, Activities of Digestive Enzymes, and Body Composition of GIFT Juveniles Reared in Inland Saline Water

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Respectively, 1128 million hectares globally and over 10.1 million hectares in India of fertile land have become unfit for agricultural use due to over-salinization and sodification. To ensure protein security for the ever-growing human population, these lands have been strategically converted to aquaculture resources for the culture of suitable euryhaline species. In this context, GIFT tilapia could be the most promising one for inland saline aquaculture (ISA) due to its hardy nature and fast growth, although some degree of ionic variation (high Ca and Mg and low K ions) mediated osmotic stress of this fish cannot be avoided. Therefore, the use of growth-enhancing and stress-mitigating feed additives could be the right approach to augment fish production. In this context, a 60-day trial was conducted to assess the growth, activities of digestive enzymes, and body composition of GIFT juveniles reared in ISW (10% salinity) and fed with selected additives-supplemented diets. Accordingly, four isonitrogenous (31%), isolipidic (8%), and isocaloric (385 kcal DE/100 g) diets viz., Control (0% additive), TT (Control diet + 0.5% taurine), TC (Control diet + 0.05% L-carnitine) and TTC (Control diet + 0.25% taurine + 0.025% L-carnitine) were fed to fish of respective four groups in triplicate with the stocking density of 20 fish (avg. body weight 4.43±0.01 g)/hapa (2.5 m x 2 m x 1 m). The fish of the additives-fed groups showed significantly higher (p<0.05) growth than the control group. Among additive-fed groups, FBW, WG, WG (%), SGR, TGC, and MGR of the TTC group were significantly (p<0.05) higher than TC and similar to the TT group. However, fish of all additive-fed groups and TT and TTC groups exhibited higher and lower whole-body CP and lipid, respectively compared to the control group. Although the activities of protease and amylase were similar in all groups, the lipase activity of additivefed groups was higher than the control group. In conclusion, 0.25% taurine plus 0.025% L-carnitine supplemented diet could be effective for successful GIFT culture in inland saline water (ISW) of 10% salinity with enhanced production.

KEYWORDS: Inland saline water, GIFT, Taurine, L-carnitine, Growth

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Study on the Potential of Fish Waste Hydrolysate on Reduction of Feed Requirement in Brackishwater Polyculture System

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Evaluation was conducted on the potential of fish waste hydrolysate, registered as Central Institute of Brackishwater Aquaculture-Plankton^{Plus} (PPlus), a value-added product developed from fishwaste, on reduction of feed requirement in brackishwater polyculture system. Ten brackishwater ponds (each of 0.05 ha) were used for the experiment with five different treatments, i.e., control (100% feed without PPlus), T1 (100% feed and supplemented with PPlus), T2 (80% feed and supplemented with PPlus), T3 (60% feed and supplemented with PPlus) and T4 (40% feed and supplemented with PPlus). Brackishwater species i.e., Penaeus monodon $(0.02\pm0.02 \text{ g})$, Liza tade $(1.03\pm0.09 \text{ g})$, L. parsia $(0.85\pm0.04 \text{ g})$ and Mystus gulio $(1.95 \pm 0.12 \text{ g})$ were stocked @ 1, 1.75, 1.25 and 1 no./m², respectively, in culture ponds. Plankton Plus was used @ 40 ppm. After 180 days of culture, the average body weight attained by *P. monodon* was 23.75±0.40 g, 26.70±0.45 g, 25.40±0.48 g, 24.18±0.44 g and 20.30±0.47 g; L. tade was 62.80±0.53 g, 67.30±0.50 g, 65.20±0.49 g, 63.6±0.56 g and 60.90±0.47 g; L. parsia was 52.70 ± 0.54 g, 58.00 ± 0.44 g, 56.20 ± 0.41 g, 53.80 ± 0.45 g and 47.40 ± 0.54 g; Mystus gulio was 40.70 ± 0.45 g, 46.10 ± 0.49 g, 43.50 ± 0.46 g, 42.70 ± 0.51 g and 36.80 ± 0.50 g, in control, T1, T2, T3 and T4, respectively. The productivity was 1477.94±9.54 kg/ha, 1626.12±5.77 kg/ha, 1554.52±5.44 kg/ha, 1518.96±5.63 kg/ha and 1371.78±0.74 kg/ha in control, T1, T2, T3 and T4 ponds, respectively. The results showed that the species performed better in ponds supplemented with Plankton than in the control ponds even when 40% feed was reduced. Experiment clearly showed that CIBA-Plankton^{plus} could save 40 % feed without affecting the productivity.

KEYWORDS: CIBA-PlanktonPlus, Polyculture, Feed reduction, FCR, Productivity

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The Phytobiotics in Curry Leaf (*Murraya koenigii*) Augmented Reproductive Development in Drapefin Barb, *Oreichthys crenuchoides* Under Captivity

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Reproductive arrest in any animal is a major concern which causes economic and ecological impacts. It occurs due to a variety of reasons, of which stress is a major one. This problem is quite common in the wild-collected fishes kept in captivity for culture or *ex-situ* conservation. Captive stress in wild-collected fish impedes steroidogenesis, thus critically affecting reproductive development. This problem can be subdued by the use of certain phytobiotic compounds which directly or indirectly act upon steroidogenesis and facilitate gonadal maturation. The present study investigated the effects of phytobiotic compounds present in the curry leaf, Murraya koenigii in augmenting gonadal development in a wild-caught fish, drapefin barb (*Oreichthys crenuchoides*) reared under captivity. These phytobiotics are already known for their effectiveness in fertility elevation in higher animals. O. crenuchoides with no record of captive maturation and breeding was used as the experimental animal. The phytobiotics in M. koenigii (PMK) were screened by high-resolution liquid chromatography mass spectrometry (HR-LCMS/MS). Phytochemical classification was carried out and the structural complexity of the biomolecules was overviewed by molecular networking to understand synergy. The effect of PMK in augmenting reproductive performance was examined by incorporating graded doses of 0% (control), 0.5% (T1), 1% (T2), 1.5% (T3) and 2% (T4) in the diet of O. crenuchoides for 60 days under captive condition. At the end of the trial, females from T1 and males from T2 were observed with significantly higher gonadosomatic index. It regulated 11-keto-testosterone and 17β-estradiol in male and female fish, respectively. Further, it markedly elevated 17α , 20β -dihydroxy progesterone levels in both the sexes, which is responsible for the maturation of gametes. Histostructural analysis and software-based histomorphometric analysis of testis and ovaries confirmed the increased number of matured spermatozoa (1161±66 cells/mm²) and oocytes (83±10 eggs/fish) in T2 males and T1 females, respectively. Therefore, this study suggests that the phytobiotics in M. koenigii can be used as a potential dietary supplement in augmenting reproductive development of wild-collected fish reared in captivity.

KEYWORDS: Phytobiotics, Drapefin barb, Wild fish, Captive maturation, Murraya koenigii

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Effects of Dietary Tryptophan on Growth Performance, Physio-Metabolic Responses and Expressions of Igf-1 and Igf-1r Genes in Gift Juveniles Cultured in Inland Ground Saline Water

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Use of agriculturally unfit huge inland ground saline water (IGSW) for inland saline aquaculture (ISA) with suitable euryhaline species could be an effective strategy to ensure protein security for an ever-growing human population, which is projected to be 11.2 billion by 2100. Among euryhaline species, GIFT tilapia is the most suitable due to its fast growth, tolerance to wide environmental variation and enhanced disease resistance. In this context, dietary nutrient optimization especially essential amino acids could be the right strategy for effective feed formulation to augment fish production in ISA. Therefore, this study investigated the effects of varying dietary tryptophan levels on growth performance, physiometabolic responses and expressions of growth-related genes in GIFT juveniles raised in IGSW over 60 days period. GIFT juveniles (average weight 3.67±0.02 g) were randomly assigned to seven treatment groups (with graded levels of dietary tryptophan) viz., T2 (2 g/kg), T2.5 (2.5 g/kg), T3.0 (3.0 g/kg), T3.5 (3.5 g/kg), T4 (4.0 g/kg), T4.5 (4.5 g/kg) and T5 (5.0 g/kg) in triplicate with the stocking density of 15 fish/replicate. Accordingly, seven isoproteic, isolipidic and isocaloric formulated diets were fed to fish of respective groups on a satiation basis, twice daily. Results showed that increasing dietary tryptophan levels up to 3.5 g/kg significantly enhanced WG, WG%, SGR, PER, body protein, alanine and aspartic acid, muscle and liver AST and muscle ALT activities, serum Alb and TP and IGF-1 and IGF-1R expressions and decreased FCR and body lipid. However, the activities of liver and gill superoxide dismutase and catalase and WBC count linearly increased with increasing tryptophan levels. On the other hand, hepatosomatic and viscerosomatic indexes, percent survival, whole-body moisture, ash, carbohydrate and amino acids other than alanine and aspartic acid, activities of digestive enzymes and liver ALT, serum glucose, globulin and albumin-globulin ratio, hemoglobin level and RBC count were insignificant among treatment groups. Considering IGF-I expression and WG%, polynomial regression and broken-line analyses optimized dietary tryptophan for GIFT at the overall range of 3.28-3.50 and an average of 3.39 g/kg diet. This information will be valuable to formulate and develop a quality diet for a sustainable GIFT culture in IGSW.

KEYWORDS: Growth, Dietary tryptophan, GIFT, IGSW, IGF-I



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High Dietary Saturated Fat Enhances the Performance of GIFT Reared at High Temperature

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Under conditions of thermal stress, such as those associated with global warming, the increased metabolic demands of Genetically Improved Farmed Tilapia (GIFT) could be met by strategically incorporating higher levels of SFAs in their diet. This hypothesis builds upon previous research from our laboratory, which demonstrated that hyperthermal stress potentiates enhanced lipid metabolism in GIFT reared at elevated temperatures. By providing a readily available energy source in the form of SFAs, we aimed to test whether fish could more efficiently meet their increased energy requirements under thermal stress, potentially improving their growth performance and metabolic efficiency. Four isonitrogenous (34%) lipidic (10%) diets were thus formulated with graded inclusions of SFA at 0, 10, 20, and 30% (designated as SFA0, SFA10, SFA20, and SFA30, respectively). GIFT (initial weight: 9.3±0.07 g) were exposed to two temperature regimes (28°C and 33°C) in a thermally regulated recirculatory aquaculture system. Results indicated that GIFT generally tolerated SFA supplementation up to 20% at both temperatures. However, at 33°C, fish fed the SFA30 diet exhibited significantly higher (p<0.05) growth performance in terms of weight gain percentage (WGP) and thermal growth coefficient (TGC). Serum lipid levels were reduced at 33°C compared to 28°C, suggesting enhanced lipid mobilisation under thermal stress. Moreover, serum triglycerides were significantly lower in fish fed the SFA30 diet. Intestinal lipase activity was significantly (p<0.05) elevated and comparable across all SFAsupplemented diets relative to the control. Hepatic carnitine palmitoyl transferase activity was highest in the SFA20 group, followed by the SFA10 and SFA30 groups. A significant (p<0.05) upregulation of the peroxisome proliferator-activated receptor alpha $(PPAR\alpha)$ in the liver of fish fed SFA20 and SFA30 diets, particularly at 33°C, indicating enhanced lipid metabolism. These findings have important implications for formulating high-performing, climate-resilient diets. By strategically incorporating higher levels of SFAs, it may be possible to formulate diets that not only sustain but potentially enhance fish performance under the thermal stress conditions associated with global warming.

KEYWORDS: Thermal stress, High-performing diets, Metabolic efficiency, Lipid utilisation

Dietary Carnitine and Taurine Enhance Growth, Lipase Activity and Reduced Body Fat in GIFT Juveniles Reared in Inland Saline Water

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Inland saline-affected areas, rendered unsuitable for agriculture, are being converted to aquaculture to enhance protein security for the ever-growing human population. In this context, GIFT tilapia could be the most promising one for inland saline aquaculture (ISA) due to its hardy nature and fast growth, although ionic variation (high Ca and Mg and low K ions) mediated some degree of osmotic stress of this fish cannot be avoided. Therefore, using stress-mitigating and growth-enhancing feed additives could be an effective approach to boost fish production. In this context, a 60-day trial was carried out to evaluate the growth, digestive enzyme activities, and body composition of GIFT juveniles reared in 10% inland saline water (ISW) and fed diets supplemented with selected additives. Accordingly, four isonitrogenous (31% CP), isolipidic (8%), and isocaloric (385 kcal DE/100 g) diets viz. Control (0% additive), TT (Control diet + 0.5% taurine), TC (Control diet + 0.05% L-carnitine) and TTC (Control diet + 0.25% taurine + 0.025% L-carnitine) were fed to fish of respective four groups in triplicate with the stocking density of 20 fish (avg. body weight 4.43 ± 0.01 g)/hapa (2.5 m x 2 m x 1 m). Fish in the additive-fed groups showed significantly higher (p<0.05) growth than those in the control group. Among these, FBW, WG, WG (%), SGR, TGC, and MGR were significantly (p<0.05) higher in the TTC group than in the TC group and comparable to the TT group. Additionally, fish in all additive-fed groups had higher whole-body crude protein, while the whole-body lipid content of TT and TTC groups was higher than control group. On the other hand, protease and amylase activities were similar across all groups, while lipase activity was higher in the additive-fed groups. In conclusion, a diet supplemented with 0.25% taurine and 0.025% L-carnitine could enhance GIFT production in 10% inland saline water (ISW).

KEYWORDS: Inland saline water, Tilapia, Taurine, L-carnitine, Growth, Digestive enzymes

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L-Carnitine and Taurine Supplementation in Low-Protein, High-Lipid Diets Boosts Growth, Antioxidative Status, and Immunity in Penaeus vannamei Juveniles in Inland Saline Water

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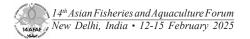
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A 60-day experiment was conducted to evaluate the effects of L-carnitine and/or taurine supplemented diets with varying protein and lipid levels on growth responses, antioxidant status and immunity of white-leg shrimp, *Penaeus vannamei* juveniles reared in ISW of 15% salinity. Seven hundred and ninety-two acclimated shrimp (average weight 3.53±0.02 g) were randomly distributed in 12 experimental groups in triplicate with the stocking density of 22 shrimp/circular tank (500 l water volume). Accordingly, twelve LPHL heteronitrogenous (40 to 32% crude protein), hetero-lipidic (6 to 10%) and hetero-caloric (384 to 406 Kcal DE/100 g) experimental diets viz., T1 (40% CP and 6% lipid), T1C (T1 + 0.05% L-carnitine), T1T (T1 + 0.5% taurine), T1ct (T1 + 0.025% L-carnitine and 0.25 taurine), T2 (36% CP and 8% lipid), T2C (T2 + 0.05% L-carnitine), T2T (T2 + 0.5% taurine), T2ct (T2 + 0.025% L-carnitine and 0.25 taurine), T3 (32% CP and 10% lipid), T3C (T3 + 0.05% L-carnitine), T3T (T3 + 0.5% taurine), and T3ct (T3 + 0.025% L-carnitine and 0.25 taurine) were prepared and fed to shrimp in each group to satiety, four times daily. Final body weight, weight gain percentage, specific growth rate, and feed efficiency ratio decreased with increasing dietary lipid levels. However, the inclusion of lipid-utilizing nutraceuticals improved these parameters, with the highest values observed in the T2ct group. However, the highest protein efficiency ratio and lipid efficiency ratio were found in the T2ct and T1ct groups, respectively. The hepatopancreatic somatic index value of the T1ct group was similar to the T1T and T2ct groups, but higher (p<0.05) than other groups. Shrimp fed the highest lipid diet (10%) showed significantly higher (p<0.05) activities of branchial and hepatopancreatic superoxide dismutase, catalase, prophenoloxidase, and respiratory burst. However, supplementation with nutraceuticals, both individually and in combination, significantly reduced these values, with the lowest (p<0.05) values observed in the T2ct group. In conclusion, the T2ct diet achieved optimal growth performance and health in P. vannamei reared in 15% inland saline water.

KEYWORDS: White-leg shrimp, Ionic imbalanced water, Functional feed additives



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Synergistic Effects of Nutritional Regimens and Feeding Frequency on Growth Dynamics and Biochemical Homeostasis for Captive Maturation in Zebra Loach (*Botia striata*)

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Botia striata is a prized indigenous ornamental fish, endemic to the Western Ghats of India. According to IUCN, it is endangered due to habitat loss and heavy wild capture. Despite being endangered, India exports huge quantities of zebra loaches posing challenges for its conservation primarily due to illegal fishing and habitat degradation caused by wild collection for ornamental trade. This grim projection underscores the urgent need for conservation efforts to safeguard this endangered species from further decline and potential extinction and take steps towards captive breeding through effective and sustainable feeding practices. Feed and feeding frequencies play a vital role as feed costs constitute a major share (60%) of operational expenses for the ornamental fish farmer. Protein being the most expensive component of fish feed, tapping potential sustainable protein and lipid sources (HUFA) for fast swimming hill stream fishes such as loach, do help in optimization of lipid:protein ratio for effective captive maturation, keeping in mind the protein sparing effect of lipids. In this context, a 90-days experiment was conducted to optimize the captive maturation of the zebra loach using selected feeding regimes, i.e. three selected feeds at two levels of feeding frequencies following a 2x3 factorial design, viz., T1 (formulated feed, twice daily), T2 (formulated feed, 4 times daily), T3 (frozen whole feed, twice daily), T4 (frozen whole feed, 4 times daily), T5 (formulated feed + frozen whole feed, twice daily) and T6 (formulated feed + frozen whole feed, 4 times daily). Superior growth, digestive (amylase, protease and lipase), metabolic enzymes (GOT, GPT, LDH and MDH), and reproductive parameters (11-KT, 17B-estradiol, 17-OHP, vitellogenin, LDL, HDL) and lowest stress (glucose and cortisol) levels were recorded in T2 with highest relative fecundity showing advanced tertiary oocytes. The present study therefore provides a solution towards the conservation of the striped loach, by bringing a precise cost-effective diet formula coupled with the best daily feeding regime for effective growth dynamics, biochemical homeostasis, captive maturation and subsequent breeding of this endangered ornamental fish.

KEYWORDS: Zebra loach, Cost-effective Diet formulation, Feeding regimes, Growth dynamics, Captive maturation



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Evaluation of Seaweed (*Hylemenia venusta*) Meal as a Replacer of De-Oiled Rice Bran in the Diet of Angel Fish, *Pterophyllum scalare*

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A 60-day feeding trial was conducted to evaluate growth response, and digestive enzyme activities of Pterophyllum scalare juvenile fed with seaweed (Hylemenia venusta) meal (SWM) by gradually replacing de-oiled rice bran (DORB). One hundred and eighty juveniles were randomly distributed into four distinct experimental groups in triplicates. Four semi-purified iso-nitrogenous diets (300 g/kg CP) with different combinations of SWM and DORB such as T1 (diet with 300 g/kg DORB + 0.0 g/kg SWM), T2 (diet with 200.0 g/kg DORB + 100.0 g/kg SWM), T3 (diet with 100.0 g/kg DORB + 200.0 g/kg SWM) and T4 (diet with 0.0 g/kg DORB +300.0 g/kg SWM) were prepared and fed to satiation level. Among the various groups, T4 showed a significant reduction (p<0.05) in feed intake than the other experimental groups. The T3 group exhibited the highest (p<0.05) weight gain, specific growth rate (SGR), and protein efficiency ratio (PER) compared to the T1, T2 and T4 groups. Significantly higher (p<0.05) amylase, protease, and trypsin activities but lower chymotrypsin activity were recorded in the T3 group compared to the control group. Metabolic enzyme activities were significantly higher (p<0.05) for T3 diet fed fish compared to other groups. Overall results revealed that SWM can be effectively included up to 200.0 g/kg by successfully replacing an equal amount of DORB without compromising the growth. Hence, it could be used as an alternate ingredient in the diet of *Pterophyllum* scalare juveniles.

KEYWORDS: Digestive enhancer, Growth, Pterophyllum scalare, Hylemenia venusta

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Effect of Dried Henna Leaf Powder (*Lawsonia inermis*) Incorporated Fish Feed on Growth, Survival and Pigmentation of Guppy, *Poecilia reticulata* (Peters, 1859)

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The present study aimed to investigate the effects of dried henna leaf powder (Lawsonia inermis) on the growth, survival, and pigmentation of guppy (Poecilia reticulata). For the experimental trial, 120 male guppies (0.19±0.006 g Average Body Weight) were stocked in eight tanks (30 fishes per treatment in duplicate) and fed with four isonitrogenous (33%) Crude Protein) feeds with different concentrations of Henna viz., Control (0%), T₁ (1%), T₂ (2%) and T₃ (3%) for 60 days. At the end of the experiment, fish samples were analyzed for growth parameters and pigment accumulation. The mean final length was significantly (p<0.05) higher in T_3 (3.31±0.23 cm) than in T_2 (2.88±0.51 cm). The fish samples in T_1 recorded the highest net weight gain of 0.089±0.08 g at the end of the experiment followed by T₂ (0.086±0.05 g). However, no significant differences (p>0.05) were observed in net weight gain, weight gain percentage and specific growth rate. The highest survival rate was observed in T₂ (91.66%) followed by T₃ (83.33%) and T₁ (75%) and the least survival rate was observed in control (54%). The carotenoid concentration was found to be significantly highest (p<0.05) in control group (9.212 \pm 0.22 μ g/g) followed by T₂ (7.779 \pm 0.07 μ g/g), T_3 (7.737±0.05 µg/g) and significantly (p<0.05) lowest value observed in T_1 (4.937±0.05) μg/g). All treatments recorded significantly (p<0.05) higher carotenoid concentration than the initial (Day 0) level (1.650±0.02 µg/g). Colour intensity of fish was measured in image J software® to check the role of lawsone in pigment impartment and the green colour value was significantly (p<0.05) higher in the control group than all other treatments and no significant difference (p>0.05) was observed in red and blue colour among the treatments and control. Thus, it is concluded that dried leaf powder of Lawsonia inermis can be incorporated at 2% concentration in the diets of *Poecilia reticulata* to enhance its survival rate. Moreover, the results also proved that the lawsone pigment by itself had no significant role in colour enhancement of guppy at the present level of inclusion.

KEYWORDS: Pigmented feeds, Colour additives, Lawsone, Carotenoid

Evaluation of Controlled and Normal System Raised Defatted Black Soldier Fly Larvae (CSDBSFL and NSDBSFL) Meals in the Diet of *Penaeus vannamei* Juveniles: Effects on Growth Performance, Stress Response and Immunity

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Feed-based intensified aquaculture is gaining momentum to ensure protein security for the ever-growing human population. Consequently, there is escalated demand for aquafeed with elevated pressure on conventional protein-rich ingredients especially fish meal (FM). Thus, there is an urgent need to find suitable FM alternatives for sustainable production and supply of aquafeeds to support intensified fish, especially shrimp production. In this context, the DBSFL meal could be an effective alternative. Therefore, the present study aimed to evaluate the CSDBSFL and NSDBSFL meals in the diet of *Penaeus vannamei* juveniles reared in brackishwater in relation to stress and immunity. Thus, P. vannamei juveniles with an average body weight of 2.0±0.25 g were randomly assigned to nine treatments (Control with no DBSFL and T1, T2, T3, T4, T5, T6, T7 and T8 with inclusion of CSDBSFL in former four and NSDBSFL in later four groups in replacement of 25, 50, 75 and 100% FM) in triplicate with the stocking density of 40 numbers/hapa. Accordingly, nine isonitrogenous (36% CP) and isolipidic (6%) diets were prepared and fed to fish of respective groups on a satiation basis four times per day. Shrimp of the T3 group showed highest WG%, SGR, and FER. Lower FCR was found in the control, T1-T3, and T6 groups. In comparison to the control, significantly higher SOD and CAT activity was recorded in T5-T7 and T4 and T8, respectively, remaining group showed similar activity. However, the shrimp of T4, T7, T8, and T1-T8 showed significantly lower phenoloxidase (PO) activity and malondialdehyde (MDA) level, respectively. In conclusion, 75% dietary FM could be replaced by CSBSFL without compromising growth performance, antioxidant status, and immunity of brackishwaterreared Penaeus vannamei with reduced stress.

KEYWORDS: Penaeus vannamei, Fish meal, BSFL, Growth, Immunity

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Study on the Effect of Indole Acetic Acid (IAA) and Nitrogen Stress on the Nutrient Profile of *Nannochloropsis* Algae

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Phytohormones are natural or synthetic chemical stimulators that aid in the accumulation of biomass and metabolites (such as lipids, carbohydrates, and fatty acids) in microalgae. The strategy of combining phytohormones and abiotic stress may provide efficient and cost-effective techniques to produce microalgae metabolites. The axenic culture of Nannochloropsis algae was transferred to the 500 ml Erlenmeyer flask containing BBM (Bold Basal Medium). The culture was maintained at a temperature of 25 to 27°C throughout the 21-day culture period. Indole Acetic Acid (IAA) at three different concentrations (5 ppm, 7.5 ppm, and 10 ppm) was supplemented in the BBM-containing algae culture for 21 days. In the nitrogen limitation study, two different levels of nitrogen (50% and 25%) were incorporated with BBM culture medium for 12 days. The measured cell count of *Nannochloropsis* algae in the control culture was 72.60 x 10⁶ cells/ml on the 19th day of culture. However, compared to the control culture, the IAA-treated algal culture showed a maximum cell count of 99.1 x 10⁶ cells/ml at 7.5 ppm IAA on the 17th day. In IAA-supplemented algal culture; protein, lipid and carbohydrate content ranged from 29 to 33%, 31 to 40%, and 14 to 20% respectively. In the nitrogen starvation study, the cell count of *Nannochloropsis* algae in the control culture was 3.40 x 106 cells/ml and 8.75 x 106 cells/ml on the 6th and 12th day of 50% nitrogen treatment. Likewise, a cell count of 4.02 x 106 cells/ml and 6.73 x 106 cells/ ml could be observed on the 6th and 12th days of 25% nitrogen treatment. However, in IAA treatment, the highest cell growth (20.36 x 10⁶ cells/ml) was observed on the 12th day of 50% nitrogen limitation. In IAA 7.5 ppm Nannochloropsis culture, the lipid content ranged from 31% to 48%. The observed lipid content in the 25% nitrogen-limited condition was found to be 36.76% and 48.32% on the 6th and 12th day respectively. From this study, the maximum growth of Nannochloropsis algae was obtained at 7.5 ppm of IAA, and that yielded higher than 35% lipid content on a dry weight basis (39.48%) compared to the control culture. In the nitrogen limitation, the yield of lipid content was more than 40% (48.32%) in IAA of 7.5 ppm compared to the control culture.

KEYWORDS: Indole Acetic Acid, Nitrogen stress, *Nannochloropsis* algae, Cell count, Nutrient profile

Dietary Zinc Requirement of Fingerling *Labeo catla* (Hamilton, 1822) Based on Growth Performance, Hematology and Tissue Mineral Composition

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Zinc (Zn) is an essential micronutrient required in fishes due to its involvement in several important biochemical processes, including normal growth, metabolic and immune function, gene regulation, and reproduction. Zn deficiency in diets can reduce the growth and survival rate of fishes, causing cataract, dwarfism, and bone malformations. Conversely, excessive Zn in the diet is toxic to fish, reducing reproductive performance, antioxidant ability, and immune response. Although fish can utilize Zn from water, its concentration in controlled aquaculture systems is insufficient to meet requirements for normal fish growth. Therefore, this study was conducted to determine the optimum dietary Zn requirement of fingerling Labeo catla based on the growth, hematology, and tissue zinc concentration. Six isonitrogenous (350 g/ kg crude protein) and isoenergetic (16.7 kJ/g gross energy) diets were prepared containing graded levels of dietary Zn as 9.64 (Zn1; basal diet), 29.93 (Zn2), 50.73 (Zn3), 70.88 (Zn4), 94.29 (Zn5), and 114.16 (Zn6) mg/kg diet. A total of 360 fish (initial body weight: $3.38 \pm$ 0.03 g) were randomly allocated to 18 fish tanks (20 fish/tank), each with 55 l water capacity. Diets were hand-fed to the fish thrice daily (8:00, 12:00 and 16:00 h) at apparent satiety for 12 weeks. Growth, conversion efficiencies, hematology, tissue zinc concentration and survival were improved with increasing levels of dietary zinc up to 50.73 mg/kg zinc followed by no change in further inclusion of dietary zinc. The highest live weight gain (944.71%), specific growth rate (2.79%/day), and best feed conversion ratio (1.56) were recorded in fish fed with a 50.73 mg Zn/kg diet. Zn contents in the whole body and vertebrae linearly increased with the increasing level of dietary Zn up to 50.73 mg/kg and then leveled off. Broken-line regression analysis of growth, hematology and tissue Zn concentration data against increasing dietary Zn levels indicated the optimum dietary requirement of Zn to be in the range of 48.97-51.31 mg/kg for better growth, health and survival of L. catla fingerlings.

KEYWORDS: Labeo catla, Dietary zinc, Requirement, Growth, Body mineral composition

Effects of Organic Dietary Selenium on Growth, Conversion Efficiency, Antioxidant Status and Immune Response of *Heteropneustes fossilis*

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Selenium (Se) is a vital trace element for normal growth, health and stress resistance. Organic Se forms have higher bioavailability, better ability to improve fish immune status and relatively lower toxicity than inorganic Se forms. The present study was conducted to explore the effects of dietary organic selenium on the growth, conversion efficiency, antioxidant status and immune response of *Heteropneustes fossilis* by feeding isonitrogenous (40% crude protein) and isocaloric (17.89kJ/g gross energy) purified experimental diets with different levels of selenium to apparent satiation thrice a day for 8 weeks to the triplicate groups of fish. Selenium levels in the diets were 0.09 (D1; basal diet), 0.21 (D2), 0.33 (D3), 0.45 (D4), 0.57 (D5) and 0.69 (D6) mg/kg dry diet. Fish fed increasing amounts of selenium reflected improved growth performance and conversion efficiencies. The highest absolute weight gain (48.26 g/fish), specific growth rate (3.89%/day), and protein retention efficiency (26.86 %) were recorded in fish fed diet containing 0.45 mg/kg selenium (D4). The best feed conversion ratio (1.62) was also reflected by the group fed the above diet. Dietary selenium concentration also improves the antioxidant status of fish. Highest activity of antioxidant enzymes such as superoxide dismutase, glutathione peroxidase and lowest malondialdehyde content was recorded in the group fed D4 diet having 0.45 mg/kg selenium. Dietary selenium significantly (p<0.05) improved the whole-body protein and fat content of the fish fed diets upto the above level of selenium. However, a decline in whole-body moisture was observed with increasing dietary selenium concentration up to diet containing 0.45 mg/kg and then levelled off. No significant difference was noted in the whole-body ash content. Dietary selenium levels also significantly affected the activities of digestive enzymes. Survival was not affected by feeding diets containing different levels of selenium. Broken line regression analysis of growth, conversion efficiencies, antioxidant and immune response data against the increasing levels of dietary selenium reflected that 0.37 mg/kg selenium is optimum for growth of *Heteropneustes fossilis*.

KEYWORDS: Growth, Aquaculture, Organic selenium, Heteropneustes fossilis

Effect of Diet Type on Digestive Enzyme Activities and Intestinal Structure of Himalayan Snow Trout (Schizothorax richardsonii)

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This study was carried out to examine the effect of natural and artificial feeds on the digestive physiology of snow trout (Schizothorax richardsonii), with respect to intestinal microanatomy and digestive enzyme activity in different intestinal segments. The experimental fish were collected from the Shipra stretch of river Kosi in Uttarakhand, India. During the 15-days feeding experiment, two groups of snow trout were fed either their natural feed (periphyton attached to submerged rocks) or a commercial trout feed (48% protein and 16% lipid). At the end of the trial, the digestive tract of fish from the two dietary treatments were collected and subjected to histological observations and enzyme assays. The hepatosomatic index was significantly higher in fish-fed artificial feed than in fish-fed natural diets, indicating superior nutritional status. Concurring with this, the activities of digestive enzymes such as alpha-amylase, trypsin, chymotrypsin, leucine aminopeptidase and total protease, were significantly elevated in fish-fed the artificial feed, in all the intestinal sections (proximal, middle, and distal). Regardless of the food source, the proximal and middle zones of the snow trout intestine showed higher activity of digestive enzymes than the distal segment. Histological analysis revealed healthy, uniformly elongated, dense villi with numerous goblet cells in fish-fed artificial feed across all intestinal sections. In contrast, fish-fed natural feed exhibited thicker villi with numerous goblet cells and fat droplets across the intestinal zones. These findings collectively provide a better understanding of snow trout digestive physiology, and the foundation for developing specific feeds and feeding strategies for this vulnerable teleost.

KEYWORDS: Snow trout, Digestive tract, Enzyme activity, Microanatomy, Food source

Comparative Efficacy of Duckweed (*Spirodela* and *Lemna*) Paste as Fish Feed Binder on the Growth Performance, Health Status and Coloration of Ornamental Koi Carp, *Cyprinus carpio* (Linn.)

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Duckweeds offer a great scope of application as organic fish feed binders in aquafeed formulation owing to the presence of cuticular waxy components and various growthpromoting immuno-modulating bioactive compounds. To explore these properties, the comparative efficacy of duckweed (Spirodela polyrhiza and Lemna minor) species was tested as the organic binder in terms of survival, growth, health, and colouration of ornamental Koi carp, Cyprinus carpio in a 180-days feeding trial. Nine feeds viz., control feed without binder (WB), Cane molasses (5%) binder feed (CM5), Corn starch (5%) binder feed (CS5), Spirodela paste binder feeds - 5% (DWS5), 10% (DWS10), 15% (DWS15); and Lemna paste binder feeds 5% (DWL5), 10% (DWL10), and 15% (DWL15) were prepared and offered @5% fish body weight in two split doses. Water quality parameters remained in the optimum range for fish culture indicating no negative impacts of duckweed binder feeds. Although insignificant differences were observed for mean fish survival (%) among all treatments, however, it was comparatively higher in WB, DWS10, and DWL10. Significant variations (p<0.05) in net weight gain (g) and specific growth rate (% increase in weight/day) were apparent in DWL15 with enhanced growth performance of 50-88% and 36-51%, respectively, in comparison to control feeds. Similarly, DWL15 depicted a significantly improved feed conversion ratio (1.70), which showed an enhancement of 27-28% as compared to control feeds. Fish health in terms of total protein and albumin (gd/l) showed significant improvement (15-27% higher) in DWL15 in comparison to control feeds whereas globulin level was significantly improved (13-30% higher) in all duckweed feeds as compared to control feeds. Coloration in terms of total carotenoids (µgg⁻¹) was observed to be significantly highest in DWL15 (41-95% higher) feeds in comparison to control feeds. Overall net economic return was significantly highest (p<0.05) in DWL15 and DWL10 with 16-68% net profit, 24-50% reduction in feed cost and 13-84% higher biomass production as compared to control feeds. The overall findings revealed that among two duckweed species, Lemna paste binder feeds @15% outperformed Spirodela and traditional binder feeds in terms of fish survival, growth, feed conversion efficiency, health, and coloration, indicating its potential in terms of organic fish feed binder resulting in increased fish production and higher net profit.

KEYWORDS: Koi carp, Spirodela polyrhiza, Lemna minor, Coloration, Binders

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Quantifying Nitrogen and Phosphorus Discharge from Spiny Lobster Cage Culture: Environmental Considerations for Sustainable Mariculture

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Mariculture, a rapidly growing and sustainable sub-sector of aquaculture, is expanding globally to meet seafood demand while reducing pressure on wild fish stocks. The cultivation of spiny lobster is gaining attention due to increasing global demand, high market value and rising concerns over the sustainability of wild stocks. Gujarat state with the longest coastline of the country, holds a promising growth of sea cage farming for shellfish in particular, providing local employment and foreign exchange earnings through lobster exports. However, this method enriches nutrients in the coastal environment, accelerating eutrophication, making nutrient monitoring essential to maintain environmental sustainability. In this context, the study was conducted along the Saurashtra coast off Gujarat to quantify nitrogen and phosphorus release during the cage culture of lobsters. Six farming cages, located 0.8 km offshore with a mean depth of 8.1±1.2 meters, were stocked with spiny lobster, *Panulirus* polyphagus and deployed from January to April. The nitrogen concentration in the body of stocked lobster was estimated before stocking, and the accumulation of nitrogen in the stocked lobster body was estimated monthly throughout the culture period based on the results of the proximate composition analysis of lobster. Total release into the environment was estimated based on an equation by Beveridge (1984). The lobsters were fed with fresh trash fish (Croakers Johnius spp., Lizard fish Saurida spp. and Japanese threadfin bream Nemipterus spp.) at 8 % body weight. Nitrogen in the feed, as estimated ranged from 3.6% to 6.8%, and 11.1% of which was utilized by the lobsters while the rest 88.9% was discharged into the environment through various means. Similarly, the phosphorus content estimated ranged from 0.2% to 0.47%, and 10.6% of phosphorus was assimilated, and the rest 89.4% was released into the environment. The study highlights the significant feed nutrient wastage, and the possible release of these nutrients into the environment, suggesting the need for exploring the possibilities for any alternative artificial pellet feeds and feeding strategies to minimize the nutrient loss and its possible environmental impacts.

Keywords: Environmental sustainability, Nutrient monitoring, Cage culture, Lobster, Eutrophication

Duckweed: A Potential Sustainable Feed Ingredient in Next-Gen Aquafeeds

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The escalating demand for sustainable, environment-friendly and high-quality protein sources in aquaculture has directed attention towards the utilization of plant-based alternatives. Duckweed (Lemna spp.), with its nutrient recycling potential, rapid growth rate, and high protein content, presents a promising solution. This study attempts at mass production of duckweed in tanks to be used as a potential good quality and cheaper plant protein source in the preparation of feed for commercially important fish and shellfish species. A mixture of duckweed species was collected from the wild and sub-cultured to obtain a pure culture of Lemna spp. in controlled conditions. This pure Lemna spp. was cultivated outdoors in 1001 FRP tanks in triplicate using fresh water with the addition of fermented nutrient slurry to test the productivity of this aquatic macrophyte. A starter biomass of 50 g (wet weight) was introduced in each tank and kept in a place with ample sunlight. Total harvest was done on the 3rd day with an average yield of 141.7 g (wet weight), i.e. *Lemna* biomass increased by 2.834 times in a time span of 3 days. Proximate analysis showed that the harvested *Lemna* biomass has a protein content of 35.56%, 7.64% fat, and 7.85% fiber per g of dry matter. To be used as a feed ingredient in trials and to confirm its high productivity, mass production of Lemna spp. was conducted. The previously employed protocol was replicated on a larger scale using two cement tanks (20x10x5 ft) with fresh water (0 \infty and 15 cm depth). A series of continuous culture were conducted for 25 days using a starter culture of ~1kg healthy Lemna spp. added to each tank along with 1% fermented nutrient slurry per water volume. Plant biomass covering 50% tank surface area was collected upon each harvest conducted every 3rd day, leaving the rest to proliferate for the next 3 days. The average yield per harvest per tank was found to be 5.2 kg wet weight.

KEYWORDS: Sub-culture, Plant protein, Nutrient slurry, Aquatic macrophyte, Aquaculture feed

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Nutritional Composition Analysis of Twenty-Eight Small Indigenous Fishes from The River Ganga: Insights into Gross Chemical Composition, Fatty Acid and Mineral Composition

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Fish is a nutritious diet rich in minerals, high-quality animal proteins, and polyunsaturated fatty acids (PUFAs), particularly (ω)-3 eicosapentaenoic acid and docosahexaenoic acid. Furthermore, fish are more readily available and reasonably priced in tropical nations than other animal protein sources. Nonetheless, fish nutritional data is essential for using fish to achieve nutritional security and will be useful in setting aquaculture species priorities. In this context, the small indigenous fish (SIFs) can play a crucial role in being nutrient-dense; therefore, the nutritional composition was generated for twenty-eight SIFs from the river Ganga regarding gross chemical composition, fatty acid and mineral composition analysis. The fatty acid composition analysis was done using gas chromatography-mass spectrometry and the minerals were analysed using inductively-coupled plasma mass spectroscopy. The SIFs *Clupisoma garua*, *Cabdio morar* and *Crossocheilus latius* were found to be rich in ω -3 PUFAs like EPA and DHA. Similarly, the SIFs *Eleotris fusca*, *Cabdio morar* and *Crossocheilus latius* were found to be mineral-rich fish species. Therefore, the nutritional information generated in the present study offers promise to be used for the proper utilization of these fishes in meeting the daily nutritional requirements of the human body.

KEYWORDS: Small indigenous fish, Fatty acid, Mineral composition, River Ganga

Effects of Dietary Selenium Supplementation on Growth, Body Composition, and Lipid Metabolism of Grouper, *Epinephelus lanceolatus*

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The study aims to evaluate dietary selenium (Se) supplementation on growth, body composition, and lipid metabolism of giant grouper, Epinephelus lanceolatus. Basal diet was supplemented with 0, 0.3, 0.6, and 1.0 mg Se/kg of sodium selenite (Na,SeO₂), providing actual Se concentrations of 2.30, 2.61, 2.93, and 3.08 mg Se/kg, respectively. The four experimental diets were each fed to triplicate groups of juvenile grouper (initial weight: 13.14±0.03 g) in a recirculation system for eight weeks. The final weight, weight gain, feed efficiency, survival, and body proximate composition were not affected (p>0.05) by the dietary treatments. Fish fed the diet with 2.61 mg Se/kg had lower hepatic glutathione peroxidase activity than fish fed other diets. According to linear regression analysis, Se concentrations in the whole body, muscle, and liver increased significantly by increasing the dietary Se levels. Hepatic eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) concentrations also increased with the increment of Se levels in the diet. Comparing with the fish fed the control diet (2.30 mg Se/kg), fish fed diets with Se supplementation showed higher hepatic carnitine palmitoyltransferase 1 (CPT-1), fatty acid desaturase (FAD2), fatty acid elongase (FAE5), and peroxisome proliferator-activated receptors γ (PPAR-γ) gene expression. Results indicate that dietary Se supplementation can enhance fatty acid metabolism-relative gene expression and increase hepatic EPA and DHA concentrations.

KEYWORDS: Nutrition, Grouper, Selenium, Lipid metabolism

Interactive Effects of Solvent Extraction and Drying Methods on LC-ESI-QTOF-MS/MS-Based Characterization of Bioactive Phenolics and Antioxidant Activities in Duckweed (*Wolffia globosa*)

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This study evaluated the effects of extraction solvents and drying methods on the bioactive compounds, antioxidant activities, and metabolite profiling of *Wolffia globosa* using LC-ESI-QTOF-MS/MS. Samples were oven-dried (OD), sun-dried (SD), or freeze-dried (FD) and extracted with 100% ethanol, 50% ethanol, and aqueous solution. FD with 100% ethanol resulted in the highest contents of TPC (830.40 mg GAE/g), TFC (91.02 mg QE/g), TTC (18.44 mg TAE/g), TCC (2.34 mg/g), and Chl-a (17.95 mg/g). The highest Chl-b content (5.75 mg/g) was observed in FD with 100% aqueous extraction. Antioxidant activities (DPPH 74.01%, ABTS 79.66%, FRAP 1545.87 μM FeSO₄/g) were also highest in FD samples with 100% ethanol samples. Correlations were found between Chl-a and FRAP (r=0.92), TFC and DPPH (r=0.86), and TCC with both ABTS and FRAP (r=0.86). FTIR analysis showed higher phenolic -OH groups in FD-ethanol. Metabolite profiling identified 67 compounds, including 12 phenolic acids, 20 flavonoids, and 35 polyphenols, with 44, 30, and 35 compounds in FD, SD, and OD, respectively. This study highlights the role of solvents and drying methods in enhancing *Wolffia globosa* bioactive composition for potential use in food and pharmaceuticals.

Keywords: Wolffia, Extraction, Drying methods, Antioxidant Activities, LC-ESI-QTOF-MS/MS

Balancing Dietary Eicosapentaenoic Acid (EPA) and Docosahexaenoic Acid (DHA) along with N-3/N-6 Fatty Acid Ratios for Optimal Performance in Silver Pompano Larvae

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This study investigated the impact of varying dietary eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) levels, alongside different n-3/n-6 fatty acid ratios, on the growth performance and fatty acid requirements of silver pompano (Trachinotus blochii) larvae. Eight experimental diets were formulated with EPA+DHA levels at 1%, 1.5%, 2%, and 2.5% of total feed, and n-3/n-6 ratios of 1 and 1.5, along with a commercial diet for comparison. Larvae at 16 days post-hatch (dph) were randomly assigned to 27 tanks, stocked at 500 larvae per 250 l tank, and fed their respective experimental diets in triplicate. During the initial stages, the larvae were co-fed experimental diets with rotifers and Artemia from 16 to 18 dph, and then with Artemia alone until 20 dph, after which only the experimental diets were provided. Growth performance and larval survival were assessed after 30 days of feeding (at 50 dph), and samples were collected for transcriptomic and metagenomic analyses. Results showed that larvae fed with 1% EPA+DHA and an n-3/n-6 ratio of 1 exhibited significantly reduced growth compared to other diets. In contrast, fish fed with 2% EPA+DHA and an n-3/n-6 ratio of 1 achieved growth performance comparable to that of the commercial diet. Ongoing analyses aimed to elucidate the underlying molecular mechanisms through transcriptomic analysis, which would be presented. The study demonstrated that dietary inclusion of 2% EPA+DHA with an n-3/n-6 ratio of 1 was optimal for the growth of silver pompano larvae, providing growth performance equivalent to a commercial diet. These findings offered valuable insights into the precise EPA and DHA requirements of silver pompano larvae for efficient feed formulation.

KEYWORDS: Silver pompano, Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA), n-3/n-6 fatty acids



Exploring the Effects of 17 α -Methyltestosterone and Letrozole on Masculinization and Physiological Status in Rosy Barb, *Pethia conchonius* (Hamilton, 1822)

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The production of high-value, high-demand species could benefit the ornamental fish market. The value and demand of fish are influenced by factors such as gender, size, and color. This study aims to assess the efficacy of 17α-methyltestosterone (MT) in combination with letrozole (LET), an aromatase inhibitor (AI), in promoting masculinization in the rosy barb (Pethia conchonius). The experimental design included a control (without AI) group and three treatment groups: T1 $(M_{12.5}+L_{150})$, T2 $(M_{25}+L_{100})$, and T3 $(M_{37.5}+L_{50})$ mg/ kg feed. The highest percentage of males ($86.90\pm0.59\%$) was recorded in the M_{37.5}+L₅₀ mg/ kg group after 90 days, which was significantly different from the other groups. Similar to previous findings, histological sections showed suppressed ovarian development with atretic oocytes, while testicular development remained unaffected. Additionally, the concentration of antioxidant enzymes, including superoxide dismutase (SOD), catalase (CAT), glutathione S-transferase (GST), and glutathione peroxidase (GPX), significantly increased in the control group. Instrumental color analysis on the basis of L*, a*, and b* values showed that fish fed gel-based feed with M_{37.5}+L₅₀ mg/kg had significantly more vibrant colors than those in the control groups (p<0.05). Digestive enzyme activity, such as protein (70±0.52), protease (0.054±0.001), lipase (11.16±0.28), and amylase (8.80±0.78), varied among treatment and control groups. Consequently, the use of AI at M_{37.5}+L₅₀ mg/kg in gel-based feed appears to be a promising approach for masculinization without adversely affecting the growth, color, or antioxidant activity of rosy barb, making it a valuable tool in the ornamental fish industry for achieving an all-male population.

Keywords: *Pethia conchonius*, Aromatase inhibitor, Letrozole, 17α-methyltestosterone, Masculinization

Exploring Gel-based Feed Formulations: Enhancing Nutritional Acceptance in Aquaculture

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Gel-based feed applications provide promise for revitalizing and establishing a low-impact aquaculture practice. Fish will quickly consume gel feed because it is viscoelastic, nutrientdense, hard, flexible, and aesthetically pleasing. It can also be shaped into appealing forms. Rosy barb (Puntius conchonius), a model fish, was used in this study to assess the qualities and acceptability of a gel diet that has been thoughtfully designed utilizing several gelling agents. Three gelling agents viz., starch, calcium lactate and pectin were included at 2%, 5%, and 8% in a fish muscle-based diet. Physical properties of gel feed were standardized using texture profile analysis, sinking velocity, water stability, gel stability, water holding capacity, increased volume, proximate composition, colour and sensory characteristics. The lowest nutrient leaching protein (0.57±0.15) and lipid (14.3±14.3) were observed up to 24 hours in the water column. The highest score for overall physical and acceptance characteristics was found for the 5% concentration of calcium lactate-based gel feed. Further, a 20-day acceptance feeding experiment was conducted using 5% calcium lactate. Results indicate better acceptability (3.55±0.199) and water stability (-2.5±2.5) of the gel feed compared to the control. Overall, the study provides insight into the application of gel-based diets for ornamental fish rearing, besides ensuring efficient nutrient uptake and minimal leaching for a clean environment.

KEYWORDS: Fish, Gel-based feed, Gelling agents, Physical properties, Feed acceptability

Nutritional and Molecular Benefits of Quercetin-Enriched Diet on Growth and Immunity in *Labeo rohita* Fingerlings

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The current study examined the effects of feed supplemented with quercetin on the expression of growth genes and the measurement of enzymes related to growth, metabolism, antioxidant defense, and immune response in Labeo rohita fingerlings. The five experimental diets were prepared with quercetin inclusion levels of 0 (control diet), 0.2% (T1), 0.4% (T2), 0.8% (T3), and 1.6% (T4). Growth performance, weight gain percentage (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein energy ratio (PER), hepatosomatic index (HSI), and intestinal somatic index (ISI) were all significantly different (p<0.05) between the treatment and control groups, with the largest differences observed in T4. Comparing the treatment groups to the control group, quercetin supplementation at 200, 400, 800, and 1600 mg/kg resulted in a significant increase (p<0.05) in the relative expression levels of IGF-1 gene expression in the liver and muscle. The TNF-α, IL-1β, TLR-22 and INF-γ mRNA levels significantly (p<0.05) increased with increasing quercetin levels and the highest expression was found in T4 treatment group (p<0.05). The study found a significant difference (p<0.05) in the expression profiles of genes associated with antioxidants, such as SOD, CAT, GSH, and GPx, between the treatment and control groups. Our research indicates that supplementing Labeo rohita with 1600 mg/kg of quercetin increases their immune system, growth performance, and antioxidant status.

KEYWORDS: Quercetin, Immune genes, Growth, Antioxidant status, Blood parameters

Dietary L-Carnitine and Taurine Synergistically Improve Growth Responses and Somatic Index of *Penaeus vannamei* Juveniles Reared in Inland Saline Water

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Feeding shrimp with lipid utilizing nutraceuticals supplemented with a low protein and high lipid (LPHL) diet could be the appropriate strategy for sustainable shrimp production. Thus, a 60-day experiment was conducted to find out the effects of L-carnitine and taurine supplemented diets with varying protein and lipid levels on growth responses and antioxidant status of white-leg shrimp, *Penaeus vannamei* juveniles reared in inland saline water (ISW) of 15% salinity. Seven hundred and ninety-two acclimated shrimp (av. wt., 3.53±0.02 g) were randomly distributed in twelve experimental groups in triplicate with the stocking density of 22 shrimps/circular tank (500 l water volume). Accordingly, twelve LPHL hetero-nitrogenous (40 to 32%), hetero-lipidic (6 to 10%) and hetero-caloric (384 to 406 kcal DE/100 g) experimental diets viz. T1 (40% CP and 6% lipid), T1C (T1 + 0.05% L-carnitine), T1T (T1 + 0.5% taurine), T1ct (T1 + 0.025% L-carnitine and 0.25 taurine), T2 (36% CP and 8% lipid), T2C (T2 + 0.05% L-carnitine), T2T (T2 + 0.5% taurine), T2ct (T2 + 0.025% L-carnitine and 0.25 taurine), T3 (32% CP and 10% lipid), T3C (T3 + 0.05% L-carnitine), T3T (T3 + 0.5% taurine), and T3ct (T3 + 0.025% L-carnitine and 0.25 taurine) were prepared and fed to shrimps of respective groups on satiation basis four times a day. Final body weight, weight gain percentage, specific growth rate and feed efficiency ratio decreased with increasing dietary lipid, but dietary lipid utilizing nutraceuticals increased these parameters with the highest values in the T2ct group. The feed conversion ratio showed the opposite trend. However, the highest protein efficiency ratio and lipid efficiency ratio were found in the T2ct and T1ct groups, respectively. The hepatopancreas somatic index value of the T1ct group was similar to the T1T and T2ct groups, but higher than other groups. However, no variation in the survival rate of shrimp was found among dietary groups. In conclusion, the T2ct diet (36% CP and 8% lipid supplemented with 0.025% L-carnitine and 0.25% taurine) showed the highest growth performance of P. vannamei reared in ISW of 15% salinity. This data could help in environment-friendly feed formulation for sustainable shrimp culture in ISW.

KEYWORDS: Penaeus vannamei, Inland saline water, L-carnitine, Taurine, Growth response



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Impact of Dietary Ashwagandha Root Powder (ARP) Incorporation on Feed Intake and Metabolic Activity of *Labeo rohita* Fingerlings in Cold Condition

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Fish are poikilothermic species and the physiological processes of fish are intricately regulated by water temperature. One of the most important environmental factors influencing aquatic organisms and controlling their physiological and metabolic functions is temperature. Low temperatures can make fish less able to metabolize food, which might cause lethargy. Ashwagandha has been extensively studied as a potential metabolic modulator for a variety of fish species. To assess the impact of Ashwagandha (Withania somnifera) root powder (ARP) on feed intake, growth performance, and physio-metabolic responses in *Labeo rohita* fingerlings raised at low temperatures, the current study was conducted. Four iso-nitrogenous and iso-caloric practical diets were formulated and prepared by supplementing ashwagandha root powder at 0, 5, 10 & 20 g/kg inclusion and designated as control (C), AP0.5, AP1.0 & AP2.0, respectively. L. rohita fingerlings were randomly distributed to treatment tanks in a low temperature (20±3°C) recirculatory aquaculture system (RAS) following a completely randomised design. Feed intake was significantly higher in ARP-supplemented fed groups (p<0.05) than non-supplemented group (C). Fish fed with ARP-based diets exhibited higher growth rates (weight gain percentage and specific growth rate) than control (p<0.05). 20 g/ kg dietary ARP-supplemented group exhibited the highest IGF-1 gene expression (P<0.05). Malate dehydrogenase (MDH) and isocitrate dehydrogenase (IDH) activities exhibited a linear trend in rohu fingerlings fed with ARP levels (p<0.05). Superoxide dismutase (SOD) and glutathione S-transferase (GST) activities were higher in ARP groups than in control (p<0.05). The feeding trial's results concluded that 20 g/kg ashwagandha root extract (ARP) enhanced feed ingestion and growth performance in Labeo rohita fingerlings reared at low temperatures.

KEYWORDS: Ashwagandha root powder, Low temperature, Feed intake, Growth, Labeo rohita

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Potential of Green Pea Pod Meal (GPM) in the Diet of *Labeo rohita* Fingerlings in Terms of Growth, Digestive and Antioxidant Enzyme Activities

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The utilization of biomass originating from agro waste through potential strategies pave the way for finding low-cost alternative feed ingredients. Therefore, in the present study, exogenous enzyme supplementation (equal mix of cellulase and xylanase at 0.1%) and solidstate fermentation (SSF) were applied as strategies to utilize Green Pea pod Meal (GPM) in carp diet. SSF of GPM with Aspergillus niger enhanced crude protein levels and digestibility, whereas, lowered crude fibre and anti-nutritional factors. A 60-day feeding trial was carried out with 315 nos. of *Labeo rohita* fingerlings (8.00±0.21 g) which were randomly distributed in 21 tanks with a stocking density of 15 nos. /150 l to assess growth, nutrient utilization, and enzyme activities. The isonitrogenous (30% CP) and isocaloric (371 kcal/100g) diets were prepared with GPM at two different levels (15 and 30%) in three different forms: raw GPM (GPM15 and GPM30), raw GPM with an exogenous enzyme (GPM15+EE and GPM30+EE), and fermented GPM (FGPM15 and FGPM30). The growth and nutrient utilization parameters such as weight gain, weight gain %, specific growth rate (SGR), protein efficiency ratio (PER), and apparent net protein utilization (ANPU) were significantly (p<0.05) higher in FGPM15 and FGPM30 followed by GPM15+EE and GPM30+EE groups. Nonetheless, these groups showed a significantly lower feed conversion ratio (FCR). Amylase and protease activities were significantly (p<0.05) higher in fermented and GPM 15+ EE groups than GPM30 and control group. The hepatic SOD and catalase activity were found to be higher in GPM 30 fed group while the reduced activity was observed in fermented and enzyme supplemented groups. Hence, the study concludes that raw GPM can be included in aquafeed at a maximum of 15% level, however feeding fermented GPM at a rate of 15% to 30% or with enzyme supplementation (0.1%) can improve the growth and nutrient utilization in L. rohita fingerlings.

KEYWORDS: Vegetable waste, Complimentary ingredients, Waste utilization, Rohu, Solid state fermentation



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Growth Performance of GIFT Tilapia in Biofloc Systems with Varied Protein Diets

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Biofloc technology (BFT) presents a sustainable alternative for aquaculture by reducing effluent release and maximizing fish production. This study evaluated the growth performance, water quality parameters, feed utilization, and optimal protein requirement of GIFT tilapia fingerlings (*Oreochromis niloticus*) in biofloc tanks. Over a 60-day period, GIFT tilapia fingerlings were stocked in 15 experimental tanks of 200 l each, fed with diets containing graded levels of crude protein (CP) at 24% (T1), 28% (T2), 32% (T3), 36% (T4), and 40% (T5). Water quality parameters, including temperature, pH, dissolved oxygen, ammonia, alkalinity, nitrite, and nitrate, were monitored throughout the study. Significant variations in water quality parameters were observed within the experimental period and among treatment groups, although all parameters remained within suitable ranges for fish growth and survival. The highest growth performance of GIFT tilapia was observed in T5 with a 40% CP diet; however, weight gain and specific growth rate (SGR) in T5 were not significantly different from T3 and T4, suggesting that higher protein levels did not further enhance growth. Conversely, the 24% CP diet resulted in suboptimal growth, likely due to inadequate protein content. The study suggests that a 32% CP diet may be optimal for the growth of GIFT tilapia in biofloc systems, with microbial protein in the biofloc partially compensating for protein deficiencies.

KEYWORDS: GIFT tilapia, Optimum protein requirement, Biofloc, Growth performance

Role of Attractants and Minor Ingredients in Enhancing Feeding Performance of Stinging Catfish *Heteropneustes fossilis*

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In the current scenario, aquaculture stands as a profitable venture that boosts farmers' incomes while also helping to meet the nutritional demands of the burgeoning population. To promote yield and profitability, diversification in terms of species and system is required. A shift towards profitable and climate-resilient species coupled with quality and cost-effective feed may promote production with higher returns. To develop a cost-effective feed, we should focus on locally available quality ingredients and utilize these as per the nutritional requirement of the targeted organism. Also evaluating the attractant potential of feed ingredients is essential, as it can significantly enhance feed intake of targeted species. Considering the requirement, a trial is conducted on *Heteropneustes fossilis* juveniles where minor ingredients and additives are used to evaluate the intake potential and performance of the feed. Six iso-nitrogenous feeds (38% crude protein) were formulated, each containing 5% fish meal, 5% black soldier fly (BSF) meal, and 5% gastropod meal as minor ingredients, along with 0.5% betaine, 3% lysine, and 2% glucose as additives to evaluate feeding performance. The inclusion of 5% BSF Meal has resulted in promising results in terms of weight gain percentage, specific growth rate, feed efficiency ratio, and protein efficiency ratio. Elevated liver and muscle lactate dehydrogenase, malate dehydrogenase, glucose-6-phosphate dehydrogenase along with SOD and catalase activities signified better physiological performance of the feed. Serum biochemical parameters such as bilirubin, SGOT, SGPT, and glucose levels were found at optimal levels which suggests BSF meal at a 5% inclusion level can significantly enhance feed intake, growth and physiological responses in *Heteropneustes fossilis*. This study supports the sustainable production of catfish Heteropneustes fossilis by utilizing alternative protein sources, thereby upholding environmental integrity and promoting longterm sustainability.

KEYWORDS: Attractants, Minor ingredients, *Heteropneustes fossilis*, BSF meal, Alternative protein source

Dietary Incorporation of Tubifex Meal Based Diet on the Growth Performance of *Anabas testudineus* (Bloch, 1792)

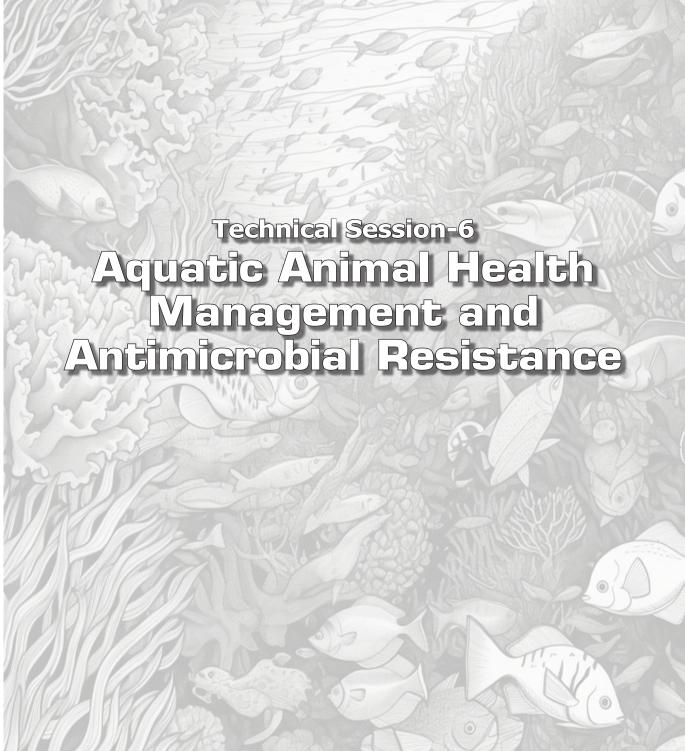
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Feed is the cornerstone of the aquaculture industry, contributing 40-60% of the total operational costs and relying heavily on fish meal as a primary component. To meet the rising demand for aquaculture products, sustainable and cost-effective alternatives are needed. This study evaluated the impact of Tubifex meal-based diets on the growth, feed utilization, and economic viability of Anabas testudineus (fry) under controlled conditions over a 90-day period (August-October 2022). A Completely Randomized Design was employed in glass aquaria, with five dietary treatments of Tubifex meal inclusion: 0% (control, T0), 25% (T1), 50% (T2), 75% (T3), and 100% (T4). Each treatment was replicated three times, with 10 fish per aquarium. The initial mean weight and length of the fish ranged from 3.43-3.50 g and 3.13–3.33 cm, respectively. Water quality parameters, including dissolved oxygen, pH, and temperature, were monitored and remained conducive to fish growth. At the experiment's conclusion, T4 (100% Tubifex meal) yielded the highest growth performance, with a mean weight of 33.47 g, followed by T3 (29.26 g), T2 (25.01 g), T1 (23.49 g), and T0 (22.12 g). The highest specific growth rate (SGR) and survivability were also observed in T4. The feed conversion ratio (FCR) was lowest in T4 (0.70±0.02), indicating superior feed efficiency, compared to the highest FCR in T0 (1.10±0.03). Fish harvest numbers were highest in T4 (29 fish) and lowest in T0 (23 fish). Economic analysis revealed the net yield and benefit-cost ratio (BCR) were greatest in T4, demonstrating the economic viability of Tubifex meal-based diets. These findings suggest that Tubifex meal can effectively replace traditional fish meal, enhancing growth performance, feed utilization, and profitability while reducing dependency on conventional feed sources. Furthermore, the study underscores the feasibility of incorporating Tubifex meal into the diets of Anabas testudineus to enhance growth performance, reduce feed costs, and promote sustainability in aquaculture practices.

KEYWORDS: Anabas testudineus, Tubifex meal, Growth performance, Economic viability

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Pharmacodynamics and Pharmacokinetics of Lufenuron, an Anti-Parasitic Drug in Asian Seabass, *Lates calcarifer* Fingerlings under Tropical Indian Climate

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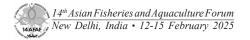
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Parasites are silent killers of productivity and profitability in aquaculture. Several ectoparasitic copepod and branchiuran crustaceans have been reported in brackishwater aquaculture, but the availability of safe and effective treatment protocols is scanty. Hence, we have identified in-feed lufenuron (LF) administration for the prevention and control of crustacean parasites. Healthy Asian seabass, Lates calcarifer fingerlings (4.71±0.01 g) were procured and stocked at 20 fish per 500 l flow-through tank in triplicate and fed @ 4% body weight (BW)/day divided equally between three feedings. Pharmacodynamic study was conducted to assess the safety under tropical Indian climate by feeding at doses of 0, 5 (1x), 25, and 50 mg/ kg of fish/day for 21 days (3x duration) per os by top-coated medicated feed. In addition, pharmacokinetic by QTRAP 4000 LC-MS/MS with 5 mg/kg of fish BW/day for seven days, leaching studies with guar gum and egg albumin as binders, efficacy against sea louse, Caligus minimus and co-habitation studies with C. minimus infested pearlspot, Etroplus suratensis were also conducted. The samples were collected and analysed for haematology, gene expression, gut content, histopathology, and LF residues. Results showed that LF was biologically safe up to 10 times the recommended therapeutic dose and three times the recommended therapeutic duration, respectively based on the behaviours, clinical signs, haematology, gross and histopathological findings. The gut content analysis revealed that there was a significant difference in quantities of plankton (p<0.01) and digested particles (p<0.05) between treatment groups. The level of LF was found to be least on the 28th day of post-treatment with a limit of quantification (LOQ) at 0.01 ppm. In addition, no significant difference was observed in the rate of LF leaching with 3.52 and 5.36% in guar gum and egg albumin coated feeds, respectively after soaking the top-dressed feeds in water for 40 min. It was concluded that there was an adequate margin of safety and efficacy in using LF medication against parasites in brackishwater aquaculture at the proposed therapeutic dose of 5 mg/kg fish/day for seven days with a withdrawal period of 28 days.

KEYWORDS: Parasites, Aqua medicine, Biosafety, Efficacy, Withdrawal



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Comprehensive Diagnosis of Clinical and Subclinical Occurrence of Tilapia Lake Virus Infection by Biochemical, Serological and Molecular Methods in Maharashtra and Gujarat States of India during 2020-23

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Tilapia lake virus (TiLV) emerged as a novel infectious agent that is a vital threat to Nile tilapia and for different farmed tilapias. TiLV recovered from the naturally infected farmed tilapia was confirmed with RT-PCR and Sanger sequencing. The virus was successfully detected in the mucus. The virus inoculum prepared from the infected tissues was tested for in vivo and in vitro pathogenicity. Around 100-140 nm-sized electron-dense virus particles were observed in the infected OniL cells. In this study, clinical and subclinical TiLV infections were noticed. Hence, innate immune response and haemato-biochemical alterations in naturally infected fish stock were analyzed to identify biomarkers for clinical and subclinical TiLV infection and the data were compared with the fish stock tested negative for TiLV. The clinical and subclinical fish showed severe anaemia and abnormal liver function parameters (p<0.05). Interestingly the CRP, creatinine, and SOD levels were unaltered in TiLV infection (both the groups) compared to control. Out of all hematological parameters, Platelet Distribution Width (PDW) was found as a specific biomarker for subclinical infection. A semi-quantitative lesion scoring technique for TiLV infection, based on gross and microscopic pathological changes, has been developed for the first time that establishes a clinical relevance and prognostic ability to distinguish between clinical and subclinical infection. Using polyclonal antisera against TiLV (TiLV-Ab), an indirect enzyme-linked immune sorbent assay (iELISA) was developed for the detection of TiLV in fish tissue and mucus. High analytical sensitivity and moderate specificity were displayed by the developed iELISA. The Positive and Negative Likelihood Ratio (LR+, LR-) were 1.75 and 0.29, respectively. The estimated Positive and Negative Predictive Values (PPV and NPV) of the test were 76.19% and 65.62%, respectively. The accuracy of the developed iELISA was estimated as 73.28%. An immunological survey was performed using the developed iELISA with samples from the field. 155/195 fishes tested positive, indicating a 79.48% TiLV antigen positive. Among the pooled organs and mucus tested, the highest positive rate of 92.3% (36/39) was observed in mucus compared to other tissues, and the least positive rate of 46% (18/39) was found in the liver. The newly designed iELISA proved sensitive and may be helpful for extensive examinations of TiLV infections and monitoring disease status even from apparently healthy samples.

KEYWORDS: Tilapia lake virus, Diagnosis, Biochemical, Serological and molecular methods



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Genotyping of White Spot Syndrome Virus Using Comparative Genomics Based MRF Tool

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Viral disease outbreaks remain a major concern impeding the development of the shrimp aquaculture industry. The viral disease due to white spot syndrome virus (WSSV) observed in the early 1990s still continues unabated affecting the shrimp farms resulting in huge economic loss to the shrimp aquaculture industry. In the absence of effective therapeutics to control the viral disease in general and WSSV in specific, research is being conducted to develop improved diagnostic tools and to understand shrimp response to WSSV for better disease management and control. At the molecular level, recent advances made in next-generation sequencing technologies, transcriptome sequencing, CRIPR-CAS technology, and the availability of shrimp and WSSV genome sequences are providing critical information to facilitate in area of diagnostic research. In the immediate future, the main challenges are to integrate the available genomic data with genotyping of pathogens and related epidemiological studies on disease spread and control of WSSV in particular. In the present study, we have used bioinformatic tools (Missing Region Finder) to genotype WSSV isolates.

KEYWORDS: WSSV, Genotyping, Missing Region Finder

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An Immersion Vaccine against Zoonotic Fish Pathogen *Lactococcus* garvieae for Coldwater Fish Rainbow Trout (*Oncorhynchus mykiss*) of India

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Rainbow trout (Oncorhynchus mykiss) is the topmost important coldwater species in fish farming of hills of India. However, due to intensification and change in climate, farmed rainbow trout has been facing the "warm water lactococcosis" disease caused by Lactococcus garvieae. Vaccination by immersion is known to have several advantages over injection, such as reduced stress to fish and mass vaccination within a short time. Therefore, in this study, the efficacy of the formalin-killed autogenous vaccine in rainbow trout (23.45±5.87 g) was evaluated by immersion (20 min). Vaccination was done as primary and booster dose at an interval of 7 days, and fish were challenged 7 days post booster dose (pbd). The experiment was conducted in duplicate with two group: treatment group (TG; n=72) - vaccinated and infected by inducer, and control group (CG; n=72) - non-vaccinated and infected by inducer. Blood serum and organs (gill, liver and kidney) for histology was collected 3, 5, 7, 14 and 21 days pbd from TG and CG. Approximately 100% relative percent survival (RPS) was observed in TG in comparison to CG, when exposed to homologous L. garvieae strains (3.56×10⁶ cfu/ml). The serum lysozyme activity and bactericidal activity increased significantly in TG, in comparison to CG on 21 days pbd. However, no significance difference was found in total protein, albumin, and globulin content of the serum of both the groups. Biosafety evaluation of the vaccine in rainbow trout (n=10; 28.96±18.56 g) indicated no pathological changes at tissue or cellular level till 7 days pbd. No cytotoxicity of the vaccine was observed on EPC cell line. Animal behavior scoring, survival percentage, body weight, gross lesion scoring, and histopathology scoring confirm the biosafety of this vaccine in rainbow trout. The findings of this study suggested that the immersion of rainbow trout to formalin-killed L. garvieae vaccine protects against disease caused by L. garvieae.

KEYWORDS: Warm water lactococcosis, Antibiotic resistance, Vaccine, Rainbow trout, Immune gene

Effect of *Ocimum gratissimum* (African Basil) Extract on Growth, Hemato-Biochemistry, Immunity, Stress Response, and Aeromonas Resistance in *Labeo rohita* (Hamilton)

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The use of phytobiotics in aquaculture has emerged as an effective alternative to antibiotics, mitigating antimicrobial resistance (AMR) with minimal side effects. Ocimum gratissimum, known as Clove basil, Wild basil, or African basil, is native to Africa and prevalent in tropical and subtropical regions. This aromatic plant is used as a spice and contains bioactive compounds like alkaloids, phenols, essential oils, peptides, flavonoids, and glycosides, which have medicinal properties. Extracts from the plant leaves are used as supplements in fish diets to avoid anti-nutritional factors impairing fish growth. In this study, Ocimum gratissimum leaf extract (OGE) was obtained using different organic solvents. Antibacterial in-vitro tests against fish pathogenic bacteria: Aeromonas diversa, A. sobria, A. jandei, Edwardsiella piscicida, Escherichia coli, and Pseudomonas putida, revealed zones of inhibition ranging from 10-28 mm, with the ethanolic extract showing the highest inhibition (20-28 mm). The Minimum Bactericidal Concentration (MBC) and Minimum Inhibitory Concentration (MIC) of OGE were assessed against fish pathogenic A. sobria LRK7, and based on an MBC/MIC ratio of ≤ 4 , OGE was further evaluated for its time-kill activity against A. sobria LRK7. Labeo rohita (55.50±0.02 g) were fed an iso-nitrogenous diet with OGE at 500 mg/kg for 60 days and subsequently exposed to a sub-lethal dose (1.8x10⁵ CFU/ml) of A. sobria LRK7. The OGE-supplemented diet significantly modulated hemato-biochemical variables in a dose-dependent manner. Fish fed with OGE for 60 days exhibited significantly (p<0.05) enhanced innate immune parameters including serum respiratory oxidative burst activity. anti-protease activity, myeloperoxidase activity, antioxidant activity (FRAP), ceruloplasmin, and C-reactive protein levels. Post-bacterial challenge, the OGE-fed group displayed a higher immune response from 1 to 10 days post-infection (dpi) compared to the control groups. Hemato-biochemical responses and histological analyses also showed improvements in the OGE-supplemented group. The stress biomarkers (glucose and cortisol) were significantly (p<0.05) downregulated in the OGE-fed fish compared to the control. OGE supplementation also significantly increased the specific growth rate (SGR) and reduced the feed conversion ratio (FCR), indicating its growth-promoting effects on *L. rohita*.

KEYWORDS: Phytobiotics, *Ocimum gratissimum*, Antimicrobial resistance (AMR), Innate immunity, Specific growth rate (SGR)



CIBA EHP Cura I: A Novel Therapeutic for Effective *Ecytonucleospora hepatopenaei* (EHP) Management in Shrimp Culture

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Ecytonucleospora hepatopenaei (EHP), the causative agent of hepatopancreatic microspordiasis (HPM) has been reported to cause severe epizootics in shrimp farming nations. EHP affects shrimp digestion, physiology, and metabolism, and causes growth retardation, morbidity, and ultimately results in severe economic loss. Presently, prophylactic and therapeutic protocols for the treatment and control of EHP are very limited. The present study developed a therapeutic agent named 'CIBA EHP Cura I' for the effective control of EHP. CIBA EHP Cura I' (Cura) contains phytochemical and beneficial fatty acids and was found to inhibit the EHP spore germination *in-vivo* at 0.05%. EHP-challenged shrimp (n=30 in triplicate) were fed with Cura at different concentrations (0.05%, 0.1%, 0.15%, 0.2%, and 0.3%) and were compared with control (challenged, un-supplemented) for 60 days. At the end of the experiment, the shrimp fed with Cura were observed to have significantly higher immune parameters such as total hemocyte count, phenoloxidase, and catalase activity. Cura-fed shrimp hepatopancreas histological sections were found to be largely normal whereas control shrimp showed severe degeneration and necrosis of tubules. Cura-fed shrimp were found to have significantly lower EHP load at the end of 60 days when compared to the control. Also, Cura-fed shrimp were found to have significantly higher final body weight, weight gain, specific growth rate, and survival than control. Especially, Cura at a concentration of 0.15% produced higher values across all the treatment parameters. Thus, Cura significantly improves the immune parameters, reduces EHP load, causes protective changes to hepatopancreas, and ultimately enhances the growth and survival of shrimp. In conclusion, Cura can be effectively used as a neutraceutical for the treatment and control of EHP in shrimp culture.

KEYWORDS: CIBA EHP cura I, Ecytonucleospora hepatopenaei, Shrimp, Growth retardation

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Antioxidant, Immunostimulatory and Antifungal Potential of Essential Oils Against Saprolegniasis

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Natural compounds of plant origin, which include essential oils (EO) could be used as antimicrobial and immunostimulants in aquaculture The present study aimed to investigate the effectiveness of five essential oils against fungal pathogens of fish. Selective compounds were screened for the minimum inhibitory concentration in single and in combination for actinomycetes activity, and then mycelium growth inhibition test was performed against Saprolegnia parasitica and S. australis; Fusarium oxysporum and F. equiseti. DPPH (α, α-diphenyl-β-picrylhydrazyl) radical scavenging activity, Alkaline DMSO radical scavenging activity, Hydrogen peroxide radical scavenging assay and 2,2-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) radical cation (ABTS+•) were studied for antioxidant activity. Nitric oxide production and myeloperoxidase activity of the compounds were tested in peripheral blood mononuclear cells of rainbow trout, Oncorhynchus mykiss to assess the immunostimulatory potential. Among all, the Carvacrol (CRVO) treatment group had MICs ranging from 15.62 mg/l to 250 mg/l against S. parasitica, S. australis zoospores, F. oxysporum, and F. equiseti zoospores. The Thyme oil (TO) treated group demonstrated a MIC range of 15.62 to 500 mg/l against S. parasitica, S. australis zoospores, F. oxysporum and F. equiseti zoospores. CRVO and TO showed increased Nitrite oxide production at the highest concentration of 15.62 and 31 mg/l TO showed significantly higher peroxidase activity (p≤0.05) at a concentration of 16-128 mg/l. The nitric oxide and total peroxidase activity of Ajwain seed oil (AJO) showed a significant difference only at higher concentrations against the control. The results conclude that CRVO, TO and AJO showed the best anti-Saprolegnia activity. Among all, the inclusion of CRVO and TO will provide additional immunostimulatory activity.

KEYWORDS: Anti-oomycetes, Immunostimulatory, Plant active ingredients, Saprolegnia sp.

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Aeromonas veronii Causing Mortality of Asian Seabass (Lates calcarifer) Cultured in Freshwater Environment

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Asian seabass (*Lates calcarifer*) is a desirable high-valued fish in Asian countries yielding high income and is a promising domesticated finfish for the aquaculture industry across the coastal states in India. Cultured Asian seabass has its challenges such as diseases due to infectious and opportunistic pathogens, nutritional deficiencies and varied environmental parameters in attaining marketable size. On investigation, farmed seabass juveniles (100 - 150 g) in freshwater environments were reported to have 5 to 10% daily mortality. The fish had gross changes like paleness, dullness, scale loss, and eroded skin. The microbial isolation and characterization of moribund fish were done to identify the cause of death. The samples were screened for nervous necrosis virus (NNV) and Red Seabream irido viral disease (RSIVD) and were found to be negative through PCR. Through comprehensive morphological, microbiological, histopathological and molecular analysis, Aeromonas veronii, a gram negative rod shaped motile bacterium was identified in the blood of diseased fish, and the same was also confirmed by 16s rRNA sequencing and blast analysis. The nucleotide sequence showed 98% similarity with A. veronii (KF413415). Aeromonas veronii is an emerging pathogen in Asian seabass, significantly causing various diseases like sepsis. ulcer syndrome, and mass mortality in aquatic animals. Antibiotic susceptibility testing was carried out for the strain. As this bacterium is reported to infect a wide host range, its antibiotic microbial resistance profiles in commercial aquaculture are expected to play an important role in one health approach.

KEYWORDS: Asian seabass, Lates calcarifer, Aeromonas veronii, PCR, 16s rRNA

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Disease Surveillance in *Litopenaeus vannamei* Shrimp Farms in Thiruvallur District of Tamil Nadu Revealed Dominance of *Enterocytozoon hepatopenaei*

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Shrimp aquaculture is one of the fastest growing sectors globally, susceptible to many emerging infectious diseases during recent years because of the intensification of the culture systems. Pathogens like WSSV, IHHNV, TSV, IMNV, YHV, and EHP are important for crustaceans and affect their production, hence they are listed as important pathogens by WOAH. Disease surveillance plays a significant role in studying endemic and emerging diseases and to develop preparedness to control them. Mortality due to unknown etiology often occurs, requiring disease investigation and identifying the cause of death. It contributes to our baseline knowledge of the pathogen status. Previous studies indicated that white gut syndrome is seen in a majority of the farms in this area and these farm samples gave positive for Wenzhou shrimp virus 8 (WzSV8). With this background disease surveillance in Litopenaeus vannamei shrimp farms in Tiruvallur district in Tamil Nadu was carried out from September 2022 to July 2024. Samples were collected from 134 shrimp farms and screened for WzSV8 in addition to WOAH-listed shrimp pathogens. It was found that hepatic microspordiasis caused by *Enterocytozoon hepatopenaei* was the major disease followed by infections due to IMNV and WSSV. Out of the 134 farms analysed, 41% of farms were affected by EHP, 9.6% of farms showed positivity for IMNV and 6.6% of farms had WSSV infection. Further, the average Days of Culture (DOC) of EHP-infected farms was found to be 61 days, for WSSV it was 58 days and IMNV for 70 days. Diseases like IHHND, YHD, TS, DIV1, and AHPND were found to be negative in all these farms. However, a few farms had mixed infections (35%), and the pathogens seen in mixed infections were mostly EHP and WzSV8. The study indicated that shrimp culture above 50 DOC are highly prone to infectious viral diseases occurrence and need to be in constant surveillance for effective control in Thiruvallur district of Tamil Nadu, India.

KEYWORDS: Disease surveillance, Shrimp pathogens, Viral disease, Litopenaeus vannamei

Biological Effects of Florfenicol on Environmental Toxicity Indicator Organisms: Microalga, *Chlorella marina* and Copepod, *Apocyclops* sp.

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One of the most often used antibiotics in aquaculture is florfenicol (FFC). However, the residual concentration of FFC in the aquatic environment and its effect on non-target organisms need to be studied under tropical climates. Hence, the current study examined how FFC affected marine alga, Chlorella marina, and copepod, Apocyclops sp. on their growth, chlorophyll content, photosynthetic pigmentation, antioxidant capacity, ingestion, and metabolism, respectively, at the doses of 0, 2, 4, 8, 16, 32 mg/l (ppm). The findings demonstrated that the chlorophyll content was reduced after 96 hours of exposure to FFC (2-32 ppm), in coincidence with retardation in the growth of C. marina as compared to that of control. Moreover, the longer exposure time (96 h) and higher FFC concentration (32 ppm) reduced the photosynthetic parameters by inhibiting algal cells and lowering the ingestion and metabolism in copepod rather than causing mortality. Additionally, after 96 hours of exposure, the reactive oxygen species (ROS), and superoxide dismutase (SOD) were found to be increased and glutathione (GSSH), which increased up to 16 ppm and then decreased drastically at 32 ppm is indicative of oxidative stress on algae at high concentrations and long exposure of FFC. Catalase (CAT) and malondialdehyde (MDA) showed significant drop-in activity at 32 ppm of FFC. The equilibrium between oxidants and antioxidant systems was upset by the concurrent rise in ROS. When FFC concentrations were high, algae produced an excessive amount of ROS, which impacted membrane permeability and further reduced cell biomass. The results of this study demonstrated that even though physiological dysfunction in microalgae C. marina was found at an FFC concentration of 32 ppm, 96 hours of exposure at environmentally relevant concentrations of 4-16 ppm was found to be safe. Hence, it is recommended that FFC can be used against bacterial infections in aquaculture at the recommended dose of 10-15 mg/kg fish body weight without affecting the environment as evidenced by these indicator organisms.

KEYWORDS: Florfenicol (FFC), Environmental indicator, Toxicity, Antioxidant, Antibiotic

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Detection and Characterization of Wenzhou Shrimp Virus 8 (WzSV8) in Shrimp Farms in India

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Indian shrimp farms, like other parts of the world, have been continuously suffering from disease and associated loss. Frequent emergence of pathogens has been noticed recently which has created serious problems. Here, an attempt was made to investigate the presence of the newly described shrimp virus, Wenzhou shrimp virus 8 (WzSV8). More than 200 shrimp samples from different locations in India were collected and analysed for the presence of this virus. Wide-spread detection of WzSV8 was observed in shrimp farms in India where 58% of samples were found to be positive for this virus. Many of the samples had only WzSV8 infection and in others, co-infection with other shrimp pathogens such as WSSV, IMNV, and EHP was also observed. The presence of WzSV8 was confirmed through PCR, histopathology, in situ hybridization, transmission electron microscopy, and transcriptomics. To find out the target organs for the detection of WzSV8; hepatopancreas, gut, stomach, gill, and muscle were processed by PCR. Only samples from HP, gut, and stomach were positive for this virus, and muscle and gill were negative. A strong correlation of WzSV8 with shrimp white gut syndrome (WGS) was observed where WGS samples always had a high load of this virus. Phylogenetically the Indian isolates were closer to Chinese isolates. The role of this virus in causing disease directly or precipitating the pathological conditions through coinfection needs to be further studied. Particularly, analysing the role of WzSV8 in shrimp white gut syndrome could provide clues about the disease mechanism.

KEYWORDS: Wenzhou Shrimp Virus 8, Characterization, Prevalence, Pathology, White gut syndrome

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Surveillance for Antibiotic Resistance in Freshwater Aquaculture Farms of Andhra Pradesh, India

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The occurrence of antibiotic resistance and bacterial pathogens in various aquaculture settings is alarming. Their mode of entry and existence may pose a threat to aquaculture sustainability, aquaculture-derived food, and the environment. Hence, to address the challenges that the freshwater aquaculture sector would confront, the present study was carried out in fish farms in Andhra Pradesh, India, from January 2020 to December 2023. Based on primary and secondary data from farms (n=520), sampling was done and bacterial pathogens were isolated from selected fish farms (n=110) where risk factors were predominant and antimicrobial use was rampant. Isolates were screened for cultural and biochemical characteristics and different phenotypic resistance mechanisms for characterization, such as antibiotic susceptibility, biofilm formation, efflux pump activity, extended-spectrum beta-lactamase production, and hyper-mucoviscosity. The present study documented major risk factors in aquaculture and a total of 336 different aqua inputs represented by >50 manufacturing units. Aqua inputs were dominated by disinfectants and toxin binders (29.8%), followed by feed additives and growth promoters (21.5%), probiotics (20%), unlabelled groups (10.4%), pesticides (8.9%), antibiotics (5.2%), and fertilizers (4.2%). In the present study, a total of 57 A. hydrophila, 44 A. caviae, 35 P. aeruginosa, 21 P. putida, 16 P. fluorescens, 32 K. pneumoniae, 12 K. oxytoca, 33 S. marcescens, 15 M. luteus, and 04 E. tarda were isolated and identified. Among these, A. hydrophila (n=57), P. aeruginosa (n=35), and K. pneumoniae (n=32) were highly resistant to different antibiotics, possessed biofilm and efflux pump activity, were capable of transferring resistance genes by conjugation and harboured various virulence genes. These findings highlight the need for a multifaceted approach from all the stakeholders in the sector to tackle disease and AMR issues. Promoting the adoption of best management practices, conducting regular disease surveillance, identifying causative agents, and performing antibiotic susceptibility testing before using antibiotics, when necessary, are all essential steps to minimize the emergence of antibiotic-resistant bacterial strains that pose potential public health risks.

KEYWORDS: Antibiotic resistance, Biofilm, Efflux pump, Virulence, Public health

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A Novel Synbiotic Formulation for Improved Shrimp Immunity and Growth

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The application of substances like probiotics, prebiotics, nutritional supplements, etc. has been an effective strategy for improving disease resistance and growth in shrimp aquaculture. The present study evaluates the efficacy of a novel synbiotic formulation (*Bacillus* spp., *Lactobacillus* spp, yeast, microalgae) in enhancing the growth and immune enhancement in *Penaeus vannamei* (3±0.2 g). Shrimp were supplemented with four diet combinations (I, II, III & IV) and fed three times a day at 4% of their body weight for seven consecutive days. A novel formulation (Treatment IV) improved immune genes and antioxidant activities, average body weight, and specific growth rate compared to the groups provided either with probiotic microbes (Treatment II) or microalgae (Treatment III). The animals provided with novel formulation showed significantly higher (p<0.05) expression of prophenoloxidase, lysozyme, peroxinectin, crustin, heat shock protein 70 (HSP70), superoxide dismutase (SOD), and catalase genes in the intestine and hepatopancreas. Further, higher levels of digestive and antioxidant enzymes in the hepatopancreas were observed in the group fed with the novel formulation. The results revealed the potential of novel synbiotic formulations for improved immune response and growth in penaeid shrimp, *P. vannamei*.

KEYWORDS: Synbiotics, Immune genes, SGR, P. vannamei

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Protective Efficacy and Immune Responses in Nile Tilapia, Oreochromis niloticus by an Inactivated Tilapia Lake Virus (TiLV) Vaccine

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Tilapia lake virus (TiLV) is a novel orthomyxovirus that has emerged as a devastating pathogen for tilapia aquaculture worldwide. However, no commercial vaccine is available vet against this pathogen. The present investigation aimed to evaluate the efficacy of the whole virus vaccine for protection against TiLV. The vaccine was developed from the cell culture-based whole virus material. It was inactivated with formalin, emulsified with Freund's incomplete adjuvant (FIA), and injected intraperitoneally into 60 numbers of naïve Nile tilapia, Oreochromis niloticus (30-40 g) at a dose of 1 mg/kg body weight. The same number of fish in the control group received PBS with FIA. A booster dose was given similarly after 14 days. After 21 days of the booster, the fishes in both vaccinated and control groups were challenged intraperitoneally with virulent TiLV strain and observed for mortality up to 28 days post-challenge. The results showed a cumulative mortality of 81.67% in the control and 0% in the vaccinated group. The relative percent survival was 100% indicating the effectiveness of the vaccine. Further, the immunological responses induced by the vaccine were measured by the specific IgM response in serum and skin mucus of vaccinated fish by a developed indirect ELISA, as well as immune gene expression in different immunologically active tissues. The IgM response was found significantly enhanced in vaccinated fish from 14 days post 1st dose of vaccination in both serum and mucus samples in comparison to the control and persisted till 180 days of observation. The peak response was on days 28 and 42 for serum and mucus, respectively. The expression of innate and adaptive immune genes (IgM, IgT, IgD, CD4, IL1β, MHC I, MHC II, MX, NFκβ, RSAD2, IRF3, and TLR2) was also elevated in kidney and spleen tissues of vaccinated fish at different days of observation compared to the respective controls. Enhanced IgM response and up-regulation of immune gene expression following immunization supported the protective response shown in the immunization-challenge experiment. All these findings suggest that the developed whole virus vaccine is effective in protecting tilapia against TiLV and could be a game changer in the management of TiLV in tilapia aquaculture.

KEYWORDS: Tilapia lake virus, Inactivated whole virus vaccine, IgM response, Immune gene expression



Pharmacokinetics and Tissue Distribution of Oxytetracycline in Silver Pompano (*Trachinotus blochii*) Following a Single Dose in Feed Administration

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Appropriate dosage regimens based on pharmacokinetic data can enhance the treatment efficacy of the drug and lessen adverse effects on the environment, consumers, and hosts. Oxytetracycline is the most frequently used antibiotic for aquaculture in Asian countries. The present study reports the pharmacokinetic profiles of oxytetracycline in *Trachinotus* blochii under tropical marine conditions (35±0.9%; pH: 8.0±0.5; temperature: 29±0.35°C) following a single oral administration of the recommended dose (80 mg/Kg). The blood and tissue samples (intestine, plasma, gill, liver, muscle and skin in natural proportions, and kidney) were collected at 11 sampling points; 0.5, 1, 2, 4, 6, 8, 10, 12, 18, 24, and 48 h of drug administration. The oxytetracycline was extracted and analyzed by Liquid Chromatography-Tandem Mass Spectrometry. Oxytetracycline was detected only up to 24 h in plasma and muscle+skin. However, 170±123.05 ng/g remained in the liver at 48 h. The maximum concentration (Cmax) in plasma and tissues was observed within four hours. The Cmax (ng/g) in different tissues was in the order of intestine (63500) > liver (8093.33) > kidney (2926.67) = gill (2443.67) > muscle+skin (885.67) > plasma (144). The elimination half-life (t 1/2\textit{B}) was significantly higher for the gill and liver. The maximum area under the curve (AUC) was observed for the liver and intestine. The mean residence time was in the order of liver = gills > plasma = kidney > muscle + skin > intestine. The AUC tissue/plasma was more than 1 for all the tissues and was in the order of intestine > liver > gill = kidney > muscle+skin. The AUC (0 to infinity) in the liver was ~30.33, 10.02, 3.49, and 2.9 times higher than plasma, muscle+skin, gills and kidney, respectively. The results demonstrated that oxytetracycline was rapidly absorbed from the intestine, distributed extensively, and eliminated quickly. However, data suggested a higher oxytetracycline dose in T. blochii in tropical mariculture conditions to ensure activity against less-susceptible bacterial strains. The generated data can be applied for formulating efficient therapeutic protocols in *T. blochii*, a promising mariculture species.

KEYWORDS: Liquid Chromatography-Tandem Mass Spectrometry, Therapeutic dose, Marine fish, Antibiotic



Comparative Genomics of Harveyi Clade: Insight into Virulence Related Factors

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Vibrio harveyi clade is a group of 13 closely related Vibrio species that causes diseases in brackishwater and marine animals resulting in significant economic losses. Pathogenic determinants carried over chromosomes and plasmids decide the pathogenic behavior of bacterial strains. To understand the genetic features and pathogenicity among important clade groups (Vibrio harveyi, V. campbellii, V. parahaemolyticus, V. alginolyticus, V. rotiferianus, V. owensii, V. jasicida, V. diabolicus, V. antiquarius) a pangenome level in silico analysis of virulence factors were carried out in 2244 isolates of these species. The core genome-based phylogeny and genome-level average nucleotide identity suggested a lack of species barrier among the few species. Based on the characterization of secretion systems toxins (Type III), colonization factors, and conjugative plasmids; 6 species are classified as pathogenic and 4 species as non-pathogenic. A challenge trial was carried out to verify the in silico analysis and to understand the virulence mechanism of the selected Vibrios. The present study will pave the way for diagnostic development to differentiate pathogenic and non-pathogenic species in the future.

KEYWORDS: Genomics, Vibrio harveyi, Vibrio campbellii, Virulence

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Gut Microbiome Modulation as a Preventive Approach to Fish Diseases

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Probiotics are live microorganisms that have gained significant attention in recent years attributable to their potential to improve growth, better immune responses and overall health of the host. In the context of aquaculture, probiotics offer a promising alternative to antibiotics that have been associated with global health and development concerns due to anti-microbial resistance (AMR) and Multi-drug resistance (MDR). It has been documented that by manipulating the host microbiota, probiotics not only improve the health of farmed fish but also align with the One Health concept. The present study investigated the effects of probiotic Lactobacillus plantarum on the growth, defense, disease resistance and gut health of Pangasius catfish. A total of 120 fish were divided into four treatment groups (T1: Control; T2: Probiotic-fed; T3: Control + Bacterial challenge and T4: Probiotic-fed + Bacterial Challenge) for a 45-days feeding trial, followed by a bacterial challenge with Aeromonas hydrophila. Probiotic-fed fish exhibited significant development in growth, overall health and immunity. In order to elucidate the underlying mechanisms of probiotic action, the gut microbiome of Pangasius catfish was analysed using 16s rRNA amplicon sequencing. The results revealed significant variation in the alpha and beta diversity indices between all the treatment groups. The bacterial community belongs to the phyla i.e., Bacterioidata, Proteobacteria and Firmicutes were identified as the core microbiome of pangasius fingerlings during the study. Furthermore, functional annotation of the gut microbial community was also analysed. Notably, the genus heatmap analysis exhibited that the prevalence of Akkermansia which was affected by the bacterial infection in T3 was restored in T4. This implies that the probiotic application can modulate the gut microbiota composition in fish. The findings of the study highlight the potential of probiotics that can be used as a preventive strategy to control microbial diseases and improve the productivity of farmed fish through microbiota manipulation, ultimately supporting the One Health Concept.

KEYWORDS: Aquaculture, Gut microbiota, One Health, Lactobacillus plantarum

Functional Significance of Lipopolysaccharide Binding Protein Gene during Bacterial Infection in Asian Seabass, *Lates calcarifer*

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Understanding the crucial immune genes governing responses against microbial diseases is fundamental in comprehending the dynamic interplay between pathogens and the host's immune system. The current research work discusses the functionality of one of such important immune-related genes, Lipopolysaccharide-Binding Protein (LBP) gene, responsible for eliciting immune responses against bacterial Lipopolysaccharide (LPS) during infections. Asian seabass, Lates calcarifer is an economically important food fish in the tropical and subtropical regions and infectious diseases are one of the major constraints of seabass production. During the study, an exploratory survey was carried out in 13 freshwater Asian seabass farms across the States of Andhra Pradesh, Karnataka, Maharashtra and Gujarat to identify prevalent bacterial pathogens. A total of 44 gram-negative bacterial isolates from diseased Seabass samples were subjected to phenotypic and molecular characterization. During the tissue-specific expression profiling of LBP gene, the highest level of expression was found in the spleen tissue when compared to the liver, kidney, blood, gill, brain and intestine. Full-length characterization, ORF Prediction and Protein Structure Prediction of LBP gene were also carried out. The results identified Lipopolysaccharide-Binding Protein gene, as a biomarker associated with immune responses during bacterial infection in Asian Seabass. This key candidate gene (LBP) can contribute to the development of strategies for disease resistance against microbial diseases, consequently enhancing fish health and minimizing economic losses in aquaculture.

KEYWORDS: LBP gene, Immunity, Biomarker, Bacterial infection

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Environmental Transition Navigates Phenotype Switching, Affecting the Virulence of Pathogenic Bacteria

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The ability of bacteria to respond to environmental changes is critical to their survival. This allows them to withstand stress, form complex communities, and induce virulence responses during host infection, a phenomenon known as phenotypic switching. The study investigates the role of shaking conditions on the phenotype switch of shrimp and fish pathogenic bacteria. Acute hepatopancreatic necrosis disease (AHPND)-causing shrimp pathogenic Vibrio parahaemolyticus and fish pathogenic Morganella morganii were evaluated for in vitro and in vivo conditions. The results showed that V. parahaemolyticus and M. morganii grown at lower shaking speeds, possibly causing low fluid shear, developed cellular aggregates or floccules and significantly higher biofilm formation. Meanwhile, the bacterium grown at a higher shaking speed was non-flocculated and produced less biofilm. This phenotype switch causes a major shift in the protein secretome and multidrug-resistant profile. These observations are matched with a very strong reduction in the *in vitro* and *in vivo* virulence of V. parahaemolyticus and M. morganii grown at lower shaking speed, namely, haemolysin, swimming motility, histomorphological changes, and survival assay as compared to bacterial cells grown at a higher speed which displayed increased in vitro and in vivo virulence. Furthermore, cells grown at a lower shaking speed have higher expression of structural genes that promote biofilm formation and increased antimicrobial resistance. In contrast, the higher speed induces higher expression of virulence-related genes, resulting in high mortality in aquatic animals. Taking together, the study provides substantial evidence for the existence of two phenotype forms in the fish and shrimp pathogenic bacteria, V. parahaemolyticus and M. morganii displaying differential phenotypes. Moreover, as water flow and movement are common features in aquaculture systems, they can inflict fluid shear on the standing microbial agents. Hence, our study could provide a basis for understanding the behavior of V. parahaemolyticus and M. morganii in aquaculture settings and open the possibility of monitoring and controlling this pathogenic bacterium by steering phenotypes.

KEYWORDS: Vibrio parahaemolyticus, AHPND, Morganella morganii, Phenotype switch, Virulence

Evaluating the Impact of Thermal Discharge from a Coal Power Plant on *Escherichia coli* and its Antibiotic Resistance Pattern in River Ganga

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Temperature has a major impact on the growth, survival, and overall physiology of Escherichia coli (E. coli), a common bacterium found in the intestines of people and animals. Like many other species, E. coli has a limited tolerance to temperature. E. coli grows slowly or not at all at temperatures much higher or lower than ideal. Temperatures exceeding 45°C (113°F) cause stress in E. coli, which leads to its eventual death. In the present study, soil samples were collected from the thermal discharge of a coal power plant, in river Ganga with average water temperatures of 45±2.5°C. The soil sample was serially diluted and 10⁻⁵ dilution was transferred to EC broth (Himedia, Mumbai, India) and incubated at 37°C for 24 hours. One loopfull of culture was transferred to the MacConkey agar (Himedia, Mumbai, India) plate for isolation of pure culture. Gram staining, IMViC test, oxidase test, and catalase test were performed. Gram staining of every culture produced rod-shaped, gram-negative bacterial cells. Oxidase, citrate, and the Voges-Proskauer test produced negative results, whereas tests for indole, methyl red, and catalase produced positive results. Triple sugar iron agar showed the presence of acid/acid and gas production. The results all added up were indicative of E. coli. The single lactose-producing bacteria were picked from the MacConkey agar plate and transferred to TSB for genomic DNA isolation. A multiplex PCR was used to confirm the E. coli isolates by using five different primers (Modak et al., 2012), uidA (\(\beta\)-galactosidase), lacZ (ß-D-galactosidase), lacY (lactose permease), cyd (cytochrome bd complex), and phoA (bacterial alkaline phosphatase). Electron microscopy was conducted to evaluate the morphological changes caused by temperature variations. Using the Kirby Bauer disc diffusion test with commercially available antimicrobial discs (HiMedia, Mumbai, India), each isolate's antimicrobial susceptibility to 16 antimicrobials was evaluated. E. coli isolated from the soil of the thermal discharge point were resistant to Amoxycillin-clavulanic acid, Ampicillin, Aztreonam and Gentamicin, Ampicillin, and Ceftriaxone respectively. The study revealed the morphological changes and adoption of E. coli isolated from the thermal discharge site with antibiotic resistance in comparison to the control strain of E. coli ATCC 25922.

KEYWORDS: Escherichia coli, Thermal discharge, Antibiotic resistance, River Ganga

Evaluation of Effect of *Achyranthes aspera* Supplemented Diets on the Growth, Innate Immunity, Antioxidant Status and Expressions of Immune Related Genes in Catfish *Clarias batrachus*

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The application of plant ingredients as a feed additive improves the health status of the aquacultural species. The present study evaluated the influence of seeds and leaves of Achyranthes aspera in Asian catfish Clarias batrachus in pond conditions. Catfish (0.51 ± 0.032 g) were cultured in hapas set inside a pond. Fish were fed with two experimental diets, SD1 and LD2 containing 0.5% seeds and leaves of A. aspera, respectively, and the control diet CD3. The control diet was prepared without the plant ingredient. Fish were immunized with chicken RBC after forty five days of feeding. The samples were collected on days-7, 14, and 21 after immunization for various assays. The average weight and specific growth rate were significantly higher in SD1 diet-fed fish compared to others. LD2 followed the SD1 treatment for these parameters. The feed conversion ratio was minimal in SD1 diet-fed fish. Dietary supplementation of seeds significantly enhanced the serum lysozyme, myeloperoxidase, nitric oxide synthase, hemagglutination titer, and superoxide dismutase levels in SD1 diet-fed fish compared to others. The thiobarbituric acid reactive substances and carbonyl protein levels were significantly lower in the SD1 treatment compared to others. In the liver and head kidney of enriched diet-fed catfish, the inducible nitric oxide synthase, superoxide dismutase Cu-Zn, nuclear factor-kB, and tumor necrosis factor-α expression were up-regulated. The dietary supplementation of A. aspera seeds and leaves enhanced the growth and improved the health status of catfish. This is an eco-friendly and sustainable approach to the health management of catfish.

KEYWORDS: Achyranthes aspera, Clarias batrachus, Lysozyme, Myeloperoxidase, Inducible nitric oxide synthase

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Comparative Antimicrobial Resistance Profiling of Bacterial isolates from Freshwater Aquaculture systems in Odisha and Andhra Pradesh

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Antimicrobial resistance (AMR) poses a significant threat to global health and food security. In the aquaculture industry, various sectors, including fish, crustaceans, and shellfish, frequently use chemotherapeutic agents, including antibiotics, to prevent and treat diseases and minimize production losses. Despite restrictions on certain drugs like Fluoroquinolones, Nitrofurans, and Chloramphenicol in many countries, their use persists in some areas. The introduction of antibiotics into aquatic environments can lead to the emergence of drugresistant bacteria, negatively impacting both human and animal health. To assess the status of antibiotic resistance in aquatic systems, a questionnaire-based survey was conducted in Odisha and Andhra Pradesh. This survey collected information on culture practices, drug usage during various stages of fish farming and hatchery operations, and other farm inputs. A total of 208 freshwater fish farms were surveyed, yielding 87 fish samples and 297 water samples for analysis, focusing on the isolation of E. coli, Aeromonas sp., and Staphylococcus sp. In total, 990 bacterial isolates were obtained, including 328 E. coli, 332 Staphylococcus sp., and 330 Aeromonas sp. These samples analyzed by antibiotic susceptibility testing (AST), with results analyzed using WHONET 5.6 software according to CLSI guidelines. The antibiotic sensitivity testing revealed that E. coli isolates exhibited significant resistance to Cefoxitin, Trimethoprim-sulfamethoxazole, Nalidixic acid, Tetracycline, and Ampicillin. Aeromonas sp. and Staphylococcus sp. showed high resistance to Penicillin and Erythromycin, among others. Notably, some bacterial isolates demonstrated resistance to antibiotics not used in aquaculture for fish disease management, suggesting potential contamination from external sources related to human healthcare. This paper elaborates on the prevalence of diseases, varied drug usage, AMR profiles, and associated issues.

KEYWORDS: Antibiotics, Antimicrobial resistance, AMR, Aquaculture drugs

Functional Characterization of Septin 8 in *Labeo rohita*: Role in Development and Immune Response Against Infections

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Septins are a highly conserved family of GTP-binding proteins, first discovered in Saccharomyces cerevisiae. It plays a crucial role in coordinating membrane polarity and regulating cell division both in spatial and temporal aspects. Septins are initially discovered as the proteins affected by mutations leading to cell cycle arrest and abnormal bud growth, septins are recruited to the site where bud growth begins. However, their functional characterization in Indian major carps remains unexplored. In this study, we successfully cloned the full-length septin 8 cDNA from rohu carp (Labeo rohita). The septin 8 gene in L. rohita contains a 1263 bp open reading frame (ORF) that encodes 420 amino acids, and the phylogenetic analysis revealed 99.29% similarity to Myxocyprinus asiaticus and Triplophysa rosa. Tissue-specific expression analysis indicated higher septin 8 expression in the gills, anterior and posterior kidneys, spleen, eyes, heart, and brain. Ontogeny studies also demonstrated increased septin 8 expression during early developmental stages, highlighting its potential role in early development and protection. Additionally, septin 8 transcript levels were upregulated in response to three different infection models: Aeromonas hydrophila, poly I:C, and Argulus siamensis, suggesting its involvement in immune responses. A recombinant septin 8 protein (~48.78 kDa) was produced and administered to rohu at a dose of 1 µg/g, which led to the modulation of immune-related gene expression, including pro-inflammatory cytokines, antiviral proteins, antioxidant genes, apoptosis-related genes, antimicrobial proteins, and toll-like receptors. In vivo experiments further showed significant protection against A. hydrophila (55% relative percent survival) and delayed mortality in A. siamensis infections. Moreover, a septin 8 knock-out line was generated using CRISPR-Cas9 to study the gene expression profile in mutant fish for further functional validation. This study provides valuable insights into the diverse functions of septin 8 in L. rohita, highlighting their critical role in fish immune responses presenting new avenues for research and potential applications for immunity enhancement.

KEYWORDS: Functional characterization, Immunity, Labeo rohita, Septin 8

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Impact of Polystyrene Microplastics Exposure in Zebrafish: Effects on Condition Factor, Haematology, Tissue Integrity and Biochemical Parameters

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Microplastics are increasingly recognized as widespread pollutants in both freshwater and marine environments. Their presence has been detected in the tissues of various fish species in the wild, while experimental studies have shown that microplastics can negatively affect fish health. This research aimed to investigate the toxic effects of polystyrene microplastics (PS-MPs) in zebrafish (*Danio rerio*), specifically assessing bioaccumulation, Fulton's condition factor, and hematological, histological, and biochemical changes. Zebrafish (mean weight: 0.957±0.07 g; mean length: 3.92±0.11 cm) were exposed to 8 μm PS-MPs at concentrations of 0, 10, 100, and 1000 ug/l for 21 days. Significant reductions in body weight and condition factor were observed in fish exposed to 100 and 1000 µg/l PS-MPs. Bioaccumulation of PS-MPs occurred in a concentration-dependent manner, with the highest accumulation recorded in the gastrointestinal tract, followed by the gills and ovary. Hematological analysis indicated significant genotoxic effects, with an increase in erythrocyte nuclear abnormalities at 100 and 1000 µg/l. Moreover, exposure to PS-MPs led to elevated counts of erythrocytes (RBCs) and immature erythrocytes, coupled with a reduction in lymphocytes. Histological examination revealed notable tissue changes, such as an increase in goblet cells in the gastrointestinal tract, liver inflammation and lipid accumulation, and hyperplasia of gill filaments. Biochemical analysis showed that PS-MP exposure at levels above 100 µg/l induced stress responses in multiple organs (e.g., gut, gill, muscle, and ovary), with significant alterations in glucose, total protein, alkaline phosphatase, acid phosphatase, cholesterol, triglycerides, superoxide dismutase (SOD), and catalase (CAT). In conclusion, PS-MP exposure, especially at higher concentrations, triggered a range of adverse effects in zebrafish, influencing multiple organ systems and physiological functions. These findings suggest that even relatively low concentrations of microplastics in aquatic environments can pose significant risks to fish health. The observed bioaccumulation and physiological stress responses raise concerns about the long-term ecological impacts of microplastic pollution, underlining the need for stricter regulations and more comprehensive environmental monitoring to mitigate the risks associated with microplastics in freshwater ecosystems.

KEYWORDS: Microplastic, Zebrafish, Bioaccumulation, Histopathology, Biochemical

Dietary Supplementation of *Bacillus amyloliquefaciens*, Alone and in Combination With B-Glucan, Effected Growth Performance, Immune Expression, and Disease Resistance in Striped Snakehead, *Channa striata* Fingerlings

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Incorporating β -glucan and *Bacillus* sp in the diets of striped snakehead either individually or in combination represents nutritionally enriched therapeutics for preventing bacterial infections in Channa striata farming. A strain of Bacillus amyloliquefaciens CS5, designated as Ba-CS5, was characterised from the digestive tract of *Channa striata* (striped snakehead). To gain a better understanding of the possible amplitude and application of Ba-CS5 in snakehead farming, four different test diets consisting of individual or combination with immunostimulants were prepared by incorporating β-glucan. These diets were then fed to the snakehead fingerlings (4.0 g±0.71) in four experimental groups in triplicate tanks: group C (control, without the addition of either probiotics or β -glucan), 0.5% β -glucan (Bg), Bacillus amyloliquefaciens (Ba-CS5) @ 10⁸ CFU/g, and β-glucan + B. amyloliquefaciens (BgBa-CS5). The current study assessed the snakehead growth performance, feed utilization, immunological response, and Aeromonas hydrophila resistance following a 56-day feeding trial. Results revealed a significant improvement (p<0.05) in the growth performance of snakehead fingerlings in treatments Bg and BgBa-CS5 at the end of the feeding trial. Control groups showed significantly highest (p<0.05) feed co-efficiency (FC), whereas BgBa-CS5 treatments had the lowest FC. Dietary probiotics and β-glucan supplementation enhanced the activities of lipase, amylase, and total protease digestive enzyme; while significantly increased (p<0.05) digestive enzyme activity was shown by the BgBa-CS5 treatment group. The non-specific immunity such as myeloperoxidase, respiratory burst activity, and lysozyme levels were significantly higher (p<0.05) in treatments Bg and BgBa-CS5, respectively. Compared to the treatments Ba-CS5, Bg, and BgBa-CS5, the antioxidant capacity of control was found to be significantly lower (p>0.05). The relative survival percent of snakehead after the intraperitoneal challenge of A. hydrophila was significantly high in treatments Ba-CS5 individual incorporation or mixed with β-glucan. Nevertheless, significantly increased (p<0.05) expression of pro-inflammatory cytokines and growth-related genes (Internal growth factor-1, growth hormone), including antioxidant enzymes (superoxide dismutase) was shown in the treatments than control. Present findings suggest that Ba-CS5 supplementation, either alone or in combination with β -glucan, can enhance growth and act as a potential immunomodulator in snakehead farming.

Keywords: Channa striata, Immune expression, Probiotics, β-glucan, Aeromonas hydrophila



Combined Natural Infection of *Citrobacter fruendi* and *Candida* sp. Caused Mortality in Blood Parrot Cichlid

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The study investigated a mass mortality event of blood parrot cichlid, a hybrid of *Amphilophus citrinellus* and *Vieja melanurus*, at an ornamental fish hatchery during August 2024. Moribund fishes exhibited symptoms like erratic swimming, hemorrhagic and whitish patches at body parts, rotten tail, gill, and fin. A total of 26 blood parrot cichlids died within 9 days. The detailed investigation approach was performed to identify the infectious causative agent. On applying microbiological and molecular techniques, a common fish bacterial pathogen, *Citrobacter fruendi* and Yeast, *Candida* sp. was confirmed. The bacterium was isolated from blood whereas the fungus was isolated from fish muscle and gill. Molecular identification of isolated bacteria and fungus were based on the amplification of partial fragments of 16S rRNA and 18S rRNA gene followed by sequencing of ~1400 bp and ~600 bp amplicon, respectively. All the vital organs like gill, liver, kidney, spleen, and muscle were studied for histopathological changes to correlate with the co-infection from the moribund fishes. To our knowledge, this is the first report of combined infection of *Citrobacter fruendi* and *Candida* sp. in blood parrot cichlid.

KEYWORDS: Candida, Citrobacter, Infection, Blood parrot

Ecological Interactions and Community Patterns of Parasites in Gangetic Fish

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Habitat characteristics, host diversity and abundance are key factors determining the nature of fish parasitism. In India, the Ganga River traverses through multiple agro-climatic zones and habitats, harbouring more than 195 fish species. However, habitat degradation and changes in fish diversity and abundance are occurring at an alarming rate, which might also influence fish parasitism. The present study aimed to assess the nature of fish parasitism and its relationships with ecological variables in the lower stretch of the Ganga River. Examination of 20 fish species from different sites of the river and in different seasons identified the presence of seven parasites, namely, Argulus foliaceus, Alitropus typus, Posthodiplostomum sp., Isoparorchis hypselobagri, Euclinostomum spp., Clinostomum spp., and Contracaecum spp. in 11 fish species. Digenetic trematode, *Clinostomum* spp., had a comparatively wider host range, higher prevalence, and distribution pattern than other recorded parasites. Comparative analysis of the parasites' community characteristics revealed spatio-temporal variations among phylogenetically close and distant fish hosts. Most of the sampling sites along the lower Gangetic stretch displayed distinct patterns of mean intensity, mean abundance, and prevalence of parasites. Canonical correspondence analysis has identified greater roles of biochemical oxygen demand (BOD), pH, and total alkalinity in structuring the abundance of parasite groups. Prevalence and mean abundance of parasites were significantly influenced by BOD, specific conductance, and total dissolved solids of water. Additionally, bicarbonate alkalinity and nitrate nitrogen were found to affect the mean intensity of parasites. Seasonal changes in the water quality favoured the abundance of branchiuran and isopod in the winter season. During the rainy and autumn seasons, variations in water quality parameters were positively correlated with the mean abundance of parasites. However, the overall prevalence level of parasite infection was found to be higher in the summer season. Additionally, the study found that host phylogeny, sex, diet, and habitat preference were correlated with both intra and interspecific variability in infection patterns of the studied fishes. The baseline information on parasitism presented in the present study would help in planning similar studies in the upper and middle stretches of the river and in other rivers towards fish health management planning and fish germplasm maintenance in rivers.

KEYWORDS: Ganga River, Fish parasitism, Ecological variables

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Identification and Preventive Measures for Parasitic Infestation in Sea Cage Farmed Marine Finfish, Indian Pompano—Towards Sustainable Mariculture Practices

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Sea cage farming of marine finfish is one of the important farming practices in the mariculture production sector across the world. Indian pompano farming in marine cages is gaining importance in India and is considered to be one of the major sources of marine food fish. The expansion of sea cage farming activities with improved production rates has also resulted in the emergence of parasite-associated infections in stocked animals. Sea cage farming demonstrations of the Indian pompano along the north-east coast of India since 2017 have also experienced similar infections. The monogenetic trematode infestation was frequently observed on sea cage cultured Indian pompano. The parasite was identified as Neobenedenia girellae based on morphological identification and molecular characterization using 28S rDNA sequencing. Mortality was observed after 25-30 days post-infection varying from 1.6 to 3.4% daily till the onset of treatment. The trematode species was observed in fish sizes ranging from 55±10 g to 750±50 g in weight. Skin lesions and erosion were seldom observed in farmed fish, and the causative parasite was identified as an isopod parasite. In isopod parasite infestation, the mortality rate varied from 0.3 to 2.1% but occurred rarely, and infestation was mostly reported in fish weighing 600±50 g to 750±50 g. Controlling measures for parasitic infestation were developed, where the N. girellae was immediately controlled by freshwater dip treatment for consecutive three days for about 10 to 60 min depending on the fish size and tolerance limit. Use of anti-helminthic, Praziquantel @ 0.3 % in feed for five days could control up to 95 % of parasitic infestation when the infected stocks were fed separately. The infection rates could also be controlled in cages by frequent net exchange and maintaining the optimum fish stocking density. Despite different controlling measures, advocating different management strategies such as maintaining optimum stocking density of 25 nos/m³, frequent net exchange of once within 45 days, and frequent cage frame cleaning helps to control the parasitic attacks, which will pave the way for the sustainable cage culture operation of the marine finfish.

KEYWORDS: Cage culture, Parasites, Neobenedenia girellae, Sustainable cage farming

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A Microtiter Plate Method to Optimize the Concentration and Exposure Time of Potassium Permanganate for Disinfecting Fishing Nets

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Fishing nets are potential vehicles for the transmission of aquatic animal pathogens and human pathogens, both within and between aquaculture farms. Proper disinfection of nets employing potassium permanganate (KMNO₄) is an important biosecurity measure to prevent disease transmission. To determine the optimum concentration of potassium permanganate and the exposure time required for effective disinfection, a microtiter plate assay was developed. Sterile nylon threads (10 cm length) were soaked in seawater spiked with Vibrio parahaemolyticus (5x10⁵ cfu/ml). Potassium permanganate treatment was given at five different concentrations viz., 10 ppm, 20 ppm, 30 ppm, 50 ppm and 100 ppm for five exposure periods viz., 1 min, 5 min, 10 min, 20 min and 30 min. At the end of each exposure time, 30 µl from each potassium permanganate treatment concentration was transferred to a well of 96-microtiter plate containing 270 µl of nutrient broth supplemented with 3% NaCl (NBS) and the absorbance (OD₆₀₀) was measured at regular intervals up to 450 min. Positive, and negative were included and all tests were run in duplicate. The results showed a continuous increase in OD₆₀₀ value of 0 ppm and 10 ppm potassium permanganate treatments at all the exposure periods indicating that the use 10 ppm was ineffective. However, potassium permanganate treatments at 20 ppm and above at all the exposure periods were found to be effective in controlling the growth and survivability of V. parahaemolyticus. The nylon threads at the end of 1 min, 10 min, and 30 min of exposure from all the five potassium permanganate treatments were transferred to tubes containing sterile NBS and incubated overnight. Similar to the microtiter plate method, V. parahaemolyticus survived on the nylon threads soaked in 10 ppm potassium permanganate but not at concentrations above 20 ppm. The microtiter plate method is an effective tool to evaluate the antibacterial effectiveness of potassium permanganate in disinfecting fishing nets, thereby helping in preventing the spread of bacterial pathogens and antimicrobial-resistant bacteria.

KEYWORDS: Vibrio, Fishing nets, Disinfection, Potassium permanganate, AMR, Microtiter plate

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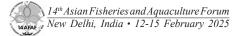
Prevalence of Antimicrobial Resistance in the Bacterial Isolates from Freshwater Fish Farms in Odisha, India—A Case Study

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Antimicrobials, including antibiotics, are frequently used in aquaculture to treat different bacterial infections. When antimicrobials are used, there is a risk that the pathogens can develop resistance to them. Excessive or inappropriate use of antimicrobials can accelerate the development of antimicrobial resistance (AMR). Also, indirectly antimicrobial residues from external sources can contaminate the aquatic environment and contribute to the development of resistance in wild bacterial populations. The present study was undertaken to investigate the prevalence of AMR in pond water samples from freshwater fish farms (n=72) in two aquaculture districts (Khordha and Puri) of Odisha, India. Water samples from the fish ponds were collected for the isolation of targeted bacteria, and resistance patterns harboured by them were analysed. Total 374 isolates comprising *Enterococcus* spp (73), Salmonella spp (73), Klebsiella spp (73), Acinetobacter baumannii (9), Pseudomonas spp (73), and Escherichia coli (73) were processed for antimicrobial susceptibility testing (AST) in a Vitek 2 system. Based on the minimum inhibitory concentration (MIC) values obtained, the bacteria were classified as resistant, intermediate or susceptible according to the Clinical and Laboratory Standards Institute (CLSI). The results revealed that Enterococcus spp is resistant to erythromycin (14.75%), followed by tetracycline (9.83%). Salmonella spp were found highly resistant to amikacin and gentamicin (95.9%), followed by ampicillin (93.1%), and amoxicillin/clavulanic acid (57.53%). Klebsiella spp were fully resistant to ampicillin (100%), followed by imipenem (19.2%) and meropenem (6.85%). Even though the prevalence percent is very low, Acinetobacter baumannii isolates were found resistant to many of the antibiotics, viz., ticarcillin/clavulanic acid, ceftazidime, cefoperazone/ sulbactam, and trimethoprim/sulfamethoxazole (100%) followed by amikacin (88.9%), and gentamicin (88.9%). Pseudomonas spp were resistant to trimethoprim /sulfamethoxazole (12.5%) followed by aztreonam (12.3%), tigecycline (11.1%), piperacillin/tazobactam (9.86%), and minocycline (9.72%). The Escherichia coli isolates are resistant to ampicillin (11.26%), cefuroxime (9.86%), nalidixic acid (9%), and ceftriaxone (8.45%). Overall, the study identified antimicrobial resistance patterns harboured by different bacteria groups in freshwater fish farms. These findings suggest AMR in aquaculture is a significant concern for both environmental and human health and further investigation is needed to know about its mode of transmission and to frame possible mitigation measures.

KEYWORDS: Antimicrobial resistance, Freshwater aquaculture, Antibiotics, Antimicrobial susceptibility testing



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Trophic Troubles: Assessing Environmental BPA Levels in Fish and Potential Health Risks

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Bisphenol A (BPA), a designated environmental pollutant, has become an emerging issue owing to its extensive distribution in aquatic habitats and possible detrimental effects on aquatic animals. The term, environmental BPA (eBPA) refers to the contaminant found in the natural environment due to anthropogenic activity. The persistence and bioaccumulation of eBPA in fish provide a significant hazard to the health and welfare of the piscine population, resulting in cascade effects on aquatic ecosystems and potential risks to human health. The current study evaluated eBPA levels in several fish species residing in the river Ganga. Tissues from wild-caught fish were dissected, and BPA was extracted using a standard protocol; subsequently, an immunosorbent assay was employed for eBPA detection. Results indicate substantial eBPA contamination in all fish categories, with demersal and pelagic fish displaying markedly elevated levels compared to benthopelagic fish. Among demersal fish, Polynemus paradiseus had the highest BPA accumulation at 119.26 ng/gdw, whereas Setipinna phasa in the pelagic habitat recorded 205.82 ng/g-dw. In contrast, benthopelagic fish such as Channa gachua and Salmostoma bacaila displayed negligible eBPA contamination. The current findings highlight the widespread eBPA contamination in aquatic environments, with demersal and pelagic fish serving as potential bioindicators of environmental BPA exposure. The findings of this study indicated that environmental BPA adversely affects edible fish models, advocating for its replacement in consumer products to reduce its concentrations in the environment.

KEYWORDS: Emerging contaminant, Bioaccumulation, Demersal, Pelagic, Ganga River

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Nanotechnology to Combat the Antimicrobial Resistance in Aquaculture

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Antimicrobial resistance has emerged as an important global concern in combating pathogens and in treating diseases of humans and animals, including fishes. Although several antimicrobials are available in the market to prevent and treat the infectious diseases of fishes, their repeated use and improper regulation have created concern for deteriorating water and soil conditions in aquaculture, resulting in multi-drug resistant microbes that pose a threat to the animals, humans and vice versa. Nanotechnology-based innovations have provided promising potential in the health care sector and nanoparticles have been designed to address different pathogenic microorganisms. Antimicrobials prepared from inorganic and organic materials have been used in different sectors including aquaculture. Metal-based nanoparticles are well studied in many agriculture and aquaculture research and applications and these include silver, gold, zinc oxide, titanium dioxide, copper, aluminum oxide, magnesium oxide, iron oxide, metal matrix, etc. These nanoparticles have been reported to have antimicrobial properties against important fish pathogens namely, Aeromonas, Vibrio, Streptococcus, Pseudomonas, and Flavobacterium sps, and several fungal pathogens viz., Saprolegnia, Aphanomyces, Candida and Branchiomyces sps. The mode of action of metal nanoparticles against different microbes is the breaking of cell membranes by electrostatic interaction and disrupting the ion transport. These nanoparticles also break the double strand of the DNA via electrostatic interactions and interfere with enzymatic activity and ribosome assembly, triggering higher oxidative stress with the production of more reactive oxygen species (ROS), resulting in damage to DNA, lipids, proteins and other micro molecules. Silver is considered one of the most effective metallic nanoparticles due to its wide range of chemical, biochemical and antimicrobial properties. Colloidal silver nanoparticles are widely used against a broad spectrum of pathogens, including viruses, protozoa, parasites, fungi, and bacteria. Silver nanoparticle also destroys different strains of bacteria namely Staphylococcus, Klebsiella, and Escherichia sps. in water and are in much use for tackling antimicrobial resistance. Several other nanoparticles like zinc oxide (ZnO), copper oxide (CuO), silver (Ag) and silver-doped titanium dioxide (Ag-TiO₂) have shown broad-spectrum antibacterial, antifungal and anti-algal activities in aquaculture use.

KEYWORDS: Antimicrobial resistance, Nanoparticles, Nanotechnology, Aquaculture

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Heat Killed *Mycobacterium* Induced Immune Training Enhances Vaccine Orchestrated Immunity in Tilapia

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Molecular insights and the existence of trained immunity in fishes have been demonstrated extensively. Various prototypical training ligands are now being evaluated for their potential to develop into trained immunity-based adjuvants (TIbAs). In the present study, we demonstrated the potential of heat-killed Mycobacterium (HKMb) to induce trained immunity and its capacity to enhance the adaptive immune response against inactivated TiLV vaccine in Tilapia. Intraperitoneal administration of HKMb was given as a training ligand two weeks before intraperitoneal (IP) vaccination with formalin-killed TiLV. The trained immune phenotype of the fish head kidney macrophages was characterized by increased production of IL-1 β , IL-6, and TNF- α , change in cellular metabolism and positive enrichment of histone markers such as H3K27Ac, H3K4me1, and H3K4me3. Fish trained with a single dose of HKMb before vaccination elicited higher antigen-specific antibody levels, viral neutralization titre, and higher transcript abundance of adaptive immune markers (CD4, CD8, IgM and IgT) and cytokines (TNF, IFN-γ, and IL-2) compared to the untrained group. Furthermore, prior innate immune training enhanced the antigen-specific IgM B cell response and nonspecific cell cytotoxicity elicited by subsequent stimulation with the TiLV vaccine. The trained group performed better with an increased relative percent survival of 95% compared to the normal vaccinated group of 85% following the TiLV challenge. These results strongly suggest that the administration of trained immunity inducers with a traditional formalin-killed vaccine can elicit robust adaptive immunity, offering a promising vaccination strategy to mitigate disease burden in aquaculture using autologous vaccines.

KEYWORDS: Trained immunity-based adjuvants, Epigenetic marks, TiLV Vaccine, RPS

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Natural Co-Infection of Tilapia Parvo Virus Along with Tilapia Lake Virus and *Aeromonas veronii* in *Orechromis niloticus* in A City Sewage Fed Wetland

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Multiple bacterial and viral infections are not uncommon in commercially important fish species. Tilapia Lake Virus (TiLV) and Tilapia Parvovirus (TiPV) are emerging infections in tilapia-based aquaculture globally. During the present disease outbreak investigation in Orechromis niloticus, the affected fish displayed various symptoms, including popped eyes, fin erosion, depigmentation on the body, hemorrhagic spots at the anal portions, eye, and abdomen. Upon dissection, findings revealed watery intestines and an absence of food particles in the stomach. The PCR-based diagnosis identified the presence of TiLV and TiPV in the infected fish. All tested individuals were positive for TiLV, while 90% of them were positive for TiPV. Further examination of infected fish involved sampling the kidney, liver, and blood to assess bacterial infections. Aeromonas veronii were isolated and identified through 16S rRNA gene sequencing. Overall, the study highlights the occurrence of a severe Tilapia mortality event in East Kolkata Wetland attributed to TiLV and TiPV infections, along with the presence of A. veronii bacterial infections in the affected fish. This report offers valuable insights into the prevalence and possible co-infections involving Tilapia Parvovirus in Nile tilapia. It enhances the understanding of emerging infectious diseases in the field of aquaculture.

KEYWORDS: Tilapia, Virus, Bacteria, Infection, Mortality

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Praziquantel Treatment: A Strategy for Combatting Gill Flukes in Asian Seabass (*Lates calcarifer*)

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Monogenean parasites, particularly gillflukes (*Dactylogyrus* spp.), are significant ectoparasites that lead to high mortality rates in freshwater and marine aquaculture systems. This study investigates the efficacy of praziquantel (PRZ), a commonly used antihelminth drug, against gill flukes in brackishwater fish. In vitro and in vivo assessments were conducted on infected Asian seabass (*Lates calcarifer*) using PRZ concentrations ranging from 5 to 120 mg/l and 5 to 100 mg/l, respectively. Both assessments demonstrated that a 40 mg/l dose of PRZ for 1 hour effectively eliminated all living flukes, with treated fish remaining healthy for up to 7 days post-treatment. In contrast, lower doses (below 15 mg/l) proved ineffective in controlling the parasites. While in vitro studies showed that PRZ concentrations of 75 to 120 mg/l were effective in killing gill flukes, higher doses (50 to 100 mg/l) were detrimental to the fish. This study establishes a bath treatment protocol for PRZ as an effective method for controlling gill flukes in Asian seabass, highlighting the importance of dosage optimization for both efficacy and fish health.

KEYWORDS: Monogeneans, PRZ, Bath treatment, Asian seabass

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Elucidating the Pathogenesis of *Photobacterium damselae* subsp. damselae on Asian Seabass Reared in Brackishwater

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Asian seabass, Lates calcarifer is a highly valued and widely cultured food fish, making it a key species in commercial fish farming. To meet the increasing demand for Asian seabass in the domestic and international markets, large-scale intensive production systems have been adopted. The success of aquaculture depends largely on the efficient use of aquatic resources with extensive knowledge of health management. Photobacteriosis is one of the major bacterial diseases reported to cause heavy mortality in Asian seabass hatcheries. During the exploratory survey in Karnataka State, an incidence of mortality of Asian seabass fingerlings was noticed. The moribund samples were collected with clinical signs exhibiting opaque eyes, darkening of gills, haemorrhages and exophthalmia. The biochemical characterization of isolated bacteria from diseased fish revealed it as *Photobacterium damselae* subsp. damselae which was further confirmed by 16S rRNA sequencing (PP514760). Antibiotic sensitivity profiling was recorded and through infectivity studies, an LD₅₀ dose of the isolated bacteria Photobacterium damselae subsp. damselae was determined. Experimental infection of Asian seabass fingerlings caused loss of balance, rapid movements, haemorrhages on the body surface and eyes as well as extreme exophthalmia. Simultaneously, blood profiling (haematocrit value, RBC count and WBC count), non-specific immune parameters (NBT assay, lysozyme activity, and MPO assay) and histopathological studies were also carried out for the control and infected groups. The purpose of the present study was to report the pathogenicity of bacteria leading to heavy mortality at the initial stages of growth thus causing economic losses to fish farmers. The information will support fish farmers and stakeholders to take precautionary measures against Photobacteriosis in Asian seabass hatcheries for better production.

Keywords: Asian seabass, *Photobacterium damselae* subsp. *damselae*, LD50 dose, Pathogenesis, Antibiotic sensitivity profiling

Isolation and Characterization of Emerging Fish Pathogen Chryseobacterium sp. from Infected Goldfish (Carassius auratus)

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Chryseobacterium sp. belonging to the family Flavobacteriaceae is an emerging fish pathogen. This species is generally regarded as an opportunistic bacterial pathogen in nature. In this study, we investigated a clinically infected Goldfish (Carassius auratus) from a fish farm during a disease outbreak. The bacterial colonies were isolated from the kidneys of infected goldfish (C. auratus). After incubation at 28°C for 24 hours, the colonies displayed yellow pigmentation in nutrient agar and were characterized as Gram-negative, rod-shaped, catalasepositive, and oxidase-positive. Twenty-eight antibiotics belonging to different classes were used to determine the antibiotic resistance pattern. From the total of 28 antibiotics, 25 antibiotics are resistant, in contrast, Vancomycin, Cotrimoxazole and Cefoxitin are highly susceptible, no intermediate results were obtained. Moreover, the multiple antibiotic resistance (MAR) index was estimated to be 0.892. Amplification and sequence analysis of the 16S rRNA gene identified the microorganism as Chryseobacterium sp., sharing 100% sequence similarity. The pathogenicity of this bacterial pathogen was experimentally confirmed in goldfish by a challenge experiment. Histopathological analysis of the infected fish revealed necrosis and degenerative changes in the kidney and spleen. Additionally, gene expression studies in the kidney and spleen of the infected fish demonstrated modulation of immune-relevant genes such as CD8, CD4, IFN-Y, IL-10 and IL-12. To control the spread of this opportunistic pathogen, proper management practices and quarantine measures are essential. This study underscores the virulence of *Chryseobacterium* sp. as a significant opportunistic pathogen in goldfish, highlighting the need for vigilant monitoring and intervention strategies to prevent outbreaks.

KEYWORDS: Chryseobacterium sp., Pathogenicity, Gene expression, Histology

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Comparative Metagenomics Analysis of Farmed and Wild Murrel (*Channa striata*) Gut Microbiomes

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The gut microbe plays an important role in nutrient absorption, immune responses and physiological functions, impacting the overall fish health. The current study aimed to compare the gut microbiomes of farmed and wild striped murrel (*Channa striata*) using a Metagenomics approach to identify differences in microbial diversity, community structure and functional potential. Gut samples of fishes from both environments were analysed through Illumina MiSeq sequencing 16S rRNA amplicons. The results revealed an abundance of Proteobacteria and Bacteroidata in both farmed and wild striped murrels. However, higher values of indices like Shannon, Simpson and Chao1 were observed in farmed murrel in comparison to wild murrel, indicating higher species diversity, richness, evenness and presence of rare species. Functional annotation of microbial communities showed the prevalence of genes associated with energy metabolism in both farmed and wild striped murrel. Further, genes related to amino acid metabolism, cell motility, and immune system were found in the wild. Such a broader function range of gut microbes in the wild may be attributed to their interaction with the environment. The findings of the study indicate that the environment plays a crucial role in shaping gut microbial diversity and functional metabolism.

KEYWORDS: Metagenomics, Channa striata, Shannon index, Simpson index, Chao1 index

Coincidence of Skeletal Deformities and Mortality of *Osteobrama belangeri* (Valenciennes, 1844) with Infection of a Novel Myxozoan Parasite *Myxidium osteobrami* sp. nov. (Myxidiidae, Thelohan, 1892) During Fingerling Rearing in Biofloc System

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Filter feeding habits of the highly preferred endemic minor carp Osteobrama belangeri make it an ideal candidate for high-density culture in biofloc system (BFS). However, limited information on its health management and disease risks is available currently. During rearing of fry to fingerling at varied densities (50, 75 and 100 per m³) in BFS, skeletal deformity, lethargic surface swimming, and swollen abdomen, followed by mortality were observed in fingerlings (7.02±0.73 cm) in all treatments, with 16-20% loss over two weeks in one replicate tank of the highest density treatment. Typical hernia-like hump behind the dorsal fin and bent caudal peduncle was the most remarkable observations in all affected fish. Radiographic imaging revealed kyphosis and dislocation of abdominal vertebrae, and lordosis in caudal vertebrae, possibly due to pressure from the overinflated swimbladder and increased caudal muscle activity. Microscopy revealed myxozoan parasites in the gall bladder while scanning electron microscopy reflected ellipsoidal spores measuring 11.6 µm in length and 4.91 µm in width with longitudinal surface sculptures. The partial 18s sequence (PQ308094 1081bp and PO217632 920 bp) and phylogenetic analysis revealed the parasite to be a novel Myxidium sp. i.e. Myxidium osteobrami sp. nov. (Myxidiidae, Thelohan, 1892), having 96.87% identity with other Myxidium sp. reported in freshwater. The intestinal wall showed significant histopathological changes, including vacuolization of the ganglion cell layer and muscular externa which are characteristic of Intestinal Pseudo Obstruction (IPO) disorder. While such gastrointestinal myopathy has been documented in cows, dogs, horses, cats and humans, it is probably the first observation in fish. Although serum biochemical changes indicated signs of cholestasis, liver histopathological observations were unremarkable. While such observations repudiate the parasites to be the only cause of mortality, it might also be associated with some other factor causing uncontrolled swimbladder inflation and severe skeletal deformities. The study emphasizes the discovery of a new myxidium parasite and the correlation between intestinal pseudo-obstruction and swim bladder hyperinflation, resulting in significant skeletal deformities in fish.

KEYWORDS: Osteobrama belangeri, Myxidium osteobrami, Gastrointestinal myopathy, Swimbladder, Deformed vertebrae



Isolation and Characterization of Multiple Pathogenic Bacterial Strains from Infected Grass Carp (*Ctenopharyngodon idella*) and Common Carp (*Cyprinus carpio*) Reared in Mid-Himalayan Cages

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In the foothill and mid-altitude Himalayan regions of India, the two-species combination of common carp (Cyprinus carpio) and grass carp (Ctenopharyngodon idella) is commonly practiced because of their good market demand and superior growth. Mid-hill lakes and reservoirs have witnessed an upsurge in the use of cage fish farming in recent years. The current communication details a mass mortality event in the populations of common carp and grass carp raised in two grow-out cage units in Bhimtal Lake. During the disease outbreak in June-August, water temperature was in a range of 22°C to 26°C, associated with a decrease in the dissolved oxygen value (2-3 ppm). A total mortality of 78% was recorded. The affected fish were in the weight range of 80.6±12.7 to 260±20.5 g. They showed lethargic swimming behavior, emaciation, white dermal ulceration, and, in a few cases, complete body skin peeling off with acute internal infections. Bacterial isolation was performed from various tissues, including lesions, liver, kidney, gill, muscle, spleen, and lower intestine, to identify the causative agent. Concurrently, water quality was assessed. Parasitic infections were ruled out as no parasites were detected in the gills or other organs. Bacterial isolates obtained from skin and internal organs were identified using both biochemical and molecular techniques. including partial amplification of the 16S rRNA gene. Aeromonas salmonicida, Aeromonas hydrophila and Aeromonas veronii were the bacterial isolates identified. Histopathological examination revealed significant tissue damage, including inflammation and necrosis in several organs. Severe congestion and hyperplasia were observed in the secondary lamellae of the gill, while the spleen showed siderophore deposition. The study highlights the need for the development of effective management and diagnostic strategies to manage unexpected mortality events in cage aquaculture systems, mainly pertaining to the challenges posed by the emergence of multiple bacterial pathogens that result in mass mortality under conditions of environmental stress.

KEYWORDS: Mid Himalayan lake, Cage fish farming, Skin ulceration, Multiple bacterial pathogens

Assessment of Antimicrobial Resistance in *Aeromonas* Species Isolated from Freshwater Fish

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Aeromonas species are Gram-negative, oxidase-positive and facultative anaerobes. Several mesophilic species of Aeromonas cause septicemia in a variety of aquatic organisms and gastrointestinal diseases in humans. Resistance of Aeromonas to antimicrobials at the human-animal-environment interface could lead to treatment failures. This study was aimed to estimate antimicrobial resistance (AMR) in Aeromonas species isolated from freshwater fish in 128 aquaculture farms in Uttar Pradesh, India. The cross-sectional study revealed the prevalence of eleven species of Aeromonas, identified by phenotypic and molecular methods. The farm prevalence showed the dominance of A. veronii bv. sobria (50.0%), followed by A. caviae (18.8%), and A. veronii bv. veronii (11.7%). The prevalence of other species A. dhakensis, A. hydrophila, A. media, A. jandaei, A. allosaccharophila, A. salmonicida, A. crassostreae and A. taiwanensis was less than 10%. The prevalence of AMR in Aeromonas species to one or more antimicrobials was 54% with dominance to β-Lactams and least to phenicols. Resistance to one or more antimicrobials was highest in A. veronii bv. veronii and A. caviae. The findings of our study suggest surveillance of freshwater fish farms using Aeromonas as indicator species for mapping the spread of AMR in aquaculture.

KEYWORDS: Aeromonas species, Prevalence, Freshwater fish, Antimicrobial resistance

Whole Genome Sequencing Reveals Antibiotic Resistance and Virulence Genes in *Aeromonas jandaei*: An Emerging Pathogen Isolated from Diseased Oscar Fish (*Astronotus ocellatus*)

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Motile aeromonads are a common cause of disease in freshwater aquaculture, with Aeromonas jandaei emerging as a significant pathogen across various species, including fish, reptiles, and even mammals. Although A. jandaei is recognized as a significant pathogen, its genomic and molecular mechanisms in fish remain largely unexplored. This study aims to uncover the genomic features of A. jandaei from diseased Oscar fish (Astronotus ocellatus), highlighting the molecular mechanisms of its pathogenicity. Whole-genome sequencing of A. jandaei was performed using the Illumina NovaSeq 6000 platform. A total of 38.1 million 150 bp pairedend reads were generated and trimmed to eliminate low-quality reads and adapter sequences. The resulting trimmed reads were used for de novo genome assembly. The assembled scaffolds underwent gene prediction and annotation, followed by Gene Ontology analysis, and pathway mapping. The identification of antimicrobial resistance and virulence genes was conducted using the CARD and Virulence Searcher databases, respectively. The genome of A. jandaei consists of a single circular chromosome with a size of 4.418,963 bp and a G+C content of 58.8%. The genome is organized into 32 scaffolds with an average scaffold length of 138,092 bp. Furthermore, the genome comprises 3,973 predicted coding genes with an average length of 976 bp. In addition to these coding genes, the genome harbours 105 tRNA genes (including two pseudogenes), and 10 rRNA genes specifically, eight genes for 5S rRNA, one for 16S rRNA, and one for 23S rRNA. A total of 289 genes associated with antibiotic resistance were identified, highlighting the potential of the bacteria for resistance to multiple antimicrobial agents. Furthermore, important virulent genes such as invasin D, rtxA, rtxB, hemolysin B, etc., were identified in the genome of A. jandaei. These findings offer critical insights into the genetic makeup and adaptability of A. jandaei, particularly its virulence mechanisms and antimicrobial resistance. Our study lays the groundwork for developing targeted therapeutic strategies to mitigate outbreaks in aquaculture, contributing to improved fish health management.

KEYWORDS: Whole-genome sequencing, *Aeromonas jandaei*, Antibiotic resistance, Virulence genes, Aquaculture pathogens



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Evaluation of Biosafety and Tissue Level Residue of Oxolinic Acid Fed Orally in Graded Doses to *Labeo rohita* Fingerlings

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The present study aimed to assess the effect of a graded dose of oxolinic acid (OA) medicated feed on growth, liver enzymatic activities, biosafety and tissue-level residue in Labeo rohita fingerlings. Rohu juveniles (18±2.5 g) were fed various dosages of OA viz., 0 (control), 60 (1X), 180 (3X), 300 (5X), and 600 (10X) mg/kg of fish biomass per day for fifteen days, followed by a withdrawal period of eleven days. Sampling of fish from each treatment and control group was conducted at three-day intervals to assess growth, edible tissue residues, and liver functional enzyme activities. The average growth of the fish showed insignificant (p>0.05) variations between the treatments and control groups but reduced feed consumption was marked in high-dose treatment groups. Additionally, groups fed with 5X and 10X OA showed elevated serum glucose concentrations, while serum albumin levels exhibited a significantly higher (p<0.05) concentration in the 1X and 3X OA-fed groups at 3 and 5 days, respectively. Liver functional enzymes such as alanine transaminase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) were elevated in all OA-fed groups. Additionally, dose and duration-dependent increased activities of antioxidative enzymes viz... superoxide dismutase (SOD), catalase (CAT) and malondialdehyde (MDA) were found in OA treatments. Further, OA also showed in-vitro antibacterial activity against some strains of Aeromonas hydrophila and Pseudomonas putida with MIC and MBC values in the range of 15-20 μg/ml and 64.0 - >256.0 μg/ml respectively. On histopathological analysis, liver and kidney tissue showed severe alterations such as hepatic fusion, necrosis, cytoplasmic vacuolation, and degeneration of renal epithelium in 10X group at prolonged feeding duration. LC-MS/MS analysis revealed dose-dependent OA retention in muscle tissues, and in all dosage groups, the edible tissue OA residues peaked on day 15 and then started to decline after the medication was stopped. The muscle residual OA content of the therapeutic dose treatments was below the extreme residual limit fixed by the Food Safety and Standards Authority of India. These results might be useful in the formulation of policy documents for the responsible use of OA in carp aquaculture to ensure fish health and welfare.

Keywords: Aquaculture, Labeo rohita, Oxolinic acid, In-vitro antibacterial, Antioxidants, Tissue level residue

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Negative Synergistic Effect of Sublethal Ammonia Toxicity and Bacterial Infection in *Clarias magur*

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To assess the effect of unionized ammonia and bacteria (Aeromonas caviae) on the immunological and stress parameters of *Clarias magur*, a 14-day comprehensive toxicity experiment was conducted in a static water environment. The experimental groups were subjected to exposure of sublethal levels of ammonia at a concentration of 2.4 mg/l, exposure to bacteria (A. caviae) at a concentration of 1.53 x 10⁵ CFU/ml, and a combination of both ammonia and bacteria at before mentioned concentrations. Sampling was conducted on the 3rd, 7th, and 14th days of the experiment. Elevated level of superoxide dismutase (SOD) and catalase activity suggests that all treatment groups experienced extreme levels of stress compared to the control group. On the other hand, immunological parameters such as myeloperoxidase activity, lysozyme activity, and respiratory burst activity initially showed an increase, but prolonged exposure eventually resulted in a decline, suggesting a weakening of the immune system. Molecular analysis of the HSP 90α gene highlighted significant upregulation in response to bacterial exposure, suggesting that bacterial exposure alone induced more pronounced stress-related gene expression. Liver tissue experienced its peak upregulation at day 14, with a 1.34-fold increase, whereas kidney and spleen tissues exhibited higher upregulation, with 3.73-fold and 5.37-fold changes, respectively, on the 3rd day in the case of only the bacterial-exposed fish group. However, a notable decrease in the expression of the HSP90\alpha gene was observed in the case of fishes exposed to only ammonia and a combination of ammonia and bacteria. This outcome of the study shows that there was an increase in protection in the combined-exposed fishes against bacteria as it has been observed that only the bacteria-exposed fishes were more stressed as compared to the combined-exposed fishes. The group exposed to bacterial challenge alone exhibited higher negative effects compared to the group exposed to both bacteria and ammonia.

Keywords: Aeromonas caviae, Clarias magur, Unionized ammonia, HSP90α, Superoxide dismutase, Catalase

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Anti-Oomycete Potential of *Pseudomonas fluorescens*: A Molecular Docking and *In Vitro* Analysis Against *Saprolegnia*

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Saprolegnia is a genus of oomycetes responsible for causing severe diseases in fish, resulting in considerable economic losses within the aquaculture sector. Traditionally, the management of Saprolegnia infections has depended on chemical treatments, which may pose detrimental effects on the environment. Consequently, there is an increasing interest in biological control strategies, particularly the application of beneficial microorganisms. During the isolation of Saprolegnia samples from infected fish, several bacterial strains exhibiting inhibitory effects on Saprolegnia growth were discovered. One of these bacterial isolates was subjected to further characterization. This isolate displayed a distinct bluish-green fluorescence when exposed to ultraviolet light. Biochemical analyses revealed that the bacterium was ureasepositive and demonstrated glucose oxidation in oxidative/fermentation tests, while it tested negative for gelatinase. Molecular identification through the amplification and sequencing of 16S rDNA confirmed the isolate as *Pseudomonas fluorescens*. This bacterium is recognized for its production of secondary metabolites with antifungal properties. In molecular docking studies, these secondary metabolites showed interactions with vital proteins of Saprolegnia parasitica, recognized as the most pathogenic species. The anti-Saprolegnia efficacy of P. fluorescens was subsequently evaluated in vitro against S. parasitica using both the supernatant and bacterial lysate from overnight cultures. The supernatant effectively inhibited Saprolegnia growth even at high dilutions, whereas the bacterial lysate exhibited reduced activity. These findings suggest that the secondary metabolites produced by P. fluorescens are instrumental in its anti-oomycete activity, warranting further investigation to develop nature-derived compounds for the control of Saprolegnia infections.

KEYWORDS: Saprolegniasis, Biocontrol, Secondary metabolites, Molecular characterization

Efficiency of *Bacillus* spp. for Removing Inorganic Nitrogen in Shrimp Farms

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To reduce toxicity in aquatic organisms, the removal of inorganic nitrogen, specifically ammonia and nitrite, is crucial in aquaculture systems. Two strains of *Bacillus* spp., B. oceanisediminis Ba9 and B. thuringiensis Ba11, were studied, with a 50:50 mixture of these strains yielding the highest ammonium removal efficiency at 67.31%. Among the agricultural by-products tested, rice bran proved to be the most effective for producing a powdered formulation, achieving the highest ammonium removal rates. In laboratory tests, this powdered formulation of heterotrophic nitrifying bacteria mixed with rice bran demonstrated an impressive ammonium removal efficiency of 98.07%, while also generating nitrite and nitrate at levels of 5.28% and 67.47%, respectively. In comparison, liquid formulations of these bacteria had an ammonium removal efficiency of 96.25%, removed nitrite at 47.58%, and produced nitrate at 46.87%. The performance of these heterotrophic nitrifying bacteria was further evaluated in shrimp ponds. The results indicated that the ammonium concentration in the ponds treated with the heterotrophic nitrifying seedlings was maintained below 1.56 mg-N/l, which was significantly lower (p<0.05) than that observed in ponds using commercial bacterial seedlings. Over time, the levels of nitrite and nitrate in the ponds with the heterotrophic nitrifying seedlings increased, likely due to the nitrification process converting ammonia to nitrite and subsequently to nitrate.

KEYWORDS: Bacillus, Ammonium removal, Aquaculture, Wastewater improvement

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Molecular Characterization of Motile Aeromonads Associated with Septicaemic Indian Major Carps Cultured in West Bengal, India

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Motile Aeromonas septicaemia (MAS) is one of the most common bacterial diseases diagnosed in cultured freshwater fish. The current study evaluated the prevalence of MAS as a major disease among the cultured Indian major carps (IMC) of West Bengal, and the characterization of associated aeromonads. About 70% of farmed and septicaemic IMCs had the association of motile aeromonads. Besides, pseudomoniasis (27.82%) and multiple bacterial infections (1.73%) were noticed. Prevalence of MAS was more common in Labeo rohita (31.30%), followed by Catla catla (28.70%) and Cirrhinus mrigala (21.73%). A total of 118 motile aeromonad strains associated with haemorrhagic septicaemic carps were subjected to haemolytic assay *in-vitro*. The β -haemolytic, α -haemolytic and γ -haemolytic strains belonging to A. sobria, A. jandaei, A. hydrophila, A. veronii, A. popoffii, A. caviae, A. fluvialis, A. tecta, A. diversa, A. schubertii, A. simiae, A. taiwanensis, A. rivuli and A. sanavelli were noticed. About 46.61% of the motile aeromonads were β-haemolytic. Twentysix randomly selected β-haemolytic strains from diseased carps were identified as Aeromonas popoffii (2), A. hydrophila (3), A. jandaei (2), A. sobria (5), A. veronii (5), A. veronii biovar sobria (1), A. fluvialis (1), A. tecta (1), A. simiae (2), A. caviae (2) and A. bestiarum (2) by 16S rRNA analysis. The molecular pathogenicity of 26 haemolytic and non-haemolytic strains was assessed by targeting aerolysin, haemolysin, cytotoxic enterotoxin, elastase and serine protease genes. The results documented possession of aerolysin, haemolysin, cytotoxic enterotoxin, elastase and serine protease genes in 19, 20, 19, 14 and 19 strains, respectively. In addition, 9 β-haemolytic strains were subjected to PCR-RFLP analysis, and generated RFLP banding patterns. The resultant 2-6 fragments ranged from 215 to 680 bp and 142 to 1172 bp for *MboI* and *MspI*, respectively. Overall, the incidence of MAS with the association of several virulent aeromonads was observed throughout the year in cultured carps of West Bengal, with more severity during the winter months.

KEYWORDS: Carps, Aeromonas, 16S rRNA, RFLP, Virulent genes

The Effects of Different Salinities on Some Physiological Characteristics of Freshwater Drum *Aplodinotus grunniens*

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This study aimed to expand the culture area of *Aplodinotus grunniens* for improved production outside of its natural habitat by examining the species' reaction to water salinities. The study investigated the growth and physiological responses in *A. grunniens* using chronic and acute salinity testing. In a 36-day chronic salinity trial with 120 juveniles exposed to salinities of 0‰ (control), 4‰, 8‰, and 12‰, optimal growth and survival were observed at 8‰ salinity (p< 0.05). In a separate 4-day acute salinity trial with salinities of 0‰ (control), 7.5‰, and 15‰, the findings revealed that *A. grunniens* exhibited tolerance to salinity up to 15‰. According to the study, *A. grunniens* thrives in salinities ranging from 7.5‰ to 15‰, showcasing optimal growth and physiological resilience without physical harm. This adaptation offers important information for aquaculture since it indicates the species' capability for brackish water environments. The preliminary results also imply that *A. grunniens* thrives better in specific salinity ranges under oxidative stress than in freshwater settings.

KEYWORDS: Salinity, Physiological characteristics, Freshwater Drum, Aplodinotus grunniens

Accretion and Depletion of Enrofloxacin Residues, Withdrawal Period Estimation, Genotoxic and Oxidative Stress Responses in *Oreochromis niloticus*

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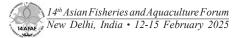
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Aquaculture urgently needs improved bacterial disease management, highlighting the importance of regulating antibiotic usage. This study investigated the effects of dietary enrofloxacin (ENF) on *Oreochromis niloticus* at 10 mg (1 \times) and 30 mg (3 \times)/kg biomass/ day for five consecutive days in comparison to the control. The genotoxic effects of ENF were gauged using themicronucleus test and the comet assay, both performed on tilapia erythrocytes. Both 1× and 3× groups experienced mortalities (0.67-2.67%) during the dosing period. Analysis of plasma biochemistry revealed an increment in glucose, alanine transaminase, aspartate transaminase, alkaline phosphatase, and creatinine, alongside a decrement in calcium and chloride, signifying altered physiology. The kidney and liver tissues showed signs of oxidative stress as indicated by increased malondial dehyde, ferricreducing antioxidant power, total nitric oxide, and decreased glutathione S-transferases and catalase levels. ENF administration for five days resulted in significant DNA damage. reflected by increased tail moment and higher micronucleus formation. The frequency of micronuclei dose-dependently rose from 0.50 to 0.83 MN/2000. Additionally, the tail moment showed a 2.2-fold increase, while the percentage of tail DNA increased 1.3fold in the 3× group compared to the 1× group after the dosing regimen. ENF residues peaked in muscle and skin, liver, and plasma the next day after dose-cessation. In the kidney, it peaked on day 2 post-dosing. Maximum residual accumulation was in the liver, followed by muscle and skin, kidney, and plasma. Residues persisted in the muscle and kidney even on day 42 post-dosing. In the 1× group, residues inplasma and liver were undetectable on days 2 and 14 post-dosing, respectively, indicating faster depletion. Histologically, the kidneys revealed renal epithelial degeneration, vacuolation, hydropic swelling, necrosis, and nephrocalcinosis. The liver had a dose-dependent increase in glycogen-type vacuolation, cytoplasmic vacuolation, and cellular hypertrophy. Though the fish showed signs of recovery, not all parameters returned to normal even on day 42 post-dosing. Overall, the recommended ENF dose elicited reversible biological responses in fish and can be used cautiously adhering to aquaculture regulations.

KEYWORDS: Quinolones, Medicated feed, Residues, Genotoxicity, Bioresponses



Phenotypic and Genotypic Characterization of Extended-Spectrum Beta-Lactamase (ESBL) - Producing *Klebsiella* sp. from Retail Market Fish

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ESBL-producing Klebsiella spp can be significant, as variations in the genetic sequences of ESBL enzymes can affect their overall resistance and virulence profiles. 94 fish samples were collected from the retail fish markets in Assam to conduct active surveillance and detection of AMR-Klebsiella spp (K. oxytoca, K. aerogenes, K. pneumoniae), and its determinants. Klebsiella species identification and AST were performed in automated system (BD, USA), and ESBL genes and virulence genes were done by PCR. Our study revealed that the prevalence rate of Klebsiella species was 24.47%. Of these, Klebsiella oxytoca was the dominant species (82.61%), followed by K. aerogenes (13.03%) and K. pneumoniae (4.35%). Among the Klebsiella sp., 13.05% were ESBL and 52.17% were non-ESBLs; 8 and 3 nos. of isolates were probable carbapenem-producing K. oxytoca and K.aerogenes, respectively. 14 Klebsiella strains were resistant to ampicillin and cefazolin. Of the 23 strains of Klebsiella, 14 were amikacin resistant (11 were K. oxytoca, and 3 were K. aerogenes), and 6 were amoxicillin/clavulanate resistant. Whereas, 5 of the strains were resistant to cefoxitin and tetracycline. Cefotaxime and chloramphenicol resistance were detected for three K. oxytoca strains. Aztreonam and trimethoprim/sulfamethoxazole resistance was observed in two K. oxytoca strains. Gentamicin resistance was observed for only one, K. oxytoca. A total of 10/23 of the *Klebsiella* strains were resistant to ≥ 3 classes of antibiotics tested, classifying them as multidrug-resistant (MDR) strains. In Klebsiella, only one strain was positive for bla_{TEM} and no other strain carried bla_{SHV} or $bla_{\text{OXA-1-like}}$ resistance genes. Only one K. oxytoca strain, which was identified as a PCP, contained the MOX, DHA and $bla_{\text{CMY-2}}$ genes. The virulence genes such as ybtS and rmpA genes were detected in a few strains of Klebsiella sp. The ybtS gene was detected in 56.5% of the Klebsiella oxytoca strains, while the rmpA gene was found in 60.8% of the Klebsiella strains that included 12 K. oxytoca and 2 K. aerogenes strains. Fishes can act as reservoirs for pathogens harboring different betalactamases and other multidrug resistance genes, thus creating an environment for infection and dissemination through clonal expansion. Circulating such strains naturally propagate beta-lactamase resistance to other species in aquatic habitats, subsequently spreading to the human population.

KEYWORDS: Antimicrobial Resistance, Extended-Spectrum Beta-Lactamase, Fish, *Klebsiella* species, Virulence



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Optimization of Top-Dressed Ivermectin Incorporated Medicated Feed using Guar Gum: Method Validation in Fish and Recovery Study in Feed Matrices via Triple Quadrupole Mass Spectrometry

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Ivermectin, an antiparasitic agent commonly used in aquaculture, was incorporated into fish feed using guar gum as a binding agent. Guar gum exhibited favourable biocompatibility and gelling properties, enhancing the stability of ivermectin within feed formulations. To facilitate accurate quantification of ivermectin in both feed and fish matrices, a robust analytical method utilizing QTRAP mass spectrometry was developed and validated. The extraction procedure followed the QuEChERS Extract Pouch AOAC method. Results demonstrated that the incorporation of guar gum significantly improved the stability and release profile of ivermectin in feed. The validated QTRAP method serves as a reliable analytical tool for monitoring ivermectin concentrations in aquaculture environments. Data analysis revealed a linear regression for both fish and feed matrices, with a regression coefficient (r²) of 0.999. The method was validated according to European Union Regulation 2021/808, establishing key performance metrics including sensitivity, specificity, and recovery rates. The method exhibited high sensitivity, with limits of detection (LOD) and quantification (LOO) within acceptable ranges for both matrices. These findings contribute to the development of more effective ivermectin delivery systems, potentially enhancing therapeutic outcomes in fish farming practices.

KEYWORDS: Ivermectin, Validation, Guar gum, Feed matrix, QuEChERS

Optimization of Protectants for Freeze Drying of Fish Probiotic *Bacillus amyloliquefaciens* COFCAU_P1: Evaluation of its Viability, Storage Stability and Beneficial Attributes for Aquaculture Applications

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The study aimed to optimize protectants for freeze-drying the fish probiotic Bacillus amyloliquefaciens COFCAU P1 and evaluate its viability, storage stability, and beneficial attributes, specifically for use in aquaculture. Freeze-drying is a standard method for producing stable probiotic powders, but it often leads to reduced viability, limiting its application. To address this, various protectants like trehalose, sucrose, gum Arabic, and inulin were tested, using a total of 36 combinations. The combination of 10% trehalose and 2% gum Arabic was found to be the most effective, preserving up to 99.02% of the probiotic's viability immediately after freeze-drying and 92.44% and 91.87% after 180 days of storage at room temperature and 4°C, respectively. The scanning electron microscopy (SEM) analysis further confirmed that this combination maintained the structural integrity of the cells, ensuring their effectiveness. Additionally, the freeze-dried probiotic formulation (BAFP) exhibited superior thermal stability, pH tolerance, and bile tolerance compared to its fresh form (BA), suggesting its robustness in the gut environment. The BAFP also retained its antimicrobial activity against common aquaculture pathogens and demonstrated the ability to produce essential digestive enzymes like proteinase, amylase, and lipase. Its hydrophobicity, autoaggregation, and co-aggregation capabilities were on par with the BA, underscoring its potential for gut colonization and pathogen exclusion. Moreover, the BAFP maintained significant antioxidant activity, crucial for mitigating oxidative stress in aquaculture settings. These results suggest that the freeze-dried B. amyloliquefaciens formulation, with trehalose and gum Arabic as protectants, offers a viable and effective solution for overcoming the challenges of probiotic application in aquaculture.

KEYWORDS: Bacillus amyloliquefaciens COFCAU_P1, Freeze-drying, Protectants, Trehalose, Gum Arabic



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Toxicity and Physiological Effects of Green Synthesized ZnO Nanoparticles on Silver Pompano (*Trachinotus blochii*)

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Synthesis of nanoparticles is a rapidly evolving technology in aquatic animal health with applications in feed formulation and vaccine development. However, because of their toxicity effects, safer green synthesis has been replacing the chemical synthesis of nanoparticles. The present work was carried out to determine the acute toxicity and physiological effects of the green synthesized nanoparticles in marine fish, silver pompano (Trachinotus blochii). The ZnO nanoparticles were synthesized using guava leaf extract and zinc nitrite as a precursor. The synthesized nanoparticles were characterized by UV, XRD, FTIR and SEM. The silver pompano was exposed to nanoparticles at different concentrations viz. 0, 20, 40, 60, 80 and 100 mg/ml. After 96 hours post-exposure to the nanoparticles, the LC₅₀ value was found to be 90.45 mg/l. The study showed that ZnO nanoparticles significantly (p<0.05) altered the haematological parameters such as RBC, WBC, Hb, HCT and MCH and immunological parameters such as catalase (CAT), myeloperoxidase (MPO) and superoxide dismutase (SOD), but decreased the platelets count only slightly. Conversely, respiratory burst activity (RBA) slightly increased at the concentration of 100 mg/l compared to control. Histological sections of the fishes exposed to higher concentrations showed liver damage with extensive vacuolation, erythrocytic infiltration into blood sinusoids, degeneration of hepatocytes and hepatocytic infiltration. The study indicates that the green synthesized nanoparticles have less toxic effects at lower concentrations on fish and can be used for applications in aquatic animal health such as vaccine development or as feed supplement.

KEYWORDS: Haematology, Histology, Immunology, Nanoparticles, Toxicity

Evaluating Probiotic Characteristics of *Bacillus* Isolates in Rohu (*Labeo rohita*) Gut Microflora

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The gut of table-sized rohu (*Labeo rohita*) was sampled from various aquatic environments including a community pond, a cultured fish pond without probiotic application, and a cultured fish pond with probiotic application. Gut microflora was isolated, and pure cultures of each isolate were prepared aseptically. Their probiotic potentials were assessed through various tests such as biofilm formation using the Congo red agar method, gastric juice tolerance, bile juice tolerance, pH tolerance, and antibiotic susceptibility. The samples from the community pond and the cultured fish pond without probiotic application showed negative results for probiotic potential tests. However, two isolates from the cultured fish pond with probiotic application, designated as Isolate I and Isolate II, demonstrated positive results. These isolates formed dry crystalline black colonies on the Congo red agar plate. The survivability rates for Isolates I and II after 3 hours in gastric juice at pH 2.5 were 35.38% and 64.70%, respectively. Isolate I showed less tolerance to bile juice than Isolate II at bile concentrations of 2.5%, 5%, 7.5%, and 10% over 3 and 6 hours. In the pH tolerance test, both isolates exhibited increased survivability from pH 4 to 7, with a decline beyond pH 7. In the antibiotic susceptibility test, both isolates were more susceptible to ampicillin and less susceptible to vancomycin, with Isolate I showing greater antibiotic susceptibility than Isolate II. The probiotic potential tests concluded that Isolate II had superior probiotic potential compared to Isolate I. Biochemical tests identified Isolate I as Bacillus coagulans and Isolate II as Bacillus polymyxa.

KEYWORDS: Probiotic, Bacillus sp., Biochemical tests, Labeo rohita

Application of Quantitative Real-time PCR for Rapid Diagnosis and Prognosis Assessment of White Shrimp *Litopenaeus vannamei* Infected with Microsporidia *Enterocytozoon hepatopenaei*

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Enterocytozoon hepatopenaei (EHP) has recently been one of the significant pathogens affecting shrimp. It primarily infects the shrimp hepatopancreas, explicitly targeting the epithelial cells, leading to cell necrosis and progressive impairment of hepatopancreatic function. This results in stunted growth, weakened health, and increased susceptibility to secondary infections, ultimately leading to mortality. Unlike traditional acute infectious diseases in shrimp, the progression from EHP infection to death is a slower process. Some infected shrimp may overcome the disease threat through proper management strategies, grow to market size, and be harvested successfully. Our previous studies observed a preliminary correlation between the EHP load in the hepatopancreas and the severity of pathological conditions. Based on this finding, we hypothesized that the prognosis of EHP-infected shrimp is strongly associated with the pathogen load. This study tracked and analyzed 11 shrimp farms in Taiwan infected with EHP in 2024, using quantitative real-time PCR for continuous sampling and monitoring. The results showed that in cases of low infection (Ct > 27) levels, 100% of the farms successfully harvested their shrimp (n = 2); in cases of moderate infection levels ($24 < \text{Ct} \le 27$), 50% achieved successful harvests (n = 2). However, in cases of severe infection (Ct \leq 24), all farms ultimately stopped cultivation (n = 7). It represents a strong correlation between the prognosis of EHP infection, the pathogen load, and co-infections with other diseases. We hope these findings provide valuable insights and potential reference strategies for shrimp farmers effectively managing EHP infections.

KEYWORDS: Enterocytozoon hepatopenaei, Quantitative real-time PCR, Prognosis, Rapid diagnosis

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Characterization of *Vibrio* Species from *Penaeus monodon* Culture Ponds

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Shrimp aquaculture is a vital industry globally, contributing significantly to food security and economic development. The Whiteleg shrimp, *Penaeus vannamai* and black tiger shrimp, Penaeus monodon are cornerstone species in global aquaculture, yet highly susceptible to bacterial infections, particularly from Vibrios. In shrimp aquaculture, Vibrio species, particularly Vibrio harveyi, Vibrio campbellii, and Vibrio parahaemolyticus are notorious for causing diseases. These pathogens are major contributors to acute hepatopancreatic necrosis disease (AHPND) and other vibriosis-related conditions, leading to significant morbidity and mortality in shrimp populations. Running mortality syndrome (RMS) was characterized by body reddening and dark patches on the exoskeleton, with mortality starting around 75 days of culture (DOC) in the Ongole district of Andhra Pradesh. In ponds, the physicochemical parameters and stocking densities were optimal except for nitrite. Test results were negative for all major WOAH-listed pathogens, including Enterocytozoon hepatopenaei (EHP). Bacteriological examination of the haemolymph and hepatopancreas of RMSaffected shrimp revealed a predominance of Vibrio species including V. parahaemolyticus and V. campbellii. Both isolates were confirmed by biochemical and molecular technique. In V. parahaemolyticus, both toxR and tlh genes were detected, whereas only the toxR gene was found in V. campbellii. Both the isolates were screened for antimicrobial susceptibility tests for selected patterns of antibiotics based on intrinsic and acquired antimicrobial resistance patterns. Both isolates were found resistant to ampicillin, cefotaxime, ceftazidime, and cefoxitin, while *V.campbellii* also exhibited resistance to oxytetracycline. This study highlights that *Vibrio* species are opportunistic pathogens causing huge losses in aquaculture. Antimicrobial-resistant *Vibrio* species in shrimp and their environments are raising concerns for both the shrimp industry and for public health management; therefore, suitable alternatives to antibiotics should be considered for disease management.

Keywords: Running mortality syndrome, Vibrio campbellii, Vibrio parahaemolyticus, Pathogen, Antimicrobial-resistant

Cloning of Capsid Protein Gene of Red-Spotted Grouper Nervous Necrosis Virus into Vectors for Expression in Microalgae, *Chlamydomonas reinhardtii*

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Nervous Necrosis Virus poses a serious risk to aquaculture, particularly in brackishwater environments, as it is responsible for causing viral nervous necrosis (VNN) in a variety of finfish species. This virus belongs to the Betanodavirus genus under the family of Nodaviridae. Infection results in significant neurological damage and a high mortality rate, especially in early juvenile and larva stages. NNV is a 25 nm non-enveloped virus, featuring a bi-segmented, single-stranded, positive-sense genome. The RNA-1 segment, around 3.1 kb in length, encodes the RNA-dependent RNA polymerase, The RNA-2 segment 1.4 kb long, encodes the capsid protein, 42 kDa. The aim of the study is clone the codon-optimized NNV capsid protein into an expression vector for transformation into Chlamydomonas reinhardtii to produce recombinant microalgae. Red-spotted grouper nervous necrosis virus (RGNNV) was isolated from infected Asian seabass using SSN-1 cell line. The virus was plaque purified and characterized by whole genome sequencing. The capsid protein gene of RGNNV was codon optimized using online software for expression in microalgae and synthesised commercially. Primers were designed with restriction sites (SapI and SphI) for amplifying the codon-optimized capsid protein. The codon-optimized gene was PCR amplified and purified. Expression vectors (pSRSapI and pASapI) for C. reinhardtii were procured and propagated in Escherichia coli DH5α cells. The purified plasmids and PCR products were double digested with restriction enzymes, SapI and SphI. The digested products were purified, ligated and transformed into DH5 α competent cells by chemical method and plated on LB agar containing ampicillin. Positive colonies were identified by colony PCR. Positive colonies were propagated in LB broth with ampicillin and plasmid was isolated. The presence of the insert in the correct orientation in the plasmid was confirmed by restriction enzyme digestion and sequencing. The codon-optimized capsid protein gene was present in the correct orientation in both plasmids. The recombinant plasmids will be used to transform C. reinhardtii to produce recombinant cells that can express the capsid protein.

KEYWORDS: Red-spotted grouper nervous necrosis virus, Viral nervous necrosis, Capsid protein, Microalgae

Effect of Different Combinations of Immunomodulators on Pacific White Shrimp, *Penaeus vannamei*

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Probiotics, prebiotics, and immune stimulants are products that have been previously proven to have beneficial effects on the growth and survival of different shrimp species. They also act as an effective way to control diseases, improve immunity, provide nutrition, promote digestion, and control water quality. Moreover, antimicrobial agents are generally discouraged due to the development of resistance and other adverse effects. In this context, immunomodulators provide greater hope to overcome the disease effect. We conducted a trial where Probiotic (Bacillus subtilis – 10⁷cfu/ml), Prebiotic (Inulin – 10g/kg) and Immunostimulant (β-Glucan - 5g/kg) were used in four different combinations, that is, Group 1 (prebiotic and probiotic), Group 2 (prebiotic and immunostimulant), Group 3 (Immunostimulant and probiotic), and Group 4 (prebiotic, probiotic and immunostimulant) along with Control group (Group 5). All three components were individually studied and initial ideal concentrations were found. The feed was coated with respective components and a feeding trial was carried out for 30 days. After the trial, the growth performance indicated that regardless of the combinations, all four groups had better growth when compared with the control, but Group 1 and Group 4 had better growth and survival rates. Further, when challenged with WSSV (by oral feeding), the experimental groups showed better resistance than the control. Higher levels of immune gene expression in the experimental groups, mainly 1 and 4, were recorded than in the control. Therefore, the combinations having both probiotics and prebiotics provided better results.

KEYWORDS: β-Glucan, Bacillus subtilis, Inulin, Gene expression, Growth, Disease resistant

Characterization of Broad-Spectrum Bacteriophages Against Vibrio Infections in Aquaculture

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Vibrio-related diseases pose significant challenges to shrimp and finfish aquaculture by affecting their health and productivity. The present study is aimed to isolate, identify and characterize bacteriophages with broad-spectrum efficacy that could be utilized to mitigate Vibrio infections in aquaculture systems. A comprehensive screening of environmental samples, including water and sediment from aquaculture ponds, and sewage from fish markets of Chennai was conducted to isolate bacteriophages with lytic activity against multiple pathogenic Vibrio species. Preliminary screening was done by spot assay and a total of 24 bacteriophages were collected from 6 samples. The isolated phages were purified by multiple rounds of plaque assay and subjected to a spectrum analysis to evaluate their efficacy across different Vibrio species including Vibrio campbellii, V. harveyi, V. rotiferianus, V. owensii, V. jusicida and V. parahaemolyticus. Results indicated the successful isolation of phages with substantial activity against multiple Vibrio species, demonstrating promise for use in biocontrol applications within aquaculture systems. The spectrum analysis highlighted variations in phage effectiveness, offering insights into their potential roles in reducing Vibriorelated diseases and improving aquaculture sustainability. This study provides valuable data for the development of phage-based strategies to combat Vibrio infections, contributing to enhanced health management in aquaculture environments.

KEYWORDS: Aquaculture, Plaque assay, Spot Assay, Phage

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Evaluating the Efficacy of Disinfectants for Vibrio Control in Shrimp Aquaculture

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Disease outbreaks continue to threaten profitable and viable aquaculture operations throughout the world. Vibrio species are predominant bacterial pathogens of the shrimp especially in early growth stages requiring the application of disinfectants. The present study assessed the effectiveness of four disinfectants commonly used in aquaculture, against three shrimp bacterial pathogens belonging to the genus Vibrio (Vibrio harveyi, V. campbelli and V. parahaemolyticus). Among the disinfectants studied, benzalkonium chloride (BKC) was most effective showing antibacterial activity at 1ppm. All the disinfectants tested showed reduced efficacy when the organic load was >2%. A contact time of 20 min was optimum for BKC and formaldehyde while potassium permanganate (KMnO₄) and iodophor were effective at 30 min. The acute toxicity test (LD₅₀) was done where BKC showed 50% mortality at 10 ppm, KMnO₄ at 120 ppm, formaldehyde at 200 ppm, and iodophor at 180 ppm. The in vivo efficacy at No observed effect concentration (NOEC) against Vibrio spp at a median infective dose (ID₅₀) was 2 ppm for BKC, 10 ppm for KMnO₄, 20 ppm for formalin, and 80 ppm for iodophor. The study identifies the effective concentration, contact time, acute toxicity, and the water quality parameters influencing the efficacy against the pathogenic bacterial pathogens.

KEYWORDS: BKC, Disinfectant, Formaldehyde, Iodophor, Potassium permanganate, Vibriosis

Cost-Effective Dot Blot Assay for the Onsite Detection of EHP in Shrimp Culture

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Shrimp aquaculture plays a crucial role in food security and economic growth, by providing a sustainable source of animal protein. However, diseases are the major challenges in the growth of shrimp aquaculture. Ecytonucleospora hepatopenaei (EHP), an emerging microsporidian poses a serious threat by causing severe outbreaks. EHP cause morbidity and affects shrimp metabolism, feed intake, and growth and results in significant economic losses. The early diagnosis of EHP is very much necessary in the sustainable management of shrimp culture. Several molecular diagnostic methods such as PCR, qPCR, etc. are available for the detection of EHP. However, those methods require skilled personnel, and expensive equipment, and are less suitable for field use. This study evaluates the Dot blot method for diagnosing EHP in shrimp. This membrane-based immunoassay was optimized to detect EHP spores in faecal samples of shrimps. Polyclonal antibodies, produced by immunizing rabbits with whole spores and spore wall proteins of EHP, were used to detect antigens on a nitrocellulose membrane. A secondary antibody conjugated with alkaline phosphatase binds to the primary antibody and results in indigo-blue color when treated with BCIP/NBT substrate. This method has been clinically validated with field and experimental samples. The assay was found to have 100% detection accuracy with the clinical samples. The duration required to perform this immunoassay is about 4 hours and it is equivalent to PCR and rapid compared to histology and *in-situ* hybridization. Furthermore, this method is costeffective, requires minimal equipment, and sample preparation, and is well-suited for farmlevel detection, and routine disease screening.

KEYWORDS: EHP, Dot-Blot, Diagnostic methods, Immunoassay, Field application

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Effects of Diets Enriched with Curcumin, β-glucan, and Garlic Extract on Growth Performance, Hematology, and Immunological Responses of Tilapia

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This study explores the effects of dietary supplementation with curcumin, β-glucan, and garlic extract on the survival, growth performance, hematological parameters, and immune responses of tilapia, a species widely farmed in aquaculture. A total of 240 tilapia fingerlings were randomly divided into three experimental groups, each with triplicates, along with a control group. The fish were fed for four weeks on diets enriched with curcumin (0.1%), β-glucan (0.1%), and garlic extract (0.1%). A challenge study with Aeromonas hydrophila was also done in the last week of the trial. Growth performance indicators, including weight gain, feed conversion ratio (FCR), and specific growth rate (SGR), were analysed. Hematological parameters such as red blood cell (RBC) count, haematocrit (Hct), and white blood cell (WBC) count were measured, along with serum parameters like myeloperoxidase and superoxide activity to assess immunostimulatory effects. In addition, immune parameters such as superoxide dismutase (SOD), catalase, and glutathione peroxidase levels were evaluated. The expression of immune-related genes, including IL-6, TNF-α, and INF-γ, were also examined. The results demonstrated that fish fed with curcumin, β-glucan, and garlic extract had significantly improved growth performance compared to the control group, with curcumin and β-glucan having the most notable impact on SGR and FCR. All three supplements contributed to higher survival rates. Haematological analysis showed a significant increase in RBC and WBC counts in the β-glucan-supplemented group, indicating improved health status. The curcumin-enriched diet resulted in enhanced expression of immune-related genes, signifying a more elevated immune response compared to the other treatment groups. The relative percentage of survival (RPS) in the A. hydrophila challenged fish was higher in the curcumin-fed group. Dietary inclusion of curcumin, β-glucan, and garlic extract has a positive effect on the survival, growth performance, haematological profiles, and immune function of tilapia. Among the tested additives, β-glucan and curcumin exhibited the most comprehensive benefits, making them promising candidates for improving health and productivity in tilapia farming.

Keywords: Curcumin, Tilapia, β-glucan, Growth, Immune parameters, Immune genes



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Epizootics of Infectious Keratitis Caused by *Vibrio alginolyticus* in Hatchery-Raised Cobia Juveniles *Rachycentron canadum* (Linnaeus, 1766) and its Pathomorphological Alterations

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The epizootics of infectious keratitis were recorded in hatchery-produced cobia juveniles at the Regional Center of Central Marine Fisheries Research Institute, Mandapam Camp, Tamil Nadu. The mortality of juveniles occurred during April 2024. The cobia juveniles of 70 days post-hatch (DPH) were with an average weight of 10 g and length of 9 cm. The clinical signs of infected fishes were anorexia, unilateral and bilateral corneal opacity and whitening was observed with loss of vision. In acute cases, bilateral corneal opacity with congestion was observed followed by mass mortality. Except for the corneal opacity and white discolouration, other gross lesions were not observed both internally and externally. The severity of the corneal opacity observed was 10% unilateral and 89% bilateral, and the total affected fingerlings were 90.8%. After 12 days duration, 100% mortality was observed. From the moribund fishes, eye, and kidney samples were collected for bacterial isolation. Differential diagnosis was performed, and there were no parasitic or protozoal organisms in the gill, and the results were negative against Viral nervous Necrosis (VNN) and Mycobacterium marinum. In the Antibiotics Sensitivity Test, the common antibiotics like Ampicillin-AMP, Chloramphenicol-C, and Tetracycline-TE did not exhibit the zone of inhibition, therefore, it could be that the organism was resistant to these antibiotics. However, the organism was sensitive to Ceftazidime- CAZ, Ceftriaxone- CTR, and Cefuroxime axetil-CXM. Based on the phenotypical and molecular characterization, the causative organism for the infectious keratitis was confirmed as the pathogenic V. alginolyticus. The confirmation was also correlated with its cultural, biochemical, and pathomorphological changes.

KEYWORDS: Cobia, Rachycentron canadum, Juveniles, Corneal opacity, Keratitis

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Molecular Characterization and Antibiotic Resistance Gene Identification in *Escherichia coli* Isolated from Fish and Water of East Kolkata Wetland, West Bengal, India

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India has one of the highest antibiotic resistance rates for community and healthcareassociated microorganisms. The 65% increase in global antibiotic consumption from 2000 to 2024 is a significant statistic, reflecting growing challenges in public health and medicine. Escherichia coli indicates environmental and faecal contamination. It is also pathogenic to humans and aquatic species. However, aquaculture environments frequently encounter numerous sources of contamination. The examination of the effects of urban wetlands on aquaculture offers an essential understanding of how various pollutants affect the antibiotic resistome and the emergence of β -lactamase-mediated resistance genes in *Escherichia coli*. The present study used molecular methods to characterise E. coli and discover its antibioticresistant genes from the sewage-fed environment, East Kolkata Wetlands in Kolkata, West Bengal. Standard methodology was followed for fish and water samples. Different biochemical tests and PCR amplification were used to identify E. coli. Multiplex PCR was used to screen positive E. coli isolates for lacY, lacZ, cvdA, uidA, phoA. Also, 17 antibiotics were tested for antimicrobial susceptibility. Ampicillin resistance in E. coli was found 90%. After molecular characterisation, 4 of 9 samples (7 fish and 2 water) were positive for E. coli. Only fish (3) were tem-1 gene positive among these 4 positive samples. The research found 44.4% E. coli antibiotic-resistant genes in sewage-fed fish samples. Therefore, E. coli which is considered an indicator of environmental and faecal contamination could have developed a high degree of antibiotic resistance due to these environmental stressors.

KEYWORDS: Water contamination, Antimicrobial-resistant bacteria, Resistant pattern, Multiplex PCR, Beta-lactamase gene

Antibiotics Resistance of *Aeromonas* sp., and β -Lactamase Mediated Resistance Gene Distribution in Sewage Fed Aquaculture, West Bengal, India

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Sewage-fed aquaculture systems have been the potential breeding grounds for antibioticresistant bacteria. In this, we investigated the antibiotic resistance pattern of Aeromonas sp. and the prevalence of β -lactamase-mediated resistance genes in sewage-fed aquaculture systems. Aeromonas sp., a pathogen in fish was isolated and evaluated for resistance to popular antibiotics, including β-lactams. In East Kolkata wetlands, West Bengal, the sewage-fed aquaculture is exposed to untreated effluents and greater levels of pollutants and is therefore expected to have a higher proportion of antibiotic-resistant bacteria. Antibiotic susceptibility testing (AST) found a considerably greater incidence of multidrug-resistant (MDR) Aeromonas sp. in sewage-fed aquaculture. This study reported a selective pressure that fosters the emergence of a wide variety of resistance genes, with resistance to cefoxitin (43.5%), cefepime (9.3%), chloramphenicol (7.4%), tetracycline (14.8%), trimethoprim/ sulfamethoxazole (16.7%), amikacin (4.6%), amoxicillin/clavulanic acid (50.9%), cefotaxime (4.6), ceftazidime (12%), ceftriaxone (2.8), imipenem (3.7%), and ciprofloxacin (7.4%). Moreover, molecular research revealed a greater prevalence of β-lactamase genes, notably blaTEM (63.9%), blaCTX-M (15.7%), and blaSHV (13%). β-lactamases genes are present in sewage-fed systems, most likely due to the continual input of antibiotic residues. These findings highlight the importance of sewage-fed aquaculture as a reservoir for antibiotic resistance genes (ARGs), which constitute a considerable public health risk due to possible human exposure via the food chain or environmental pollution.

KEYWORDS: Antibiotics, Sewage-fed aquaculture, Environmental pollution, Anti-bacterial resistance, Beta-lactamase

Evaluation of Recombinant Subunit Vaccines and Adjuvant Efficacy Against Vibriosis in Asian Seabass (*Lates calcarifer***)**

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Vibriosis, caused by Vibrio alginolyticus, poses a major threat to Asian seabass aquaculture, necessitating sustainable disease management strategies. This study investigated the potential of recombinant subunit vaccines (RSV) targeting the GAPDH gene of V. alginolyticus, with and without an adjuvant (algel), to protect against vibriosis. Asian seabass was immunized intraperitoneally, and their immune responses (antibody titers, lysozyme activity) and protection against a V. alginolyticus challenge were assessed. The adjuvanted RSV conferred remarkable protection, with 100% relative percent survival (RPS) at 21 days postvaccination, compared to 71.5% RPS for the unadjuvanted RSV. Both vaccines triggered a robust and sustained antibody response, with elevated titers from 14 days post-vaccination onwards. Importantly, vaccinated fish, particularly those receiving the adjuvanted RSV, exhibited significantly reduced bacterial counts compared to the controls in in bactericidal assay. These findings underscore the crucial role of adjuvants in amplifying both the immune response and the protective efficacy of the vaccine. In conclusion, this study highlights the potential of recombinant subunit vaccines, especially when formulated with adjuvants, as a powerful tool for combating vibriosis in Asian seabass. This approach offers a promising avenue for sustainable disease management in aquaculture, reducing reliance on antibiotics and promoting fish health.

KEYWORDS: Asian seabass, Vibrio alginolyticus, Recombinant Subunit vaccines, Adjuvant, RPS, Immune response



Calcium Phosphate Nanoparticles Conjugated with Outer Membrane Protein of *Aeromonas hydrophila* for Vaccine Development in Tilapia

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The development of an effective vaccine for Oreochromis niloticus (Tilapia) against Aeromonas hydrophila, a major pathogen in aquaculture, is crucial for enhancing disease resistance and sustainability in fish farming. This study investigates the use of calcium phosphate (CaP) nanoparticles conjugated with the outer membrane protein (OMP) of A. hydrophila as a novel vaccine delivery system, referred to as CaP-OMP. Opsonophagocytic killing assays (OPKA) further demonstrated improved pathogen clearance in vaccinated fish. Furthermore, immune gene expression analysis was performed using quantitative PCR (qPCR) to monitor the expression levels of key immune-related genes, including Cd4, Cd8, IgM, IgT, IL-6, MHCI, MHCII, TNF- α , IFN- γ , and β -actin. The results showed a significant upregulation of these immune markers in the CaP-OMP vaccinated groups compared to that of OMP vaccinated groups, suggesting enhanced activation of both the innate and adaptive immune responses. The vaccine's protective efficacy was demonstrated by a relative percentage survival (RPS) of 83.3%, indicating significantly lower mortality in the CaP-OMP vaccinated group compared to controls following a challenge study with virulent A. hvdrophila. Overall, this study underscores the potential of calcium phosphate nanoparticles conjugated with outer membrane proteins as a promising vaccine platform for aquaculture. The enhanced immune response, combined with targeted antigen delivery, positions this strategy as a viable tool for controlling A. hydrophila infections in Tilapia, contributing to improved disease management in aquaculture.

KEYWORDS: Nanoparticle, Drug delivery system, Outer membrane protein, Vaccines

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Phytochemical Analysis, Antioxidant Activity and Antibacterial Efficacy of Polyherbal Extracts Against Shrimp Pathogen, *Vibrio parahaemolyticus*

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According to traditional medicinal approaches, individual herbs may be insufficient to achieve the desired therapeutic effect. Developing a combination of products from multiple herbs in a specific ratio can enhance their therapeutic potential effects. The present study aimed to develop a polyherbal solution of ethanolic extracts from the peels of Citrus limon, Citrus medica, and Terminalia chebula; the root of Curcuma longa, Cyperus rotundus, and Tinospora cordifolia; the bark of Cinnamonum verum, and the leaf of Ulva lactuca. This study investigated the ethanolic extracts through preliminary phytochemical screening and the identification of chemical compounds using gas chromatography-mass spectrometry (GC/MS) analysis. Following this, the antioxidant activity was assessed using the DPPH scavenging assay. The ethanolic extracts and identified chemical compounds were further screened for their antivibrio activity against selected gram-negative shrimp pathogenic bacterium Vibrio parahaemolyticus using both in vitro and in-silico approaches. The findings of the study revealed qualitative and quantitative analysis of major secondary metabolites. The total phenolic and flavonoid content were measured at 3.98±0.13 mg/g and 2.80±0.05 mg/g. The GC-MS analysis identified thirteen structural compound derivatives. The antioxidant activity exhibited an IC_{so}value of 413.51 µg/ml, while the anti-vibrio activity showed varying inhibitory effects at different concentrations of the extracts from 5000-1000 μg/ml, with the maximum zone of inhibition observed at 5000 μg/ml (20 mm) and 1000 μg/ ml (12 mm). Additionally, the binding affinities of the identified chemical compounds for various bacterial protein targets were validated through in-silico approaches, with molecular docking performed using the PyRx software. Thus, the presence of secondary metabolites of these polyherbal extracts significantly influences their antioxidant and antibacterial activities, demonstrating considerable potential for inhibiting the growth of pathogenic Vibrio species in shrimp aquaculture.

KEYWORDS: Phytomedicine, Gas chromatography-Mass spectrometry (GC/MS), Molecular docking, Vibriosis, Shrimp aquaculture



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Probiotic Potential of Beneficial Bacterial Consortium on Elimination of *Vibrio* Loads in Water and Fish Gut of Indian Pompano, *Trachinotus mookalee*

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An experiment on the probiotic potential of beneficial bacterial consortium (BBC) on larval and nursery rearing of Indian pompano, *Trachinotus mookalee* was carried out in one tonne tanks. Water and fish quality in control and experimental tanks were monitored at every 3 days interval. The study revealed the occurrence of heavy loads of total viable heterotrophic bacteria and presumptive *Vibrios* in the water and fish gut during the initial 3 days of larval rearing in all the tanks. However, with culture progression, presumptive *Vibrios* in rearing water and fish gut decreased at all the tested concentrations (1x104 cfu/g, 1x106 cfu/g and 1x1010 cfu/g). Supplementation with the consortium (BBC) was evaluated during nursery rearing at three different concentrations (1x108 cfu/g, 1x1010 cfu/g and 1x10112 cfu/g). In nursery rearing tanks, the presumptive *Vibrios* were 10-28 % in control, whereas the loads were significantly lower in tanks treated with BBC. A significantly higher growth was recorded in fishes supplemented with BBC daily once at a higher concentration of 1x10112 cfu/g. Gut microbiota studies of Indian pompano revealed lower presumptive *Vibrio* counts in BBC treated fish and zero count was observed on 60 DOC. After 120 days of culture, the probiotic bacteria was reisolated from fish gut supplemented with BBC.

KEYWORDS: Probiotics, Vibrio, Fish Gut, Indian Pompano

Expression of Antimicrobial Peptide Genes in Hemocytes of *Penaeus indicus* During *Vibrio parahaemolyticus* Infection

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In the shrimp immune system, antimicrobial defense mechanisms play a pivotal role in fighting infectious pathogens. It is crucial to develop effective strategies for controlling or managing diseases to produce healthy shrimp. A study was conducted on *Penaeus indicus* to assess the relative expression of antimicrobial peptide (AMP) genes in circulating hemocytes following an immersion challenge with *Vibrio parahemolyticus*. Juvenile shrimp, averaging 2.0 ± 0.5 g (n=30 per tank), were exposed to *V. parahemolyticus* at a concentration of (1x10⁻⁶ CFU/ml) in triplicates for 30 minutes. Hemolymph samples were collected at intervals of 0, 12, 24, 48, 72, and 96 hours for gene expression analysis. Results indicated that the expression of AMP genes, including penaeidin, crustin, anti-lipopolysaccharide factor (ALF), and stylicin, was significantly upregulated at various time intervals (p<0.05), with the most notable accretion observed at 96 hours post-infection (hpi). Initially, at 12, 24, 48, and 72 hpi, the expression levels of penaeidin, crustin, and ALF were relatively low. However, these genes were triggered and began to express more significantly at 96 hpi. At that time, a notable downregulation of penaeidin, crustin, and stylicin was recorded, while ALF showed a gradual increase in expression level from 24 hpi, and the highest expression was observed on ALF (4.2-fold) and stylicin (24-fold) at 96 hpi. This is the first study to report the expression of stylicin in the hemocytes of *Penaeus indicus*. Overall, the findings suggest that the AMP genes are directly linked to the shrimp's innate immune response against Vibrio parahaemolyticus infection.

KEYWORDS: Penaeus indicus, Innate immune system, Antimicrobial peptides, Vibrio parahemolyticus: qRT-PCR analysis

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Tilapia Parvovirus as A New Threat for Tilapia Farming in India: Host Range and Non-Invasive Sampling for Rapid Diagnosis

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Parvoviridae family is known to infect a variety of animals including humans, and even cross-species transmissions of this group of viruses are reported. The first outbreak of parvovirus in fish was reported from China in 2020, and the same was named as tilapia parvovirus (TiPV). Since its identification, the virus has been commonly reported in several other tilapia-culturing countries including India. The present study investigated a disease incidence of TiPV in tilapia farms, and the pathogenicity of the virus, and the host range. A sequencing of 2090 bp of the present isolate was obtained and the phylogenetic analysis revealed its closest relation with an isolate reported earlier. The histopathological alteration induced by TiPV in the liver includes the accumulation of hemosiderin pigments, swelling, pyknosis and individualization of hepatocytes, marginalized nuclei, and the presence of inclusion bodies in the hepatocytes. Among three different size groups of tilapia (small:10 to 20 g, medium: 50 to 60 g and large: 150-200 g), medium and large-sized tilapia were found to be highly susceptible to TiPV infection under experimental challenge. Further, 10 different fish species (Labeo rohita, Catla catla, Cirrhinus mrigala, Systomus sarana, Pangassius hypophthalmus, Melanochromis auratus, Labidochromis caeruleus, Maylandia estherae, Labidochromis chisumulae and Pseudotropheus barlowi) were experimental challenged to study their susceptibility to TiPV infection and interestingly, the virus was found to be non-infective to all these fish species. In addition, a sensitive PCR-based method was also developed for rapid and early detection using non-invasive sampling. Skin and gill mucus were found to be the best samples for non-invasive sampling for TiPV diagnosis. The present piece of work provides holistic information on TiPV infection and its diagnosis which can be used further for effective management of the virus.

KEYWORDS: Diagnosis, Host range, Non-invasive sampling, Tilapia and TiPV

Co-Infection of *Aeromonas hydrophila* and *Aeromonas veronii* in Farmed Pacu, *Piaractus brachypomus* (Cuvier, 1817) in India: A Case Study

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India ranks as the second largest fish producer in the world. In the recent years, increased demand for fish production has led to the culture of diversified species. Piaractus brachypomus (pacu) culture as a part of the polyculture has expanded since its introduction to India in 2003–2004 through the ornamental fish trade. Due to the increase in demand and culture intensification, there is an increase in incidences of disease occurrences in pacu. The present study, investigated a mortality case of pacu in Puri district of Odisha, India, showing overt clinical signs of hemorrhages over the body surface, sluggish movement, and anorexia before death. The causative agent was identified as Aeromonas hydrophila and A. veronii using biochemical reactions, 16S rRNA, PCR, sequencing (NCBI sequence similarity >99%), and phylogenetic analysis. Koch's postulate was experimentally established through intramuscular challenge for both pathogens, and the LD₅₀ doses for A. hydrophila and A. veronii were found to be 5×10⁶ and 2.5×10⁷ CFU/ml, respectively. Further, the LD₅₀ dose for A. hydrophila and A. veronii together (mixed 1:1) was estimated as 1x10⁷ CFU/ml. Histopathological alterations in different bacteria injected groups were observed in the gills, liver and kidney. Antibiotic susceptibility tests against 26 antibiotics exhibited that both A. hydrophila and A. veronii are resistant to amoxyclay, cefoxitin, cefuroxime, clindamycin, oxacillin, vancomycin, and linezolid. Further, A. hydrophila showed resistance against azithromycin, and imipenem whereas, A. veronii to amoxicillin/clavulanic acid, and cephalothin individually. Both the bacterial isolates were found to pose several virulent genes including flagellin (flgM, flgA, flgN), outer membrane protein A (OmpA), aerolysin (aer), cytolytic enterotoxin (act), DNases, and hemolysin. This is the first report to describe the involvement of two Gram-negative bacteria A. hydrophila and A. veronii causing mortality in pacu. Further understanding of the dynamic interaction and role of two Gram-negative bacteria in the disease prognosis will pave the way for future preparedness and development of sustainable management strategies.

Keywords: Aeromonas hydrophila, Aeromonas veronii, Co-infection, Pathogenicity, Piaractus brachypomus

Expression of Antimicrobial Peptide Genes in Hemocytes of *Penaeus indicus* Against *Vibrio alginolyticus* Infection

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The shrimp immune defence system protects against invading pathogens by the initial secretion of antimicrobial compounds. Shrimp have both anionic and cationic antimicrobial peptides that exhibit potent antimicrobial activity. In this study, we attempted an ideal and natural way of establishing a Vibrio infection in shrimp via immersion technique. This study investigated the changes in the gene expression level of antimicrobial peptides in circulating hemocytes of *Penaeus indicus* in response to *V. alginolyticus* infection. The experiment was conducted in triplicate with *P. indicus* juveniles with average body weight (2.0±0.5 g) (n=30/ replicate). The shrimps were challenged by immersion with a pathogenic bacterium V. algonolyticus (1x10-8 CFU/ml). Indeed, the hemolymph samples from the control group and challenged group at different time intervals of 12, 24, 48, 72 and 96 hours post-infection were collected aseptically and analysed for expression of AMP-related genes such as penaeidin, crustin, anti-lipopolysaccharide factor, stylicin, and hemocyanin. We found the AMP gene expression fold changes in the shrimp hemocytes, after infection of V. alginolyticus. The results showed that the penaeidin expression drastically increased from 3 to 8.6-fold after at 72 and 96 hpi, whereas lower expression (fold expression < 0.1) appeared from 12 to 48 hpi. A drastic downregulation of crustin gene expression was observed from 12 to 72 hpi but upregulated at 96 hrs. The ALF and stylicin transcript increased the expression 5.5 and 3.6-fold at 12 hpi. The expression of hemocyanin transcript was increased 4.6 and 5.2-fold at 12 and 96 hpi. However, the significant expression of penaeidin, crustin, anti-lipopolysaccharide factor, stylicin, and hemocyanin was observed upregulated at 96 hpi and downregulated during 24 and 48 hpi. This is the first study to report the expression of stylicin in the hemocytes of P. indicus. All AMP gene transcripts were found to play a role in the defence mechanism, as shown in the shrimp hemocytes. These results suggest that the shrimp hemocytes respond to bacterial infection and also express the antimicrobial peptide gene transcript, which directly activates the shrimp's innate defence response.

KEYWORDS: Indian white shrimp, Innate immunity, Antimicrobial peptides, Vibrio alginolyticus, qRT-PCR analysis

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Co-occurrence of Multidrug Resistance, Beta-Lactamase, and Plasmid-Mediated AmpC Genes in *Aeromonas* spp. from Lower Ganga Basin Tributaries: Insights into AMR in India

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The detection of multi-drug resistant (MDR) Aeromonas spp. in aquatic environments raises significant public health concerns, as these bacteria can act as reservoirs for antimicrobialresistant (AMR) genes. Addressing AMR in open water is particularly critical in South Asia, where it plays a vital role in the dissemination of antimicrobial-resistant genes (ARGs). Surface water samples were collected from various tributaries of the Ganga River in West Bengal, India and a total of 33 different *Aeromonas* spp. were isolated. This study investigates the prevalence of MDR, extended-spectrum beta-lactamase (ESBL), and plasmid-mediated AmpC-producing Aeromonas spp. Out of 33 isolates, 24 exhibited MDR traits. The isolates showed maximum resistance to beta-lactamase inhibitors (A/S=94%, AMC=67%), carbapenems (IMP=91%), and cephalosporins (CX=61%, CPM=55%, CAZ=47%, CTR=39%), followed by tetracycline (18%) and chloramphenicol (15%). ESBL production was confirmed in 56% of the isolates, with the genes bla_{TEM} (94%), bla_{SHV} (39%), and bla_{CTX-M} group (27%) detected. Plasmid-mediated AmpC was identified in 15% of the isolates. The high prevalence of MDR and ESBL-producing Aeromonas in the Ganga River tributaries poses a significant human health hazard by potentially facilitating the spread of antimicrobial resistance to other bacteria pathogenic to humans, terrestrial animals and fish.

KEYWORDS: Multi-drug resistant (MDR), Aeromonas, Extended-spectrum beta-lactamase (ESBL), AmpC-producing, Ganga River

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Understanding the Virulence Potential of *Vibrio* spp. for the Development of Oral Encapsulated Nano Vaccine

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Vibriosis is a significant bacterial disease that causes high mortality rates and severe economic losses in hatchery-reared marine finfish. This study aims to enhance the efficacy of oral vaccines against vibriosis, a persistent challenge in aquaculture due to antigen degradation in the gastric environment, which hampers effective vaccine delivery. β -glucans, non-digestible immunomodulatory polysaccharides, are employed as immune adjuvants with promising applications in vaccine delivery. Presently, β -glucans were utilized to formulate a nanoencapsulated, oral polyvalent *Vibrio* vaccine. We confirmed the virulence of various *Vibrio* strains through PCR-based amplification of key functional genes, including the transcriptional regulator, quorum sensing, bioluminescence initiation, and chitinase genes. These strains were subsequently inactivated using formalin. A nanoparticle emulsion of β -glucans was then developed to encapsulate the inactivated microbes. The study demonstrated efficient encapsulation by β -glucans and highlighted their potential for creating a robust nanoencapsulated vaccine. This research provides a foundational step toward developing an effective oral nano-vaccine to combat vibriosis in marine finfish, contributing to the sustainability of aquaculture.

KEYWORDS: Virulence Potential, Vibrio spp., Nano vaccine

Agricultural Waste-Derived Micro Biochar: A Sustainable Solution for Oxytetracycline Removal in Aquaculture Effluent

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Oxytetracycline (OTC) is one of the most widely used antibiotics in animal husbandry and aquaculture systems. However, its indiscriminate use in these sectors contributes to the growing issue of antibiotic resistance genes (ARGs). In this study, micro biochar derived from agricultural waste, specifically banana peduncle and mango leaves was utilized to remove oxytetracycline from aqueous systems. Techniques such as Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and Brunauer-Emmett-Teller (BET) analysis were employed to investigate the surface morphology, functional groups, and surface area responsible for OTC adsorption. The elemental composition of the microbiochar was analysed using Energy Dispersive Spectroscopy (EDS). The removal efficiency of OTC was assessed through batch experiments at varying initial concentrations (20-100 mg/l) and biochar dosages (1-4 g/l). Adsorption kinetics were evaluated using Pseudo-firstorder and Pseudo-second-order models, while adsorption isotherms were analysed by fitting data to the Freundlich and Langmuir models. The micro-biochar achieved an 85% removal of 60 ppm OTC at an optimal biochar dose of 3 g/l, with a maximum adsorption capacity q max of 18.656 mg/g. This study highlights the potential of low-cost agricultural waste to address emerging contaminants like OTC and mitigate antibiotic resistance.

KEYWORDS: Mango leaves, Banana peduncle, Micro biochar, Oxytetracycline, Antimicrobial gene resistance

Natural Infestation of Sea Lice (*Caligus* sp.) and Gill Fluke (*Dactylogyrus* sp.) in Silver Moony, *Monodactylus argenteus*: A Case Study

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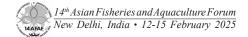
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The silver moony, Monodactylus argenteus, is a high-valued euryhaline ornamental brackishwater fish with good market demand. It is recognized for its omnivorous feeding habits, schooling behaviour, capacity to withstand a broad range of salinities, good market price, and compatibility with other fish species in aquaria. Hence, an attempt was made to standardise the methodology for hatchery seed production at the finfish hatchery of Muttukadu Experimental Station (MES) of ICAR-Central Institute of Brackishwater Aquaculture, Tamil Nadu to avoid endangering this economically important ornamental fish. During this process, we encountered parasitic infestations and the same is reported in detail. Silver moony fry (2.6±0.8 g; 4.3±0.8 cm) was maintained at a density of 50000/ha for developing broodstock. Mortality was observed with unusual behaviour. Post-mortem examination was conducted on moribund fish. Sea lice and gill flukes were collected, preserved and identified as Caligus *elongatus* and *Dactylogyrus* sp. based on gross, microscopic and molecular characterizations. The infested water body was successfully treated with ButoxÒ (Deltamethrin 1.25%) @ 300 ml/ha, and a repeat dose was given two weeks later. The parasitic intensity (PI) reached zero after the second administration of ButoxO. It was concluded that the ButoxO was effective in controlling both sea lice and gill flukes. Further research is required on biosafety, withdrawal and environmental safety before recommending this drug as a therapeutic measure to be used in aquaculture.

KEYWORDS: Ornamental fish, Parasitic infestation, Caligus sp., Dactylogyrus sp., Therapeutics

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Metagenomic and mRNA Expression Profiling of *Penaeus indicus* and Efficacy Assessment of Probiotic Consortia for Better Health and Productivity in Indian Shrimp Hatcheries

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The burgeoning shrimp aquaculture industry in India faces significant challenges, including disease outbreaks and the emergence of antimicrobial resistance. There is a rising push to investigate probiotics as potential substitutes for conventional antibiotic therapies in response to this urgent problem. In order to further comprehend probiotic benefits and methods of action, this research conducts a thorough examination of their effectiveness for minimising shrimp diseases. The study utilizes amplicon sequencing for metagenomic analysis, focusing on the Vibrionaceae family, which includes pathogenic Vibrio species. In the probiotic-treated animals, the Vibrio load in the intestine was reduced to 13%, 17%, 23%, 20%, and 23% in the groups PC1, PC2, PC3, PC4, and PC5, respectively, compared to the control group, which showed a Vibrio load of 29%. In contrast, Terrabacteria, which has many probiotic species, was found to be lower in the control group at 20% but was higher at 29%, 23%, 22%, and 20% in the probiotic-treated groups (PC1, PC5, PC2, PC4, and PC3, respectively). The study also employed 16S rRNA sequencing techniques to identify and characterize bacterial strains with potential for probiotic applications. Further gene expression analysis, and antimicrobial and anti-biofilm activity were carefully carried out to target common shrimp pathogens, which also supports the metagenomic data. Results indicate that the inclusion of probiotic strains decreases the Vibrio load and improves the gut health and diversity in the shrimp gut. Taken as a whole, the data demonstrate the potential benefits of probiotics in shrimp farming. This work defines pathways for future research and practical uses of probiotic therapies in aquaculture management, drawing conclusions from an informed assessment of the data. Further investigation to obtain candidate-specific microbiota to enhance production and maintain healthy environmental conditions is recommended.

KEYWORDS: Antibiofilm activity, Probiotics, Penaeus indicus, Metagenomics, Gene expression

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Effects of Oxygen Levels and Microbial Activity on Sulfamethoxazole and Trimethoprim Transformation in Aquaculture Environment

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The residues of sulfamethoxazole (SMX) and trimethoprim (TMP), two antibiotics administered in aquaculture, are detected in aquatic environments. This study aimed to investigate the influence of two environmental factors viz., oxygen levels (aerobic and anaerobic conditions) and microbial activity (sterile and non-sterile conditions) on the degradation of SMX, TMP, and their combination in water and sediment slurry samples collected from shrimp Litopenaeus vannamei culture ponds. The results demonstrated that SMX underwent the fastest transformation under aerobic microbial conditions, with a half-life $(t_{1/2})$ of 9.7 days, while its degradation was significantly slower in anaerobic environments without microbial activity ($t_{1/2} = 59.2$ days). In contrast, TMP exhibited a rapid transformation rate ($t_{1/2} = 8.2$ days under aerobic and 9.2 days under anaerobic conditions) in the presence of microorganisms, compared to non-sterile conditions ($t_{1/2} = 30.7$ days and 23.5 days, respectively). Notably, the presence of SMX inhibited the transformation of TMP, particularly in anaerobic environments, where the conversion rate of TMP was seven times slower than when administered alone. Additionally, the study revealed that antibiotic transformation rates were significantly higher in sediment compared to water, underscoring the critical roles of microbial diversity and oxygen availability in facilitating antibiotic degradation. Furthermore, the transformation processes of these antibiotics were found to be influenced not only by biotransformation but also by other pathways, including hydrolysis and redox reactions. These findings highlight the importance of considering the combined use of antibiotics in environmental assessments and underscore the potential impacts of environmental factors on antibiotic persistence and associated ecological risks.

KEYWORDS: Sulfamethoxazole (SMX), Trimethoprim (TMP), Aquaculture, Antibiotic Transformation, Environmental Factors

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Response of Acute Phase Protein Genes under Various Stressors in *Labeo catla* (Hamilton, 1822)

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The present study was conducted to elucidate the effect of various stressors in the expression profiling of the acute phase protein genes in Labeo catla. Four genes were chosen for the study, viz., Transferrin (Trfn), Alpha 2 macroglobulin (A2ML), Serum amyloid A (SAA) and HSP 70. The experiment consisted of four treatment groups, i.e., T1: Catla challenged with LD₅₀ dose of Aeromonas hydrophila (Biotic stressor); T2: Catla exposed to hypoxia (Abiotic stressor); T3: Catla challenged with LD₅₀ dose of A. hydrophila and exposed to hypoxia (Combination of biotic and abiotic stressor); and C: Control. T1 and T3 groups of fish were injected at 1.7 x 106 CFU/ml dose of ATCC 7966 strain of A. hydrophila. For the abiotic stress condition, the dissolved oxygen of the tanks of T2 and T3 was maintained at 1.5-2.0 ppm to keep the hypoxic condition. The experiment was conducted for 15 days with nine sampling intervals (3h, 6h, 12h, 24h, 48h, 72h, 96h, 7th day and 15th day). The expression profiling of the four genes was checked in the liver tissues. The results showed an upregulation of the positive acute phase protein genes (A2ML and SAA) in T1 and T3, recording the highest expression in the combined stress group (T3). HSP70 showed upregulation during hypoxia (T2) and combined stress (T3). The results of the current study conclude that acute phase protein genes could be taken as marker genes under biotic and abiotic stress conditions.

KEYWORDS: Stress, Expression profile, Hypoxia, Bacteria

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Effect of Benzalkonium Chloride on Different Life Stages of Indian Major Carp, *Labeo rohita* and Evaluation of Its Efficacy in Treating *Aeromonas veronii* Infection

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Infection with microorganisms in eggs, larvae and juveniles is one of the major challenges in aquaculture especially in hatcheries, which greatly affect the larval survival and overall well-being of the fish seed. Hence, using a broad-spectrum disinfectant like benzalkonium chloride (BKC) can be an important fish health management strategy to control microbial infection in hatcheries. Keeping this in mind, we evaluated the effect of BKC on different life stages (eggs, larvae, and fingerlings) of Indian major carp, Labeo rohita. The results indicated that prolonged bath with BKC at different concentrations i.e. 0.1, 0.5 and 1 ppm affected the hatching percentage and larval survival, and highest hatching and survival was observed at 0.5 ppm. In short term immersion, the eggs were treated with BKC at different concentrations i.e. 1, 2, 5, 10, 20 and 40 ppm for a period of 20 min, and the results indicated that eggs can sustain an immersion treatment up to 5 ppm. For dip treatment, eggs were treated with BKC at different concentrations i.e. 5, 10, 20, 50, 100, 500, 1000 ppm for 2 min, and the results revealed that a 2 min dip (10 - 20 ppm) would be beneficial for hatching and larval survival. Further, as observed from the laboratory experiment, L. rohita fingerlings could sustain up to 1 ppm of BKC without any adverse effect. However, cumulative mortality ranging between 40-100% was observed in 1.5, 2 ppm and 5 ppm group. Additionally, to understand the efficacy of BKC in treating bacterial infection, the fingerlings of L. rohita were challenged with a LD50 of a virulent strain of Aeromonas veronii through immersion, and subsequently treated with different concentrations of BKC (0.25, 0.5 and 1 ppm). There was significant reduction in mortality in the BKC-treated groups compared to the control, and the therapeutic efficacy in different groups of BKC-treated rohu corroborated with the reduced bacterial count compared to the control group.

KEYWORDS: Benzalkonium chloride, Disinfectant, Bacterial infection, Larval survival, Administration route

Evaluation of Probiotics Properties and the Effects of Probiotic-Enriched Feed on Growth Performance and Survival of *Pangasianodon hypophthalmus* Against Pathogens

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Pangasianodon hypophthalmus is a vital species in aquaculture due to its high adaptability and economic significance for farmers. However, its susceptibility to bacterial infections, including Aeromonas hydrophila and Edwardsiella tarda, during the juvenile stage leads to significant mortality, resulting in substantial economic losses. Challenges such as disease outbreaks and reliance on antibiotics hinder sustainable production and contribute to the rise of antibiotic-resistant microbes. This study explored the properties of the probiotics, Lactococcus lactis (strain S1) and Weissella confusa (strain L1) which were previously isolated from *P. nasutus* including their antagonistic activities against pathogens A. hydrophila through antagonistic assays, enzymatic activity, biofilm formation, co-culture assay and adverse pH tolerance. This study also aimed to develop a probiotic-enriched feed as a natural alternative to enhance the growth performance and survival of *P. hypophthalmus*. In the antagonistic assays (disc diffusion assay), L. lactis (S1) and W. confusa (L1) both could inhibit the growth of the A. hydrophila with an inhibition zone of 10.5±1 mm and 8.5±1 mm respectively. In co-culture assay, L. lactis (S1) and W. confusa (L1) at three concentrations (10⁴, 10⁶ and 10⁸ CFU per ml) successfully inhibited the growth of the A. hydrophila (with concentrations 10⁷ CFU per ml) at 6, 12 and 48 h while W. confusa (L2) at 24 and 48 hrs. In addition, L. lactis (S1) has the highest biofilm formation recorded at 36 h with OD 2.196. L. lactis (S1) exhibited gradual growth within a pH range of 3 to 10 (pH 8 was the highest), while W. confusa (L1) showed significant growth from a pH range of 4 to 10 (pH 9 was the highest). In in vivo trials, a 100% survival rate was observed in all treatments, confirming the safety of the probiotics. Treatment 1 (L. lactis 10⁶ CFU per ml) exhibited the highest weight gain (141.58 \pm 14.84 mm), while treatment 3 (W. confusa 10⁶ CFU per ml) showed the highest length gain (381.00 \pm 29.66 mm). The findings suggest that these probiotics exhibit strong antimicrobial properties, able to improve fish survival and growth rates. These results highlight the potential of probiotics as a sustainable alternative to antibiotics, offering a promising approach for improving fish health and productivity in aquaculture systems.

Keywords: Lactococcus lactis, Weissella confusa, Growth, Probiotic properties, Aeromonas hydrophila, Pangasianodon hypophthalmus



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Type VI Secretion Systems (T6SS) in Gram-negative Bacteria: Structural Insights and its Possible Implication in Next-generation Vaccine Development

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To ease the transport of a variety of virulence agents across the bacterial cell membrane, bacteria have developed a stunning range of nanomachines that are quite sophisticated. During recent years, substantial advancements have been made in the interpretation of the structural and molecular processes behind the six secretion systems (Type I to Type VI) that are found in Gram-negative bacteria. T6SS plays a multifaceted role in host-pathogen interactions. This study evaluated 30 strains of Aeromonas veronii, an emerging Gram-negative bacterial pathogen responsible for infection and mortality in freshwater fish populations. An insilico investigation was performed to examine the existence of T6SS in the isolates, along with their structural components, genome length, and phylogenetic relationships using appropriate bioinformatics software. The study has produced significant findings indicating that T6SS is consistently present in all A. veronii isolates, comprising around 13 principal gene components within the T6SS system. Additionally, a few selected genes viz., Tss-B and Tss-A/D were validated and appropriately aligned to formulate primer sets (upstream and downstream) for executing in-frame deletion mutations in the specified gene sets utilizing a two-step allele exchange methodology. Hence, the foremost aim of this exploration was to investigate the presence of T6SS in A. veronii isolates, as well as to utilize these genes for the creation of mutants ($\Delta Tss-B/\Delta Tss-A/D$) and then employ these mutants for the advancement of an effective live attenuated vaccination program. Therefore, the present study has produced valuable data to assess the possible selection of genes as well as to removal or deletion of a few significant numbers of nucleic acid base pairs from the above-mentioned T6SS gene component, following which attenuated or less virulent strains could be made available for possible down-stream applications. Thus, following a comprehensive safety and efficacy assessment study (both in vitro and in vivo), these mutants may serve as viable candidates for potential use as live attenuated vaccines in freshwater fish culture systems to combat A. veronii infections and mitigate the losses associated with aeromoniasis.

Keywords: *In-silico*, In-frame deletion mutation, Live attenuated vaccine, Aeromoniasis, Aquaculture

Argulus japonicus (Thiele 1900) Infestation in Farmed Rainbow Trout, Oncorhynchus mykiss in Mid-altitude Himalayan Region of Northern India

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From September to October 2023, approximately 60% mortality was observed in adult rainbow trout (average body weight: 250±50 g; N=7) in Bhimtal (29°36′10″ N and 79°55′32″ E) due to the external parasite of class Ichthyostraca, occupying the whole-body surface including eyes, mouth, and gill. Samples of this parasite (total body length 3.5 to 6.0 mm) were collected and classical and molecular methods were used to identify the same. Tissue samples were also collected for bacterial profile study. The parasite was identified as Argulus *japonicus*, a Japanese fish louse, based on its external body parameters such as bifurcated sternal furca, the broadly oval cephalothorax and well-developed second maxillae modified into strong hooked claws. Partial amplification of the 18S rRNA gene (amplicon length: 850 bp) confirmed the identity of this parasite as A. japonicus. The parasites were mainly gathered at lateral and ventral regions of the head, gills, pectoral, and pelvic fins, with an infestation rate ranging from 250 to 350 individuals/fish. Phylogenetic analysis further supported this identification, clustering the isolated A. japonicus (nucleotide sequence similarity: 98%) with A. japonicus reported worldwide. This parasite caused significant harm to rainbow trout by attaching to their skin and feeding on their blood and tissue, which resulted in haemorrhage and tissue necrosis. To understand the damage caused by A. japonicus at cellular level, gills, kidney, spleen, lower intestine, and muscle samples were collected for histopathological examination. These tissues showed severe inflammation, infiltration of RBC, and damage at cellular level in the gill and muscle. The compromised immune status of the rainbow trout, resulting from the parasitic infestation, facilitated secondary infections by opportunistic bacteria, including Bacillus sp. (1 isolate), Aeromonas hydrophila (2 isolates), and Plesiomonas shigelloides (4 isolates).

KEYWORDS: Parasitic, Copepods, 18S rRNA, 16S rRNA, Opportunistic bacteria

Development of Framework for Biosecurity Scoring in Shrimp Aquaculture

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Biosecurity is a critical component in any food animal production system, aimed at preventing the introduction and spread of pathogens within and between farms, hatcheries, and other establishments. A biosecurity scoring tool has been developed to measure this preparedness at the farm level. A biosecurity framework was developed, identifying the key biosecurity practices in consultation with the experts using the Delphi technique. The study has identified in total of 63 risk factors which were classified into five major categories. Weightage for each of the factors and relevance-based scores for each of the categories were assigned. The robustness of the scoring was validated using Cronbach's alpha coefficient. The scoring system developed allows quantitative assessment of biosecurity protocols which helps in identifying the vulnerable areas requiring intervention. This system can be used at farm, region and national levels across the farming systems to generate the information required for farm operators, researchers, and policymakers for the development and implementation of targeted biosecurity measures to effectively mitigate pathogen risks at both local and national levels.

KEYWORDS: Aquaculture, Biosecurity scoring, Cronbach's alpha coefficient, Shrimp

Application of Quantitative Real-time PCR for Rapid Diagnosis and Prognosis Assessment of White Shrimp *Litopenaeus vannamei* Infected with Microsporidia *Enterocytozoon hepatopenaei*

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Enterocytozoon hepatopenaei (EHP) has recently been one of the significant pathogens affecting shrimp. It primarily infects the shrimp hepatopancreas, explicitly targeting the epithelial cells, leading to cell necrosis and progressive impairment of hepatopancreatic function. This results in stunted growth, weakened health, and increased susceptibility to secondary infections, ultimately leading to mortality. Unlike traditional acute infectious diseases in shrimp, the progression from EHP infection to death is a slower process. Some infected shrimp may overcome the disease threat through proper management strategies, grow to market size, and be harvested successfully. Our previous studies observed a preliminary correlation between the EHP load in the hepatopancreas and the severity of pathological conditions. Based on this finding, we hypothesized that the prognosis of EHP-infected shrimp is strongly associated with the pathogen load. This study tracked and analyzed 11 shrimp farms in Taiwan infected with EHP in 2024, using quantitative real-time PCR for continuous sampling and monitoring. The results showed that in cases of low infection (Ct > 27) levels, 100% of the farms successfully harvested their shrimp (n = 2); in cases of moderate infection levels (24 < Ct \leq 27), 50% achieved successful harvests (n = 2). However, in cases of severe infection (Ct \leq 24), all farms ultimately stopped cultivation (n = 7). It represents a strong correlation between the prognosis of EHP infection, the pathogen load, and co-infections with other diseases. We hope these findings provide valuable insights and potential reference strategies for shrimp farmers effectively managing EHP infections.

KEYWORDS: Enterocytozoon hepatopenaei, Quantitative real-time PCR, Prognosis, Rapid diagnosis

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Streptococcus Infection in Tilapia — An Experimental Investigation with Insights to Pathological Impacts and Disease Outbreak

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Tilapia culture is gaining importance as a candidate species for aquaculture in India in recent days. As culture becomes more intensified, chances for the occurrence of diseases also increase. Although tilapia is a hardy species, stress at higher temperature becomes a main factor for the onset of disease and this combination leads to the prevalence of bacterial diseases. Occurrence of Streptococcosis has been reported in tilapia from other countries but not yet from India. Since India is a tropical country, the chances for the occurrence of Streptococcosis by Streptococcus agalactiae are higher. In the same line, an experimental study was performed comprising four groups of fishes maintained in duplicate. Of these, one group acted as a control and the other three groups were injected with 10⁶, 10⁷ and 108 cfu/ml of Streptococcus agalactiae inoculum. The clinical signs like cessation of feed, haemorrhage in eyes and body, tail and fin rot, erratic and spinning-like movement, fishes coming up to the surface of the water and lying near the corner of tanks were observed in all three treatments that were injected with S. agalactiae. Upon post-mortem examination, the fishes in all three treatments other than control had enlarged and pale-coloured spleen, liver and gall bladder, pale-coloured gill and soft brain. On swabbing of different organs into Brain Heart Infusion agar plates, colonies of Streptococcus agalactiae were re-isolated and confirmed as the causative agent for the diseased condition. The haematological parameters i.e., haemoglobin content showed decreasing trend with an increase in the concentration of bacteria in the injected fishes. However, RBC count was found to increase from lower to higher concentrations of injected fishes, but the size of erythrocytes was much smaller, which is a condition typical of hypochromic microcytic anaemia. Blood smear observation clearly showed the haemolysis of RBCs, confirming the occurrence of haemolytic anaemia. Distinct pathological signs viz; encephalitis, increased vacuolation, congestion and RBC infiltration were noticed in the brain, wherein heart showed RBC infiltration and slight oedema. The liver of infected fishes showed vacuolation, cellular swelling, congestion and RBC infiltration irrespective of the dose. The microbiological findings helped in understanding the severity of pathogenicity by Streptococcus agalactiae in Tilapia.

KEYWORDS: Streptococcus agalactiae, Streptococcossis, Haemolysis of RBCs, Tilapia, Brain Heart Infusion agar

A Salmonella enterica Lethal Pathogen Isolated from Infected Pangasius sutchi: Whole Genomic Approach to Understand the Bacterial Virulence Factors

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A case of high mortality in farmed *Pangasius sutchi* was investigated to characterize the causative agent. In this study, a new pathogenic bacterial strain, *Salmonella enterica*, was isolated from the liver and kidney of infected *P. sutchi* using biochemical, antibiogram, and haemolysis assay. The in-vivo challenge experiment showed that *S. enterica* causes 100% mortality at the dose of 2.1×10⁴ CFU/fish. The genomic study of that newly emerging pathogen has been carried out on a nanopore-based long-read sequencer, and the whole genome has been submitted to the NCBI database (Accession no: SAMN45225699). The isolated strain was resistant to one antibiotic, Nystatin (50 mcg), while susceptible to seven other antibiotics. The bacterial pathogen negatively affects fish, including high mortality, creating concern and a need for *S. enterica* management in *P. sutchi* farms. The knowledge gained from this study would facilitate future research aimed at assessing the pathogenicity of *S. enterica*, with an emphasis on microbial disease management in other farmed fish species.

KEYWORDS: Pathogenic, Salmonella enterica, Nanopore, Disease

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Rapid Detection Kit for *Aeromonas hydrophila* Infecting Nile Tilapia Using Gold Nanoparticle-Based DNA Probe

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A major problem worldwide is the emergence of aquatic pathogens, such as Aeromonas hydrophila, that are widely distributed in the environment. Thus, accurate and rapid identification of the causative agent is important for the treatment and control of fish diseases. In this study, a laboratory-based rapid detection kit for A. hydrophila was developed using a colloidal gold nanoparticle-based DNA probe. A series of trials, modifications and optimizations was done to fully optimize the rapid detection protocol for A. hydrophila. The detection kit can detect the target pathogen, without obtaining false positive and false negative results, at a minimum detectable limit of 5±1.0 ng/μl and a maximum detectable limit of 139±6.08 ng/ul. Two modified protocols (1 and 2) in the detection of A. hydrophila were developed. The modified protocol 2, which was simplified by removing some steps led to a faster detection time at a reduced cost when compared to the standard protocol and modified protocol 1. Modified detection protocol 2 for A. hydrophila had 100% sensitivity and 90% specificity. The developed kit can be stored up to one month at room temperature without affecting its sensitivity and specificity. In conclusion, the developed rapid detection kit using a simplified protocol is user-friendly and can be used to detect A. hydrophila which is affecting the tilapia industry.

KEYWORDS: Nanotechnology, Aquaculture, Fish health, Pathogenic bacteria

Pharmacokinetics and Tissue Residue Depletion of Praziquantel in Nile Tilapia (*Oreochromis niloticus*)

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Anthelmintics play a crucial role in aquatic health management, particularly in controlling parasitic diseases. However, specific regulations for aquaculture medications remain limited. Fish-borne trematode infections significantly impact human and animal health globally, especially in Asian countries. In this study, we used praziquantel (PZO), currently unregulated for application in aquaculture. The present study aimed to investigate the plasma pharmacokinetics and muscle tissue residue depletion of PZQ in Nile tilapia (Oreochromis niloticus). Fish averaging 75±5 g, kept at 27°C, received PZQ dosing of 30 mg/kg body weight orally for 10 days. The levels of praziquantel were determined in the plasma, muscle, and skin of O. niloticus (for determination of withdrawal time) with oral and intraperitoneal treatment at 30 mg/kg body weight of praziquantel after 0.25, 0.5, 0.75, 1, 1.5, 2, 4, 6, 8, 12, 24, 36, and 48 hours and 12, 24, 36, 48, 72, 96, 120, 144, 168, 192, 216, and 240 hours of sampling time, respectively, using HPLC. The peak plasma concentrations (Cmax) at Tmax in Nile tilapia varied between intraperitoneal (1467.315 µg/ml, 0.168 h) and oral (90.07 μg/ml, 11.4 h) administration. The calculated half-lives (t1/2ka) and the area under the plasma concentration-time curve (AUC) were observed to be 0.04 h, 4426.754 µg*hr/ml for intraperitoneal and 7.61 h, 2770.22 µg*hr/ml for oral route, respectively. The study revealed that the depletion of PZO from edible Nile tilapia tissues was rapid, as PZO concentrations decreased to 33 µg/g as early as 24 h post-treatment and reached below 1 µg/g on the 8th day. Praziquantel concentrations consistently declined with the lapse of time. The results affirm the likelihood of praziquantel being swiftly absorbed and eliminated, leading to a substantial drug concentration in the bloodstream of O. niloticus. Based on the observed pharmacokinetic data, PZQ can be considered a promising candidate for treating parasitic infections in O. niloticus.

KEYWORDS: Anthelminthics, Depletion patterns, Pharmacokinetics, High Performance Liquid Chromatography (HPLC), Praziquantel

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A Comparative Analysis of the Frequency and Mortality Associated with *Ecytonucleospora hepatopenaei* (EHP) Illness in *Litopenaeus vannamei* Across Shrimp Farms in Eastern India

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The microsporidian parasite Ecytonucleospora hepatopenaei (EHP) was initially recognized and investigated in the giant tiger prawn Penaeus monodon. Infection by the former results in stunted growth and poses a serious hazard to shrimp aquaculture. A fish disease monitoring and health management program was conducted by our team in West Bengal, India, where we observed shrimp farms associated with diseased conditions. The shrimps depicted lethargy, decreased rate of consumption, retarded growth and a higher degree of heterogeneity in their sizes, and white excreta was seen to be floating all over the pond. The diseased shrimp samples were initially collected on suspicion of a microbial illness and thereafter, aseptically transported to the ICAR-Central Inland Fisheries Research Institute laboratory for molecular confirmation. The potential existence of hepatopancreatic microsporidiosis caused by E. hepatopenaei has been screened for in shrimp tissue, excrement, feed, and environmental samples employing the nested PCR technique. The findings substantiate the shrimp samples to be EHP positive. The histopathological analysis revealed the existence of severely necrotic HP tubules and epithelial cells in the symptomatic group and confirmed the presence of mature spores in the lumen of the tubules. Gene expression analyses revealed the significant upregulation of ProPO, Hsp70 and α2-macroglobulin while a significant decrement was observed in the expression patterns of LGBP, PXN and Integrin B. Using Artemia franciscana as a model crustacean, the in vivo survival experiment was conducted, which indicates that symptomatic shrimp gut samples contain pathogenic Vibrio parahaemolyticus and Vibrio campbellii. These findings greatly contribute to our understanding of the molecular and ecological components of EHP pathobiology.

Keywords: Ecytonucleospora hepatopenaei, Penaeus monodon, Gut microbiome, Immune response

Exploring Potential of Use of Antibiotic Oxolinic Acid Through Pharmacokinetic Study in Striped Catfish *Pangasianodon* hypophthalmus (Sauvage, 1878)

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With the horizontal and vertical growth of intensive aquaculture several antimicrobials, antiparasitics and antifungal drug find their use in finfish and shellfish disease management. However, their non-scientific and unchecked application can intensify disease resistance altering ecological functioning and put a toll on consumer health. To curb such negative effects, few pharmacologically active compounds are currently permitted by different countries for aquaculture use. However, India does not have legally approved antibiotic(s) for use in aquaculture farms. Oxolinic acid (OA), a broad-spectrum quinolone antibiotic, has been approved by some of the European countries and Japan for treatment in freshwater fish species. In the present study, the pharmacokinetics of oxolinic acid have been elucidated following in-feed administration in the most intensively cultured catfish Pangasianodon hypophthalmus. Post single oral administration at therapeutic dose (12 mg/kg body weight), OA concentrations in serum, liver, and kidneys at predetermined time intervals were quantified by LC-MS/MS. Analysis of the kinetic profile of various pharmacokinetic parameters determined the distribution half-life $(t_{1/2n})$ and elimination half-life $(t_{1/2n})$ of the drug as 0.75 and 15.45 h, respectively. The drug distribution from the plasma to other tissues was found to be satisfactory as the apparent volume of distribution of the drug at steady-state $(V_{d(ss)})$ was found to be 3.12 l/kg. The mean residence time (MRT) of OA was short (17.78 h) and the total clearance rate $(Cl_{\rm T})$ of the drug was low (0.25 l/kg/h). Maximum values were observed for serum post 24 h injection. For liver and kidney samples, the highest drug concentrations were obtained at 8 h and 12 h respectively. The fast depletion of OA suggests a short withdrawal time with reference to human consumption of the treated fish. Overall, the pharmacokinetic parameters show promise for the potential use of the antibiotic in the catfish.

KEYWORDS: Oxolinic acid, Pharmacokinetics, Pangasius



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Antibiotic Florfenicol-Induced Alterations in Gut Microflora and Digestive Enzymes of *Pangasianodon hypophthalmus*

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The gut microbiota plays a crucial role in nutrient assimilation and metabolic processes, and disturbances in the gut microbiota have been linked with several disease conditions in human and lower vertebrates. Here we examined the effect of oral administration of florfenicol, an antibiotic approved for aquaculture use in several countries, on digestive functions and intestinal microbiota of the most widely cultured catfish Pangasianodoon hypophthalmus. Healthy P. hypophthalmus (45±2.5 g biomass) was in-feed administered florfenicol @ 10mg/ kg biomass for 10 days, followed by a 10-day withdrawal period. Following humane sacrifice of fish, the intestine was collected aseptically, whole DNA content was extracted and sequenced by next-generation sequencing (NGS) targeting V₃-V₄ regions of 16sDNA. Blood samples were collected from the caudal vein, plasma separated and tested for digestive enzymes on day-10 of FFL dosage and post-dosing. High-quality gut microbe sequence reads showed that FFL-treated fish had the highest taxonomic diversity, evaluated by OTUs, compared to the control group. Campylobacterota, Fusobacteriota, Firmicutes, Bacteroidota, Proteobacteria, Verrucomicrobiota, and Desulfobacterota made up 99% of the ribotypes in healthy untreated fish which decreased to 95.7% after antibiotic treatment. Relative abundance of Bacteroidata and Proteobacteria increased, while Crenarchaeota, Dependentiae, Gemmatimonadota, Hydrogenedentes, Spirochaetota, Deinococcota, and others were only found in the treated fish. At the most fundamental taxonomic level, Cetobacterium somerae dominated the gut microbiota of healthy P. hypophthalmus. Day 10 of FFL dosing showed a substantial decrease in amylase levels in the treatment group compared to day 10 in the control group (p<0.05). The treatment group's protease levels decreased slightly compared to the control but remained stable throughout the experiment and returned to the control level by day 10. The treatment group's lipase level increased far less than the control group and was steady across both seasons. This study is the first to disclose the unexpected consequences of an authorised antibiotic on a commercially important freshwater catfish's gut microbiome.

KEYWORDS: Microbiome, Catfish, Florfenicol, Digestive enzyme

Effect of Tilapia Parvovirus (Tipv) on Fish Health: An *In Vitro* Approach

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Tilapia Parvovirus (TiPV) is an emerging pathogen in aquaculture, causing significant mortality in tilapia populations. Understanding TiPV's pathogenesis is crucial for developing effective management strategies. This study aimed to elucidate TiPV pathogenesis by evaluating its cytotoxic effects on *Danio rerio* gill (DRG) cell monolayers and its impact on host immune responses. TiPV-infected DRG cell monolayers were subjected to an MTT assay at 24, 48, 72, and 96 hours post-infection to assess cell viability and cytotoxicity. The MTT assay revealed a progressive decline in DRG cell viability over time, with live cell percentages decreasing from 66.71% at 24 hours to 31.28% at 96 hours in TiPV-infected cultures, compared to consistently high viability in controls. Concurrently, quantitative realtime PCR (qPCR) was employed to analyze the expression of key immune-related genes, including Interleukins (IL-1\beta, IL-8), Toll-like receptor 7 (TLR7), Major Histocompatibility Complex II (MHC-II), Tumour necrosis factor α (TNF-α), Nuclear Factor Kappa B (NFκB), and Chemokine Receptors (CRs). qPCR analysis showed an upregulation of IL-8, IL-1β, TNF- α and CRs, indicating an early inflammatory response. However, significant downregulation of TLR7, MHC-II, and NF-κB suggests TiPV's ability to modulate host immune responses. The results highlight that TiPV induces significant cytotoxicity in DRG cells, leading to severe cellular damage. The virus also alters host immune responses by modulating the expression of key immune genes, which may contribute to its virulence and persistence. These findings enhance our understanding of TiPV pathogenesis and highlight the need for targeted research to develop effective control strategies for TiPV in aquaculture systems.

Keywords: Tilapia Parvovirus, Cytotoxicity, Immune gene expression, Pathogenesis, Aquaculture

Evaluation of Growth, Immunity, Enzymatic Indices, Immune Gene Expression and Disease Resistance of *Labeo rohita* Fry in Biofloc Systems Using Different Exogenous Probiotics Supplementation

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The present study evaluated the impacts of two potential probiotics viz., Bacillus subtilis and B. amyloliquefaciens single or in combination in Labeo rohita fry. The experiment was conducted in biofloc culture (BFC) tank and L. rohita (avg. wt. 0.40±0.031 g) were randomly allotted in four different groups in triplicates, viz., C: BFC or control; T1: BFC + Bacillus subtilis; T2: BFC + B. amyloliquefaciens; T3: BFC +Bacillus subtilis + B. amyloliquefaciens. In addition, to maintain the optimal level of carbon and nitrogen (C:N) ratio at about 15:1, molasses was added in all tanks uniformly irrespective of treatment group. Upon completion of about 11 weeks of the experimental trial, fish (L. rohita) were sampled and the findings of the study observed that there were significant (p<0.05) synergistic effects of probiotics in the fish fry-rearing biofloc culture (BFC) unit. The results have shown that the addition of probiotics to the BFC has significantly (p<0.05) enhanced weight gain, survival, and digestive enzymes activities, especially in treatment T3 where the combination of probiotics was administered through water. Few selected immune parameters viz., lysozyme, myeloperoxidase, and total immunoglobulin levels have significantly (p<0.05) improved along with important digestive enzyme activity. Study has also reported that addition of probiotic bacterium in BFC superiorly improved the liver anti-oxidative activities like superoxide dismutase (SOD), catalase (Cat), glutathione peroxidase (GPx), malondialdehyde (MDA) and alkaline phosphatase (AKP) in all the treatment groups (T3>T2>T1) compared to control (only BFC). In addition, the T3 group showed minimum glucose and cortisol levels compared to T1 and control (only BFC). Moreover, the expression of pro-inflammatory cytokines (IL-1 β , TNF α), antioxidant molecules (SOD, GPX, catalase), and pattern recognition molecules (TLR-22) were also significantly (p<0.05) upregulated in T3 and T2 groups. The relative percentage survival (RPS%) was significantly (p<0.05) highest in the T3 group (50.00%) followed by T2: 16.67% and T1: 33.34% after a challenge trial against a virulent Aeromonas hydrophila. Hence, it may be concluded that the addition of probiotics in combination with the BFC system effectively improved rearing water quality, and immunity in farmed fish, and also increased the disease resistance capacity against A. hydrophila.

KEYWORDS: Innate immunity, Immune gene expression, Probiotics, Aquaculture

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Pathological Alterations Associated with *Amyloodinium* Infestation in Nursery-Reared Silver Pompano (*Trachinotus blochii*)

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Silver pompano (Trachinotus blochii) is a valuable species for mariculture due to its fast growth and high market demand. However, the health of this species is increasingly threatened by parasitic infections, particularly by Amyloodinium ocellatum, a dinoflagellate known for causing marine velvet disease during the early rearing phase in hatcheries. The present study aimed to investigate the taxonomic identity, prevalence, pathology, and treatment of A. ocellatum infestation in T. blochii. Three hundred and fifty fish (weight 2±0.3 g, length 5±1 cm) collected from the nursery rearing tanks at the Karwar Regional Station of Central Marine Fisheries Research Institute during 2021-23 were screened for Amyloodinium infestation. Pathological alterations were studied using routine histopathology techniques. Infested fish exhibited excessive mucus secretion on the skin and gills, and numerous small, white trophonts were found attached to the gill surface. The parasite was identified as A. ocellatum based on its morphological characteristics. The prevalence of infection varied from 53.33% in 2021, 75% in 2022, and 85% in 2023, which could be linked to the fluctuations in water quality parameters. Histopathological analyses revealed significant tissue damage, which included hyperplasia and lamellar fusion in gills, hepatocyte degeneration in the liver, renal tubular necrosis, and splenic congestion. Understanding these pathological changes is essential for developing effective management strategies to mitigate the impact of A. ocellatum on silver pompano. Thirty-minute bath treatment with formalin @ 25 mg/l for seven days was successful in controlling the parasite.

KEYWORDS: Amyloodinium, Silver pompano, Pathology, Prevalence, Histopathology

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Toxicity Assessment of Titanium Dioxide Nanoparticle (TiO₂-Np) in Rohu (*Labeo rohita*)

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Nanomaterials represent the cutting edge of rapidly emerging indispensable nanotechnology. Titanium dioxide nanoparticles (TiO2-NPs) are one of the most commercially manufactured and widely applied NPs in various fields such as consumer products, medicine, environmental remediation, sensing, and energy. However, empirical data suggests that TiO2-NPs inevitably leak into the environment during manufacture, usage, and waste disposal and accumulate there, making aquatic animals' exposure to TiO2-NPs inevitable. Consequently, a deeper comprehension of TiO₂-NPs toxicity testing in fish is of utmost importance for risk assessment and regulatory evaluation. An in-vivo toxicity assessment was conducted using various biomarkers to evaluate the effects of TiO2-NP exposure at a sub-lethal concentration of 0, 1, 2.5, and 5 mg/l at 24 hour post-exposure (hpe), 4th days post-exposure (dpe), and 14th dpe in rohu (Labeo rohita). The average zeta potential of TiO₂-NP was determined to be -20.5 mV. The 96-hour lethal concentration (96h LC50) of TiO₂-NP in rohu was calculated to be 77.49 mg/l. Quantitative bioaccumulation analysis of TiO₂-NP showed the highest bioaccumulation in the intestine followed by the liver, gill, kidney and spleen, and negligible in muscle tissue. Nevertheless, the TiO₃-NP concentration returned to its pre-exposure baseline level on the 40th dpe in all the organs. TiO₂-NP executed the immunotoxic response by destabilization of serum lysozyme activity and antiprotease activity. The immunotoxic response was further potentiated by increased production of MPO and RBA activity leading to higher production of reactive oxygen species (ROS) that contribute to oxidative stress, inflammation, and cellular damage. The molecular level study demonstrated that TiO₂-NP is recognised and processed by signaling PRR, TLR22 leading to initiation of the immune-signaling cascade and pro-inflammatory cytokines production such as IL-1β, TNFα, and TGF-β. The TiO2-NP exposure induced the SOD, CAT and GPx antioxidant gene expression significantly (p≤0.05). Nevertheless, caspase3, BAX and p53 apoptotic gene expression were found to be induced significantly (p≤0.05) only on the 14th dpe. Histological deformities chromatin condensation, vacuolization in hepatocytes, fatty degeneration, hepatocyte necrosis, and hypertrophied nuclei with coarse chromatin were observed in the liver tissue on 14th dpe. Our study infer that TiO2-NP executes immunotoxic response and histological alterations in Labeo rohita.

KEYWORDS: Titanium dioxide, Nanoparticle, Labeo robita, Toxicity, LC50, Bioconcentration



Unhygienic Conditions in Biofloc Systems: Potential for Disease Emergence in *Anabas testudineus* Through Reverse Zoonosis and Antimicrobial Resistance

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In India, biofloc systems for freshwater fish farming have encountered significant challenges, with many projects failing due to widespread disease outbreaks. This study investigates the causes of these outbreaks, revealing that unhygienic conditions play a major role in the emergence of new diseases. Focusing on Anabas testudineus, the study examines the link between poor biofloc management, reverse zoonosis, and antimicrobial resistance. Twelve pathogenic bacterial isolates were recovered from fish reared in biofloc environments and identified through morphological, biochemical, and molecular techniques. Among these, eight were gram-negative rods and four were gram-positive bacilli. Notably, molecular identification revealed that most of the isolates, including Enterobacter cloacae, Klebsiella aerogenes, Citrobacter werkmanii, and Acinetobacter seifertii, are primarily human pathogens, rarely reported in fish. These bacteria exhibited various exoenzyme activities, indicating their pathogenic potential. Antibiotic susceptibility testing revealed inherent resistance in most isolates, raising concerns about biofloc systems fostering antimicrobial resistance even without prior antibiotic exposure. The study also underscores the risk of reverse zoonosis, emphasizing the need for stronger biosecurity measures to prevent the transfer of pathogens between humans and fish.

Keywords: Biofloc, *Anabas testudineus*, Antimicrobial resistance, Pathogenic bacteria, Reverse zoonosis

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Incidence, Antimicrobial Resistance and Virulence Genes Associated with *Klebsiella pneumoniae* in Fish Retail Markets of Visakhapatnam, Andhra Pradesh

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Klebsiella pneumoniae is a hospital-acquired pathogen which causes liver abscesses, diarrhoea and septicaemia in humans. As a zoonotic pathogen, information on its incidence in farmed fish and retail seafood is limited. The present study investigated the incidence, virulence genes and antimicrobial resistance profile of K. pneumoniae isolated from retail fish markets of Visakhapatnam, Andhra Pradesh, India. A total of 130 samples consisting of fishes (n=84), waters used for cleaning fish (n=41), source water from bore wells and municipal water supply points (n=5) were screened. The isolates were identified by amplifying khe gene and 16S rRNA gene sequencing on the Sanger sequencer platform. The incidence of K. pneumoniae in this study was 8.46%. The farmed fish samples that were positive for K. pneumoniae were red-bellied pacu (n=2), catla (n=2), rohu (n=2), common carp (n=1), mrigal (n=1) and L. vannamei (n=3). Out of nine virulence factors (rmpA, entB, vbtS, kfu, K2, allS, mrkD, iutA, magA) tested, the most common virulence genes detected in K. pneumoniae were entB (95%), mrkD (915), allS (785) and kfu (52%). Overall, 23 K. pneumoniae isolates were tested for antimicrobial susceptibility test against 12 classes of antibiotics (n=28 antibiotics) following the Kirby-Bauer disc diffusion method. The highest percentage of resistance was observed towards, nitrofurantoin (34.7%), tetracycline (21.7%), ciprofloxacin (21.7%), levofloxacin (21.7%) and nalidixic acid (21.7%). The multidrug resistance observed in K. pneumoniae was 21.7%. In total, 13% of the isolates showed resistance to a single antibiotic class, 13% against two antibiotic classes, 4% against three antibiotic classes and 17% of the isolates exhibited resistance against 5 classes of antimicrobials. Overall, 52% of the isolates showed susceptibility against all the antibiotics tested. The results of this study underscore that farmed fish and shrimp harbour K. pneumoniae, and the presence of virulence genes and the occurrence of multidrug-resistant isolates pose a potential threat to fish handlers as well as to consumers, which cannot be underestimated.

KEYWORDS: Klebsiella pneumoniae, Seafood, Virulence gene, Antimicrobials, Multidrug resistance

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Virulent and Multidrug Resistant *Lactococcus garvieae* Isolated from Clinically Infected Oscar Fish (*Astronotus ocellatus*) and their Immunological Response

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Oscar fish (Astronotus ocellatus) is a high-value ornamental fish belonging to the family Cichlidae and commercial Oscar fish farms are often affected by infectious diseases. In this study, we investigated the outbreak of lactococcosis caused by Lactococcus garvieae in an Oscar fish farm in Kerala, India. The affected fish exhibited clinical symptoms such as irregular swimming, apathy and ocular lesions, with a monthly mortality rate of 9-10%. Gross pathological examination revealed typical signs of septicaemia, including skin and fin haemorrhages. Moreover, the paleness of the gill was also observed. The bacteria were isolated from the kidney of the affected fish and were identified using 16s rDNA sequencing and biochemical characterization. Subsequently, the detection of virulent genes and antimicrobial resistance patterns was done in the isolated bacteria. Virulent genes such as hemolysin 1, hemolysin 2, hemolysin 3, NADH oxidase, adhesin pay, adhesin cluster 1, and capsule gene were identified in the isolated L. garvieae. Out of the 35 antibiotics tested, only gentamycin, ampicillin, and cefixime were found to be susceptible. A challenge study (LD₅₀ was 7.4 x 10⁸ CFU per ml) was performed to evaluate Koch's postulate and the immunological response exhibited by the host upon infection. Furthermore, modulation of immune-relevant genes (Chemokine, Interlekin-8 and Immunoglobulin M heavy chain) was observed in the kidney and spleen of the infected fish. The study highlights the significant threat posed by L. garvieae to commercial Oscar fish farming. The high mortality rate and the presence of virulence and antimicrobial resistance genes in the isolated bacteria underscore the severity of the infection. Additionally, the immune response modulation observed in the infected fish provides insight into the host-pathogen interaction.

KEYWORDS: Aquaculture, Surveillance, Pathogen, Virulent genes, Antimicrobial resistance

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Ontogeny and Tissue-Specific Expression Patterns of Immune-Related Genes in the Near-Threatened Endemic Catfish *Clarias dussumieri*

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Clarias dussumieri, an air-breathing catfish endemic to India's Western Ghats, is classified as 'Near Threatened' by the IUCN. With high regional consumer demand, it is a prioritized species for aquaculture diversification and conservation efforts. Despite its ecological and commercial importance, there is a lack of in-depth studies on its immune system. This study investigates the ontogenetic development and tissue-specific (brain, kidney, gill, spleen, muscle, liver, and hindgut) expression patterns of key immune-related genes in C. dussumieri. Larvae were sampled at different post-fertilization stages, and gene expression related to inflammation (IL-1β, TNF-α, iNOS), antimicrobial defense (LYS, HAMP), stress response (HSP70), the complement system (C3), cell-mediated immunity (MHC-II, CD4), and adaptive immunity (IgM) was analyzed in adult tissues. IL-1β expression peaked at 60 days post-fertilization (60D), while TNF- α reached its highest level at 25D before declining at 60D. iNOS expression peaked at 7D, indicating its early role in immune defense. LYS showed high expression at 10D, and HAMP at 60D, suggesting their importance in antimicrobial defense. HSP70 levels increased from 15D, while C3 showed low but consistent expression throughout, MHC-II and CD4 expression increased significantly at 10D and 7D, respectively. indicating the onset of cell-mediated immunity. IgM expression surged at 15D, marking the development of adaptive immunity. In adult tissues, IL-1β, TNF-α, LYS, and HSP70 were most highly expressed in the hindgut, while C3 was predominantly expressed in the liver. MHC-II and CD4 were strongly expressed in the spleen and kidney, and IgM was abundant in both the kidney and spleen. This research provides essential baseline data on the immune development of C. dussumieri, offering insights for vaccination and disease management in aquaculture and contributing to conservation efforts by improving the understanding of fish immunology.

KEYWORDS: Aquaculture, Ontogeny, Immune genes, Tissue-specific expression, qPCR

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Physicochemical and Microbial Profiles in the Marine Cage Farm Environment of Karwar, South West Coast of India

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This study, conducted from April to December 2021 in Karwar, Karnataka (14°48'20.1"N 74°06'38.7"E) was aimed to evaluate the physicochemical characteristics and total cultivable heterotrophic bacteria in water and sediment samples near a marine cage fish culture site. The physicochemical parameters of the water remained largely consistent, showing no significant variation (p<0.05), indicating stable water quality. The total aerobic bacterial count (TAC) in surface water samples ranged from 1.5×10^{1} to 2.38×10^{3} CFU/ml, while the total presumptive Vibrio count ranged from 1.1×10^1 to 2.68×10^3 CFU/ml. In bottom water samples, the TAC ranged from 5×10^{1} to 1.87×10^{3} CFU/ml, and the total presumptive Vibrio count ranged from 2×10^{1} to 1×10^{2} CFU/ml. In the sediment samples, the TAC ranged from 4×10^{1} to 1.5×10^{3} CFU/g, and the total presumptive Vibrio count ranged from 0 to 1.27 × 10³ CFU/g. All bacterial loads were compared to those at a reference site in the deep sea, showing that the bacterial counts at the cage site were within acceptable and optimal ranges. These findings suggest that the water and sediment quality at the cage farm site remained stable. The data indicates that the cage farming system, with only a limited number of cages, did not lead to significant deterioration in water or sediment quality. As such, the cage fish culture practice at this location appears sustainable, posing minimal environmental impact under current conditions. This reinforces the potential for sustainable mariculture practices in this coastal region, contributing to both environmental conservation and local economic benefits without compromising the ecosystem's health.

KEYWORDS: Assessment, Water quality, Bacterial loads, Sustainable practice, Mariculture

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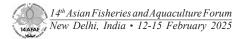
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The Assessment of the Effects of Geographic Distribution and Environmental Parameters on the Performance of Glass Eels (Anguilla marmorata) in Indoor Culture Systems in Vietnam

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The giant mottled eel (Anguilla marmorata) is a commercially valuable species that is actively farmed in Vietnam, contributing significantly to the country's aquaculture industry. The capture and cultivation of this species play an increasingly important role, with most juvenile eels at the glass eel stage either imported from neighboring countries such as Indonesia and the Philippines or naturally sourced within Vietnam. However, the survival rate of glass eels transitioning to the elver stage remains a challenge due to high mortality during the nursery phase. The objective of this study was to assess survival rates and weight gain of glass eels reared in two indoor culture systems during the nursery period. A 90-day experiment was conducted to evaluate the effects of different environmental parameters in two indoor systems on the performance of Anguilla marmorata stocked at densities of 224.90 pcs/m³ and 224.94 pcs/m³ at farms in Ho Chi Minh City and Da Nang City, respectively, with three replicates per density. The eels were fed Hayan feed, imported from Taiwan. Throughout the experiment, water quality parameters were monitored, including water temperature, pH, dissolved oxygen (DO), ammonia (NH₂), and nitrite (NO₂). In Ho Chi Minh City, water temperature averaged 28.44±1.483°C (ranging from 25.2 to 31.1°C), pH was 7.72±0.210 (ranging from 7.4 to 8.1), DO was 6.18±0.196 mg/l (ranging from 5.9 to 6.5 mg/l), NH, was 0.19 ± 0.104 mg/l (ranging from 0 to 0.5 mg/l), and NO, was 0.05 ± 0.059 mg/l (ranging from 0 to 0.2 mg/l). In Da Nang City, water temperature averaged 27.96±1.547°C (ranging from 24.5 to 30.5°C), pH was 7.85±0.178 (ranging from 7.5 to 8.2), DO was 6.29±0.273 mg/l (ranging from 5.9 to 6.6 mg/l), NH₃ was 0.22±0.105 mg/l (ranging from 0 to 0.5 mg/l), and NO₂ was 0.06±0.067 mg/l (ranging from 0 to 0.2 mg/l). The results indicated significant differences in pH and temperature between the two locations (p<0.05), which could potentially impact the growth and survival rates of glass eels during the nursery period. The survival rates (SR%) observed were 64.87±9.97% and 61.36±10.51% in the farms located in Ho Chi Minh City and Da Nang City, respectively. The weight gain (WG) was 1.39±0.055 g/pc in Ho Chi Minh City and 1.47±0.048 g/pc in Da Nang City. Significant differences (p<0.05) in both survival rates and weight gain were found between the two locations. Overall, these findings demonstrate the influence of environmental parameters on survival and growth performance in indoor culture systems for A. marmorata in Vietnam.

KEYWORDS: Indoor culture, Glass eel, Anguilla mamorata, Giant mottled eel, Survival



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Aquaculture as a Reservoir of Antibiotic-Resistant ESKAPEE Pathogens in Kerala: A Study on ARG Profiles and Biofilm Formation

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The aquaculture industry in India, particularly in Kerala, has significantly contributed to the nation's economic development and food security. However, it also poses a threat as a reservoir for antimicrobial-resistant pathogens. This study aimed to isolate, characterize, and analyze ESKAPEE pathogens viz., Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter cloacae, and Escherichia coli from fish and shrimp samples collected from aquaculture farms in Kerala. These isolates were identified, and antibiotic susceptibility testing (AST) was performed using the BD PhoenixTM M50 automated system for a panel of antibiotics used in clinical and veterinary settings. Major antibiotic resistance genes (ARGs) were detected by PCR, focusing on resistance mechanisms against β -lactams, aminoglycosides, and quinolones. Enterococcus faecium isolates exhibited resistance to gentamicin and nitrofurantoin, confirmed by the presence of the aac(6')Ie-aph(2")-Ia, nfs A, and nfs B genes. The Enterobacterales species demonstrated resistance to cephalosporins, penicillin, and monobactams, confirming them as ESBL producers with identification of CTX-M, TEM, SHV, and Amp C genes. Staphylococcus aureus isolates displayed resistance to oxacillin, penicillin, erythromycin, and tetracyclines, with resistance confirmed by PCR detection of mec A, erm A, erm B, tet K, and tet M genes. Biofilm formation, a key factor in pathogen persistence, was assessed using a standard microtiter plate assay. The study found a high prevalence of multidrug-resistant ESKAPEE pathogens in aquaculture sources, with many isolates harboring multiple ARGs and exhibiting strong biofilm formation. Notably, Pseudomonas aeruginosa and Staphylococcus aureus were identified as strong biofilm formers compared to other Gram-positive (Enterococcus faecium) and Gram-negative bacteria (Klebsiella pneumoniae, Acinetobacter baumannii, Enterobacter cloacae, and Escherichia coli) in the aquaculture environmental settings. The association between MDR and biofilm formation enhances the survival and resilience of these pathogens in aquaculture environments, posing significant challenges for infection control. This research highlights aquaculture as an emerging reservoir for antimicrobial resistance (AMR) pathogens and ARGs, underscoring the urgent need for AMR surveillance and biosecurity protocols to mitigate the spread of antibiotic-resistant elements through the aquaculture food chain.

KEYWORDS: Antimicrobial resistance (AMR), Biofilm formation, ESKAPEE pathogens, Multidrug-resistant (MDR) bacteria



Exploring Antibacterial Activities of Mangrove and Medicinal Plant's Extract against Pathogenic *Aeromonas hydrophila*

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In the era of antimicrobial resistance, multi-resistant Aeromonas hydrophila needs to be addressed by devising novel natural antimicrobial agents for safety of aquatic animal health and public health. This study aimed to investigate the antimicrobial activity of two mangrove plants viz., Ceriops decandra and Heritiera fomes, and one medicinal plant, Houttuynia cordata against A. hydrophila. The significance of choosing mangrove plants for antimicrobial activity tests is due to their rich biodiversity and unique biochemical composition, which often include secondary metabolites with potential antimicrobial properties. Their adaptation to saline environments makes them promising sources for discovering novel compounds effective against a wide range of pathogens. Bhitarkanika of Odisha is a renowned sanctuary of rich mangrove–ecosystem and biodiversity, from where the two plants have been sourced. H. cordata is a rhizomatous perennial plant used as herbal medicine in many parts of India, China, Japan, Korea and south-east Asia. Crude extracts were prepared using three solvents (methanol, acetone and water) via the Ethos Easy microwave digestion. The primary screening of extract was done by agar well diffusion minimum inhibitory concentration (MIC) assay. The agar well diffusion assay revealed significant antimicrobial activity of acetone extract of C. decandra and H. fomes with maximum zone of inhibition of 18.5±2.12 mm and 18±2.82 mm respectively against A. hydrophila. Similarly, methanol extract of H. cordata also showed good zone of inhibition of 17.5±2.90 mm. MIC assays revealed the potent antimicrobial properties of C. decandra and H. fomes acetone extracts, with complete inhibition of bacterial growth observed at concentrations as low as 1 mg/ml and 2 mg/ml, respectively. Biofilm inhibition study highlights the potent antibiofilm activity C. decandra acetone extract against A. hydrophila, being most effective at a concentration of 0.5 mg/ml. These findings underscore the therapeutic potential of mangrove plant extracts C. decandra, H. fomes, and H. cordata and demands further investigation as sources for developing antimicrobial agents against various pathogens.

Keywords: Anti-microbial, Mangrove, Ceriops decandra, Heritiera fomes, Houttuynia cordata, Biofilm

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Temperature-Dependent Growth Kinetics and Virulence Determinants in *Aeromonas salmonicida* subsp. *salmonicida* COFCAU_AS: Implications for Pathogenicity

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This study aimed to comprehensively examine the growth kinetics and phenotypic and genotypic virulence characteristics of Aeromonas salmonicida subsp. salmonicida COFCAU AS across a range of temperatures: 20°C, 25°C, 30°C, and 35°C. Growth rates were determined using both spectrophotometric and hemocytometric direct count methods. Results indicated that bacteria cultured at 20°C exhibited the highest growth rate, while those cultured at 35°C demonstrated the lowest. Phenotypic virulence assays revealed maximum activity in hemolysis, amylase, gelatinase, and casein hydrolysis tests at 35°C. In contrast, lipase activity peaked at 25°C, and DNase activity was highest at 30°C. Genotypic analysis further revealed that the expression of aerA, hlyA, and vapA genes was highest at 35°C, with the lowest expression for aerA and hlyA at 20°C and for vapA at 25°C. These findings underscore the significant impact of temperature on the growth and virulence of A. salmonicida subsp. salmonicida. The study reveals that the bacterium's virulence potential is enhanced at higher temperatures due to increased enzymatic activities and elevated gene expression levels. This finding has significant implications for understanding its behavior and pathogenicity under varying environmental conditions. The observation that bacterial growth rates are higher at lower temperatures, while virulence properties intensify at higher temperatures, suggests that the stress experienced by the bacteria at elevated temperatures may trigger an increase in virulence factor expression. Although these findings provide valuable insights, further transcriptome analysis is necessary for a more comprehensive understanding of the underlying mechanisms. The comprehensive data provided by this study offer valuable insights for future research and potential strategies for managing infections caused by this pathogen.

KEYWORDS: Growth kinetics, Virulence, Temperature, Genotypic expression, Aeromonas salmonicida subsp. salmonicida

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Pathogenicity and Host Immune Responses of *Acinetobacter nosocomialis* and *Acinetobacter seifertii* in *Labeo rohita*: First Report of Aquaculture-Associated Infections

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Acinetobacter spp. are emerging pathogens with diverse virulence factors, affecting both human infections and fish diseases across various environments. This study aimed to investigate the in vivo pathogenicity, virulence potential, and post-infection (LD₅₀) immune, hematological, and biochemical responses of two known human pathogenic Acinetobacter nosocomialis and Acinetobacter seifertii, which were isolated from diseased fish of biofloc culture system in Tripura, India. The identification of the isolates was confirmed through a range of biochemical tests and 16S rRNA gene sequence analysis. An in vivo pathogenicity test was conducted to determine the LD₅₀ dose of the bacteria in Labeo rohita fingerlings, which was found to be 1x10^{4.7} and 1x10^{4.3} cells/fish for A. nosocomialis and A. seifertii, respectively. Clinical signs and mortalities were also observed when the LD₅₀ dose was injected into L. rohita fish, including lethargy, skin discoloration, hemorrhage, ulcers, exophthalmia, eye opacity, dropsy, and fin rot, indicating severe disease manifestation. Total RBC count, Hb, PCV, Na⁺, albumin, respiratory burst activity, and anti-protease activity were significantly (p<0.05) lower in the infected group compared to the control group. In contrast, the total WBC count, total protein, glucose, globulin, ALP, SGOT, SGPT, and K⁺ levels were significantly (p<0.05) higher in the infected group compared to the control group. The pathogenic potential of A. nosocomialis and A. seifertii poses a threat to aquaculture. This is the first description of A. nosocomialis and A. seifertii as pathogens in aquaculture.

Keywords: Acinetobacter nosocomialis, Acinetobacter seifertii, Labeo rohita, Pathogenicity, LD50, Virulence genes

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Characterization of the Spring Salt Used to Cure Skin Diseases of Eel (Anguilla bicolor pacifica)

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Spring salt is one of the highest qualities of salt formed when rock salts underground dissolve with hot water and emerge to the surface through fault lines. They are found in small quantities in the world and are believed to contain 84 minerals that have health benefits. Commonly used as a food flavor enhancer, spring salt can also be used to correct the acidity of the soil and maintain the ionic balance of ponds in aquaculture. The use of spring salt as a prophylactic treatment or as a primary treatment to control some fungal and bacterial diseases in fish has not yet been fully tested. Through in vitro experimental trials, the use of spring salt to cure disease infection in Eel (*Anguilla bicolor pacifica*) shows promising results. There were nine minerals extracted namely Potassium, Zinc, Nickel, Manganese, Copper, Chromium, Sodium, Magnesium, and Calcium. Sodium chloride was highest when cooked.

KEYWORDS: Mineral salt, Eel skin diseases

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Back to Basics: Assessing the Long-Term Viability of *Vibrio* Species Stored on Modified Filter Paper Strips at Various Temperatures

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Preserving pathogenic microbial strains is essential for microbiological research, with cryopreservation being the preferred method for long-term stability. The effectiveness of cryoprotectants, however, varies among bacterial species, which can lead to reduced viability over time due to factors such as intracellular ice formation, solute concentration, temperature fluctuations, and changes in salt and pH. Vibrio species, reported as common seafood pathogens, pose unique challenges in cryopreservation due to their adaptability to varying salt levels and pH, potentially inducing stress and promoting a viable but nonculturable (VBNC) state. The present study evaluated a user-friendly, cost-effective paper strips-based method for the long-term storage of Vibrio sp. The viability of Vibrio strains (V. cholerae, V. parahaemolyticus, V. alginolyticus, and V. vulnificus) spotted and dried on sterile filter paper, were examined after storage at different temperatures viz., room temperature (RT), 4°C, -20°C, and -80°C. The preservation medium was TSB supplemented with 5% gelatin and 5% trehalose, adjusted to a pH of 8.0–8.5 with 2% salt. The results demonstrated that all the strains remained viable for 40 days (ongoing) at 4°C, -20°C, and -80°C, except V. vulnificus which displayed turbidity in re-suspension (TSB+2% Salt) broth, indicating a VBNC state. However, none of the strains were viable at RT. In conclusion, it was discovered that the modified filter paper strip-based storage technique was a rapid and affordable way to preserve the Vibrio strains. The current study is being conducted over a 40-day period, which will be continued for one year. This is the first study on storing Vibrio strains on modified filter paper strips. To determine the most effective method for the long-term preservation of these bacteria at room temperature, future research should focus on modifying medium supplements to improve the viability of *Vibrio* species.

KEYWORDS: Vibrio sp., Trehalose, Gelatin, Paper strips, Preservation

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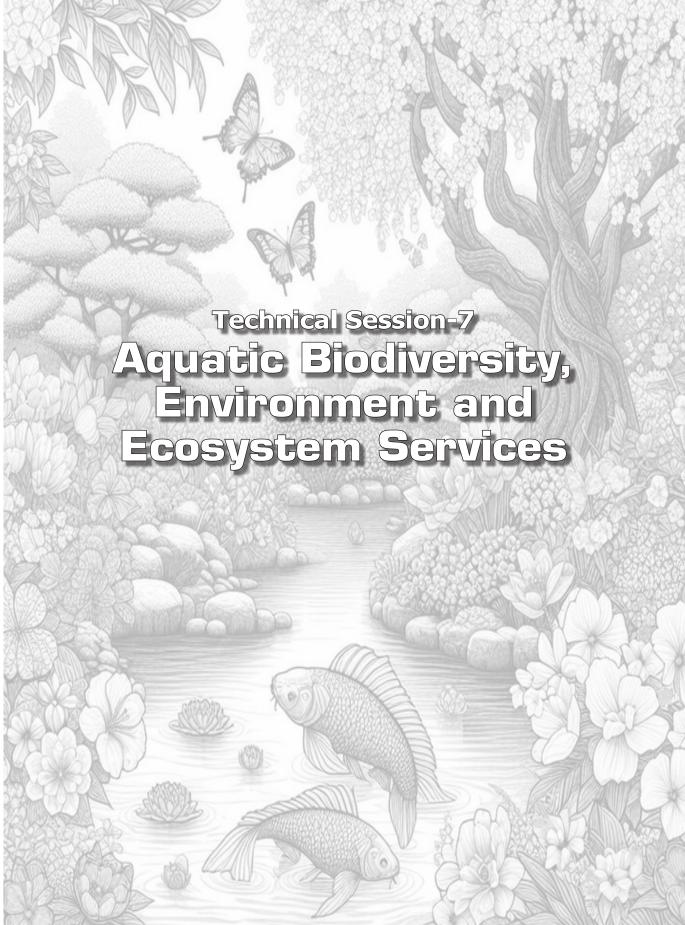
Prevalence of Antimicrobial Resistance and Their Genetic Determinants, Biofilm-Forming Ability and Enzymatic Activity in Bivalve-Associated *Escherichia coli* From the Southwest Coast of India

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Worldwide, Escherichia coli have been the indicator organisms for the microbiological quality of water. The present study deals with the phenotypic and genotypic patterns of antimicrobial resistance, enzymatic activity pattern, and the ability to form biofilm in the E. coli isolated from Perna viridis and Magallana bilineata, sampled from their natural habitats along the southwest coast of India. A total of 350 bivalves were sampled from three ecologically and economically significant sites, with a prevalence of 23.3% E. coli in P. viridis (35/150) and 35% in M. bilineata (70/200), totalling 105 isolates across all the sampling sites. Among the enzymes studied, 82.8% of the E. coli isolates showed caseinase activity. Moderate caseinase activity was exhibited by 69.5% isolates. Considerable biofilmforming ability under aerobic conditions was shown by 58% isolates, with four isolates being very powerful biofilm makers. Under anaerobic conditions, 52.4% of the isolates showed strong biofilm-producing potential. The highest antimicrobial resistance was found against B-lactams (48%) class of antibiotics followed by aminoglycosides (17%), tetracycline (9%), and quinolones (8%). With a MAR index value greater than 0.2, about 41.9% isolates were resistant to at least four different antibiotics examined. Among the 105 isolates analysed, 49.5% possessed β-lactamase gene, 42% of the isolates harboured the blaTEM-1 gene, whereas 12.4% harboured the blaSHV-1 gene. About 5.7% of the isolates harboured both blaTEM-1 and blaSHV-1 genes. Five isolates carried the blaCTX-M-1 gene, whereas no additional isolates carried the blaCTX-M-2, blaCTX-M-9, or blaCTX-M-8/25 genes. One of the isolates harboured genes that conferred resistances to DHA-1, belonging to the AmpC β-lactamases family. The isolate KLK8 that possessed the DHA-1 gene had blaTEM-1, blaSHV-1 genes in their genome. Twenty-six (24.76%) isolates were positive for TET-A gene.

KEYWORDS: Escherichia coli, Antimicrobial Resistance, Genetic Determinants, Biofilm forming ability, Enzymatic Activity





Valuation of Watershed Sediment Retention Ecosystem Service Using InVEST SDR Model: A Case Study from Ujjani Reservoir in Bhima River, India

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Reservoir watershed serves as a critical sediment retention system, preventing excessive sediment transport downstream. This function ensures the enhancement of water quality as well as habitat conditions for aquatic organisms, thereby fostering the prosperity of fisheries and aquaculture within the reservoir. Since ecosystem-based models usually require large amounts of data, identifying priority sites for soil conservation is still difficult. The dynamics of sediment export in the basin have been affected by the dramatic changes in land use brought about by rapid economic development. However, little is currently known about how changes in land use and land cover (LULC) impact the export of sediment. The Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Sediment Delivery Ratio (SDR) model is employed to estimate sediment retention, soil loss, and sediment export in the Ujjani reservoir watershed area in Solapur district, a drought-prone area. This study uses the Digital Elevation Model, 20 years of rainfall data, LULC map, soil data, and management practice as input parameters. The analysis confirmed that the watershed has a total soil loss of about 342.76 kilotons annually. The mean annual erosion rate from the watershed is estimated to be 0.23 t/ha/yr. The total amount of sediment that is exported to nearby streams in the watershed is estimated to be 165.48 kilotons. In terms of LULC, the highest sediment export is estimated from barren land, contributing 2% of the total sediment retention. Due to the existing forest cover, a total of 199.17 kilotons of sediment is retained. Due to its narrow area coverage and presence of a high-sloping zone, the capacity of forestland for sediment retention is not fully utilized in the watershed, resulting in a decreased overall quantity of sediment retention. Agricultural land around the reservoir is the region with a higher quantity of sediment retention. The replacement cost method of reservoir dredging is used in this study to calculate the economic value of sediment retention ecosystem service. The cost of sediment yield is estimated at 2.8 million US\$. The findings of this study enable the formulation of policies and programs in response to land conversion, deterioration of water quality, and soil loss.

KEYWORDS: Ujjani watershed, Reservoir sedimentation, InVEST SDR model, Soil erosion, Land cover, Ecosystem service valuation



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Ichthyofaunal Distribution of Hooghly-Matlah Estuary: Present State of Diversity, and Threats

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The largest, most productive, and most dynamic estuary in India, the Hooghly-Matlah estuary, is laden with fishery resources. In the present study, seasonal samplings were conducted for three successive years (2021-2023) at ten pre-selected sites. The study recorded a total of 234 fish species under 22 orders and 82 families against 212 species reported in the year 1991. Out of 234 fish species, 2 species were categorized as endangered, 4 as vulnerable, and 8 as near threatened as per IUCN Red List status. As per habitat distribution, 27 species were truly marine, 46 species were truly freshwater, 45 species were both freshwater and brackishwater, 58 species were both brackishwater and marine, as well as 58 fish species have been recorded from all three i.e., freshwater, brackishwater, and marine habitats. Silurids dominated the fish diversity with 33 species, followed by both cyprinids and perciforms with 29 species each, carangids with 25 species, and so on. Seasons and stations both showed a significant variance (p<0.05) in the fish species richness. Amongst the ten sampling locations, the sea mouth area at Fraserganj was found to be the most species-diversified, harbouring the most brackishwater as well as marine migratory species. The highest seasonal species richness was observed in the post-monsoon, followed by pre-monsoon and monsoon, respectively, with the highest species evenness during the monsoon season. Salinity was found to be the primary physico-chemical variable to determine the fish assemblage patterns across the estuary, while the freshwater parts are majorly impacted by reduced water depth and transparency. Overfishing, wild fish seed collection, habitat degradation, reduced river discharge, silt deposition, mangrove destruction, and pollution pose threats to the fisheries of the estuary. In addition to the strict ban on illegal fishing methods, emphasis should also be given to anthropogenic threats to maintain the existing biodiversity and replenish depleted fish stocks.

KEYWORDS: Ecological variables, Finfish diversity, Hooghly-Matlah estuary, Threats

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Distribution of Geochemical Fractions of Phosphorus and its Ecological Risk in Mangrove Sediment Cores from the World's Largest Delta: Insight into the Source, Bioavailability and Eutrophication

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Reconstructions of past fluvial contamination through the analysis of sediment cores are rarely reported in the literature. Here, the intertidal sediments of the Sundarbans mangrove ecosystem from the Indian side were studied for sedimentary phosphorus cycling and phosphorus bioavailability. Sediment cores were collected from the Jhakhali, Dhmakhali and Patharpratima stretch of the Sundarbans mangrove ecosystem. Different geochemical fractions [exchangeable (Ex-P), aluminum-bound (Al-P), iron-bound (Fe-P), calcium-bound (Ca-P), and organic-bound (Org-P)] forms of phosphorus were studied to understand the biogeochemical cycling and bioavailability of phosphorus in the mangrove sediments. The total sedimentary P in the cores varied between 227.2-473.0 mg/kg. The average concentration of respective P fractions in the three cores collected from Indian Sundarbans followed the order: Ca-P > Org- P > Fe-P > Al-P > Ex-P. The high total phosphorus (P) content in Jharkhali sediment may be due to its relatively pristine environment and the presence of mangroves, which help preserve more phosphorus. Fe-P fraction decreases with depth which implies that the sedimentary redox conditions regulate the adsorption of phosphate onto Fe-oxides/ hydroxides, Ca-P increased with depth which may be due to post-depositional transformation from Fe-P and Org-P into Ca-P. Bioavailable phosphorus (BAP) accounted for over 50% of the total phosphorus, suggesting that mangrove sediments are an important internal nutrient source of phosphorus, contributing to coastal eutrophication and hypoxia events in the impacted tropical mangrove ecosystems. Risk assessment based on the total concentration of P suggested a relatively low risk of P from sediment as an internal load in the studied areas. Anthropogenic activities, on the other hand, may increase the inorganic P fractions, which are more released under anoxic conditions. In the future, a deep study is required to identify the real mechanisms happening at the sediment and bottom water interface of the mangrove ecosystem. Hence, the present study urges us to take necessary measures for reducing the effect of external phosphorus factors, in impacted mangrove ecosystems.

KEYWORDS: Mangrove, Sediments, Phosphorous, Bioavailability, Eutrophication, Sundarbans

Mass Nesting of Olive Ridley Turtle (*Lepidochelys olivacea*) in Rushikulya Rookery, Odisha: Does it Have Any Impact on Biocoenosis in Rushikulya River-Estuary?

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Mass nesting (Arribada) of Olive ridley sea turtles (Lepidochelys olivacea) in Rushikulya rookery, sea mouth of Rushikulya river, Coastal Odisha is a natural phenomenon. These turtles congregate between October and April month every year. The present study (2022 - 23) attempted to elucidate any influence of turtle congregation on biotic components (phytoplankton and benthos) in the Rushikulya River estuary. Results showed that phytoplankton species richness was comparatively higher (108 species) after turtle congregation than the pre (98) and during (92) mass nesting phenomenon. No significant variation was observed in phytoplankton species richness (F=1.1367; p=0.347) and density (F=2.730; p=0.093) between before, during, and after turtle congregation in the estuary. However, phytoplankton biomass (Chl a) present before and after the assembly showed significant variation (p<0.05). Assessment of Ecological Quality Status (EcoQS) using the Index of phytoplankton integrity (IPI) and the Multimeric phytoplankton index (MMPI) consistently showed 'moderate' ecological health (0.72>IPI\ge 0.53; 0.6>MMPI\ge 0.4) with a slightly higher index value during and post-assembly period. Similarly, the richness of benthic taxa, distributed among 4 functional groups (Scrappers/Shredders, Filter Collectors, Collector Gatherers, and Detrital Shredders), increased after mass nesting (44 taxa) over that during the congregation period (36 taxa). There was insignificant variation (p>0.05) in benthic species abundance between the during and post-assembly periods. The polychaete species, Cirrulatus cirratus, and Prionospio cirrifera occurred as indicator taxa after congregation (IndV=>30%), however, the presence of these species was remarkably low during aggregation. Significantly higher concentrations of NO₃⁻ and PO₄³⁻ in the estuary water were recorded during post-congregation. Pearson's correlation study showed a close relationship between phytoplankton abundance and nutrients (NO₃ and PO₄) in the postassembly period indicating the influence of additional/extraneous nutrients on phytoplankton succession in the estuary after mass nesting. The consistently moderate EcoQS across time periods and the statistically insignificant (p>0.05) changes in abundance and diversity of plankton and benthos communities suggest no major influence of mass nesting on estuarine biocoenosis.

KEYWORDS: Aaribada, Olive ridley turtle, Impact, Estuarine biota, Rushikulya

Predictive Modelling of Chlorophyll-a Concentration along Mumbai Coastal Waters: A Machine Learning Approach

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Chlorophyll-a (Chl-a) concentration is a vital parameter of phytoplankton biomass and water quality in coastal regions. This study focuses on predicting Chlorophyll-a levels in the coastal waters of Mumbai using Sentinel-2 satellite data combined with machine learning models. The field datasets in the years of 2017, 2018 and 2019 were collected from several locations of the Mumbai coastal region. Different independent variables including the different bands, their combinations and indices have been considered. In this study, random forest regression and support vector regression were taken into consideration to predict Chlorophyll-a concentrations. The models were validated using in-situ Chlorophyll-a measurements collected from the Mumbai coastal region. Feature importance analysis highlighted the significance of specific spectral bands and indices, such as the red band and normalized difference chlorophyll index, in predicting Chlorophyll-a levels. The results demonstrated that the machine learning models, particularly the Random Forest algorithm, provided accurate predictions ($R^2 = >0.75$, RMSE = 0.32) with a high correlation to observed values. This approach presents a promising method for continuous monitoring and management of coastal water quality, aiding in the assessment of ecological health and the early detection of algal blooms in the region. The study underscores the potential of integrating satellite data with machine learning techniques for effective environmental monitoring and resource management in coastal zones.

KEYWORDS: Predictive modelling, Chlorophyll-a, Coastal waters, Machine learning

Fish Assemblage Longitudinal Trends in the Yamuna River, India with Respect to Environmental Conditions

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An assessment of the fish species composition of the Yamuna River was carried out in order to determine the driving force behind the patterns in the fish assemblages and their associated environmental conditions along the longitudinal gradients. The data were gathered seasonally from the nine sampling sites along the Yamuna River between February 2021 and May 2023. A total of 126 fish species from nine sampling sites in the Yamuna River, representing 13 orders, 34 families, and 82 genera were identified. Eight were alien species, and the remaining 118 were native. The most prominent family, with 36 species, was Cyprinidae, followed by Danionidae, Bagridae, and Sisoridae. The fish assemblages upstream were dominated by Schizothoracinae, a type of mountain species that prefers fast-moving water and boulder habitats. On the other hand, common river species that like slow-moving water, such as Danionidae, Cyprininae, Bagridae, and Siluridae, dominated the mid-downstream fish assemblages. The ichthyofaunal species' Canonical Correspondence Analysis (CCA) with environmental factors revealed that the fish communities were substantially affected by water temperature, specific conductivity, water velocity, and dissolved oxygen. The findings of this study offer a basic scientific foundation for comprehending the fish assemblages of the Yamuna River, which will help with biodiversity management and the preservation of the habitat of aquatic species.

KEYWORDS: Assemblages, Biodiversity, Conservation, Cyprinidae, Schizothoracinae

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Assessment of Water Quality of Anthropogenically Stressed River Yamuna Using Multiple Water Quality Indices

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The present study investigated the spatiotemporal water quality assessment of the Yamuna River and its suitability for drinking purposes. Water samples were collected at 11 locations from the Yamuna River. The result suggested that Delhi to Mathura was the most anthropogenically stressed stretch where the lowest values of DO and flow, and the highest values of TDS, COD, EC, Chloride, hardness, nitrate, and phosphate were found. At ITO, Delhi, DO was below the desired limit of 5 mg/l for fisheries. For the drinking water category, the WQI ranged from almost good (upper stretch) to inappropriate (middle and lower stretch). $PI_{Nemerow}$ and the comprehensive pollution index suggested that most of the studied sites were strongly and moderately polluted. The trophic state index indicated that the upper stretches of Yamuna were mesotrophic, the middle stretches were moderately eutrophic, and the lower stretches were low eutrophic in nature. The indices used to evaluate the water quality and degree of pollution levels in the Yamuna River are effective tools for policymakers and legislators to assess the level of contamination and make informed decisions about managing and improving the river water quality. The present study suggests that anthropogenic attributes are responsible for river water quality deterioration beyond the river resistance limits especially from ITO, Delhi to Mathura region, thus, necessary steps should be taken to revive and restore the pristine nature of the river.

KEYWORDS: Yamuna river, Water quality, Pollution index

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Ecological Health Assessment, Fish Community Structure and Physico-Chemical Properties of Narmada Estuary, India

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The present study was conducted to assess the aquatic organisms and several limnological environmental properties for potential biotic habitat in downstream of Narmada River, from Sardar Sarovar dam to the river mouth. Seasonal samplings were conducted at ten selected sites during 2018-20. A total number of 98 fish species were recorded belonging to 35 families and 13 orders. Planktonic communities comprising phytoplankton and zooplankton, with spatio-temporal variation in total abundance varied from 198 to 2359 nos/l. A total of eight benthic invertebrate groups were observed with the highest abundance of 1638 nos/m². Important environmental parameters like water temperature, water depth and transparency, electrical conductivity, pH, salinity, dissolved oxygen, BOD, and other nutrient parameters showed variations across the different sites due to the involvement of potential biotic habitat and tidal effects. This was reflected in the water quality as well as in the fish community structure of the rivers. Observations made during the study reveal that ecological status is in threatened condition due to human interventions and other anthropogenic activities. Limnochemical parameters in this stretch of river Narmada exhibited a conducive range for fish production. For the protection of ecological profiles, fish diversity, and enhancement of fish production, a rational management strategy should be implemented for this river system. This study can be used as a prime method for determining the ecological health of riverine systems.

KEYWORDS: Water quality, Plankton, Benthos, Fish fauna, Riverine ecology

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Impact of Anthropogenic Modifications on River Ecosystem Services in India: Conflicts, Case Studies and Pathways for Sustainable Management

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Rivers, shaped by the interplay of climate, topography, vegetation, and geology, are increasingly exploited for economic activities such as power generation, irrigation, and flood control. This exploitation has significantly altered river hydrology and the surrounding ecosystems, affecting the balance between consumptive (e.g., irrigation) and non-consumptive (e.g., fisheries) uses. The research categorizes human-induced alterations into damming, stream channelization, inter-catchment transfers, sand mining, groundwater abstraction, and land use changes. These modifications cause various ecological, hydrological, and socioeconomic impacts, including disruption of fish migration, biodiversity loss, groundwater recharge impairment, and community displacement. The study utilizes the Environmental Justice Atlas to map conflicts arising from water management practices across India, highlighting over 75 documented cases of river management conflicts. These conflicts, prominently caused by damming, groundwater extraction, pollution discharge, and sand mining, are concentrated along major rivers such as the Ganges, Yamuna, Narmada, and Brahmaputra. Representing 78.67% of the cases, damming is the most significant cause of conflict followed by groundwater extraction (6.67%). The map reveals a pattern of environmental and social injustices, showing how modifications have led to biodiversity loss, degraded water quality, and socio-economic issues like displacement and livelihood loss among riparian communities. From an ecosystem services perspective, the study evaluates these modifications' on economic, ecological, and socio-cultural impacts, such as the negative effects on fish migration, water quality, and floodplain connectivity. The findings highlight the need for a balanced approach that considers the rights of rivers and the diverse interests of stakeholders, including marginalized communities. The study calls for policies that ensure rivers' rights to flow freely while addressing the conflicting needs of stakeholders. A holistic and inclusive approach is crucial for sustainable river ecosystem management, addressing the complex dynamics between economic development, ecological preservation, and social equity.

KEYWORDS: Ecosystem services, Environmental justice, Rivers, Sustainable development

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Utilization of Microalgae *Graesiella emersonii* for Nutrient Recovery from the Sewage of East Kolkata Wetland: A Ramsar Site in India

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The East Kolkata Wetlands (EKW) is a renowned community-led, sewage-fed aquaculture system and is designated as a Ramsar site. In recent years, an increased nutrient load from industrial and domestic sewage has led to eutrophication and the gradual deterioration of EKW. This issue requires attention to meet the FAO Sustainable Development Goals (SDGs) on "Life Below Water," "Good Health and Wellbeing," and "Sustainable Cities and Communities." Microalgae have been identified as a potential solution for nutrient recovery from sewage water. In this context, we utilized the microalgae Graesiella emersonii for the removal of nutrients (total phosphorus and nitrate) from the system, and its tolerance level was assessed by measuring oxidative stress. Raw sewage was collected from EKW and diluted to different concentrations using laboratory-grade water (LW) (i.e., sewage: LW~ 50:50; 60:40; 80:20; 100:0) in 100 ml conical flasks. One milliliter of pre-grown, exponentialphase microalgae (1.02×10 □ cells/ml) was inoculated into the treatments and observed for 12 days under laboratory conditions at 24±2°C, with the light intensity of 1300±400 lux and a photoperiod of 14 hours light and 10 hours dark. The results revealed nutrient removal efficiencies in the following order: 100 > 80:20 > 50:50 > 60:40. The addition of microalgae removed 84% of nitrate and 67% of total phosphorus from the undiluted sewage, though a lower growth rate (0.121) was observed. In contrast, the 80:20 treatment yielded a comparatively higher growth rate (0.177) while removing 81% of nitrate and 56% of total phosphorus. The oxidative stress developed in the microalgae during the sewage treatment was eliminated as estimated by enzymatic (SOD, CAT, GST) and non-enzymatic antioxidants (GSH). In conclusion, the test microalgae can be effectively utilized for nutrient recovery from wastewater used in sewage-fed aquaculture. This approach may help address high nutrient loads entering the East Kolkata Wetland aquaculture system. Additionally, the spent microalgal biomass could serve as a natural feed for fish cultured in the East Kolkata Wetlands.

KEYWORDS: Sewage, Microalgae, Wetland, Nutrient removal, Ecosystem services

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Phytoplankton Functional Groups Regulated by Cascading Reservoirs in the Subtropical Ganga River, India

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Dams and barrages significantly impact the ecological functions of rivers by regulating water flow, causing fragmentation, affecting water quality and biodiversity. To find out how dams and barrages influence the ecosystem of the rivers, this study used phytoplankton functional groups (FGs) as bioindicators of aquatic habitats in the subtropical Ganga River, India. We identified a total of 114 phytoplankton species including 25 FGs. Genera Nitzschia and Ulneria were detected at all sites under FG D, accounting for greater than 22%. The summer season recorded the highest functional diversity (i.e., number of FGs), followed by the winter. The SIMPROF (Type 3) test classified phytoplankton FGs into six SIMPROF groups based on their frequency and location, using the coherent curve and dendrogram cluster analysis of FGs. Hierarchical cluster analysis using FGs suggested that dams and barrages influenced distribution and abundance. Kanpur was very polluted due to the highest levels of specific conductivity, phosphate, and total phosphorus. However, precipitation and surface runoff dilution significantly reduced pollution during the monsoon season. Redundancy analysis (RDA) strongly influenced six functional groups, namely D, A, P, C, MP, and X1, out of the 15 most prevalent functional groups. Consequently, we hypothesised that the series of dams and barrages would modify the hydrological features of successive reservoirs, affecting the regional and seasonal variations in functional diversity. To improve water quality and promote a wider range of FGs in the study region, it is necessary to strive for minimal environmental flow.

KEYWORDS: Cascading reservoir, Flow regimes, Nutrient dynamics, Dams, Barrages

Evaluating the Length-Weight Relationships and Growth Patterns of Seven Catfish Species in the Middle Stretch of the River Ganga: Insights for Sustainable Fisheries Management and Conservation Perspective

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This study investigates the length-weight relationships (LWR) of seven catfish species in the middle stretch of River Ganga based on 290 specimens collected from November 2022 to October 2023, with lengths ranging from 13.1 cm to 96.1 cm and weights ranging from 15 g to 6000 g. The species examined include Rita rita, Sperata aor, Sperata seenghala, Clupisoma garua, Eutropiicthys vacha, Wallago attu and Bagarius bagarius. Linear regressions of length-weight data revealed high statistical significance (p<0.001) with R² values ranging from 0.66 to 0.93. Four of the seven species had R² values greater than 0.90 and all linear regressions were statistically significant (p<0.001). The b values, indicating the growth pattern of each species, varied between 1.976 for Sperata aor and 3.305 for Sperata seenghala, with an overall mean of 2.8397. Notably, positive allometric growth was observed in Sperata seenghala (b=3.305) and Clupisoma garua (b=3.21), suggesting a more rapid increase in weight relative to length. The deviations from the ideal b value of 3.0 highlight variations influenced by environmental factors, including food availability and maturity stages. This study adds to the Fish Base database by offering crucial information on the growth dynamics of catfish species. Variations in R² values and departures from the optimal "b" value demonstrate how biological and environmental factors affect growth. These results provide significant baseline information for fisheries management by illuminating growth trends particular to every species. The work contributes to the creation of focused conservation strategies and sustainable management practices, which are essential for the preservation and best use of catfish resources in the middle stretch of the Ganga River. This works by improving our understanding of length-weight relationships, or LWRs.

KEYWORDS: Length-Weight relationship, Catfish, River Ganga, Allometric growth, Fisheries management

Assessing Impact of Fingerling Stocking, Fish Diversity and Habitat Variables in A Medium Reservoir of North-East India

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The Dumbur reservoir (3049 ha), Tripura plays an important role in fish production, farmers' income and livelihood in the NE state. A total of 3908 fishers reside in and around the reservoir. The present study was carried out in Dumbur Reservoir during 2021-2022 to assess the impact of supplementary stocking, fish diversity and, habitat variables in the reservoir. Information on annual fish seed stocking and yield (1978-79 to 2021-22) was collected from secondary sources. Data on finfish diversity and habitat variables were assessed seasonally from the reservoir through field studies. Long-term average fish productivity from the reservoir was found to be 153.58 kg/ha/year (2001-02 to 2021-22). The reservoir registered a 257.5% increase in fish production during 2006-07 to 2021-22 in comparison to 1978-79 to 1992-93; which may be attributed to higher supplementary stocking of fish fingerlings. The reservoir has rich finfish diversity and we recorded 55 finfish species belonging to 9 orders, 23 families and, 41 genera across the different seasons. Cyprinidae was the main family that accounted for 65.40% of fishes caught by numbers followed by Ambassidae (18.65%). Small indigenous fishes (SIFs) namely Amblypharyngodon mola and Chanda nama were the predominant species recorded in numbers. Commonly referred Indian major carps (IMC), Labeo catla, L. rohita, and Cirrhinus mrigala contributed 38.66, 5.89 and 8.33%, respectively to the total fish catch by weight followed by large catfishes (Sperata seenghala (9.07%), S. aor (7.74%) and Wallago attu (6.74%). Exotic fishes like Cyprinus carpio, Ctenopharyngodon idella, Hyophthalmichthys molitrix, H. nobilis and Oreochromis niloticus were also recorded in the catches along with the native fish fauna. Salient water quality parameters of the reservoir were generally suitable for fish growth. Average water temperature ranged from 22.80°C to 28.57°C. Water pH was slightly acidic to alkaline in nature (6.8-7.2). Dissolved oxygen (DO) of water was sufficiently high (7.23-8.43 mg/l). Average electrical conductivity (76.67-114.33 μS/cm), total dissolved solids (50.67-95.67 mg/l), and total alkalinity recorded (43.67-60.67 mg/l) across different seasons indicated the productive nature of the reservoir. Certain management and conservation plans have been suggested for sustainable management of the reservoir based on the present study.

KEYWORDS: Dumbur reservoir, Supplementary stocking, Finfish, Water quality, Tripura



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Seasonal Dynamics in Fish Community Structure and Environmental Attributes in Wetlands in Changing Climate: A Study from Deepor Beel - A Ramsar Site of International Importance

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Environmental characteristics and climate change can influence the distribution of fish communities in aquatic habitats. The present study in Deepor beel aimed to reveal the relation between fish community structure and environmental and climatic characteristics. Sampling was carried out across seasons (pre-monsoon, monsoon and post-monsoon and winter) during 2023 and 2024. Comparative analysis revealed that 46 fish species were recorded during the monsoon of 2023, which increased to 51 species in the same period in 2024. Seasonal analysis showed that, the highest number of species was recorded during monsoon, followed by post-monsoon (39), pre-monsoon (37) and winter (34). Shannon index (H') values were higher and ranged from 2.872 to 3.135 during the monsoon of 2024, while the values ranged from 1.192-2.088 in the monsoon sampling of 2023. The increase in fish diversity may be attributed to the increased monsoonal rainfall received in the study area in 2024 owing to the effect of La Nina. Relative abundance of fish families was found to range from 0.0009 to 49.15% with cyprinids being most abundant. Cluster analysis reflected that monsoon samples were distinctively separated as compared to other seasons. Correlation analysis and RDA plot explained that water temperature, transparency, conductivity, and total alkalinity were critical environmental parameters playing crucial roles in the spatiotemporal variation of ichthyofaunal diversity within the beel ecosystem. RDA1 explained 37.59% of the total variation and RDA2 explained 22.76%. BIO-ENV module reflected that variables such as Turbidity, depth, NH, PO, and chlorophyll were significantly correlated (r=0.435) with fish abundance and composition. The present study provides insights into the role of the environment in fish community structure in important and less-explored tropical wetlands and can help in the sustainable management of wetland fish diversity.

KEYWORDS: Floodplain wetlands, Fish diversity, Environmental interactions, La Nina

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Nanozyme Sensors for Detection of Potentially Toxic Elements in Inland Open Waters

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Aquatic pollution by potentially toxic elements (PTEs) like chromium (Cr), arsenic (As), etc. has increased exponentially in India. PTEs in inland aquatic ecosystems are adversely affecting biodiversity and are also reported to cause potential human health hazards throughout the food chain. Detection of PTEs in water bodies is one of the major concerns faced by the different quality regulatory agencies. Several lab-scale instruments like AAS and ICP-MS are available for the detection of PTEs. However, on-site/real-time detection of PTEs like arsenic (As) and Chromium (Cr) remains a challenge. Hence, real-time sensor development is desperately needed for field application because traditional testing techniques are costly and time-consuming. To address this gap, nanoparticle-enabled NanoZyme sensors are developed for fast detection of As(V) and Cr(VI). In the case of As(V), the sensing mechanism involves inhibition of FeOOH nanoparticle-induced peroxidase-mimic catalytic activity via surface adsorption by As(V) leading to a colorimetric response in the presence of tetramethylene benzidine (TMB) as enzyme substrate and hydrogen peroxide. Whereas, in the case of Cr(VI), the colorimetric response is obtained by Cr(VI) induced generation of hydroxyl radicals which oxidize TMB in a concentration-dependent manner. The method was further improved by the addition of EDTA in the sample preparation protocol to reduce the false positive result by the presence of ions like Cu²⁺, Fe³⁺, etc. The sensors are found very specific and sensitive, enabling rapid and visible detection of As(V) and Cr(VI) with detection limits of <10 µg/l and < 50 µg/l, respectively. The methods enabling the use of Nanozyme sensors have great potential for rapid analysis of PTEs in inland aquatic ecosystems.

KEYWORDS: Nanozyme, Sensor, Arsenic, Chromium, Water

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Species and Community Diversity of Phytoplankton in Hooghly Matlah Estuary: A Study Using Indicator Species Analysis

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Phytoplankton are an integral ecological component of the estuarine food web and productivity. The phytoplankton community has been recognized as an excellent indicator of environmental conditions and the health of an aquatic ecosystem. The present study aimed to understand the dynamics of phytoplankton and the identification of indicator species in various saline zones of the Gangetic estuary. Seasonal samplings were conducted to assess phytoplankton diversity and water quality variables in the Hooghly Matlah estuary during 2021- 2023. The study recorded 132 species of phytoplankton belonging to 95 genera across 12 algal groups from 10 selected stations in the estuarine system. Hierarchical cluster analysis of the water quality data identified four distinct clusters representing different salinity regimes. The relationship between species and the environment indicated that the water variables viz. temperature, salinity, pH, silicate, and nitrate concentrations had profound influence on phytoplankton distribution and abundance. The maximum mean phytoplankton density was during the post monsoon (2.88 x 10⁴ u/l) followed by monsoon (2.419 x 10⁴ u/l) and pre-monsoon (1.574 x10⁴ u/l). Indicator species serves to monitor environmental changes, evaluate management effectiveness, and signals potential ecological shifts. In the Hooghly-Matlah estuary, indicator species analysis was used to identify key phytoplankton indicators. The diatom Aulacoseira granulata was recorded as the most abundant species in the estuary except at Pathar Pratima sampling station, the prevalence is likely linked to nutrient enrichment in the estuary. In the freshwater zone, Aulacoseira granulata and Scenedesmus quadricauda were dominant, while *Pleurosigma* sp. and *Coscinodiscus* sp. prevailed in the intermediate zone. The upper Sundarbans showed a high abundance of Cyclotella sp. and Closterium sp., whereas salinetolerant species such as Entomoneis sp. and Chaetoceros sp. were more common in the lower Sundarbans. The distribution and proliferation of phytoplankton are influenced by various factors, with anthropogenic stress being particularly impactful, as observed in the more polluted sites of the study. The study emphasizes the importance of plankton studies in managing the estuarine system to counteract anthropogenic eutrophication and maintain primary productivity

KEYWORDS: Sundarbans, Phytoplankton diversity, Indicator species, Estuarine management



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The Seasonal Bloom of Jellyfish Around the Indian Subcontinent and Associated Climate Conundrums

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Jellyfish, which constitute the foundation of the marine food web, are consumed by fish, birds, and other larger creatures. The proliferation of jellyfish during blooming periods affects the primary players in the food chain, referred to as Copepods, who serve as a crucial food source for many marine species. The repercussions of commercial fishing around the Indian coast are significant. Since the beginning of the industrial era, humanity has been releasing unprecedented amounts of carbon dioxide into the Earth's atmosphere. A substantial proportion of this carbon dioxide is absorbed by the ocean, whereby it undergoes a reaction with water to generate carbonic acid. Most species exhibit suboptimal performance in mildly acidified water. Jellyfish, in comparison to other species, evidently have a higher level of resilience to ocean acidification. Therefore, it is crucial to know the blooming dynamics of various jellyfish species in the Indian subcontinent and the corresponding abiotic factors to deepen our understanding of them. Initiated in 2017, this study consistently observes the Indian coastline in all maritime time zones to identify jellyfish focus sites where recurring jellyfish bloom takes place. So far, this study has identified 74 locations along the Indian coast as focal points for jellyfish distribution. The study elucidated the diversity of blooming jellyfish in these regions and documented their spatial distribution. While *Chrysaora* is the most populous jellyfish genus in the coastal waters of India, Genus Cyanea is the biggest in terms of biomass. This study successfully distinguished the taxa that produce bloom on the

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eastern and western coasts of India. Within the coastal regions of India, boundary currents significantly contribute to the dispersion and aggregation of several kinds of jellyfish. During the northeast monsoon (November to February), East India Coastal Current (EICC) and Winter Monsoon Current (WMC) maintained the continuous flow from the northern Bay of Bengal to the northern Arabian Sea having low salinity. During the southwest monsoon (June to September), the West India Coastal Current (WICC) flows southward and feeds to EICC with the help of the Summer Monsoon Current (SMC) carrying high saline Arabian Seawaters. This study hypothesizes that jellyfish species migrate from the western coast to the eastern coast of India. Although Genera *Cephea*, *Netrostoma*, and *Marivagia* were more prevalent along India's western coast between 2017 and 2020, they are being more observed in the coastal waters of the eastern coast after 2020. Monitoring the jellyfish focus areas identified in this study, together with investigating physical parameters such as sea surface temperature and salinity, is crucial for constructing a comprehensive dataset that elucidates the mechanisms of jellyfish blooms and their impact on the marine food chain in the seas surrounding the Indian subcontinent.

KEYWORDS: Jellyfish bloom, Indian subcontinent, Jellyfish Focal Areas, Boundary currents

Influence of Dams and Barrages on Periphyton in Pre-Monsoon and Monsoon Seasons in the Subtropical Ganga River, India

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The current study was undertaken in the subtropical Ganga River at its upper and middle stretches to assess the diversity and assemblage pattern. This study documented a total of 159 periphytic species (128 sp. in pre-monsoon and 66 sp. in monsoon) belonging to seven phyla (Heterokontophyta, Chlorophyta, Cyanobacteria, Charophyta, Euglenophyta, Cryptophyta and Ciliophora) in the Ganga River. All periphytic species belonged to 12 classes, 27 orders and 46 families. The species richness was highest downstream (107 sp.) than upstream (97 sp.) during pre-monsoon whereas species richness was highest upstream (66 sp.) than downstream (57 sp.) during monsoon season. The abundance averaged 1.76 x 10⁶ cells/cm² upstream and 1.65 x 10⁶ cells/cm² downstream during pre-monsoon. In contrast, abundance averaged 3.2 x 106 cells/cm² upstream and 2.9 x 106 cells/cm² downstream during monsoon. The abundance was highest upstream during both seasons. Simpson diversity index averaged 0.91 upstream and 0.87 downstream during the pre-monsoon season, while during the monsoon season, it was 0.83 for upstream and 0.84 for downstream. Shannon diversity index averaged 2.89 upstream and 2.75 downstream during pre-monsoon, and during monsoon season, it was 2.2 for upstream and 2.35 for downstream. The diversity indices were greater upstream during pre-monsoon and greater downstream during monsoon season. The upstream and downstream of dams and barrages highly influenced the periphyton in the Ganga River.

KEYWORDS: Cascading reservoirs, Index of association, Dams, Barrages, Periphyton

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Improving Fisheries Resource Management for Sustainable Utilization and Livelihood Generation in the NEH Region: Status and Way Forward

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Fisheries and aquaculture play a pivotal role in supporting global food systems, economies, and sustainability efforts. With more than 500 species, the North Eastern Hill (NEH) region of the country possesses unique potential for fishery activities representing freshwater fishery potentials of all agro-climatic zones ranging from warm water to cold water conditions. There has been a drastic reduction in the abundance of fish in this region due to natural and anthropogenic stresses. Considering the necessity, the ICAR-National Bureau of Fish Genetic Resources (NBFGR) has been implementing a region-specific collaborative research program on fish germplasm exploration, characterization, and development of live fish germplasm resource centers in the NEH region involving partners from various institutions. The institute has established two Live Fish Germplasm Resource Centers in collaboration with the Guwahati University and the Central Agricultural University, which maintains over 40 indigenous fish genetic resources in the region. Another important contribution includes explorations, through which 19 rivers (224 sites) have been surveyed with information on the occurrence, abundance, and distribution of fish germplasm resources. These explorations have led to the discovery of several new species including Creteuchiloglanis nuthemuensis. Glyptothorax punyabratai, G. hymavatiae, Mustura subhashi, Cabdio crassus, Neolissochilus kaladanensis, Laubuka parafasciata, Channa stiktos, and Psilorhynchus nahlongthai. Considering the importance of cave fishery resources, explorations were carried out in the limestone caves of Meghalaya which led to the discovery of a new species, Schistura sonarengaensis. Additionally, the DNA barcode of over 112 species has been generated. Karyotyping of many indigenous finfish species like Badis assamensis, Puntius terio, Pethia conchonius, and Trichogaster lalius has been carried out which has high significance in classification, breeding, evolution, and genetics studies of fishes. Over the years, the Bureau has been involved in demonstrating improved practices of conservation-based aquaculture and capacity building of the stakeholders which has led to livelihood enhancement. The future research aims include the use of artificial intelligence and drainage-based characterisation of species for effective conservation planning. The institute eventually aims to address the emerging challenges in fisheries and aquaculture while harnessing modern technologies for the conservation and enhancement of aquatic biodiversity.

KEYWORDS: Biodiversity, Conservation, Posterity



Influence of Physicochemical Dynamics on the Occurrence, Environmental Partitioning and Toxicological Effect of Triclosan in the Southwest Coast, India

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In recent times, increased urbanization and population expansion with a pandemic outbreak have resulted in the release of a significant quantity of Emerging Contaminants (ECs) into the aquatic systems. Among these, triclosan (TCS), a commonly used antimicrobial agent in pharmaceutical and personal care products is of great concern. TCS is a broad-spectrum biocide with applications as an antiviral and antifungal agent, commonly incorporated into a variety of consumer products such as mouthwashes, toothpaste, soaps, body washes, deodorants, shaving creams, plastics, and textiles. The unregulated use of TCS and the inability of wastewater treatment plants to effectively remove TCS have led to its detection in nearly all natural water bodies. This study reports the first detection of TCS in marine environments along the southwest coast of Kanyakumari, India. TCS concentrations was in the range of "not detected" (ND) to 9 ng/l in marine water and ND to 2.6 ng/g dry weight in sediments. Investigations into chemical transport dynamics reveal that riverine sediments and their partitioning dynamics are a primary source of TCS contamination in marine systems. The influence of the physico-chemistry of the marine environment on TCS in water and sediment matrices was further investigated. The persistence and distribution of TCS in the marine environment were found significantly influenced by factors such as salinity, pH, and total organic carbon (TOC) through principal component analysis. Ecotoxicological risk assessment revealed a risk quotient (RQ) value of less than 1, indicating minimal ecological risk associated with TCS in these ecosystems.

KEYWORDS: Principal component analysis, Physicochemical parameters, Water and sediment

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Microplastic Contaminants in Benthic Fauna of Jalangi River: A Concern to The River Pollution

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A river's ecosystem consists of two main components: biotic and abiotic. The widespread disposal of plastics into aquatic ecosystems leads to debris fragmentation to form tiny particles known as microplastics. Jalangi river is a major tributary of Bhagirathi River, it covers 233 km. Mainly domestic and agricultural runoff is directly mixed in this river without any treatment. It is one of the most polluted tributaries of the Bhagirathi-Hooghly River, which accumulates particles of polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS). However, no research has documented MP contamination in benthic organisms from the Jalangi River. Analysis from the riverine water showed different morphotypes comprising 54% of foam, 15% fragment, 23% beads and 8% fibres, while sediment comprised of 35% fibres and fragments, and 18% and 12% foam and beads respectively. Maximum accumulation of foam was observed from surface layers of water, whereas fibres were identified from sediments. The fiber colours were categorized as red (46%) and transparent (41%), with the film seeming to be entirely gray. Over all sites, MP accumulation in the benthic organism tissue varied from 0.02 to 0.16 items/g wet weight (ww) or 0.07-1.21 items/individual. This study exhibits the distribution of macro and microplastics in the Jalangi river, emphasizing the concern regarding the emerging pollutant in this inland river system.

KEYWORDS: Microplastic, Jalangi, Benthic fauna, Anthorpogenic, Agricultural sewage

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Study on Ameliorating Potential of Vitamins Against Microcystin-LR Toxicity in Rohu, *Labeo rohita*: Interplay of Multiple Biomarkers

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Inflict of microcystin-LR (MC-LR), a noxious environmental contaminant has been globally penned due to its extreme toxicological implications in aquatic organisms. In the present study, Labeo rohita (rohu) were intraperitoneally injected with a single LD₅₀ dose (i.e., 713.0 µg/kg) of MC-LR. An amelioration study of MC-LR toxicity has been attempted to restore normal physiological, structural, cellular and molecular functions through dietary supplementation of vitamins C, and E individually and in combination at a dose rate of 1000 mg/kg feed for thirty days. Sampling (tissue and blood) was carried out on the 4th, 15th and 30th day post-injection. Histomorphology, non-specific immunity, serum biochemistry and gene expression of inflammatory mediators (IL-1β and TNF-α), detoxification (CYP1A and GST), oxidative stress (SOD, CAT, and NF-κB), apoptosis (caspase 9) and pyroptosis (NLRP3 and caspase 1) were investigated to elucidate the amelioration potential of tested vitamins. Massive sinusoidal engorgement, congestion of the central vein, individualization, swelling, rounding and necrosis of hepatocytes were signatures in the toxin-treated group under histological investigation. Whereas, deposition of hemosiderin, reduced sinusoidal engorgement and merely intact cellular architecture were featured as a part of regeneration and adaptation in vitamin-supplemented toxin-treated groups on day 4. From histology, periodic acid Schiff (PAS) staining, biochemical and immune parameters and gene expression analysis, it was found that both vitamin supplementation provides more effective protection than the individual vitamin-fed group. Comprehensively, the likelihood of restoration of physiological and molecular functions indicated vitamins as a potential functional feed supplement to ameliorate MC-LR toxicity in rohu.

KEYWORDS: Amelioration, Vitamins, Detoxification, Labeo rohita, MC-LR

Marine Debris: An Emerging Threat to Fishermen's Livelihoods in North Kerala Coast

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This study investigates the growing threat of marine debris pollution and its impact on the livelihoods of fishermen at Kodikkal Beach, Kozhikode, during the monsoon season of June and July 2024. The influx of debris, predominantly plastics and discarded fishing gear, caused severe disruptions to fishing activities, resulting in economic losses and environmental degradation. Monsoonal weather events exacerbated debris accumulation, affecting coastal ecosystems and fishing operations. Extreme weather events like cyclones, torrential rains, and storm surges also played a role in the transportation and accumulation of marine debris, amplifying its impact on specific areas. The survey revealed an alarming mean litter density of 1359 gm², with debris mainly composed of plastics, derelict fishing gear, rubber, wood, and glass. Entanglement with fishing gear and boat engines increased maintenance costs, degraded catch quality, and hindered boat launches, severely affecting fishermen's livelihoods. Economic losses were substantial due to higher repair costs and reduced income stability. The study emphasizes the urgent need for comprehensive waste management strategies, including the proper disposal and recycling of fishing gear. Implementing beach cleaning initiatives, constructing coastal barriers, and developing climate-resilient infrastructure are critical to mitigating future pollution and safeguarding livelihoods. Raising awareness within local communities is essential for addressing marine debris and climate change impacts on coastal ecosystems.

KEYWORDS: Marine debris pollution, Fishing livelihoods, Monsoonal impact, Economic losses, Climate change

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Conservation and Restoration of River Ganga: CIFRI-NMCG Eight Years Initiatives

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The National Mission for Clean Ganga (NMCG), under the Ministry of Jal Shakti, is focused on reducing pollution and conserving the Ganga River through coordinated efforts across various states. As part of this mission, the Ministry of Jal Shakti initiated an eight-year financial support (2016-2023) to ICAR-Central Inland Fisheries Research Institute (CIFRI) for extensive studies on fisheries and ecology of the Ganga River system. The project, formally launched on 7th July 2016 at ICAR-CIFRI, Barrackpore, and its regional center in Prayagraj, and focused on assessing fish populations, monitoring ecological conditions, identifying conservation hotspots, and initiating river ranching programs in its first phase (2016-2020). In the second phase (2020-2023), ICAR-CIFRI concentrated on boosting indigenous fish stocks, especially Carps and Mahseer, assessing their populations, restoring Hilsa fisheries upstream of the Farakka Barrage, and promoting sustainable fisheries through extensive awareness campaigns. Over the course of the project, ICAR-CIFRI documented 215 fish species from the entire stretch of the Ganga. As part of efforts to enhance fish stocks, over 143 lakh fingerlings, including Indian Major Carps (IMC), Mahseer, and other native species, were released across five states through 100 river ranching events. More than 303 lakh wild IMC seeds were produced for serving the purpose through ex-situ conservation of wild fish germplasm. Detailed ecological assessments, including water quality, plankton, and benthic organisms, were recorded across various stretches of the Ganga. In a significant step toward restoring Hilsa populations, over 1.22 lakh Hilsa fingerlings, 39 lakh fertilized eggs and 0.56 lakh spawns were introduced upstream of the Farakka barrage, with detailed tagging procedures for monitoring. Stock assessments of several key Gangetic fish species were completed, and a comprehensive Fisheries Conservation and Restoration Plan for the Ganga River system was developed. ICAR-CIFRI has also spearheaded awareness campaigns on sustainable fisheries and conservation of the Gangetic Dolphin as part of a broader conservation effort. Till date, 774 mass awareness campaigns have been conducted covering 19 thousand fisher folks across the river Ganga. The institute remains actively engaged in restoring the ecological health of the Ganga Basin, ensuring the long-term sustainability of fish populations and environmental protection in the Ganga and its tributaries.

KEYWORDS: NMCG, River Ganga, ICAR-CIFRI

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Ichthyoplankton Abundance and Distribution in the Eastern Arabian Sea During the Winter Monsoon and the Role of the Controlling Variables on their Distribution

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The Eastern Arabian Sea (EAS) is one of the highly productive regions in the northern Indian Ocean and the coastal EAS plays an important role in the marine fish catch of India. The EAS experiences prominent changes in the abiotic and biotic characteristics along different seasons and the winter monsoon has a distinct influence on the ecology of the EAS. The information on the spawning habitat of fishes is important in any marine environment and the available information in this aspect is limited in this region. In this background, we aimed to study the abundance and distribution of ichthyoplankton in the EAS during the winter monsoon period of 2024. We also studied physicochemical parameters and phytoplankton biomass (chlorophyll a) to understand their potential influence on ichthyoplankton distribution. The study covered an area from 8°N to 22°N along different transects, and ichthyoplankton sampling was carried out in surface waters from coastal to offshore locations up to 1000 m. The presence of winter cooling was evident from the north to the part of central EAS, and the high level of chlorophyll a was also observed in this part of EAS. The abundance of fish eggs and larvae was higher in the northern and central parts of the EAS than in the southern EAS, indicating the influence of winter cooling on the abundance of ichthyoplankton in this region. A total of 31 major spawning grounds were identified during the period and most of them were in the northern to central EAS regions. The food-rich environment of the northern to central EAS regions was favorable for fish spawning, resulting in higher ichthyoplankton abundances. This comprehensive study significantly contributes to our understanding of the distribution pattern of ichthyoplankton in the Eastern Arabian Sea, offering valuable insights into sustainable fishery in this region.

KEYWORDS: Ichthyoplankton; Abundance, Distribution, Eastern Arabian Sea, Winter monsoon

Importance of Upwelling in the Distribution of Ichthyoplankton in the Eastern Arabian Sea During Peak Summer Monsoon

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Fisheries play an important role in the socio-economy of the coastal Indian population. The eastern Arabian Sea (EAS) is one of the important eastern boundary upwelling systems in the world and is known for its high productivity. The fishery in the EAS also has a significant contribution to the Indian fishery. The information on the spawning period and ground of fishes can be vital in the decision-making regarding sustainable fishery in the marine ecosystem. The information on the spawning habitat of fishes is limited in the EAS and thus necessitates detailed investigation in this aspect. The Summer monsoon is considered as the most important period regarding not only fisheries but also as the breeding period of fishes in this region. Hence, we studied the ichthyoplankton abundance and distribution in the EAS during the peak summer monsoon period. During this period, the upwelling was evident from the south upto 14°N. The phytoplankton biomass and ichthyoplankton abundance was relatively higher in the central Arabian Sea upto 14°N and in the southern EAS, was relatively less, respectively. The upwelling is known to be first observed at the southern tip of the west coast of India during May and it propagates northwards as the monsoon advances. As the study was conducted during the peak summer monsoon period (June), with the propagation of upwelling towards the north, the spawning ground might have propagated towards the north resulting in relatively high ichthyoplankton abundance in the central EAS.

Keywords: Ichthyoplankton, Abundance, Spawning, Eastern Arabian Sea, Peak summer monsoon

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Diversity of Freshwater Fish Family Cobitidae Swainson, 1838 (Cypriniformes: Teleostei) of Northeast India

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Northeast India boasts a remarkable diversity of ichthyofauna, situated in the Eastern Himalaya Freshwater Biodiversity Hotspot due to its varied topography and a multitude of water bodies. Fishes of the family Cobitidae, commonly referred to as spined loaches, are characterized by their movable bifurcated suborbital spine. These loaches are well adapted to benthic habitats, displaying elongated or very elongated bodies with thick skin, reduced scales, and small, sometimes diminished eyes. In this study, the diversity of spined loaches inhabiting the Brahmaputra, Barak-Surma-Meghna and Chindwin basins of northeast India have been examined through morphometry, meristic counts, osteology and oromandibular structures. A preliminary survey found the occurrence of 13 species belonging to 5 genera viz., Acantopsis, Canthophrys, Lepidocephalichthys, Neoeucirrhichthys and Pangio. The highest diversity is observed in the genus Lepidocephalichthys with 8 species. Mitochondrial cytochrome c oxidase I (COI) and cytochrome b (Cyt b) gene sequences of some of the species were generated and analysed using MEGA 7 for studying the phylogenetic relationship. A new species of *Pangio* from the Chindwin basin, Manipur, India was observed in the present study. In northeast India, most spined loaches are caught from the wild leading to a decline in their population. These fishes also face many other threats owing to various natural and anthropogenic activities. Furthermore, due to difficult hill terrain and poor road connectivity, the region is not fully exploited yet and there is scope for discovering many new species of loaches. Therefore, detailed exploration and proper documentation of fishes of the family Cobitidae of northeast India needs to be undertaken with support from the government and local communities.

KEYWORDS: Taxonomy, Loaches, Eastern Himalaya, Phylogeny

Garras of the Chindwin and Barak Basins: An Integrative Taxonomic Characterization Study

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Garras are small to medium-sized, bottom-dwelling fishes which inhabit fast-flowing water of streams, rivers, lakes and sometimes caves all along the foothills of the Himalayan region in India. Garras also exhibit structural modifications to the hillstream mode of life. Under the family Cyprinidae and subfamily Labeoninae, the genus Garra has the most species, 65 species in Northeast India out of which 17 species are from Chindwin and five from the Barak basin. Taxonomic characterization is made based on snout morphology, the position of the gular disc and other characteristics. The study shows that six species of Garra belong to the smooth snout group; three to the rostral flap; two to the rostral lobe; one to the transverse groove; and 10 belong to the proboscis group. Scanning electron micrographs and DNA barcode markers aids the study. Furthermore, partial sequences of the cytochrome c oxidase I (COI) gene were also analyzed for species resolution and the phylogenetic relationship was established in some Garra species of Northeast India. This study also reveals the possible functions of the structural modifications as means of adhesion, mechanical protection and hydrodynamic effects. However high the diversity and endemism of Garras, it is always associated with serious threats. Over the past few decades, there has been an astounding increase in several anthropogenic activities, which pose threats, like overfishing, habitat destruction, water pollution, urbanization, flow modification due to dams, etc. Considering the diversity, and prominence of the snout morphology of Garras, and the ornamental value of Garra more studies on biology and ontogenic changes in the structural modifications of biology need to be carried out. This study also assesses the IUCN status and possible conservation measures are also discussed.

KEYWORDS: Labeonines, Integrative taxonomy, Structural modifications, IUCN status, Conservation

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Chronic Exposure to Ambient UVB Brings Sub-Lethal Molecular and Physiological Changes in the Juveniles of a High-Altitude Fish of Central Himalayas, *Tor putitora*

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Solar ultraviolet-B (UVB) radiation incidence positively correlates with geographical altitude. Global climate change can further increase the magnitude of the solar UVB on the earth. The present study used a high-altitude dwelling fish as a model for studying the impact of ambient UVB on aquatic organisms. For this, the two sets of the juveniles of T. putitora (22±6.3 g) were exposed to ambient levels of UVB light- 1.0 and 1.5 W/m2 (T1 and T2), corresponding to 24.0% and 36.0% of the daily UVB incidence of summer, for 60 days. One extra set was not exposed to UVB light and served as a control. The UVB exposure significantly increased plasma biochemical indices: total antioxidative capacity (TAC), nitric oxide (NO), glucose, cholesterol, cortisol, ALT, and AST, dose-dependently. Lipid peroxide levels increased, and SOD activity decreased in both the liver and kidney, whereas NO and TAC decreased only in the kidney of the UVB-exposed fish. Among the non-specific immune parameters, plasma lysozyme and neutrophil respiratory burst activity increased dose-dependently in the treatments. However, lysozyme activity was decreased in the kidney of the T2 treatment group. Among the carbohydrate metabolism enzymes, LDH and MDH activities were significantly increased in the liver, kidney, and muscle of the UVBexposed fish. The qPCR results showed that the antioxidative genes (gst, cat1, sod1, and cyp1a1) were differentially expressed in the liver, kidney, and muscle tissues of the UVBexposed fish, showing an overall downregulatory trend. The cortisol-related gene, hsd11b1a, was upregulated in the kidney and downregulated in the liver of the UVB-exposed fish. Immune gene, nf- $\kappa b2$, was uniformly downregulated in all the tissues of the UVB-exposed fish. The UVB exposure also resulted in structural changes in the gill, liver, and kidney histology. Our study showed that although chronic exposure to ambient UVB did not severely affect the physiology of fish, it did increase its energetic costs and affected the antioxidative mechanisms. Any further increase in the environmental UVB can harm the welfare of the aquatic organisms. The study emphasizes taking UVB as one of the determinants while framing the strategies for conserving delicate natural resources.

KEYWORDS: Abiotic stressors, Differential changes, Ecosystem conservation



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Species Diversity of Gastropods in Wetlands of West Bengal, India vis-a-vis DNA Barcoding

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Freshwater gastropods play a very important role in ecosystem functioning and serve as bioindicators of the health of aquatic ecosystems. Accurate identification of gastropods using both conventional and molecular techniques is essential for understanding intraspecific variation. Barcode information for freshwater gastropods of West Bengal, India has not been explored so far. The present investigation approaches to generate a DNA barcode of freshwater gastropods in the wetlands of West Bengal, India. A total of 76 isolates of 8 species of freshwater gastropods belonging to the family Ampullariidae, Viviparidae, Thiaridae, Lymnaeidae and Planorbidae were morphologically identified using key characteristics. The morphometric measurement revealed significant differences among the different species. A total of 48 COI barcode sequences were generated using a universal primer targeting the COI gene. The phylogenetic analysis revealed the grouping of the same species under a clade with a bootstrap value of >60. Pairwise distance analysis indicated distinct variations among different taxa. Building a DNA barcode library is essential for species identification, confirmation and biodiversity conservation efforts as intraspecific variations in shell shape are common for some species. Such information could be utilized to build a DNA barcode library for species identification, confirmation and biodiversity conservation to overcome the problem of morphological identification. This study anticipated establishing the baseline database of DNA barcodes for freshwater gastropods specific to the agroclimatic zone of India.

KEYWORDS: Barcode, Gastropod, Wetland

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Physiological Impact of Nitrite-Induced Stress in Freshwater Pearl Mussel, *Lamellidens marginalis*

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The freshwater pearl mussel, Lamellidens marginalis is considered to be a promising candidate species for pearl farming in India as well as in the South East Asian countries. In India, the farming sector has indeed evolved significantly, with many farmers now utilizing indoor culture system for pearl production where the chances of accumulation of nitrite level is very high. Thus, it is essential to study the adverse impact of nitrite toxicity in L. marginalis to maintain a conducive environment for its culture. A study was carried out to evaluate the toxicity of nitrite on L. marginalis using a static renewal method. The median lethal concentration (96 h LC₅₀) of nitrite was found to be 366.68 mg/l over 96 h indicting a high tolerance level of nitrite. Earlier reports on other freshwater mussels also indicated higher tolerance to nitrite level. Subsequently, a nitrite challenge test was conducted, exposing mussels to half the 96-hour LC50 level (183 mg/l). This exposure significantly affected haemolymph activity (p<0.05), including glucose, total protein, SGOT, and SGPT levels. However, alkaline phosphatase activity remained unaffected. Histological examinations revealed significant changes in the gills and hepatopancreas of the mussels, including enlarged inter-lamellar spaces, exfoliation of cilia, and shrinkage of the hepatopancreas lumen. These findings provide insights into the physiological impacts of nitrite exposure on L. marginalis, aiding in the development of mitigation strategies against aquatic toxicity.

KEYWORDS: Mussel, Lamellidens marginalis, Physiological changes, Nitrite challenge test

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Assessment of Ecological Risks of Heavy Metals in Water, Sediments and their Histopathological Effects on Forked Venus Clam, *Gafrarium divaricatum* (Gmelin, 1971) along the Maharashtra Coast of India

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Heavy metals are serious threats to marine and coastal ecosystems due to their toxicity, persistence, and bioaccumulation ability within aquatic organisms. Originating from natural processes and anthropogenic activities, these metals are persistent environmental contaminants that do not degrade over time. Once introduced into marine environments, they accumulate in aquatic living organisms, leading to bioaccumulation and bio-magnification within the aquatic food chain and cause health problems in aquatic organisms and humans. The research investigated the potential of the forked venus clam, Gafrarium divaricatum (Gmelin, 1971), belonging to the family Veneridae, for assessing heavy metal pollution along the Maharashtra coast, India. It is widely distributed and traditionally recognized as a nutritious food source in coastal areas. The concentrations of eleven heavy metals (Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, As, Pb, and Hg) were analyzed in the water, sediment, and gill and digestive gland of clam of three selected sites along the Maharashtra coast. Pollution indices, including the contamination factor (CF), contamination degree (CD), and ecological risk index (RI), were derived from the metal concentration in sediment. The results revealed that the selected sites were highly contaminated with cadmium (Cd) and arsenic (As), indicating serious ecological risks. The bioaccumulation analysis of heavy metals in the gills and digestive glands of G. divaricatum revealed that most of the heavy metals exceeded the permissible limits except Cu and Zn. Histopathological examinations of clam tissues such as gills and digestive glands revealed cellular damage, including haemocytic infiltration, inflammation, and necrosis. These histopathological findings can serve as reliable biomarkers in biomonitoring programs for pollutants in aquatic ecosystems. These findings further highlight the utility of G. divaricatum as a bioindicator species for monitoring coastal pollution and its management of conservation of marine biodiversity.

KEYWORDS: Bioaccumulation, Biomonitoring, Contamination factor, Bioindicator

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Spatio-Temporal Distribution of Chlorophyll-a Concentration Using Aqua-Modis Satellite along the Coastal Waters of Mangaluru and Udupi

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The distribution of phytoplankton and its chlorophyll-a concentration in relation to water quality parameters were studied in the coastal waters off Mangaluru and Udupi. The spatial and temporal variations in the coastal waters off seven selected stations namely, Netravathi-Gurupura barmouth region, Thannirbhavi, Panambur, Chitrapura, Surathkal, Mulki and Padubidri were assessed for a period of 16 months from October 2020 to May 2022. The water quality parameters including salinity, pH, dissolved oxygen and nutrients like ammonia, nitrate, nitrite, phosphate and silicate were recorded. The study observed that diatoms predominated, with 27 genera including Chaetoceros spp., Ceratium spp., Thallasiocera spp., Triceratium spp., Biddulphia spp., Ditylum spp., Coscinodiscus spp., Rhizosolenia spp., Nitzschia spp. and followed by dinoflagellates with seven genera, and blue-green algae with one genus. The current study was applied with IDW to create various continuous surfaces to present the Chlorophyll-a and phytoplankton patterns influenced by each potential source. Ocean colour 3 was estimated and Aqua Modis (satellite) data were carried out for satellite images. The distribution of phytoplankton ranged between 0.54 and 9.96 mg/m³ with a difference of 9.42 mg/m³. The ArcGIS software tools were used for spatial and temporal variation of Chlorophyll-a and phytoplankton distribution. The maximum phytoplankton biomass was recorded in September 2021 at station Suratkal, while the minimum was found in August 2022 at station Netrayathi-Gurupura barmouth region. The chlorophyll-a (mg/m³) in the present study ranged between 0.12 and 2.37 mg/m³ with a variation of 2.25 mg/m³. The mean value of chlorophyll-a was 0.43 mg/m³.

KEYWORDS: Chlorophyll, ArcGIS, Water quality, Phytoplankton, Diatoms, Coastal Waters

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Comparative Investigation on the Ecophysiology, Behaviour and Organismal Traits of Two Himalayan Stream Dwelling Cyprinid Fish in Wild and Captive Conditions

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In this study, we have comparatively elucidated the differences in morphometry, metabolic oxygen consumption, digestive capacity, antioxidative status, thermal tolerance, behavioural preferences, growth, feed use, and muscle composition of two co-inhabiting cyprinids, namely Schizothorax richardsonii (snow trout) and Naziritor chelynoides (dark mahseer). The experimental fish were collected from the Shipra stretch of the Kosi River in Uttarakhand, India. Wild collected snow trout showed active swimming behaviour and correspondingly higher routine and maximum metabolic oxygen consumption rates, which could underlie their lower body condition factor as compared to dark mahseer. Relative gut length, viscerosomatic and hepatosomatic indices, and lipase activity was higher in snow trout than dark mahseer, possibly indicating their feeding habit. Whereas, wild-caught dark mahseer showed higher total protease, catalase and superoxide dismutase activities, and selective preference for dark shelters. After 15-weeks in captivity, snow trout showed significantly higher feed intake, growth, feed efficiency and risk-taking capacity than dark mahseer. Conversely, captive dark mahseer showed higher critical thermal tolerance thresholds, routine metabolic rate, hepatic TBARS, intestinal trypsin and alkaline phosphatase activities than snow trout. In both species, wild to captivity transition was found to enhance body condition factor, muscle protein and lipid content, and hepatocyte size; routine metabolic rate was also altered. Particularly, in dark mahseer, captive transition resulted in enhanced swimming activity, risk-taking, maximum metabolic rate, trypsin, chymotrypsin and lipase activity, hepato-somatic index and hepatic TBARS; and concurrently reduced antioxidative enzyme activities. While in snow trout, captive transition resulted in change in shelter preference from stones to dark places, reduction in leucine aminopeptidase, alkaline phosphatase activities and muscle ash content; and enhanced glutathione S-transferase activity. Overall, our comparative observations elucidate the species-specific differences in various physiological, morphological and behavioural aspects of wild-caught and captive-reared snow trout and dark mahseer. Also, our findings highlight the ability of both these fish species to adapt to environmental (wild-captivity) transitions in distinct ways.

KEYWORDS: Snow trout, Dark mahseer, Behavioural adaptation, Metabolic oxygen consumption, Digestive capacity, Antioxidative status, Thermal tolerance



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Role of Silicate and Dissolved Nitrogen in Co-Limiting the Primary and Secondary Productivity of the Bay of Bengal Euphotic Zone

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Understanding fishery variability in the present climate change scenario in India is crucial for policy-making and conservation. Since fisheries feed on phytoplankton and zooplankton; modeling of primary and secondary producers in the ocean have a crucial place in fishery modelling and assessment. A single-column coupled physical and biological model based on the North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO) with nitrogen and silicon cycles is adapted for the Bay of Bengal (BoB) environment. The model simulated plankton biomass and nutrients along the track of Bio-Argos over East and West BoB (from 2016 to 2017) are validated with the observations. The model fairly simulates the perennial structure of subsurface chlorophyll maximum (SCM). Further, three experiments are carried out to know the limitations in primary and secondary production in terms of nitrogen (NO3 + NH4) and silicate (Si(OH)4) in the open ocean BoB. In a 'no-NO₃ experiment, the nitrate limiting term [i.e., NO₃/(NO₃ + KNO₃)] is set to zero so that the difference from the control case gives the role of 'regenerated production' in the total primary and secondary production. Similarly, a no-NH₄ experiment was conducted to infer the role of 'new production'. The new (regenerated) production fuels 85±1% (28±6%) of the living biomass in the East part of open ocean BoB (East BoB). The corresponding values for the west part (West BoB) are 86±1% (42±2%). Among the primary producers, the new (regenerated) production contributed 72±1% (24±6%) in the East BoB and 74±1% (37±2%) in the West BoB. The silicate limits the diatom production by 46%±22% (45%±27%) of the actual amount of diatom in the East BoB (West BoB) diatom.

KEYWORDS: Ecosystem modeling, Primary production, Secondary production, Nitrate, Silicate

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Artificial Reefs for Lobsters - Application in Marine Fisheries Enhancement, Management and Conservation

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Marine lobsters are a luxurious delicacy world over and one of the costliest seafood exported from India. Increasing demand and intensified efforts have taken our local stocks, particularly spiny lobsters, to the edge of overfishing and some areas into collapses too, due to the unsustainability of current fishing above MSY and management. The lesser valued slipper lobster, targeted subsequently, living in softer and flat sea beds becomes more vulnerable. The unintentional reef-like sea structures (groynes, sea walls, breakwaters, jetties and harbours, offshore platforms and stations and wrecks) deployed and erected on the harbours and seashores have shown increasing settlements of spiny lobster populations in the last decade. This was identified and small efforts with modified skills have yielded catches (Chennai, Mahabalipuram, Thiruvotriyur, Kovalam, and Ennore). However, with the subsequent interventions using Artificial Reefs (AR) from 2014 onwards in these areas, there has been a gradual recovery of fishery and an increase in populations of spiny lobster and sand lobster in the restored habitats. This trend has shown promise for the long-term abundance and productivity of the group, raising hopes for the revival of the fishery. The settlements of latestage post-larvae and pueruli on the crevices and substrate-laden structures were recorded on the deployed reefs within the first year. These larvae established aggregations in their juvenile and sub-adult stages, subsequently exporting the faunal population to adjacent areas. This supports the production hypothesis of AR. As the ontogenetic stages are supported and are reflected in the improved fishery, the ARs are serving as good restoration and resilient habitats for lobsters, thus playing a key role in conservation as well as extending shelters/ refugium (early PL/post moult/mating hostility and incubation dens) at delicate life cycle stages. The ARs when locally managed, the selective fishing of the bigger-sized individuals ensures a management regime and conservation within. This paper attempts to discuss the 'attraction' versus the 'production' from Artificial reefs with emphasis on the marine lobster population in the Indian coastal waters.

KEYWORDS: Marine lobsters, Artificial reefs, Conservation, Marine fisheries enhancement

Spatio-Temporal Variability of Chlorophyll-a, Coloured Dissolved Organic Matter and Phytoplankton Size Classes in the Coastal Waters of Cochin and Mandapam

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Ocean colour imageries play an important role in the assessment of ecological health and productivity of oceanic, coastal and inland waters. This study investigates the spatio-temporal variability of chlorophyll a (Chl a), coloured dissolved organic matter (CDOM), and phytoplankton size classes (PSC) using satellite data over a five-year period (2019 to 2023) in two coastal locations of India - Cochin, on the southwest coast of India and Mandapam, on the southeast coast of India. Both areas are characterised by distinct environmental conditions influenced by monsoonal patterns, oceanographic parameters, ecology and biodiversity. We used MODIS-Aqua monthly level-3 data at 4 km resolution acquired from National Aeronautics and Space Administration (NASA)'s Ocean Color Web supported by the Ocean Biology Processing Group (OBPG) (https://oceancolor.gsfc.nasa.gov). For spatial analysis, the coastal and offshore regions near Cochin were divided into three 1-degree resolution grids to capture the variations between coastal and offshore waters, while the Mandapam region was analysed using a single grid. The abundance-based model was used to calculate the Chl-a concentration of each PSC. Cochin, on the southwest coast of Kerala, is strongly influenced by the southwest monsoon, which promotes nutrient-rich upwelling, primary productivity and phytoplankton growth. Additionally, higher riverine discharge contributes to fluctuations in phytoplankton abundance and size classes in this region. In contrast, Mandapam, situated in the Gulf of Mannar, is primarily influenced by the northeast monsoon. This region is rich in marine biodiversity including coral reefs and seagrass ecosystems providing habitats for numerous marine species. Further, the cage culture activities in the gulf enrich the waters with excess nutrients, leading to frequent harmful algal bloom (HAB) events. The environmental conditions in Mandapam are more stable, shaped by tidal influences and the unique ecology of the Gulf of Mannar. This comparative study provides valuable insights into the variations in PSC and water quality in response to the circulation dynamics and anthropogenic insults of these two regions, enhancing the understanding of coastal ecosystem dynamics and supporting sustainable resource management and conservation efforts in light of climate change.

KEYWORDS: Upwelling, Primary productivity, Harmful algal bloom

Integrating Multi-Metric Index and Regression Model for Evaluating Trophic State in a Large Freshwater Ramsar Lake

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The present study assessed the trophic status and the environmental factors influencing phytoplankton biomass of Loktak Lake, a large freshwater Ramsar Lake listed under the Montreaux Record using a combination of multimetric trophic indices (Carlson Trophic Index (CTSI), Trophic Lake Index (TLI), Water Quality Index (WQI)) and a regression model approach (Generalized Additive Model). This Ramsar lake, locally known as *phoomdi*, is known for its unique floating biomass and is a lifeline for the people of Manipur. The lake's ecology is threatened by various anthropogenic activities such as barrage, pollution, invasive fish species, land-use change, overfishing, etc. Based on 120 samples, a predictive model for phytoplankton biomass and response water quality variables was developed by observing for two years from February 2021 to January 2023 at 10 sampling stations. Average values of the CTSI (59.90), TLI (4.43), and WQI (65.13) reflected that the lake has a moderate degree of eutrophication with 'intermediate' water quality. The developed GAM model identified total phosphorus as the primary predictor of phytoplankton biomass, with other significant factors including pH, temperature, silicate, and turbidity. This study offers valuable insights into monitoring the lake's water quality and supports efforts for ecosystem restoration.

KEYWORDS: Loktak Lake, Phytoplankton biomass, Generalized Additive Model, Carlson Trophic State Index, Trophic Lake Index

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Seaweed as a Source of Bioactive Nutraceutical: Immunomodulatory Effects of Sulfated Galactofucan from *Turbinaria conoides*

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Seaweeds, or marine macroalgae, are recognized as a valuable source of nutrients, bioactive compounds including polysaccharides. An increasing number of recent studies and patents emphasize the potential of these compounds to enhance human health and well-being. Notably, bioactive compounds from marine macroalgae, especially oligosaccharides and carbohydrate polymers, are suitable for use in functional foods, nutraceuticals, and dietary supplements. The immune system is recognized as a key factor in maintaining human health and well-being, especially during the SARS-CoV-2 pandemic. In search for naturally derived immunomodulator from macroalgal source, this study explores a sulfated galactofucan (TCP-3) isolated from the brown algae *Turbinaria conoides*. Through a detailed spectroscopic characterization (FTIR, 1D and 2D NMR spectroscopy) and high-resolution mass spectrometry (HRMS), TCP-3 was determined to possess (1→3) linked fucopyranose and (1→4) linked galactopyranose backbone. TCP-3 (100-400 mg/kg BW) demonstrated immunomodulatory potential by enhancing bone marrow stem cell differentiation (10-13 cells/femur/ml x 10⁶), increasing α -esterase activity (1200-1700 number of positive cells/4000 BMC), and promoting lymphocyte blastogenesis in cyclophosphamide (CTX)induced immunosuppressed mice. TCP-3 also prompted antiviral and immune activation by elevating levels of serum interferon (IFN)-γ (1.31-1.49 pg/ml), interleukin (IL)-2 (3.49-3.99 pg/ml) and WBC count (> 3000 cells/cu mm) levels in CTX-induced animals. Antiinflammatory activities of TCP-3 were demonstrated by its ability to regulate the secretion of pro-inflammatory cytokines, such as ILs-6/1 β /12, TNF- α , TGF- β , and NO in different in vitro and in vivo models. Cytopathic effect and viral copy formation in Vero cells infected with SARS-CoV-2 were significantly reduced ($< 2 \times 10^7$ number) after TCP-3 treatment, in comparison with the infected group ($> 5 \times 10^7$ number). TCP-3 could interact with membrane-associated pattern recognition receptors to inhibit the virus entry via cellular signaling pathways and stimulate the production of inflammatory cytokines. These findings indicate that TCP-3 treatment could serve as a promising natural alternative for providing health benefits in combating inflammation and autoimmune conditions. Additionally, TCP-3 could be utilized as a potent natural antiviral algal polysaccharide against SARS-CoV-2 infection.

KEYWORDS: *Turbinaria conoides*, Galactofucan, Immunomodulation, Anti-SARS-CoV-2 effect, Functional food ingredients



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Unravelling the Nile Tilapia Invasion in a Large Tropical Reservoir in India: Pathways of Introduction and Ecological Impacts

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Biological invasions pose significant threats to ecosystems worldwide, necessitating an investigation into the pathways of non-native fish introductions to mitigate their spread. This study, conducted in the Panam Reservoir in Panch Mahal District, Gujarat, documented the recent establishment of Nile Tilapia (*Oreochromis niloticus*) within this ecosystem. Reservoir ecosystems are increasingly subjected to anthropogenic influences, including the introduction of exotic species, which can have lasting impacts on ecosystem dynamics. Many Indian reservoirs have seen the introduction of various exotic fish species to enhance food fisheries. While most research suggests that tilapia invasions disrupt ecological balance and negatively affect native fish through competition for resources, trophic modeling in certain peninsular Indian reservoirs indicated positive interactions of tilapia with major carp species. Unlike in the case of most Indian reservoirs that are invaded by many alien species, this is the first case of invasion of an exotic fish species in Panam reservoir. Rapid Rural Appraisal focusing on stakeholders especially fishers possessing historical knowledge, with participatory techniques like focussed group discussions, historical timelines, and mapping exercises were carried out to engage the community in sharing historical information about the reservoir fish catch, followed by data validation techniques like randomization and reliability testing, for cross-validating the survey results and to check for consistency and accuracy. Analysis of the invasion pathways revealed a mix of both intentional and accidental pathways of introduction, with tilapia entering the reservoir through unintentional escapes from cages that are intentionally stocked for aquaculture purposes. Since its accidental introduction in 2019, tilapia yields have surged, becoming the third most significant fish species in the catch, contributing over 20% of total landings by 2023. This study underscores the urgent need for enhanced biosecurity measures in aquaculture practices and the importance of using sterile or monosex stock for exotic prolific breeders like tilapia in enclosure culture, to ensure the sustainability of reservoir fisheries.

KEYWORDS: Exotic species, Invasion, Tilapia, Large reservoir, Enclosure culture

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Diversity and Conservation of Serranids in Indian Waters: Ecological Significance and Fisheries Management

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India is renowned for its tremendous biodiversity and for having a unique biogeographic maritime ecoregion. It is one of the world's twelve megadiverse countries. The 7517 km of coastline in India, home to several coastal ecosystems, is home to abundant and diverse resources with significant economic value. With an estimated 2443 (75.6%) valid species, the marine diversified resources include half of all living vertebrates. Groupers are a diverse group of predatory marine fish that belong to the family Serranidae, within the subfamily Epinephelinae. Grouper fish are found in tropical and subtropical regions worldwide. This incredibly varied collection of fish is important to coral reef ecology. They control the composition and structure of communities and serve as a crucial connection in the food chain. Groupers are apex predators that are sedentary, typically move slowly, grow slowly, and have extended lifespans. Their meat is white, soft, and flavourful, and it sells for a premium price. Many species are prioritised for mariculture. Worldwide, 16 genera with 163 species have been recorded. India's waters, particularly along the coasts of the Arabian Sea, the Bay of Bengal, and the Andaman and Nicobar Islands, host a variety of grouper species. Groupers are significant in commercial and recreational fisheries and are found in coral reefs and rocky areas. Red List assessments show that 20 species (12%) face the risk of extinction if current trends continue, and an additional 22 species (13%) are considered to be Near Threatened. Groupers also play a vital role in India's fisheries, supporting coastal communities and contributing to the seafood industry. However, the growing demand for grouper in international markets, along with habitat degradation, has led to pressures on grouper populations, with some species facing overfishing and habitat loss. A study on the diversity of serranids was conducted across India recording species landed in different maritime states across different gears. Results showed that fifty-nine species of serranids in 13 genera are available in Indian waters. This study highlights the significance of groupers in India's marine ecosystems, emphasizing the need for conservation strategies to ensure the sustainability of these keystone species. Enhanced research on population dynamics, habitat requirements, and fisheries management is critical for protecting grouper diversity and promoting sustainable utilization.

KEYWORDS: Serranid, Biodiversity, Conservation, Management

Decoding the Methylome: Investigating DNA Methylation Mechanisms in Brown Algae

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Brown algae, classified under stramenopiles, are key contributors to aquatic ecosystems. Due to their growing commercial significance, the aquaculture industry is developing methods to cultivate these species in controlled environments, which requires an understanding of gene regulation at the molecular level. Furthermore, brown algae have substantial ecological and evolutionary relevance, making it crucial to thoroughly understand their genomic structure. This study examines the methylome, focusing on DNA methylations, their regulatory elements, and their evolutionary development. We conducted a bioinformatic analysis to annotate the presence and evolution of DNA methyltransferases (DNMTs) in 20 novel brown algal genomes, evaluating their potential to employ DNA methylation as an epigenetic mechanism. In other eukaryotes, DNMTs facilitate the methylation of DNA cytosines. Previously, only DNMT2, which primarily participates in tRNA methylation rather than DNA methylation, was found in the genomes of Saccharina japonica and Ectocarpus. Our study detected DNMT2 in all 20 species, but it suggests that DNMT1, a maintenance DNA methyltransferase, was lost early in the evolutionary history of brown algae as we found it to be present in the sister taxa. We identified certain methyltransferase domains similar to DNMTs, which might contribute to DNA methylation in brown algae. Our research indicates for the first time that DNA methylation in brown algae may be driven by DNMT2 only. Additionally, we observed that DNA methylation patterns in context to the arrangement of nucleotides are conserved throughout the Phaeophyceae class, and these patterns are similar to those found in other eukaryotes such as protists and dipterans. This study provides new insights into the epigenetic mechanisms and evolutionary processes in brown algae.

KEYWORDS: Brown algae, DNA methylation, Epigenetics, Methyltransferase

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Ramification of Pirimicarb on the Biochemical Changes in Protein Constituent of Freshwater Fish *Cirrhinus mrigala* After Acute Exposure

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Toxicology is the branch of science that deals with the study of poisons or toxicants and their adverse effects on living organisms. Poison is a quantitative concept, almost any substance is harmful in some dose but at the same time, some low dose has no harmful effect. These two limits have a range of potential effects from mild long-term chronic toxicity to immediate lethality. Pirimicarb is a selective insecticide belonging to the class of chemical pesticides called carbamates. Pirimicarb is significantly applied to target aphids (blue alfalfa aphids, pea aphids and spotted alfalfa aphids), and is used as a foliar spray to infested crop plants. Aphids are little sap-sucking insects belonging to super family Aphidoida. In the present study, the content of total protein upon insecticide Pirimicarb exposure to the fish tissue viz., gill, liver, muscle and brain was estimated by standard method. In the current investigation, fish exposed for 96 hours to pesticides showed significant protein inhibition. This may be due to the increasingly close interaction between the pesticide and fishes which eventually resulted in protein degradation. The breakdown of tissues, the disturbance of the cellular component, and the ensuing change of the synthetic proteins might also be blamed for the decline in protein content.

KEYWORDS: Pirimicarb, Protein, Cirrhinus mrigala

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A Study on Integrated Biomarker Response of Microplastics and Triclosan in *Pangasianodon hypophthalmus*

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This study aimed to assess the Integrated Biomarker Response (IBR) in *Pangasianodon* hypophthalmus following single and combined exposure to triclosan (TCS) and polystyrene microplastic (PS-MP). Fish were exposed to PS-MP (2500 µg/l, T1) and TCS (58 µg/l, T2) as well as three combinatorial groups: T3 (235 µg/l TCS + PS-MP), T4 (117 µg/l TCS + PS-MP) MP), and T5 (58 μg/l TCS + PS-MP), along with a control group (T0: having 0.01 M NaOH (solvent), T0) for 45 days. Biomarkers related to oxidative stress (superoxide dismutase [SOD], catalase), immune function (nitroblue tetrazolium [NBT], myeloperoxidase [MPO]), and protein levels (total protein, albumin, globulin, total immunoglobulin) were measured in liver, gills, blood, and serum. IBR indices of these biomarkers were calculated, the higher IBR values indicating greater overall response to pollutant exposure. The highest IBR index in blood was observed for NBT in the T0 group, while in liver tissues, SOD showed the highest index in the T3 group, followed by the catalase in gills. Serum total protein in T0 and globulin also displayed elevated IBR values. The results suggest that PS-MP significantly enhances the bioconcentration, oxidative stress, and immunotoxicity of TCS, with combinatorial exposure (T3) showing the most pronounced biomarker responses. These findings highlight the effectiveness of the IBR index as a tool for evaluating the toxicological impacts of emerging contaminants in aquatic organisms, offering a comprehensive view of pollutant-induced stress.

KEYWORDS: Integrated Biomarker Response, Pangasianodon hypophthalmus, Microplastic, Triclosan

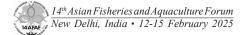
Artificial Intelligence-Based Prediction Profiler for Assessing the Role of Environmental Parameters in Landscape Composition and Fish Species Diversity in the Ganga River Basin

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The management of quality water and soil is essential for a healthy ecosystem, and India, as a signatory to the Convention on Biological Diversity, prioritises its natural resource management and species conservation for sustainable specific species distributions. This study employs Artificial Intelligence-Artificial Neural Network (AI-ANN) modelling to evaluate the favourable and non-favourable roles that environmental parameters play on the Ganga River's landscape composition. Thirteen environmental parameters viz., temperature, pH, total dissolved solids (TDS), electrical conductivity (EC), sulphate, phosphate, alkalinity, chloride, total hardness, nitrate, dissolved oxygen (DO), BOD, and COD for three key landscapes (Prayagraj, Kanpur and Varanasi) for the period 1960 to 2019 were analysed in a time series metadata framework. The landscape composition was characterised by Principal Component one, and this accounted for 30.45% of the variation among the three landscapes with loadings in the range (-)0.28-0.47. Six parameters viz., temperature, pH, DO, sulphate, alkalinity, and total hardness were found to have a positive contribution (or loadings) and seven parameters viz., TDS, phosphate, EC, chloride, nitrate, nitrate, BOD, and COD had a negative contribution in landscape composition. For the simultaneous visualisation of the role of the 13 parameters in landscape composition over Component one during the period 1960-2019, a network of relationships for all 13 parameters in ANN-model was applied. The AI-ANN model consisted of thirteen environmental parameters as input layers, three hidden layers, and the activation function-NTanH (3). Random Holdback (0.333) was used as the validation method. The model was then run several times, and the distribution of root mean square error (RMSE) values were observed in training and validating sub-data for obtaining an optimised AI-ANN model. Optimised ANN-model (NTanH (3)) was used for deriving a prediction profiler, a network of relationship-diagram, a surface profiler, a contour profiler, a prediction and residual diagnostic, a prediction model etc for information about landscape composition vs. environmental parameters. The prediction profiler was used to visualise the role of the 13 parameters, and showed that while 1) temperature, 2) pH, 3) alkalinity, 4) total hardness, and 5) DO played a positive role in landscape composition, the other factors, namely TDS, EC, phosphate, nitrate, chloride, nitrate, and COD played a negative role and at quantification level values close to mean values of the landscape composition. The Artificial Intelligence-ANN modelling was thus employed to obtain a prediction profiler to observe at quantitative level and type of role played by environmental parameters in landscape composition of the Ganga basin.

KEYWORDS: Ganga River, Species diversity, Artificial Intelligence model, Sigmoid curve, Neural network



Decadal Analysis of Harmful Algal Blooms in the Gulf of Mannar: Drivers, Patterns, and Impacts on Aquaculture

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Harmful algal blooms (HABs) pose a significant threat to marine ecosystems, fisheries, and coastal livelihoods. The Gulf of Mannar, a highly diverse and ecologically sensitive region along the Indian coastline from Tuticorin to Rameswaram, is particularly vulnerable to HABs due to its unique environmental conditions. This region regularly experiences highly intense HAB events, which result in widespread fish kills, as observed in 2016 and 2021, highlighting the urgency for understanding and forecasting these phenomena to safeguard both biodiversity and local livelihoods. This study assesses the seasonality, distribution, and intensity of HABs in the Gulf of Mannar over a decade, from January 2013 to December 2023. Weekly Aqua-MODIS satellite data were analyzed, with chlorophyll concentrations above 10 mg/m³ serving as a threshold for identifying HAB events. The decadal analysis revealed strong seasonal patterns, with post-monsoon months (October, November, and December) exhibiting increased HAB intensity, likely driven by optimal environmental factors such as sea surface temperature, wind, and ocean currents. These findings suggest that climate variability significantly influences HAB patterns, leading to annual and seasonal fluctuations in its intensity. Further, the spread and duration of HAB events were assessed and correlated with the fish kill in the region. This proved that routine monitoring of environmental variables and Chl-a concentration can help in identifying areas at risk of HAB events. This could help in the management of the cage culture practices in the Gulf of Mannar and prevent economic loss by mass mortality of cultured fish. By enhancing the understanding of HAB dynamics, this study underscores the importance of developing reliable forecasting models, aiding in the sustainable management of marine resources in the Gulf of Mannar and other sensitive ecosystems.

KEYWORDS: HABs, Chl-a, Satellite remote sensing, Climate change, Fisheries management

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Heavy Metal Variability in Different Matrix along the Coastal Zone of Dakshina Kannada

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Dependence on coastal zones is increasing around the world, and population growth overall is coupled with increased degradation of terrestrial areas. It is estimated that 80% of the pollutant load into the oceans is from terrestrial sources. Heavy metal refers to a group name for metals and semimetals, such as arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc that have been associated with contamination and potential toxicity. The elements mercury (Hg), Arsenic (As), Cadmium (Cd) and lead (Pb) rank among the priority metals based on toxicity that are of significance to public health. In the present study, the levels of metals (As, Cr, Cd, Cu, Pb and Ni) in sediment collected from the River (0-5 m water depth), Near Shore (5-10 m water depth) and Sea (10-40 m water depth) were within the effect range medium (ERM) specified by Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment (1999). EPA 3052 method was adopted for the complete digestion of the sample as it is suitable for microwave-assisted acid digestion of complex matrices including siliceous and organic matrices. Elements such as As and Hg was transformed into hydrides and measured by hydride generation (HG)-AAS. The mean concentration of various metals in sediment (mg per kg dry weight) was Hg (0.45±0.16), As (0.33±0.15), Cr (53.87±3.10), Cd (2.04±0.18), Cu (6.32±0.73), Pb (37.29±2.33) and Ni (15.93±1.0) respectively. In muscle tissue of fin and shell fishes analysed during 2017 to 2021 (1330 samples), the concentration (mg per kg dry weight) of analysed metals differed in the order in different groups of fishes, ANOVA showed that the metals As, Cd, Cu, Pb and Ni were significantly different (p<0.001) yearly in the different groups, while between groups significant difference was not observed in metals Hg, Cu, Pb and Ni. The levels observed are within the permissible limit of WHO standard 1987 for fish and seafood on a dry weight basis. Identification of key threats due to human activities, and integrated management could lead to sustainable development of the coastal zones.

KEYWORDS: Heavy metal, Coastal zone, Sediment, Tissue, Environment

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Marine Mammal Fishery Interactions and Mitigation Measures in India, with Special Note on Indian Ocean Humpback Dolphin (*Sousa plumbea*) Interaction with Trawl Fishing Systems off Kochi, India

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Mammal fishery interactions have significant ecological, economic and management implications. Fishers practice various indigenous mitigation measures to get rid of mammals from the fishing systems. In recent times there have been reports on the interaction of cetaceans with trawlers. The present study discusses the incidence of Indian Ocean humpback dolphin interaction with trawlers off Kochi, Kerala, Indian Ocean humpback dolphins are shallow-water dolphins that occur very close to the shore and estuaries. They have a narrow habitat preference and restricted distribution. According to the IUCN Red List, this species is classified as endangered. Onboard observations were made from ICAR-Central Institute of Fisheries Technology Research Vessel Matsyakumari II, from October 2023 to April 2024. Data from 138 fishing operations was recorded. Independent observers recorded the interactions of Indian Ocean humpback dolphins during trawl operations, focusing on the primary behaviours. Despite consistent sightings of Indian Ocean humpback dolphins in the fishing grounds, only three direct interactions with trawlers were recorded during the study period. Behavioural observations revealed that the activities come under three major types: traveling, foraging, and socializing. Traveling was the most common activity, followed by socializing and foraging. Foraging is the major activity associated with trawl nets. During the time of hauling trawl, dolphins were approaching the cod-end to depredate the fishes dropping out of the net. Cetaceans' sightings and interactions were maximum in March. Trawl fishermen of Kerala are practicing various indigenous mitigation measures to protect the gear and catch from dolphin attacks. Providing a cover to the trawl cod made of thicker twines, attaching unwound ropes at the tip of the cod end, etc. are some of the mitigation measures followed

KEYWORDS: Humpback dolphin, Marine mammal protection, Marine mega fauna

Comparative Toxicity of Bisphenol A and Cigarette Butt Leachate on Croaking Gourami, *Trichopsis vittata* (Cuvier in Cuvier and Valenciennes, 1831)

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Bisphenol A (BPA) is used in the manufacture of plastic products and is a common pollutant in the environment. It is profoundly used in different industrial products and is associated with adverse health effects on human and wildlife. More than 7000 toxic chemicals such as nicotine, carbon monoxide, hydrogen cyanide, nitrogen oxide, polycyclic aromatic hydrocarbons (PAHs), ammonium, formaldehyde, chemicals of benzene, toluene, ethylbenzene and xylene, phenol, pyridine, heavy metals, and acetone are released from cigarettes and are polluting the aquatic environment. Thus, both BPA and cigarette butt leachates are expected to pollute aquatic environments and pose toxicity to aquatic life due to the presence of xenobiotic substances. To study the acute toxicity effect, cigarette butt (CB) leachates at different concentrations viz., 0, 0.125, 0.25, 0.5, 1.0, 1.5, 1.75 and 2.0 CB/l were prepared and croaking gourami, Trichopsis vittata were exposed to each concentration in the aquarium as per OECD guidelines. The LC₅₀ value at 96 hours was found to be 1.69 CB/l, indicating that 50% mortality of T. vittata occurs at this concentration. The mortality rate increased with higher CB concentrations, reaching 100% at 2 CB/l within 2 hours of exposure. Abnormal swimming behavior, flared opercula, and hanging head up was observed at higher concentrations after 24 hours of exposure. Enumeration of microplastic from cigarette butt leachate was also estimated through staining and microscopy as the butt is composed of cellulose acetate and there is a chance of microplastic deposition in leachate. Catalase activity was decreased upon increasing CB concentration. To study the toxicity of BPA, different BPA concentrations (0, 2, 4, 6, 8, 10 and 12 mg/l) were taken. Mortality of fish was recorded at different time intervals (24, 48, 72, and 96 h) of exposure to BPA and LC_{50} value was found to be 8.4 mg/l. Behavioral changes were also studied during LC₅₀ determination. At higher concentrations, fish show erratic swimming, surfacing and profuse mucous secretion. The study concludes that CB leachates and BPA cause significant detrimental effects on the freshwater fish species *Trichopsis vittata*, emphasizing the importance of proper disposal and management to minimize their impact on aquatic ecosystems.

KEYWORDS: Acute toxicity, LC₅₀, Mortality, Heavy metal, Microplastics, Histology

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Thiamethoxam Induced Reproductive Impairments and Larval Deformities in Zebrafish (*Danio rerio*)

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Thiamethoxam, a neonicotinoid pesticide, is frequently used for pest control in agricultural fields and ultimately reaches the surrounding water bodies through irrigation or rain which results in adversely affecting non-target organisms including fish. In the current study, we have checked the toxicological effect of thiamethoxamon reproduction in zebrafish. First, we assessed the 96 hr LC₅₀ value of thiamethoxam in adult zebrafish which was 9.98 mg/l. After that, based on LC_{50} value, we took 3 different doses $1/40*LC_{50} = 0.25$, $1/20*LC_{50} = 0.5$ and $1/10*LC_{50}=1$ mg/l and one control without any pesticide dose. The fishes were exposed to these concentrations for 30 days and then bred in single pairs from each group, multiple times. The spawning rate was highest in the control group (100%), while in other treatment groups, a significant reduction was observed with the lowest in the T3 group (33%). The hatching percentage was highest in the control group (94.9%), while in the treatment groups, it reduced significantly with the lowest in the T2 group (44.8%) and the fertilization rate was also significantly higher in the control group. The other studied parameters like GSI and egg diameters were significantly decreased at 0.5 and 1 mg/l doses of thiamethoxam. The larval analysis for deformity at 6 hrs of hatching showed yolk sac edema (YSE) in the larvae from fish exposed to 0.25 mg/l. Notochord abnormality (NA) was observed at 0.5 mg/l, whereas 1mg/l of thiamethoxam caused haemorrhage, bulging heart, notochord abnormality (NA) and irregular caudal fin (ICF). The haematological parameters showed that RBC count was significantly decreased (p<0.05) with an increase in doses whereas, WBC count was significantly increased (p<0.05) with an increase in the dose of thiamethoxam. The metabolic enzymes like LDH and catalase were significantly (p<0.05) increased in different treatment groups as compared to the control group. Further, the higher doses of thiamethoxam also led to histological damage in the ovaries of zebrafish, resulting in atretic and deformed oocytes. Altogether, our findings conclude that even at low doses (0.5 mg/l), thiamethoxam has detrimental effects on the reproduction of zebrafish.

KEYWORDS: Zebrafish, Thiamethoxam, LC₅₀, Reproduction, Larval Deformity

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Study on the Biomagnification of Heavy Metal, Lead along the Aquatic Food Chain

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Lead is highly toxic to aquatic organisms, including fish, invertebrates, and aquatic plants. Contamination of lead in aquatic ecosystems can result in a range of harmful effects to aquatic organisms. This study was carried out to evaluate the acute toxicity (96h-LC₅₀) and sublethal toxicity of lead in the selected food chain. The acute toxicity study was carried out to find the threshold limit of Chlorella vulgaris, Moina macrocopa, Rasbora daniconius and Channa striata with 96h of lead exposure. The acute toxicity study with three different lead concentrations revealed that the 96 h-LC₅₀ value of lead for *C. vulgaris was* 0.6 mg/l; M. macrocopa was 4.5 mg/l; R. daniconius was 38 mg/l and C. striata was 162 mg/l. Behavioural and morphological changes observed during acute toxicity studies were noted. The concentration of lead accumulated in *Chlorella*, *Moina*, and different organs of fishes was analyzed using ICP-MS. Histological and haematological changes were also recorded. Histological changes in tissues of the gill (Telangiectasia), liver (cytoplasmic vacuolation,), kidney (melano-macrophages) and intestine (degeneration of mucosal epithelium) were recorded in R. daniconius and C. striata. Sub-lethal effects of lead to C. striata were studied with the exposure of lead through feed with four treatments i.e., T1 (LC₅₀ of C. vulgaris), T2 $(1/3^{rd} \text{ of LC}_{50} \text{ of } C. \text{ vulgaris})$, T3 $(1/5^{th} \text{ of LC}_{50} \text{ of } C. \text{ vulgaris})$, and T4 $(1/10^{th} \text{ of LC}_{50} \text{ of } C.$ vulgaris). In each treatment, C. vulgaris was exposed to the respective concentrations for 96 h and given as feed to consecutive trophic levels in the food chain. The order of biomagnified lead content in C. striata during sub-lethal toxicity studies was: Intestine > Kidney > Liver > Gill. Overall, the concentration of lead in the intestine was observed to be higher followed by liver of C. striata in all the treatments. This study concludes that while exposing C. striata to lead incorporated feed, accumulation of lead was detected in organs during this 45 days study. Histological and haematological changes were also observed in each treatment.

KEYWORDS: Bio-magnification, Heavy metal, Lead, Acute Toxicity, Food Chain

Pilot Level Drone-Based Observations on Marine Mammal Interactions with Fishing Systems in India

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Marine mammals are known to interact with fishing systems and understanding these interactions is crucial for sustainable management of fishery resources and marine biodiversity conservation. Generating accurate estimates of the group sizes and their behavior through boat-based surveys can be challenging because most of their activity occurs underwater and observations are nearly impossible horizontally on a subsurface level. Traditional methods for studying these interactions are also often limited by logistics observer biases. Drones offer a non-invasive and efficient alternative, providing high-resolution aerial footage that captures the real-time behavior of marine mammals around fishing operations. Therefore, have the potential to improve population and behavioral studies and enhance conservation programs. Drone observations were made off Kochi to study various aspects of marine mammal interaction. Operations were at the traditional ring sine and trawling fishing grounds. The Pod of the Indian Ocean humpback dolphin (Sousa plumbea) was spotted in the fishing systems. Number of animals in each pod was two to five. Various behavioral activities, viz. traveling, foraging, and socializing were recorded during the observations. This is the first drone-based study in India to monitor the interaction of marine mammals with fishing systems. The observations highlight the importance of implementing drone technology for future marine mammal research and conservation efforts in India.

KEYWORDS: Marine mammal behavior, Marine megafauna, Humpback dolphin, Marine mammal protection

Ichthyofaunal Diversity of Rivers of Manipur and its Conservation using Cultural Diversity

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Manipur, a land bejeweled with hills ranging from 1500-2990 m above sea level (m asl) has a picturesque valley measuring 1800 sq. km (800-1000 m asl) in the middle. The land is also blessed with numerous torrential hill streams which harbour endemic fishes having ornamental as well as food value. Manipur state is considered to be the meeting place of the eastern Himalayas and the Burmese region. The main concerning factor of biodiversity of the region is that the state falls in North-east India, which falls in the Indo-Burma hotspot, one of 34 hotspots of freshwater fish biodiversity in the world. The diversity is attributed to many reasons, viz., the geomorphology, consisting of hills, plateaus and valleys, resulting in the occurrence of a variety of torrential hill streams, rivers, lakes and swamps; and the drainage pattern which includes the Barak and Chindwin-Irrawaddy systems. Another important factor is the tectonic setting in the Indo-Chinese sub-region. Various ethnic tribes inhabit the land. There are about 34 recognized tribes in the state, all differentiated mainly by their distinctive dialects, costumes, cultures and traditions. Many of them have their own culture associated with fishing. Their method of fishing serves to be a boon to the biodiversity conservation of the state. Various anthropogenic activities including hazardous methods of fishing like the use of dynamite, electric fishing, chemicals like bleaching powder, overfishing, and indiscriminate fishing during breeding season have been proving to be one main cause of the decline in fish population. The present work gives a summary of the fishes reported from Barak as well as the Chindwin basin of the state. The importance of the conservation of cultural diversity is highlighted to promote the conservation of endemic fishes of the state.

KEYWORDS: Ichthyofaunal diversity, Rivers of Manipur, Conservation, Cultural diversity

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New Record, Taxonomic Description and Biology of the Brachyuran Crab, *Himalayapotamon emphysetum*, from Gaula, Uttarakhand

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The pristine freshwater streams and rivers in the Indian Himalayan region harbours a unique aquatic biodiversity which includes brachyuran crabs (Crustacea: Decapoda). However, there is limited information on their taxonomical identity, morphological characteristics, biology and behaviour. Therefore, in this study, we collected and examined live freshwater crab specimens of different sex and size class from river Gaula in Nainital district, Uttarakhand, India. Based on the taxonomic checklist and morphological features, the crab specimens were identified as *Himalayapotamon emphysetum*, belonging to the family Potamidae. The dorsal side of the crab was dark brown-orangish and the ventral side was light yellow-orangish. It had a trapezoidal carapace with a cervical groove. The number of teeth on the left and right anterolateral margins of the carapace were not equal. Likewise, the orbital distance, eve diameter and length of pereopods varied on both sides, indicating bilaterial asymmetry. Manus, dactylus, propodus, carpus and merus were well differentiated in the chelate and other walking legs. Internal anatomical observations captured the biogeography and structure of the digestive tract, hepatopancreas, gills and heart. Male and female could be easily differentiated based on the shape of the abdominal flap; the presence of two pairs of gonopods in males; and the presence of vulvae and four pairs of swimmerets in females. Adult berried females had a gonadosomatic index of 12.9% and relative fecundity of 11 eggs per gram body weight. The eggs were reddish-orange in colour and 2-3 mm in diameter. Behavioural observations indicated that the crabs were nocturnal, territorial and carnivorous benthic feeders. They exhibited cannibalism, periodic moult cycles and the ability to regenerate legs. Habitat-wise, they preferred to stay more in water than terrestrial, and preferred stone shelters over gravel, sand and pipe-structure. Based on oxygen consumption data, the maximum metabolic rate was found to be 0.5±0.2 mg O, per g body weight per hour and the routine metabolic rate was found to be 0.07±0.01 mg O₂ per g body weight per hour. Overall, this first taxonomic record and biological description of Himalayapotamon emphysetum crab from river Gaula could support their future captive propagation and conservation efforts.

KEYWORDS: Crab, Taxonomy, Morphology, Sexual dimorphism, Behaviour, Oxygen consumption

Floristic Composition of Mangroves in Cagatan, Gamay, Northern Samar

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Ecotourism emerges as one of the vital components of the national economy. The diversity of flora, fauna and the complexity of mangrove systems attract educational, research and health tourism. Knowing the species composition of the mangrove in the study area is important since the future direction will be for education purposes and tourism. Ocular survey and quadrat sampling were done for the collection and documentation of the species. The species inside and outside the quadrat were identified based on leaves, inflorescence, fruits, buttresses and bark. Results showed a total of 49 mangrove species belonging to 31 families, 15 species of major mangroves, nine minor mangroves and 37 species of mangrove associates (25+ 12 aerial). Among the major mangrove species recorded, the family Rhizophoracea had the most (8) number of species. Three Bruguiera species namely B. sexangula, B. gymnorrhiza and Bruguiera x rhynchopetala were observed. The genera Ceriops pseudodecandra and Bruguiera x rhynchopetala were documented for the first time in the province of Northern Samar. The minor mangrove species belong to families Meliaceae, Pteridacea and Pandanaceae, Sterculiaceae with two species each, while families of Euphorbiaceae and Combretaceae had one species each. For the mangrove associates, the families Acanthaceae and Rubiacea had three species each. Twelve species of aerial plants belonging to the families Asclepiadacea, Orchidaceae, Rubiaceae, Lycopodiaceae, Polypodiaceae and Aspleniaceae. The species Phlegmariurus phlegmaria and Grammatophyllum speciosum complex were recorded growing in the mangrove trunks. The Bruguiera, and Timonius species were found only in the landward zone together with the *Heritiera littoralis*. Large stands of mangrove trees were recorded in the landward zone only. Thus, the LGU and the DENR shall continue activities on information-education campaigns, and strict enforcement of laws and policies.

KEYWORDS: Major species, Associate species, Diversity

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Variations in the Seasonal Catch Composition of Commercially Important Finfish Caught from Ranjit Sagar Reservoir in Punjab

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Ranjit Sagar, India's tallest earth core with gravel shell dam, is an 87.60 km² reservoir in Pathankot, Punjab, India. Established in 1981, it provides habitats for various plant, bird, and fish species, including irrigation, navigation, hydroelectric production, fisheries propagation, and flood control. This reservoir sustains a diverse flora and fauna including finfishes. Local and migrant fishermen engage in both commercial and subsistence fishing, employing a variety of nets and gears. The field survey was conducted at different sampling points and landing sites in the reservoir at Pathankot including the fish market. The reservoir has 23 finfish species, with Cyprinids being the largest contributor. Live catfishes like *Heteropneustes* fossilis and Channa punctatus were recorded during the flood season. The Ranjit Sagar reservoir hosts a diverse array of fish species, including major carps, minor carps, barbs, minnows, loach, sisorid, garfish, glassfish, live fishes, perch, and spiny eel. A study recorded four prominent fish species from the reservoir, with Silver carp (Hypophthalamichthys molitrix) contributing the most (44.08%), followed by Labeo dero (21.84%) and Cyprinus carpio (18.37%). Golden Mahseer (Tor putitora) constituted the lowest catch percentage (15.82%). The study found that the four dominant species contributed the most (21.82%) to the total catch during September, with fluctuations in the remaining months (19.49% in August, 18.72% in February, 14.03% in December, 9.87% in November, 9.59% in January) and the lowest in October (6.45%). The highest catch was recorded in winter (42.36%), followed by post-monsoon (38.15%) and monsoon (19.49%). Hypophthalamichthys molitrix had the highest percent catch contribution (55.56%), followed by Labeo dero (30.69%) and Cyprinus carpio (13.80%). In the post-monsoon season, Hypophthalamichthys molitrix (Silver carp) had the highest percent catch contribution (30.10%), followed by *Tor putitora* (29.58%), Cyprinus carpio (23.41%) and Labeo dero (17.22%). Reservoir's fish diversity and catch composition indicate that Ranjit Sagar water is still favourable for the growth and survival of a variety of fish species.

Keywords: Seasonal fluctuation, Catch Composition, Commercially-important, Ranjit Sagar Reservoir, Pathankot

Water Quality and Fish Diversity of Keshopur Chhumb Wetland, A Ramsar Site Community Reserve in Punjab

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Keshopur Chhumb Wetland community reserve in Gurdaspur, Punjab, spans 850 acres of natural waterbodies and includes interconnected wetlands. It was designated as a Ramsar site in 2019. Water samples were collected from the Keshopur wetland in Punjab, and various water quality parameters were measured to understand chemical constituents and pollution levels. The water quality parameters viz; temperature, transparency, turbidity, conductivity, TDS, salinity, pH, free CO, total alkalinity, chloride, hardness, dissolved oxygen, BOD, COD, etc were analysed following standard protocols. The water quality characteristics at different sampling points of the wetland were found to be under optimum conditions. Fisheries status was also surveyed near landing sites and local fish markets in district Gurdaspur, collecting a variety of fish species. The reserve is home to a diverse range of fish species, including major carps, exotic carps, barbs, live fish, catfish, perch, and spiny eel. The wetland has 12 distinct species from 11 different genera, 4 families, and 3 orders. Cyprinids are the predominant contributors to the fish species, with less diversity among catfish and live fish. Eight species hold significant commercial value, including Catla catla, Labeo rohita, Cirrhinus mrigala, Hypophthalamichthys molitrix, Ctenopharyngodon idellus, Cyprinus carpio var. communis, Channa striatus, and Mastacembelus armatus. Miscellaneous species of limited economic significance have also been recorded from the Keshopur wetland region. Keshopur wetland's fish diversity indicates that water is suitable for various species' survival, but conservation and management are crucial. Local people and fishermen rely on water bodies that sustain a variety of fish species, and the paper discusses factors influencing wetland fishery.

KEYWORDS: Water quality, Fish diversity, Keshopur Chhumb Wetland, Gurdaspur, Punjab

The Influence of Bottom Type on the Species Composition, Annual Catch and Value of Mollusc Gleaning in Various Areas in Panay Island, Western Visayas, Philippines

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Gleaning is one of the most undervalued and under documented fisheries, primarily involving women and children, that provides a readily accessible source of food and income. The mollusc gleaning fisheries of Panay Island was monitored daily across seven sites, categorized by a gradient of bottom types: sandy-muddy, sandy-coralline, and rocky, over a two-year period from March 2018 to April 2020. A total of 41 species were recorded, with gastropods making up 63.4% and bivalves 36.6% of the catch. However, in the total monthly catch, bivalves predominate at 1,511.1 kg per month (93.3%), compared to gastropods at 108.3 kg per month (6.7%). This strong dominance of certain species is likely due to targeted harvesting, particularly of the hooded oyster (Saccostrea cucullata Born, 1778). Gastropods were more prevalent in sandy-coralline habitats, while bivalves thrived in sandy-muddy bottoms, reflecting their respective feeding and habitat preferences. Mean annual catch showed the highest range in the sandy-muddy bottom (101.9-172.1 tonnes/yr), followed by sandy-coralline (9.6-11.3 tonnes/yr) and lowest in the rocky intertidal (1.6-2.0 tonnes/yr), where gleaning is restricted during the lowest low tides. The corresponding value followed the same trend as the annual catch. Estimated mean annual income was marginal, indicating that gleaning, while highly accessible and requiring minimal capital investment, serves as a subsistence form of fishing. In-depth population dynamics and reproductive biology studies are necessary to provide management guidelines for the most highly exploited species.

KEYWORDS: Bivalves, Bottom type, Gastropods, Income, Subsistence fishing

New Record of *Prymnesium parvum* (N. Carter, 1937) from Indian Waters

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A fast-swimming flagellate with golden brown colour was found by chance during the regular water quality monitoring at ICAR-CMFRI Kovalam, Field Laboratory, Tamilnadu, India. The strain was obtained by the capillary method and xenic monocultures were developed in autoclaved natural seawater enriched with f/2-si or walnes medium. The external morphology of the cells was examined by both light and electron microscopy. Based on the cellular features and the presence of haptonema, the genus was identified as *Prymnesium*. Further molecular level identification confirmed that the flagellate is *Prymnesium parvum* (GenBank accession number: MH182064). Molecular identification, performed by comparing the partial 18S rRNA with the reference sequences retrieved from GenBank database, indicated 100% identity to *Prymnesium parvum*. This is the first record of the bloom-forming species isolated from the coastal waters of the southern part of the Bay of Bengal region and also the first genetic data of *Prymnesium parvum* from Indian waters.

KEYWORDS: Haptophyta, Prymnesium parvum, Isolation, Indian waters

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Charting Phytoplankton Diversity and Abundance in the Fishing Grounds of Tamil Nadu

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Phytoplankton abundance serves as a critical indicator of a region's potential fisheries output and can reflect water quality changes, including pollution levels. These organisms are highly sensitive to environmental shifts, to which they respond by altering species composition, abundance, and community structure. Therefore, assessing phytoplankton populations is essential for understanding marine ecosystem dynamics. In this study, seawater sub-samples (5 l) were collected from various active fishing grounds along the Tamil Nadu coast, including Cuddalore (10 sites), Nagapattinam (17 sites), Thanjayur (13 sites), Ramanathapuram (13 sites), and Pudukkottai (10 sites). A total of 97 phytoplankton species were identified, comprising 63 Bacillariophyceae (diatoms), 21 Dinophyceae (dinoflagellates), 7 Cyanophyceae (bluegreens), 4 Chlorophyceae (greens), and 2 Chryophyceae (silicoflagellates). Diatoms were the most abundant and diverse group across all sites, followed by dinoflagellates and bluegreens, while greens and silicoflagellates were less prevalent. Phytoplankton density ranged from 4.4 x 10⁴ to 13 x 10⁴ cells/l. The species like *Bacteriastrum delicatulum*, *Bidduphia* sinensis, Chaetoceros affinis, C. didymus, Cosinodiscus centralis, Cosinodiscus gigas, Cosinodiscus radiates, Navicula delicatula, Nitzschia closterium, Pleurosigma elongatum, Rhizosolenia alata, Ceratium furga, Dinophysis caudate were encountered in most part of the surveyed active fishing grounds. The species like Asterionella sp., Amphiprora sp., Biddulphia sinensis, Cosinodiscus excentricus, Dinophysis caudate, Navicula spp., Pleurosigma spp., Skeletonema sp., Ceratium sp., Protoperidinium venustum, Scrippsiella trochoidea, Anabaena sp., Microcystis sp., were less abundant. The derived diversity indexes on phytoplankton Species Richness (Margalef), Piolous Evenness (J'), Shannon (H'(loge)) and Simpson (1-Lambda') exhibited significant spatial variation among the surveyed active fishing grounds. These findings indicate that the fishing grounds along the Tamil Nadu coast are characterized by a highly abundant and diverse phytoplankton community, emphasizing the fishery production potential of these regions.

KEYWORDS: Phytoplankton, Community structure, Fishing grounds, Tamil Nadu coast

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Spread of Invasive Charru Mussel, *Mytella strigata* (Hanley, 1843) in Ennore-Pulicat Wetland Ecosystem and its Impact on Fisheries

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In Ennore-Pulicat wetland, the invasive mussel Mytella strigata (Charru mussel/Kaaka Aazhi) was found attached to protective walls, bridges, pillars, and artificial structures, forming dense mats and out-competing native green mussel Perna viridis and rock oyster Crossostrea madrasensis. It might have been introduced through ships and later spread to Ennore Creek and Pulicat Lake through the smaller fishing vessels that frequently traverse between the coastal waters and the creek. Scientific studies were carried out in Ennore Creek and Pulicat Lake periodically to monitor the water quality and conduct biological studies of M. strigata. Samples were collected from 9 different sites. Among these stations, the native oyster C. madrasensis and the Windowpane oyster Placuna placenta were observed only in the VNC Bridge conveyer belt area. Another native species of green mussel, P. viridis is present only in Pulicat Lake. It is wholly vanished in the Ennore Creek area. The density of Charru mussel was higher in the Puliyamaram Conveyer Belt area (688 numbers per square meter area). The abundance of mussels was high in intertidal shallow areas and along the bridges. Most of the Ennore Creek area is with a depth of less than 0.3 m. Hence, the fishing boat movement is very much affected. The maximum depth of the creek is 2.70 m. The abundance of 'Charru mussels' presence is much less in deeper regions. The sex ratio of the invasive mussels was also studied. The female population was higher than the male in all the stations. It indicates the fast-spreading capability of mussels. The mussel's length ranges from 28 mm to 54 mm. The maximum size of invasive mussels was observed in Pulicat Lake. Most of the mussel's meat content was on average, 0.5 g only, making the fishermen uninterested in extracting the meat for fish meal or other purposes. Studies showed that 90% of catches from Ennore Creek were white prawn Penaeus indicus, 4% tiger prawn Penaeus monodon, 5% fish Mugil cephalus, and 1% crabs. Presently, the occurrence of white prawn is very rare, and only 3 Nos. could be collected. The tiger prawn was absent. The dead mussel shells cover the bottom of the creek causing oxygen depletion, which leads to prawn mortality. The fishermen's livelihoods are very much affected due to the Charru mussel's invasion.

KEYWORDS: Ennore-Pulicat, Mytella strigata, Fisheries, Impacts, Fishermen livelihood

The Study of Microbial Profile in the Aquaponics System

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The Aquaponics System, the combination of a Recirculating Aquaculture System (RAS) and hydroponics system, is a pivotal and economically sustainable technique used for the cultivation of aquatic organisms for commercial purposes. Microbial communities present in the biofilter of RAS play an important role in the maintenance of the water quality in the culture units. Asian seabass Lates calcarifer and giant freshwater prawn Macrobrachium rosenbergii were cultured along with aquatic plants, Water spinach Ipomoea aquatica and Buffalo spinach Enhydra fluctuans in the Aquaponics System. The whole microbial profile of the biofilter of a freshwater recirculating system was evaluated in the present study. The metagenomics study showed that the abundance of bacteria (60%) was higher compared to the archaea (40%). The presence of beneficial microorganisms was recorded in the biofilter. The Proteobacteria, Planctomycetes, Acidobacteria, Verrucomicrobia and Bacteroidetes were the most abundant bacteria. The archaea belonged to the phylum Crenarchaeota and Euryarchaeota (2%). Three pure isolates were identified as Lysinibacillus sp., Ralstonia sp., and Stenotrophomonas rhizophila; these were cultured. The Scanning Electron Microscopic study showed that strains were rod-shaped and present in clusters. Their presence in the Aquaponics System helped in the maintenance of optimum water quality for the culture of fish and prawn in a sustainable manner.

KEYWORDS: RAS, Hydroponics, Biofilter, Metagenomics, Scanning Electron Microscopy

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Optimizing Spore Release and Germination in Gracilaria salicornia for Commercial Production

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Gracilaria salicornia, a red seaweed species of commercial significance, has widespread applications across various industries, including food, pharmaceuticals, and biotechnology. Efficient spore production is imperative to ensure a sustainable and high-quality seed supply for seaweed farming. The present study investigated the influence of salinity on spore production in G. salicornia to optimize the cultivation protocols. Specimens of G. salicornia were collected from a culture pond and meticulously cleaned to remove any epiphytic growth. Subsequently, the seaweed samples were divided into three experimental groups: a control group maintained at 28% salinity (standard seawater salinity) and two treatment groups exposed to hypo-saline conditions of 10% and 5%, respectively. A 21-day trial revealed that, despite analyzing particulate matter from G. salicornia specimens across all treatments (5\%, 10\%, and 28\%), spores were only observed in the control group. The collected spores were then inoculated into Provasoli's Enriched Seawater (PES) medium and monitored for germination. Successful thallus buds were subsequently examined under a stereo microscope for morphological characterization. This experimental design allowed for the study of spore release and subsequent germination in G. salicornia under varying conditions. These findings highlight the crucial role of well-controlled cultivation conditions in ensuring optimal reproductive success and growth of this commercially valuable seaweed species.

KEYWORDS: Brackishwater, G. salicornia, PES medium, Spore culture

Effect of Bisphenol-A on Ovarian Development and Reproductive Hormonal Profile of *Anabas testudineus* (Bloch, 1792)

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The plastic pollution in the world is causing more production of plasticizers in water bodies and many of the plasticizers are endocrine disrupters and mainly they are xenoestrogens. One of the major xenoestrogens in water bodies is the BPA (Bisphenol-A), which binds to the estrogen receptors and alters the synthesis of sex steroids, affecting the normal gonadal development of fish species. There is a scarcity of information on the effect of BPA on gonad development and steroidogenesis in climbing perch, Anabas testudineus. The lethal concentration (LC-50) of BPA in juvenile A. testudineus (mean weight, 22±5 g; mean length 10±2cm) was determined by Probit analysis. Based on the LC-50 result (LC-50, 96 h, 16.77 ppm), A. testudineus were randomly distributed to three different concentrations of BPA viz. 0.419 ppm, 0.838 ppm and 1.677 ppm in triplicate (n=3) and reared for 60 days. A control group was also maintained without BPA. In all the experimental tanks, fish were stocked at the ideal density of four individual m³ and reared at a normal photoperiod. All the experiment fish were fed twice daily with the formulated feed (Crude protein, 40%; Lipid, 6%) to the satiation. Results of the current experiment showed that the Gonado Somatic Index (GSI %) increased gradually with an increase in the concentration of BPA (p<0.05). A similar increasing trend was noticed for 17- β estradiol (239%) and vitellogenin (84%) levels (p<0.05). Contrary to the present findings, an inverse relation was recorded for 11-ketotestosterone (23%) and testosterone (81%) with increasing concentrations of BPA (p<0.05). A significant increase in blood glucose (103%) and cortisol (202%) with the increase in concentration of BPA (p<0.05) was also noticed. Results of the study conclude that the LC-50 for juvenile A. testudineus is 16.77 ppm and, even the lower concentration of BPA altered the reproductive physiological responses of captive-reared A. testudineus.

Keywords: Plasticizer, LC-50, 17-β estradiol, Xenoestrogens

Diversity and Ornamental Potential of Brackishwater Gobies in Muttukadu Backwaters

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Gobies that inhabit the brackish water habitat have a lot of commercial value as ornamental species. Tamil Nadu has diverse ecosystems that support rich fisheries, aquaculture, and unique habitats such as lagoons, estuaries, and backwaters. Among these, Muttukadu backwaters stand out as a crucial ecological zone characterized by brackish water that supports a wide range of aquatic life, including ecologically and economically significant species. Notably, this area is home to various gobies, which hold potential as ornamental fish. Despite the ornamental fish trade being dominated by freshwater and marine species, brackishwater species are underrepresented, highlighting a market gap that can be filled by introducing lesser-known species. Our ichthyological surveys in Muttukadu backwaters, identified seven ornamentally attractive goby species. The collection was dominated by Mugilogobius tigrinus, followed by Pseudogobius melanosticta, Oligolepis acutipennis, Mangarinus waterousi, Bathygobius sp, Acentrogobius audax, and Eugnathogobius mindora. Out of these, the maximum size was observed in M. waterousi (4.8 cm) and the smallest species was M. tigrinus (2.2 cm). The salinity during the survey ranged from 7 to 25%. These gobies were collected from various habitats, including burrowing sand, oyster beds, twig masses, and seaweed beds. Establishing captive breeding programs would minimize the impact of wild harvesting and support conservation by reducing pressure on natural populations. Exploring the potential gobies could significantly diversify the ornamental fish market with aesthetically appealing and high-value species.

KEYWORDS: Backwaters, Ichthyological surveys, Oyster beds, Conservation

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Diel Variation of Phytoplankton at Prayagraj in The Ganga River

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The present study examines the diel variation of phytoplankton at Daragani and Chhatnag of Prayagraj in the Ganga River from December 2020 to April 2021. A total of 57 phytoplankton species were identified including 10 classes (Chlorophyceae, Bacillariophyceae, Cyanophyceae, Trebouxiophyceae, Zygnematophyceae, Coscinodiscophyceae, Cryptophyceae, Euglenophyceae, Dinophyceae and Mediophyceae). Chlorophyceae was the dominant class among phytoplankton, followed by Bacillariophyceae and Cyanophyceae. Species richness was highest at 6 pm at Daragani and 6 am at Chhatnag. The high species richness and dominance of Chlorophyceae suggested favourable conditions for green algae, supported by rich nutrient availability. The abundance ranges from 4.0 x10⁵ cells/l to 1.4 x10² cells/l at Daraganj and 2.5 x 10⁵ cells/l to 2.3 x 10² cells/l at Chhatnag. The highest mean phytoplankton abundance was observed at noon in both the stations suggesting high photosynthesis. Cyclotella sp. was the most dominant species, followed by Scenedesmus ellipticus at both stations. Pearson correlation coefficient of Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, Mediophyceae, Trebouxiophyceae and Zygnematophyceae exhibited a significant positive correlation with DO (p<0.05) and negative correlation with TDS (p<0.01). Coscinophyceae and Cryptophyceae demonstrated significant negative correlations with TDS (p<0.05). This study underscores the resilience of phytoplankton in response to environmental changes and emphasizes their role as bioindicators for assessing the ecological health of river ecosystems.

KEYWORDS: Phytoplankton, Physico-chemical parameters, River Ganga, Diel variation

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Trends of Marine Litter on Selected Beaches Along the Palk Bay and Gulf of Mannar, Tamil Nadu

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Marine litter is man-made objects discarded directly or indirectly into beaches, seashores, fish landing centers, etc. There are a variety of litters, ranging from plastic lids and spoons to large fishing nets, that have emerged as important threats to the coastal and marine ecosystems, endangering the flora and fauna and also affecting the livelihood of fishers. The one-time rapid survey on Beach Litter was conducted during August 2023 along the Palk Bay coast i.e., Gopalapatinam, Kodiyakarai (Manamelkudi), Pudhukudi, Panaikulam, Azhagankulam, Ariyaman (Kushi beach), and Dhanuskodi, and the Gulf of Mannar coast i.e., Arichalmunai, Mukunthurayar Chathiram, Thonithurai, Pudhumadam, Periyapatinam, Keelakarai, Erwadi, and Vallinokkam. The quantification and grouping of non-biodegradable wastes were done by following UNEP guidelines, which include plastic covers and bottles, nylon nets and pieces, glass bottles, thermocol/polyurethane, and e-waste. The total marine litter abundance (g/sq.m and nos/sq.m) was estimated using a rope quadrate of 10 x 10 m operated in triplicate with 100 m intervals on a line transect. Along the Palk Bay area, Ariyaman Beach recorded the maximum litter abundance of 30.73 g/sq.m and 4.1 nos/sq.m, and Panaikulam Beach recorded the minimum litter values of 9.83 g/sq.m and 2.4 nos/sq.m. In the Gulf of Mannar area, Keelakarai Beach recorded the maximum litter abundance of 36.83 g/sq.m and 3.2 nos/ sg.m., and Arichalmunai Beach recorded the minimum litter value of 8.46 g/sg.m and 1.5 nos/sq.m. This survey gives an overall picture of the non-biodegradable litter status along the beaches of Palk Bay and the Gulf of Mannar region, and the need for implementation of management strategies for controlling the litter pollution in these areas.

KEYWORDS: Non-biodegradable, Marine litter, Palk Bay, Gulf of Mannar, HDPE rope

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Avian Fauna of a Community Reserve in Kerala, India: Diversity, Threats and Possible Interventions

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Considering the ecological significance, diversity of avian fauna and burden of anthropogenic pressures, the Kadalundi estuary was declared as a Community Reserve in 2007. Fishing and eco-tourism are the mainstay of livelihood of the people of Community Reserve. Our studies in the Kadalundi-Vallikunnu Community Reserve documented 182 species of birds and of these, 95 species were recorded based on sightings during the survey which belonged to 69 genera, 33 families and 15 orders. The Order Charadriiformes forms the most diverse group (40.0%) followed by Passeriformes (20.0%), Pelecaniformes (13.68%) and Coraciiformes (5.25%). Of the 95 species of birds recorded, 44 species were resident fauna, seven species show local migration, while 44 are migratory. Species such as Lesser sandplover, Eurasian whimbrel, Common redshank, Common greenshank, Eurasian curlew, Little tern and Lesser crested tern were found over-wintering during June and July. Of the recorded species, Great knot is listed as an Endangered species (EN) in the IUCN Red List. Seven species viz., Black-tailed godwit, Eurasian curlew, Black-headed Ibis, Oriental darter, Bar-tailed godwit, Eurasian oystercatcher and Woolly-necked stork are listed as Near Threatened (NT) while the remaining 87 species have been listed as Least Concern (LC). The Brahminy kite, Black kite and Shikra are listed in Schedule I of the Indian Wildlife (Protection) Act, 1972. While one species is listed in Schedule V, 91 species are listed in Schedule IV of the Act. Sand accretion at the bar mouth has restricted the exchange of water between the sea and estuary, which affects the availability of prey bases. Also, the accretion of sand has resulted in the dwindling of mudflat areas. Also, the spread of Sonneratia alba to the mudflats over a vast extent deprives the foraging area of birds. The problems are further compounded by the dumping of plastics and discarded fishing nets. Although motorised boats are not permitted inside the Community Reserve, fishing boats with outboard engines, enter the estuary for berthing and the engine sound threatens the avifauna. Stakeholder workshops were organised involving all stakeholders, and guidelines for sustainable management were prepared which are detailed in the present paper.

KEYWORDS: Avian fauna, Community Reserve, Kadalundi, Management, Wetland

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Ichthyofaunal Assemblages of the River Churni, A Tributary of River Ganga

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River Churni is the tributary of river Ganga, originates from the Mathabhanga river near Majhdia village in the Nadia district of West Bengal, India, and eventually meets the River Bhagirathi near Payradanga after covering 53 km of its stretch. The study shows the fish diversity and distribution patterns in response to different environmental gradients and pollution ranges of the five sampling sites of the river Churni. Polluted water from Darshana Sugar Mill was observed to be the reason for the river's lack of fish diversity. For the past four to five years, fishing in this area has been discontinued due to the significant river pollution caused by domestic dumping and industrial runoff. A total of 18 fish species belonging to the 9 orders and 13 families, namely Cyprinidae, Bagridae, Clariidae, Heteropneustidae, Gobiidae, Channidae, Anabantidae, Notopteridae, Belonidae, Penaeidae, Palaemonidae, Mastacembelidae and Ambassidae were recorded from this river. Anabantiformes (38%) holds the dominant order, followed by Gobiiformes (15.3%), Cypriniformes (12.5%), and Siluriformes (12.4%). Among the families, Channidae (21.8%) represents the highest contribution, followed by Anabantidae (16.2%), Gobiidae (15.3%) and Cyprinidae (12.5%). Among the 5 sampling sites, site Rabonbore Ferry Ghat (34.04%) showed the highest fish diversity, followed by Kalinarayanpur Foot Bridge (27.66%) and Aranghata Ferry Ghat (19.15%). Only air-breathing catfishes were found common in all the sites of the river. Destructing fishing is also observed using carbide dumping in Churni, particularly in Kalinarayanpur Foot Bridge and Aranghata Ferry Ghat. Among the 18 fish species, 15 species were in the Least Concern (LC), 2 species Parapenaeus lanceolatus and Macrobrachium rosenbergii come under the Not Evaluated (NE) category and Clarias magur is in the Endangered (EN) category as per the IUCN status. The assessment of ichthyofaunal diversity in the Churni River highlights a less diverse fish population due to domestic dumping and industrial runoff, underscoring the ecological importance of the river and the urgent need for conservation measures to protect biodiversity from ongoing environmental challenges.

KEYWORDS: Churni river, Ichthyofaunal assemblages, Pollution, Conservation measures

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Study on Ichthyofaunal Diversity of the River Ichamati

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The Ichamati River, a bifurcation of the Mathabhanga River, originates in Majhdia village in the Nadia district of West Bengal. This life-sustaining transboundary tidal river flows through West Bengal and Bangladesh, covering approximately 216 km before joining the Kalindi River at Hasnabad in North 24 Parganas and eventually emptying into the Bay of Bengal near Moore Island. A total of 44 species belonging to 13 orders and 21 families namely, Palaemonidae, Penaeidae, Synodontidae, Gobiidae, Sciaenidae, Sparidae, Oxudercidae, Arridae, Cynoglossidae, Leiognathiae, Mugilidae, Synbranchidae, Bagridae, Polynemidae, Paralichthyidae, Sillaginidae, Dorsomatidae, Scatophagidae, Engraulidae, Hemiremphidae, and Platycephalidae were identified. The Relative abundance (RA) of *Planiliza persia* was observed to be higher at Hemnagar site (42.15%). At Kalitala, Parapenaeopsis sculptilis is showing the highest RA (26.6%) and Eleuthronema tetradactylum is showing the highest RA (39.5%) at Itinda ghat. The IUCN status of the species shows that the majority of the species are categorized under LC (47%) followed by NE (26%), DD (24%) and NT (3%). The river zone also faces challenges of domestic pollution, siltation and illegal land occupation. The shrimp seed collection also provides a significant occupation of the region. The study of ichthyofaunal diversity in River Ichamati reveals a rich and varied fish population, emphasizing the ecological significance of the river and the need for conservation efforts to preserve its biodiversity amidst growing environmental pressures.

KEYWORDS: Ichamati river, Ichthyofaunal diversity, Pollution, Conservation

Assessment of Physico-Chemical Parameters and Heavy Metal Contamination and Their Impact on Plankton Diversity in the Adi Ganga River, India

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This study investigates the relationships between physicochemical parameters, heavy metal concentrations, and the diversity of plankton communities in the Adi Ganga River, encompassing six distinct sites. Key environmental factors, including water temperature, depth, transparency, specific conductivity, pH, dissolved oxygen, and concentrations of heavy metals (chromium, nickel, lead, arsenic, cadmium, and copper) and nutrients, were correlated with the abundance and composition of diatoms and other phytoplankton species. Strong correlations were observed between temperature and species diversity, with pollutiontolerant species such as Lyngbya, Geitlerinema, and Nitzschia thriving in areas with elevated heavy metal levels, particularly nickel, lead, and chromium. In contrast, sensitive species like Asterionella and Diatoma were significantly reduced or absent in heavily contaminated sites, particularly those with high concentrations of cadmium and arsenic. The Shannon-Wiener diversity index (H') analysis indicated moderate biodiversity across most sites, with the highest diversity noted in areas exhibiting a mixture of tolerant and sensitive species. Zooplankton diversity, represented by species such as Lepocinclis and Mytilina, demonstrated considerable variation, with low diversity linked to high heavy metal concentrations. These findings underscore the critical impact of heavy metals on plankton community dynamics and the ecological health of riverine ecosystems. Regular monitoring of physicochemical parameters and heavy metal concentrations is essential for effective biodiversity conservation and management in sensitive aquatic environments like the Adi Ganga.

Keywords: Physicochemical parameters, Heavy metals, Plankton, Diversity, Pollution, Adi Ganga

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The Effect of Pollution Load on the Phytoplankton Community: An Insight from River Matla in Indian Sunderbans

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Five sites have been examined to assess the effects of ecological parameters on the phytoplankton community and the ecological health of the Matla River from January 2024 to September 2024. 38 phytoplankton species were recorded during the study period from all these sampling locations, of which 24 genera belonged to the class Bacillariophyceae, and of which *Coscinodiscus* sp. was found to provide the highest percentage of 43.27% to the total phytoplankton density. The average metal concentration in sediment (mg/kg) was Chromium 7.29, Arsenic 2.79, Lead 2.27, and Cadmium 0.03; while in water (mg/l), it was Chromium 0.042, Lead 0.016, Arsenic 0.009, and Cadmium 0.006. Using Pearson correlation, CCA analysis, and heat map analysis, we were able to determine some physicochemical parameters i.e. total phosphorus, alkalinity, BOD, COD levels, available sulphate, and available phosphate that had a favourable effect on several plankton species during our investigation. Out of the five sampling locations, sampling site I exhibited a higher phytoplankton load related to organic contamination, according to the Shannon-Weiner index results.

KEYWORDS: Matla River, Phytoplankton, Ecological parameters, Heavy metal

Pollution Assessment of Heavy Metals in the Adi Ganga River: Analyzing Contamination Indices in Water and Sediments

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Heavy metal (HM) contamination in riverine environments has emerged as a critical environmental concern, posing significant ecological and human health risks. This study investigates the metal concentration of the Adi Ganga River, once the lifeline of Kolkata, but now severely degraded due to rapid urbanization, waste dumping, and pollution, leading it to become a narrow, dying river. Surface water and sediment samples were collected from six locations to assess heavy metal concentrations. The average metal concentration in water (mg/l) followed a descended order of Cr (3.363) > Pb (1.8) > As (1.114) > Cd (0.213) and in sediment (mg/kg), the order was Pb (27.883) > As (16.995) > Cr (9.381) >Cd (0.213). The metal concentrations in water samples exceeded the values prescribed by the USEPA's 2024 drinking water guidelines, highlighting a serious threat to aquatic life and ecosystem health, indicating that the water is unsuitable for drinking purposes. According to the Canadian Interim Sediment Quality Guidelines (IQSGs), the mean metal concentration of Cr and Pb in sediment remained below the levels but Cd and As, the levels were higher. Various indices such as contamination factor, degree of contamination, enrichment factor, geo-accumulation index, and pollution load index were evaluated to determine the source and extent of metal pollution. These indices reveal the significant anthropogenic influence on metal contamination and the extent of pollution in the river's water and sediments.

KEYWORDS: Heavy metals Contamination, Adi Ganga, Enrichment factor, Pollution load index

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River Ranching of Indian Major Carps: A Biodiversity Conservation Strategy for the River Ganga

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Fish are globally recognized as the primary source of protein for human consumption, and river-based capture fisheries significantly contribute to fish output. The River Ganga, the largest river in India, is abundant in numerous aquatic species concerning fisheries. The Ganga's fishery and water quality are continuously impacted by a numerous anthropogenic activity, which has a direct impact on fish variety and output. Despite the economic significance of Indian major carps (Labeo rohita, Labeo catla, Cirhinnus mrigala, and Labeo calbasu) in Ganga fisheries, available literature indicate a considerable decline in their capture across various river stretches over the past few decades. Therefore, we proposed an excellent strategy through river ranching of IMCs in various depleted stretches of river Ganga and aimed to enhance the river's fish population. Ex-situ seed production of the IMCs carrying riverine germplasm was selected for species restoration. Broodstock fish were propagated through hypophysation, and consecutive spawns were grown to fingerling size at nursery ponds. Around 42.5 million spawns were produced over seven years from 2017 to 2023 by annual seed raising programs. The average yearly production was 6 million. During the period, more than 100 ranching programs were organised throughout the stretch and 9.41 million fingerlings were ranched in river Ganga. Compared to 1959, the landing of IMC in 2020 was increased by 28% at Prayagraj and 49% at Buxar which reflects the impact of riverine ranching and its necessity. In summary, riverine ranching is crucial for restoring Gangetic fish biodiversity, which not only revitalizes the riverine ecology but also improves the livelihoods of fishermen.

KEYWORDS: Riverine germplasm, Brooder Fish, Rohu, Catla, Mrigal

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Ecological Aspects of Biofoulers on Marine Cage Culture Nets at Karwar, Karnataka

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Biofouling is a complex process recurring on all the mariculture surfaces submerged in the culture site. The cage culture nets are at higher risk of getting damaged by the biofouling communities. The present study is carried out to reveal some ecological aspects of biofoulers on marine cage culture nets. Biofouling involves initial microfoulers attachment and slowly shifting to a complex succession of macrofoulers. Experimental HDPE-net panels of (mesh size-22 mm) size 10 x 10 cm² were installed in the cage culture site of the Karwar sea cage farm in duplicates. The panels were vertically placed at 3 depths in two study sites. The abundance and growth of macrobiofoulers were calculated by monthly averaging biofoulers of three depths. Initially, the bacterial fouling settlement was analysed by using standard methods (APHA). Microbiofoulers below 200 microns were sewed and counted using a plankton counting chamber and Labline-Olympus microscope (4x) for 1cm² area (10 random counts). Larger macrofoulers were counted for a 10 x 10 cm² area. In the present study, the bacterial communities and diatoms were observed in the initial phase, and then other microfoulers were found to attach to the experimental panels. The micro-fouling has slowly transformed into a different succession of macrofouling communities. The attaching larval forms are the major contributors for the macrobiofouling organisms to settle and cause major damage to the culture organisms. The results revealed that biofilm observed after 3 days of installation showed bacteria (2.07x10⁴ cfu/cm²) and diatoms (1.2x10³ cells/cm²), followed by other microfoulers. After 15 days, macrofouling organisms like hydroid colonies (0.05x10²/ cm²) were found, followed by bryozoans, poriferans, annelids, crustaceans and finally, dominated by molluscan biofoulers (188/100 cm²) on the cage culture net forming the climax after 360 days of immersion. This research also attempts to find the ecological interactions between the fouling organisms and their environment.

KEYWORDS: Microfoulers, Macrofoulers, Ecology

Metatranscriptome Analysis of Pollution-Induced Microbial Diversity from Sediment of Wetlands Under Urban Influence

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India's wetlands are rich ecosystems that sustain a wide variety of unique habitats and offer numerous ecological benefits. However, they face significant pressure from rapid urban growth, industrial expansion, and intensified agriculture. This has led to a reduction in their size and a decline in their hydrological, economic, and ecological roles. Microbial communities play a crucial role in various biogeochemical processes and are essential for the sustenance of this wetlands system. To understand the impact of pollution on significant pathways and anthropogenic activities on the microbial communities of wetlands, the structure and diversity of the microbiome in the sediment samples of Chobadanga and Jagrashisa near urban Kolkata were examined using meta-transcriptomics approaches. This study generated 9097 differential expressed genes (DEGS), including 3923 downregulated and 5174 upregulated genes. Gene Ontology (GO) enrichment analysis revealed that significant DEGs were associated with system development, mesoderm development, mitochondrial respiration, and, purine ribonucleoside as the biological process (BP); protein binding, lowdensity lipoprotein, culin family protein, and, protein kinase binding as molecular function (MF); cellular component, mitochondrial respiration, cytoplasm, and, nucleoplasm as cellular component (CC). The Kyoto Encyclopedia Genes and Genome (KEGG) analysis indicated that these DEGs were highly involved in Neuroactive ligand-receptor interaction, Cytokinecytokine receptor interaction, cAMP signaling pathway, Calcium signaling pathways, RNA polymerase, and Glutamatergic synapse. It was found that bacteria constituted over 70% of the microbial presence in sediment samples. Acidobacteria emerged as the predominant bacterial phylum, followed by Actinomycetota, Apicomplexa, Aquificae, Armatimonadetes, and Ascomycota. Notable genera in the taxonomic profiling included Aminomonas, Anaerohalosphaera, Anaerolinea, Andihavirus, and Bigelowiella. The next generation of meta-transcriptomics tools offers immense potential for enhancing our understanding of pollution-induced microbiomes, and their functions. This new knowledge will also aid in recognizing microbial communities' importance and indispensable roles in maintaining a healthy wetlands ecosystem.

KEYWORDS: Wetlands, Sediment, Metatranscriptomics, Microbiome diversity, Biogeochemical

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Toxicological Effects of Ammonia on *Catla catla* Fry: Assessing Lethal Concentrations and Physiological Responses to Sub-Lethal Exposure

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Aquatic ecosystems are increasingly impacted by anthropogenic stressors, with ammonia pollution posing a significant threat to freshwater fish populations. This study investigates the toxicological effects of ammonia on Catla catla fry by determining the 96-hour lethal concentration (LC50) and analyzing physio-metabolic responses to sub-lethal ammonia exposure. The 96-hour LC50 was calculated as 25.02 ppm, resulting in 100% mortality at concentrations of 75 ppm and above, and no mortality at concentrations up to 5 ppm. Fry were then exposed to sub-lethal concentrations of 12.51 ppm (1/2 LC₅₀), 6.25 ppm (1/4th of LC₅₀), and 2.50 ppm (1/10th of LC₅₀) for 30 days. Behavioral observations revealed erratic swimming, abnormal gill movements, and loss of equilibrium, intensifying with higher ammonia levels. Biochemical analysis indicated significant increases in blood glucose, SGOT, and SGPT, suggesting hepatic stress. Total protein, albumin, and globulin levels decreased, while the albumin-globulin (A/G) ratio increased at higher concentrations, indicating impaired protein synthesis. Elevated oxidative stress markers (SOD and catalase) highlighted adaptive responses to oxidative stress. Growth metrics showed the highest specific growth rate (SGR) in the control group, with significantly reduced growth in ammonia-exposed fry. Water quality analysis indicated a decline in dissolved oxygen and increased pH and nitrogen compounds with higher ammonia levels. These findings provide valuable insights into the physiological and biochemical responses of freshwater fish to ammonia toxicity, contributing to conservation efforts and sustainable ecosystem management.

KEYWORDS: Ammonia, Toxicology, Sub-lethal, Catla catla, Fry

Meroplanktonic Assemblage Characteristics in Lagoon and Forereef Regions of Selected Atolls of Lakshadweep, India

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Investigations were held on the meroplanktonic assemblages of selected regions in Lakshadweep to assess the robustness of the ecosystem. Quantitative and qualitative analysis of zooplankton samples from lagoon and forereef areas in Agatti and Kavaratti atolls Lakshadweep during the post-monsoon season revealed diverse meroplanktonic assemblages peculiar to the biota of the region. Planktonic larvae form belonging to gadid, scarid, pleuronectid and exocoetid fishes, and scleractinian corals, jellyfish, brachyurans, malacostracans, squids, starfish, gastropods, bivalves, and holothurians among invertebrates were recorded by microphotography of the plankton samples. Quantitative analysis of the lagoon and forereef samples confirmed that biomass was higher in forereef regions and lower in lagoon areas. All planktonic eggs and larvae follow a similar pattern except decapod larvae which were found to be higher in the lagoons by two orders of magnitude. Bivalve larvae were of an order of magnitude higher than gastropod larvae. Fish larvae were more abundant in forereef regions. Most notable among fish eggs were elliptical eggs of scarids. The density of plankton was higher in Kavaratti than in Agatti, perhaps due to a higher nutrient load. Substantial meroplanktonic representation of diverse phyla is indicative of the reproductive success of component species and good health of the reef ecosystems in Agatti and Kavaratti atolls.

KEYWORDS: Eggs and larvae, Coral reef ecosystems, Planktonic diversity, Reef health

Comparative Study on Phytoplankton Diversity in Two Flood Plain Wetlands of Lower Gangetic River Basin

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Wetland is one of the most important ecological components and it provides vast ecological services to the environment as well as to the rural population. Phytoplankton plays an important role in wetlands in many ways as it enhances primary productivity, dissolved oxygen in water, maintains pH and alkalinity and also controls many other physio-chemical properties of water. Two important floodplain wetlands, Duma and Sindrani in North 24 Parganas, West Bengal, were studied from 2021 to 2023. The total abundance of phytoplankton was found as 4.017×10³ unit/l in Duma, whereas it was 3.506 ×10³ unit/l in Sindrani. In Duma wetland, a total of 51 genera of phytoplankton were observed under 21 families, whereas in Sindrani wetland, 46 genera of phytoplankton were recorded under 18 families. Bacillariophyceae contributed the maximum to the total phytoplankton diversity of 30% and 26% respectively in both wetlands. In Bacillariophyceae, a total of 22 genera were identified in Duma and 19 in Sindrani wetland. Blue-green (Cyanophyceae, 29%) algal growth and diversity were more in the Sindrani wetland because of its degrading nature, shallowness and more organic load, whereas the Chlorophyceae (34%) was more abundant in the Duma wetland. The most influencing environmental factors which drove the phytoplankton growth are dissolved oxygen (6.54-8.92 mg/l), surface water temperature (27.25-34.68°C), pH (7.17-9.05), total alkalinity (85-168 mg/l), total hardness (101.23-174.35 mg/l) and Ca²⁺ (6.27-33.49 mg/l). The values of the Algal Pollution Index show both the wetland's phytoplankton diversity and richness to be adversely affected by anthropogenic activities.

KEYWORDS: Wetlands, Phytoplankton, Diversity, Algal Pollution Index

Exploring the Diversity of Crustacean Fauna of Korapuzha Estuary, Kerala, India

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The Korapuzha estuarine ecosystem, acting as a link between the freshwater expanse of Akalapuzha and the seawater at Elathur, is characterized by delicate and fragile features. Despite its ecological significance, research on the faunal diversity of Korapuzha is limited, emphasizing the need for extensive studies. This study focuses on crustaceans, a diverse group of invertebrates playing a crucial role in biogeochemical cycles. This research aims to comprehensively study the crustaceans in the Korapuzha estuary, addressing a critical gap in understanding the estuarine ecosystem of Korapuzha. Sampling efforts started from 2021 to 2023 and involved various fishing gears and the active participation of local fishers. The study identified 30 crustacean species across 21 genera, 11 families, and two orders revealing the complexity of crustacean faunal assemblages of the estuarine environment. Shrimps and crabs, particularly Fenneropenaeus indicus and Scylla serrata, emerged as economically important components of local fisheries. The study also highlighted the diversity of noncommercial species like hermit crabs (Clibanarius infraspinatus), barnacles (Balanus Amphitrite and Balanus balanoides) and mantis shrimp (Oratosquilla sp). These findings contribute to the detailed understanding of the Korapuzha estuary, providing baseline data crucial for conservation and management strategies in the future. The study underscores the economic importance of crustaceans in the region's fishery resources and emphasizes the need for long-term observations to support effective conservation measures in the face of environmental changes.

KEYWORDS: Diversity, Crustacean fauna, Estuary

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Spatio-Temporal Variations in the Diversity of Perch Fishes along the Coromandel Coast of Tamil Nadu, Southeast India

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The Coromandel coast of Tamil Nadu supports a rich fauna of fishes and a well-established fishery contributing to the finfish diversity in India. The study objective was to assess the spatio-temporal variation in diversity and abundance of perches along the selected locations on the Coromandel coast of Tamil Nadu, India. The sampling was carried out by random sampling method fortnightly at Chennai Fishing Harbour, Nagapattinam Fishing Harbour and Cuddalore Fishing Harbour between August 2022 to September 2023. The perch catches observed were obtained by trawl net, gillnet and hook and line. In the present study, a total of 112 species were documented belonging to 15 families, 22 genera. The family Lutjanidae dominates with 20 species followed by Nemipteridae with 16 species, Serranidae with 15 species and Mullidae with 14 species. In the context of different locations, the highest species diversity was observed at the Chennai fishing harbour and the lowest at the Cuddalore fishing harbour during the study period. Among all the fishing harbours, Lutjanus fulvus, Nemipterus japonicus, Epinephelus tauvina, and Parupeneus indicus had the highest occurrence. The species diversity varied with season, with the highest diversity in the post-monsoon season (105 species) and the lowest in the summer season (75 species). These findings offer crucial foundational data for the sustainable management and conservation of perch resources on the Coromandel coast of Tamil Nadu. The results on the species diversity, richness, evenness and phylogenetic diversity calculated using PRIMER (v7.0) software are elucidated in the paper.

KEYWORDS: Biodiversity indices, Distribution, Occurrence, Fauna, Trawlers

Plastic Waste Management in a Coastal Village — A SWOT Analysis

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The creation of new synthetic chemicals, combined with the engineering capabilities of mass production has turned plastics into the most indispensable materials in modern times. It is estimated that India generates 9.46 million tonnes of plastic waste annually, of which 40%, remains uncollected; 43% is used for packaging, most of which is of single-use. The proliferation of one-time use plastic is the greatest contributor to the huge piles of plastic waste. Accumulation of enormous quantities of this non-degradable litter jeopardises the health and sustainability of the aquatic ecosystems and may become a potential threat to human health, particularly if there is contamination in the food chain. Understanding the need to resolve the issue of plastic menace in the coastal waters, a community-based participatory approach aiming at mitigation of pollution was attempted in a coastal village, Mulavukad in the Ernakulam district, Kerala, India, through the formulation and implementation of a model protocol named, 'Nirmala Dhara'. The Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was conducted to explore the possibilities and ways for the successful implementation and expansion of the mitigation measures of Nirmala Dhara activities, in the rest of the villages. The quantitative analysis of the strengths, weaknesses, opportunities and threats of the participatory program showed that it is possible to convert the weaknesses into opportunities which would increase the strength and nullify the threats. As SWOT analysis is an excellent tool to explore the possibilities and ways for initiating and successfully implementing such activities, it can help planners formulate strategic action plans towards attaining the sustainability of a healthy green ecosystem.

KEYWORDS: Plastic pollution, Mitigation, Participatory approach, SWOT

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Liquid Fertilizer from the Aquatic Weed Water Hyacinth: Conversion of the Problem into An Elegant Solution

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The 'beautiful blue devil' water hyacinth is a perennial free-floating, aquatic plant that grows rapidly in all types of stagnant freshwater environments and is recognized by its lavender flowers and long, spongy and bulbous stalks of shinning bright leaves. Water hyacinth has been called the world's worst aquatic weed as it spreads fast and can double its mat size in six to ten days. The plant has a huge potential for novel application by preparation of liquid fertilizer as the species is rich in nitrogen content, proteins and minerals which makes it suitable for manuring. Furthermore, the water hyacinth is available round the year, with an unhampered supply of raw material and easy propagation. As the utilisation of the species is extremely pivotal for ecosystem balance, an experimental study on the production of liquid fertilizer from water hyacinth was performed at Krishi Vigyan Kendra, Gautam Buddh Nagar by using different sets of a variety of natural ingredients. The study involved the analysis of the biochemical composition of water hyacinth and the selection of quality plants followed by fermentation of the various formulations in anaerobic conditions for the preparation of liquid organic fertilizer. Later, the bio-chemical composition was determined to evaluate its suitability as a macronutrient fertilizer. The green manure prepared by water hyacinth paves a new path for organic and natural farming practices in agriculture, aquaculture and horticulture. The production of green gold from an aquatic nuisance can be taken up by agroentrepreneurs as a low-input cost venture. In developing countries, where mineral fertilizers are expensive, water hyacinth-based liquid fertilizer is an elegant solution to the problem of species proliferation, water clogging, and also an eco-friendly way of improving soil quality as well as fertilizing the fish ponds for maximum natural food production in an inexpensive way.

KEYWORDS: Eco-friendly, Fertilizer, Natural farming, Low-cost venture, Freshwater

Symbiosis in Sea Anemones: Case Reports with Phoronid Worm and Gastropod from Southern Tamil Nadu

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The symbiosis between phoronids and cerianthids is unknown; the precise ecological relationship is yet to be clearly understood. In addition, symbiotic relationships between parasitic anemones and live sacred chanks have not been reported in Indian waters. This study recorded the first occurrence of the obligatory commensalism of phoronid worm Phoronis australis with Pachycerianthus magnus. P. australis constructs its tube within the tube walls of P. magnus, with specific characteristics observed in its position where the ampulla consistently occupies the fourth layer of the cerianthid tube, while the lophophore extends externally, utilizing its tube for shelter and as a substrate. The parasitic anemone Calliactis is typically associated with hermit crabs. However, in the present case was attached to a whorl of the live gastropod T. pyrum for the first time. This interaction exemplifies a classic case of commensalism, in which the host experiences neither benefits nor harms. The results of the captive experimental behavioral observations shed light on the fitness of the host and the symbiont and are given in detail. The present study also elucidated a comparative examination of earlier reports of symbiosis in phoronid worms and gastropods with sea anemones to provide insights into the dynamics of symbiosis in the Gulf of Mannar, Southern Tamil Nadu, India.

KEYWORDS: Anemone, Chank, Gulf of Mannar, Phoronid, Southern India

Biomass Production and Carbon Sequestration Potential of Cultured Red Algae: A Strategy for Climate Change Mitigation

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Seaweeds or macroscopic marine algae can sequester carbon through photosynthesis, which helps mitigate the effects of climate change. Geospatial approaches and in-suite experimental seaweed Kappaphycus alvarezii farming trials were carried out from 2013 to 2024 to document monoline farming, seaweed farming area, and carbon sequestration potential along the Mullakadu coast of Thoothukudi. The estimated average cumulative carbon sequestration potential of the culture period was 248 kg CO /plot (750 sq.m; 100 lines of 15 m length). After 35 days of culture, the wet weight gain of the resulting biomass increased 4-6-fold, and the biomass increased to a total wet weight of 12±5.0 tonnes in a single plot. To estimate the farmed area accurately, we clipped Google's visible seaweed culture plots from 2013 to 2024 and georeferenced them using GIS software. The study's findings show that the farming area ranges from 1.9 to 4.5 ha, and the net carbon sequestration ranges from 118 to 288 kg CO. In 2018, the biomass of 479.5 t had the highest area cover (4.5 ha) and net carbon sequestration rate (288 kg CO□). The present study revealed multiple factors involved in fluctuations in seaweed production, such as reduced farming months due to seasonal changes, non-availability of seeds, extreme weather events, and the shift of some seaweed farmers to traditional fish farming due to local demand. The study also revealed that the estimated potential area for seaweed cultivation along Mullakadu indicated the potential for further expansion to improve yield.

KEYWORDS: Biomass, Carbon sink, Google Earth, Kappaphycus alvarezii, Seaweed farm

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Assessment of Anthropogenic Marine Litter Pollution along Chennai Coastline

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Marine litter is a global issue that has a significant impact on marine ecosystems, marine life, and human health with plastics making up the largest proportion. Beach litters are mainly because of anthropogenic activities with objects discarded either directly or indirectly. The present study brings out a synoptic picture of the status and composition of litter from sixteen randomly selected beaches all along the Chennai Coromandel coast, starting from Pulicat in the North to Kalpakkam in the South covering a distance of 150 kms. Forty-eight quadrants with debris per square meter were surveyed, sorted, weighed and expressed as number/weight. The major debris was categorized as plastics (pet bottles, caps, carry bags, microplastic fragments), nylon (fishing nets and ropes), fibre, glass, rubber materials and miscellaneous groups. The total marine litter abundance in terms of weight was highest in Devanari Beach (20.20 g/m²) followed by Kovalam (13.22 g/m²) and Marina North (10.38 g/m²). The major constituents were ropes, nets, rubber and plastics. The litter abundance is due to a lot of anthropogenic activities in these stations, being recreational tourist spots and also used for net mending activities. The relative percentage values of plastics along the southern part of Chennai registered the highest mean percentage from Nochikuppam (65.7%) followed by Marina North (38.7%) and Pulicat Kuppam (37.1%). The rubber debris registered the highest mean percentage from the Kovalam coast (75.6%); followed by plastic ropes at Oyyalikuppam (44%), Karikattukuppam (30%) and Neelankarai (22.7%). Out of all stations surveyed, Thiruvanmiyur Beach was found to be very clean and green. The rapid survey revealed that the most abundant litter on beaches of Chennai are plastic carry bags followed by plastic ropes, rubber and fibre glass fragments. The study helps to assess the pattern of pollution on different beaches to create awareness among the coastal community about the impact of pollution on the marine ecosystem. The analysis also helps the policymakers to grade the beaches for certification to drastically bring down the quantum of polluted beaches.

KEYWORDS: Anthropogenic, Coromandel coast, Debris, Marine litter, Rapid survey

Spatial Diversity Patterns in Marine Fish Landings in Kerala

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Marine Fisheries in Kerala is characterized by a multispecies resource base, encompassing a diverse assemblage of pelagic and demersal fish species, crustaceans and molluscs. These fishery resources are exploited by several fishing sectors targeting various species using a variety of fishing gears that differ in their selectivity. The average annual catch from the fisheries over the last decade has been 0.46 million tonnes, which varied from 0.36 to 0.68 million tonnes. Slight fluctuations have occurred, the most notable of which were the low catches recorded in 2020, during the Covid-19 pandemic. Despite a few shifts in the relative importance of some resources, oil sardine continues to dominate in the landings, followed by Indian mackerel, scads, cephalopods, threadfin breams, penaeid prawns, tunas, anchovies and ribbon fishes. In Kerala, 204 marine fish landing centres are spread across 22 fishing zones. The monthly fishery landing data from these fishing zones were generated using a scientific sampling method called the Stratified Multistage Random Sampling Design (SMRSD), developed by the ICAR-Central Marine Fisheries Research Institute. The harvested resources were identified at the species level and during 2023. 717 species of fish were landed along the Kerala coast belonging to 47 orders, 176 families and 353 genera. These data were used to evaluate the species composition and taxonomic diversity pattern of the harvested marine fishery resources using the Importance Value Index (IVI), and the inclusion index at the taxonomic level (TINCL:). The IVI is a comprehensive index that shows how well a particular species functions within the community. Oil sardine was the most prevalent and dominant species with the greatest IVI in all fishing zones, followed by Indian mackerel. Other common and dominant species included squids, tunas, penaeid prawns, ribbonfish, scads, and threadfin breams. The highest species richness was observed in Munambam Harbour (333), whereas Chombala had the lowest species richness (98). Further, the TINCL was employed to analyse the concentration of fish species distribution at each taxonomic level and to investigate the diversity of fish composition as well as the interrelationship among different taxonomic levels. The highest TINCL value at the speciesgenus level was observed in Cochin Fisheries Harbour (1.74) indicating a greater number of species at the genus level, suggesting a more concentrated distribution indicating a lower taxonomic diversity. In the case of order (genus or family), the maximum concentrated distribution was observed in Cochin, Vizhinjam and Munambam fisheries harbour. The values for the other fishing zones showed lower TINCL; values indicating a more dispersed distribution of fish species.

KEYWORDS: Spatial diversity, Marine fish landings



Otolith Morphometry: A Decisive Taxonomic Tool for Species and Stock Discrimination in Teleost Fishes

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In the realm of teleost fish taxonomy, the utilization of otolith morphometry emerges as a powerful and indispensable tool, providing unparalleled precision in both species and stock discrimination. Otoliths, the small calcified structures found in the inner ears of fish, serve as unique biological markers that carry valuable information about the individual's life history. In recent studies on fish otoliths, researchers have increasingly recognized the species-specific morphology of these structures, positioning them as a reliable alternative taxonomic tool. In the current investigation, we leverage sagittal otolith morphometry to unveil previously unrecognized species, thereby contributing to the resurrection of taxonomic clarity. Digital images were analyzed for computing wavelet shape coefficients, which were further analyzed using Canonical Analysis of Principal Co-ordinates (CAP) to determine the extent of morphometric similarities and divergence to distinguish between the species. The statistical tests were performed to determine differences in otolith length, width, area, and perimeter between species. Despite a certain extent of similarity in the general appearance and shape among congeneric species, the mean otolith shape reconstructed based on wavelets implies a significant difference in their morphology (p<0.001) indicating them as separate stock/ species. The taxonomic distinctness was further ascertained by conventional morphometric and phylogenetic evidence. This innovative approach has led to the identification and description of four finfish species; a new barracuda species, named Spyraena arabiansis (Family: Sphyraenidae), a distinct queenfish species, Scomberoides pelagicus (Family: Carangidae), within the Scomberidae family, unveiled two new species: the chub mackerel (Scomber indicus) and the seerfish (Scomberomorus avirostrus). Furthermore, it aided in the resurrection of a species previously synonymized, now rejuvenated as Scomberomorus leopardus. This application of advanced taxonomic tools not only expands the understanding of finfish diversity but also emphasizes the significance of adopting modern methodologies for precise species characterization and discovery. This investigation conclusively demonstrates the utility of otoliths as a reliable and cost-effective tool for determining species and stock identity, aligning with the recommendations of numerous researchers who have previously emphasized the robust nature of otoliths. It is, however, needed to be further ascertained, whether the difference in the shape of otolith is linked to genetic heterogeneity or not.

KEYWORDS: Sagital otolith, Morphometry, Taxonomic tool, Teleost fishes



Fish Diversity and Aquatic Ecosystems in Northeastern India: Assessing Fishers' Knowledge, Status, Actions, and Commitment to Biodiversity Management and Conservation

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North-eastern India, with its diverse aquatic ecosystems and significant fisheries potential, is home to rich ichthyofaunal biodiversity. However, the region's floodplain wetlands, including Ramsar sites, are increasingly threatened by both natural and anthropogenic pressures. Overfishing and intensive aquaculture practices have exacerbated environmental stress, endangering many native fish species and highlighting an urgent need for effective biodiversity management and conservation. Community-based and institutional interventions are essential for preserving these ecosystems. A comprehensive assessment of fish farmers' and ethnic fishers' knowledge, status, actions, and commitment towards biodiversity management in this region provides insights into the level of awareness and current practices among local stakeholders. Such knowledge forms the foundation for sustainable aquaculture, biodiversity conservation, and livelihood support. Training, workshops, and research collaboration are vital strategies for enhancing fish farmers' capacities in environmentally sustainable aquaculture practices. Understanding the knowledge status and conservation practices of these communities is crucial for developing informed, actionable policies and advancing regional efforts in biodiversity management.

KEYWORDS: Biodiversity management, Fish farmers' Knowledge, North-eastern India, Aquatic ecosystems, Conservation

Fish Fauna of Manakudy Estuary, Kanyakumari District, Southern Coast of Tamil Nadu, India

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Estuaries form a significant component of coastal ecosystem due to their immense biodiversity values in aquatic ecology. The total estuarine water resources of India are estimated to be 1.44 million ha, whereas the total estuarine area of Tamil Nadu was estimated to be 56,000 ha, which accounts for 3.88% of the total estuarine area of India. Manakudy estuary which has an area of about 150 ha is situated about 8 kilometers northwest of Cape Comorin in Kanyakumari District, Tamil Nadu. The Manakudy estuary abounds with varied habitats that include shallow open waters, sandy beaches, muddy flats, mangrove forest, river delta and sea grass. In the present study, an annotated checklist of fish fauna diversity of the Manakudy estuary has been prepared. To study the diversity and species abundance of the fish fauna, specimens were collected and identified by using standard identification key. Occurrence and abundance data have been generated to study the species composition and for the preparation of the checklist. A total of 98 estuarine species including finfish and shellfish belonging to 64 genera, 45 families and 22 orders have been recorded. The identified species were described in detail in terms of taxonomic classification, habitat and distribution. Among the identified species, 16 number of species recorded belong to the order 'Eupercaria incertae sedis' followed by 13 number of species from 'Carangiformes' and 8 number of species belong to 'Acanthuriformes'. The estuarine fish families namely Cichlidae, Sillaginidae and Mugilidae were recorded in large numbers contributing to a substantial fishery of portunids, occurring throughout the year.

KEYWORDS: Manakudy estuary, Fish fauna diversity, Taxonomy, Sustainable Fishery

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Seasonal Fluctuation in Catch Diversity of Clupeid Species in the River Ganga at Patna

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The River Ganga (2525 km), the lifeline of the Indian sub-continent, originates at an altitude of 4100 meters above mean sea level from an ice cave, Gaumukh, near Gangotri in the Himalayas and discharges into the Bay of Bengal. The Ganga basin is the largest river basin in India (861404 sq. km). The freshwater fish fauna of India is quite interesting and offers an exceptional opportunity to study the diversity and their distribution. The fishery resources of the River Ganga are of tremendous economic and nutritional value. The Ganga has been a major source of capture fisheries in India. The river sustains a diverse flora and fauna including 382 species of fishes. A field survey was conducted during summer, monsoon and winter seasons at landing sites in a total stretch of more than 20 km in and around the Patna region. Shad belongs to the Order-Clupeiformes and Family-Clupeidae. Clupeid includes Gudusia chapra (Ham.) and Gonialosa manmina (Ham.) species. Both are schooling migratory fish and are recognized as commercially important surface-feeder clupeid in the freshwater resources of India. These species consume planktonic crustaceans as the major and regular food item and breed twice a year in stagnant or running water. During the study period, the total catch of shads was estimated to be 5.1%, 11.34% and 10.3% during monsoon, winter and summer respectively. The trend of catch ranged from 4.0 kg to 4278.2 kg during winter whereas in summer it was 9.69 kg and 9795.61 kg at the landing site. The paper discusses the catch diversity of shads in the Ganges and the need for developmental activities in the above stretch.

KEYWORDS: Seasonal fluctuation, Catch diversity, Shads, River Ganga, Patna

Influence of the Aquatic Environment on Algal Bioluminescence

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The backwaters of the Kumbalangi area, Ernakulam, Kerala, India which report recurring bioluminescent phenomena due to the Dinoflagellate Gonyaulax spinifera bloom was regularly monitored on a monthly basis to assess the water and sediment quality during 2023. The water samples were analysed using standard methods for temperature, salinity, dissolved inorganic nitrogen (DIN), dissolved inorganic phosphate (DIP), dissolved inorganic silicon (DISi), chlorophyll a, total suspended solids (TSS) and biochemical oxygen demand (BOD). Principal Component Analysis (PCA) revealed that the salinity, phosphate-P and silicate-Si concentrations of water were highly influencing the water quality in this area. Medium influence on water quality was observed with variables viz. water temperature, TSS, chlorophyll a, Biochemical Oxygen Demand and molar ratios of Dissolved Inorganic Nitrogen/Dissolved Inorganic Phoshorus as well as Dissolved Inorganic Silicon/Dissolved Inorganic Nitrogen. The sediment samples were analysed in the laboratory following the standard protocols for sample processing and standard methods of sediment analysis based on international guidelines of sediment quality. As per the PCA, the sediment quality was seen mostly influenced by the sediment salinity. Medium influence on the sediment quality was seen for sediment grain size fractions viz., sand, silt and clay percentages. While assessing the phytoplankton community in the study area, Dinoflagellates dominated during the premonsoon period, in the Kumbalangi backwaters, and it was taken over by the dominance of the Diatoms during the monsoon season and the Diatoms along with Chlorophyceae dominated during the post-monsoon period. The bioluminescence was characteristically observable from March-April, the pre-monsoon period when Dinoflagellates were predominant.

KEYWORDS: Bioluminescence, Dinoflagellates, Aquatic environment, Water and sediment quality, Molar ratios

Enriched Methanotrophic Communities Isolation and Activity Screening from Brackishwater Systems

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Aquaculture ponds with more reducing pond bottom conditions are the potential source of methane gas emission. The resilient strategies for the mitigation of methane are achieved by the methane-oxidizing bacteria, which aid in reducing the effects of global warming due to methane gas. The present objective was to isolate and screen methane-oxidizing bacteria (MOB) from brackishwater sources and aquaculture systems. Sediment samples were collected from shrimp culture ponds (n=16), crab pond (n=3), barmouth (n=3), lagoon (n=3) and estuary (n=4) from Muttukadu, Adyar, Nagapatinam, Karankadu, and Padapai in Tamil Nadu (n=18), Gudur in Andhra Pradesh (n=7) and Kakdwip in West Bengal (n=4). Sediment samples were inoculated in the nitrate mineral salt enrichment medium. Twenty-six bacterial strains were obtained from the enrichments. The MOB count and soluble methane monooxygenase (sMMO) activity were recorded in these isolates. MOB count (log10 CFU/ ml) and sMMO activity (nmol/min/mg of protein) were 5.62±0.62 and 0.18±0.11, 6.84±0.34 and 0.17 ± 0.01 , 4.56 ± 0.27 and 0.13 ± 0.06 , 5.72 ± 51 and 0.11 ± 0.04 , 5.65 ± 0.42 and 0.10 ± 0.06 in shrimp culture ponds, crab pond, barmouth, lagoon and estuary, respectively. Further, isolates were screened for methane metabolizing genes viz., mmox, pmoA and mxaF gene with specific primers. From the current findings, the potential methanotrophic isolates with methane-oxidizing activity would be taken forward with further studies for its use in the mitigation of methane in aquaculture ponds as beneficial bio input.

KEYWORDS: Methane oxidizing bacteria, Shrimp culture ponds, Microbial mitigation, Methane

Optimization of Laccase-based Triclosan Degradation in Aqueous Solutions and Assessment of Environmental Safety through Bioassays

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Triclosan (TCS), an antimicrobial biocide has raised serious concern among scientific community owing to its ubiquitous presence around the globe and toxicity to aquatic organisms. The present study aims on optimization of laccase enzyme mediated TCS degradation in water and evaluate the effects of treated water on aquatic organisms. Response surface methodology (RSM) along with Box-Behnken modeling showed that pH, temperature and laccase concentration combinations of 5, 30°C, 1 U/ml and 5, 40°C, 0.625 U/ml exhibits a significantly higher percentage (90.64% and 98.72%) TCS degradation efficiency, respectively. After analyzing the concentration of residual TCS in the 17 experiments using RSM, the best combination chosen for the final experiment was pH 4.93, temperature 39.77°C and laccase concentration of 0.912 U/ml giving a percentage degradation efficiency of 96.56%. Bioassay test on Chlorella vulgaris and Pangasianodon hypophthalmus showed that the percentage inhibition in algal cell counts and cumulative mortality in fish was significantly less in enzyme treated TCS group as compared to the group exposed to water containing TCS. The results of the present study reveal that the most significant factor affecting the laccase-mediated TCS degradation is pH, followed by temperature, and the concentration of the laccase enzyme and the laccase-mediated TCS degradation could reduce the endpoint toxicity of TCS on aquatic organisms.

KEYWORDS: Triclosan, Laccase, Bioassay, Response surface methodology, Toxicity

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Chlorophyll-a Concentration Dynamics in Coastal Waters off Mangaluru and Udupi: A Spatio-temporal Analysis Using Aqua Modis Satellite Data

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The distribution of phytoplankton and its Chlorophyll-a concentration in relation to water quality parameters were studied in the coastal waters off Mangaluru and Udupi. The spatial and temporal variations in the coastal waters off seven selected stations namely. Netravathi-Gurupurabarmouth region, Thannirbhavi, Panambur, Chitrapura, Surathkal, Mulki and Padubidri were assessed for a period of 16 months from October 2020 to May 2022. The water quality parameters include salinity, pH, dissolved oxygen and nutrients like ammonia, nitrate, nitrite, phosphate and silicate were recorded. The study observed that diatoms predominated, with 27 genera including Chaetoceros spp., Ceratium spp., Thallasiocera spp., Triceratium spp., Biddulphia spp., Ditylum spp., Coscinodiscus spp., Rhizosolenia spp. and Nitzschia spp., and followed by dinoflagellates with seven genera, and blue-green algae with one genus. The current study applied IDW to create various continuous surfaces to present the Chlorophyll-a and phytoplankton patterns influenced by each potential source. Ocean colour-3 was estimated and Aqua Modis (satellite) data were carried out for satellite images. The distribution of phytoplankton ranged between 0.54 and 9.96 mg/m³ with a difference of 9.42 mg/m³. The ArcGIS software tools were used for spatial and temporal variation of Chlorophyll-a and phytoplankton distribution. The maximum phytoplankton biomass was recorded in September 2021 at station Suratkal while the minimum was found in August of the year 2022 at station Netravathi-Gurupurabar-mouth region. The chlorophyll-a (mg/m³) in the present study ranged between 0.12 and 2.37 mg/m³ with a variation of 2.25 mg/m³. The maximum chlorophyll-a was recorded in September 2021 while the minimum was found in September 2021. The mean value of chlorophyll-a is 0.43 mg/m³.

KEYWORDS: Chlorophyll-a, Phytoplankton, Distribution, Aqua Modis, Ocean color

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Modelling and Optimization of Phlorotannin Extraction from Stoechospermum marginatum Using Response Surface Methodology and Evaluating its Activity Against Marine Microfouling Bacteria

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The detrimental effects of synthetic antifouling ingredients have underscored the necessity for the development of eco-friendly antifouling compounds. Phlorotannins are secondary metabolites biosynthesized exclusively in brown seaweeds with a potential as an antifouling compound. This study optimised the extraction of phlorotannins from Stoechospermum marginatum using the Box-Behnken design of response surface methodology and evaluated its potential for antifouling activity against marine microfouling bacteria isolated from the hull of a fishing boat. Based on the biofilm formation index. 13 bacterial isolates identified by 16S rRNA sequencing were found to have the ability to form biofilm in the initial stage of biofouling. The conditions that produced the highest phlorotannin content of 2.75±0.02 mg of phloroglucinol equivalents/g are as follows: ethanol concentration of 83.9%, solventsolid ratio of 32.9 ml/g and temperature of 40.5°C. The purified phlorotannin fraction was subsequently tested for antifouling activity, showing promising antibacterial activity against all tested bacteria with a minimum inhibitory concentration and minimum bactericidal concentration ranging from 16 to 128 µg/ml and 32 to 256 µg/ml, respectively. Grampositive bacteria were more susceptible to phlorotannins than gram-negative bacteria. This study demonstrated the ability of phlorotannin to inhibit biofilm formation and eradicate mature biofilms in a concentration-dependent manner. Analysis of the structural damage of bacterial cells by scanning electron microscopy further confirms the antifouling activity. Therefore, phlorotannins from S. marginatum are a promising sustainable and biocompatible antifouling alternative to the synthetic antifouling compounds

KEYWORDS: Seaweed, *Stoechospermum marginatum*, Phlorotannins, Response surface methodology, Biofilm formation index

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Carbon Sequestration Efficiency of Phytoplankton in Coastal Waters off Mangaluru: A Comparative Study

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The carbon fixation by phytoplankton in the coastal waters off Mangaluru at seven selected stations namely, Netrayathi-Gurupurabarmouth region, Thannirbhavi, Panambur, Chitrapura, Surathkal, Mulki and Padubidri were assessed for a period of 16 months from October 2020 to May 2022. Carbon sequestration by phytoplankton, a total of 35 different genera belonging to three groups were observed. The study observed that diatoms predominated, with 27 genera including Chaetoceros spp., Ceratium spp., Thallasiocera spp., Triceratium spp., Biddulphia spp., Ditylum spp., Coscinodiscus spp., Rhizosolenia spp. and Nitzschia spp., and followed by dinoflagellates with seven genera, and blue-green algae with one genus. The maximum phytoplankton biomass was recorded in September 2021 at station Suratkal while the minimum was found in August of the year 2022 at station Netravathi-Gurupura bar-mouth region. The carbon sequestration by phytoplankton ranged between 0.60 and 1.07 mg C/m³, with a high variance of 0.46 mg C/m³. The highest level of carbon sequestration was found at Suratkhal and Thannirbhavi region during the pre-monsoon of 2021, which was attributed to the high nutrient availability and phytoplankton abundance, while the lowest was recorded at station Chitrapura during pre-monsoon of 2021. The lower amount of dissolved oxygen in the marine environment leads to a slowdown in the decomposition process and could be attributed to the variation in carbon sequestration by phytoplankton.

KEYWORDS: Phytoplankton, Diatoms, Carbon fixation, Carbon sequestration, Blue-green algae

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Innovative Techniques for the Detection and Remediation of Microplastic Pollution in Aquatic Ecosystems

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Microplastics (MPs), which are minute synthetic particles, are significant pollutants in aquatic ecosystems, presenting substantial dangers to both marine and freshwater habitats. These contaminants disrupt ecological equilibrium by infiltrating food chains, resulting in the bioaccumulation and biomagnification of hazardous substances. The strengths and limitations of MP detection techniques across a variety of environmental matrices are assessed in this review, which synthesizes advancements in spectroscopic methods such as Fourier-transform infrared (FTIR) and Raman spectroscopy, chemical fingerprinting, and innovative extraction methods such as automated pressurized liquid extraction (APLE) and cloud-point extraction (CPE). Furthermore, the review investigates the potential of novel bioremediation strategies, which employ microbial degradation and enzymatic processes to reduce MP pollution. These methods, which was used microbes, fungi, and enzymes that are capable of degrading plastic polymers, are proposed as sustainable solutions to complement detection and removal methods. The ecological effects of MPs, including ingestion, entanglement, and physiological disruptions in aquatic organisms, are critically analyzed. In habitats such as mangrove ecosystems, the prevalence of MP is alarmingly high as a result of anthropogenic activities. Particular emphasis is placed on these habitats. The imperative need for standardized protocols to combat MP pollution is addressed by the integration of bioremediation with advanced monitoring and mitigation techniques, which is emphasized as a promising pathway that will protect aquatic life and promote sustainable development.

KEYWORDS: Ecosystem, Bioaccumulation, Microplastics, Sustainable development, Anthropogenic effects

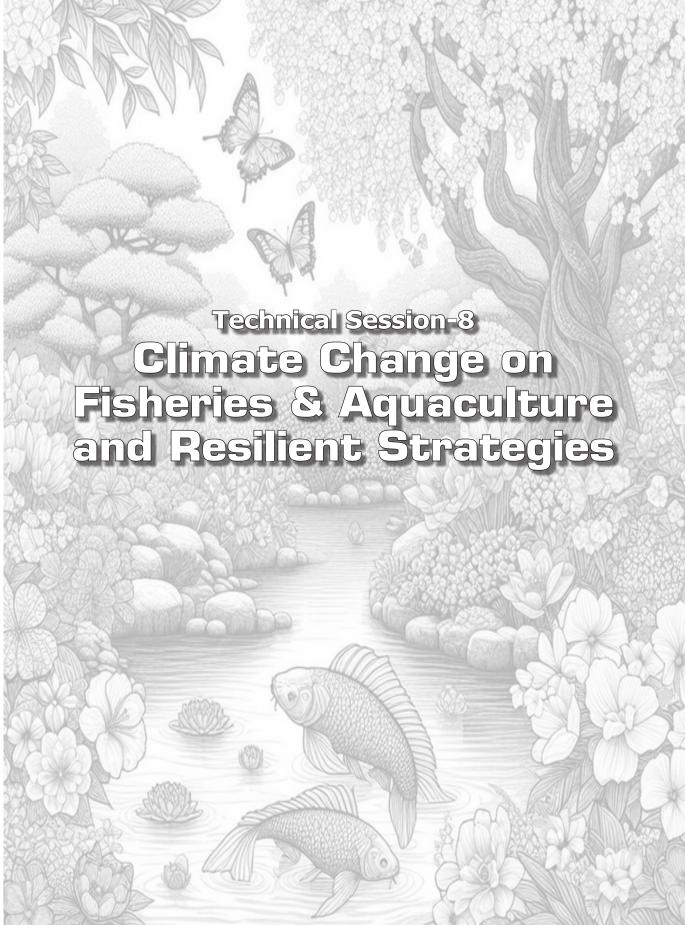
Taxonomic Profiling and Functional Gene Annotation of Microbial Diversity in Sediment of River Ganga Using Whole-genome Metagenomics Study

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The Ganga, a perennial river, is recognized as one of the largest rivers in India. However, the river's ecosystem is now at risk as a result of current anthropogenic activities. The advancement of next-generation sequencing technology has transformed metagenomics in the study of the microbiome and its critical role in a variety of aquatic ecosystems. In this research, we used a high-resolution metagenomics approach with the Illumina HiSeq 2500 to explore the structure of the community microbiome and its functions in the sediments of the river Ganga in India, at polluted stretches. Bacteria account for over 82% of the microbes in the three contaminated sediment samples of the river Ganga. The phylum of bacteria that dominates the sediment samples is *Pseudomonadota* (alpha, beta, and gamma). The microbiome of polluted stretches was significantly enriched in genes that are involved in the degradation of xenobiotic compounds, including nitrotoluene, benzoate, aminobenzoate, chlorocyclohexane, and chlorobenzene. The sediment metagenome data from the Ganga River was shown a greater abundance of genes involved in energy metabolism, including oxidative phosphorylation, nitrogen, methane, sulphur, and carbon fixation pathways, as determined by pathway analysis using the KEGG database. The polluted microbiome contains a larger number of pollutant-degrading enzymes, including catalase-peroxidase, altronate hydrolase, and 4-hydroxybenzoate 3-monooxygenase, which indicates that these enzymes are involved in the degradation of plastics and dyes. Our investigation provides information regarding the dynamics of bacterial diversity in community structure and function from the microbiome of a polluted river. This information is expected to assist in the investigation of novel functional genes and enzymes with the potential to be used in bioremediation and health.

KEYWORDS: River Ganga, Pollutant degrading enzymes, Metagenomics, Microbial communities, Xenobiotic biodegradation





Change in Ecosystem Services Valuation of Dimbhe Reservoir, Maharashtra Under the Climate Change Scenario

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Climate change and Local Land Use Land Cover Changes (LULCC) are two of the most important drivers that are affecting ecosystem services. To assess the environmental cost and benefits of the LULCC and climate change, it is necessary to measure the impact of the same on various ecosystems. The study has been conducted to understand the impact of climate and land use/land cover change on the Dimbhe reservoir ecosystem. To understand the pattern of future changes in climate trends, selected important climatic variables have been assessed and processed using Ferret software under the two RCP scenarios, i.e., RCP 4.5 and RCP 8.5. Landsat images of the past 21 years have been selected (2002 to 2022) to estimate the temporal land use/land cover change in the Dimbhe reservoir ecosystem. Supervised classification was carried out using the Random Forest (RF), SVM (Support Vector Machine) and Classification and Regression Tree (CART) model using Google Earth engine, while ArcGIS desktop software was used for mapping to evaluate the LULC changes. To estimate the impact of climate change and land use/land cover on ecosystem services the correlation between five climatic variables with each ecosystem service has been assessed. The valuation of the ecosystem services has been done based on the benefit transfer method. There were strong correlations between ecosystem valuation and fluctuations in important climatic parameters like temperature and precipitation. Also the Integrated Valuation of Ecosystem Services Tradeoffs (InVEST) model was used to estimate the sediment delivery ratio for Dimbhe Reservoir Ecosystem to understand the changes in soil retention capacity, which is one of the most important regularity services. From the trend analysis it was found that mean maximum and minimum temperatures had increased and will continue to increase significantly in the future also. Precipitation, wind speed and humidity have not shown any significant trend in any of the future scenarios. Studies have confirmed a significant increase in agriculture, settlement and dense forest, whereas barren land and open forest have declined. Waterbody has shown very little change. Total Ecosystem Services valuation has shown an increase of three percent in 2022 compared with 2002.

KEYWORDS: Dimbhe Reservoir, Climate change, Land use change, Ecosystem services

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Development of Ecological Modeling for Indian Fisheries: Present Status and Future Scope to Understand Fishery Variability and Climate Change Impacts

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Environmental parameters and nutrient cycling play a critical role in marine productivity and thereby, the fisheries sector. These factors are closely related to the physiology, metabolism, reproduction, survival and growth of marine fish. The indirect linkage is via ecosystem processes and primary production in addition to their role in the abundance of prey, predators and pathogens. Observation and modelling studies show that climate change would result in stock fluctuation, shifts in distribution, alter migration patterns and finally, affect the economics of fisheries and national GDP. As fish always prefer favorable habitats, their spatial availability and growth could be predicted by using these variables. This study shall focus on the development of a fish bioenergetic model coupled with a lower ecosystem model to reproduce the growth of Indian oil sardines along the Indian coast. For this, we have adopted an intermediate complex ecosystem model called North Pacific Ecological Modeling for Understanding Regional Oceanography (NEMURO). The model has been transformed for the Indian Ocean with appropriate tuning to suit the ecosystem variables. The model has 13 component ecosystem variables with plankton, particulate and dissolved organic matter, and cycling of nitrate, ammonia, silicate and calcium. In the coupled model, the prey densities which are derived from the lower trophic level model are used as input to the fish bioenergetic model.

KEYWORDS: Fishery variability, Pelagics, Fish bioenergetics, Ecosystem model, Fisheries prediction

Impact of Cyclone-Induced Extremely Heavy Rainfall and Flood on Pond Water Quality and Shrimp Immunological Parameters: A Case Study in Andhra Pradesh

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This study explores the impacts of extremely heavy rainfall and subsequent flood events on water and immunological parameters in shrimp farming areas of Gudur and Nellore, Andhra Pradesh that were affected by the MICHAUNG severe cyclonic storm between 1st to 6th December 2023. Wind speeds of 90-100 km/h damaged infrastructure and pond bunds, while extremely heavy rainfall of 215 mm within 24 hours led to pond inundation, causing shrimp to escape into open waters in some areas and resulting in significant losses for the shrimp aquaculture sector. During 2023, many farmers in the region cultured black tiger shrimp Penaeus monodon due to the availability of specific pathogen-free seed. Water and shrimp samples were collected from seven ponds during pre-flood (one week before flood), flood and post-flood (two weeks after flood) and analysed for pH, salinity, dissolved oxygen, total alkalinity (TA), total hardness (TH), TAN, NO, N, NO, N, PO, A, Ca++, Mg++, Na+, and K⁺ in water. Phenol oxidase (PO) was measured as optical density at 490 nm and superoxide dismutase (SOD) inhibition rate (%) was measured in shrimp hemolymph. Heavy rainfall caused significant disruptions, particularly affecting the water quality parameters due to the influx of freshwater from the rainfall. During the flood, physiochemical parameters and mineral concentration in water showed a decreasing trend compared to pre and post-flood values (pH-7.83, 7.43, 8.21; Salinity-10, 5, 12%; TH-2900, 2100, 3300 ppm as CaCO₃; TA-316, 189, 251 ppm as CaCO₃; Ca-280, 240, 320 ppm; Mg-535, 364, 758 ppm during pre-flood, flood and post-flood respectively). Shrimps were under stress as evidenced by the values of immune parameters during the flood (PO-0.723, SOD-93.2%) compared to pre-flood (PO-0.543, SOD-98.2%) and post-flood (PO-0.470, SOD-98%). PO levels showed an increase immediately after heavy rainfall and then led to a decrease at low salinities. It is recommended to improve the drainage systems during the off-season, increase the pond bund height, and implement better management practices immediately after floods to avoid stress to the animals.

KEYWORDS: Michaung cyclone, Shrimp farming, Stress, Water parameters

Differential Proteomic Responses in Rohu (*Labeo rohita*) to Combined Heat and Salinity Stresses

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Climate change is affecting the physiology of aquatic organisms through increased temperatures and the occurrence of freshwater salinization. In this study, the effects of heat stress, salinity stress, and their combined effects were evaluated at the proteomic level in the liver, kidney, and gills of freshwater fish rohu (Labeo rohita). The L. rohita fingerlings were exposed to heat stress, salinity stress (6%), and the combined heat and salinity stresses in three different tanks along with one control tank. The temperature exposure pattern involved a gradual increase from 30°C at morning 5.00 am to a maximum temperature of 36°C with an incremental rate of 1°C every 1.5 hours. The fish were maintained for 3 h at that peak temperature and then the temperature was decreased back to 30°C at the rate of 1°C every 1.5 hours. This temperature cycle was maintained for 15 days. Subsequently, the liver, kidney and gill tissue samples were collected, snap-frozen and preserved at -80°C. The tissue samples were homogenized and, the proteins precipitated and extracted. The extracted proteins were compared using two-dimensional gel electrophoresis (2DGE) followed by mass spectrometry (MALDI-TOF-TOF). A total of 149 differentially expressed protein (DEP) spots were identified in the 2D gel analysis from the three stress groups compared to the respective control groups; out of which 63 proteins were identified by mass spectrometry. The abundance of some selected DEPs was validated by qPCR. Most of the DEPs were found involved in the lysosomal pathway, linoleic acid metabolism, and the pentose phosphate pathway. Some proteins were also implicated in energy metabolism, immune system regulation, cytoskeletal stability, and reactive oxygen species (ROS) management. The findings of this study will aid in developing strategies to mitigate stress caused by various environmental factors.

KEYWORDS: Labeo rohita, Proteomics, Heat stress, Salinity stress

Characterization of Metabolite Signatures in Gift Tilapia (*Oreochromis niloticus*) Exposed to Acute Thermal Stress Using Untargeted Metabolomics and Chemometric Analysis

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Understanding the metabolic adjustments underlying the thermal adaptation of commercially exploited aquatic species is crucial for developing mitigation strategies. Tilapia fish fingerlings with an average weight of 27.13±0.19 g were chosen to elucidate the influence of acute thermal stress (a control group maintained at an ambient temperature of 28°C and acute thermal stress groups at 34°C and 36°C) in the liver metabolome. The exposure trial was conducted in triplicates in a temperature-controlled aquarium for 2 and 12 hours. The liver metabolites were then extracted and analysed using untargeted metabolomics employing LC/HRMS (Liquid Chromatography/High-resolution Mass spectrometer) Thermoscientifc Q-Orbitrap exploris 120. A total of 700 and 523 annotated features were identified from the samples in positive (ESI⁺) and negative (ESI⁻) ionisation modes, respectively. The PCA analysis revealed the existence of distinct clusters, revealing that the liver metabolome was affected by both time and temperature. Pairwise OPLS-DA (Orthogonal Partial least square – discriminant analysis) models were then used to find the distinct biomarker metabolites that are up-and down-regulated based on VIP > 1 scores. Two-way ANOVA analysis revealed 95 and 91 metabolites affected by temperature, time and their interaction in ESI⁺ and ESI mode, respectively. Pathway and Enrichment analysis showed significant changes in the metabolism of arachidonic acid, linolenic and linoleic acid, gluconeogenesis, transfer of acetyl group to mitochondria, enhanced monosaccharide catabolism and lactate production and minor changes in the metabolism of endocrine signals such as serotonin and catecholamines. Heat map analysis of the biomarkers showed the upregulation of different inflammatory eicosanoids viz., prostaglandins, leukotrienes, varanicacid, di and tripeptides, malic acid, and lactic acid with hyperthermal exposure. On the other hand, a consistent reduction was observed for metabolites such as fatty amides, bile acids, anti-inflammatory eicosanoids, lysophospholipids, oligopeptides, and vitamin D. Acute thermal stress leads to the oxidation of unsaturated fatty acids, producing inflammatory eicosanoids and significant shifts in energy metabolism. We also demonstrated that metabolites associated with acute responses to thermal stress can be identified through untargeted metabolomics of liver tissue.

KEYWORDS: Aquaculture, Thermal stress, Untargeted metabolomics, Biomarkers, Energy metabolism



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Influence of Cropping Pattern and Culture Practices on Greenhouse Gases Emission in Shrimp Farms

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Shrimp aquaculture, like other food production and livestock systems, emits greenhouse gases (GHG) during the culture period. However, there is no data on GHG emissions from the shrimp farms throughout the year including culture, fallow, drying and pond preparation periods. Investigations were conducted in shrimp farms with a single crop and two crops per year to assess the contribution of the culture period of 110 days, fallow period, and drying practices on GHG emissions. The standardized methodology of collecting the gas flux with the stand-alone designed closed chambers and gas sampling pump, and simultaneous analysis of GHGs (methane, nitrous oxide and carbon dioxide) by modified Gas Chromatograph was followed. In the shrimp farms with a single crop, the CO, equivalent GHG emissions during the culture period varied from 290-346 kg/ha. The CO₂ equivalent GHG emissions increased after harvest during the drying and pond preparation period, including scraping and ploughing compared to the culture period, and then decreased gradually. Single crop culture period of 3.5 months, 7 months of fallow and drying period, and pond preparation period of 1.5 months in a year contribute to 19, 65, and 16 percent of total GHG CO, equivalent emission. In shrimp farms with two crops per year, the GHG emissions were 290 to 357, and 234 to 323 kg CO, equivalent/ha during the first and second crops, respectively. After each crop harvest, emissions increased compared to the culture period and decreased gradually during the drying period. The first crop culture period of 3.5 months, drying period of 2 months after 1st crop, second crop culture period of 3.5 months, and drying period of 3 months after the second crop in a year contribute to 22, 31, 21, and 26 percent of total CO, emission equivalent. From the point of the contribution of shrimp aquaculture to global warming potential (climate change), it is suggested that two crops per year not only helps to increase shrimp production per unit area but also decreases the emissions per ton of shrimp as the drying period contributes significantly to GHG emissions.

KEYWORDS: Shrimp farm, Carbon dioxide, Methane, Nitrous oxide, Global warming

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Remarkable Role of Iron Nanoparticles in Enhancing Thermal Efficiency and Gene Regulation in Fish Under Multiple Stress Conditions

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The study examines the impact of unregulated temperature and pollution in aquatic ecosystems. with a focus on the capacity of fish to resist high temperatures. A study was conducted to assess the role of iron nanoparticles (Fe-NPs) in enhancing the thermal efficiency of fish grown under high-temperature stress, and arsenic and ammonia toxicity in *Pangasianodon* hypophthalmus. The dietary Fe-NPs were formulated and prepared at 10, 15, and 20 mg/kg diet. The treatments were designed as follows, the control group was fed a control diet; the group was treated with arsenic, ammonia, or concurrent exposure to arsenic and ammonia; and a group was provided a diet containing Fe-NPs at 10, 15, and 20 mg/kg with and without stress. Fe-NPs at 15 mg/kg diet considerably lowered the critical thermal minima (CT min) (14.44±0.21°C) and lethal thermal minima (LTmin) (13.46±0.15°C). In contrast, administering Fe-NPs at 15 mg/kg diet with or without stressors significantly enhanced the critical maxima temperature (CTmax) (47.59±0.16°C) and lethal thermal maxima (LTmax) (48.60±0.37°C) compared to control and other groups. Furthermore, a significant correlation was found between LTminCTmin (R²=0.90) and CTmaxLTmax (R²=0.98). Dietary Fe-NPs (15 mg/kg) significantly increased gene expressions of HSP70, iNOS, Cas 3a, CYP 450, MT, CAT, SOD, GPx, TNFα, IL, TLR, and Ig. The gene regulation provides additional support for Fe-NPs for a mechanistic role in enhancing thermal efficiency. Overall, the study found that feeding Fe-NP to fish grown under varied stress circumstances improved gene regulation and thermal efficiency in *P. hypophthalmus*.

KEYWORDS: Iron nanoparticles, Thermal tolerance, CYP 450,HSP 70, Pangasianodon hypophthalmus

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Thermal Effects on the Early Life Stages of Silver Pompano, Trachinotus blochii

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The climate change vulnerability of silver pompano, one of India's prime mariculture species, was tested on the temperature-sensitive life stages, embryo and yolk-sac larvae. The thermal studies on embryonic development and the yolk-sac larvae (n= 24) were conducted using fertilized eggs of silver pompano produced in the multi-species fish hatchery at Vizhinjam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Thiruvananthapuram. The effects of four temperatures, 24±0.5°C, 27±0.5°C, 30±0.5°C and 33±0.5°C were tested in triplicates in recirculatory thermostatic tanks (capacity 50 l; flow rate 30 l/h). The studies showed that significantly lower (p<0.05) embryonic development time of 16.8±31 h at 30°C and 14.5±26 h at 33°C as compared to lower temperatures (19.9±73 h to 24.6±45.1 h). The hatching success was significantly (p<0.05) higher at 30°C (86.25±3.75%) and 33°C (85±6.12%) as compared to 24°C and 27°C (57.5±4.8% to 70±4.1%). The total length of larvae at hatching was significantly (p<0.05) higher at 24°C and 27°C. 19.17±10.7% of the larvae were malformed at 33°C. At the onset of exogenous feeding (48 hph), a significantly (p<0.05) higher larval activity was observed at 30°C and 33°C. At 48 h and 72 hph, the total length and body depth of larvae were significantly (p<0.05) higher at 33°C and 30°C respectively. As compared to lower temperatures, the volume of yolk-sac 12 hph at 33°C was significantly (p<0.05) lower, and a similar significant reduction (p<0.05) in yolk-sac volume 24 hph was observed at 30°C. The volume of oil-globule of larvae after hatching was significantly (p<0.05) higher at 30°C whereas it was significantly higher at 24°C and 27°C at 48 hph and 72 hph. The study demonstrated significant impacts of temperature on early life stages of silver pompano, and that 30°C was optimal for the development of early life stages of silver pompano.

KEYWORDS: Embryogenesis, Yolk-sac larvae, Temperature, Climate change, Silver pompano

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Temperature Stress Induced Gene Expression Changes in Bivalve *Gafrarium divaricatum* (Gmelin, 1791)

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This study investigates the impact of thermal stress on Gafrarium divaricatum, a bivalve species, focusing on critical thermal maxima (CTMax) and associated gene expression. As climate change intensifies, marine species, particularly those inhabiting intertidal zones, are increasingly exposed to extreme temperature fluctuations, making thermal tolerance a critical factor for survival. This research evaluates the CTMax of G. divaricatum under different acclimation temperatures (28°C, 30°C, 32°C, 34°C), with findings indicating a maximum recorded value of 44°C at 34°C acclimation. Thermal stress elicits physiological responses at the molecular level, particularly in the expression of stress-related genes such as heat shock proteins (HSP70), catalase (CAT), and superoxide dismutase (SOD). This study observed an upregulation of HSP70 across most tissues, indicating its role in thermal stress adaptation. Superoxide dismutase (SOD) exhibited tissue-specific variation, with marked upregulation in the central and edge mantle, while downregulation was observed in the gills at higher temperatures. Catalase (CAT) expression showed minimal fluctuations where SOD and HSP70 are more responsive to thermal stress than CAT. However, SOD and CAT exhibited tissue-specific responses, suggesting differential antioxidant defences under acute heat stress conditions. Histopathological analysis of gill tissues revealed marked alterations, including ciliary erosion, lamellar deformation, hyperplasia, haemocytic infiltration, lipofuscin aggregates, mucus secretion and enlargement of haemolymphatic sinuses at elevated temperatures. These findings provide valuable insights into the thermal tolerance and stress biomarkers of G. divaricatum, contributing to a broader understanding of how intertidal species might adapt to the increasing frequency of marine heat waves driven by climate change.

KEYWORDS: Temperature stress, Gene expression, Bivalve, Gafrarium divaricatum

Role of Climate Variability in the Prediction of Small Pelagic Fishery of Indian Westcoast Using Bio-Energetics Based Fishery Population Model

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Predicting and understanding the role of global climate change on marine ecosystems and fishery resources are crucial to manage sustainable marine resources. A wide variety of small pelagics inhabit the Indian west coast region. The Indian oil sardine (Sardinella *longiceps*) is a major contributor to small pelagic fishery, yielding a high value as it is used in several commercial preparations in addition to direct human consumption. Past studies have reported that oil sardine population in this region exhibited an out-of-phase relation with the Pacific Decadal Oscillation (PDO), and El Nino-Southern Oscillation (ENSO), and an in-phase relationship with the Atlantic Multidecadal Oscillation (AMO). The links between climate variability and pelagic fishery potentially open avenues for predicting such longterm changes in a mathematically meaningful way. For example, an out-of-phase variation between the Indian oil sardines and the PDO and ENSO gives us handles to predict its longterm variability. Fully coupled population dynamics models with multiple trophic levels are valuable for understanding the impact of climate change on fisheries. However, such models have not been utilized to study population dynamics along the Indian coast. Therefore, in the present study, we have developed a bioenergetic-based population dynamics model for a small pelagic fishery and discussed the ability of the model. The model was able to successfully simulate total biomass (in tonnes) for 60 years from 1960 to 2017 with the provided food, temperature and climate variables. The correlation coefficient between the modelled population of all locations on the southwest coast of India and the actual landing reported is 0.53, which is statistically significant. The driving forces for seasonal and interannual variability of the population are discussed further.

KEYWORDS: Small pelagic fishery, Fishery prediction, Fishery modeling, Climate change, Indian West coast

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Shoreline Change Assessment and the Impact of the Management Measures in Dynamic Coast Through Digital Shoreline Analysis System (DSAS): A Case Study in Muttukadu Region of Chengalpattu District, Tamil Nadu

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Coastal areas are dynamic and vibrant, responsible for many ecosystem functions with ecological values, high biodiversity, and tremendous anthropogenic developmental activities. The study was designed to assess the impact of shoreline changes on the Muttukadu coastal region of Chengalpattu District, Tamil Nadu, India, using Geographical Information System supported Digital Shoreline Analysis System (DSAS) techniques. The shoreline movement towards land in the study region has damaged infrastructure along the coast and is a major threat. Periodical changes in the shoreline positions were monitored using multidate Landsat and sentinel 2A satellite images of 2016, 2018, 2020, 2022, and 2024. The analysis of shoreline changes showed that erosion and accretion rates differed during various periods of study. The shoreline changes after the placement of Gryones has been mapped and quantified. The End Point Rate indicated an erosion rate of -16.46 from 2006 to 2018, -13.47 from 2018-2020, -7.47 from 2020-2022 and -4.12 from 2022 to 2024 respectively. Weighted linear regression analysis indicated the erosion of -15.86 m/year from 2016 to 2020 and -9.91 m/year from 2020 to 2024. The overall shoreline change was -8.90 m/year from 2016 to 2024. The mean erosion was -9.2 m/ year in 63% of the coast and an accretion rate of 7.47 m/year in 37% of the coast. After the Gryones placement, the erosion rate was reduced. The study found that there were no stable coastal areas in the study region. The severity of the changing shoreline impact will lead to the loss of infrastructure facilities, productive lands, and influence the changes in river water quality. This study highlights the vulnerability of the area to erosion and the need to create effective conservation strategies without affecting the serenity of the coast.

KEYWORDS: Climate change, DSAS, GIS, Shoreline change, Impact assessment

Biomass Production and Carbon Sequestration Potential of Cultured Red Algae: A Strategy for Climate Change Mitigation

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Seaweeds or macroscopic marine algae can sequester carbon through photosynthesis, which helps mitigate the effects of climate change. Geospatial approaches and in-situ experimental seaweed (Kappaphycus alvarezii) farming trials were carried out from 2013 to 2024 to document monoline farming, seaweed farming area, and carbon sequestration potential along the Mullakadu coast of Thoothukudi. The estimated average cumulative carbon sequestration potential of the culture period was 248 kg CO₂/plot (750 m²; 100 lines of 15 m length). After 35 days of culture, the wet weight gain of the resulting biomass increased 4-6-fold, and the biomass increased to a total wet weight of 12±5.0 tonnes in a single plot. To estimate the farmed area accurately, we clipped Google's visible seaweed culture plots from 2013 to 2024 and georeferenced them using GIS software. The study's findings show that the farming area ranges from 1.9 to 4.5 ha, and the net carbon sequestration ranges from 118 to 288 kg CO₂. In 2018, the biomass of 479.5 tonnes had the highest area cover (4.5 ha) and the net carbon sequestration rate (288 kg CO₂). The present study revealed that multiple factors are involved in fluctuations of seaweed production, such as reduced farming months due to seasonal changes, non-availability of seeds, extreme weather events, and the shift of some seaweed farmers to traditional fish farming because of local demand. The study also revealed that the estimated potential seaweed cultivation area along Mullakadu indicated the potential for further expansion to improve yield.

KEYWORDS: Biomass, Carbon sink, Google Earth, Kappaphycus alvarezii, Seaweed farm

Reservoir Fisheries Management Tools for Improved Livelihood of Stakeholders in Climate Change Scenario

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The water spread under reservoirs has been accentuated to >3.46 million ha in India, with sustenance production of 125 kg/ha/yr on average. The production target is 50 kg, 147 kg and 343 kg from large, medium and small category reservoirs of India during 2025-30, which would support a great deal of livelihood and rural economy besides dietary protein supply to the rural sector. In the last decade, the central part of India has faced severe failure of rainfall, unlike other parts where huge rain occurred within a short time. Both scenarios are detrimental to reservoir fisheries management in terms of stock loss, biodiversity loss, eutrophication, and drastic fall in water level impacting livelihood of the stakeholders. To cope with such environmental negation, alternate contingent plans 'B' or 'C' should be in a proper place to face such vagaries of climate. The issues to address include promoting spawn prospecting, protecting broodstock from being caught in drag nets, and banning the use of drag nets during lean seasons with low water levels. Additionally, modern aquaculture technologies, such as floating pens and cage culture for table fish during reduced water levels can be implemented; cultivating short-duration leguminous crops for fodder in exposed areas of the lake can be practiced; and at times, in small reservoirs with low water levels, we may need to consider the removal of all fish when necessary. The stocking materials are to be raised utilizing the bay areas of the reservoir through the pen culture technique utilizing and installing floating pens. Even during summer with reduced water levels, in-situ seed raising could be opted in the dug-out canals/channels surrounding the periphery of the small reservoirs which would be inundated in monsoon with the production of sizeable stocking materials into the system for fisheries enhancement processes. Observing closed seasons at least during breeding periods (July-August) should be made mandatory. The present study is a modest attempt to ponder upon management protocols of reservoir fisheries under extreme and erratic climatic conditions to address the issues of livelihood of stakeholders properly with the provision of need-based support for their sustenance.

KEYWORDS: Reservoir, Livelihood, Climate change, Fisheries, Enhancement, Management

Knowledge Level and Socio-Economic Determinants of Adopting Climate Resilient Practices: The Case of Aquaculture Farmers in Odisha, India

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Using cross-section data of 194 randomly sampled aquaculture farmers, the study discusses farmers' knowledge and adaptation determinants to specific climate resilient strategies (CRSs) in the context of recurring climatic events in the form of flood, cylones and rising temperatures in Odisha. Using item response theory, multivariate probit model and generalized Poisson regression, the study tried to explore farmers' knowledge level about available aquaculture-related climate change adaptive options, and socio-economic determinants of adoption and extent of adoption of the CRSs. Information was collected using a structured interview schedule. The result of the study indicates that farmers seem to have a fair level of knowledge about climate change and its effect on aquaculture, but a relatively lesser number of farmers have knowledge about adaptation strategies with possible difficulty levels inherent in specific knowledge items for the common farmers. Again, the household head's age, distance to the PWD road and experience negatively and statistically significantly influence the extent of adoption of CRSs among aquaculture farmers; while the household head's gender, education, possession of a smartphone and previous training exposure influences positively the extent of adoption of CRSs. Based on the results, the study emphasizes the need to encourage the younger generation to take up farming because of their enthusiasm to adopt climate-resilient aquaculture for better sustenance, and also the expansion of rural roads to alleviate constraints in the flow of information about climatesmart interventions/technologies. Broadening training courses on climate change impacts and mitigation measures may also prove fruitful to the aquaculture farmers of the state.

KEYWORDS: Climate change, Adaptation, Item response theory, Multivariate probit, Generalized Poisson regression

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Responses of Dietary Folic Acid on Gonadal Recrudescence and Maturation in Female *Anabas testudineus* (Bloch, 1792) Exposed to Hyperthermal Stress

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The present study aimed to investigate the possible adverse effect of hyperthermal stress on the gonadal recrudescence and maturation of female climbing perch, Anabas testudineus and its mitigation through dietary folic acid. The experiment consisted of six treatments viz. C 30B (30°C Temperature with Basal diet), T1 32B (32°C Temperature with Basal diet), T2 34B (34°C Temperature with Basal diet), T3 30F (30°C Temperature with Folic acid diet), T4 32F (32°C Temperature with Folic acid diet), and T5 34F (34°C Temperature with Folic acid diet). The female broodstock weighing 23.4±0.2g was stocked in 18 experimental units with six treatments and three replicates each. The fish were fed 1% of their body weight with two kinds of diets (basal diet and folic acid diets) and exposed to different temperatures. After 60 days of the experiment, reproductive indices, GSI and fecundity were estimated. The sex steroid profile was also estimated. GSI and fecundity were reduced (p<0.005) in the thermally stressed group, whereas the folic acid diet-fed group with high-temperature exposure of 32°C restored GSI and fecundity to near-control levels. However, such compensation due to folic acid feeding was not evident in the extreme thermal stress exposed group (34°C). There was also a significant alteration in the sex steroid hormone levels in thermally stressed groups. Testosterone, 17-β estradiol and 17-α,20-β, DHP levels declined significantly (p<0.005). These effects were found to be reversed in the group fed with folic acid in the 32°C thermally stressed group, but not in the 34°C group. The testosterone level further declined in folic acid fed thermally stressed groups. Thus, it is concluded that the mitigation of adverse effects caused by hyperthermal stress on the reproductive performance of female A. testudineus can be partially achieved by supplementing dietary folic acid at 4 mg/kg in the feed. Hence, this study suggests that folic acid appears to mitigate the adverse effects of thermal stress experienced upto 32°C, and restore the normal gonadal development and reproductive physiology in A. testudineus.

KEYWORDS: Anabas testudineus, Folic acid, Hyperthermal stress, Sex steroid profile

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Effect of Hyperthermal Stress on the Physio-Biochemical Responses of GIFT Tilapia Reared in Inland Saline Water of Different Salinities

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Climate change poses significant challenges to the fisheries sector, particularly due to the sensitivity of cold-blooded aquatic animals to environmental temperature fluctuations. This study evaluates the effects of rising temperatures on the physiology and metabolism of GIFT (Genetically Improved Farmed Tilapia) juveniles under the osmotic challenge of inland saline environments. A 60-day experimental trial was conducted, involving 225 GIFT (Oreochromis niloticus) juveniles (average body weight: 2.73±0.02 g) randomly allocated to five treatment groups: Control (Freshwater), T1 (10% Inland saline water, ISW, 28°C), T2 (10% ISW + 33°C), T3 (15% ISW), and T4 (15% ISW + 33°C), with triplicates in 15 FRP tanks (300 l capacity). The GIFT juveniles were fed with a semi-purified potassiumenriched diet containing 36% crude protein and 8% crude lipid thrice a day at 3% body weight. Temperature control was maintained using heaters connected to thermostats. The lowest weight gain percentage was observed in the T4 group indicating the negative effect of temperature and salinity interaction on the growth performance. The interactive effects of temperature and salinity on the physio-biochemical responses of GIFT were also assessed. Notably, the activity of antioxidant enzymes, including catalase (CAT), superoxide dismutase (SOD), glutathione-S-transferase (GST), and glutathione peroxidase (GPX), in the liver and gill were significantly elevated in the T4 group compared to other treatments, indicating oxidative stress and compromised antioxidant capacity at higher temperature and high salinities. Similar trends were observed in metabolic enzymes, with significant increases in liver lactate dehydrogenase (LDH) and malate dehydrogenase (MDH) activity in the T4 group, suggesting metabolic stress and altered energy metabolism. Furthermore, increased activities of protein metabolic enzymes i.e., Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) were recorded in the gills and liver of T2 and T4 groups, reflecting heightened energy demands and enhanced amino acid turnover. Although survival rates across all treatments were not significantly different, growth performance was significantly reduced at elevated temperatures, regardless of the rearing salinity. These findings indicate that higher temperatures adversely affect growth and metabolic functions in GIFT Tilapia, with these impacts exacerbated in brackish water compared to freshwater. Thus, it is concluded that hyperthermal stress-induced physio-biochemical imbalances are more manifested in waters with higher salinity compared to freshwater.

KEYWORDS: GIFT tilapia, Inland saline, Hyperthermal, Stress, Salinity



Prediction of Harmful Algae Blooms at High Latitudes under a Warming Climate

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The rise of harmful algal blooms (HABs) at high latitudes presents a significant concern as the risk of contaminating shellfish farms would increase, leading to more revenue losses. Recent studies indicate that toxic algal species might shift poleward and extend their growing seasons due to climate change, which would result in more frequent occurrences of HABs. However, a quantitative assessment of projected changes in HAB frequency remains lacking. This study utilizes 14 years of algal observation data, probabilistic HAB models, and climate models to evaluate how the future warming and freshening of coastal waters will influence the frequency of blooms. Our analysis focuses on *Dinophysis acuta* and Alexandrium tamarense, which produce diarrheic and paralytic toxins, respectively, along the Norwegian coast in a warmer climate. We found that spring and autumn ocean temperatures reach optimal levels for both species, leading to an increased frequency of blooms during these seasons. However, excessively high summer temperatures are expected to reduce the frequency of blooms, offsetting the annual increase driven by temperature rise. Additionally, the fresher coastal waters decrease the frequency of A. tamarense blooms, while D. acuta remains largely unaffected, as the former thrives in higher salinity conditions, whereas the latter can develop across a broader salinity range. Overall, under a warmer and fresher ocean scenario, we project that the annual frequency of D. acuta blooms may increase by up to 50%, while A. tamarense blooms could decrease by up to 40%. This shift will likely result in shellfish farms being exposed more to diarrheic toxins and less to paralytic toxins, occurring over extended seasons and in areas with diminished freshwater inflow.

KEYWORDS: Harmful algae blooms, High latitudes, Warming climate

Early Life Thermal Programming in Rainbow Trout: Evaluation of a Novel Climate-Resilience Approach

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Climate change associated changes in the thermal regime are comparatively high in the Indian Himalayan region and are limiting the expansion and intensification of rainbow trout (Oncorhynchus mykiss) production in vulnerable locations. To address this challenge, we tested a novel thermal programming strategy during the early life stages of rainbow trout to ascertain the appropriate development window in which thermal stimulus should be given to the fish for eliciting a positive physiological response and memory for coping up with high temperature exposure during later life stages. From the eyed-ova stage, trout embryos were exposed to either low (8±1°C, LT) or high (16±1°C, HT) temperatures until hatching. After hatching, half of the sac-fry from LT group was shifted to a higher temperature (16±1°C, LHT), and half from HT group was shifted to a medium temperature (13±1°C, HMT), for larval rearing. Incubation temperature affected ontogeny more profoundly than posthatch thermal regimes. Morphometric features were found to be substantially influenced by temperature in the early larval stages. At 45 dph, randomly selected individuals from all four treatments were examined for their thermal tolerance limits and other performance indices. The LHT group was found to exhibit higher upper thermal tolerance (CTmax: +1.5 to 3°C), weight gain and condition factor as compared to the other groups. Transcriptional analysis of biomarkers from the heat shock protein, hypoxia signalling and other stress response pathways indicated significant changes in their mRNA abundance (hsp70, hsp90, hsc70, serpinh1, hyou1, hif1a, gr1, junb and cat) due to early life thermal stimulus. After a latent phase for 75 days and subsequent high temperature challenge (23±1°C) for one month, we did not find persistent positive effects of early life thermal stimulus in the critical thermal tolerance and metabolic oxygen consumption rate of the LHT group as compared to the LT group. However, haemoglobin levels and blood oxygen-carrying capacity were significantly higher in the LHT group. This observation of cross-protection suggests the possibility of inducing long-term physiological changes in rainbow trout through early-life programming if the thermal stimulus is given at an appropriate developmental window.

KEYWORDS: Fish, Thermal adaptation, Physiological plasticity, Climate resilience

Resilience Strategies of Fishermen Communities in the Panichapra Haor of Bangladesh: Navigating the Impacts of Flash Floods and Prolonged Droughts

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The Haor region in northeastern Bangladesh, known for its unique wetland ecosystem, faces significant challenges due to extreme weather events such as flash floods and prolonged droughts. These events have a severe impact on the livelihoods of local communities, particularly fishermen who depend on aquatic resources. This study examines the effects of these events on the vulnerable fisheries community and investigates the adaptation strategies they use to cope with these challenges. Data were collected from the Panichapra Haor through field visits, questionnaire surveys, focus group discussions, and key informant interviews. A purposive random sampling method was applied to select 200 fisher households from eight villages in and around Panichapra Haor. The findings reveal that the low-lying areas are especially susceptible to flash floods, with heavy rainfall in the Haor and adjacent Indian sub-catchments being the primary causes of these events. Community coping mechanisms are severely restricted by social, economic, and political factors, leading to a cycle of debt and poverty. This cycle is characterized by dependence on money lenders and microcredit institutions, marginalization from local resources by powerful groups, and reliance on wealthier neighbors or relatives. The inability of community members to repay borrowed money creates additional financial burdens and incentives, exacerbating their economic vulnerability. The results show that the Haor community experiences recurring income losses, food shortages, malnutrition, and significant debt with high interest rates. These factors increase their vulnerability and reduce their ability to prepare for, respond to, and recover from future floods and other disasters. Many Haor residents are forced to change their occupations due to flooding, and prolonged drought resulting in income loss. Despite these challenges, the community employs various adaptation strategies, including income diversification, community-based resource management, and engaging in alternative livelihoods such as aquaculture and agriculture. By documenting the challenges and adaptation strategies, this research offers valuable insights for policymakers and supports the development of interventions that enhance the resilience of the Haor community amid the growing threats of climate change.

KEYWORDS: Climate change, Haor Region, Fishers community



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Marine Heatwaves: An Emerging Threat to the Marine Ecosystems

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Marine heatwaves are extreme weather events and are defined as extended periods where ocean temperatures rise significantly above normal levels (90th percentile of a probability density function estimated from observations). The cause of marine heatwayes is primarily the excess heat entering the ocean via the atmosphere or through ocean currents. When both processes occur together, they lead to marine heatwaves with higher intensity. Climate change is understood to increase the incidence of marine heatwaves. Marine heatwaves can lead to major economic losses because they modify the ocean's ecosystem services, the benefits that healthy marine ecosystems provide to humans. Warmer waters can lead to coral bleaching and also pose a significant threat to seagrass meadows. Temperature modifications to the tune of 0.5°C can change the recruitment pattern in fish and shellfish, and the larval fishes are reported to be more sensitive to temperature fluctuation than the adults. Heatwaves can also disrupt the feeding and breeding patterns of marine animals and even cause large-scale die-offs. These disruptions can have cascading effects throughout the marine food web. So, it is very important to know the nature and characteristics of the marine heatwaves that occur in our seas. The daily SST data for the Arabian Sea area was analyzed as per the methodology proposed by Hobday et al. (2016). The analysis revealed that the Lakshadweep Sea had faced an unprecedented incidence of marine heatwaves. From 27 October 2023, the area experienced marine heatwaves till mid-May 2024, with a small break from 16-03-2024 to 31-03-2024. The heatwave that started on 27 October lasted for 141 days and another one started on 01-04-2024 and continued till mid-May 2024. This prolonged incidence of heatwaves could be detrimental to the coral reefs of the area. The Kerala coast also experienced continuous marine heatwayes from 05-11-2023 to till mid-May 2024. These observations imply that we should properly monitor our seas for marine heatwayes, study their impacts on specific marine ecosystems and evolve suitable strategies to lessen their impacts.

KEYWORDS: Marine heatwaves, Arabian Sea, Lakshadweep Sea, Kerala coast, Ecosystem impacts

Assessing Environmental Impacts on CPUE: A Regional Analysis using Generalized Additive Models

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This study investigates trends in fishing effort across mechanized, motorized, and nonmotorized sectors, and the influence of environmental drivers on Catch Per Unit Effort (CPUE) in four key regions viz., Southwest (SW), Southeast (SE), Northwest (NW), and Northeast (NE) over a 30-year period from 1994 to 2023. Using estimated marine fish landings and fishing effort, measured by actual fishing hours (AFH), the analysis revealed distinct regional trends in fishing across sectors. In SW, mechanized fishing dominated due to better infrastructure and investment, with periodic peaks driven by seasonal fish availability, while motorized and non-motorized efforts remained steady at lower levels. SE saw a sharp decline in non-motorized fishing as the motorized sector grew due to technological and economic shifts. In NW and NE, mechanized fishing prevailed, with steady growth in NW from modernization, while NE saw fluctuations due to environmental variability. Motorized fishing increased in NW but remained stable in NE, and non-motorized efforts stayed low across both regions due to the dominance of more efficient methods. To assess the influence of environmental factors on CPUE, the study employed the Multi-Gear Mean Standardization (MGMS) method to standardize fishing effort across diverse gear types. Standardizing CPUE was crucial for creating a unified measure that accounted for the varying capacities and efficiencies of different fishing gears, allowing for more accurate comparisons across regions and sectors. Generalized Additive Models (GAM) and Generalized Linear Models (GLM) were applied to explore the influence of key environmental factors, including temperature, salinity, and oceanographic conditions. GAM was found to be more effective than GLM in capturing nonlinear interactions between CPUE and environmental drivers, providing deeper insights into region-specific factors influencing fishing productivity. Future CPUE trends were projected from 2030 to 2100 under three Shared Socioeconomic Pathways (SSP1-2.6, SSP2-4.5, SSP5-8.5), providing key insights for fisheries management. These projections underscore the importance of region-specific strategies to sustain fisheries in the face of changing environmental conditions, highlighting the need for adaptive, sustainable fishing practices.

KEYWORDS: CPUE, Environmental variables, Future projections, GAM, MGMS

Projecting Range Shifts of Oil Sardine in the Indian Ocean: A MaxEnt Approach to Assessing Climate Impacts

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The Indian Oil Sardine (Sardinella longiceps) plays a key role in the Indian Ocean ecosystem and forms major fisheries that contribute significantly to regional economies. However, this commercially important species is facing growing threats from climate change, altering the oceanographic conditions it lives within. Understanding how climate change will impact the distribution of oil sardines is crucial for developing sustainable fisheries management strategies. This study utilised species distribution models (SDMs) to understand the current extent of distribution and project potential range shifts of oil sardines in the northern Indian Ocean under different climate scenarios. We used occurrence records from fisher-aided surveys, published literature and open-source databases. Environmental data, including bathymetry, dissolved oxygen, mixed layer depth, sea surface temperature, primary productivity, salinity, seawater velocity, and pH were used as covariables. Using the Maximum Entropy (MaxEnt), a machine learning algorithm, we built models to predict the probability of oil sardine occurrence based on these environmental factors. Our models showed excellent predictive accuracy (AUC > 0.9), capturing the species' current distribution. The Jackknife test of variable importance shows Primary Productivity as a major contributing variable in determining the distribution. Future projections were made under three Shared Socioeconomic Pathways (SSPs) from the Coupled Model Intercomparison Project Phase 6 (CMIP6): SSP1-2.6 (low emissions), SSP2-4.5 (intermediate emissions), and SSP5-8.5 (high emissions). The projections indicate a general northward shift in suitable habitat, with potential range constriction in the Indian Ocean. Under the high emissions scenario, a substantial decline in suitable habitat is projected in the northern Indian Ocean. These findings highlight the vulnerability of oil sardines to climate change. The projected range shifts could lead to changes in fishing grounds, potentially causing economic and social disruption. Adaptive fisheries management strategies are crucial to ensure the sustainability of this resource. These strategies may include: implementing robust monitoring programmes, promoting diversification in fishing activities, and fostering regional cooperation to manage shared fish stocks. By proactively addressing the challenges of climate change, we can help safeguard the future of oil sardine populations and the livelihoods they support.

KEYWORDS: Climate change, Environmental variables, MaxEnt

Unusual Accumulation of Cellophane Tubeworm Castings in Coastal Beaches of West Coast of India: Causes and Impact

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Cellophane tube worms, small polychaete annelids, inhabit the benthic zones of coastal waters, where they construct delicate, translucent tubes using mucous secretions combined with fine sediments. These tubes function as protective burrows on the seafloor and are integral components of benthic ecosystems, serving as a food source for various marine organisms, including fish and other invertebrates. During the monsoon months of 2023, an unusual and substantial accumulation of cellophane tube worm castings was observed along the beaches of Malpe, Karnataka. The castings, resembling light, transparent tubes, were scattered extensively across the shoreline, raising concerns among local communities and environmental observers. To assess the extent of this phenomenon, a coastal survey was conducted along the beaches of Goa and Karnataka in June 2024. Semi-structured interviews with fishers and coastal residents were employed to gather insights into the historical occurrence of similar events and community perceptions. The survey, combined with a literature review, revealed that minor accumulations of tube worm castings are common during the monsoon season; however, large-scale beaching events are rare and potentially linked to increased cyclonic activity, exacerbated by climate change. The study highlights the dynamic interactions between marine organisms and environmental forces, particularly the role of cyclonic disturbances in displacing benthic structures. The increased frequency and intensity of cyclonic storms due to changing climatic conditions may lead to more frequent mass displacements of cellophane tube worm tubes, posing broader ecological implications for coastal and marine ecosystems. Understanding these occurrences is crucial for assessing the impacts of extreme weather on benthic communities.

KEYWORDS: Polycheate worms, Climate change, Karnataka, Goa, Cyclonic events

Influence of Temperature on Embryogenesis of Indian Rice Fish Oryzias dancena

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The Indian rice fish Oryzias dancena was selected as a model fish to study the effect of temperature (control-24°C, 27°C, 30°C, 33°C; in triplicates) on embryonic development of marine fish. Eggs were collected from rice fish broodstock (0.6-0.9 g) that were reared in a 300 l aquarium (30%). Newly spawned eggs (n=72) were uniformly distributed into 500 ml meshed plastic containers placed in recirculatory thermostatic tanks (capacity, 50 l; flowrate, 30 l/h, salinity, 30‰) to maintain constant temperatures, 24±0.5°C, 27±0.5°C, 30±0.5°C and 33±0.5°C (in triplicates). At control temperature of 24°C, continuous monitoring of rice fish embryos was done through careful observation using Leica S8APO stereozoom microscope fitted with a Leica DFC camera to record the key embryonic development stages based on the standard diagnostic features described for medaka Oryzias latipes. This information was used to study the embryonic development at 27°C, 30°C, and 33°C, which was recorded at every 24-hour interval from 0 dpf to 23 dpf. It was found that the duration of the embryonic period was significantly different (p<0.05) and reduced by 11%, 40%, and 60% at 27°C (492±9 h), 30°C (331±34 h) and 33°C (221±40 h), relative to that at 24°C (Control, 552±19 h). No significant variation was recorded in the hatching percentage with respect to the four tested temperatures. We conclude that temperature did not affect the chronology of ontogenic events but caused a major shift in the timing of occurrence for key ontogenic events during the embryogenesis of rice fish.

KEYWORDS: Embryonic development, Climate change, Incubation period, Hatching

Comparative Analysis of Net Tube and Monoline Culture Techniques for Seaweed Farming and its Carbon Storage Potential in Climate-Resilient Aquaculture Along the Kutch Coast, Gujarat

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The impacts of climate change have posed serious challenges to coastal ecosystems, fisheries, and aquaculture, calling for innovative and resilient strategies to mitigate environmental stresses. Seaweed farming has emerged as a climate-resilient practice that not only provides ecological benefits, such as carbon sequestration but also serves as a sustainable livelihood option for vulnerable coastal communities. By absorbing CO, and acting as natural biofilters, seaweed farms contribute significantly to reducing greenhouse gas emissions, supporting global climate change mitigation efforts, and enhancing the resilience of aquaculture systems to climate-induced fluctuations. This study explores the effectiveness of two seaweed cultivation techniques: Net Tube and Monoline, along the Kutch coast of Gujarat, to determine their potential for growth and contribution to climate-resilient aquaculture. Field trials conducted at Juna Bandar, Luni, and Jarapara revealed that the Monoline method demonstrated superior growth performance compared to Net Tube, showing a 1.14-fold increase in yield which has more carbon storage potential. This improvement is attributed to better sunlight availability, reduced epiphyte colonization, and minimized debris accumulation. The highest growth rates were observed at Juna Bandar, highlighting the site's suitability for large-scale sustainable seaweed cultivation. Our study emphasizes the significant potential of seaweed farming, particularly the Monoline technique, in contributing to climate change mitigation by enhancing carbon storage capacity in marine ecosystems. It promotes climate-resilient aquaculture, offering sustainable livelihoods, enhancing ecosystem services, and informing policies for scalable, nature-based solutions to combat climate-induced challenges.

Keywords: Seaweed farming, Carbon storage, Climate Resilient aquaculture, Net Tube, Monoline, Climate change

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Impact of Climate Change, and Smart Aquaculture for Resource Use Efficiency

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Climate change presents significant challenges to global aquaculture production, including rising sea temperatures, ocean acidification, and extreme weather events. These factors disrupt marine ecosystems, impact fish health and growth, and reduce overall productivity. This extreme weather leads to many changes such as disrupted growth patterns, adverse physiological changes, altered or poor reproductive performance, etc. To address these challenges and ensure sustainable aquaculture practices, the adoption of smart aquaculture technologies is essential. Here we explore the multifaceted impacts of climate change on aquaculture and highlight the potential of smart aquaculture systems to enhance resource use efficiency. Smart aquaculture incorporates advanced technologies such as IoT, data analytics, and automation to optimize feed management, water quality control, and energy consumption. By leveraging these technologies, aquaculture producers can mitigate the negative effects of climate change, reduce environmental footprint, and improve economic viability. This study delves into specific strategies, including precision feeding, recirculating aquaculture systems (RAS), and climate-resilient aquaculture infrastructure, that can be implemented through smart aquaculture to enhance resource utilization and promote sustainable aquaculture practices.

KEYWORDS: Climate change, Aquaculture, Advanced technologies, Sustainable

Enhancing Carbon Capture Through Advanced Seaweed Farming Technologies in the Gulf of Kutch, Gujarat: A Pathway to Sustainable Development Goals

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Seaweeds are marine macrophytes that play a vital role in ecosystems by providing habitat, oxygen, and facilitating carbon sequestration. As part of the blue carbon ecosystem, seaweeds capture and store organic carbon in coastal waters, contributing significantly to carbon storage. Although most seaweed farming focuses on biomass production for industrial use such as bio-stimulants, agar, and carrageenan, it plays an essential role in reducing carbon footprints by replacing carbon-intensive materials. While seaweed cultivation offers shortterm carbon sequestration due to frequent harvests, it offsets emissions in industries like food, agriculture, and bioplastics. Additionally, seaweed farming improves livelihoods for coastal communities, supports food security, and contributes to achieving Sustainable Development Goals (SDGs) related to climate change mitigation, sustainable ocean, and responsible consumption. The study focuses on the cultivation of the commercially important red seaweed species *Kappaphycus alvarezii* at five sites along the Gulf of Kutch: Kori, Padala, Juna Bandar, Luni, and Jarpara. A total of 100 customized HDPE rafts, each covering an area of nine square meters, were deployed at these sites, utilizing the net tube and monoline method for efficient seaweed cultivation. Collectively, the sites produced over 24.5 metric tonnes of seaweed biomass during the period from October 2023 to May 2024, with varying cultivation durations across different locations. Using the dry weight method, carbon storage assessments revealed a total of 688 kg of carbon stored across all sites. These findings underscore the role of seaweed farming in assisting net zero emissions by capturing substantial amounts of carbon in marine ecosystems. By integrating seaweed cultivation into broader carbon sequestration strategies, we can enhance long-term carbon capture, reduce atmospheric CO, levels, and mitigate the impacts of climate change. Seaweed farming also offsets emissions by replacing carbon-intensive products, promoting ecosystem resilience, and supporting global sustainability efforts.

KEYWORDS: Carbon sequestration, Blue carbon ecosystem, SDGs, Seaweed farming, Climate change mitigation

Effects of Sublethal Low Water Temperature on Hormonal Profiles of *Clarias magur*

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Environmental temperature plays a key role in regulating the fitness as well as the distribution of the organisms. The present study aimed to evaluate the changes in the hormonal profiles of *Clarias magur* specimens after exposure to sublethal cold temperature in temperature-controlled water re-circulatory system for 15 days, along with the control individuals maintained at 26°C. Cortisol is a steroid hormone that helps the body to respond to stress and fight infections. Plasma cortisol levels have been used to evaluate the stress response in a variety of cultured fish species. The results showed an increase in serum cortisol and thyroxin levels for the first 10 days after which the cortisol decreased when compared to the control. The findings could be used as a marker indicator to know the adaptive capability of *C. magur* in the climate change scenario, and these studies also can be used for the selection of sites for culture and introduction of this species in the colder agro-climatic zone.

KEYWORDS: Clarias magur, Temperature, Stress, Hormone, Climate change

Carbon Budget Along the Southwest and Southeast Coast of India as Influenced by the Ocean-Atmospheric Parameters

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The carbon biogeochemical cycle along the southwest and southeast coast of India during 2023 was investigated at three bathymetric stations (5 m, 10 m and 20 m). The carbon flux, known to be affected by climate change, was studied off-Cochin on the southwest coast and off-Mandapam on the southeast coast, following standard oceanographic protocols. Surface partial pressure of carbon dioxide (pCO₂) was calculated with the CO₂SYS software, based on measured salinity, temperature, pH, total alkalinity (TA), and dissolved inorganic carbon (DIC). The study revealed contrasting DIC variations, with the lowest levels in off-Cochin recorded from May to October (426.35 µmol/kg to 1024.88 µmol/kg) because of the strong positive relation with salinity and high freshwater efflux as well as the low surface oxygen (5.6 to 7.6), while DIC remained consistent off-Mandapam throughout the study period. However, both coasts observed a strong increase in DIC value over the pre and post-monsoon seasons. It was observed that the freshwater influx reduces the salinity and pCO₂ values in the innermost station compared to the outermost stations. This might result in comparatively high pCO, water towards the outermost stations, which can be attributed to the shifts in phytoplankton community structure in the water column. The analysis indicates a relatively significant influence of physio-chemical factors over the spatial variation of the partial pressure of CO, in the southwest and southeast coastal waters. The study offers insights into the carbon budget of off-Cochin and off-Mandapam coastal waters by examining the dynamics and consequences of the carbon biogeochemical cycle and subsequently assessing the sustainability of the food web in these coastal waters. This has wider ramifications as climate change is understood to increase the quantity and intensity of rainfall in this area influencing the salinity pattern which in turn could impact the biogeochemical cycle of carbon.

KEYWORDS: Carbon flux, Dissolved inorganic carbon, pCO2, Physio-chemical property

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Towards a Climate-Resilient Aquaculture Future: Integrative Approaches for Sustainability and Food Security

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The increasing effects of climate change pose challenges for the sustainability of aquaculture, impacting ecosystems, production efficiency, and the health of cultured species. Adapting aquaculture practices to meet these challenges requires a combination of innovative technologies, management strategies, and supportive policies that prioritize resilience and long-term sustainability. Key technological interventions include improved genetic breeding for climate-tolerant species, integrating alternative energy sources, and implementing Recirculating Aquaculture Systems (RAS) to reduce environmental impacts. Additionally, the use of blue carbon ecosystems, such as mangroves, tidal marshes, and seagrasses is crucial for sequestering carbon and mitigating greenhouse gas emissions. Nutrition is another essential factor in species resilience, with bioenergetic models helping to optimize dietary requirements under fluctuating temperatures. Nutritional supplements like antioxidants and immunostimulants further enhance stress tolerance, supporting the adaptation of species under climate stressors. Biotechnology advancements, including selective breeding, gene banking, and molecular techniques like genomic selection, play a pivotal role in developing resilient aquaculture stocks with improved stress tolerance. Diversifying aquaculture systems is also vital; integrated approaches such as polyculture and Integrated Multi-Trophic Aquaculture (IMTA) enhance productivity, reduce waste, and support resource conservation. These systems offer significant adaptation benefits, particularly in regions where environmental conditions are becoming more unpredictable. Furthermore, promoting livelihood diversification and community-based adaptations can help build resilience among small-scale producers, who often face greater challenges due to limited resources and adaptive capacity. To enhance adaptive capacity, insurance schemes, and other financial support mechanisms offer security against climate-induced losses. Complementing scientific knowledge with indigenous insights into local environmental changes can also strengthen resilience strategies. Ultimately, while adaptation is essential for maintaining aquaculture productivity and resilience, reducing greenhouse gas emissions remains critical for mitigating climate change itself. This holistic approach, combining technology, diversified practices, supportive policies, and financial incentives, is essential for building a climate-resilient future for aquaculture and securing its role in global food security.

KEYWORDS: Blue carbon ecosystems, Carbon sequestration, Selective breeding, Greenhouse gas emissions



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Effect of Hyperthermal Stress on the Social Behaviour and Growth Performance of All-Male Genetically Modified Farmed Tilapia

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The present study investigated the effects of social hierarchy and hyperthermal stress on the growth performance, behaviour, and physiological responses of all-male *Oreochromis* niloticus in the face of global warming. Fish were assigned to social groups with varying social conditions, such as small-sized fish groups (Sg) (10-12 individuals), small-sized fish solitary (Ss) (1 individual), large-sized fish groups (Lg) (5 individuals), large-sized fish solitary (Ls) (1 individual), and mixed groups with one large-sized fish (LSL) and smallsized fish (LSS) (5 individuals). These groups were then subjected to ambient temperatures (29±0.5°C) and high temperatures (34±0.5°C) to assess the impact of social stress in combination with thermal stress. Elevated temperatures did not affect survival rates but adversely affected growth. However, grouping fish, especially with larger males or in mixedsize groups, resulted in mortality due to high aggression and increased fighting. Smaller tilapia experienced reduced stress and showed better growth when grouped, whereas Lg and LSS tended to experience more stress and performed less efficiently. Thermal tolerance, as measured by CTmax, was higher in the high-temperature group. Gill ventilation rates increased (p<0.05) in the high-temperature group and varied among social groups. Serum testosterone levels were unaffected by temperature, while cortisol levels increased (p<0.05) in the high-temperature group. Small fish in the mixed group and large fish in the groups showed increased cortisol levels, while the Ss group showed decreased cortisol levels. The results demonstrated that both temperature and social hierarchy impacted behaviour, survival, growth, and physiological responses, and social stress exacerbated the effect of high temperature. Thus, social hierarchy is critical in shaping the growth and physiological resilience of O. niloticus in aquaculture systems, particularly in the face of rising global temperatures.

KEYWORDS: Global warming, Social hierarchy, Thermal tolerance, Gill ventilation, Testosterone

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Tipping Temperature: Insights to the Thermal Tolerance and Cellular Responses of the Green Seaweeds Along the Coasts of Maharashtra, India

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Seaweeds are important floral resources that play a vital role in intertidal ecosystems and offer various ecosystem services. Increased anthropogenic intervention, industrialization, and climate change are impacting seaweed diversity. In the present study, *Ulva lactuca* from thermally non-polluted and *Ulva lobata* from thermally polluted sites along the West Coast of India were grown at 25°C, 30°C, 35°C and 40°C temperature gradients in an indoor culture experiment maintained for 21 days to understand the effect of temperature on the growth and morphology of the *Ulva* spp. The findings showed a significant difference in the daily growth (DGR) rate of *U. lactuca* and no significant difference in the DGR of *U. lobata*. The U. lactuca showed a maximum DGR of 4.31% in the treatment subjected to 25°C and the lowest DGR at 35°C and 40°C. In *U. lobata*, the maximum DGR was observed at 25°C of 3.52%. Growth declined with consistent exposure to the temperature treatment after 7 days at 30°C, 35°C, and 40°C, and showed negative growth. The thallus width of the *U. lactuca* and *U. lobata* in the present study was 114.13µm and 63.60 µm at 25°C, respectively. There was little variation in the thallus thickness between the wild and the cultured at 25°C. This indicates that the optimum temperature for healthy growth for *Ulva* is 25°C. The thallus cell length of *U. lactuca* and *U. lobata* was 40.8 µm and 29.10 µm, whereas the thallus cell width was 14.36 µm and 14.43µm respectively. The thallus cell length and cell width decreased with an increase in temperature. The increasing temperature variations in the intertidal areas impact the growth of the seaweeds and their propagation. The release of the thermal effluent in the intertidal regions of the study area was interval-based, due to which the impact of temperature on the seaweed growth in the wild was understood to be neutralized. However, continuous exposure to the increased temperatures due to increased effluent discharge may certainly impact the green seaweed growth and propagation, affecting the intertidal ecosystem on par with the extreme climate change scenario.

KEYWORDS: Seaweeds, Ulva lactuca, Ulva lobata, Thermal pollution, Growth, Thallus

Salinity-Dependent Changes in Branchial Morphometry and Na⁺, K⁺-ATPase Responses of the Giant Grouper (*Epinephelus lanceolatus*)

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The giant grouper (*Epinephelus lanceolatus*), a stenohaline teleost, is widely distributed in tropical and subtropical waters and holds significant economic value in aquaculture. Although classified as stenohaline, meaning it generally prefers stable salinity levels, the giant grouper shows an impressive tolerance to a broad salinity range, surviving in brackish waters with salinities as low as 11% and tolerating higher salinity levels up to 41%, such as those found in the Red Sea. Despite this adaptability, there is limited knowledge on how the giant grouper physiologically adjusts to various salinity conditions. This study aims to explore the osmoregulatory mechanisms that allow the giant grouper to survive in fluctuating salinities. Specifically, it will focus on examining the morphology, density, and distribution of ionocytes within the gills and assessing the expression levels of Na+, K+-ATPase (NKA) protein, a key enzyme in ion regulation. By detailing the role of ionocytes and NKA in osmoregulation, this research provides the first comprehensive analysis of the giant grouper's adaptation strategies in diverse salinity environments, offering insights beneficial to both ecological studies and aquaculture practices.

KEYWORDS: Salinity-dependent changes, Branchial morphometry, Giant grouper

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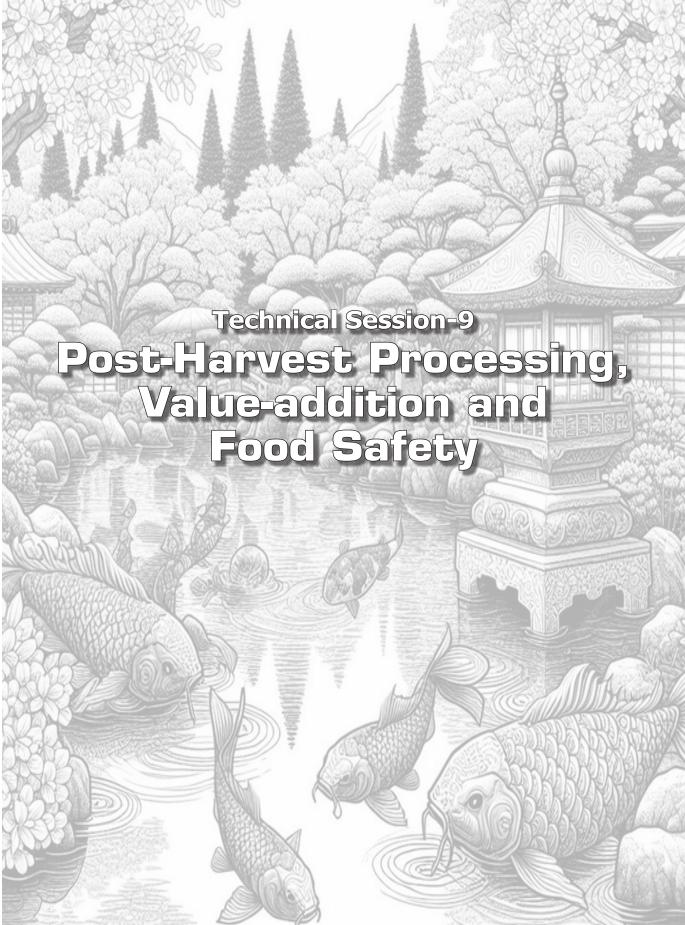
Greening Aquaculture's Blue Growth through Nature-based Climate Solutions

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Aquaculture is highly affected by climate change, so adaptation innovations and planning for the sector are urgently needed. As a low carbon food source, aquaculture can also help mitigate climate change, and aquatic ecosystems can play a role in carbon sequestration. In this panel, we consider the role of nature-based solutions (NbS) in meeting these climate challenges. Speakers share lessons from their research with the International Development Research Centre's (IDRC) AQUADAPT initiative co-funded by IDRC and the Government of Canada. First, we consider climate impacts on aquaculture across Asia-Pacific. These include warming water, ocean acidification and deoxygenation, increased risks from disease and harmful algal blooms, extreme weather events, and fluctuations in water resources. Second, we consider how these regional changes are experienced "on the ground" through site and population-specific impacts. Small-scale producers, Indigenous people, and Pacific islanders are especially vulnerable to these shifts. Climate hazards also have gendered impacts. Women often occupy the lowest paid and least recognized segments of aquaculture value chains, which limits their adaptive capacities. Third, what is the climate resilience potential of NbS? In aquaculture, nature-based climate solutions include selecting salt or heat-tolerant species, protecting ecosystems that support resilience like mangroves, adopting mixed aquacultureagriculture systems that recycle nutrients and water, and diversifying production through integrated multitrophic aquaculture. NbS are already showing promising results in achieving adaptation and mitigation outcomes across aquatic ecosystem. Yet, their readiness forwider adoption is uneven. NbS must also address gender and social inequities. Finally, we consider what would be needed to mobilize the ambition to scale-up these solutions. While aquatic ecosystems are receiving increased attention in climate negotiations, finance has not kept up. Few adaptation plans for the sector exist—let alone those that integrate NbS and prioritize gender equality and social inclusion (GESI). Marginalized producers may need financial incentives or access to credit to facilitate independent NbS uptake. Given these challenges, what would it take to harness the public and private sectors to "green the blue growth" through NbS while ensuring that GESI is at the core of these efforts?

KEYWORDS: Climate resilience, Aquatic ecosystems, Gender, Biodiversity, Regenerative aquacultur





Transforming the Future of Marine Waste Resources: A Blue Biorefinery Approach towards Circular Economy

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According to FAO, marine by-products represent up to 70% of the whole fish/animal that are often discarded. However, such by-products serve as a good source of valuable biomolecules. Irregular dumping of such processing discards also creates environmental concerns if dumped irregularly in the oceans or in landfills. Hence, processing discards become a significant challenge for processing plants and hold a greater potential to serve as a source of high-value components in functional food, nutraceutical, pharmaceutical, and cosmeceutical sectors. Due to the rich biochemical constituents and multiple health benefits of marine by-products, more and more in-depth research has been carried out in recent years. The focus of this talk is to highlight the intense applied research work of Marine Bioprocessing group of CASD (Centre for Aquaculture and Seafood Development), Marine institute on utilization of marine wastes as value-added products implementing biorefinery approach, focusing on their use in innovative manners or via extraction, identification, isolation, and characterization of high-value compounds and study of their beneficial effects on human health, food preservation, and cosmeceutical product formulation in order to ensure full utilization of the resources in a circular economy.

KEYWORDS: Marine waste, Biorefinery, Circular economy

Optimization and Evaluation of Fish Patty Fortified with Dietary Fibre

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A standard fish patty was processed from Pangasionodon hypophthalmus using three formulations: S1 (10% smashed potato), S2 (3% corn flour), and S3 (15% smashed potato). These patties were cooked using grilling, oven cooking, or a combination of both. Cooking characteristics such as yield, loss, fat retention, and shrinkage were measured. S2 grilled exhibited the highest cooking yield, while S3 oven-cooked had the lowest. S2 ovencooked showed the lowest cooking loss, whereas S1 grilled plus oven had the highest. S3 grilled retained the most fat, while S3 oven-cooked had the least. Finally, S2 oven-cooked experienced the least shrinkage, and S1 grilled plus oven had the highest shrinkage. Colour values (L*, a*, b*) varied with cooking methods. S3 had the highest L* in grilling and oven cooking, while S1 had the lowest. S1 had the highest redness (a*) in grilling, and the lowest in grilling. S1 had the highest vellowness (b*) in grilling, and S2 was the lowest in grilling. Texturally, S2 oven-cooked was the best, being softer, firmer, less chewy, and less adhesive. Raw patties had higher moisture, while cooked patties had higher protein. S1 had the highest lipid content post-cooking, and S2 had the highest ash content. Sensory scores by an experienced panel rated S2 oven-cooked as the best formulation, making it the standard for further studies. This standardized patty (S) was fortified with dietary fibers: apple (AF), oatmeal (OF), and ragi (RF). These were analyzed for water-holding capacity, fat retention, moisture %, and texture. AF had the highest water-holding capacity and moisture retention, while the control had the least. The control absorbed the most fat, and AF the least. AF-enriched patties had the best texture attributes. Based on functional properties, AF was selected as the best dietary fibre-enriched fish patty.

KEYWORDS: Texture, Cooking methods, Formulations, Sensory scores, Water holding capacity

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Nutritional Profile and Compositional Characteristics of Deep-sea Shrimp *Penaeopsis jerryi* from the Arabian Sea

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The proximate composition, amino acid, and fatty acid profiles were analyzed in the deep-sea shrimp *Penaeopsis jerryi* from the Arabian Sea, with a focus on gender differences. This study presents the first comprehensive analysis of the nutritional profile of *P. jerryi*. The proximate composition followed the order: moisture > protein > fat > ash. Male prawns had a higher moisture content, while females showed higher levels of protein, fat, and ash. Gas chromatography (GC) analysis revealed that palmitic acid (16:0), oleic acid (18:1n-9), and the n-3 fatty acid 22:6n-3 (docosahexaenoic acid) were the dominant saturated, monounsaturated, and polyunsaturated fatty acids, respectively, with higher concentrations in females. Seventeen amino acids, including essential and non-essential types, were identified in the muscle tissue. Glutamic acid and lysine were the predominant non-essential and essential amino acids, respectively, and were more abundant in females. Overall, the combined analysis of proximate composition, fatty acids, and amino acids highlights the presence of valuable nutrients in the edible tissues of *P. jerryi*.

KEYWORDS: Proximate composition, Nutritional analysis, Fatty acid profile, Amino acid profile, Seafood nutrition

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Fish Processing Industries in India: Growth and Productivity Aspects

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As the third-largest fish and aquaculture-producing country, India's fish processing industry stands as a core sector interconnected with fisheries. It adds value to the fish and seafood products harvested through processing, packaging, and distribution activities. The fish processing industry not only enhances the self-life and marketability of seafood but also creates additional employment opportunities and generates revenue for the economy. The core idea of the paper is to evaluate the productivity of India's fish processing industry using Annual Survey of Industries (ASI) data. The literature lacks sufficient studies on the productivity levels of the fish processing industries. However, a comprehensive investigation is necessary to fully understand the dynamics of this sector and its productivity levels. The paper measures trends in industries, partial productivity and total factor productivity (TFP) growth. To address the endogeneity problem in the TFP measurement, a Levinsohn-Petrin (LP) method is used. A mixed pattern of growth is observed across different industries within the fish processing sector. Industries like fishmeal production and crustacean processing showed significant growth, and the other industries such as radiation preservation of fish, saw declines. The industries exhibited a positive trend in productivity, highlighting opportunities for increased investment and technological advancements. A substantial yearto-year TFP growth indicates the industry's sensitivity to both external and internal factors. The study emphasizes the need for strategic investments and innovation to sustain and boost productivity in India's fish processing industry.

KEYWORDS: Levinsohn-Petrin method, Productivity, Nutrition, Total factor productivity

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CFD Analysis of Smoke Flow and Heat Distribution in A Fish Smoking Chamber

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Smoking preserves fish through heat treatment, drying, salting, and deposition of phenols from burning wood. Efficient fish smoking requires a properly designed smoking kiln, with modern kilns incorporating smoke flow and heat exchange systems to remove moisture. This study utilizes Computational Fluid Dynamics (CFD) to improve the design of a fish smoking chamber by analyzing factors like chamber geometry, smoke inlet positioning, heater placement, and blower systems. The goal is to enhance smoke flow efficiency and uniformity, reducing hot spots, dead zones, and uneven temperature distribution before physical implementation. This method saves time and resources, supporting the development of superior designs. The study used ANSYS software to simulate smoke flow and temperature distribution within a 3D model of a smoking chamber created in Fusion 360. After meshing the geometry into finite elements, boundary conditions mimicking real-world scenarios were applied, including velocities, pressures, and thermal conditions. Initial simulations at 1 m/s smoke inlet velocity and 80°C inlet temperature revealed uneven smoke distribution and blind spots in the lower tray areas (0-1.35 m/s), even though the temperature contour was satisfactory. Increasing the inlet velocity to 5 m/s improved flow slightly but did not resolve blind spots due to sharp chamber corners. Design modifications, such as reshaping the smoke inlet from round to oval and rounding the corners of the smoke-directing plates, enhanced smoke flow but challenges remain. Further adjustments reduced the gap between trays and smoke-directing plates to minimize pressure differences. Simulations with 5 m/s smoke velocity and 80°C temperature resulted in more uniform smoke flow (1.781-3.862 m/s) and satisfactory temperature distribution (80°C), though the exhaust conditions required improvement. The results of the CFD simulation showed that the temperature contour was 80°C, the smoke flow at tray areas was between 1.7 and 2 m/s, where the inlet velocity was 3 m/s and the exhaust velocity was 2 m/s indicating the necessity to increase smoke inlet velocity slightly. Based on CFD results, the chamber's dimensions were modified from 1000×1500×590 mm to 1000×1210×645 mm. CFD proved effective in refining the smoking chamber design, emphasizing the importance of iterative simulation and adjustments for better performance.

KEYWORDS: Airflow, Computational fluid dynamics, Design modification, Fluid flow efficiency, Smoked fish



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Pilot Scale, Conveyor Type Infrared Dryer with Hot Air Assistance for Fish Drying: Development and Performance Evaluation

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Infrared (IR) radiation drying is highly appropriate for the thin-layer drying of food materials with a larger surface area exposed to IR radiation. IR radiation has many benefits above convection heating methods such as greater heat transfer, shorter process time, and lesser energy. However, the use of combined IR and hot air heating is reported as the efficient method since it gives a synergistic effect. On the other hand, continuous conveyor-type dryers are essential equipment in the food industry since they offer a convenient and cost-effective drying process for the preservation of food products. Hence, a conveyor-type infrared dryer with hot air assistance was designed and fabricated for fish drying purposes. To evaluate the performance of the developed dryer, the clam samples (Villorita cyprinoides) were dried using the IR dryer at various IR intensities (1500 and 3000 W/m²), air temperature of 55°C, and IR source distance of 10 cm. The drying kinetics curves were plotted and the physical, quality parameters were evaluated in the clams dried at two IR intensities. The drying time of 5 h and 4 h were noted for the clam dried at 1500 and 3000 W/m², respectively to attain the required final moisture of 10-15% wb. An increase in IR intensity increased the drying efficiency (52.42%) and decreased the time of drying (25%) and specific energy consumption (76.65%). The Midilli model showed the best fit to explain the drying characteristics of the clam in an IR dryer at both intensities with the highest R² values (0.9999), and lowest RMSE $(6.23 \times 10^{-5}, 9.38 \times 10^{-5}), \chi^2 (8.90 \times 10^{-6}, 1.88 \times 10^{-5})$ values. The developed dryer is found to be suitable for commercial-level production of dried clam in continuous mode.

KEYWORDS: Conveyor type, Clam drying, Drying characteristics, Infrared dryer, Modelling

Exploring the Potential of Carbon Nanodots (CND) Synthesized from Fish Eyes to Enhance the Shelf Life of Chilled Indian Mackerel (*Rastrelliger kanagurta*)

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The study extensively investigated the use of carbon nanodots (CNDs) in preserving the quality and shelf life of chilled mackerel fish. Analysis of sensory attributes, chemical composition, microbiological characteristics, and antibacterial properties highlighted the efficacy of CNDs as a preservation agent. CND-incorporated iced (CNDI) fish consistently outperformed control samples, exhibiting higher sensory scores, better chemical quality, and lower microbial counts. The CND-incorporated iced samples maintained excellent sensory attributes and chemical composition for a longer duration, with noticeable deterioration only by the 18th day, whereas control samples began deteriorating by the 9th day. The results indicate that CND-incorporated iced samples maintained superior quality parameters, significantly delaying spoilage. This delay in deterioration is attributed to the antibacterial and antioxidant properties of CNDs, which inhibited microbial growth and reduced lipid oxidation. The findings suggest significant benefits for the seafood industry, offering a promising solution to extend the marketability and consumer acceptability of chilled mackerel fish. The use of CNDs can effectively preserve the quality, safety, and shelf life of seafood products under refrigerated storage conditions. The present study holds promising implications for the seafood industry and future research endeavors. By demonstrating the efficacy of CNDs in inhibiting microbial growth, reducing lipid oxidation, and preserving sensory attributes, this study contributes to advancements in seafood preservation technology.

KEYWORDS: Quality parameters, Consumer acceptability, Seafood industry

A Smart Portable Device for Rapid On-Site Assessment of Fish Freshness

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Fish freshness is generally determined by sensory assessment which is highly subjective, thus requiring an objective instrumental method. Hence, the study was formulated to develop a handheld, portable device for non-destructive real-time evaluation of the quality and freshness of fish using image processing and a machine learning approach. The fresh fish samples were subjected to iced storage under hygienic conditions. The variations in the eye region of fishes indicated different stages of edibility and spoilage during storage. The fish images were captured daily and the data set was created to obtain valid reference data for freshness classification. Simultaneously, destructive laboratory fish quality analysis was carried out using biochemical and microbial approaches and later correlated with deep learning results. The daily acquired images were pre-processed, augmented and the eve region was segmented using open CV. The deep learning models were trained using MATLAB software. The optimized model is transferred to the Raspberry Pi-based portable device for the rapid onsite assessment of the fish freshness. The portable device consists of a raspberry-Pi micro-computer, arduCam camera module, liquid crystal display, a pi-sugar 2 pro portable power platform and a 3D printed outer cover. The micro-computer is flashed with the latest version of Ubuntu and an algorithm is written to execute the testing of samples in the trained deep-learning model using NumPy and TensorFlow Lite libraries. The test results for Indian Mackerel, GIF tilapia and Sardine showed that the portable device with algorithm and optimized model predicted the "days after caught" and "remaining shelf-life (days)" and classified the freshness level of fish into "Extremely Fresh, Fresh or Spoiled" with an average prediction accuracy about 74 - 83.21%. The methodology can be adapted to different fish species and can provide practical solutions to consumers for the freshness assessment of fish.

KEYWORDS: Deep learning, Recurrent neural network, K-value, Psychrotrophic count, Raspberry-pi

Influence of Glycerol on the Enhancement of Functional Properties in Apple Pectin/Konjac Glucomannan/Fish Myofibrillar Protein Composite Films

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In recent years, the development of biodegradable films has gained significant attention due to the environmental concerns associated with synthetic plastic films. This present study investigates the formulation of biodegradable films using apple pectin, konjac glucomannan (KGM), and fish myofibrillar protein (FMP), with glycerol serving as a plasticizer. The physical properties of the films, including moisture content, thickness, pH, total soluble matter (TSM), swelling power (SP), color characteristics, stability in frying oil, light transmittance, and opacity of the films, were thoroughly analyzed. The initial moisture of the film was 10.93%, decreasing with 20-30% glycerol, then increasing at higher concentrations. The findings suggest glycerol's hydrophilic nature influences moisture retention, indicating an optimal threshold for film formulation. The film thickness ranged from 0.154 mm (control) to 0.275 mm (50% glycerol), indicating that glycerol acts as a plasticizer, enhancing film volume and solubility while reducing transparency. Further, the pH of the films decreased from 3.24 to 3.04 with increasing glycerol concentration, suggesting potential benefits for stability and microbial resistance. TSM was highest in the control film (54.17%) and significantly reduced with glycerol addition, indicating improved film integrity. The SP decreased with higher glycerol concentrations, enhancing dimensional stability in moist conditions. The films exhibited varying L* (lightness), a* (red-green), and b* (yellow-blue) values, with Treatment C showing the highest lightness ($L^* = 81.59$) and Treatment T3 displaying the lowest lightness ($L^* = 78.92$). The a* values indicated a slight reddish hue in the control film (C) and a stronger red hue in T3. The b* values revealed a vellowish tint in C and a more pronounced yellow in T3. Increasing glycerol concentrations generally enhanced redness and yellowness while affecting lightness subtly. The hue angle remained consistent across treatments, indicating minimal influence from glycerol. Additionally, the films demonstrated effective light barrier properties, crucial for food preservation, with lower transmittance values observed at higher glycerol concentrations. Overall, glycerol's role as a plasticizer and its impact on the physicochemical properties of the films highlight its importance in developing effective biodegradable packaging materials.

KEYWORDS: Biodegradable film, Glycerol, Plasticiser, Apple pectin, Konjac glucomannan

Development and Quality Assessment of High-Protein Meat Powder and Instant Soup Mix from An Underutilized Bivalve, *Meretrix meretrix*

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Meretrix meretrix is an underutilized bivalve resource of Indian waters. Being an affordable source of good quality protein, clams have great potential for developing protein-rich powder. The present study investigates the potential of *M. meretrix* for the preparation of high-protein powder and ready-to-cook soup mix to enhance its utilization. Dried clam powder was prepared from Asiatic hard clam following popular pre-cooking methods and its nutritional and physicochemical qualities were evaluated. The yield of dried clam powder from raw clam meat was 8-10% with a protein content of nearly 70% on a wet-weight basis. Instant soup mix was prepared using clam meat powder and steam-cooked clam meat. The soup mix had a protein content varying from 6 to 13% and showed excellent organoleptic qualities. The reconstitution properties of steam-cooked clam meat soup were better than those prepared from clam meat powder. Instant soup prepared with cooked clam meat had superior nutritional qualities compared to the soup mix prepared with dried clam meat powder. The soup mix had a shelf life of 6 months at ambient temperature. The results from the study demonstrated the potential of preparing nutritionally rich meat powder and instant soup mix from *M. meretrix*, unveiling its enhanced utilization in the food industry.

KEYWORDS: Meretrix meretrix, Pre-cooking, Meat powder, Nutritional profile, Instant soup mix

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Rapid Softening of Mantis Shrimp Meat During Iced Storage: Role of Endogenous Proteases and its Prevention

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Harpiosquillid mantis shrimp (Harpiosquilla raphidea) (HMS) is a typical delicacy of southern Thailand. Rapid texture softening is a major problem associated with quality loss and consumer dissatisfaction. When endogenous proteases in muscles and the digestive tract were monitored during the iced storage, trypsin, mainly from the digestive tract, played a profound role in protein degradation, while cathepsins L and L+B had a negligible impact on the hydrolysis of muscle proteins. Trypsin showed maximal activity at pH 8.5 and 55°C when BAPNA was used as the substrate. SEM and histology analysis revealed significant destruction of muscle arrangement during the extended iced storage. Proteases, especially trypsin, correlated well with the losses in firmness and toughness, mainly due to the enhanced degradation of myofibrillar proteins and collagen. Those phenomena resulted in the undesirable pasty/mushy texture within 3 days of iced storage. To tackle the softening of HMS meat, HMS samples without and with decapitation and pre-treated with a pulsed electric field (PEF) (15 kV/cm, 800 pulses, 5 min) were subsequently soaked in chitooligosaccharide (COS) solution at varying concentrations (0, 1 and 2%, w/v) for 20 min before storage in iced water. It was noted that decapitated HMS pre-treated with PEF and soaked in 2% COS solution showed the maximum efficacy in inhibiting trypsin activity and proteolysis, thus retaining muscle proteins, especially myosin heavy chain, actin and troponin T. The reduction of shear force was minimized up to 3 days of iced storage. In addition, the aforementioned treated samples had the lowest psychrophilic bacterial count and Enterobacteriaceae count at day 3, compared to the others. Thus, the combination of the prior PEF and 2% COS treatment of decapitated HMS could effectively inhibit proteases. retard microbial growth and maintain the quality, particularly textural property, of HMS stored in iced water within 3 days.

KEYWORDS: Proteolysis, softening, Mantis shrimp, Trypsin, Chitooligosaccharide, Iced storage, Decaptication

Development of aDNA Biosensor for the Authentication of Pacific White Shrimp (*Penaeus vannamei*) in Raw and Processed Shrimps

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Shrimps are important resources from both commercial fisheries and aquaculturein many countries, accounting for more than 30% of global consumption of seafood worldwide. The high demand and popularity of shrimp products have paved the way for species substitution in the commercial market. Identification of species becomes complicated once its external morphological identification characteristics are removed particularly in frozen and precooked shrimp products. Therefore, to prevent product substitution, there is a need for sensitive analytical methods that are fast and reliable for the identification of shrimp species. The present innovation encompasses the development of an impedimetric electrochemical sensor assay that involves the hybridization of target DNA to thiol-modified detector probes firmly anchored to the sensor surface. This method is designed to swiftly authenticate the presence of *Penaeus vannamei* in both raw and processed shrimp products. Notably, a species-specific sensor tailored for P. vannamei has been meticulously designed. This inventive approach boasts remarkable specificity, enabling precise species identification in raw as well as processed products. The assay operates with remarkable rapidity, delivering results within a time frame of an hour. This technology holds immense promise for adoption within food quality control laboratories and regulatory authorities, offering a robust defense against seafood fraudulence in international trade.

KEYWORDS: Biosensor, *Penaeus vannamei*, Seafood authentication, Mislabelling

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Emergence of Antibiotic-Resistant *Escherichia coli* in Seafood: A Threat to Public Health and Food Safety

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Escherichia coli, a Gram-negative bacterium from the family Enterobacteriaceae, typically resides as a commensal organism in the gastrointestinal tracts of warm-blooded animals. However, certain strains or lineages of E. coli have evolved into pathogens capable of infecting both humans and animals. This bacterium is frequently used as an indicator of fecal contamination in seafood. In the present study, fresh seafood sourced from landing centres and retail markets was investigated for the presence of antibiotic-resistant E. coli and the distribution of key antibiotic resistance genes. A total of 50 fresh seafood samples- 37 fish and 13 shellfish were analyzed for E. coli through sample homogenization and plating on MacConkey agar. From these samples, 475 E. coli were isolated, with 325 from finfish and 150 from shellfish. Of these, 340 isolates (71.58%) exhibited an extended-spectrum β-lactamase (ESBL)-positive phenotype, with a high percentage of isolates showing resistance to third-generation cephalosporins such as cefotaxime (95%), cefpodoxime (90.88%), and ceftazidime (90.29%). Conversely, higher susceptibility rates were observed against imipenem (74.41%), cefoxitin (66.76%), and meropenem (51.18%). Furthermore, 331 isolates (97.35%) demonstrated a multiple antibiotic resistance (MAR) index of \geq 0.18. The antibiotic resistance genes bla_{CTY} , bla_{SHU} , and bla_{TEM} were detected in 62.37%, 23.35%, and 2.6% of the E. coli isolates, respectively. ESBL-producing isolates also harboredmetalloβ-lactamase encoding genes, with bla_{OXA} detected in 7.06%, bla_{NDM} in 4.42%, and bla_{VIM} in 0.88% of the isolates. Conjugation experiments suggested that the bla_{NDM} gene could be horizontally transferred to a recipient E. coli strain. The survivability of \overline{bla}_{NDM} harbouring E. coli in shrimp (Metapenaeus dobsonii) was further investigated under frozen (-20±2°C) and chilled (iced) conditions through artificial inoculation. The bla_{NDM} -positive $E.\ coli$ strain (EC114) was able to survive for 60 days in frozen storage, with a 2.46 log CFU/g reduction in bacterial counts. In ice-stored shrimp, the bacterial counts decreased by less than 1 to 1.30 log CFU/g. This study highlights the significant risk of multidrug-resistant E. coli dissemination in seafood and emphasizes the urgent need to improve hygiene practices in coastal waters, landing centers, and retail markets to protect seafood consumers and public health.

Keywords: *Escherichia coli*, Antibiotic resistance, Seafood contamination, Extended-spectrum β-lactamase (ESBL), Public health risk



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Developing A Portable Near-Infrared Reflectance (NIR) Device and Machine Learning Algorithms for Onsite Authentication of Species Identity of Seafood

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Shrimps and squids are popular seafoods and traded globally through complex supply chains. After processing, these seafood products look morphologically similar. However, the price varies widely depending on the true identity and origin of the species. Hence, the cases of economically motivated mislabelling of these seafoods are growing worldwide. Recognising the problem, the European Union (EU) has made it mandatory to declare the species identity on seafood products. Authenticating species identity requires DNA or mass spectrometrybased assays in the laboratory. However, fishers, processors, and food safety officials need a rapid method that can be deployed on-site to authenticate the species identity immediately. Portable near-infrared reflectance (NIR) sensors and machine learning algorithms hold great potential in authenticating seafood species' identity on-site within seconds. In this study, we evaluated a low-cost digital light processing-digital micromirror (DLP-DMM) NIR sensor, and a microelectromechanical system (MEMS) NIR sensor on a Raspberry Pi board for the development of a portable device. NIR spectra of a large number of authentic samples of shrimps (Litopenaeus vannamei, Fenneropenaeus indicus, and Penaeus monodon) and squids (Uroteuthis singhalensis, Uroteuthis edulis, and Uroteuthis duvauceli) were recorded using the NIR sensors. After spectral filtering and data cleaning, the dataset was used to train five machine learning algorithms, namely gradient boosting machine (GBM), K-nearest neighbour (KNN), naive bayes (NB), partial least square discriminant analysis (PLS-DA), support vector machine-linear (SVM-L), and support vector machine-radial (SVM-R). Internal validation of the models with five-fold cross-validation showed that the GBM and SVM-L models performed best with cross-validation accuracy and Cohen's Kappa values of 1, indicating a near-perfect fit of the models for authenticating shrimp and squid species identity. For external validation, the dataset was randomly divided into a training set and a test set with a 70:30 ratio, respectively. The prediction accuracy of the training and test sets was similar for the GBM and SVM-L models, indicating that the models are not overfitted. The prediction accuracy achieved with the GBM model was 100% for the test set, proving the prediction accuracy for unknown samples of squids and shrimps.

KEYWORDS: Species mislabelling, Adulteration, Seafood authenticity, Shrimp, Squid



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Development of Innovative Synbiotics Incorporated with Unconventional Seaweed-Derived Prebiotics for Future Functional Food Applications

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Recently, there has been a significant global focus on developing synbiotic functional food products due to increased consumer demand for foods with enhanced nutritional and therapeutic values. Synbiotics are combinations of probiotics and prebiotics that work synergistically to promote a healthy balance of gut microbiota. Probiotics are live microorganisms that confer a health benefit on the host when administered in adequate amounts and prebiotics are non-digestible food components that promote the growth and activity of beneficial bacteria in the gut. The polysaccharides of marine seaweeds possess prebiotic potential and can thus serve as food for probiotic bacteria. However, polysaccharides in today's human diet originate primarily from terrestrial plant cell walls, while other sources, such as seaweeds, are less represented. In the present study, the crude polysaccharide from the red seaweed, Kappaphycus alvarezii was obtained by hot aqueous extraction and lyophilized. The yield of polysaccharides was 24.3%. The carbohydrate content was found to be 80.64%, while the reducing sugar content was 14.11%. The polysaccharide was whitish in colour and the values of colour parameters L*, a* and b* were 74.09, -0.24 and 4.97, respectively. The live probiotic strains of Lactobacillus rhamnosus were microencapsulated by lyophilization to enhance their stability and viability. The probiotic cell viability of the synbiotic microcapsules containing seaweed prebiotic was compared with those containing the commercial prebiotic, inulin. The developed synbiotic microcapsules were further incorporated into a finger millet (Eleusine coracana)-based instant non-dairy beverage/ porridge powder dried differently using a hot air oven (OD) and freeze dryer (FD). The OD sample exhibited a tapped density of 0.49 g/cm³ whereas the FD sample showed a tapped density of 0.32 g/cm³. The Carr Index (CI) value for FD was determined to be 21.30%, while a higher CI of 42.84% was reported in OD, indicating its poor flowability. The results revealed that synbiotic microcapsules containing seaweed prebiotics can maintain probiotic viability and extend the shelf life, which thus could be a convenient method to incorporate probiotic bacteria into dry food matrices.

KEYWORDS: Kappaphycus alvarezii, Lactobacillus rhamnosus, Finger millet, Seaweed polysaccharides

Importance and Potential of Microalgae: Future of Aquaculture (Sustainable Sources of Feeds), Industries (High Value-added Products) and Climatic Changes

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Microalgae can live in almost every habitat preferentially from aquatic environments to extreme conditions; including deserts, volcanic waters, and highly acidic and frozen soils. The so-called single-cell proteins are now recognized as the most significant components of the biotic systems. Therefore, studies and research have to be pursued globally based on their potential for various challenges from nutritional to high-value products through bioremediation, and clean air through algae trees, to energy. The oceans provide the most important and vital ecosystem services (OECD, 2022) to the entire world. The most critical of these services are food provision and the ocean's central role as managers of global climate apart from the fact that they alone contribute approximately 50% to the global net primary production and sequester roughly a quarter of anthropogenic CO₂ emissions (Le Quéré et al., 2014). Microalgae can convert atmospheric CO, into valuable products like carbohydrates, lipids, and other bioactive compounds which are the potential sources of numerous highvalue molecules like proteins or fatty acids, amino acids, and carotenoids. These high-value products (PUFA, DHA, EPA, ARA, etc.) from microalgae are unique and can be used as such or processed into feeds, health complements, medicines, cosmetics, pharmaceuticals, nutraceuticals, and biofuels and have diverse uses in aquaculture and in industries to provide nutrition and high-value molecules. The ability of algae to accumulate metals and reduce metal ions makes them a superior contender for the biosynthesis of nanoparticles, and hence they are called bio-nano factories. The array of other applications of microalgae in predicting the present climatic conditions by acting as the major tool for remote sensing and paving the way to future changes, renewable energy, biopharmaceutical, and nutraceutical industries with good market opportunities have recently attracted a lot of attention around the scientific world to culture it and make it superior to other sources. Interest in microalgae cultivation continues to increase based on its potential commercial value. Algae convert CO₂, nitrates, phosphates, and other nutrients into biomass that can be processed and used in many industries as a renewable, sustainable, and easily reproducible source of raw material for all these purposes.

KEYWORDS: Microalgae, Primary production, PUFA, DHA, Bioremediation



Effect of Proteolytic Enzyme on the Production of Hetero Chitosan Oligomers from Chitosan

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Chitin and chitosan are one of the major biopolymers derived from marine sources. Chitin and chitosan are versatile compounds that have applications in different fields. However, chitin and chitosan have their limitations in food, pharmaceutical, and biomedical applications due to their lower solubility in neutral pH. Chitosan oligomers (COS) are the depolymerized form of chitosan that has biological activities which include antimicrobial, antioxidant, and anti-inflammatory properties. These properties make COS a promising compound for various applications. In this study, the objective is to produce chitosan oligomers using a nonspecific proteolytic enzyme (pepsin). Low molecular weight chitosan was used for the production of chitosan oligomers (COS). COS was characterized by its physico-chemical, structural, thermal, and antioxidant properties. Chitosan oligomers from chitosan using pepsin enzyme showed a yield of 64.98% with a molecular weight of 5.1 KDa. The viscosity of the solution was decreased during depolymerization of chitosan. The structural variation of chitosan and COS was confirmed by Fourier-transform infrared spectroscopy (FTIR) Spectra. The thermal behavior of changes in chitosan and COS using Differential Scanning Calorimetry (DSC) showed changes in the glass transition temperature. The prepared COS was evaluated for its ability to scavenge the free radicals using a 2,2-Diphenyl 1-picrylhydrazyl (DPPH) radical scavenging assay. H-NMR spectra analysis showed the internal structural changes of COS. The DPPH activity was 74.49% at 5 mg/ml concentration. Similarly, higher antimicrobial activity was found in the COS against gram-negative bacteria (E. coli). The results of the present study provide knowledge about the use of proteolytic enzymes in the depolymerization process of chitosan for the production of hetero chitosan oligomers.

Keywords: Chitosan oligomers, Proteolytic enzyme, Depolymerization, Post-harvest processing, Value-addition

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Colorimetric LAMP and mPCR-LFD Assay: A Promising Approach for Rapid Identification of Commercially Important Crustaceans

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Seafood substitution has become a widespread problem in the global seafood market. Due to rising consumer demand, the global seafood trade is facing fraudulent practices regarding species replacement and intentional mislabeling, which ultimately compromise seafood safety and traceability. Among them, crustaceans hold considerable importance in the seafood industry. However, they are susceptible to adulteration practices by substitution with other closely related species due to relatively similar appearances. Therefore, efficient and accurate identification techniques for crustacean species must be developed to ensure precise labeling and preventing fraudulent activities. In this study, the species-specific C-LAMP (Colorimetric based loop-mediated isothermal amplification) and mPCR-LFD (Multiplex PCR combined with lateral flow dipstick) assays targeting the COI gene of three mussel and three crab species, including *Perna canaliculus*, *Mytilus galloprovincialis*, and *Perna viridis*, and Portunus pelagicus, Portunus sanguinolentus, and Charybdis feriata were developed, respectively. The LAMP and mPCR-LFD assay condition was optimized by varying the temperature and time. The developed C-LAMP assay provided accurate results at 63°C in 30 mins. The specificity was assessed, and the developed C-LAMP and mPCR-LFD assay showed no cross-reactivity among closely related species. The C-LAMP showed a higher sensitivity for *P. viridis* and *P. canaliculus*, with limits of detection of 0.003 and 0.01 ng/ reaction, respectively and the mPCR-LFD assay also achieved high sensitivity by detecting DNA concentrations as low as 0.1 ng, 0.006 ng, and 0.01 ng for blue swimming crab, threespotted crab, and crucifix crab, respectively. In-house validation of mussels and crabs was determined by using various treatments, which included boiling, steaming, frying, and canning at different time intervals. Outhouse validation of crab species revealed 28% mislabeling. From this study, three commercially important mussel and crab species were successfully authenticated using C-LAMP and mPCR-LFD under optimal thermal processing conditions. Therefore, the C-LAMP and mPCR-LFD assay developed in this study is simple, rapid, and cost-effective for authenticating seafood products. Hence, this novel technology serves as a promising alternative for routine fishery examinations to stakeholders, industry people, and regulatory authorities, which contributes to seafood safety and authenticity.

KEYWORDS: C-LAM, mPCR-LFD, Seafood adulteration, COI, Seafood authentication



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Turning *Echinorhinus brucus* Liver into an Omega-3 PUFA Rich Oil Source *via* Greener Extraction Protocol – A Detailed Insight

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Turning fishery waste into high value-added compounds has become a topic of significant interest globally. Bramble shark, which is often discarded as a by-catch, can be turned into a valuable commodity by extracting omega-3 PUFA-rich oil from their liver by adopting appropriate extraction techniques. The present study was hence carried out to bio-valorize Bramble shark (Echinorhinus brucus) liver via green extraction technique. Supercritical fluid extraction was selected as the green extraction method for the same. The effect of three variables, viz, extraction pressure, time and temperature on recovering superior-grade liver oil was investigated in detail to optimize the best extraction condition by employing RSM. Based on the results obtained from conducting 15 experiments, an extraction condition was optimized based on the high desirability score. The optimized extraction was found to be 400 bar pressure, 43.34°C temperature, and 5.45 h for isolation of squalene-rich shark liver oil. It can be concluded that supercritical carbon dioxide could be considered as an effective solvent for extraction of squalene-rich oil from shark liver. The method is environmentally friendly, requires less amount of solvents and is less time-consuming. Further, the oil extracted is found to be not only rich in squalene; but also rich in beneficial long-chain PUFAs such as EPA, DHA, AA; and most importantly, vitamin A and E in good concentrations; suggesting shark liver as a potential raw material for production of functional food formulations enriched with biomolecules of human health care significance.

KEYWORDS: Bramble shark, Supercritical fluid extraction, Eicosapentaenoic acid, Fat-soluble vitamins

Pathotype Distribution, Virulence and Antibiotic Resistance of Escherichia coli from Seafood of Retail Market of Veraval, Gujarat

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Foodborne outbreaks caused by seafood contamination with pathogenic E. coli are a growing global health concern. Escherichia coli is one of the most common enteric pathogens that cause intestinal illness in humans, with infections ranging from mild non-bloody diarrhoea to bloody diarrhoea, haemolytic uremic syndrome, and thrombotic thrombocytopaenic purpura. The present study aimed to determine the incidence of pathogenic E. coli in the seafood of Veraval, as well as their pathotype distribution, virulence genes, and antibiotic resistance. A total of 60 samples, comprising 40 fish and 20 shrimp, were collected from the retail market of Veraval, Gujarat. The results revealed that E. coli was present in 53 (88%) of the samples. Around 177 E. coli strains were isolated and analysed for pathogroupspecific virulence-associated genes using polymerase chain reaction (PCR), 45% of the strains possessed at least one or more virulence genes. Based on the distribution of virulence genes, 62 (35.0%) of the strains belonged to the enterohemorrhagic E. coli (EHEC) group, 12 (6.8%) to enteropathogenic E. coli (EPEC), 20 (11.3%) to enterotoxigenic E. coli (ETEC), 16 (9.03%) to enteroaggregative E. coli (EAEC), and 4 (2.25%) to enteroinvasive E. coli (EIEC). Antimicrobial susceptibility test of the strains against ten classes of antibiotics revealed that 25 (14.2%) of the strains showed multidrug resistance against more than five antibiotics, and the highest resistance was found against ampicillin, cephalexin, cefotaxime, and tetracycline. The presence of pathogenic and antibiotic-resistant E. coli in seafood is a potential threat to the handlers and consumers, and effective control strategies have to be undertaken to mitigate the risk posed by this pathogen.

KEYWORDS: Seafood, EHEC, Incidence, Multidrug resistance

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Influence of Brown Seaweed (Sargassum wightii) Inclusion on Nutritional Quality and Antioxidant Properties of Fish Crackers

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Seaweeds provide a variety of nutritional and bioactive benefits that can enhance human health when integrated into food products. Brown seaweed, specifically Sargassum wightii, commonly found along the Indian coastline, has significant nutritional and bioactive potential. This study aimed to produce fish crackers enriched with Sargassum wightii and assess their nutritional and antioxidant properties. The fish crackers were formulated using Sargassum wightii in two forms: flakes (SF) and extract (SE), at inclusion levels of upto 3%. The moisture content of all crackers ranged from 5.77% to 7.15%. The addition of Sargassum wightii increased the levels of protein, ash, and insoluble fiber in the fish crackers. Notably, the inclusion of the seaweed extract resulted in the lowest oil absorption rate (4.73%) and the highest total phenolic content (2.33 mg GA eq/g). All cracker formulations contained significant amounts of minerals, with sodium being the most abundant, followed by potassium and magnesium. 3% SF inclusion resulted in 29080 ppm sodium while 3% SE inclusion resulted in 30280 ppm of sodium in the fish crackers. Among trace minerals, manganese, copper, and boron were also present in notable quantities across all samples. Sensory evaluations indicated a higher preference for the crackers containing the seaweed extract, with ratings ranging from "Like extremely" to "Like very much" on a 9-point hedonic scale. The fish crackers with seaweed flakes had higher levels of bitter-tasting amino acids compared to both the control and the seaweed extract formulations. In conclusion, the findings suggest that the positive attributes of Sargassum wightii can be effectively utilized in fish products like crackers, particularly through the inclusion of its extract.

KEYWORDS: Seaweed flakes, Seaweed extract, Crackers, Amino acids, Antioxidant

Comparison of Liquid Form of Nano-ZnO-Chitosan Composite with its Powder Form for Biomedical Applications

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Most prior research has examined chitosan-ZnO-nanoparticles in liquid form (liquid composite) and suggested for food and medicinal applications based on their antibacterial properties. However, it has a major disadvantage i.e., inadequate solubility, which necessitates acidic conditions for more effective application. To overcome the shortfall, the ZnO-nanoparticle composite was transformed from a liquid to a powdered form by coating the ZnO-Nanoparticle with chitosan (powder composite), which was compared to the liquid composite. For better comparability in the research, ZnO-Bulk particles were further coated with chitosan and checked for antibacterial activity and cytotoxicity. The ZnO nanoparticles were synthesized by co-precipitation in the present work, while commercially available ZnO was used as the bulk particle. Initially, both ZnO nanoparticles and bulk particles were analyzed for size confirmation using UV spectra (blue shift), dynamic light scattering, and scanning electron microscopy. The liquid chitosan composite was prepared by incorporating ZnO nanoparticles into chitosan dissolved in 1% acetic acid. The powdered form was prepared by coating it with chitosan and dried in the oven. Antibacterial activity was checked by agar well diffusion method and Minimum Inhibitory Concentration. The cell viability was carried out by MTT assay using the L929 cell line. The results indicate that the powder composite is equivalent to the antibacterial activity of the liquid composite, demonstrating no significant difference in antibacterial activity (p>0.05). Ironically, there is a significant variation in the IC value (p<0.01) in cytotoxicity, specifically, the powder composite exhibits a higher IC50 value, indicating reduced toxicity. So, it is concluded that the powdered form of chitosan i.e., Chitosan-capped ZnO-nanoparticles is better than the liquid form in terms of safety and efficacy; making it a promising candidate for biomedical applications.

Keywords: Nano-ZnO-Chitosan, Bulk-ZnO-Chitosan composite, MTT assay, Cytotoxicity, Cell lines

Health Risk Assessment of Potentially Hazardous Materials in Fish Along NE Arabian Sea, Indian Coast

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A study was conducted to analyze the mineral content and metal pollution index (MPI) in the edible portion (muscle), livers, and gills of ten commercially important fish species landed along the Saurashtra coast. Further carcinogenic and non-carcinogenic risk posed to the consumer was also evaluated. The species included Indian Mackerel (Rastrelliger kanagurta), Croaker (Johnius boornensis), Spinycheek Grouper (Epinephelus diacanthus), Areolate Grouper (Epinephelus aerolatus), Torpedo Scad (Megalaspis cordyla), Atlantic Triple Tail (Labotes surinamensis), Giant Catfish (Arias maculatus), Dorab Wolf Herring (Chirocentrus dorab), Savalai Hairtail (Trichiurus lepturus), and Dolphinfish (Corryphaena hippurus). The result reveals that all the fishes are good sources of macro and micro minerals viz., magnesium, phosphorus, potassium, and calcium. The average concentrations of Magnesium (Mg) ranged from 1765.04 mg/kg to 2364.84 mg/kg, with the highest levels in Dorab Wolf Herring (2364.84 mg/kg). Phosphorus levels ranged between 13489.80 mg/kg to 20058.43 mg/kg, with Dorab Wolf Herring also having the highest concentration. Potassium content was significant, varying from 18101.23 mg/kg to 32801.48 mg/kg, with the highest level in Giant Catfish. The calcium levels ranged from 144.27 mg/kg to 809.95 mg/kg, with the highest concentration in Atlantic Triple Tail. The MPI was evaluated across the different tissues like muscles, livers, and gills of these species to assess the degree of metal contamination. The result shows that MPI is highest in the liver followed by gills and least in the muscles. The MPI values ranged between 0.35 to 0.70 in muscles, 0.54 to 3.30 in the liver and 0.36 to 1.54 gills. The non-cancer risk was characterized by Hazard Index which ranged between 3.16E-06 in Rastrelliger kanagurta to 7.18E-06 in Epinephelus aerolatus indicating that the fishes are safe and possess no potential risk associated with the consumptions. The target cancer risk was calculated by the ingestion cancer slope factor which is the probability of an individual developing cancer from oral exposure to contaminants level over a lifetime, and for all the species, values were less than 10⁻⁶ indicating there is no carcinogenic risk associated.

KEYWORDS: Macro-minerals, Metal Pollution Index (MPI), Hazard Index, Target Cancer Risk, Non-Cancer Risk



Optimizing the Extraction Protocol for β -Chitin and Chitosan from Squid Pens: Structural and Functional Perspectives

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The occurrence of β -crystalline form of chitin is rare. It offers a more flexible and chemically open structure that enables enhanced chemical activity than α -chitin. Industrial processing of squid contributes to the generation of enormous quantity of pen as processing waste, which are untapped resource of bioactive compounds. Hence, squid pen being a potential source, was taken for the study, to standardize an effective method for the β -chitin and chitosan extraction without losing its functional potency. Cleaned and dried squid pen powder was prepared and characterized for composition; which accounts for nearly 61.57% protein and 28% chitin. Hot and cold extraction process at different time and temperature combinations was tried to reduce the protein content. Cold extraction process with extended deproteinization was found to give better results when compared to hot extraction process. The Whiteness index increased when the demineralization step was added in treatments with extended deproteinization. Chitin to chitosan was done under optimized deacetylation conditions but with varying time-temperature combinations. An average yield of 32-34% chitin and 25-28% chitosan was observed. Characterization studies revealed that on average, 90% and above degree of deacetylation (DDA) was observed in cold-extracted chitin samples. XRD analysis exhibited three diffraction peaks at 8.5, 19.9 and 26.4 showing the crystalline nature of the polymer. FTIR results showed similar peaks in squid pen chitosan with different functional groups of organic compounds such as out-of-plane, bending (557 cm⁻¹), C-O-C stretching (892 cm⁻¹), and CH, stretching (1161 cm⁻¹) as in normal chitosan. Optimizing the condition of chitin and chitosan extraction from squid pen, unlike from the crustacean exoskeleton helped in making the process more economical and environment friendly by less chemical usage.

Keywords: Squid pen, β -chitin, Chitosan, Degree of deacetylation, Fish waste utilization

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Sequential Extraction of Phenolics and Semirefined Carrageenan from *Kappaphycus alvarezi*: A Biorefinery Approach for Seaweed Valorization

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In India, the only marine algae species commercially farmed for the past 20 years is Kappaphycus alvarezii. The biomass produced has mostly served as a raw material for refined and semirefined carrageenan. However, the sequential extraction of different compounds from seaweed helps the bio refinery process. In this study, phenolic compounds were first extracted from the dried K. alvarezii biomass using water as a solvent. Subsequently, semirefined carrageenan was recovered from the residue of the phenolic extraction using alkali (KOH). The ideal extraction conditions for phenolic compounds were determined to be 6 hours of extraction time and a seaweed-to-solvent ratio of 1:30 at 200 RPM in an orbital shaker at ambient temperature. These settings yielded an extract with commendable antioxidant properties while maintaining the quality of semi-refined carrageenan. The total phenolic content of the extract was 2.43±0.05 mg Gallic Acid Equivalent/g, and the presence of Embelin in extract, aphenolic compound known for its various biological activities including antioxidant properties, was identified by liquid chromatography. This identification was supported by the extract's strong DPPH radical scavenging activity (16.73±0.39 μmol Trolox/g), Ferric reducing antioxidant power (3.12±0.10 µmol Trolox/g), and total antioxidant activity (3.30±0.05 mg Ascorbic acid/g). The yield and native gel strength of the sequentially extracted semi-refined carrageenan were comparable to those of the control sample. Additionally, the sequentially extracted sample exhibited enhanced whiteness relative to the control. This integrated approach for concurrently generating a phenolic extract with strong antioxidant properties and semirefined carrageenan with improved attributes, including whiteness, can enhance the profitability of the seaweed industry.

Keywords: Sequential extraction, Kappaphycus alvarezii, Semi refined carrageenan, Phenolic compounds

Impact of Polyphenols on Myoglobin Redox State and Prevention of Discoloration and Quality Changes of Refrigerated Longtail Tuna (*Thunnus tonggol*) Slices

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Tuna meat, especially raw slice, known as sashimi in Japanese, has become popular for consumers. The bright red color of tuna meat is a crucial indicator of freshness and prime quality of raw tuna-based products. The red color of tuna meat is primarily due to the presence of oxymyoglobin (oxyMb), which undergoes oxidization to metmyoglobin (metMb), causing undesirable browning during storage or distribution. To maintain the color of tuna meat, some additives such as nitrites/nitrates or carbon monoxide have been illegally employed to maintain redness, which poses health risks. To conquer this drawback, plant polyphenols offer a safe and effective alternative to maintain color, while providing health benefits apart from their preservative effect. In the present study, the effects of different phenolic compounds on the redox state of myoglobin and the prevention of discoloration of refrigerated longtail tuna (Thunnus tonggol) were investigated. Purified myoglobin from the longtail tuna with a molecular weight of 15.83 kDa was prepared. Different phenolic compounds [catechin, epigallocatechin gallate (EGCG), quercetin and hyperoside] were used as reducing agents in tuna slices at concentrations of 50 and 100 ppm. The absorption spectra and redox state of metMb during storage of all slice samples up to 72 h at 4°C were monitored. Based on the reducing ability of metMb, EGCG and quercetin (200 and 400 mg/kg) were selected to treat longtail tuna slices. The color (a* and a*/b*), proportion of myoglobin content and quality changes were monitored during 72 h of storage at 4°C. Among all samples, the tuna slices treated with EGCG at 200 mg/kg showed higher maintenance of oxyMb and had superior color retention with coincidentally lower metMb formation, compared to other treated slices. Therefore, those phenolic compounds, particularly EGCG, could be used as a safe additive for keeping the prime quality and lower oxidation of myoglobin of tuna slices. thus preventing undesirable discoloration or consumer rejection.

KEYWORDS: Phenolic compounds, Longtail tuna, Metmyoglobin, Oxymyoglobin, Color, Sashimi

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A Value Chain Model for Effective Utilisation of Black Clam (*Villorita cyprinoides*) Resources of Kerala

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Black clam (Villorita cyprinoides) forms a major fishery of the estuaries and lakes of Southern Kerala and is commercially exploited by local communities. The clam meat is an important source of food and the shells support the lime industry. Under a DST - SEED project a value chain model was demonstrated in Perumbalam Island in Alleppey, Kerala where clam resources are abundant. Validation of the clam value chain model was carried out to ensure safe and hygienically processed clam meat and diversified products for consumers. A depuration unit capable of processing 1-ton clams per day was established. The water used for the depuration unit was subjected to sand filtration, AC filtration and UV treatment. The aerobic plate count (APC) reduced from 1.68 x 10⁷ cfu/ml to 7.5 x 10⁴ cfu/ml and the E. coli was absent in the filtered water. 12 hours of depuration reduced the APC of clam meat and the sand content from 3.55% to 0.75% demonstrating that depuration in UV-treated filtered water is effective in lowering bacterial load and sand content. The controlled steam shucking using a boiler and steamer helped in optimal cooking for shell opening. A hand-operated rotatable meat shell separator with a capacity of 300 kg/hour was designed and fabricated to separate the meat from the shell with 85-95% meat separation efficiency depending on the clam size and number of rotations. The separated clam shells are used in the lime industry. The shelf life of depurated shucked clam meat during chill storage in low-density polyethylene and polyester polythene laminates showed extended shelf life in laminates. Value-added products from depurated clam meat namely, pickles, dried, smoked, condiment incorporated, curry-based products, ready-to-eat products like coated and wrapped products and thermally processed products have been standardized and evaluated. Hands-on training and capacity-building programmes at different levels were successfully demonstrated. Currently, this model unit in Perumbalam is successfully operated for the production of depurated clams for local and export markets and is the only one of its kind in the state of Kerala and probably in India.

KEYWORDS: Clam, Depurated, Value-addition, Demonstration, Kerala

Storage Conditions Affect Consumer Preferences for Export-Oriented Giant Freshwater Prawn in Sri Lanka

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Giant Freshwater Prawn (GFP), Macrobrachium rosenbergii, is a high-value commodity in global aquaculture markets, yet quality preservation remains a challenge due to inadequate post-harvest handling practices. Colour, texture, and sensory attributes influence consumer preference and product value, especially in export markets. The present study investigates the effects of different storage conditions, ice storage, freezing at -20°C, and air-blast freezing at -35°C followed by storage at -20°C on GFP quality over a 21-day period. Fresh GFP specimens collected from the Ridiyagama Reservoir, Sri Lanka, were evaluated for physical and sensory characteristics at three-day intervals. Colour measurements using CIE parameters (L*, a*, b*) and texture properties (hardness, springiness, chewiness, and cohesiveness) were analysed for raw samples. Sensory evaluations were conducted by a trained panel assessing raw and cooked samples for attributes such as odour, texture, colour, flavour, and oral texture with consumer preference, analysed using the Analytical Hierarchy Process (AHP). Results indicated that ice storage effectively preserved GFP quality for up to nine days, after which sensory and physical attributes deteriorated. In contrast, freezing methods initially induced rapid colour changes and provided superior overall preservation, maintaining acceptable quality over the entire 21-day period, with no significant differences between freezing and blast-freezing treatments. Consumer preferences were aligned with sensory quality trends, favouring ice-stored GFP initially but shifting to frozen and blastfrozen samples beyond nine days. Present findings underscore that ice storage is suitable for short-term preservation, albeit blast-freezing is optimal for maintaining GFP quality in export markets over longer durations. Present findings offer valuable insights for the prawn industry, highlighting the need for optimized storage protocols to meet export standards and enhance consumer satisfaction.

KEYWORDS: Freezing, Blast-freezing, Sensory attributes, Postharvest quality

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Beyond the Scale: Fish Gelatin Peptides from Lethrinid Scales and their Bioactive Potential

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Gelatin, obtained from the fish scale, skin and bones, is widely used in biomedical, cosmetic and other industries. Hydrolysis of gelatin into gelatin hydrolysate enhances its process suitability and bioavailability. Based on the idea of "Greening the Blue Revolution", the present study made use of the discarded fish scales for extraction of gelatin using the hydrothermal extraction method thus avoiding the use of harsh acids and alkalis. The hydrothermal extraction of gelatin from the fish scales was done using an autoclave at 121°C and 15 psi pressure for 90 min. The maximum gelatin yield of 21.48% with a protein recovery of 16.5% was obtained from decalcified scales. Fish scale gelatin hydrolysate (FSGH) was prepared using the papain enzyme through enzymatic hydrolysis, exhibiting a degree of hydrolysis of 16.51% and an average peptide chain length of 5.24. The crude FSGH was subjected to fractionation based on the molecular weight using molecular cut-off filters to obtain 3 fractions, 10FSGH (10 kDa), 3-10FSGH (3-10 kDa) and 3FSGH (3 kDa). The chemical structure of fish scale gelatin, FSGH and its fractions was assessed through the Fourier transform infrared (FTIR) spectroscopy analysis which showed the presence of five functional groups: amide-A, amide-B, amide-I, amide-II and amide-III. The amino acid profile of gelatin and FSGH fractions revealed that glycine was present in the highest amount. The anti-oxidative ability of the FSGH was determined by in vitro antioxidant assay using a DPPH free radical scavenging mechanism and in vivo assay using the sardine meat model system. The crude fraction showed the highest antioxidant ability with the DPPH free radical scavenging activity of 95.45%. The sardine mince mixed with the crude gelatin hydrolysate showed a minimum TBARS value of 4.22%, thus indicating that the crude FSGH possesses the highest antioxidant ability. The anti-hypertensive activity was determined by evaluating the ACE-inhibitory activity, whose results indicated that the 10FSGH fraction showed the highest ACE-inhibitory activity of 56.02±0.25%. Hence, a hydrothermal extraction process can be adopted for efficient extraction of gelatin from the fish scales and the several bioactive properties of the FSGH should be further explored.

KEYWORDS: Gelatin, Hydrothermal, Anti-oxidant, Anti-diabetic

Dynamics of Methicillin-Resistant *Staphylococcus aureus* (MRSA) Survival in Raw and Cooked Shrimp under Frozen Storage Conditions

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Foods that are extensively handled during preparation and stored without refrigeration are usually associated with staphylococcal food poisoning. Staphylococcal food poisoning is one of the most widespread food-borne diseases globally, following the ingestion of staphylococcal enterotoxins produced by enterotoxigenic strains of coagulase-positive S. aureus. The emergence of methicillin-resistant S. aureus has raised concerns about these pathogens potentially contaminating food and serving as vehicles for transmission. The present study investigated the survival dynamics of MRSA in raw peeled and cooked shrimp under frozen storage. The raw and cooked shrimp was inoculated with MRSA at 104 and 10⁴ log CFU levels and stored at -20°C. The results showed that the MRSA populations in shrimp stored at -20°C were more stable. MRSA counts in frozen peeled shrimp exhibited a 28% reduction in the 10⁴ log CFU inoculated sample and a 6% increase in the 10⁴ log CFU inoculated sample. Total plate counts in frozen peeled shrimp showed a 0.92 log CFU reduction. Similarly, the MRSA counts in cooked and frozen-stored shrimp declined by 26% in the 10⁴ CFU inoculated sample, while the total plate count showed a minor decrease of 0.371 log CFU/g. These results suggest that MRSA is better able to survive when present in low population densities. MRSA survives better in frozen-stored shrimp in both high and low population densities, indicating that temperatures around -20°C are conducive to its survival. In conclusion, MRSA demonstrated significant survivability in low-temperature preserved seafood, and future studies may investigate the physiological and genetic bases underlying this ability.

KEYWORDS: Emergence, Methicillin-Resistant S. aureus (MRSA), Survives, Total Plate Count

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Natural Based Coating Solution Chitosan, Fish Protein Isolate and Wolffia globosa Extract on The Shelf-Life Extension of Refrigerated Litopenaeus vannamei

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The effect of coating solution-based mixture which included chitosan (3%), fish protein isolate (2.798%) and *Wolffia globosa* extract (1.162%) as a natural preservative was studied on the shelf life of shrimp at a refrigerated condition. The combined effect of chitosan, fish protein isolates and *Wolffia globosa* extract has shown an inhibitory effect on the psychrophilic bacteria, pH values, trimethylamine nitrogen, total volatile base nitrogen, peroxide value and thiobarbituric acid; free fatty acid values of samples were recorded lowest in coated shrimps. The textural properties and colors of the coated shrimps were significantly improved than the uncoated shrimp. The results suggested that the edible coating of chitosan, fish protein isolate and *Wolffia globosa* extract enhanced the shelf-life of refrigerated shrimps to 5 days due to the synergistic effects of combined coating solution.

KEYWORDS: Chitosan, Fish Protein Isolate, Wolffia globosa, Shelf-Life, Litopenaeus vannamei

Influence of Chitooligosaccharide on Physiochemical and Functional Properties of *Pangasius surimi* Gel

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The present study investigated the effect of chitooligosaccharide (CHOS) at different concentrations (0, 2.5, 5.0, 7.5, and 10 g/kg) on the physiochemical and functional properties of gel prepared from pangasius. Breaking force and deformation of gel were increased when the concentration of CHOS was increased up to 7.5 g/kg (p<0.05). Water holding capacity, trichloroacetic acid soluble peptide content, Ca²⁺ ATPase activity and whiteness index of gel were increased with the incorporation of CHOS than those of control (p<0.05) whereas expressible moisture and total sulfydryl content of gel were decreased with the addition of CHOS than that of control (p<0.05). Gel incorporated with 7.5 g/kg CHOS showed the highest gel strength. Moreover, the textural properties like hardness, gumminess and chewiness of gel incorporated with CHOS was significantly higher than the control (p<0.05). Thus, the incorporation of 7.5 g/kg CHOS could enhance the physicochemical and gel properties of pangasius surimi gel and retard protein deterioration.

Keywords: Chitooligosaccharide, *Pangasius*, Gel strength, Whiteness index, Texture profile analysis

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Development of Beetroot Powder Fortified Burger Patty Premix Incorporated with Fish Surimi Powder

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The objective of this study was to develop novel gluten-free patty premix incorporating rohu fish surimi powder fortified with beetroot powder. Formulation with quinoa flour, almond flour, soy flour, oat flour, and flaxseed powder were optimized. Surimi powder incorporated patty premix powder was incorporated with varying levels (0.5, 1, 1.5, and 2 %) of beetroot powder. The OAC rose substantially as the beetroot powder increased, whereas the WAC ranged from 135.36% to 134.79 %. The addition of beetroot powder resulted in a decrease in the textural parameters. The sensory results revealed that the 1.5% beetroot powder incorporation scored the highest in all sensory attributes.

KEYWORDS: Rohu, Surimi powder, Beetroot powder, Patty premix, Gluten-free

Recycling of Shrimp Shell Waste into Nano Chitosan Biopolymer: Exploring *in vivo* and *in vitro* Applications

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The current work demonstrates the potential of using waste materials to produce valuable biopolymers, emphasising sustainability, wherein discarded shrimp shells of Penaeus monodon are used to produce chitosan, a biopolymer derived from chitin, through chemical methods. After extracting chitosan, sodium tripolyphosphate is employed to convert it into nanoparticles. This process highlights the perspective of using marine waste for sustainable biopolymer production. It opens avenues for applications of developed chitosan nanoparticles in various fields such as biomedical, food preservation, and environmental remediation. To affirm its possible usage various physicochemical characterizations were conducted using FESEM, FT-IR, TGA, XRD, and viscometry. Dynamic Light Scattering revealed that the shrimp chitosan nanoparticles had a defined particle size of 40.09 nm. Transmission electron microscopy confirmed that the nanoparticles had stable spherical forms. FTIR spectra were used to determine the degree of deacetylation (DD) of the chitosan. A typical molecular weight of 97.52 kD was found, indicating a low molecular weight with greater solubility and reduced viscosity, enabling a larger range of medicinal applications. For both in vitro and in vivo applications, the isolated chitosan and chitosan's nanoparticles bioactivity were assessed. While in vivo application uses nano chitosan biopolymer as a feed additive to investigate the early immunological and stress gene expression in *Clarias magur*, the in-vitro application provides information on antioxidant, antibacterial activity and cytotoxicity assay at various concentrations. In summary, chitosan and nano-chitosan have potent antibacterial, antioxidant, and immunostimulant properties. However, nano-chitosan frequently exhibits superior efficacy because of its improved physical and chemical properties, such as its larger surface area and increased active sites at the nanoscale, which facilitate better interaction with immune cells, free radicals, and bacterial cells. It also has improved cell membrane penetration with bioavailability and has greater immunostimulatory effects by producing more cytokines alongside activating immune cells more effectively.

KEYWORDS: Antibacterial, Antioxidant, Chitosan nanoparticle, Cytotoxicity, Immune response



Authentication of Salmonid Species Using High-Resolution Melting Analysis: A Comparative Study of COI and ND1 Gene

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Seafood consumption has increased globally in recent years, particularly for salmonid species, which are popular seafoods globally. Despite advancements in DNA barcoding, substitution or mislabeling of salmonid species persists, causing significant environmental harm and economic damage. These highlight the urgent need for improved authentication. In this study, the High-Resolution Melting (HRM) technique has been employed to identify and authenticate seven closely related salmonid species (Oncorhynchus keta, O. kisutch, O. gorbuscha, O. tshawytscha, O. mykiss, Salmo trutta and O. nekra) which are different in price and value. This study compared the efficiency of two mitochondrial gene-based primers, COI-Sal and ND1-Sal, in discriminating and identifying species substitution, fraud, and mislabeling related to salmonid species. The designed primers provided short amplicon sizes of 127 bp and 84 bp for the COI and NDI genes, respectively. The analysis time was under 80 minutes. Both COI and ND1 primers exhibited positive amplification of seven salmonid species that are similar in terms of appearance. The COI-Sal and ND1-Sal primers displayed high stability in increased melting temperatures, ranging from 78°C to 81°C. However, the ND1-Sal primer demonstrated higher fluorescence intensity, ranging from 1.1 million to 2.4 million units, compared to the COI-Sal primer, which ranged from 700,000 to 1.35 million units. The DNA and primer binding efficiency is proportional to fluorescence intensity and the primer's ability to amplify the targeted region. The NDI gene exhibited greater stability with an increased melting temperature of 81°C and higher fluorescence intensity, establishing it as a suitable alternative genetic marker for identifying adulterated and substituted salmonid species. This has significant implications for the import and export of salmonid products, particularly in the fillet and other processed forms. Consequently, the ND1 genetic marker is valuable for industry and government agencies in ensuring the authenticity of seafood products.

KEYWORDS: Food fraud, High-resolution melting analysis, Salmonid species authentication, DNA barcoding, COI and ND1 gene

Detection of Multidrug Resistance Seafood-Borne Non-Typhoidal Salmonella Serovar Newport in Seafood from Fish Landing Centres and Fish Markets in Mumbai, India

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Among the various Salmonella serovars, Salmonella Newport has emerged as a particularly problematic pathogen, posing a significant threat to public health worldwide. The diverse non-typhoidal Salmonella (NTS) serotypes associated with seafood might vary regarding their virulence potential. In this report, 82 seafood samples collected from three fish landing centers and seven retail fish markets in Mumbai were studied with respect to the distribution pattern of Salmonella serovars Newport. A total of 94 Salmonella isolates were isolated from seafood samples using multiple enrichment broths and selective isolation media with an overall incidence of 20.73 %. Altogether, the contamination levels of fish landing centers and fish markets were shown to be 15.95% and 84.1%, respectively. All 94 isolates of Salmonella were serotyped. Of these, only 10 (10.63%) isolates were serotyped as S. Newport. Out of 10 isolates of S. Newport, 5 (50%) were from fish landing centers, and 5 (50%) were from fish markets. Antibiotic susceptibility patterns of the 10 isolates against 17 antibiotics revealed that 3 (30%) isolates of S. Newport were multidrug resistant. Three isolates of S. Newport fish market were not resistant to any tested antibiotics. Seven isolates of S. Newport from the fish landing centres and fish markets were resistant to 1-3 and 3 tested antibiotics, respectively. S. Newport from the fish landing center and fish markets showed 6 different resistant patterns viz. CTX, PIT, COT-TR, CTX-COT-TR, COT-IMP-TR and COT-PIT-TR. These findings reveal the possibility of transmission of multidrug-resistant S. Newport to humans through the seafood chain.

KEYWORDS: Salmonella Serovar Newport, MDR, Seafood, Fish landing centre, Fish market

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Smart Fishing: Blockchain Technology in the Field of Seafood Traceability and Authenticity

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The fishing industry contributes to the national economy and has a vital role in global food security and faces significant challenges including fraudulent fish supply, overfishing and inefficiencies in supply chain management. This has also increased the incidents of occurrence of fish fraud, which serves as a severe blow to seafood authenticity. To reduce this risk and maximize added value, Block Chain Technology, a decentralized and ledger-based database system, is used to properly trace the origin of the seafood product to its source. Blockchain guarantees that the seafood record is freely accessible and safe from the risk of hacking, thus providing the requisite assurance of the seafood quality and authenticity. Blockchain's realtime data sharing can enhance traceability, allow stakeholders to verify the origins of seafood products and ensure compliance with sustainable standards. Blockchain platforms promote secure digital collaboration of the Internet of Things (IoT), Radio Frequency Identification (RFID) and Fish Microchip Technology across the value chain. The primary data entered by the fishermen across the country is compiled using the IoT. Further, the anglers will attach a unique identification number or a microchip to the fish to facilitate the processor to access the data. The further data provided by the processor can be made available to the consumer in the form of a label, scanning which will enable them to get detailed information regarding the product and trace its origin. Incorporating blockchain helps in the improvement of the safety of the seafood, and the creation of a more authentic seafood sector with documented records of traceability. World Wildlife Fund (WWF) project ensures ethical product sourcing and the use of quick response scanning and Radio Frequency Technology (RFT) to track fish. Despite the several advantages associated with it, the widespread adoption of blockchain in fisheries is still limited. Coordinated collaboration among stakeholders will serve as the cornerstone for the successful implantation of blockchain technology.

KEYWORDS: Seafood fraud, Authentication, Blockchain, RFID, Fish microchip

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A Study on Review of Some Ethnic Traditional Methods of Fish Smoking in Manipur, India

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Manipur is indeed a region rich in natural resources and cultural diversity. Among these, fish smoking is one of the popular practices in Manipur. It serves as a method of preservation and enhances the flavor of fish, making it a sought-after delicacy. The demand for smoked fish is driven by local culinary traditions and the growing interest in regional foods across the country. This practice not only supports local economies but also preserves cultural heritage related to food preparation in the region. Many people of Manipur use it as a tool for earning and maintaining their households. It also helps the economic growth and development in Manipur. The present aim briefly reviews the studies on traditional methods of fish smoking in different regions of Manipur. All these methods are mainly performed by women. This traditional practice forms the backbone for biodiversity conservation and sustainable livelihoods in Manipur.

KEYWORDS: Resources, Heritage, Biodiversity, Sustainable

Extraction and Quantification of Freeze-Dried Sarcoplasmic Protein from *Pangasianodon hypophthalmus* (Sauvage, 19780) Surimi Wash Water with Effect of Precipitation

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The conventional method used for surimi processing with three washing cycles and a 1:3 (mince: water) ratio was used in the present investigation. Fat pigments, skins and sarcoplasmic protein were present in the surimi wash water. Sarcoplasmic protein was recovered by the precipitation with the treatment of 10% TCA, 1 N HCL, 0.1% Chitosan and 5 mM citric acid. The yield percentage of recovered freeze-dried proteins from wash water varied with washing steps. Maximum yield was found in the first wash with 4.68% in 10% TCA. The color values were significantly different (p<0.05) among the treatments, L^* value was highest at 66.79±1.17 in chitosan treatment due to its clarifying agent properties. Bulk density was found to be highest (58.78±1.95 g/cc³) in TCA extract and lowest in chitosan extract (28.90±4.03 g/cc³), and could be because of its particle size. The minimum waterholding capacity of freeze-dried sarcoplasmic protein was found at pH 6, except for HCl treatment. Better solubility of freeze-dried sarcoplasmic protein precipitate was at pH 12 in all the treatments due to the presence of the amino acid ionization, unfolding, and hydration protein. The foaming properties of sarcoplasmic protein were also higher at pH 10 due to the effect of penetration and reorganization of protein molecules at the air-water interaction. The sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) study revealed the quantification of protein. Scanning electron microscope (SEM) images of freeze-dried sarcoplasmic protein showed structures with rough networks, with no compactness to each other. It can be concluded that the precipitated extract freeze-dried sarcoplasmic protein with different treatments had better overall quality from the nutritional point of view.

KEYWORDS: Surimi wash water, Sarcoplasmic protein, SEM, SDS-PSGE

Valorization of Catla (*Catla catla*) Visceral Waste Derived Peptone and its Application as a Potential Culture Media Ingredient

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This present study explored the production and characterization of peptone derived from Catla catla viscera using papain enzyme with an enzyme-substrate ratio of 1:100. The resulting peptone demonstrated a yield of 4.86%, with a degree of hydrolysis of 94.31%, and an excellent solubility (98.06%). The color properties included lightness of 83.71, redness of 0.73, yellowness of 17.81 and whiteness of 76.30. The proximate composition of the peptone was 4.27% moisture, 61.97% protein, 0.14% lipid, and 32.66% ash. The study also evaluated the growth and biomass production of *Bacillus velenzensis* in broths and agar supplemented with both commercial and fish peptone separately. Results showed that broths supplemented with fish peptone (NBFP) significantly enhanced B. velenzensis growth and biomass production, with an optimal biomass yield of 142.7 mg per 100 ml observed at a peptone concentration of 30 g/l. Growth of B. velenzensis on agar media was better than commercial peptone and media. Statistical analysis indicated significantly higher growth rates (p<0.05) in broths with fish peptone compared to those with commercial or standard nutrient broths. This research underscores the potential of catla visceral peptone as a sustainable and nutrient-rich alternative for microbial culture media, supporting enhanced growth and biomass yield.

KEYWORDS: Bacillus velenzensis, Fish peptone, Catla viscera, Biomass production, Microbial growth

Newly Formulated Biodegradable Tertiary Packaging Material Developed Using Sustainable Resources

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A novel approach has been developed for creating biodegradable packaging material by integrating sustainable components: Poly β-hydroxybutyric acid (PHB) sourced from wastewater-cultured *Spirulina* (*Arthrospira*) platensis, along with agricultural waste from sugarcane bagasse and coconut husk fibers. Additionally, chitosan, a polymer derived from fish processing byproducts, is incorporated into the formulation. The resulting biobased material showcases promising biodegradability and mechanical properties, making it a viable alternative to conventional non-degradable options like thermocol. Comprehensive evaluations, including biodegradability testing and assessments of mechanical strength, were conducted to highlight its performance. A thorough cost analysis indicated that this innovative formulation can be produced at a competitive price, emphasizing the potential of utilizing agricultural waste, wastewater, and industrial byproducts to create affordable and eco-friendly biodegradable packaging solutions. This research underscores the viability of sustainable practices in the packaging industry, paving the way for more environmentally friendly materials.

Keywords: Poly β-hydroxybutyric acid, *Spirulina*, Agro-waste valorization, Biodegradable, Tertiary packaging, Mechanical strength

First Comprehensive Study on Multiple Antibiotic Resistance, Biofilm, Virulence and Biocides Profile of *Acinetobacter baumannii* from Food Fishes in India

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The rising prevalence of antimicrobial-resistant bacteria seriously threatens global food safety and public health. While most of the pathogenic AMR bacteria falling under the WHOdesignated ESKAPE group, such as E. coli, K. pneumoniae, and S. aureus, are routinely monitored in aqua food under national schemes, they are not listed as critical by WHO in 2024. In contrast, Acinetobacter baumannii, categorized as a critical pathogen and occasionally reported in seafood and aquaculture systems with limited study, poses a concealed threat often linked to environmental contamination, demanding urgent surveillance. This study examines A. baumannii's antibiogram, focusing on its virulence, biofilm formation, and biocide resistance, all contributing to its human pathogenicity. From 103 seafood samples, A. baumannii was isolated in 10.67% of cases (n=11), confirmed by the species-specific gene (bla OXA-51-like). Antibiotic susceptibility testing was performed using the BD Phoenix M50 system, with isolates exhibiting resistance to multiple antibiotics, including imipenem (64%), meropenem (9%), gentamicin (36%), piperacillin-tazobactam (9%), ceftazidime (9%), and trimethoprim-sulfamethoxazole (9%). PCR analysis detected various resistance genes, including ESBL (bla TEM, bla CTX-M, bla PER), aminoglycosides (strA, aadA1, acc (6')-Ib-cr) and carbapenem (bla OXA-24-like), tetracycline (tetA) and sulfonamides (sul1). Strong biofilm formation was noted in all isolates, with virulence and biofilm genes such as fimH and iutA, fyuA, and bfmS present. The agar dilution method observed disinfectant resistance to benzalkonium chloride and chlorhexidine, with the qacE Δ 1 gene detected in 88% of isolates. Pearson's correlation analysis highlighted significant links between antibiogram, biofilm formation, and disinfectant resistance, suggesting that biofilm formation might influence its role in elevated quaternary ammonium compounds' (QAC) MIC values. This study emphasizes the need for comprehensive monitoring of robust biofilm-forming, multidrug-resistant A. baumannii in seafood, which pose major threats to public health, and the presence of ARGs, virulence genes in seafood that impede the seafood supply chain.

KEYWORDS: Acinetobacter baumannii, Seafood, Genotypic Profile, Disinfectant

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Technical Session-10 Socio-Economic Dynamics & Extension in Fisheries and Aquaculture



Exploring the Demographics, Practices, and Challenges in Marine and Coastal Cage Aquaculture

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The present study explored the demographics, practices, and challenges associated with cage aquaculture among marine and coastal farmers in seven maritime states of the country. The research surveyed 212 cage farmers, providing substantial insights into the sector's dynamics. The analysis reveals a gender imbalance, with cage ownership predominantly held by males. Nearly half of the respondents (49.9%) list fishing as their primary occupation. A significant majority (83%) of farmers showed a strong interest in forming Fish Farmers' Producer Organizations (FFPOs), indicating a demand for dedicated platforms to address their unique challenges. Experience levels among farmers vary, with 40.6% having 3-5 years in cage farming. Ownership patterns show that 44.3% of farmers manage a single cage, and 76.4% operate as sole proprietors. Institutional support, particularly from ICAR-CMFRI, has been instrumental in encouraging many of them to start cage farming. It was found that rectangular cage, measuring 4x4x3 meters, was the most prevalent type (35.3%), and sea bass (Lates calcarifer) was the most dominant species, farmed by 90.6% of respondents. However, several constraints hinder the sector's growth. High investment and operational costs are the primary challenges, followed by issues such as inadequate credit facilities, pollution-induced mortality, and lack of insurance support.

KEYWORDS: Cage aquaculture, Demographics, Farmer producer organisation

Impact of COVID-19 on the Indian Marine Fisheries Sector: A Difference-in-Differences Analysis

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The COVID-19 pandemic adversely affected India's marine fisheries sector, impacting livelihoods and the national economy. This study quantifies the impact of the COVID-19 pandemic on India's marine fish landings using a Difference-in-Differences (DID) approach. Employing a panel dataset of monthly landings across coastal states from 2014 to 2023, we leverage the nationwide lockdown as a quasi-natural experiment. Our findings reveal a significant initial decline in landings following the lockdown, attributed to restrictions on fishing activities, logistical constraints, and reduced demand. However, a subsequent recovery phase emerged, with the motorized sector showing the strongest rebound. While the pooled OLS DID model suggests a positive trend post-intervention, the dynamic panel model, accounting for autocorrelation, tempers this finding, indicating some recovery might be due to a low baseline effect. The study further highlights the negative impact of lockdowns and seasonal fishing bans on landings, varying significantly across states. Robustness checks confirm the validity of our results. Overall, this research underscores the vulnerability of India's marine fisheries sector to sudden shocks and the need for targeted interventions to ensure its resilience

KEYWORDS: COVID-19, Marine fisheries, DID analysis, Fish landings, External shock

Role of Inland Capture Fishing in Employment Generation: A Study Across the States of India

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The importance of fisheries sector in the agricultural economy of India has been increasing as evidenced by the increasing share of the value of fishing in the total value of output from agriculture and allied sectors. Inland capture fisheries has been an important source of livelihood for a large section of the economically underprivileged population of the country, especially in the rural areas. The present study was conducted in 10 states of India, covering fishing in rivers, estuaries, reservoirs, wetlands, lagoons, and backwaters. For each category of fisheries, the important states were sampled. Altogether 1900 fishers were interviewed, and selected through well-planned sampling strategies. The data were collected and referenced to the year 2019-20. The employment generated in terms of total man-days in a year per fisher family was worked out based on an average number of fishing days in a year, hours of fishing per day, and the average number of family members engaged in fishing. The study shows that a fisher family gets yearly engagement of 202 to 530 man-days, averaging 388 through fishing in rivers. Narmada and Mahi (Gujarat) created higher employment, a little above 500. The same is the case for rivers Ganga and Tons in Uttar Pradesh. The study found that fishing in estuaries is a better employment provider ranging from 257 to 744, with a mean value of 462 man-days in a year. The Hooghly-Matlah was found to be the highest employment generator at 744 man-days per year per fisher family. Fishing in reservoirs, on an average, created 242 man-days per fisher family in a year which ranged from 156 in Uttar Pradesh to 282 in Chhattisgarh. Fishing in wetlands proved to be a lesser employment generator as compared to the other resources, ranging from 98 in Uttar Pradesh to 174 in Assam and West Bengal. The Chilika (lagoon) and Vembanad were found to be another significant employer of fishers providing 377 and 371 man-days of engagement per fisher family in a year. Taking all the resources together, inland capture fishing generates 305 man-days of employment per family per year. From a macro-economic perspective, the total annual man-days generated will be around 113 million taking only the full-time inland fishers (1.846 million). Taking 1:4 ratio, the total annual man-days created along the entire fish value chain will be 450 million. However, this sector faces numerous challenges, which are to be tackled to reap the benefit of full employment generation for equitable and inclusive growth.

KEYWORDS: Inland capture fishing, India, Employment, Man-days



Impact Assessment of Aquaculture Technologies Using Econometric Tools

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Statistical tools are used to assess the potential economic benefits of aquaculture technologies developed at R and D institutions. Important statistical techniques and their application in the impact assessment of aquaculture technologies are discussed. Field evaluation of the technological intervention may bring confounded biases due to the lack of randomization in observational studies. To overcome these biases the following methods, Propensity score matching (PSM-with and without), Instrumental variable (IV) estimation, Regression discontinuity design (RDD) and Difference in difference (DID, before and after) model were used in the causal effect estimation. Appropriate tools will be selected based on the objectives and expected outcomes of the technological interventions. In PSM, different matching estimators (Nearest Neighbor Matching (NNM), Radial based NNM matching, Caliper based NNM matching and Kernel-based matching) are used to match treatment and control observations to estimate the technology's average treatment effect. The regression models (Tobit, Double hurdle and logistic) are fitted to find the factors influencing the adoption of the technology. Using the observational data, the expected benefit of the technological intervention may be predicted using a two-stage least square estimation method in IV technique. The differential effect of the technology in the particular location may be estimated based on the before and after the intervention yield data using the DID method while RDD uses exclusion criteria to model the discontinuity and minimize the bias. These statistical methods help in the authentic impact assessment of aquaculture technologies.

KEYWORDS: Aquaculture technologies, Observational studies, PSM, IV, DID, RDD

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An Economic Evaluation of Mussel Farming in a Tropical Estuary in Northern Kerala, India

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Green mussels (*Perna viridis*) are widely cultured in the estuaries of Northern Kerala. The Palakkode estuary in Kannur district providesa suitable environment for the successful farming of green mussels, providing livelihood for many coastal people. Twenty-one active mussel farming units were observed in the study area during November-April 2024. The economic valuation of eleven farming units operated by four groups, each group comprising four individuals was analyzed. Each farming unit has a mussel rack of an area of 100 m² with 400 seeded ropes suspended from the rack. Female individuals (63%) form the major percentage of mussel farmers compared to male individuals (37%). The mean annual mussel production was 480 kg with an average farm-gate sale price of Rs.130/kg. The total Annual Fixed Cost, Total Cost of Production, Net Operating Income, Net Cash Return, Break-even price, and Capital Recovery Factor are Rs. 5620, Rs. 43040, Rs. 24980, Rs. 19360, Rs. 90 and 1.8. Even though mussel farming provides employment opportunities for many people, sudden environmental changes such as increased temperature, fluctuations in salinity due to unexpected rainfall, non-availability of mussel seeds, and the presence of invasive bivalve mussel species *Mytella strigata* have been found to adversely affect the mussel production.

KEYWORDS: Green mussel, Palakkode, Perumba River, Rack culture

Artificial Reefs and Livelihoods: Assessment of Socio-Economic Status of Fishers' Stakeholders in Reef Deployed Areas in Southern Districts of Tamil Nadu

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Artificial reef is a form of fish aggregating devices, that are deployed for the improvement of bio-mass in the sea. Post-tsunami, the deployment of artificial reefs gained momentum on the coast of Tamil Nadu, in particular. A project for the site selection and deployment of artificial reefs along the coast of six districts (Tirunelveli, Thoothukudi, Ramanathapuram, Thanjavur, Pudukottai and Thiruvarur) was prepared for the Government of Tamil Nadu and implemented. As a part of the proposal, the socio-economic status of the stakeholders in the site selected for deployment of artificial reefs was assessed since the socio-economic status of the stakeholders decides the acceptance (or) otherwise of any innovations, interventions, schemes, and related programmes. The sites selected for deployment are Kootapuly. Pattinamarudur, Pirapanyalasai, Gandhinagar, Yeripurakkarai, and Muthupettai. Stakeholder meetings were conducted and the purpose of the study was explained to them. Using a pretested schedule, the data were collected from the stakeholders. The basic parameters of the socio-economic status were assessed in the selected sites. It was found that the middle age group was the predominant share in the age group of the stakeholders. Fishing is the major livelihood option for all the stakeholders. All of them are literate but mostly up to the primary level (83%). The average family size is 4, which is near to the national average of 4.5. Regarding fishing methods, they follow single-day fishing with the average duration of fishing ranging from 4.5 to 5.3 hours across the seasons. Most of the stakeholders (89.5%) use fibre boats for fishing with a limited number of catamarans. The average annual income realized is about Rs. 2.79 lakhs. They harvest fish species like crabs, squids, lobsters, prawns, perches, mullets, tilapia ribbonfishes, and catfishes. The deployment of artificial reefs in these selected sites will further help to improve the fish assemblage and bio-mass, which will also further enhance their income levels.

KEYWORDS: Fish aggregating device, Biomass, Fishing method, Livelihood, Family size

Small Indigenous Fish (SIF) for Nutritional Security: Marketing and Consumption Pattern in Lower Gangetic Floodplains in India

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Duma is a large horse-shoe shaped wetland in the lower Gangetic plains (227 ha) with a fishery resource consisting of SIF (71.45% of the total fish harvest). SIFs are critical to the nutritional security of millions in rural communities in South Asia. Data about the role of SIFs in Duma wetland for consumption patterns and marketing was collected from 100 fishers in June 2022. The fishers harvest SIF during their daily fishing schedules either individually or in small groups which is open-access in nature. The time spent for fishing in the monsoon and post-monsoon season is 4 hours daily and 2.83 hours daily in premonsoon. 15 varieties of SIFs are consumed in fisher households. Analysis of longitudinal fish consumption was done by estimating the quantity of individual fish species consumed by a household on a weekly recall basis. Each household consumed on an average of 0.51 kg per week in monsoon (June to September), 2.45 kg per week in post-monsoon (October to January), and 1.19 kg per week in pre-monsoon season (February to May). One-way ANOVA test revealed that there were significant differences in the seasonal consumption patterns at p = 0.001 level of significance. With an average family size of four, 4.15 kg SIF per family per year was available for consumption, resulting in 1.04 kg per capita per year and 0.09 kg per month. 33% of SIF catch is consumed by the fishers. Three types of marketing channels exist in which the most common is direct sale from fisher to consumer (57%). The price of SIF is highest in the summer season from April to June @ ₹ 275 per kg. There is no catch or profit-sharing mechanism with the Primary Fishermen Co-operative Society (PFCS). Female participation to varying degrees was found in the SIF value chain in gear fabrication, fish sorting and fish sale. Appropriate institutional management measures including benefit sharing mechanisms are recommended for the sustainability of the SIF fishery resource. Conflict resolution mechanisms should also come up between the members and non-members of PFCS to sort out other problems such as aquatic weed infestation, siltation and fish mortality due to jute retting.

KEYWORDS: SIF, Consumption, Fishers, Duma, PFCS

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Marginal Fishers Belongs to Bhumij Tribal Community Empowered Through Integrated Coastal Pond Farming at Balasore, Odisha

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Balasore, the northern most coastal district of Odisha has rich fisheries and aquaculture potential. Nearly 12.4% of the district's population belongs to the scheduled tribe community, which falls under the socially and economically backward category. Scheduled Tribe families belonging to the weaker section of society were selected from the district and provided training along with all necessary inputs required for the polyculture of grey mullet with black tiger shrimp. The saline ponds were prepared before stocking and wild-caught seeds of grey mullet (Mugil cephalus) measuring 7-15 cm total length (20-30 g body weight) were procured and stocked @ 10,500 nos/ha in September and advanced PL of black tiger shrimp (*Penaeus* monodon) of 1-3 cm Tl @ 25,000 nos/ha were stocked in the same pond after 5 months of culture. These shrimps were caught from the wild by local fisherwomen. Better survival rates were observed in grey mullets (74%) when compared to black tiger shrimp (60%). Fishes were fed a mixture of wheat flour and floating pellets initially at 10% of their body weight, which was reduced to 5% body weight after 3 months. The cultured animals were harvested after 8-9 months, with grey mullet attaining an average weight of 450 g (wt. range 400-700 g) and the black tiger shrimp reaching an average weight of 30 g. A total production of 3.5 tonnes of grey mullet and 400 kg of black tiger shrimp per hectare was harvested. An additional income was generated through backyard poultry rearing by the women of the families. Total revenue of Rs. 9.5 lakh was realized from the sale of harvest and Rs. 1.0 lakh from the sale of meat and eggs from poultry in every cycle. The poultry droppings were also used as manure in culture ponds and kitchen gardens. This income was distributed among the beneficiaries. The successful demonstration of this technique is expected to provide better livelihood support through skill up-gradation ensuring continuation of the activity for additional income generation and social upliftment of these socio-economically weaker sections of the society.

KEYWORDS: Saline ponds, Socio-economically, Beneficiaries, Demonstration

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A Scientometric Analysis of Global Research Trends on Socio-Ecological Vulnerability in Fisheries

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In recent years, there has been a significant surge in scholarly interest surrounding the socioecological vulnerability of fisheries, driven by escalating environmental challenges and their implications for aquatic ecosystems and dependent communities. This paper provides a scientometric analysis of global research trends on socio-ecological vulnerability within the fisheries sector, focusing on key themes, geographic research distribution, and influential publications. Using a comprehensive dataset retrieved from Scopus, keywords such as "socio-ecological," "vulnerability," and "fisheries" etc. were employed to analyze the evolving body of literature. Advanced data visualization techniques, including VOS Viewer (Version 1.6.20), facilitated the mapping of keyword co-occurrences, citation networks, and research collaboration patterns. The findings of this analysis highlight several predominant research themes, including vulnerability assessment frameworks, climate change adaptation strategies, and fisheries management approaches, with significant scholarly contributions emerging from institutions in Europe and North America. Notably, the highest volume of publications occurred between 2018 and 2022, underscoring the increasing recognition of socio-ecological resilience in response to global environmental shifts. Marine Policy was identified as the journal with the highest number of publications, at 47, while the Coastal Vulnerability Index (CVI) emerged as the most frequently applied assessment method, particularly in coastal regions. The research field has demonstrated a strong interdisciplinary character, encompassing insights from environmental sciences, social sciences, and economics. This study envisages a comprehensive overview of the major thematic areas in socio-ecological vulnerability research in fisheries and underscores the critical importance of ongoing investigations to inform adaptive management strategies. The Scopus-derived dataset serves as a foundation for future exploration and strategic planning to address vulnerabilities in communities reliant on fisheries.

KEYWORDS: Socio-ecological vulnerability, VOS Viewer, Scientometrics

A Comprehensive Study on the Ecological Health of Kosi River and Livelihood Status of its Dependent Fishing Communities

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The Kosi River, a crucial tributary of the Ganga, supports diverse aquatic ecosystems and sustains numerous communities in Bihar. However, both its ecological balance and the livelihoods of local fishers are under significant threat. This study, conducted by ICAR-Central Inland Fisheries Research Institute, Barrackpore under the National Mission for Clean Ganga-III initiative, assesses the ecological health of the Kosi River and the socioeconomic conditions of fishers residing along its banks. The survey, conducted across five key sites, highlights critical challenges, including an alarming decline in fish stocks, habitat degradation, and recurring river embankment breaches. Fishers heavily rely on the river's resources, yet many face dwindling catches, with average monthly incomes of Rs. 15,000 which is less than the national per capita income, with the highest earnings reported in Dubiahi, Supaul district. The decline in fish populations, primarily caused by harmful fishing practices such as electrofishing, the use of small mesh nets, and pesticide contamination, threatens the livelihoods of these communities. Additionally, embankment breaches result in the flooding of agricultural lands, worsening the economic struggles of both fishers and farmers, leading many to migrate in search of alternative livelihoods, particularly in agriculture and contract labour. Despite awareness campaigns led by ICAR-Central Inland Fisheries Research Institute promoting sustainable fishing and river conservation, more comprehensive and collaborative efforts are urgently needed. Sustainable management strategies, including stricter regulation of fishing practices, habitat restoration, and improved embankment maintenance, are essential for the well-being of both the river ecosystem and the communities dependent on it. Without such interventions, the long-term sustainability of the river's resources and the livelihoods of local fishers remain at serious risk.

KEYWORDS: Kosi River, Ecological health, Socio-Economic, Livelihood, Conservation

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Household Fish Consumption in India: Insights from the Latest Consumption Survey

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Anemia and nutritional deficiency are one of the key health issues in India, stemming from a lack of sufficient nutrients in the human body. Fish is a low-saturated fat rich in nutrients, and it is the second-largest source of protein after chicken. It contains essential components such as iodine and omega-3 fatty acids, which are effective in maintaining healthy blood cholesterol and triglyceride levels, particularly in marine fish species. Additionally, the meat, organs, and bones of fish provide significant amounts of vitamin A, iron, and iodine, which are crucial for addressing specific nutritional deficiencies that can lead to the above-mentioned issues. At the same time, nationally representative consumption survey results were published by the government after a decade. The present study examines the consumption level of Indian households in fish as a food item. It examined the last two household consumption surveys of 2011-12 and 2022-23. The paper found that the share of households consuming fish has declined over the decade. One key factor contributing to this decline is the rising price of fish, while the proportion of households consuming chicken has doubled during the same period as an alternative non-vegetarian food item. Households have reduced their share in monthly per capita consumption expenditure on fish and reallocated spending toward other categories, such as non-food expenditures. In response to rising fish prices, we can propose providing technical and financial support to small-scale fish farmers to boost production and reduce costs. Public campaigns should be launched to raise awareness about the nutritional benefits of fish. Additionally, improving cold storage infrastructure and facilities will help reduce post-harvest losses and ensure the freshness of fish.

KEYWORDS: Anaemia, Consumption survey, Household consumption, Nutritional deficiency

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Pond-Based Integrated Farming: A Pathway to Economic Empowerment for Farmwomen

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Pond-based integrated farming enhances the livelihoods of the farmwomen by combining aquaculture, agriculture, poultry and livestock in a sustainable system. The Krishi Vigyan Kendra-Khordha, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, demonstrated a Pond-based Integrated Farming System model on a 3.5-acre area in Balianta block of Khordha District, Odisha, showcasing sustainable aquaculture and agricultural practices and their benefits for local farmers. The primary components of the Pond-based Integrated Farming System included fish, dairy, poultry, fruits and vegetables and honey bee, creating a diversified and sustainable agricultural ecosystem that maximizes resource utilization and enhances overall productivity. The result revealed that from a culture period of eight months, a total of 8.5 quintals of fish, including Jayanti Rohu, GI Catla, and Mrigal, was harvested from the 1-acre pond, yielding a net income of Rs. 1.15 lakh. From six nursery ponds covering an area of 1.2 acres, the farmwomen earned a net profit of Rs. 4.20 lakh by selling 18 quintals of yearlings and 12,000 fingerlings. Aquaculture contributes the largest share of income in the Integrated Farming System model. The farmwomen maintained two dairy cattle of the Sahiwal and Gir breeds, generating an annual net profit of Rs. 1.26 lakhs from milk sales. Additionally, she generated a net income of Rs. 2.40 lakhs from 50 honey bee boxes by selling 2 quintals of honey and bee colonies. From poultry and fruits and vegetables, a net income of Rs. 0.86 lakh was obtained. The farmwomen achieved an annual net income of Rs. 9.87 lakh from the Pond-based Integrated Farming System model. It has completely fulfilled the household's requirements for milk, meat, fish, and eggs; however, it has met 62% of the family's fruit and vegetable needs. The present case of the Integrated Farming System can be replicated in resource-rich rural areas to inspire other women farmers to adopt this viable approach, ensuring sustainable income and improved family nutrition.

KEYWORDS: Pond, Integrated farming system, Farmwomen, Livelihood, Family nutrition

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Community Aquaculture: A Case Study of Women SHGs in Adopting Fish Culture in Community Ponds

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The present study is based on the demonstration of scientific fish culture in community ponds in five villages of Khordha district during 2023-24 by Krishi Vigyan Kendra-Khordha under ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar. Five community ponds with a total water spread area of 3.8 ha were covered under the scientific fish culture with the active involvement of 14 women SHGs from the Scheduled caste community. The demonstration was expansively participatory involving community participation, capacity-building programmes and skill transfer on scientific management practices in all phases of interventions. Water quality and feed management were emphasised and the provision of critical inputs was ensured partially to motivate the group members. The results of the demonstration indicated that the average fish yield of the adopted community ponds was 3.914 tonnes/haagainst the pre-adoption production level of 2.418 tonnes/ha. The average increase in fish production and net income were 61.64 and 101.6% respectively with an increased average benefit-cost ratio from 2.11 to 2.58. The study concludes that community participation, institutional commitment and viable technology are essential to effectively utilise common property resources for supporting rural income and livelihoods.

KEYWORDS: Community aquaculture, SHG, Demonstration, KVK

Mapping the Ornamental Fisheries Research Landscape Using Scientometric Analysis

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The ornamental fish market, valued at USD 5.4 billion in 2021, is projected to grow at a Compound Annual Growth Rate (CAGR) of 8.5% from 2022 to 2030. With hobbyists comprising about 99% of the market, and only a small fraction managed by public aquaria and research institutions, the sector is playing a significant role in generating employment opportunities along with its contribution to foreign exchange earnings. Research on different aspects of ornamental fisheries is confined to a few countries, institutes and by middling authors as compared to other aquaculture sectors. Considering the importance of ornamental fisheries at the global level, the present study was undertaken to identify predominant authors, institutions, and countries contributing towards this sector and their collaboration status vis-à-vis keywords-based subject inferences through scientometric analysis. The metadata of publications on the topic of Ornamental Fisheries was retrieved from Scopus, using the search terms 'Ornamental' and 'Fish' to retrieve records on 'Ornamental Fisheries', 'Ornamental Fishes', Ornamental Fish Industry', etc. The primary search retrieved a total of 3354 records, including 2802 articles and 552 other documents. Only 2802 journal articles were taken into consideration for data analysis and discussion. Data analysis was performed using the 'Biblioshiny' application of 'R' and VOSviewer for graphical presentations for better understanding and readability. The findings revealed that research efforts on Ornamental Fisheries sector are going on primarily at the individual level as only a small group of authors are collaborating on the subject. Albeit, Brazil has contributed to the highest number of articles (438), followed by India with addition to 422 publications, whereas, the research outcomes from the United States have made the highest impact in academic and research spheres in terms of the number of citations earned. Subject analysis based on author keywords forming 116 keywords as per VOSviewer Schema revealed that the focus of most of the institutes is for sustainable development of ornamental fisheries considering all the major concerns including feeding, larval rearing, health management and biosecurity strategies through different approaches. A total of 18 journals have published ≥20 articles each, led by Aquaculture. The distribution of articles in journals complies with Bradford's Law of Scattering reflecting that publications on the subject are predominantly concentrated in 29 core journals only, forming the Core Zone.

KEYWORDS: Ornamental fisheries, Scientometrics, Collaborations, Database



Impact of Price Volatility on the Profitability of Asian Seabass (*Lates calcarifer*, Bloch, 1790) Farming: Evidence from Andhra Pradesh, India

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The present study estimated the impact of price volatility on the profitability of Asian seabass (Lates calcarifer) farming in Andhra Pradesh. A total of 60 seabass farmers were selected purposively from the Krishna and Eluru districts, and the data was collected through focus group discussions and personal interviews with the help of a structured interview schedule. Results revealed all the farm and management characteristics like average pond size, pond depth, crop duration, stocking density, feed use, chemicals use, and productivity were higher in Krishna than in the Eluru district. The average FCR (feed conversion ratio) was estimated at 7.43 for both districts. The average initial investment was Rs. 5.88 lakhs/ha/crop, with no significant difference between the two districts (p>0.05). Overall, among the total fixed cost component, land lease cost is higher (64%), followed by depreciation (25%), and others (12%) in both districts. Among the total variable cost component, feed cost is higher (69.21%), followed by interest on operating expenses (8.6%), and sea bass juveniles (8.49%) in both districts. The average total cost and average total revenue estimated was approximately Rs. 63.73 lakh/ha/crop and Rs. 48.33 lakh/ha/crop for both districts. Profitability analysis revealed that the benefit-cost ratio (BCR) was 0.75, and the net farm income was Rs.-15.40 lakh/ha/crop implying losses. Break-even analysis revealed that the average break-even yield and break-even price required to cover the total cost was 17.09 tons/ha/crop and Rs. 506.65 per kg of output. Sensitivity analysis was used to check the impact of changing input tilapia price and output market price on profitability. The net farm income decreased by 90.10% and increased by 281.18% while assuming to change from the current scenario (Feed price: Rs. 43; Output price: Rs. 373) to the worst scenario (Feed price: Rs. 50; Output price: Rs. 320), and best scenario (Feed price: Rs. 25, Output price: Rs. 570). The estimated net farm income was Rs. 17.98 lakh/ha/crop, with a BCR of 1.32 for the previous crop (Feed price: Rs. 35, Output price: Rs. 570) harvested implying good profit gain.

KEYWORDS: Asian seabass, Profitability, Sensitivity analysis, Andhra Pradesh

Fish Cage Culture in Sardar Sarovar Reservoir: An Economic Assessment

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Pangus (Pangasius hypophthalmus) is the primary species cultured in the reservoir, and its economic viability has been a subject of growing interest. However, there is inadequate information on its economic viability. This study evaluates the economic feasibility of fish cage farming in Maharashtra's portion of the Sardar Sarovar reservoir. Specifically, it analyzes the relationship between input costs and revenue generated from fish sales to determine the profitability of cage culture. Sixteen cooperative societies are engaged in cage culture in the Sardar Sarovar Reservoir area. Data for this study were collected from these societies using structured interviews and analyzed to assess farm income and profitability ratios. Members in fish cooperative societies ranged from 25 to 136. Information was collected for profitability analysis of cooperative society members. The average quantity of fish produced in the production cycle in a year was 66,104 kg, which sold at an average selling price of Rs. 90 per kg. Fish cage production was profitable, with an average revenue of Rs. 3,76,555 in a production cycle and an average benefit-cost ratio of 1.06. The costbenefit analysis of 16 cooperative societies involved in fish cage culture reveals that all societies are making a profit. The profit is shared equally among the members of society. Among these, the maximum Benefit-Cost ratio is observed for Narmada Navnirman Baba Gufanyadev Fishermen Cooperative Society Ltd. Manibeli (1.20), followed closely by Narmada Navnirman Mavnidevi Fisherman co-op Society, Dhankhedi (1.17) and Narmada Navnirman Baba Kondradev Fishermen Cooperative Society Ltd. Shelgada (1.10). On the lower end, Gangamayya Fishermen Cooperative Society Ltd. Sinduri shows the minimum BC ratio (0.97), followed by Bamnuja Fishermen Cooperative Society Ltd. Bamne (0.99). The maximum BC ratios in societies like NNBGFCS, Manibeli, and NNMFCS, Dhankhedi suggest efficient management of resources, possibly due to better market access or optimal feed usage. These societies can serve as a model for others, indicating that cost-effective feed management and strategic marketing can significantly enhance profitability. Societies with lower BC ratios, such as GFCS, Sinduri, and BFCS, Bamne, may benefit from adopting similar best practices to improve their financial outcomes. The study offers valuable insights for policymakers, researchers, and fish farmers, providing a foundation for informed decisionmaking and sustainable development of fish cage culture in the region.

KEYWORDS: Fish cage farming, Economic feasibility, Sardar Sarovar Reservoir, Pangus



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Assessment of Socio-Economic Impact of Artificial Reefs Deployment in Gaja Cyclone Affected Districts of Ramanathapuram and Pudukottai District of Tamil Nadu

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It is crucial to evaluate the socioeconomic standing of the fishermen who reside near the chosen artificial reef introduction sites, as the findings of these evaluations will be useful in determining the effects of the interventions. Eight locations in the district of Ramanathapuram and nine locations in the district of Pudukkottai were chosen for deployment. Data were gathered using a pretested schedule from the 779 fishers during the pre-deployment and 277 fishers during the post-deployment period. The artificial reefs were deployed at a distance of 7 kms and 7.5 to 10 m depth at Ramanathapuram and Pudukottai districts respectively. Daily fishing was more prevalent in both districts followed by weekly fishing. The most commonly used gears were gillnet, hook and line, goatfish net and crab net at Ramanathapuram district. Whereas, in the Pudukkottai district, the most commonly used gears were crab net, needlefish net and cuttlefish net. It was found that after reef deployment, the average catch per day was high in Ramanathapuram district (67 kg) followed by Pudukkottai district (25 kg). Trevally, emperor fish and squid catch were more in the Ramanathapuram district. Whereas, in the Pudukkottai district, catches of trevally, queenfish, squid and crab were more. At the Ramanathapuram district, maximum catch was obtained using gillnet gear, whereas the Pudukkottai district got maximum catch using crab net and cuttlefish net. Overall, due to artificial reef fishing the average monthly income of fishermen has improved significantly. Fishermen of Ramanathapuram district got an average monthly income of Rs. 18500, whereas Pudukkottai district fishermen got Rs. 14000 per month.

KEYWORDS: Artificial reef, Socio-economic, Fishing

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Improved Livelihood of Tribal Fishers of Jharkhand Through Scampi Fisheries Enhancement in Small Reservoirs

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India boasts a vast expanse of reservoirs, covering an area of 34.603 lakh hectares (FAO, 2024), which supports a thriving inland fishery. Reservoir fisheries management follows 'enhancement' principles, bridging culture and capture fisheries. Enhancement strategies include enhancement of stock (improved capture fisheries) and species (species introduction), management (introduction of new management practices) and innovative culture systems (cage culture, pen culture, fish aggregating devices, etc.) and many more. Reservoirs provide opportunities for one or more types of enhancements. The giant freshwater prawn (GFP), Macrobrachium rosenbergii, belonging to the Palaemonidae family, is notable for its largest size among palaemonids, high market value, appealing taste, and rapid growth rate. To harness the under-utilized reservoir resources in Jharkhand for the livelihood improvement of tribal communities through scampi fisheries enhancement, a MoU was executed between ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI), Barrackpore, and the Department of Fisheries, Jharkhand on the 23rd of May, 2023. Jharkhand's rural fisheries study was focused on three small reservoirs: Kelaghagh (162 ha), Ghaghra (110 ha) and Masariya (100 ha), supporting tribal communities. In September 2023, ICAR-CIFRI, with the help of tribal fishers, stocked between 2-4 lakhs scampi 23-24 PL in the reservoirs, following several management practices such as the eradication of predatory species, liming, and the installation of twigs and bushes to provide shelter for the scampi. The feeding regimen included scampi feed with 40% protein and 7% crude lipid, at a 5% ration, and mineral supplements were added every 15 days. Monthly sampling showed an average weight gain of over 100 g and a length increase exceeding 320 mm across eight months with a 3-month long winter spell. The largest selected reservoir, Kelaghagh led in productivity, reaching 25 t with an average weight gain of 110 g. This was followed by Masariya and Ghaghra reservoirs, which produced 12 t and 10 t, respectively, with average weight gains of 105 g and 102 g. Local tribal communities actively managed the reservoir, selling GFP (30 kg/week at Rs. 800-900/ kg). GFP introduction has increased women's involvement, transitioning from limited tasks to active participation, enhancing their social status and providing equal opportunities.

KEYWORDS: Reservoir, Enhancement, Scampi, Livelihood, Nutritional security

Improving Small-Scale Fisheries Viability through Cooperative Initiative: A Case Study of Sumaura Fisheries in Kobe City, Japan Yinji Li

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Despite their roles and importance in securing fisheries sustainability, Japanese smallscale fisheries face various challenges today, including unstable fishing household income, aging populations, lack of successors, losing community vitalities, etc. In addition to those challenges, a recent policy change that enables private capital to enter into coastal fisheries has caused significant concerns about the situation. Under these circumstances, efforts are being made to improve the viability of small-scale fisheries through collaboration. A good example is the Sumaura Fisheries Limited Liability Partnership Association in Kobe City, Hyogo Prefecture. This association was established in 2014 by small-scale nori seaweed farmers. According to the contract of the association, its members shall be persons with fishery rights belonging to the Sumaura District of the Kobe City Fisheries Cooperative Association and their spouses, who shall engage in the business conducted by the association and invest more than a certain amount specified by the association. In addition to nori aquaculture, it is involved in the processing and selling of marine products and other fisheries, as well as tourism. It not only contributes to the income of individual fishers but also significantly to the local economy. This study aims to analyze the specific mechanisms and socioeconomic significance of such cooperative initiatives and the reasons for their success. Understanding these factors is crucial for facilitating the transition from vulnerability to viability in smallscale fisheries.

Keywords: Small-scale aquaculture, Nori seaweed, Cooperation, Fishers' organization,
Association

Livelihood Diversification and Household Economic Security During Covid-19 Pandemic: Insights from Small-Scale Fisher Households in Kerala State, India

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The COVID-19 pandemic disrupted all facets of human life and created disproportionate impacts on various sections of society. The vulnerable sections of the population including workers in the informal sector, migrant labourers and women having low access to productive assets and social protection measures suffered the most during the pandemic. The paper attempts to analyse the economic security of small-scale fisher households during the COVID-19 pandemic and the impact of livelihood diversification on household income. Small-scale fisher households in the Alappuzha and Ernakulam districts of Kerala state in Southern India were selected for the study. The effects of the pandemic on household income, expenditure, and indebtedness were analysed. The economic security of the households was assessed by developing an economic security index (ESI). The livelihood diversification was analysed using the Simpson Index of Diversity. A multiple linear regression model was employed to examine the relationship between household income and the selected predictors. The results of the study indicated that households in Alappuzha had higher economic security (ESI-0.41) compared to households in Ernakulam (ESI-0.37). The average household income varied from Rs. 102710 in Ernakulam to Rs. 125355 in Alappuzha. There was 30% reduction in monthly household expenditure in the households in Ernakulam district, compared to the 21% reduction in Alappuzha district during the COVID-19 pandemic. The pandemic deepened the debt burden of small-scale fisher households, and more than 75% of the household's borrowed money from informal sources to cope with the economic crisis. The average borrowing during the pandemic was higher in Ernakulam district (Rs. 41025) in comparison to the Alappuzha district (Rs. 15565). The multiple regression analysis of household income and selected predictors revealed that livelihood diversification significantly influenced the household income of small-scale fisher households. The findings of the study stressed the need for livelihood diversification strategies to enhance the small-scale fisher household's resilience to stresses and shocks.

KEYWORDS: Economic security index, Household income, Simpson index of diversity, Small-scale fishers



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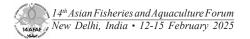
A Glimpse on STI Hub in Fisheries Sector for Improved Livelihood Entitlements in Kerala

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The state of Kerala, with its 560 km coastline and an Exclusive Economic Zone (EEZ) of 2.18 million km², holds significant potential for boosting fish production and improving the livelihoods of its coastal inhabitants. However, with the global decline in marine fish landings, it is crucial to promote sustainable coastal aquaculture practices. In Kerala, the Scheduled Caste (SC) communities, particularly in areas like Ernakulam district, are primarily engaged as wage laborers, with many working in fisheries-related activities such as fishing, fish marketing, net making, and value addition. As per the 2001 census, Kerala's SC population totals 3.12 million, representing 9.8% of the state's total population. To uplift these marginalized communities, the ICAR-Central Marine Fisheries Research Institute (CMFRI) initiated the project "Science Technology and Innovation Hub in Fisheries Sector" funded by the Department of Science and Technology, New Delhi, with a budget of 3.2 crores, executed from 2022 to 2025. This project aims to empower SC fisherfolk by mobilizing and strengthening Self-Help Groups (SHGs) and individual enterprises in the marine sector. It supports 12 sustainable, region-specific, and economically viable fishery-based microenterprises, implemented through 82 interventions across districts such as Ernakulam, Thrissur, Kollam, Pathanamthitta, Alappuzha, Kottayam, Kannur, Kozhikkode, and more. The project directly benefits 500 SC fisherfolk households, impacting 2,500 indirect beneficiaries. To date, 57 interventions have been completed, reaching 330 SC beneficiaries, who have seen an average income increase of 35% from 12 enterprises like cage culture, mussel culture, oyster culture, clam units, ornamental fish culture, fish farming, fish vending, dry fish production, integrated farming, fish fertiliser production, pearlspot seed production, value-added fish production, etc. The project also evaluated the break-even and pay-back periods, finding them satisfactory. The data from these interventions are documented at CMFRI's STI Hub, which also houses an Entrepreneurial Consultancy Cell (ECC) and an Entrepreneurial Technology Cell. Training and consultations are provided in a Digital Training Hall and through a mobile training unit with laboratory facilities. Additionally, the project facilitates SHG/individual entrepreneur linkages with government and financial institutions, with a sales outlet at ATIC-CMFRI providing a marketing platform. The STI Hub plays a vital role in enhancing employability, entrepreneurship, and self-reliance within SC communities through fishery-based microenterprises.

KEYWORDS: SHGs, Livelihood, Microenterprises, Socioeconomic development



Fostering Growth: Insights into Fisheries Development in Chhattisgarh and Madhya Pradesh

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The fisheries in India represents an emerging sub-sector with significant implications for the socio-economic development of states. The bifurcation of Madhya Pradesh into two smaller states, Chhattisgarh (CG) and Madhya Pradesh (MP), brought out contrasting growth trajectories. This study assessed the growth and development of the fisheries sector in MP and CG, pre- and post-bifurcation using various conventional growth analysis and a novel multi-dimensional Fisheries Development Index (FDI). Significant differences in growth patterns are evident. Between 2000 and 2022, CG's fisheries resources more than doubled from 45,250 ponds covering 0.63 lakh ha to 117,511 ponds covering 1.175 lakh ha; on the other hand, MP's resources declined a little from 91,000 ponds to 78,580 over the same period. This is evident from the higher fisheries sub-sector contribution (12.96%) in the agri and allied sector GVA of CG in 2020, which is much higher than MP's meagre 1.19%. CG's composite FDI score of 0.39 (39%) as compared to MP's 0.27 (27%) reflects better performance of CG on multiple dimensions of fisheries development indicators. Before bifurcation, MP's public expenditure on fisheries fluctuated, which stabilized and steadily increased post-bifurcation (8223.2 Lakh Rs. in 2019). In comparison, CG exhibited steady growth in revenue as well as capital expenditure thus indicating high public investment in the fisheries sector (10735.3 lakh Rs. in 2019). Investment and FDI scores indicated that both states utilized their resources efficiently with CG giving greater focus on the fisheries sector while MP retained its focus primarily on the crop/livestock sector. The study found limitations in the availability and quality of data, especially in MP, and recommends increasing public investment, sustaining infrastructure development, upgrading extension services and strengthening cooperative networks. 'Small is beautiful' has proven to be a truism for CG's fisheries sector as it witnessed one of the highest growths and development among the states during the last two decades, while the same was not evident in MP. Improved governance, higher public investment, and customized and effective development schemes have delivered better development outcomes, which were perhaps made possible by being a smaller state.

KEYWORDS: State bifurcation, Fisheries, Fisheries Development Index

Fishery Nutrient Profiles: A Practical Tool for Nutrition-sensitive Fisheries Management

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Small-scale fisheries are a crucial source of nutrient-dense aquatic foods in low- and middle-income countries (LMICs), yet practical tools to manage these fisheries to optimize nutritional outcomes in an ecosystem approach remain limited. We present an analytical framework and predictive model of nutrition scenarios under typical multispecies, multi-gear situations. Using six years of catch data from Timor-Leste, we modelled the nutritional contributions of various fishing methods and habitats. Our results demonstrate that fishing method and habitat are strong predictors of catch nutritional profiles, with gill net fishing in reef and pelagic habitats producing the highest nutrient density. Importantly, different combinations of fishing strategies can achieve similar nutritional outcomes, indicating complementary pathways to enhance nutrient availability for communities while balancing ecological, economic, and human wellbeing goals. This replicable framework provides actionable insights for nutrition-sensitive fisheries management and offers data-driven guidance for policies aimed at improving food and nutrition security in LMICs.

KEYWORDS: Small-scale fisheries, Nutrient profiles, Nutrition-sensitive fisheries

Assessment of Socio-economic Impact of Artificial Reefs Deployment in Gaja Cyclone Affected Districts of Nagapattinam and Thanjavur of Tamil Nadu, India

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The assessment of the socio-economic status of the fishers living in the area of selected sites of artificial reef introduction is very important and the results of the assessments will help to know the impact of the interventions. The sites selected for deployment are 13 sites in Thanjavur district and 16 sites in Nagapattinam district. Using a pretested schedule, the data were collected from the 1016 fishers during the pre-deployment and 139 fishers during the post-deployment period. The post-deployment survey revealed that the artificial reefs were deployed at a distance from shore and depth of 6 km and 6 m and 7.5 km and 16.5 m at Thanjavur and Nagapattinam districts, respectively. The frequency of fishing is slightly higher in Thanjavur district, followed by Nagapattinam district. It was found that, after the deployment of the reef, there was an increase in a few parameters like frequency of fishing in that area, gears used in the reef area, number of fishermen fishing in that area, average catch per day, and the impact of reef fish catch on the monthly income. Impact analysis revealed that in all the villages due to artificial reef fishing, the average monthly income of fishermen has improved significantly. Fishermen of Nagapattinam district got an average monthly income of Rs. 17500/-, whereas Thanjavur district fishermen got Rs. 10800/- per month. It is observed that there has been a substantial improvement in the income and employment levels of the respondents, and thus in the socio-economic status of the respondents in the reef deployed area. Hence it is recommended, that the deployment of more Artificial Reefs in suitable areas will help to improve the fish catch of the traditional and marginal fishermen and their standard of living.

KEYWORDS: Artificial reef, Fishing, Deployment

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Pollution in the Jalangi River and its Socioeconomic Ramifications for Fishers' Livelihoods

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This study examines the nexus between water quality and the socio-economic conditions of fishers along the Jalangi River, India. The Jalangi River, an essential tributary of river Ganga spanning 250 km, faces significant pollution challenges, impacting the livelihoods of the fishing communities along its banks. The primary sources of pollution include agricultural runoff, household waste, jute retting, and sand mining, leading to water degradation and a decline in fish populations. The river is highly polluted with microplastics, heavy metals, and Bisphenol A (eBPA), posing severe risks to both the aquatic ecosystem and local communities. Microplastic analysis reveals the presence of polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS). Additionally, the river is contaminated with heavy metals, with elevated levels of aluminum (0.1402 mg/l), chromium (0.00362 mg/l), and nickel (0.1088 mg/l), especially near the river's mouth, eBPA levels peaked at 340.6 ng/l, further compromising the river's health and posing risks to human and aquatic life. The fishing community, predominantly male and from the Scheduled Caste, depends heavily on the river. Throughout the year, daily fish catches range between 800-1200 grams, increasing to 2-4.5 kilograms during the monsoon season. However, younger generations are discouraged from fishing due to declining fish availability and environmental challenges. The average monthly family income is Rs. 5470, with 43% of fishers earning less than Rs. 5000 per month from all sources. Women have limited involvement in fishing but contribute through post-harvest activities. The socio-economic conditions of fishers along the Jalangi River are deeply influenced by environmental degradation and the absence of alternative livelihood options. Efforts like the National Mission for Clean Ganga (NMCG) are crucial for improving the environmental and socio-economic conditions of these communities, as the degradation of the river not only affects fish populations but also destabilizes the economic fabric of the fishing-dependent families.

KEYWORDS: Fishers, Livelihoods, Pollution, Socio-economics

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Occupational Hazards Faced by Fish and Shrimp Farm Workers in West Bengal

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A study was conducted among workers in fish and shrimp farms using interview schedules. aiming to explore the spectrum of occupational hazards they face. These hazards were categorized into physical, chemical, biological, ergonomic and psychological. The study revealed that workers are impacted by these hazards, emphasizing the need for safety measures. Statistically significant variations in hazard types between fish and shrimp farm workers were identified, particularly concerning chemical and psychosocial hazards. This disparity suggests that safety interventions should be tailored to the specific type of farm and the nature of hazard exposure encountered. To further analyze these relationships, a multivariate approach was employed using logistic regression. This analysis assessed how each type of hazard influences the likelihood of overall hazard exposure, with the dependent variable being 'overall exposure to hazards' (binary outcome: exposed vs. not exposed). The independent variables in this model included physical, chemical, biological, ergonomic and psychosocial hazards. Logistic regression models were applied to determine the Odds Ratios (OR) for each hazard type, revealing the extent to which the presence of one type of hazard affects the likelihood of encountering others. The analysis demonstrated that physical hazards had an OR of 1.2, indicating a moderate increase in the likelihood of reporting other hazards when physical hazards are present. Chemical hazards showed a notably higher OR of 2.5, suggesting a significant increase in the likelihood of experiencing additional types of hazards. This finding highlights the profound impact of chemical hazards on overall hazard exposure. In contrast, biological hazards had an OR of 1.1, which signifies a slight increase in the likelihood of encountering other hazards but was not statistically significant. Ergonomic hazards were associated with an OR of 1.3, reflecting a moderate increase in the likelihood of reporting other hazards. Psychosocial hazards exhibited an OR of 2.0, indicating a substantial impact on the likelihood of experiencing other types of hazards. The results underscore that chemical and psychosocial hazards have a significant influence on overall hazard exposure, as evidenced by their high OR and significant p-values. On the other hand, physical, biological, and ergonomic hazards did not show significant differences when controlling other variables, suggesting that their impact on overall hazard exposure is less pronounced compared to chemical and psychosocial hazards.

KEYWORDS: Shrimp farm workers, Occupational safety, West Bengal



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Exploring the Fisheries Cooperatives Involved in Cage Culture in the Sardar Sarovar Reservoir, Maharashtra

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Sardar Sarovar Reservoir, with a gross capacity of 0.95 million hectare and a live storage capacity of 0.586 million hectare, spans an area of 37,000 hectares. The reservoir extends 214 km in length with an average width of 1.7 km. Recognizing the potential for fish culture, the Department of Fisheries (DoF), Maharashtra, have facilitated the installation of fish cages and provided necessary training and inputs for the culture of *Pangasianodon* hypophthalmus. Currently, cage culture is undertaken in 470 cages by 16 fisheries cooperative societies, collectively comprising 1,019 members. A comprehensive overview of these societies was conducted through interviews and Focused Group Discussions. Societies, established between 2014 and 2022, are distributed across two blocks: Akkalkuva and Dhadgaon. Membership sizes vary from 25 to 136 with males outnumbering female members. Fish cage allocation varies, with majority of societies utilizing 20 cages. Notably, societies such as Narmada Navnirman Baba Gufanayedev Fisheries Cooperative Society and Narmada Navnirman Fisheries Cooperative Society at Chimalkhedi-1 use upto 48 cages, indicating a higher scale of operations compared to others. Statistical analyses reveal several important insights into the characteristics and dynamics of these societies. Correlation analysis between membership size and fish cage usage indicates a weak relationship, suggesting that the number of fish cages is not strongly influenced by number of members. This finding implies that factors other than membership size may play a more significant role in determining the scale of fish culture operations, ANOVA results reveal a statistically significant difference in membership sizes across different registration years. This suggests that newer societies generally have fewer members compared to older societies, reflecting the developmental stages of these cooperatives. Regression analysis further supports this, with a positive coefficient indicating that for each additional year since 2014, total number of members increased by 2. However, the effect of total membership on the number of fish cages is relatively small, with a coefficient of 0.1, meaning that, while there is a positive relationship, it is not substantial. Factor analysis identified two principal factors: Factor 1 reflects overall society size and male dominance, while Factor 2 captures the operational scale and gender distribution. Cluster analysis categorized societies into distinct clusters based on size and operational scale. Overall, the fisheries cooperative societies in the Sardar Sarovar Reservoir area exhibit diversity in membership size, gender distribution and cage usage.

KEYWORDS: Sardar Sarovar Reservoir, Cage culture, Fisheries Co-operative societies



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Livelihood Analysis of Gillnet Operators of Ratnagiri, Maharashtra State

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Gillnets are of special interest to small-scale fishermen due to their low investment, high energy efficiency and simple operation with the help of both motorized as well as country crafts. The present study was conducted to analyze the livelihood of gillnet operators of Ratnagiri block, Maharashtra. A total of 120 gillnet operators were randomly selected from thirteen coastal villages in the study area and interviewed using an interview schedule prepared as per the DFID livelihood framework. The study found that the maximum gillnet operators were Hindus, in the age group of 45 to 55 years, and had a secondary level of education. As per the sustainable livelihood framework the five capitals were considered, such as physical, human, financial, natural and social capital. The study found that the average component score of the physical capital of the gillnet operator was 0.585. Similarly, human, financial, natural, and social capital scored 0.415, 0.336, 0.592, and 0.438 respectively. The study revealed that gillnet operators had an average availability of physical, human, natural, and social capital. However, they faced limited access to financial capital, primarily due to low income and a lack of financial assistance. This shortage negatively impacted the livelihoods of gillnet operators. To improve the livelihood status of gillnet operators, the state government needs to provide financial assistance as well as training and extension services to gillnet operators to improve their livelihood status.

KEYWORDS: Sustainable livelihood framework, Gillnet, DFID, Ratnagiri

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Mussel Farming as a Sustainable Solution Enhancing Economic Resilience and Livelihood Among Coastal Fisherfolk

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Bivalve culture holds significant potential to meet the growing protein demands of the human population. Oysters, mussels, and clams, collectively known as bivalves, are among the most important cultivated species worldwide. Kerala has abundant mussel resources, usually associated with the rocky shore areas. Perna viridis (green mussel) and P. perna (brown mussel) are the two species used for culture. They are filter feeders that consume plankton and other organic matter from the water. Eco-friendly mussel culture techniques, established by the ICAR-Central Marine Fisheries Research Institute (CMFRI), are being promoted throughout Kerala's coastal belt. This study aimed to assess the economic feasibility of the rack method for mussel farming and the associated management policies among Scheduled Caste beneficiaries. The initiative was promoted as part of the Department of Science and Technology (DST) funded project, entitled "Science Technology and Innovation Hub in the Fisheries Sector, Kochi Corporation, Ernakulam District, Kerala State" granted to ICAR-CMFRI. Two mussel culture units were established at Kottappuram in the Thrissur district as part of this project. Each of the two culture systems with 100 seeded ropes has a stocking density of 400 seeds per rope. P. viridis was the cultured species. These units were undertaken by two SHGs of 12 SC beneficiaries in total. The culture has a shell-on production of 840 kg with a gross revenue of Rs. 1,68,000 showing an average Benefit Cost (BC) ratio of 1.6. While low-cost mussel farming offers considerable potential for economic growth in coastal communities, beneficiaries face significant challenges, such as the unavailability of mussel seeds on time and the presence of invasive species. This study suggests that, ensuring a steady supply of hatchery-produced mussel seeds is crucial for establishing a sustainable mussel farming system among marginalized communities. Additionally, it highlights the need for improved post-harvest technologies to develop appealing value-added products, thereby enhancing economic sustainability.

KEYWORDS: Bivalve culture, Perna viridis, Self-Help Groups, Rack Culture

Edible Oyster Farming as a Catalyst for Socio-Economic Development of Coastal Community: A Case Study from Ashtamudi Lake

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Kerala's coastline is dotted with numerous estuaries and brackish water lakes, providing significant potential for the expansion of edible oyster farming. Oysters are a highly valued seafood delicacy in countries like the USA, Europe, and Japan. The ICAR-Central Marine Fisheries Research Institute (CMFRI) has been promoting oyster farming across various regions in India. This study was conducted as part of the project titled "Science Technology and Innovation Hub in the Fisheries Sector, Kochi Corporation, Ernakulam District, Kerala State" funded by the Department of Science and Technology (DST), New Delhi granted to ICAR-CMFRI. Oyster farms were established in Ashtamudi Lake near St Sebastian Island of Kollam district. Magallana bilineata (Indian backwater oyster) was the species cultured. This study investigates the scope of oyster farming in this area and the socioeconomic development of farmers engaged. Oyster farming is usually more affordable than fish farming because it does not require supplementary feed. The main expense is the initial setup cost for the farming units. The economic indicators projecting the break-even point, gross revenue, net income, Benefit Cost Ratio (BCR), etc. were analysed from the rack of 5 m x 5 m bearing 300 oyster strings. The oyster farming unit had a BC ratio of 3, gross revenue of Rs. 74,825 and a net income of Rs. 50,749 generated from a total annual operating cost of Rs. 24,076. The primary challenge identified by the growers was the inadequate marketing channels for live oysters, limiting their ability to achieve maximum profit. The study suggests that oyster farming could serve as an excellent source of additional income for coastal communities, as it requires minimal investment and management. To fully realize its potential, the implementation of innovative market reforms in this sector is essential.

KEYWORDS: Magallana bilineata, Gross revenue, Net income, Economic empowerment

Empowering Coastal Communities: Promoting Sustainability through Fish Value Addition

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Kerala covers an area of 38,863 square kilometers and features a coastline of 590 kilometers, complemented by countless water bodies that are essential to the livelihood of its residents. These aquatic resources are not only important for ecological diversity but also for the economy. More than a million fisherfolk in the state rely on the abundant aquatic biodiversity and fish stock for their sustenance. To address the perishability of fish, converting surplus catches into value-added products is crucial for meeting protein needs, consumer demand, and quality standards, while extending shelf life. As part of the project entitled "Science Technology and Innovation Hub in the Fisheries Sector, Kochi Corporation, Ernakulam District, Kerala State" funded by the Department of Science and Technology (DST), granted to ICAR-Central Marine Fisheries Research Institute (CMFRI), two small-scale value-added fish production units were established in Navarambalam and Mouloodupuram. The study assessed the economic viability of these units, operated by two self-help groups (SHGs) with six members each, ensuring gender equality. The study recorded an average production of 288 kg of fish pickle annually with an average benefit-cost (BC) ratio of 2.2 and a payback period of 0.19 years. The findings highlight the potential of value addition as a viable microenterprise model, promoting the economic empowerment of fisherfolk with low investment and moderate profitability.

KEYWORDS: BC Ratio, SHG, Fish Pickling, Value added fish products, Economic empowerment

Bridging Technology and Tradition: Possibilities for Developing an ICT Framework to Support Recreational Fisheries

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Fish-based ecotourism has become a significant sector within agro-ecotourism, focusing on activities like sport fishing, angling, swimming, and rafting. This approach emphasises the sustainability of aquatic biodiversity while supporting local livelihoods. North-east India is rich in resources and fish-based ecotourism presents promising opportunities. Several initiatives have already been established, with the Mahseer being the favoured game fish for anglers visiting rivers such as the Kameng and Subansiri in Arunachal Pradesh and Assam. Local entrepreneurs in Meghalaya's Khasi hills have also launched similar ventures. Additionally, the ICAR-Directorate of Coldwater Fisheries Research, Bhimtal has introduced exotic trout species in Tawang to boost local tourism. Homestays integrated with fishing activities are emerging in areas like Ziro Valley and Sohra, while fish sanctuary tourism is developing in the Garo Hills Meghalaya. As fish-based ecotourism grows, it is crucial to meet tourist demands with innovative experiences that ensure sustainability and contribute to the region's economic development. Despite the historical presence of recreational fishing in India, there are currently no mobile applications (App) developed in the country for this purpose, even though there are 18 existing apps globally related to Aquaculture. This indicates an untapped potential for integrating Information Technology (IT) into the fisheries sector in India. Collaborating with IT providers to develop innovative mobile solutions could lead to sustainable and profitable advancements in the fish-to-fork food chain. For farmers, such an App can serve as a powerful tool to promote and manage fishing tournaments, reaching a broader audience with minimal effort. For tourists, this App will provide a seamless platform to book homestays and various recreational activities, all in one convenient location. Therefore, designing and developing an ICT-based application can benefit farmers and tourists. Digital technologies through ICTs open arrays of opportunities for farmers, investors, and entrepreneurs to improve the efficiency of production and marketing of agricultural produce.

KEYWORDS: Recreational fisheries, Information and communication technology, Mobile App, Northeast India, Livelihood opportunities

Group Dynamics and Performance Appraisal of Fisheries Based Self Help Groups (SHGs) in Tripura, India

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The fisheries sector has enormous potential for livelihood generation in North Eastern-India with abundant water resources and aquatic diversity. The fisheries sector has always included women in many different civilizations across the world. Their functions have been complementing or even sometimes crucial to the family food production and income generation, much as in agriculture. Women make up about half of the world's population, but in the NEH region, the sex ratio is below the national average. The overall growth and development of a nation can only be achieved when women are given equal consideration along side men in society. SHGs have emerged as a powerful instrument to eliminate poverty and for the empowerment of women by providing financial services to the poor and further improving their status in society. The current study was conducted in Tripura during 2023 and 2024 to assess the group dynamics, performance, livelihood security, and women empowerment of fisheries-based self-help groups (SHGs). The data was collected from randomly selected samples of 120 SHG women across 24 fisheries-based SHGs in the West Tripura and Gomati districts. The majority of SHG members belong to mediumsized families with moderate educational levels, predominantly from Scheduled Castes and Tribes. Group dynamics indicators such as participation, teamwork, and communication show moderate effectiveness, with regional disparities in performance. The assessment of SHG performance indicates variability, with 20.83% rated as "Very Good" and 12.5% as "Unsatisfactory." Educational and infrastructural security contributed to a maximum livelihood security index while, social security contributed a very low livelihood security index, suggesting a need for targeted interventions. The study also highlights significant empowerment gains among women through increased decision-making ability, spending power, and social participation, despite challenges in record-keeping, banking procedures, and decision-making. The research provides critical insights for policymakers to enhance SHG initiatives and rural economic conditions in North Eastern India, emphasizing the need for improved training, social security, and credit management within SHGs.

KEYWORDS: Group dynamics, Performance appraisal, Livelihood security, Fisheries-based SHG, Women empowerment

Willingness to Reduce Single-Use Plastic Waste Along the Fisheries Value Chain: Philippines

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The increasing concern on single-use plastics (SUP) causing marine pollution can be addressed by looking into the consumption behavior of men and women which in turn are affected by knowledge, perceptions, and attitude. This study explores these areas as reported by fishing input providers, fishers, processors, packers, distributors and traders along the fisheries value chain. These further shed light on the stakeholders' willingness to reduce the consumption of SUP in fishing. They, however, say that plastics are convenient to use, are cost-effective alternatives, versatile, readily available and accessible. A total of 185 stakeholders along the fisheries value chain (53% males and 47% females), mostly belonging to the 30 to 49 age group participated in the survey. They come from Catbalogan, Samar and Tacloban, Leyte fish ports, both in Eastern Visayas, Philippines. About 69% did not reach tertiary education, 62% were married, and 74% were aware of marine plastic pollution. Forty statements were included in a Likert scale, distributed into the following categories: (1) knowledge on sources/causes of marine pollution, SUP's end-of-life, and SUP impacts; (2) perceptions on personal motives to reduce SUP waste, the use of regulation to reduce SUP waste, and social (dis) approval of the behavior to reduce SUP waste; and (3) attitudes on the ability to perform the behavior of reducing SUP waste, on the social pressure to engage in the behavior, and on the personal beliefs about the behavior. The significant variables, using the Kruskal-Wallis H test and based on chi-square values, seem to show that along the fisheries value chain, it is the processors who are least knowledgeable regarding SUP endof-life, and this may explain the improper SUP disposal. They also have the least favorable perceptions with regard to personal motives and social (dis) approval of behaviors to reduce SUP use and waste. They do not believe that microplastics could get into the food chain, nor do they believe that SUP reduction campaigns by environmental groups are significant. The traders are in a similar situation as they have the attitude to continue using SUPs despite social pressure on SUP reduction. This attitude is supported by the finding on the traders' high degree of unwillingness to reduce SUP waste (chi-square value = 11.23 at p<0.05). Between the sexes, the t-test showed no significant gender differentials across the value chain nodes. An expanded study to include more fishing sites is recommended to confirm this study's conclusion that attitude which favors SUP waste reduction coupled with the ability and motivation to change behaviors are the two most important variables towards heightening the intent and the action to reduce SUP waste in fisheries.

KEYWORDS: Single-use plastics, Fisheries value chain, SUP waste



Understanding Knowledge, Perception, and Attitude Toward Willingness to Reduce Single-use Plastic Waste at Small-scale Fish Landing Sites in Indonesia

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This study investigated four latent variables: knowledge, attitude, perception, and willingness to reduce single-use plastic (SUP) in six small-scale fish landing centers in Indonesia. The poor management of SUP waste is an environmental problem in these locations. This study aimed to identify latent variables as key to reducing SUP waste at fish landing sites. A total of 101 male and 51 female respondents who played roles in the value chain were interviewed. The PLS-SEM SUP model has undergone convergent validity, discriminant validity, reliability, R-Square, and path coefficient tests. It was found that attitude change is critical for reducing SUP waste. This should be done because 52.6% of male and 28.9% of female respondents dispose of SUP waste in general dispose location (without sorting). In general, the decision was made by 22.4% of wives, 32.2% of husbands, and 45.4% of spouses. The husband's decisions were dominant in Kalibaru, Cilincing, Johan Pahlawan, and Mereubo. However, in Sawojajar and Kaliwengi, spouse's decisions played a role. Socialization programs on the impact of SUP, implementation of government regulations on SUP waste disposal, and community empowerment to utilize SUP waste to produce valuable products should be performed selectively. In Sawojajar and Kaliwengi, the husband and wife should be utilized, but in the other four research locations, the husband was the target of the activity.

KEYWORDS: Single Use Plastic, Plastic Pollution, Knowledge, Attitude, Perception, Willingness

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Knowledge, Perception and Attitude of Stakeholders on Single-Use Plastic and its Effects on the Marine Environment: A Gendered Value Chain Analysis of Fisheries in Mumbai, Maharashtra

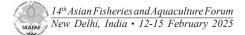
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Awareness about the dangers posed to the environment by plastic pollution, and in turn by microplastics, is an important step towards controlling the amount of plastic litter that ends up discarded in the environment. This study in Mumbai, Maharashtra aimed to assess the awareness, perception, and attitude of the fishing community towards plastic pollution and how they are influenced by some demographic factors such as gender and type of occupation. Three major landing centers- Versova, Sasson Dock (SSD), and New Ferry Wharf (NFW) were surveyed via a structured interview schedule. This study primarily adopted a descriptive survey design where 180 purposively selected respondents. including fishers, intermediaries, source suppliers, dryers, and retailers were interviewed. Findings revealed that all three centres had almost a consistent pattern of answers with a mild difference. Respondents showed a good level of awareness about plastic use although awareness regarding microplastics was poor. Respondents perceive govt and academia has an important role to play in raising awareness and regulating plastic use. They also believed that it was better to nip the evil in the bud by not only enforcing the ban but also shutting down the manufacturing companies. Community participation was also perceived as the driver to phase out the menace. Participants acknowledged that environmental education through social media platforms, school plans and other sensitization activities can help in reducing plastic use. Respondents showed a positive attitude towards learning more on this subject, willingness to reduce it, and shared commitment to support the government through cleanup volunteering and individual actions in terms of disowning the material. Mann Whitney test conducted to evaluate the significance of these behavioural variables with respect to gender revealed that both men and women held similar views regarding plastic use and its various aspects. The Kruskal-Wallis test revealed significant variations among the supply chain actors, prompting Dunn's test to pinpoint specific group differences. In all the pairwise comparisons (5C2) with Dunn's test, the most significant awareness difference was between the "Source supplier" and "Auctioneer" groups. For perception, among the five significant variables, "imparting education" had the highest pairwise significance. The study concluded that around half of the sampled respondents believed that the litter is disposed of in the oceans depicting an alarming concern that a small proportion of discarded plastics are recycled or incinerated in waste-to-energy facilities.

KEYWORDS: Single-use plastic, Marine environment, Value chain analysis, Fisheries



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Technical Session-11 Gender in Fisheries & Aquaculture



Evaluation of *Cyprinus carpio*, *Barbonymous gonionotus* and *Labeo rohita* as Potential Candidate Species for Mid-Altitude Reservoir Cages with Fisherwomen Participation of Northeast India

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Cage culture in Indian reservoirs is an ideal strategy for increasing fish production from these resources in addition to capture fisheries. Diversification of fish species and communitybased management in cage culture at mid-altitude regions need immediate attention for its success. Against this backdrop, the polyculture of carps in the Umiam reservoir through fisherwomen participation was assessed. Umiam reservoir is a small reservoir (500 ha) located in the northeastern state of Meghalaya, India (25°39'30" N and 91°43'51" E) at an altitude of above 900 m MSL. A battery of six CIFRI GI cages with an area of 100 m³ per cage (5x5x4 m³ per cage) was installed in the reservoir with a total effective water volume of 540 m³ (90 m³/cage). Fingerlings of common carp, Cyprinus carpio (60%), silver barb, Barbonymous gonionotus (20%), and rrohu, Labeo rohita (20%), were stocked in the cages with 3 stocking densities viz., 10, 15 and 20 nos/m³. Fish fingerlings were obtained from the ICAR fish farm. Umiam. Fishes were fed twice daily with CIFRI-CAGEGROW (Crude protein- 28%) floating feed @ 2-5% of their body weight. Growth and water quality monitoring was carried out at monthly intervals, daily feeding was done by the local fisherwomen under Ri-Bhoi Farmers' Union. After six months of rearing, an average fish production of 5-6 kg/m³ cage was achieved. Common carp appears to be the best-performing species followed by Silver barb in terms of growth and survival in cages installed in the mid-altitude region. Silver barb also acted as the cleaner of net cages. The growth performance of rohu was significantly less as compared to common carp and silver barb. Silver barb can be used for summer crops only, as we observed the sensitivity of the species towards low temperatures. The present finding suggested that common carp in combination with silver barb can be a model for cage culture in mid-altitude reservoirs of northeast India as a summer crop. The final harvests of the cages directly benefited 25 tribal fisherwomen families in the locality. A major portion of the cage-reared fishes (mainly Rohu) were released in the reservoir as a stock enhancement measure for sustainable fishery. Management in cages by fisherwomen participation is the key to good results and sustainability.

KEYWORDS: Cage culture, Carps, Floating cages, Umiam reservoir, India



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Nursery Rearing of Milkfish, *Chanos chanos* as A Livelihood Activity by The Self-Help Group of Navsari District, Gujarat

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Milkfish (*Chanos chanos*) is one of the most promising species for aquaculture diversification and production due to its euryhaline nature, disease resistance, herbivory, fast growth, readily acceptance of formulated feed, suitability for polyculture and low cost of production. A major bottleneck limiting the expansion of milkfish aquaculture is the inadequate availability of nursery-reared fingerlings for grow-out systems. Therefore, the Navsari-Gujarat Research Centre (NGRC) of ICAR-Central Institute of Brackishwater Aquaculture, formed a women's self-help group (SHG) comprising 6 women and 2 men for nursery rearing of milkfish in hapa in the pond as a livelihood generation activity. The trial was conducted in HDPE hapa (2m x 1m x 1m, 2 to 10 mm mesh) installed in a pond for 90 days. Milkfish fry (14,000 nos) in size range of 2.0-2.5 cm and 0.3-0.5 g were obtained from ICAR-Central Institute of Brackishwater Aquaculture hatchery, Chennai and stocked at densities of 500, 600, 700, 800, 900 and 1000 nos/hapa respectively. Selected SHG members were trained on pond preparation, seed stocking, feeding, hapa and water quality management. The experiment had a 6 x 3 factorial design and throughout the study, fry was fed with 0.6-1.2 mm pellet feed containing 30-32% crude protein @ 8-10% of body weight twice a day. Sampling was carried out at intervals of 15 days to record fish growth and survival. At the end of the study, milkfish seed reached fingerlings size of 9.2-13.4 cm and 10.6-16.8 g with an average survival of 92.72%. The highest growth viz., total weight gain (g), daily weight gain (g), specific growth rate (SGR) and survival (%) was found in fish stocked at a density of 500 nos/hapa, followed by 600 to 700 nos/hapa, and fish growth and survival at densities of 500, 600 and 700 nos/hapa exhibited significantly (p<0.05) better values than fishes stocked at higher densities of 800 to 1000 nos/hapa. Harvested fingerlings were sold @ Rs. 12-15/fish to other local shrimp farmers for polyculture in ponds and the SHG generated revenue of Rs. 1.62 lakhs. Results of the present study suggest that milkfish nursery rearing in hapa is an ideal livelihood activity in shrimp farming regions, and a stocking density of 700 nos/hapa (300 nos/m²) can yield better growth, survival, and income.

KEYWORDS: Hapa, Livelihood, Milkfish, Nursery, Self-Help Group

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Bivalve Mariculture-AWay for Livelihood and Women Empowerment of Coastal Communities of Kerala

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Global fisheries and aquaculture production surged to 223.2 million tonnes. For the first time, production of animal species from aquaculture (51%) surpassed that from capture fisheries and aquaculture production reached an all-time high of 130.9 million tonnes (FAO, 2024). While capture fisheries production has remained largely unchanged for decades, aquaculture has increased by 6.6% since 2020, contributing over 57% of aquatic animal products used for direct human consumption. Molluscs, mainly bivalves account for about 15.6% of the production. Mariculture of bivalves has greater importance in meeting the increasing protein demands of the human population. Bivalves, especially mussels, oysters and clams are considered nutritionally rich health food and form an important candidate species for sustainable aquaculture globally. Bivalves have been traditionally a subsistence food for the coastal people in the west coast maritime states of India from time immemorial. The existing technologies of mussel and oyster farming developed by the Central Marine Fisheries Research Institute (CMFRI) were converted into an income-generating activity for coastal fishers, particularly for women's self-help groups. As a result of a concerted approach, coupled with novel extension techniques, commercial mussel and oyster farming became established in the States of India, particularly in Kerala. Commercialization of bivalve farming has led to the development of several new value chains in Kerala State. The biggest outcome of the growth of bivalve farming in Kerala was the empowerment of women with 87% of the SHG farms owned by women. It is well known that women represent about 70% of the poor and there are gender inequalities. Farming of bivalves is a women-friendly technology in Kerala. The technology was chosen by the women's self-help groups (SHGs). These groups were designed as a strategy for poverty alleviation, and also to increase women's access to resources and power in household decision-making.

KEYWORDS: Women empowerment, Bivalve farming, Women self-help groups

Lifting the Imperceptible Veil of Women in Small Scale Fisheries: Are Fisherwomen Devaluing their Real Worth? A Transect in the Less Explored Coastal Tracts of Gujarat, India

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Fisherwomen have been behoving and shaping the cash influxes and outflows in every segment of the value chain, and in doing so, they are scarcely aware of the potential role played by them in mediating trade, market structures and subtle yet palpable shifts in every segment of the value chain. As the world comes to terms with heated discourses on gender equality and the need for gender-blind policies, central to the achievement of Sustainable Development Goals (SDG 5), a nuanced understanding of the transitions wrought in women's lives is imperative for providing new insights in framing gender sensitive developmental policies and fisheries panarchy. Our study situated in two coastal villages of Gujarat namely Madhvad and Rajpara attempts to capture the interplay of social, economic and technological factors which shape the behavioural dimensions of fisherwomen who were impacted differently in terms of their caste, educational status, social capital, knowledge level, awareness and participation in small scale fisheries. A mixed method of research was employed consisting of structured schedules for data collection, freewheeling interviews, narratives and observations. Fisherwomen of Madhyad scored significantly more in terms of their knowledge level in small-scale fisheries when compared to women of Rajpara who in turn had greater decision-making abilities in their families, a social transformation brought about due to mechanisation of the Dolnet fishery in the village.

KEYWORDS: Gender, Fisherwomen, Knowledge, Awareness, Small-scale fisheries

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Gender and Coping Strategies During Covid Pandemic Across Marine Fisher Households in India

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With renewed focus on gender and households in the post-Covid era, there is a need for community-specific studies to understand the impact of the pandemic on particularly vulnerable communities such as the fisher communities. By focusing on the fisher families in India, the paper attempts to bring to the fore how gender influences the choices of domains and strategies for the fisher families across 9 coastal states in India. Examining how women and men, as heads of households are engaged in various capacities (labourer, trader, auction agents) in the fisheries sector relied upon different sources to deal with the impact of covid. Based on an extensive survey covering all nine coastal districts, four major coping domains; consumption, employment, social and health were identified and specific strategies adopted by the households were examined. The paper relies on 120 women-headed households and 120 male-headed households and identified the increasing reliance of women on government and community-level structures to tide over difficulties, contrasting with the reliance of male-headed households on themselves and family. As far as consumption and social coping domains were concerned, increasing reliance by women-headed households was on self and community while male-headed households relied on family and relatives. There was greater congruence between female and male-headed households in strategies opted in the domain of employment and social with both opting to engage in part-time fishing and engaging in relief activities respectively. However, women preferred to change their own tastes to maintain consumption while men relied on using past savings. Finally, as far as health was concerned, women placed greater emphasis on maintaining hygiene while men relied on accessing the vaccines.

KEYWORDS: Covid pandemic, Coping strategies, Gender

Navigating Climate Challenges: Women Empowerment Through Small-scale Aquaculture in Indian Sundarbans

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The Indian Sundarbans, a fragile delta region, faces pressing environmental challenges due to climate change, including rising sea levels, saltwater intrusion, and extreme weather events. These impacts threaten traditional livelihoods, particularly for small-scale aquaculture, a vital source of income and food security for local communities. In this context, women are emerging as key agents of resilience, driving innovative practices in sustainable small-scale aquaculture that both adapt to and mitigate climate challenges. This study examines the transformative role of women in building climate-resilient small-scale fisheries within the Sundarbans, A total of 240 women of Indian Sundarbans, were interviewed with a semistructured interview schedule. It was found that the women-led initiatives, like the polyculture of IMC with SIF in backyard ponds and the introduction of climate-resilient SIF *Puntius* sarana, demonstrated viable pathways for adaptation that enhance ecological balance, improve household resilience and support economic empowerment. These fish species, naturally adapted to local water bodies, are hardy and more tolerant to environmental stressors such as fluctuating salinity, water temperature changes, and irregular monsoon patterns. It was also found that there was 91% income increment among the sampled women populace doing small-scale aquaculture, and that has led them to achieve economic empowerment. The small indigenous fishes are nutrition-rich, and consumption of SIF in their households has also helped in their nutritional security. Thus, small-scale aquaculture offers a significant opportunity to enhance both the income and nutrition of the region's vulnerable communities and can empower the women by providing economic stability and contributing to the overall resilience and well-being of their communities.

KEYWORDS: Small-scale aquaculture, Women empowerment, Climate-resilient, Sundarbans

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Trans: The 3rd Gender Inclusive Perspective in Indian Fisheries Sector: Paving the Way for Gender Mainstreaming and Empowerment

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This study explores the empowerment of transgender individuals within the Indian fisheries sector, focusing on their entrepreneurial potential as part of the research initiative, "Transgender as an Inclusive Perspective." Transgender individuals, particularly in the LGBTQIA++ community, face persistent socio-political and economic discrimination, and this research aims to highlight entrepreneurial opportunities for them through fishery-based ventures as secondary livelihood options. The research adopted an action-based approach, beginning with the creation of a comprehensive database of transgender stakeholders interested in fisheryrelated microenterprises. Sensitization programmes and Entrepreneurial Capacity Building training conclaves were organized to empower this marginalized group in various fisheriesbased enterprises. Data collection involved a standardized protocol and case study methods, surveying 120 transgender individuals (56 transwomen, 53 transmen and 11 unwilling to reveal) to assess their preferences for fishery-related startups. The study found that fish valueadded enterprises were the most favoured, followed by ornamental fish culture, aquatourism, and fish vending. Success case studies of transgender entrepreneurs in these fields were documented, including economic viability indicators. Constraint analysis, using Friedman's test, revealed that social isolation, financial challenges, and gender marginalization were the most significant barriers faced by transgender stakeholders in the fisheries sector. Despite these challenges, several success stories emerged, demonstrating the feasibility of fisherybased ventures such as fish vending units, ornamental fish culture, integrated fish farming, value-added fish production, etc. for transgender beneficiaries mobilised as Self Help Groups through external funding. These examples can serve as practical models for similar initiatives aimed at fostering economic inclusion for marginalized communities. The findings offer valuable insights into the entrepreneurial possibilities within the fisheries sector for transgender individuals and provide a blueprint for further research and action in this domain. This study underscores the need for targeted interventions to address the challenges faced by transgender individuals and promote their economic empowerment through fisheriesbased entrepreneurship, offering both a path for social inclusion and sustainable livelihood development.

Keywords: Transgender, Inclusive perspective, Gender mainstreaming, SHGs, Livelihood, Microenterprises



Inclusivity of Transgender in Fisheries Sector: Taking the Concept of Gender Mainstreaming Forward and Upward

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Gender equality, a universally agreed-upon principle, is adopted widely but implemented to varying degrees across different sectors. The fisheries sector, which has provided food, livelihood, and income since the dawn of human civilization, is no exception and is significantly impacted by gender and social inequalities. Traditionally, culture and capture fisheries have been dominated by men due to various social, cultural, and economic factors. However, women play a crucial role in sustaining household nutritional and income security through post-harvest technology. It is evident that both men and women contribute significantly to the fisheries sector's overall growth and development. Despite these contributions, transgender individuals often face marginalization in the fisheries sector, particularly in developing countries. They encounter substantial challenges, including limited access to and control over assets and resources, restrictive gender norms, and barriers to sustaining entrepreneurship. Consequently, transgender individuals often have fewer opportunities and are more likely to live in poverty. These challenges are not only social justice issues but also critical for the sector's sustainable development. In smallscale fisheries and aquaculture, the roles, constraints, opportunities, and benefits often vary by gender. Recognizing this, the review examines gender gaps in the fisheries sector and effective strategies to reduce inequalities, thereby contributing to gender equality (SDG 5). The review highlights innovative gender-transformative approaches and the importance of gender mainstreaming in policy and program implementation to ensure equitable sharing of benefits and achievement of Sustainable Development Goals. The study explores the unique challenges faced by transgender individuals in the fisheries sector, such as discrimination, social stigma, and employment barriers. It underscores the need to integrate gender diversity into policy frameworks and industry practices to foster a more inclusive, sustainable, and equitable fisheries community.

KEYWORDS: Gender Mainstreaming, Transgender inclusivity, SDG

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Gender Analysis in Fisheries and Aquaculture Education, Research and Extension in Nepal

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Aquaculture and fisheries provide opportunities to empower women economically and make them financially self-dependent by engaging in farming, catching and value chain development. The present study assesses gender equality, gender-related challenges and ways out in education, research and extension in Nepal. Primary data were collected using a semi-structured questionnaire among fisheries students (20 pax, 26%), faculty (7 pax, 64%) in the Agriculture and Forestry University and Tribhuvan University, research staff (14 pax, 100%) in the Nepal Agriculture Research Council and extension staff (41 pax, 26%) in the provincial and central government offices. Secondary data were collected from the records of the concerned offices. The gender gap was relatively less in universities than in research and extension institutions. The gender gap in students was found to be 14.6% while it was 16.7% in faculty. Around 29% and 26% of females were involved in research and extension respectively. No women experienced gender violence in academia, research institutes and government offices. Unequal opportunities, unfair access to resources, ignoring the voice of women, and underrating the work of women and physical work in water were major challenges in academia. Similarly, less opportunity for professional development and capacity building for women in research and discrimination in training opportunities, responsibility allocation, field visits, and often receiving secondary priority in official activities in extension were major challenges. Recognizing the voice of women, providing equal opportunities, promoting equal representation in decision-making positions, providing gender-related training, recruiting more female faculty who serve as role models to mentor students, and increasing female-targeted scholarships, and research grants could be the ways to address the challenges in academia. Research staff recommended providing specialized training programs, facilitating opportunities for higher education, and arranging educational tours to enhance women's skills and knowledge in fisheries research. Extension staff recommended capacity-building programs and equal distribution of responsibilities and opportunities as solutions.

KEYWORDS: Fisheries, Education, Research, Extension, Gender gap

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Analysing Filipino Women Polychaete Fishers' Lives from the Lens of Feminist Political Ecology

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This study is about women polychaete fishers in the island municipality of Anda in the province of Pangasinan in the northwestern Philippines. Declining fisheries production from the wild has been the trend for decades and women have resorted to catching polychaetes for income in the last 15 years. Through a mixed methods research design, the present study underscores a qualitative method that focuses more appropriately on feminist research, which highlights the subjective knowledge, voice and agency of women. Feminist political ecology is an approach that analyzes how power defines people's unequal access and control of resources. It also has the potential to challenge dominant scales of analysis and emphasizes the significance of everyday, embodied ways of knowing and experiences of women, the complexities of their emotions and their sense of belonging to place. Since it is also critical to constructions of oppositions, segregating women and nature as the "other", led to the devaluation of women's roles in social reproduction, care work, household and subsistence economy. The women polychaete fishers and their fishing activity is not well documented because their catch has no significant commercial value and they are a minority in a predominantly male fishing community. Power relations are played out in the ecological changes taking place in the coastal areas where women polychaete fishers' contributions to households and resource management have yet to be recognized. Catching for polychaetes through puspus and latag methods, innovations that are less destructive as opposed to digging or bait harvesting that is being practiced in other countries highlights Filipino women polychaete fishers' ingenuity, patience and perseverance. Women polychaete fishers' marginalization in the fisheries has provided them the perspective to manage polychaete fisheries so that they can continue to access these resources to provide for the needs of their families.

Keywords: Women, Puspus and latag method, Polychaete fishing, Feminist political ecology, Philippines

Participation of Women in Integrated Fish and Vegetable Farming to Improve Household Nutrition and Income

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The main purpose of the study was to determine the improvement in participation, knowledge empowerment and household consumption after the intervention from ICAR-Central Institute of Women in Agriculture. The study was conducted in two selected villages: Sriramchandrapur in Puri district and Solagaon in Bhadrak district. Data were collected from a total of 40 women, with 22 participants from Sriramchandrapur and 18 from Solagaon. A pre- and post-intervention assessment was performed, focusing on key indicators such as participation in agricultural activities, knowledge acquisition, empowerment, and household consumption patterns. Post-intervention data were collected after a six-month period. The findings revealed that women's participation in labour-intensive activities, particularly land preparation, increased by 45%. The implementation of training programs led to a significant enhancement in agricultural knowledge, with 77.78% of participants demonstrating an improved understanding of *rabi* and *kharif* crop cycles. Notably, the most substantial improvement was observed in the management and utilization of aquaculture resources, specifically fish farming ponds, where a 45.5% increase in effective management practices contributed to an overall enhancement in women's empowerment levels.

KEYWORDS: Participatory action research, Knowledge intervention, Empowerment

Influence of Gender on the Management of Ganges Floodplain-Wetland Resources in and Around Patna Region

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Ganges floodplain-wetlands, also known as Kol, Chaur, Dhab, and Maon, are crucial ecosystems with close ties to human society during different seasons. However, there is growing concern about their preservation as habitats for floodplain-wetland biodiversity. Women are more concerned with the environment than men and play a significant role in safeguarding natural resources, particularly those found in wetlands. They are more likely to be involved in agricultural operations, resource utilization, and preserving wetlands in rural areas. Women with greater home obligations are more sensitive to environmental changes and the availability of natural resources. Women play a crucial role in household income production and the fishing economy in the freshwater fishing sectors through gathering, sorting, processing, packaging, and marketing, among other activities. In Bihar, women, particularly fisherwomen, manage floodplain-wetlands through traditional practices. Women in rural surrounding areas of Patna contribute to the use of floodplain-wetlands resources and are often involved in environmental concerns. They care for children and contribute to conserving biodiversity. Strengthening women's education through agricultural farming methods can help them become independent and contribute to the conservation of these resources. Women's involvement in these areas is necessary for preserving the environment.

KEYWORDS: Women, Ganges floodplain-wetland, Environment, Conservation, Management

Decision Making Behaviour and Empowerment Status of Fisherwomen of Vijayapur District, Karnataka

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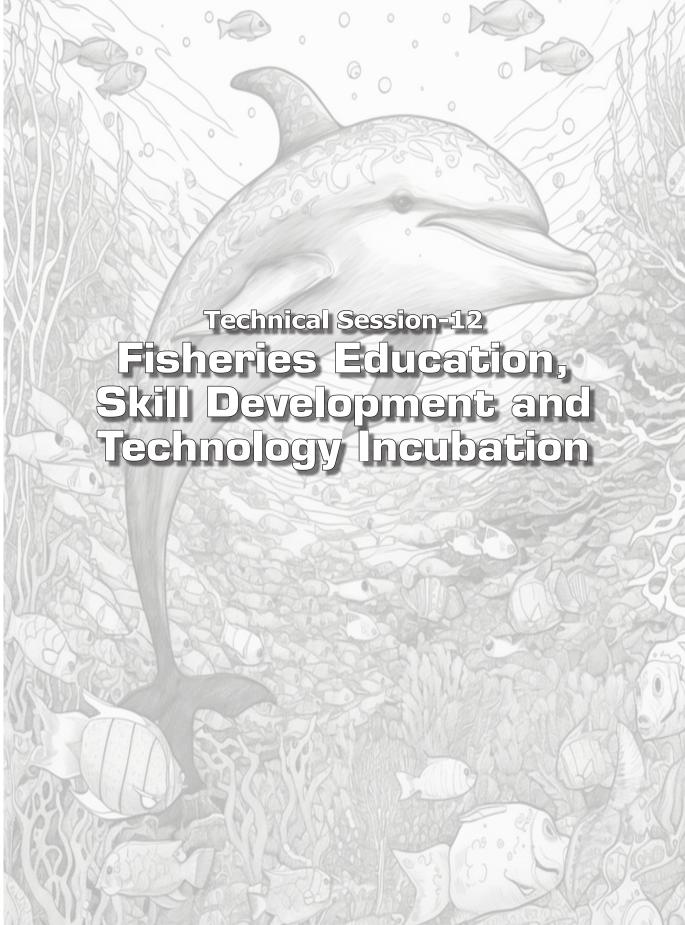
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Fisherwomen in India play a vital role in the workforce of the fisheries sector, particularly in fish marketing viz., retailing, dressing, street vending along with dry fish making, salting, etc. The contribution of the fisherwomen in all fisheries-related activities is related to their confidence levels in decision-making and eventually results in their empowerment. However, the status of decision-making capacity and empowerment status of the fisherwomen was less reported. Fisherwomen contribute substantially to the Indian fisheries economy and the present studywas conducted in Vijayapura District, Karnataka to assess their decision-making behaviour and empowerment status. This study was taken up to understand the same and the socio-economic profile of the fisherwomen indicated that 44.2% belonged to the middle age group, 46.6% have a medium level of occupational experience, 52% are illiterates, 100% are doing fresh fish marketing, 73% have a medium level of annual income, 80% of fisherwomen have small family size and 89% belong to nuclear families. 83.3% have medium access to mass media participation, and more than 50% have medium access to extension agencies and high social participation. 65.83 % of fisherwomen have a medium credit orientation, 70% have medium economic motivation, 73.33% have a medium level of risk orientation, and 60% have a high level of self-confidence. The fisherwomen of the Vijayapur district have a high level of awareness but showed a low level of participation in the beneficiary programmes of state and central government fisheries departments. The combined mean Decision-Making Behaviour Index of the fisherwomen was reported as 79.76 and was influenced by various factors like operational decisions, marketing, and economic decisions. The empowerment index of fisherwomen was reported as 77.14 and it was influenced by annual income, mass media participation, family size, family type, occupational experience, contact with extension agencies, and social participation. The constraints were categorized to be infrastructure, social, economic, transport, health and sanitation-related aspects wherein infrastructure aspects, health and sanitation-related issues/constraints were the most important. Creation of awareness, training, skill upgradation on marketing, microfinancing, credit linkages, and value addition will enhance the self-confidence and decision-making behaviour of fisherwomen; thus impacting their empowerment. The studies on the decisionmaking and empowerment status of the fisherwomen serve as baseline data and it help the policymakers to plan for their upliftment thus supporting their livelihoods.

Keywords: Fisherwomen, Socio-economics, Decision-making, Empowerment, Marketing



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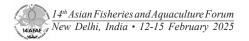
Role of Capacity Building Resource Centre for Intensive Aquaculture Technologies, Punjab in Socio-Economic Development of Aquaculture Sector in the North-Western Region of India

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Recirculatory Aquaculture System (RAS) and Biofloc-based Aquaculture System (BFAS) are gaining popularity among progressive farmers, prospective entrepreneurs and youth in the north western region of the country. The Capacity Building Resource Centre (CBRC) for Intensive Aquaculture Technologies was established in 2023 at College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Punjab, under Pradhan Mantri Matsya Sampada Yojana (PMMSY) of the Department of Fisheries (DOF), Ministry of Fisheries, Animal Husbandry and Dairying (MFAHD), Government of India, to cater capacity building needs of regional stakeholders. The said CBRC is a multidimensional asset for the region, fulfilling demonstrations and capacity building requirements of stakeholders; offering experiential learning, in-plant training, skill development and incubation facilities to promote entrepreneurial aspirations among for fisheries professionals and youth. About 200 stakeholders, including 49 Fisheries officials from DOF Puniab, have been trained so far, through orientation workshops (02) and training programs (05) at the said CBRC, while aspirant stakeholders from other states, including Haryana, Rajasthan, Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh and Madhya Pradesh, have been invited. In the near future, CBRC is going to serve as a Skill cum Technology Incubator. The culture technology for pangas catfish (Pangasionodon hypophthalmus) in both RAS and BFAS has been optimized and validated with respect to stocking density (50-60 fish/m³), while best carbohydrate sources for optimised biofloc development in BFAS has also been investigated. Both culture systems significantly enhanced pangas production, achieving productivity of 15-25 kg/m³ (RAS) and 11-15 kg/m³ (BFAS) in a crop cycle of 6-7 months, with survival rates of 90-95%; improved feed conversion ratios of 1.1 in RAS and 0.9 in BFAS; and about 70% water saving per kg fish production. Additionally, the culture of climbing perch 'Koi' (Anabas testudineus) is successfully running in both RAS and BFAS. It is also envisioned to develop RAS and BFAS-based culture technologies for other fish species like Stinging catfish 'Singhi' (Heteropneustes fossilis), murrel 'Striped Snakehead' (Channa striata), and GIFT tilapia (*Oreochromis niloticus*), besides developing suitable summer and winter culture packages to maximize economic output of these systems.

KEYWORDS: Biofloc, Capacity Building, Climate Smart, Entrepreneurship, Intensive Aquaculture, RAS



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Quantifying and Modelling Contribution of Human Capital Produced by Fisheries Universities to the Indian Economy

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Human capital refers to assets or wealth in the form of skilled/professional women and men available within an organization or an economy. Universities represent the higher education sector and the primary source of human capital. Human capital alters the productive capacity of the economy (known as supply-side) by changing the size of the workforce or the productivity of the workforce thus 'structurally' impacting the economy. With half the population less than 25 years old, the demand for more universities and quality higher education becomes obvious. But there is a decline (in real terms as % of GDP spent on education) in public investments in higher education amid an increasing chorus for privatization. In this context, it has become imperative to estimate the direct and indirect impact of universities (i.e. their output - human capital) on the economy. This would help us estimate returns to investment in higher education and help justify an increase/decrease in budgetary allocation to higher education. The present study has taken 13 representative Fisheries Colleges across all zones of the country including the premier national fisheries University ICAR-Central Institute of Fisheries Education (CIFE) as a case, and attempts to quantify the investment in human capital and its subsequent benefits/impact i.e. economic value. There is a lack of consensus among experts as to what constitutes the best approach in valuing human capital generated by universities. As there is no direct measure to value this human capital, here an income-based approach that uses the sum of discounted lifetime earnings of individuals to calculate their level of human capital has been used. With this, one can assess the value of universities' investment in skills by measuring the difference that university qualifications make to students' lifetime incomes. This reflects the increased productivity and earnings associated with higher education. Mapping and tracking the careers of CIFE's human capital over the years, the study attempts to provide an illustrative first estimate of the economic worth of human resources generated by a university and quantify their contribution towards the blue economy.

KEYWORDS: Human capital, Fisheries universities, Economy

Game-Based Learning and Immersive Technologies: A Modern Framework for Fisheries Education

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The evolving landscape of fisheries education emphasizes the need for interactive, experiential learning approaches that foster deeper engagement and retention of complex subject matter. In response, we have designed a suite of educational tools, including game cards centered on seaweed, fish species, and fish diseases, which have obtained Intellectual Property Rights (IPR) protection through copyright. These game-based resources provide a playful yet practical way to introduce essential fisheries concepts, enhancing both engagement and cognitive retention through hands-on activities. Building on this foundation, we integrated Augmented Reality (AR) and Virtual Reality (VR) modules into the curriculum to create immersive learning experiences. These advanced technologies enable students to explore virtual marine ecosystems and conduct anatomical studies of fish in 3D environments, bridging the gap between theoretical knowledge and real-world application. Interactive simulations allow learners to engage with marine organisms and ecological processes in a controlled virtual setting, fostering a deeper understanding of fisheries science. Initial feedback from students has been overwhelmingly positive, underscoring the effectiveness of these innovative methods in enhancing educational outcomes. By combining interactive game mechanics with immersive technologies, we offer a novel framework for fisheries education that stimulates curiosity, promotes active learning, and facilitates the mastery of intricate topics. This approach also aligns with cognitive theories emphasizing the importance of experiential learning and multisensory engagement in long-term knowledge retention. Looking ahead, we aim to expand our game-based learning portfolio to include modules on marine conservation and sustainable fishing practices, reflecting the growing importance of environmental stewardship in fisheries education. These efforts are expected to play a critical role in equipping the next generation of fisheries professionals with the skills and knowledge needed to address global environmental challenges. Through the integration of interactive learning tools, our approach offers a scalable and impactful model for modernizing fisheries education, fostering a workforce that is well-prepared to navigate the complexities of marine ecosystems and sustainable resource management.

KEYWORDS: Fisheries, Game-based learnings, Education

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Integrating Multiple Scientific Fisheries Information Resources with a Pretrained AI Model: A CMFRI Initiative

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Central Marine Fisheries Research Institute (CMFRI) has separate digital platforms for retrieval of fisheries data available at CMFRI Library which are made available for public access on the CMFRI Website. Eprints@CMFRI serves as the portal for CMFRI publications, DSpace@CMFRI for our rare volume collection, JGate@CMFRI for the subscribed content and OPAC (Liberty Software) is dedicated to searching the bibliographic details of hard copy collection. To meet the growing need for real-time, streamlined access to fisheriesrelated data, we propose the development of a comprehensive chatbot service integrated with multiple information platforms. Through an API or Web scraping, data will be retrieved from multiple fisheries information resources and consolidated into a unified backend for efficient querying. This bibliographic data will be uniformly indexed for seamless retrieval. The AI model like BERT/GPT will be fine-tuned with domain-specific fisheries data to enhance its ability to handle diverse queries, from publication searches to scientific explanations, ensuring accurate, context-aware responses for both experts and laypersons. Whether the inquiry is scientific or simply a layperson's question, the program will draw from the available literature to provide the most relevant and helpful answer. Research findings can often be difficult for the general public to understand, and they may struggle to frame precise questions to find the information they need. The program aims to bridge this gap by translating complex information into accessible answers. The chatbot offers a seamless interface, drawing on vast resources from CMFRI's digital repositories and external sources to enhance user experience and information retrieval. By eliminating the need to switch between multiple applications, users can save time, enhance productivity, and gain a more comprehensive understanding of complex topics. The advantages of this service are enhanced accessibility to fisheries information, saving the time of users, centralized access, tailored responses to user queries, and wider reach to both the CMFRI outputs and also the procured library resources.

KEYWORDS: Information management, AI, Chatbot, CMFRI Library, Library integration

From Pixels to Parameters: Citizen Science, Smart Phone and Satellite Synergy for Water Quality and Sustainable Fisheries in Lake Vembanad, Kerala, India

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The global Sustainable Development Goals (SDGs) 2030 agenda, with only six years remaining, prompts the question: are we there yet? Among these goals, SDG 14, "Life Below Water," has numerous critical challenges inadequately addressed or entirely overlooked. Simple, but continuous measurements of water quality were done for a period of 5 years (2019 to 2024) in the Vembanad Lake, a crucial estuarine ecosystem on India's southwest coast, which supports diverse fisheries and local livelihoods. Secchi Disk Depth (SDD) and Forel-Ule (FU) colour of water were measured using the Mini Secchi disk (Brewtek Ltd., UK) supported by an Android-based smartphone application 'TurbAqua'. This measurement was conducted as a citizen science activity which resulted in the generation of '3312' data points over the 5 years. The in-situ values and the satellite-derived (Sentinel-2 MSI) SDD and FU values were tested for linear fit. Secchi depth values exhibited inter and intra-annual variations, reflecting the lake's fluctuating flow pattern and circulation dynamics. SDD as low as 0.01m to as high as 4.4m have been recorded in the 5 years of study. The FU color was mostly found to be around 16-17, though maximum values in the range 20 to 21 as well as minimum value of 1 were recorded, indicating a shift from cola brown to lighter shades, with some areas showing clear indigo blue to greenish-blue colors by 2024. These derived trends were used to map the intrinsic colour of the water body on a spatio-temporal scale. The methodology presented here could serve as blue justice for informed water quality management for the fisher folks, promoting both sustainable fisheries and local engagement in conservation.

KEYWORDS: Secchi depth, Forel-Ule colour, Sentinel-2 MSI

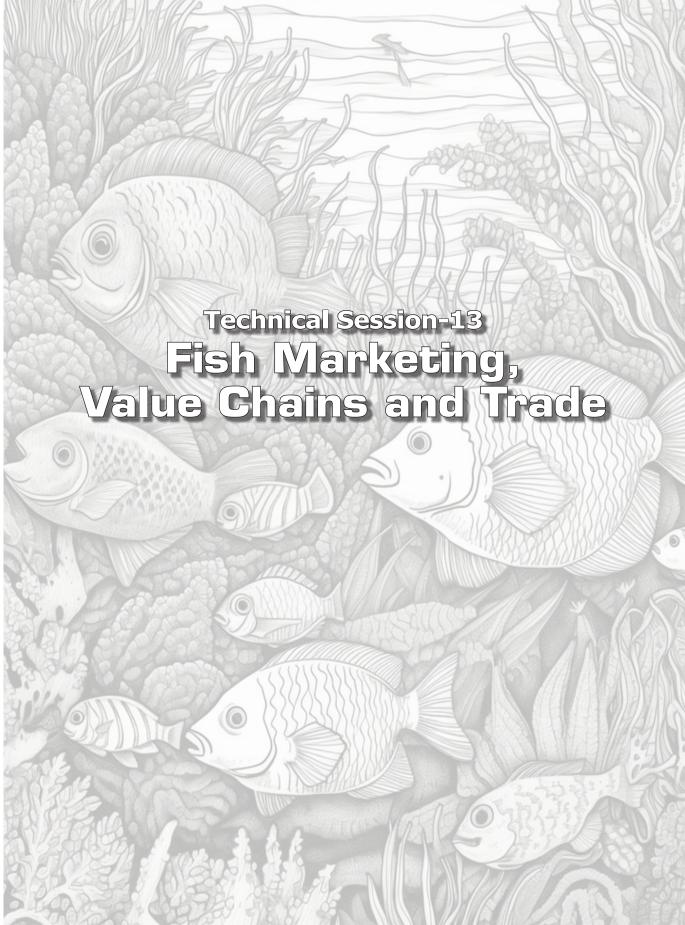
Skill Development in Fisheries and Aquaculture: Avanti Foundation

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The ever-increasing global population demands nutritious food. Fish being the best quality inexpensive protein source, there is a need to enhance production by utilizing enormous aquatic resources. To utilize these resources, advanced technologies are to be developed, refined and implemented which need qualified skilled manpower. With a greater vision to create skilled manpower for aquaculture and fisheries sectors, Dr Alluri Indra Kumar, Managing Trustee, Avanti Foundation, formed and established "AU-Avanti Aquaculture Skill Development Centre (AU-AASDC)" in collaboration with Andhra University, Visakhapatnam in the university campus during 2022. The objectives of the centre are to bridge the gap between academia and industry, create high-quality skilled manpower for current and emerging challenges and promote entrepreneurship, in the field of aquaculture. The AU-Avanti ASDC facility consists of spacious classrooms, large and mini-seminar halls and a conference hall with audio-visual Aids. Laboratories consist of soil and water analysis, microbiology, histopathology, RT-PCR and ELISA, and are equipped with the latest equipment. A wet laboratory has also been developed for maintaining live animals to conduct research and development programs on various aspects of health, diseases, and soil and water quality management. Faculty comprises of subject matter specialists from reputed national and international Institutions, aqua- and fisheries industries in addition to the in-house faculty. The centre imparts training to students, researchers, farmers, aqua-entrepreneurs, fishermen communities, etc., in priority areas such as shrimp and fish hatchery operations, farming and processing. The skill development programs are designed with more emphasis on hands-on training at respective workstations with a duration of 30 to 90 days. The trainees are sent to well-developed field stations for hands-on training. The trainees are evaluated by conducting weekly tests, video conferences and presentations. Successful trainees are awarded a combined certificate of AU and Avanti ASDC. So far, 28 skill development programs have been conducted and 614 candidates have been trained, of which 280 students have been employed in Avanti Shrimp Feeds, Avanti Frozen Foods, Avanti Shrimp Hatchery and other shrimp hatcheries, shrimp farms and shrimp processing plants. The trainees are provided with food and accommodation facilities free of cost.

KEYWORDS: Faculty, Manpower, State-of-art facilities, Research and Development





Market Structure Dynamics and Comprehensive Quality Evaluation of Selected Fish Species in Fish Markets of Punjab

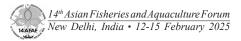
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This study aimed to systematically document the species diversity in fish markets across Amritsar, Jalandhar, Ludhiana, Mohali, and Bathinda in Punjab, while conducting a comprehensive analysis of proximate composition, quality indices, microbial load, and residues of antibiotics and formaldehyde in commercially important fish species viz., Wallago attu, Labeo rohita, Pangasianodon hypophthalmus, and Rastrelliger kanagurta. A total of 54 fish species were identified across these markets, with Ludhiana having the highest diversity (45 species), followed by Amritsar (22), Bathinda (19), Mohali (14), and Jalandhar (13). The Cyprinidae family dominated the market, with significant representation from Pangasiidae, Siluridae, and Bagridae. Locally produced Rohu (L. rohita) and imported striped catfish (*P. hypophthalmus*) were the most popular among consumers. The market also hosted three invasive species viz., Bighead (Hypophthalmichthys nobilis), Pacu (Piaractus brachypomus), and African magur (Clarias gariepinus) accounting for 0.5-5.85% of the total market share. Fish from capture fisheries were most abundant in Amritsar (40–45%), while Jalandhar had the highest percentage from culture fisheries (35-40%), and Bathinda had the most imported fish (30–35%). Proximate composition analysis of the selected species revealed moisture content ranging from 72.42 to 81.68%, with protein, lipid, ash, and carbohydrate levels varying from 9.44-18.34%, 0.56-10.84%, 1.28-4.29%, and 0.22-2.04%, respectively. Seasonal and species-specific variations were observed. Quality parameters, including free fatty acids (0.59-0.95% as oleic acid), thiobarbituric acid (1.26-1.73 µmole/ kg), peroxide value (2.34-4.44 meq O₃/kg), and total volatile basic nitrogen (18.58-32.70 mg%), were within safe limits. However, elevated levels of E. coli (2.46-4.46 × 10² cfu/g) and S. aureus $(2.33-4.73\times10^3 \text{ cfu/g})$ exceeded permissible limits, raising public health concerns. Antibiotic residues, including chloramphenicol, nitrofurantoin, and oxytetracycline, were below permissible limits, and formaldehyde was absent, indicating safety for human consumption. Prominent challenges identified in the fish markets of Punjab encompass intricate marketing channels characterized by numerous intermediaries, an unregulated fish supply chain, insufficiencies in storage facilities, and a lack of effective waste disposal systems. It is imperative to address these challenges comprehensively to ensure the efficient and sustainable operation of these markets.

Keywords: Fish markets, Survey, Catch composition, Proximate composition, Market channels



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An Insight into the Market-Oriented, Climate-Driven Seasonal Landing of Large-Sized Black-Spotted Croaker (*Protonibea diacanthus*): A Case Study from the Palk Bay of Tamil Nadu

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The family Sciaenidae (croakers), which includes 286 species across 66 genera globally, is distributed in freshwater, brackish, and marine waters of tropical and temperate regions. On the east and west coasts of India, 48 species have been recorded. The black-spotted croaker (Protonibea diacanthus), grows up to 165 cm in total length (TL) and is locally known as 'kooral' in Tamil Nadu. Recently, this species has gained considerable market attention due to the high demand for its carrot-shaped swim bladder. A case study was conducted with fishers from both the mechanized trawler and motorized gillnet sectors, as well as traders involved in the black-spotted croaker fishery along Palk Bay. Fishers using mechanized single-day trawling between Adirampattinam and Kodiyakarai catch black-spotted croakers during the northeast monsoon season (November to April), with peak landings between February and March. These fish are typically found 24 km offshore at depths of around 15 m. The intense churning of sediments near the Palk Strait during the rainy season attracts mullets, which in turn triggers the assemblage of croakers, drawn by the opportunity for predation. The size and weight of the croakers caught ranged from 102 to 158 cm TL and 18 to 33 kg, respectively. The fish fetches a price of Rs. 1,050 to Rs. 1,500 per kilogram, with a single fish costing up to Rs. 375,000, depending on its size. Traders from Nagapattinam regularly collected the fish from local fishers, selling the meat for Rs. 250 to Rs. 300 per kilogram after carefully removing the swim bladder. Occasionally, juveniles weighing between 450 to 700 g are found alongside groupers in the commercial catch, particularly from Jagathapattinam and Kottaipattinam in Palk Bay. Recently, gillnets specifically targeting seabass have also begun bringing in larger croakers from the Jagathapattinam to Adirampattinam fishing grounds. From 2012 to 2023, approximately 86% of the black-spotted croaker landings in Tamil Nadu and Puducherry came from Palk Bay, while the Gulf of Mannar and the Coromandel Coast contributed 7% and 8%, respectively. The present reporting is of its first kind, and more information about reproduction and diet would shed more light on the peculiar phenomenon of black-spotted croaker assemblage near Palk Strait and Palk Bay.

KEYWORDS: Kodiyakarai, North-East monsoon, Sediment, Swim bladder, Traders

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Value Chain Analysis of Pangas (*Pangasianodon hypophthalmus*) Marketing in Northern States in India

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Cage culture of pangas (Pangasianodon hypophthalmus) has emerged as an important commercial activity and livelihood for fishers and fish farmers in the inland open waters of India and pond aquaculture. The price and demand of pangas are comparatively higher in the northern states of India compared to its major production sites in the eastern states of India. Owing to its pin-boneless white meat, it is preferred for instant preparation of fish pokoda and fingers in hotels and restaurants, thus having a high potential to occupy the domestic market. The sustainability of the pangas farming in cages and ponds is hampered by the growing cost of inputs and reduced farm-gate prices. Vertical integration in the value chain with technological intervention is expected to augment the sustainability of the pangas culture. Ludhiana fish market is the central fish market that supplies fish to the northern states (Punjab, Harvana, Himachal Pradesh, Uttarakhand and Jammu and Kashmir United Territory). The present study was conducted in 3 fish markets in Ludhiana City using stratified random sampling techniques and structured questionnaires with face-to-face interviews in 2023, and 150 samples were surveyed. The main actors in the value chain were the farmer, local wholesaler, commission agent, city wholesaler, retailer, exporter, hotel/restaurant and common consumers. The value addition was done by manual filleting and iced packaging at the city wholesaler level. The extent of value addition by traders, marketing efficiency, marketing cost, marketing margin, producer share, price share, price spread and rate of return were calculated using standard formulae using secondary data. The commission agents and the city wholesalers earned more profit than others and the farmers earned the least profit. The value addition was more at the city wholesaler level for fish weighing > 2 kg than the fish weighing 1-2 kg. Farmer > City Wholesaler> Local Wholesaler> Hotel was the most efficient marketing channel. The study recommends value addition using effective postharvest technology in the farmgate for the sustainability of pangas farming.

KEYWORDS: Cage culture, Pangas, Value addition, Value chain

India's Shark Fin Exports: Status, Assessment of Ban Implementations and Preliminary Species Composition of Shark Fin Trade

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Cartilaginous fishes (i.e., sharks, rays, and chimeras; chondrichthyans, hereafter as sharks) are facing overfishing globally with some species experiencing a higher extinction risk. Shark fin demand from Southeast Asian countries is projected as a major reason for overfishing across the globe. India is a major shark fishing nation, however, sharks contribute less than 1% of total estimated fish landings. India has implemented a ban on shark fin trade from 2014. This study aimed to assess the species composition of the shark fin trade, analyze export trends, evaluate the ban's effectiveness, and understand stakeholder perceptions. By analyzing samples from enforcement agencies and conducting field surveys, we identified 36 shark and ray species in the trade. Carcharhinids dominated, but even smaller species were present. While the ban has been implemented, challenges remain in balancing socioeconomic interests with sustainability. Fishers have expressed concerns about the ban's impact on their livelihoods. Our findings provide a baseline for understanding the shark fin trade in India. Continued efforts are needed to improve conservation measures and address the challenges faced by both sharks and fishing communities.

KEYWORDS: India conservation, DNA, Sharks, Fisheries management, Shark fin

India's Marine Products Export Competitiveness Through Revealed Comparative Advantage

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India's fish exports have seen significant growth, with shrimp being the primary export product. This study uses the Revealed Comparative Advantage (RCA) approach to analyze the competitiveness of the Indian fisheries sector. While India exhibits a competitive advantage, further expansion of exports requires rigorous implementation of sanitary and phytosanitary measures aligned with WTO standards. However, concerns arise regarding the high cost of compliance relative to returns. Learning from other major seafood-exporting nations, India could focus on technology penetration, public-private partnerships, favorable policies, and mechanization to reduce production costs. India's competitiveness, driven by factors like productivity and value addition, has remained static, influenced by the improved performance of rival nations. To boost both domestic and international demand, India needs to increase aquaculture areas, pursue sustainable marine fisheries, enhance productivity, and invest in processing facilities. Developing countries can produce seafood at lower costs compared to developed nations, provided they meet global food safety and quality standards. This requires assistance in technology, workforce training, and adhering to global sanitation and hygiene protocols, necessitating collaboration between industry, government, and international partners. Strict food safety regulations enforced by export markets, such as the US, create trade barriers for Indian seafood exports, impacting the entire supply chain. To address this, India must strengthen its testing, certification, and laboratory accreditation programs, while focusing on private sector capacity building. Additionally, identifying emerging markets and improving market intelligence can help boost exports. Policies that enhance traceability, transparency, and accountability across the value chain are key to improving export competitiveness. While these measures may raise costs, they also increase product value. India's shrimp export market faces challenges like uneven supply, inadequate infrastructure, and gaps in price information, particularly in the US and Japan. Addressing these structural inefficiencies will enhance trade balance and competitiveness. With rising global demand for seafood, driven by urbanization and increasing incomes, particularly in developing countries, India's fisheries sector plays a critical role in food security and achieving sustainable development goals.

KEYWORDS: Export competitiveness, Traceability, Market intelligence

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Development of Fish Seed Supply Chain for Sustainable Growth in Aquaculture in NE Region of India

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Fisheries sector has been recognized as a 'Sunrise Sector' and has demonstrated an outstanding double-digit average annual growth of 10.87% since 2014-15. This sector has been recognized to contribute towards the elimination of hunger, promotion of health, and reduction of poverty by providing food and nutritional security to the vast majority of the population of the country. Fish contributes substantially to the domestic food security of India which has a per capita consumption of more than 6.00 kg per annum. Freshwater aquaculture is still a homestead activity in several parts of the country particularly in NE Region. The growth of freshwater aquaculture is highly dependent on the production and supply of quality inputs including feed and seed. In the North East Region of India, due to high terrain and undulated topography, the fish farmers' accessibility to seed and feed on time at reasonable price is crucial. Hence in this study, an attempt has been made to map the supply chain of fish seed in Tripura and Manipur state of NE Region of India. A sample of 524 respondents including all stakeholders in the seed supply chain including input suppliers, hatchery owners, nursery seed growers, seed market, seed traders, farmers and labourers were selected using a stratified random sampling technique for primary data collection. The supply chain was mapped on six dimensions i) supply chain entities; ii) relational links between supply chain entities; iii) material flows; iv) Information flows; v) management policies; and vi) lead times. The fish seed supply chain in Manipur was short comprising input suppliers, hatchery/nursery seed growers/traders of outside seed and fish farmers. Due to a lack of nursery seed markets and specialized nursery seed growers, fish farmers in remote areas are facing the challenge of seed availability. In contrast to this, the fish seed supply chain in Tripura was more organized in terms of specialized stakeholders like input suppliers, hatchery operators, nursery seed growers, traders, commission agents, seed vendors and fish farmers. The usage of ICT for getting information regarding fish seed was encouraging in the whole seed supply chain in both states. However, digital literacy on secured digital payments and usage of social media is crucial for making the fish seed supply chain more efficient. Financial inclusion of core supply chain factors was found to be at a medium level but it was very poor in the case of supporting supply chain factors such as seed vendors and labourers. The study also highlighted strategies for developing an efficient supply chain for fish seed in the NE region.

Keywords: Fish seed, Supply chain mapping, Financial inclusion, Manipur, Tripura



Assessing the Regional Fish Consumption in India: Perspectives and Paradigms

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The Indian fisheries sector continues to show an impressive growth rate and focuses on boosting fish production efficiency, improving fishermen's welfare, ensuring equity, increasing export and commerce, creating meaningful employment and ensuring food security. Fish assumes to be a major constituent of the diet with more than 60% of the Indian populace consuming fish, and consumption patterns vary spatio-temporally across the different social fabrics. On one side, fish continues to be a poor man's protein ensuring food security and, on another side, it offers a delicacy of huge prices. Nevertheless, the fish consumption demand improved mostly due to the increased fish consumption among existing fish consumers rather than adding new consumers into the fold. There exists a sizeable difference in the fish consumption pattern across the length and breadth of the country. The present study delves into assessing the trends, patterns, drivers of fish consumption and the major constraints in fish consumption of the selected states of India representing urban/rural districts and coastal/ non-coastal locations. Different statistical and econometric tools such as conjoint analysis, preference assessment index and discriminant analysis were used for analyzing the data. The consumption assessment indicated that marine fish is more preferred than others and the urban area fish consumption is more than the rural populace. The limiting factors towards fish consumption included lack of fresh and preferred fish, high price, wide fluctuations in price, irregular supply and lack of hygiene in purchase sources. The fish consumption steadily improved amongst fish fish-eating population, and the addition of new consumers is at a slow pace. The study suggests that there is an innate need for augmenting fish consumption in the country for which awareness programmes are warranted.

KEYWORDS: Fish consumption, Conjoint analysis, Discriminant analysis

Fish Anesthetizing and Recovery Machine for Waterless Transportation of Live Fish

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Indian consumers prefer live fish that guarantee freshness and quality. Live fish are conventionally transported in various vehicles carrying water up to 50%. Transportation efficiency can double if fish is transported without water. Many researchers attempted the waterless transportation of live fish using chemical anesthetics. However, these chemicals affect the health of the fish and consumers. Therefore, ICAR-Central Institute of Post-Harvest Engineering and Technology has designed a fish anesthetizing and recovery machine (FARM) that can anesthetize (or hibernate) the fish by physical agent (the thermal gradient, gradually lowering the temperature from ambient to 5°C) and recover (or wake up) hibernated fish by gradual heating. Fish can be transported during hibernation. FARM has a stainless-steel tank (500 l) with a refrigeration system (3 ToR). A reverse valve system for heating and an axial fan (450 mm dia., 3 phase) allows the anesthetized fish to recover in the same tank. PUF insulation (50 mm) maintains the temperature. FARM can anesthetize 100±10 kg fish per batch. Its tank has a recirculatory shower around its wall to increase dissolved oxygen in the water and a lid to cover it. The control panel has separate displays for chilling and heating indicators. A trip switch ensures electrical safety. Lockable wheels make FARM mobile. FARM has been tested with 100 l, 150 l, and 200 l water. The time taken to cool 100 l water was significantly less (5, 6, 10 and 11 min.) compared to that for 150 l (7, 11, 16, and 20 min.) and 200 l (10, 16, 17 and 19 min.) to the gradual reduction of the temperature from 25 to 20°C, 20 to 15°C, 15 to 10°C and 10 to 5°C respectively. Similarly, recovery time was also less for low volume; 5, 4, 3, and 2 min. for 100 l; 6, 7, 10 and 11 min. for 150 l; and 5, 7, 9 and 12 min. for 200 l respectively to gradually increase the temperature from 5 to 10°C, 10 to 15°C and 15 to 20°C and 20 to 25°C. Recovery was faster than anesthetizing. FARM can anesthetize and recover fish without the chemical anesthetics conventionally required for the waterless transportation of live fish.

KEYWORDS: Live Fish, Waterless Transportation, Fish Anesthetizing and Recovery, Machine

Impact of Including Small Fish Powder in Children's Diet Plans: A Potential Strategy for Alleviating Assam's Dual Burden Malnutrition

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The northeastern state of Assam presents a unique set of challenges concerning malnutrition among children, which is especially common in rural regions. To address this issue, the Government of Assam has launched several nutrition-specific and nutrition-sensitive schemes and interventions in recent years. One such major scheme is the Supplementary Nutrition Programme (SNP) under the Integrated Child Development Services (ICDS) which aims to improve the health and nutrition of children aged 6 months to 6 years, as well as pregnant and lactating women and adolescent girls. It bridges the gap between Recommended Dietary Allowance (RDA) and Average Daily Intake (ADI) through Hot Cooked Meals (HCM) and Take-Home Ration (THR). HCM provides spot feeding for preschoolers aged 3-6 years, who regularly attend Anganwadi Centres (AWCs), while THR is for children aged 6 months to 3 years, severely malnourished children aged 6 months to 6 years, pregnant women, and lactating mothers. To enhance nutritional outcomes from aquatic foods and to assist in accelerating the progress of reducing malnutrition among the target groups, especially in young children aged 3 to 10 years, World Fish along with ARIAS Society and the Department of Fisheries, Government of Assam and Kamrup District administration under the World Bank funded APART Project piloted the inclusion of small fish powder in the SNP during 2023-24. This entailed the blending of certified small fish powder in hot cooked and mid-day meals served to children aged 3 to 10 years of both Anganwadi and Lower primary schools. Based on a government-approved SOP, the pilot was implemented in 55 Anganwadi Centers and 43 LP schools of Bongaon development block of Kamrup rural district for 6 months during September 2023 to February 2024. This paper describes the process followed and field results achieved from the pilot. This is a groundbreaking and unique case of incorporating fish-based products in the government ICDS and School Meal Program (SNP) to address undernutrition challenge in the state. To evaluate the program's impact on children's nutritional status, Growth monitoring records from AWCs (stunting, severe stunting, underweight, severe-underweight, wasting and severe-wasting) and BMI measurements from LP schools provided valuable insights after analyzing the baseline and endline height-for-age z score, weight-for-age z score and height-for-weight z score. The findings showed statistically significant improvement in the severe stunting, underweight and severe underweight conditions in the AWCs post-intervention of the pilot initiative, and

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in lower primary schools also indicated increase in BMI among the children with whom fish powder was introduced for six months. Thus, these results highlight the effectiveness of fish supplementation in government supplementary nutrition programmes for improving nutritional outcomes. Overall, based on the children, support staff and caregivers' feedback, positive changes in anthropometric conditions and acceptance of small fish powder in SNP, as well as an enhanced understanding congregated from the pilot, we strongly advocate the adoption of this nutrition-sensitive approach at the policy level in other Indian states to ameliorate the rampant and humongous undernutrition challenge.

KEYWORDS: Small fish powder, Malnutrition, Supplementary Nutrition Programme, Stunting, Underweight, Wasting

Efficacy of Herbal Sedative for Transportation of Live Hilsa Shad

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Fish Tanavhari, a plant-based, herbal solution, that acts as a sedative and anesthetic developed by ICAR-Central Inland Fisheries Research Institute, offers a safe, effective solution for fish handling and transportation in laboratory and fields, ensuring no adverse effects on fish health and environmental sustainability. Tenualosa ilisha, or Hilsa, is a highly valued and sensitive species in the Ganga-Brahmaputra-Meghna basin. Overfishing poses a severe threat to this population; thus, live transportation is critical for conservation efforts. However, their quick movement and high oxygen consumption pose problems to long-term life. Sedation effectively reduces hyperactivity, stress, and injury during live fish transportation, yet information on Live Hilsa transport remains limited. The experiment was carried out during live Hilsa transportation for ranching upstream of Farakka Barrage in river Ganga. The efficacy of Fish Tanavhari on Hilsa physiology, haematological parameters, and behavioural changes along with physicochemical parameters of treated water was studied. Individuals (n = 4) were divided into five groups with control and four different concentrations viz., 1 μ l/l, 5 μl/l, 10 μl/l and 15 μl/l doses of Fish Tanavhari solutions were used in this experiment to sedate pre-adult Hilsa with mean length and weight 15.4±0.9 cm and 107.1±7.3 g. Among the experimental sets, 5 µl/l and 10 µl/l were suitable concentrations to lessen stress for 1-1½ hours throughout transportation by altering the major blood physiological indices with more than 80% survivability. During the swimming activity, opercular movements slow down as the concentration increases. This result is highly relevant when considering T. ilisha's physiological responses during transportation and the impact of other related stressors. More extensive research is needed to better understand the efficacy of Fish Tanavhari, including alternate dosing regimens, stress activation measurements over time, and extended recuperation periods.

KEYWORDS: Fish Tanavhari, Hilsa, Sedative, Transportation

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Cointegration Analysis and Price Transmission in Fish Markets of Maharashtra, India

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Market interaction is gauged through integration, shaping the impact of stressors on prices. In non-integrated markets, stressors strongly influence price determination; in larger, integrated markets, the impact is subdued, highlighting resilience. In this backdrop, this study explores the spatial integration of fish prices in Maharashtra, India. The annual price (in Rs.) data for the past 25 years (FY 1997-98 to 2021-22) from the Department of Fisheries was analysed. Five fish markets including Mumbai, Raigad, Ratnagiri, Thane, and Sindhudurg were used for the study. Pairwise market integration was evaluated using ARDL bounds tests. Six key species were selected for the cointegration test viz., Mackerel, Penaeid Prawns, Harpadon nehereus (Bombay duck), Non-Penaeids Prawns, Otolithoides spp and Loligo duvauceli (Loligo) based on their substantial contribution to Maharashtra's overall fish production. The results revealed partial cointegration in Thane-Mumbai, Raigad-Mumbai, Ratnagiri-Mumbai, and Sindhudurg-Mumbai markets for all the species, except Loligo. Using the Law of One Price, perfect price transmission was also examined. Penaeid prawns, Bombay duck, non-penaeid prawns, and Otolithoides species displayed perfect price transmission across most markets. Mackerel demonstrated perfect price transmission solely in Mumbai-Raigad. However, there was no perfect price transmission for non-penaeid prawns and Otolithoides in Mumbai-Raigad. Loligo notably exhibited no perfect price transmission in any market, indicating a lack of long-term price relationships. The spatial market integration for Loligo has appeared to be the least, possibly because of its greater market share outside the country. The study revealed that different fish markets were well integrated, functioning as one market. This integration minimizes arbitrage, ensures efficient price discovery, smoothens supply chain coordination, and aligns long-term prices, enhancing predictability. It also aids in inflation monitoring and improves risk management by allowing better hedging strategies across markets.

KEYWORDS: Cointegration, Price transmission, Fish markets, Maharashtra

Drivers Affecting Fish Consumption in Mumbai

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In an era of rapid urbanization and changing dietary preferences, understanding the dynamics of fish consumption is vital. India's fish production reached 16.24 million metric tons in 2021-22, driven by rising demand and a per capita consumption of 13 kg, though still below the global average of 20.5 kg. This study explored factors driving fish consumption in India by collecting data from 180 respondents across 10 traditional fish markets in 8 wards of Mumbai through personal interviews. The study aimed to identify key drivers influencing consumption behaviour in Mumbai City and the Mumbai Suburban district of Maharashtra. Quantitative variables were evaluated using a correlation matrix, multiple linear regression and factor analysis, while qualitative variables were assessed using the Theory of Planned Behaviour framework. Results showed that fish consumption is positively influenced by family size, income, and education level, with regression analysis explaining 67.3% of the variance in consumption patterns. Taste and personal habits emerged as the strongest drivers, while social norms had a moderate influence. Price was not a significant barrier, although consumers demonstrated a general awareness of fish's nutritional value but lacked specific knowledge of its health benefits. Access to fresh fish was adequate, with taste and freshness being key purchasing considerations. Enhancing consumer education on the health benefits of fish could further boost consumption.

KEYWORDS: Fish consumption, Drivers, Mumbai

Exploring the Possibility of Shared Electronic Ledger Systems in Fish Watch: Enhancing Price Transparency and Understanding Market Dynamics

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The demand for fish and seafood products is increasingly driven by growing consumer awareness of their health and nutritional benefits. However, wild-caught marine fish, which constitutes a significant portion of this market, faces availability constraints due to inherent variability in landings and prices. Understanding the dynamics of marine fish landings and prices is therefore essential for ensuring the stability and sustainability of the marine fish supply chain. Fish Watch @ CMFRI -observations during 2011-2024 indicate that data were collected from major maritime states, with notable contributions from Andhra Pradesh (5,560 counts), Maharashtra (1,783 counts), Karnataka (1,352 counts), Kerala (1,249 counts), Tamil Nadu (663 counts), and Gujarat (620 counts), culminating in a total of 11,227 observations. This comprehensive dataset provides a foundation for analyzing the interplay between landings and price variations across different regions. This study utilizes data from the Fish Watch initiative by ICAR-Central Marine Fisheries Research Institute (CMFRI), which provides near real-time estimates of landings and prices of key marine fish species at major fisheries harbours across India. For instance, data from 2011 to 2024 for penaeid prawns, a commercially significant species, at Cochin Fisheries Harbour reveals a wide range in both average and maximum prices. The average price ranged from Rs. 148 in 2023 to Rs. 294 in 2016, while maximum prices showed substantial volatility, peaking at Rs. 1,300 in 2024. This significant variation underscores the importance of creating a reliable system for tracking price changes to better understand market dynamics and price fluctuations for important marine fish species. Recognizing the challenges of trust and accuracy in the seafood supply chain, this research explores the potential of leveraging digital technologies to enhance the reliability of near real-time price data. By implementing a shared electronic ledger model with active stakeholder participation involving market functionaries and fishers, the study aims to create a more transparent and trustworthy data environment. The widespread use of mobile devices and improved internet connectivity further supports this model, enabling real-time data sharing and stakeholder engagement. This enriched data, helps to uncover the intricacies in seasonal patterns and price volatility of major marine fish species, providing insights into regional market dynamics.

KEYWORDS: Fish Watch, Shared Electronic Ledger, Supply chain transparency, Digital technologies, Market Dynamics



Live Oyster Trade in India – Perspectives and Challenges

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Globally the market for molluscs has witnessed fast growth both in quantity and value, especially after the COVID-19 pandemic mainly due to changes in food habits which gave preference to nutrient-rich foods. Among molluses, oysters which are rich in protein, omega-3 fatty acids, vitamins, and minerals including iron, zinc and the rare mineral selenium are considered a gourmet food. In 2022, the contribution of oysters and clams to global aquaculture was estimated at USD 108.4 billion, and a 3.5% compounded annual growth rate (CAGR) from 2022 to 2030 is also anticipated. In India, edible oyster (Magallana bilineata) farming started at the turn of the twenty-first century. However, due to the limited domestic market for oysters, the adoption of oyster farming by coastal communities was mainly restricted to the west coast. In 2012, the ICAR- Central Marine Fisheries Research Institute developed a value chain for live oysters under the National Agricultural Innovation Project (NAIP) and marketed 288 oysters at \(\sigma \) 8 / oysters to high-end restaurants in the metro city Kochi, Kerala. In the year 2023, the quantity reached an all-time high of 6903 numbers valued at □50/oyster. The major constraints faced by the farmers are the limited number of clients/ restaurants and the lack of efforts to increase public awareness to create local consumer demand. The value chain developed under the NAIP project is being effectively managed by the Women Self Help Group (SHG) from Moothakunnam in Ernakulam district, Kerala. The quantity and value showed a 22 times increase in 2023. At present, in India, the live oyster trade is not organised though there is immense potential to develop the same. One of the problems encountered by oyster farmers and live oyster traders is the lack of consistency in oyster meat content due to frequent spawning in tropical conditions. Hence it is suggested that research and development programmes may be taken up to develop economically viable triploid oysters (sterile or reproductively non-active) in hatcheries to maintain consistent meat weights.

KEYWORDS: Live oyster trade, Magallana bilineata, Triploid oysters

Seafood Value Augmentation by Live Transportation and Marketing

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Implementing live marketing strategies constitutes a lucrative value-addition process, as it assures prime quality with guaranteed freshness unlike the other processed commodities. attracting more customers. Further, the higher price realization for products guarantees the strengthening of the supply chain by benefitting the producers. In India, though there are several open modes of live fish transportation being done, a viable and compact closed model that can be operational for a large variety of species is not commercially available. For this to be operative effectively for different species, an optimized process or protocol needs to be established and documented which is also not available. The procedures before, during, as well as after transportation plays an important role in addressing the success of live-fish transport. One of the most effective techniques for achieving this is temperature-induced cold anaesthetization coupled with sufficient oxygenation. The current study addresses the gaps prevailing in the sector with standardized protocols: before, during, as well as after transportation for effective live marketing of selected aquaculture species including Genetically improved farmed tilapia (GIFT), Etroplus and Seabass. The resources obtained from commercial aquaculture farms were subjected to various treatment combinations of cooling rates and target temperatures before transportation followed by cold anaesthetised transportation and post-transport revitalization. Survival rates ranging from 90-95% were observed for the transported species upon revitalization for a period of upto 24 hours. Based on the study, a customized live fish transportation system was developed with a carrying capacity of about 10-15 kg. Further validation studies for commercialization possibilities ensured promising outcomes for closed transportation of table fish in the domestic market for a duration of up to six hours. Ideally, the present research is expected to improve the quality of the seafood supply chain, benefitting the farmers as well as traders, and simultaneously facilitating the availability of prime quality seafood commodities to the consumers.

KEYWORDS: Live fish, Fish transportation, Marketing, Seafood

Fish for Food and Nutrition Security in India: A Comprehensive Framework Analysis

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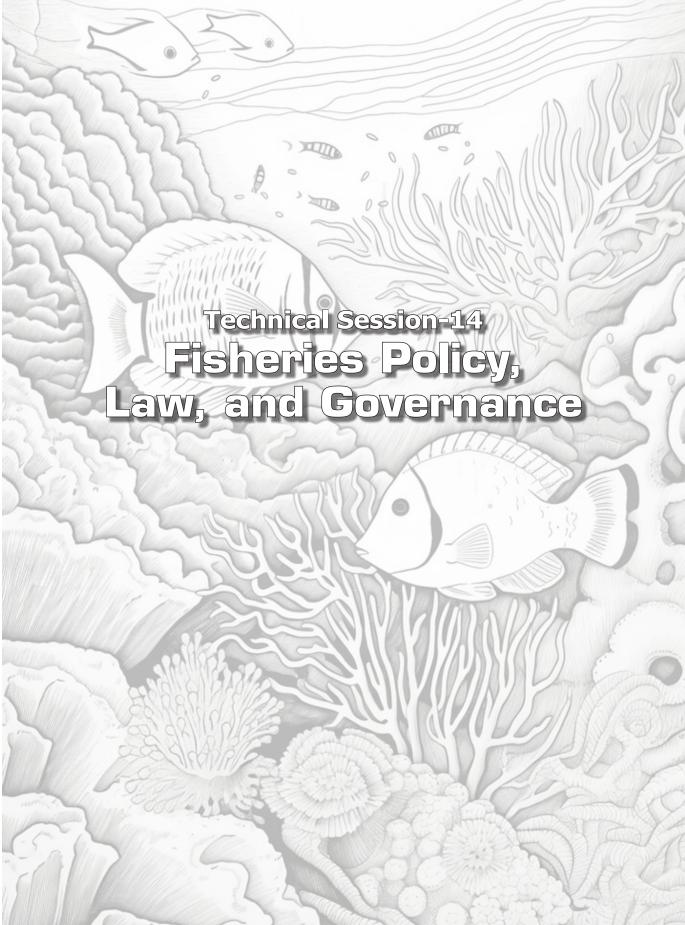
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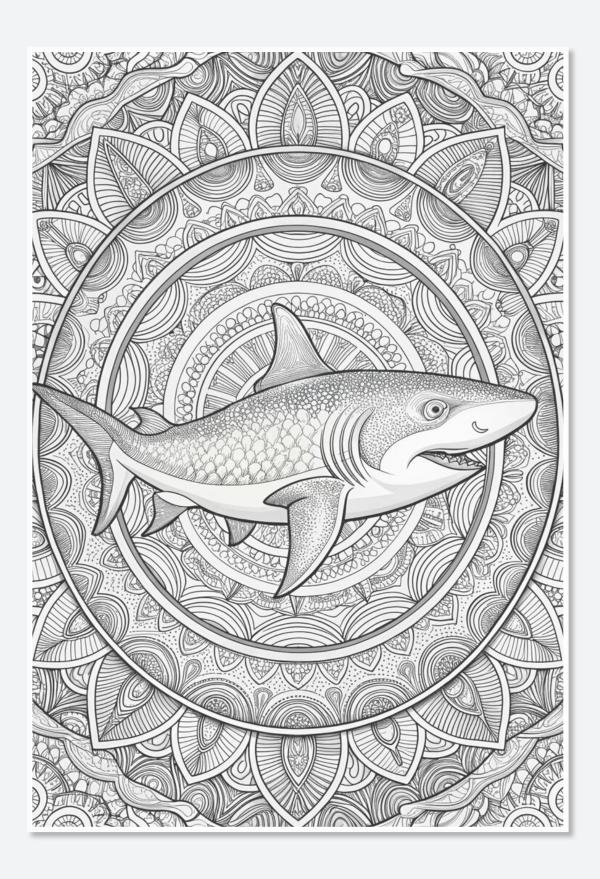
Food and nutritional security affect communities in both developed and developing countries. Food availability doesn't guarantee food and nutritional security, as it may not always be accessible to everyone. Even accessible food may not meet all requirements. Sometimes, food is abundant and accessible, but may not be acceptable or stable, leading to potential food and nutritional insecurity. Fish is no exception to these challenges, in India, fish and aquatic products are considered as important and promising sectors for food and nutritional security as well as the livelihood of the poor. Fish provides essential protein, micronutrients, and fatty acids to food-insecure populations. However, the contribution of fish to household or individual nutrition is influenced by its availability, accessibility, utilization, and stability. The study was purely based on the framework of food and nutritional security. It undertakes a comprehensive literature analysis to gain insights into food and nutritional security as a primary concern. It also examines how fisheries can ensure sustainable availability, equitable access to nutritious fish, and stability amidst physical, economic, and social challenges. Additionally, it discusses potential risks, such as climate change, seasonality, and price volatility, which could undermine fish availability and thus, food security. It is found that fish consumption is expected to rise over the next 25 years, but current growth rates and production targets are insufficient for India to excel in production and consumption. Increased availability does not guarantee fair distribution and access, and socio-economic disparities can lead to uneven access to fish, particularly for rural and lower-income populations. Fish availability alone does not ensure food and nutritional security, as challenges related to access, nutrient adequacy, utility, and stability also need to be tackled. The findings indicate that sustainable food security through fisheries hinges on proper management, conservation efforts, and policies that encourage equitable distribution and the long-term sustainability of resources. Given the complexities and trade-offs involved in balancing human needs with environmental protection, reforms are needed in the fish supply chain. These reforms should improve market conditions, infrastructure, pricing, safety, quality, and sustainable fishing practices.

KEYWORDS: Food security, Nutritional security, Food environment, Food safety and quality

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From Policy to Practice: Analyzing the Legal Instruments of South Asian Countries in Alignment with Flag State Duties Under the UN Fish Stocks Agreement

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The sustainable management of shared fish stocks in South Asia, particularly in the Bay of Bengal, is critical for the economic and ecological stability of the region, as the Bay contributes more than 80% of the Eastern Indian Ocean. In terms of institutional coverage, geographically, the whole Indian Ocean is under some or other regional arrangements. However, the three Regional Fisheries Management Organizations (RFMOs) present in the Indian Ocean Region cover a limited number of species equating to 19% of the catch. While the 1982 United Nations Convention on the Law of the Sea calls for cooperation among states to manage fish stocks that occur in multiple Exclusive Economic Zones (EEZs) or in both EEZs and the high seas, it does not provide detailed mechanisms for such cooperation. This gap was addressed by the United Nations Fish Stocks Agreement (UNFSA), which is a cornerstone for the conservation and management of straddling and highly migratory fish stocks globally. Comprising 50 articles, the Agreement sets out principles for the conservation and management of these fish stocks, emphasizing that such management must be based on the precautionary approach and the best available scientific information. However, comprehensive evaluations of the effectiveness of the UNFSA in achieving its intended objectives are notably lacking. This study, therefore, examines the effectiveness and challenges of implementing the flag state provisions of the UNFSA in selected South Asian countries (Bangladesh, India, the Maldives, and Sri Lanka) bordering the Bengal region. The study analyses the existing domestic legal frameworks of these countries and assesses their compatibility with the flag state provisions of the UNFSA. It intends to provide recommendations based on the findings, which aim to improve the governance and management of shared fish stocks in South Asia, thereby increasing the effectiveness of UNFSA and fostering sustainable fisheries management in the region.

KEYWORDS: UNFSA, Flag state duties, Bay of Bengal, Sustainability

Future-Proofing Sustainability in Indian Fisheries: Assessing National Legal Frameworks for Ecosystem Approach to Fisheries

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Over the past four decades, international and regional agreements have increasingly advocated for the Ecosystem Approach to Fisheries (EAF) to ensure sustainable fisheries management. This approach, which addresses challenges in both national and international waters, offers solutions that are especially relevant for developing states facing financial and technical constraints. Key international legal instruments, such as Article 61 of the United Nations Convention on the Law of the Sea and Article 5 of the United Nations Fish Stock Agreement, highlight the necessity of EAF. Nonetheless, despite a substantial scientific understanding of EAF in India, there remains a notable gap in the relevant legal frameworks, hindering effective EAF implementation and management. The present study used the FAOdeveloped diagnostic tool to assess the alignment of selected policy and legal instruments for the effective implementation of EAF in India to identify opportunities and weaknesses in the national policy and legal landscape for EAF implementation. The results indicate that the overall landscape is conducive to moving towards EAF, with a total of 82 EAF legal requirements. Of these, 58 EAF legal requirements were found in India's national policy and legal frameworks assessed in this EAF Legal Report, indicating a medium level of alignment with the EAF. Fisheries policies give support to address many EAF legal requirements, but gaps in fisheries legislation to incorporate the policies' guidance are evident. The main gaps in the policy and legislation are the absence of output control measures, management plans for specific fisheries, Monitoring, Control and Enforcement Processes including Vessel Monitoring Systems for vessels, introducing observer programmes, catch reporting systems and promoting cooperation between institutions, which need to be addressed. The incorporation in the national policy and legal frameworks of all the EAF relevant provisions from international legally binding instruments to which India is a party is also identified as an immediate priority. Looking ahead, EAF must be moulded to suit the Indian context, most notably by expanding its legal requirements to emphasize the socio-economic factors of fishers and fishing communities and building the science-policy communication interface.

KEYWORDS: Ecosystem Approach to Fisheries, India, Fisheries legislation, Science-Policy Interface, Sustainability



Impact of Development Schemes of the Government of India in Enhancing the Fish Production and Productivity of the Reservoirs in India: A Case Study of Telangana

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Impact assessment of government development schemes is crucial for determining outcomes and redesigning schemes in future. The present study was conducted to assess the impact of various Government of India schemes implemented during 2008-2022, including Reservoir Fisheries Development (RFD), Blue-Revolution, Integrated Fisheries Development (IFD), and Pradhan Mantri Matsya Sampada Yojana (PMMSY), on fish production, productivity in the reservoirs of Telangana and map the reduction in yield gap. The state fisheries department carried out fingerling stocking programmes with financial support from the National Fisheries Development Board and National Cooperative Development Corporation. The stocking size of Indian Major Carps such as catla, rohu, mrigal, and common carp, ranged from 4.5 to 6.2 grams, rather than the recommended size of 10 grams, and fingerlings were sourced from private hatcheries. Average stocking densities followed in large, medium, and small reservoirs were 451, 979, and 1697 nos/ha/yr, respectively. Fish yield showed a strong positive relationship with stocking density, weak to moderate negative relationship with water spread area, and moderate to strong negative relationship with stocking efficiency. Average fish yield increased to 473 kg/ha and 591 kg/ha after implementing IFD (2017-2020) and PMMSY (2020-2022), respectively. The overall fish yield (2008-2022) was recorded at 282,470, and 617 kg/ha/yr in large, medium, and small reservoirs, respectively in Telangana as against the yields recorded in 2013 i.e., 190 kg/ha/yr (small), 98 kg/ha/yr (medium), and 34 kg/ha/yr (large), with the reduction in yield gap attributed to the stocking programs. Studies on trophic levels, ecosystem services, ecological aspects, survival, and stock assessment are crucial for integrating with the assessment of fingerling stocking and RFD programs. Infrastructure development, particularly establishing fish seed hatcheries and rearing farms for the indigenous fish gene pool, will significantly enhance stock survival and production.

KEYWORDS: Reservoir, National Fisheries Development Board, PMMSY, Fish seed stocking, Fingerlings, Stocking density, Yield



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Assessment of Subsidies in Marine Fisheries: Comprehensive Overview of Gujarat, India

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The increasing global demand for fish has significantly spurred fishing capacity and effort, contributing to widespread overfishing. Among the myriad factors responsible for the over-exploitation of fish stocks, fisheries subsidies stand out as particularly consequential. These subsidies have long been a subject of contention in fisheries policy and management circles. However, within the Indian context, the quantification of fisheries subsidies remains relatively underexplored. This study seeks to address this critical gap by providing a comprehensive estimation of subsidies allocated to Gujarat, one of India's foremost contributors to marine capture fisheries, while also refining the definition of "subsidy" based on the findings. Secondary data, including union and state budgets, as well as grey literature such as speeches and news reports, were analysed for the period from 2020-21 to 2023-24. The union budget was instrumental in laying the groundwork for this analysis, allowing for a more nuanced understanding of subsidy allocation trends. Subsidies were categorized into three broad classes: capacity-enhancing, beneficial, and welfare, with eight subtypes further delineated. The findings highlight that in Gujarat, a significant portion of the subsidies classified as capacity-enhancing is channeled toward fuel, an essential input for the state's fishing industry. For a total of 10,677 beneficiaries, there has been a marked increase in subsidies post-pandemic, with fuel subsidies rising from INR 2,000 million in 2020-21 to INR 4,440 million in 2023-24. This surge in subsidy support post-pandemic signals both the state's strategic emphasis on sustaining its fishing fleet and the broader implications for resource management. Reducing capacity-enhancing subsidies is essential to addressing inequality, enhancing the economic viability of small-scale fisheries (SSF), and promoting sustainable fisheries management. The study suggests that the debate over fisheries subsidies is long-standing and pervasive, it is important to contextualize India's situation. Unlike many emerging and developed economies, where substantial subsidies have led to over-exploitation of marine resources, India's fisheries are predominantly smallscale and have yet to reach the levels of resource depletion seen elsewhere. This unique position underscores the importance of carefully calibrated policy interventions that support the sustainable development of India's fisheries without repeating the mistakes of more heavily subsidized nations.

KEYWORDS: Fishing capacity, Over-exploitation, Subsidies, Union budget, Marine fisheries, Small-scale fisheries (SSF)



Importance of Marine Spatial Planning (MSP) for Marine Fisheries Management, Conservation and Mariculture Development: Initiatives in India

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India's marine zone management involves various central and state organizations, addressing the dynamic nature of fisheries—a practice with ancient roots but often poorly communicated to stakeholders. Effective fisheries management hinges on comprehensive data concerning fishing practices, marine resources, and ecosystems. Given the variability in marine fishing activities, stakeholders require clear, illustrated data to make informed decisions. Satellitebased technology on fishing vessels collects critical data on marine resources. When this data is processed with GIS tools, it supports fisheries management and Marine Spatial Planning (MSP), aiding policymakers in effective marine zone management. The ICAR-Central Marine Fisheries Research Institute has undertaken significant GIS-based projects to map shellfish and finfish distributions along the Indian coast. This mapping provides essential baseline information on fishing practices, seasonal variations, and resource distribution, helping to prevent conflicts and improve marine safety. The GIS mapping revealed cross-state fishing activities, highlighting the need for a Vessel Monitoring System (VMS) to manage Indian fisheries. This system, along with the mapping of various fishing gears, offers valuable insights for reducing conflicts and enhancing safety. Environmental Impact Studies (EIA) are necessary for coastal developments, and GIS-based resource maps from CMFRI support site selection, ensuring a balance between ecological protection and economic growth. Marine Spatial Planning (MSP) plays a crucial role in resource allocation, reducing conflicts, and ensuring sustainable development. In India, MSP is still developing but shows promise in balancing development with conservation. States like Maharashtra and Karnataka have begun using MSP to select sites for aquaculture, such as crab farming. GIS-based models have proven effective in these efforts, aiding decision-making and promoting sustainable resource use.

KEYWORDS: GIS, Fishing ground mapping, Resource distribution, Vessel Monitoring System

Policy Issues in Ornamental Fish Farming and Aquarium Keeping Sector: Insight from India

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The total value of global ornamental fish export which was US\$ 362.08 million in the year 2011 reduced to US\$ 330.48 million in the year 2022 after achieving a highest peak of US\$ 395.96 million in the year 2021. The aquarium industry in India has grown significantly during the last two decades. The total value of domestic aquarium trade was estimated to be only about INR 55 crores at the end of the year 2000, with ornamental fish exports of only INR 2.29 crores (US\$ 0.504 million). The country is known in international trade for wild collected indigenous fishes from North-East states and Western Ghats contributing less than 0.5% to the global export of ornamental fishes. An investment of Rs.576 crores was proposed by GOI while financial assistance of Rs. 500 crores was provided by the World Bank for the development of ornamental fisheries in the country. The export of ornamental fishes from India was Rs. 33.32 crores (US\$ 4.53 million) during 2021-22 which was 1.15% of total global export with the increased share of captive-bred exotic fishes. The domestic aquarium trade including ornamental fish has already achieved a value of Rs. 800 crores. The policy issues addressed in the present study were identified based on discussions with stakeholders involving ornamental fish producers, aquarium traders, exporters, importers, researchers, academicians, hobbyists, administrators, and policymakers. The objectives were to analyse the strengths, weaknesses, opportunities and limitations of the ornamental fish industry. Data were also collected through publications, government reports, and personal visits. The study provides an insight into the evolution, characteristics, scope, and potential of the ornamental fisheries including the value of the domestic aquarium trade, the number of hobbyists, commercially important freshwater and marine ornamental fishes including production centres, major trade centre, indigenous ornamental fisheries resources, contributions to global exports and imports, technology developments and advancements, resource conservation, threats of exotic invasions, capacity building programs, institutional financial assistance schemes, etc. Given the growing global demand and the government's policy focus on developing the sector with greater investments, the ornamental fish industry in India is poised for rapid growth in the near future.

KEYWORDS: Policy Issues, Ornamental Fish Farming, Aquarium Keeping

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Allowing Commercial Vessels to Fish in Waters Designated for Exclusive Use of Municipal Fishers: Are the Arguments Valid?

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Sardines make up one of the largest fisheries in the Philippines. In western Mindanao, commercial vessels land close to 200,000 t/yr and supply local bottlers and canneries in the region which employ over 30,000 workers. Because stocks in this region have been overfished for at least 12 years, reduced production over the years has led to economic losses to the overall industry. Hence, a strong lobby for the national government to amend the existing laws for allowing commercial vessels to freely fish closer to shore (< 15 km) in waters presently designated for the exclusive use of municipal fishers. Because of inadequate consultations on this issue, the general perception is that the law will be amended in favor of the commercial fishing sector, in spite of clear indications of prolonged overfishing and meaningful progress being made towards sound management. This paper uses data from studies on small pelagic fisheries in the region to address the principal arguments for the proposed amendment, which are: (1) the small size (≤ 3 GT) of municipal vessels does not allow them to maximize the use of municipal waters, and (2) portions of the stock in nearshore waters are underfished. Catch and effort of municipal vessels employing 5 gear types (gillnets, small ringnets, encircling gillnets, multiple hook and line, and simple handline), with crew sizes ranging from 2-9 fishers, were monitored daily at 5 sites and locations of fishing operations were recorded by GPS data loggers which cooperating fishers agreed to use. The results show that for all gear types, the bulk of fishing operations within a year were done from 5-15 km from the shore, but also extended up to 20 km, clearly showing that even with small vessels, municipal fishers make full use of their waters. Examination of decadal changes in catch per trip for all gear types showed significant decreases from 2012-14 to 2022-24, consistent with overfished stocks. These data refute the validity of the premises on which the proposed amendment is based so that policymakers should be guided more truthfully to avoid further detriment to the industry.

KEYWORDS: Commercial fishing, Municipal waters, Philippines

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Access, Institution and Governance in Indian Reservoirs: Implication for Sustainable Fisheries Management

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Reservoirs are the single largest inland fisheries resource of India, covering more than 1% of the country's land resources. With an area of 3.15 million hectares including small reservoirs (14,85,557 ha), medium reservoirs (5,07,298 ha), and large reservoirs (11,60,511 ha), reservoirs are sleeping giants, With reported potential yields of 500, 250, and 100 kg/ ha for small, medium and large reservoirs, respectively, the corresponding production could be 7,43,000, 1,27,000 and 1,16,000 tonnes. The impact of fisheries developmental activities could not be realized as per expectation due to the very nature of resources under multipleuse rights. Most of the water bodies utilized under fishery belong to state governments. Access to the reservoir and their management for fishery development have been identified as major challenges in the promotion of reservoir fisheries. The size of the reservoir, traditional and customary rights, physio-graphic dimensions, accessibility and river connection, etc. are the determining variables for the nature of property rights and lease rent. The objective of the study is to review the fishers' access rights, institutional arrangement, and governance challenges in sustainable fisheries management of reservoirs in India. We discussed fishers' access in the framework of stakeholders' mechanisms to utilize the resources for fisheries management. This paper is based on the primary and secondary data collected through PRA, formal and informal interaction with the fishers, and various other stakeholders of UP, MP, Gujarat and Chhattisgarh states. Reservoir fisheries in India is governed by both revenue as well as welfare-based models. Most of the state governments focus on revenue generation along with welfare measures for the fishers' community while deciding on the allocation and withdrawal rights. In Uttar Pradesh, the involvement of the fishermen community in the management of Class 1 and 2 reservoirs is almost negligible. In Madhya Pradesh, large Reservoirs are under Cooperative management, with fishing rights to fishers. Leasing periods also vary in different states from 3-7 years. The governance of four states revealed that decisions on the use and management of waterbodies are formed within a legal and institutional context where welfare and revenue models are intertwined. There is an urgent need to recognize the role of fisher communities to restore, conserve, protect, and co-manage reservoirs.

KEYWORDS: Reservoir, Access rights, Governance, Fisheries, Leasing system, Cooperatives

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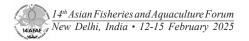
Meta Governance for Sustainability: A Probative Study on Marine Fisheries Governance in Andhra Pradesh

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Andhra Pradesh has a strong marine fisheries sector that contributes significantly to the state's economy and employment. The state has 974 kilometers of coastline, which is the second longest in India. With 1,55,062 active fishermen and 20,219 fishing crafts in operation in the fishery, the sector is an important source of employment and income. Starting with traditional fishing in ancient times to modern, technology-intensive fishing, the marine fisheries sector of the state has grown tremendously from subsistence fishing to harvesting record landings of 3.42 lakh tonnes in 2014. However, the total marine fish landings in 2023 were estimated at 1.90 lakh tonnes, reflecting a 12% decrease compared to 2022. The state has several initiatives to manage its marine fisheries, including the annual ban on marine fishing, the Code of Conduct for Responsible Fisheries (CCRF), Monitoring, Control, and Surveillance (MCS), participatory management, and diversifying to offshore fishing. The Andhra Pradesh Marine Fishing (Regulation) Act, 1994 regulates fishing by the fishing vessels in the territorial waters in the sea along the coastline of the state of Andhra Pradesh and for matters connected therewith. Despite these initiatives, the marine fisheries of the state are vulnerable to external influences namely, overcapacity and thus resulting in overuse of marine resources, environmental degradation, and climate change. Strengthened fisheries governance and institutional frameworks to set clear objectives and development paths for the sector are needed to achieve sustainable capture fisheries. In this context, this paper discusses the role of meta governance, the concept that refers to the practice of governing governance, or steering, and coordinating governance arrangements. in achieving a sustainable food system, with the significant contributions of three important stakeholders viz., the research system, state machinery and the fishers in the formulation, implementation, and compliance of institutional frameworks to sustain the marine fisheries of Andhra Pradesh. This study also documents the challenges in implementation/compliance and the way forward for strengthening the same, regarding each fishing regulation, and how its effective implementation can help in ensuring sustainability.

KEYWORDS: Meta governance, Marine Fisheries, Regulation, Conservation, Sustainability



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Blue Justice in the Face of Blue Economy Challenges for Small-Scale Fishers: Insights from Scientometrics

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The concept of Blue Justice is increasingly recognized as a crucial framework to address the diverse inequities faced by small-scale fishers globally, especially in the context of the growing focus on Blue Economy and Blue Growth initiatives. This study examines global research trends in the scientific literature concerning blue justice for small-scale fishers and identifies the various forms of injustice they experience. An iterative search was conducted across multiple databases, including SCOPUS, Google Scholar, and Dimensions, using KEYWORDS such as "Blue Justice OR Equity OR Injustice OR Conflicts OR Marginalization AND Coastal Economy OR Blue Growth AND Small-Scale Fishers," with relevant topics identified from titles, abstracts, and KEYWORDS. Using the PRISMA framework, the study retrieved 294 documents from 1997 to 2024, revealing a surge in publications from 2018 onwards. Disciplines like social sciences, agriculture, allied sectors, and environmental sciences contributed the most to the research output, with the United States, Canada, and the United Kingdom leading in terms of country contributions. The thematic analysis highlighted several forms of injustice affecting small-scale fishers globally, including distributive, social, economic, market, infrastructure/wellbeing, regulatory, procedural, and environmental injustices, with regional variations. This study underscores the importance of addressing blue justice by advocating for a more inclusive and equitable approach that protects the rights of small-scale fishers, ensuring their voices are heard and their livelihoods are sustained amid global economic changes.

KEYWORDS: Blue Justice, Small-Scale Fishers, Blue Economy, Scientometrics

Preserving Lives at Sea: An Assessment of Occupational Hazards and the Role of Life-Saving Devices for Small-Scale Motorised Fishers of Southern-most Coasts of India

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Marine fishing is recognized as one of the most dangerous professions worldwide, particularly for small vessels that are increasingly operating farther offshore due to declining near-shore fish populations and rising market demand. This study focuses on identifying the various occupational hazards and the safety equipment used by small-scale motorized fishers in the southern-most coastal regions of India. Primary data was collected from 253 small-scale motorized fishermen. To assess their perceived impact across various hazard categories, the Relative Importance Index (RII) was utilized. Additionally, the study analyzed the frequency distribution of adoption of life-saving equipment based on the adoption rate to evaluate the usage patterns of devices such as life jackets, life rings, magnetic compasses, fire extinguishers, spare outboard engines, first aid kits, Global Positioning System (GPS) devices, mobile phones, Very High Frequency (VHF) radios, echo sounders, beacons, Automatic Identification System (AIS), and satellite phones. The findings indicate that environmental, psychological, and vessel-related hazards have the greatest impact on fishers, with specific hazards including 'cyclones', 'collisions', 'capsizing', 'high currents', 'lack of visibility', 'fatigue', 'stress', 'anxiety', and 'insomnia'. Despite being aware of safety measures, fishers still show low usage rates for life jackets and life buoys. In contrast, motorized vessels are increasingly equipped with modern communication and navigation tools, which help mitigate uncertainties at sea, with adoption rates of 87.75% for GPS, 84.19% for mobile phones, 67.98% for VHF radios, and 20.16% for AIS. The study highlights the urgent need for strict enforcement of safety measures during the registration and renewal processes for fishing vessels. Enhancing the sector's safety necessitates increased awareness, comprehensive training, and regular annual inspections.

KEYWORDS: Accidents, Marine fisheries, Traditional fishing crafts, Motorised crafts

Harnessing the Humongous: Reservoir Fisheries Governance for Sustainable Fisheries in Telangana, India

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The governance structure of three representative reservoirs, viz., Sri Ram Sagar (largelicensed), Kaddam (medium-licensed) and Swarna (medium-leased) reservoirs in Nizamabad and Nirmal districts of Telangana were profiled. A total of 258 fishers of three reservoirs were interviewed using household surveys and focus group discussions. The reservoirs are owned and maintained by the state Irrigation and Command Area Development Department, and fishing rights are vested with the State Fisheries Department (SFD). Licenses were issued at Rs.155/- per fisher per annum in large and medium reservoirs, while small reservoirs are leased out preferentially to fishermen cooperative societies at Rs. 63-348 per ha benefitting the fishers as against the contractors/private parties. It indicates Telangana follows a welfare and development-oriented model rather than a revenue-oriented reservoir management model. Thermocol teppa is the major craft, with gillnets and cast nets being the predominant fishing gears used. Fishing is carried out for 10 months from September to June with July and August being closed season. Fishers in Swarna fish only for 15 days a month as per the society resolution. The quantity and size of fish caught were reported high during premonsoon season. The SFD regulates closed season and mesh size of gear. The absence of regulated market(ing) and dominance of commission agents affect fishers' income adversely. Fishes have easy access to the district fisheries office and are aware of fish seed stocking programmes implemented under Pradhan Mantri Matsya Sampada Yojana. Development of fish landing centres and marketing facilities close to the reservoirs would lower the postharvest losses while training on seed rearing, cage/pen culture practices in the reservoirs, life-saving and rescue operations, usage of alternate safe crafts, and exposure visits are needs of the hour. The possibility of participatory/co-management of reservoirs may be explored to ensure a greater share of benefits accrue to the fishers.

KEYWORDS: Reservoir, Governance, Fishers, Licensing, Leasing, PMMSY, State Fisheries Department



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Global Review of Research on Fisheries Cooperatives

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Fisheries cooperatives are the shields of the weak. The fishery cooperative movement is considered the most effective way to develop the fisheries sector and uplift the socio-economic conditions of the fishermen. Quantitative and qualitative assessment of the research output on fisheries cooperatives helps to find the research landscape and potential areas for future research. Therefore, scientometrics and thematic analysis tools were used to review global research output on fisheries cooperatives. About 310 articles were published by 535 authors were extracted from databases like Dimensions AI, Google Scholar, and Research Gate from 1941 to 2023. The global and Indian compound annual growth rate of fisheries cooperatives research was 6.81% and 8.23%, respectively. Asia ranked first with the highest number of publications (69.68%) on fisheries cooperatives research, with Japan standing first (26.13%), followed by India (23.23%). The state Kerala has the highest number (20%) of articles in India. Marine Policy Journal (4.19%) ranked first with the most publications. The top three authors from countries like Japan, Turkey, and the USA contributed 23 articles worldwide. It was observed that there was less international collaboration among authors. Despite having the highest number of publications, the author Nakamura Tomoyuki lacks collaborations with other researchers and identified that he is the sole author for most of his publications. The results of the thematic analysis identified the focused areas using Nvivo software, which included the role of cooperatives and challenges (30.38%), socio-economic and financial analysis (29.75%), governance and management (26.58%), sustainability and conservation (7.59%), gender/women empowerment (3.48%), and technology integration (2.22%). The study revealed the trends of research on fisheries cooperatives. Strategic leadership, ease of doing business, organizational behavior, and gender-friendly technology are the areas that need to be targeted in future research to improve efficiency and sustain fisheries cooperatives. especially in India. The analysis highlights the need to focus on inland fisheries cooperatives in research. There is a need to strengthen national and international collaboration to create a conducive environment for promoting research on fisheries cooperatives.

KEYWORDS: Scientometrics, Thematic analysis, Dimensions AI, Nvivo

Strengthening the Freshwater Fish Seed Supply Chain Through the 'Cluster Seed Villages' Approach in Odisha: A Strategic Initiative by ICAR-CIFA Under PMMSY

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ICAR-Central Institute of Freshwater Aquaculture (CIFA) has launched an innovative initiative to strengthen the freshwater fish seed supply chain in Odisha through the 'Cluster Seed Villages' (CSV)' approach with funding support under PMMSY from the Department of Fisheries, Government of India. Aimed to boost aquaculture productivity by improving the quality, accessibility and timely availability of fish seeds, the CSV model was implemented at the Baliapal and Nilgiri blocks in the Balasore and Bangiriposhi blocks in Mayurbhani districts of Odisha. Field training and exposure visits to ICAR-CIFA were organised for the adopted beneficiaries, mostly grow-out farmers, to increase their awareness and knowledge base on seed rearing. In 2022, fry rearing was demonstrated at these sites covering a 4.36 ha pond area (30 ponds and 25 beneficiaries). A total of 193.0 lakhs of spawn of catla, rohu and mrigal were supplied along with the required inputs for pond preparation and crop management. Survival levels of 26.4, 40.5 and 72.4% have been recorded in catla, rohu and mrigal after 20-25 days of rearing at Baliapal, while the respective levels were 21.6, 29.8 and 31.5% in Bangiriposhi after 28-40 days. Hand-holding support was provided to the farmers for fry harvesting and sale. After seeing the fry rearing result and the immediate benefit through fry sale, most of the farmers came forward to undertake the next phase of fingerling rearing. The fingerling-rearing demonstrations were carried out in 4.27 ha pond at Baliapal (25 ponds) and 4.6 ha at Bangiriposhi (24 ponds), covering 49 beneficiaries. The ponds were stocked with 8.9 lakhs of advance fry of catla, rohu and mrigal at 1.0 lakh/ha stock density. Besides, hand-holding support was also given to farmers to monitor key water quality parameters regularly and manage the crop by stationing trained project personnel at the project sites. A total of 5.13 lakh fingerlings with an average survival of 65.02 and 53.3% in Baliapal and Bangiriposhi sites, respectively, were harvested and sold by the farmers locally, apart from the stock left in their ponds as complete harvest was not possible. While all the adopted farmers were practicing grow-out farming earlier, successful demonstration of benefit realised through such seed rearing encouraged all of them to adopt seed rearing practice at Baliapal and partially at Bangiriposhi. Moreover, the seed produced through the project activity helped the local area to become self-sufficient, which also reduced the seed supply chain from neighbouring States.

KEYWORDS: Fish seed, Cluster Seed Villages, PMMSY



Recreational Fisheries as Community-Based Aqua-Tourism Option for Enhancement of the Social-Ecological and Financial Resilience of Wetland Fishers of Lower Gangetic Plains of Asia

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Wetlands are crucial ecosystems often termed "biological supermarkets" due to their rich biodiversity and ecological services. They support a diverse array of species and provide essential nutritional and economic resources for local communities. In regions like West Bengal, where millions depend on these ecosystems, fishing activities including culturebased fisheries in inland open water are vital for daily sustenance. However, income from fish sales frequently falls short of community needs, underscoring the urgent requirement for alternative livelihood options to enhance social and economic conditions. One promising solution is "aqua tourism," which capitalizes on the natural beauty and productivity of wetlands. This case study focuses on the lower Gangetic delta, specifically the Duma wetland in North 24 Parganas, one of the largest floodplain wetlands. Managed by a Primary Fisheries Cooperative Society (PFSC) with around 1,081 members, the wetland has increased its fish yield from 48 tons to approximately 82 tons annually following the implementation of an integrated wetland management plan by ICAR-CIFRI. However, relying solely on fisheries to support such a large community places significant pressure on the wetland's resources and ecology. Recent trends indicate a growing income from sport fishing, presenting an additional income source. To tackle the challenges of financial sustainability, activities such as sport fishing, fish festivals, boating, and kiosks can serve as viable alternative livelihoods. These initiatives not only provide extra income but also actively engage women and youth, helping to reduce rural-urban migration. With government support and financial assistance, these ventures can encourage entrepreneurship and create sustainable economic opportunities. By promoting community-based aqua tourism, the livelihoods of local populations can be enhanced while preserving the ecological integrity of the wetlands. This multifaceted approach holds the potential to uplift communities, ensuring that both people and the environment thrive together. The Duma wetland can thus serve as a model for sustainable development, striking a balance between economic needs and ecological conservation.

KEYWORDS: Aqua-tourism, Wetland management, Alternative livelihood, Financial resilience, Sport fishing



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Planning for Fisheries Future in Haryana and Punjab: Estimating Production Potential in Data-limited Scenarios

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Food security efforts are prioritising balanced nutrition that include livestock and fish rather than only focusing on increasing cereal and staple crop production. Fish production can be enhanced through aquaculture intensification and diversification, which requires considerable planning based on credible data on resources. Here, we assessed, in the states of Haryana and Punjab, the present fish production and the possible potential for the next 10 years at the district level. The data on district-wise fisheries resource areas in the form of ponds and fish farms available with the state fisheries departments was collated, cross-checked and triangulated with field observations in select districts. We found significant gaps and inadequacies in data on resources and fish production. We adjusted for data inconsistencies and accordingly estimated the present fish production and productivity status, and thereafter the possible potential growth for the next 10 years by making certain assumptions. The total fisheries resource area under panchayati pond and private ponds in Haryana was found to be 15,584 ha. We found the reported fish production of 2.09 lakh tonnes for 2021-22 to be an overestimate, given the available resource area and productivity and found it to be around 76,814 tonnes. In Haryana, about 86 % of fish production comes from public (panchayat) ponds and private (mainly shrimp) farms, indicating that ponds are the major fisheries resource area in Haryana, and average productivity was found to be around 5 tonnes/ha. In Punjab, the fisheries resource area under *panchayat* pond and private ponds was 24,564 ha, which is higher than that in Haryana. In Punjab, about 80% of fish production comes from panchayat ponds and private (mainly shrimp) farms, and average productivity was found to be 5.41 tonnes/ha. Freshwater fish farms in the private sector were very few in both states, while shrimp farms are still expanding. We estimated district-wise fish production potential and prospective plan for Haryana and Punjab for 2028 and 2033, and identified districts with high potential. Highlighting the need for credible data, we suggest specific interventions to realise the fish production potential.

KEYWORDS: Planning, Production potential, Data-limited Scenarios

Development of Spatial Atlas for Strategic Implementation of Seaweed Mission along Gujarat Coast: Towards Data to Decision Approach

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The spatial atlas is increasingly being recognized globally for its role in resource allocation, management and informed decision-making, especially in the field of mariculture. For the sustainable expansion of the seaweed sector, a technically modelled spatial atlas is essential. Such an approach is currently absent in the Indian context. To address this gap, we integrated spatial site suitability data by analysing topographic, physico-chemical, oceanographic and socio-infrastructure parameters to design the framework and to develop an actionable spatial atlas for assisting the seaweed sector development along the Gujarat coast. The methodological approach involved in-situ and remote sensing data collection, along with field surveys, followed by data processing and its integration using Geographic Information Systems (GIS). The results obtained from this study provided insights to develop a first comprehensive spatial atlas, mapped with 23 locations having 11,679.36 hectares (highest Kutch 29.8 % and lowest 6.3 % Amreli) across 14 coastal districts, which can be visualized through interactive tools for the concerned line agencies and stakeholders. By integrating various data layers along with benchmarked criteria/factors, the spatial atlas supports informed decision-making, and allocation of most optimal farmable sites to farmers which underpins sustainability, and promotes effective resource management while minimizing conflicts with other coastal activities. The spatial atlas depicts that there exists immense potential for developing the seaweed sector along the Kutch coast with a significant number of allocation provisions. It also aids policymakers in developing targeted regulations aligned with environmental goals and supports ongoing scientific monitoring and adaptive management strategies which is very essential for achieving sustainable development goals (SDG's). This will aid the seaweed mission to implement global best management and sustainable governance practices including sea space allocation policies. Furthermore, this initiative could strategically support India's seaweed mission mandates and serve as a national model for other maritime states in developing spatial atlases for effective management of seaweed farming technologies implementation apart from serving as a ready reckoner to policymakers.

KEYWORDS: Spatial Atlas, Seaweed Farming, Decision-Making, Sustainability, Mariculture



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Sardinella Signatures—Tropical Reflections over Co-Governance Initiatives in Kerala

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The "Pelagic fatigue" driven by the severe decline of the iconic Indian Oil sardine, known among fishers as Kudumbam pularthy (family sustainer), along the Kerala coast of India since 2015 has brought the topic of fisheries governance into a new discourse among the stakeholder constituency. Latched on the political mobilizations, post the Meenakumari committee report that dealt with the controversial Deep-sea fishing policy, the discourse has snowballed into institutional experiments in Co-Governance as well as bold policy responses from the Government of Kerala (MLS ordinance 2017, 2018 and KMFRA modification 2017). Though crisis-driven responses like the co-governance initiative in Kochi spearheaded by fish workers' trade unions and facilitated by a Government Research Agency have kindled a new interest in consensus-based decision-making both in its praxis and policy around responsible fisheries, the subsequent polarization among stakeholders led to the abortion of the historic Code of Conduct agreed by Ring seine units and Trawlers. This paper makes a reflective diagnosis over i) the dynamics and the context (socio-ecological as well as political) of these developments happening in a tropical water small-scale fisheries scenario and ii) the trajectory of the Habermasian communicative rationality in Fisheries Extension System in an attempt to characterize the new forms of stewardship alliance the State engages into and delineate the different epistemological as well as administrative/governance challenges being unfurled, all against a neoliberal leit motif in CPR regimes.

KEYWORDS: Sardinella signature, Tropical Reflection, Governance initiatives

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Comparative Analysis of Penalty Provisions in Marine Fishing Regulation Acts across India: Enforcing Responsible Fishing Practices

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With India's abundant resources, the effective regulation of marine fisheries is critical to achieving sustainable production, maintaining the livelihoods of coastal communities, and contributing to the national economy. As a signatory to several international environmental treaties and conventions, India is committed to sustainable fishing practices, as outlined in the National Policy on Marine Fisheries, 2017, which places sustainability at the core of all marine fisheries actions. Marine fishing activities in India are regulated by the Marine Fishing Regulation Acts (MFRAs) within Territorial waters (within 12 nm) enacted by individual coastal states and union territories, which aim to ensure sustainable fishing practices and regulate various aspects of marine fisheries. This study provides a comparative analysis of the penalty provisions in the MFRAs of coastal states and union territories of India. It examines the similarities and differences in penalties and sanctions imposed for violations of these regulations. By reviewing relevant legislation and legal frameworks, the analysis seeks to highlight how different states approach the enforcement of sustainable fishing practices and the management of marine resources. It is to be noted that each state has periodically amended its principal act and issued additional notifications to address changing conditions and challenges in marine fisheries. The findings of the study indicate that the general offences and penalties outlined in the marine fishing regulation acts are similar across most of the States and Union Territories. However, some states have gone beyond the generally prescribed fines and introduced new rules for imposing penalties based on the gravity and frequency of offences. Certain states have adopted more stringent penalties, such as escalating fines for repeat offences, imprisonment, or fines based on vessel engine power. These differences reflect a tailored approach to local challenges, highlighting the need for a balanced regulatory framework that both preserves marine resources and sustains the livelihoods of coastal communities. Moving forward, harmonizing these regulations and sharing best practices could enhance sustainable fishing practices nationwide.

KEYWORDS: Penalty provisions, Governance, Sustainability, MFRAs, Best practices

Exploring Lakshadweep's Pristine Environment for Resilient Fisheries and Coastal Aquaculture Technologies

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Lakshadweep, India's only coral atoll territory, stands out as a beacon of potential for sustainable fisheries and aquaculture. This work explores how Lakshadweep explores its pristine environment and favourable climate to drive advancements in both fisheries and coastal aquaculture sectors. The study was conducted in Kavaratti and Agatti Islands, involving varied stakeholders from the fishing industry. Primary and secondary data were collected using different data collection tools. It was observed that the islands' clean waters and stable climate provide an optimal setting for culturing marine organisms such as cobia, pompano, seabass (cage culture candidate species), seaweed, pearl oysters, and ornamental fishes, which can diversify income sources and reduce pressure on wild fish stocks. An attempt was undertaken to identify the history of innovations and the technologies that have been adopted by the fishers over the years. The key areas identified for growth and development includes upgrading/modernize post-harvest handling methods and expanding infrastructure for processing and marketing. Additionally, enhancing regulation and enforcement to combat illegal fishing, along with investing in community education and training, is crucial for sustainable development. The study highlights the strategic importance of developing robust marketing channels, both domestic and international, to maximize the economic benefits of Lakshadweep's fishery products. By focusing on branding, promotion, and digital platforms, Lakshadweep aims to enhance its market presence and achieve a resilient and balanced seafood industry. The results of the study will be useful for the policy makers towards designing development interventions to improve the livelihoods of the people depending on the sector.

Keywords: Lakshadweep, Fisheries, Mariculture, Sustainable development, Blue economy, Marine resources

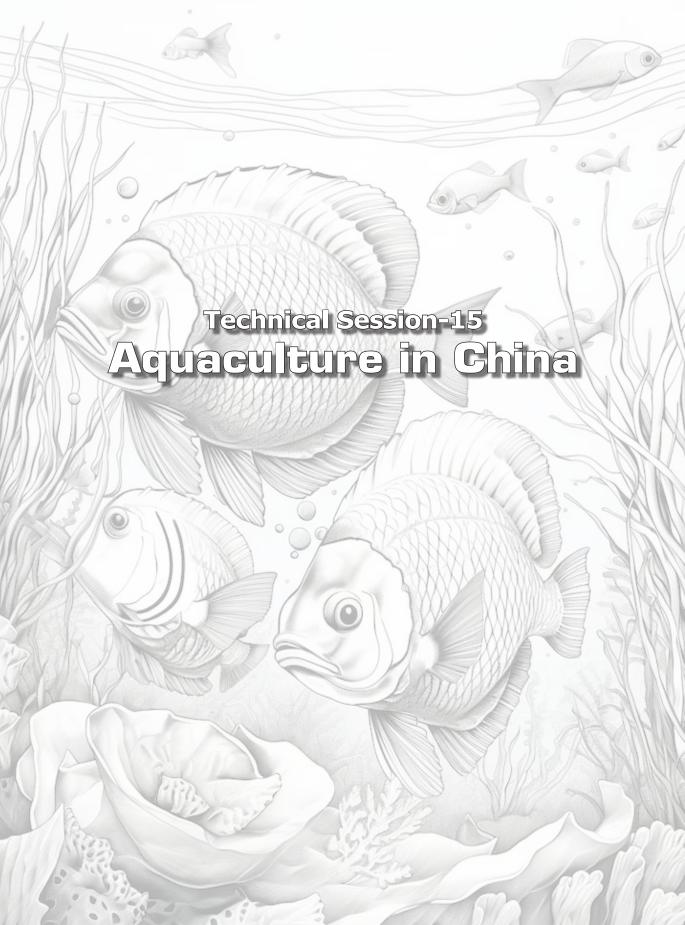
An Analysis of the Impact of the Asia-Pacific Trade Agreement (APTA) on Marine Products Exports from India

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India, as a founding member of the Asia-Pacific Trade Agreement (APTA), has played a significant role in the bilateral trade of marine fishery products within the Asia-Pacific region over the past two decades. This involvement has enhanced the competitiveness of India's fishery exports, particularly frozen shrimp, crustaceans, and dried fish, in highdemand markets such as China and South Korea. The study aimed to examine the impact of APTA on the trade of these products, using secondary data from the Trade map, analyzed through various index calculations and statistical tools. The findings indicate that APTA has positively influenced key trade metrics, leading to increased trade volumes, enhanced regional integration, and broader participation in global markets. However, despite these positive trends, the agreement has not significantly shifted the focus of intra-regional trade, as evidenced by the Regional Trade Introversion Index (Sfi), which shows limited impact on trade concentration within the region. The study also reveals a positive shift in export, import, and trade intensity post-2010, reflecting improved regional cooperation under APTA. Strong trade activity between 2019 and 2023, partly driven by Mongolia's inclusion in the agreement in 2020, demonstrates deeper regional integration and favorable global conditions. However, earlier years show fluctuations in trade performance, indicating evolving dynamics in the trade landscape. India and other APTA members maintain competitive advantages in marine fishery products, with revealed comparative advantage (RCA) values exceeding 1 in key categories like 0301, 0303, and 0305. Despite some fluctuations in competitiveness for other categories like 0308 and 0309, the study concludes that APTA has strengthened export advantages through RCA, though it has not led to uniform changes in comparative advantage across member nations. Overall, APTA has fostered external trade while maintaining balanced trade relationships both within and beyond the agreement.

KEYWORDS: APTA, Seafood Exports, India, Asia-Pacific Region





Effects of Exopolysaccharides from *Paecilomyces hepiali* on Growth Performance, Digestive Enzyme Activity, Antioxidant Capacity and Intestinal Villus Length of *Micropterus salmoides*

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This experiment was conducted to investigate the effects of exopolysaccharides of Paecilomyces hepiali on growth performance, digestive enzyme activity, antioxidant capacity, intestinal villus length, and other growth and physiological indexes of *Micropterus* salmoides. A total of 360 healthy M. salmoides with an average body weight of 9.76±0.30 g were randomly divided into 6 groups. The extracellular polysaccharide supplemental levels of P. hepiali test groups were 3%, 5%, 7% and 9%, respectively. The basic diet was blank group and 5% Astragalus polysaccharide positive control group. Growth performance data showed that 5% exopolysaccharides could significantly increase specific growth rate (SGR), decrease feed ratio (FCR), increase average weight gain rate (AWGR) and increase kidney index (RI) in M. salmoides (p<0.05). The spleen index was significantly increased in 9‰ P. hepiali exopolysaccharides group (p<0.05). The data of total protein content and various enzyme activities in the digestive tract showed that the intestinal total protein content in 3\%, and 5% exopolysaccharides groups and Astragalus positive control group could significantly increase (p<0.05), and the intestinal amylase activity in 7% exopolysaccharides group could significantly increase (p<0.05). Serum total protein content and antioxidant enzyme activity data showed that the 5% experimental group could significantly increase serum total protein content (p<0.05), 5% and 9% experimental groups and the Astragalus groups could significantly reduce serum malondialdehyde content (p<0.05), and experimental groups could increase serum catalase activity (p<0.05). Compared with blank control group and Astragalus positive control group, superoxide dismutase activity in 7% test group was significantly increased (p<0.05). Serum non-specific immune indexes showed that the serum lysozyme activity in 5% and 9% experimental groups and Astragalus positive control group could be significantly increased (p<0.05), the serum alkaline phosphatase activity in experimental groups could be significantly increased (p<0.05), and the serum acid phosphatase activity in 3‰ experimental groups could be significantly increased (p<0.05). Serum antioxidant indexes showed that both the experimental group and Astragalus positive control group

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could significantly improve the scavenging rate of DPPH free radicals, the ability to inhibit hydroxyl free radicals and the ability to resist superoxide anion free radicals in serum (p<0.05). Serum biochemical indices showed that the addition of exopolysaccharides in test groups significantly increased serum glutamic oxalacetic transaminase activity and significantly decreased serum urea nitrogen concentration (p<0.05), and the content of blood glucose in 5% test group and Astragalus positive control group could be decreased. The intestinal section results showed that both the test group and Astragalus positive control group could significantly increase the intestinal villi length of M. salmoides (p<0.05), and the intestinal villi of 5% Cordvceps sinensis group was the longest, reaching 654.73±89.24 µm. The effect of feeding 5% exopolysaccharides to M. salmoides is the most obvious, which can significantly improve the growth performance, digestive enzyme activity, antioxidant capacity, intestinal villus length and other growth and physiological indexes of M. salmoides. This study provided scientific data for the application of exopolysaccharides of *P. hepiali* in M. salmoides culture. It also provided a theoretical basis for fully exploiting and utilizing extracellular fermentation product resources of P. hepiali industry and helped the efficient utilization of biological resources of *P. hepiali* industry.

KEYWORDS: *Paecilomyces hepiali*, Exopolysaccharide, Micropterus salmoides, Promote growth, Antioxidant

Effects of Abscisic Acid on the Physiological and Biochemical Responses of *Saccharina japonica* under High Temperature Stress

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Saccharina japonica is one of the most productive aquatic plants in the world, widely used in food, feed, medicine and other industries. Predominantly inhabiting temperate marine environments in mid- to high-latitude regions of the Northern Hemisphere, the growth of S. japonica is significantly limited by high temperature stress. Abscisic acid (ABA) plays an important role in plant growth and development and stress response. However, the role of ABA on high temperature stress tolerance in S. japonica still needs to be further elucidated. Here, we found that exogenous ABA significantly alleviated disease and decay in S. japonica under high temperature stress, while also increased the relative growth rate, chlorophyll fluorescence parameters (Fv/Fm), photosynthetic pigment and osmotic substance content. Meanwhile, exogenous ABA enhanced the activity of protective enzymes and upregulated the transcript levels of antioxidant-related genes, thereby reducing oxidative damage. Most importantly, we observed a significant increase in ABA content and the transcript levels of key genes involved in ABA synthesis in S. japonica under high temperature stress, which were further amplified by the addition of exogenous ABA. In conclusion, this study provides evidence that ABA can moderate the detrimental effects of high temperature stress and provides a theoretical basis for the screening of S. japonica germplasm resources and the cultivation of new stress-resistant varieties.

KEYWORDS: Abscisic acid, Saccharina japonica, High temperature stress, Gene expression regulation

Rapid, Sensitive and Visual Detection of Mandarin Fish Ranavirus and Infectious Spleen and Kidney Necrosis Virus using an RPA-CRISPR/Cas12a System

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Iridoviruses are large cytoplasmic icosahedral viruses that contain dsDNA. Among them, infectious spleen and kidney necrosis virus (ISKNV) and mandarin fish ranavirus (MRV) are particularly notable due to their high contagiousness and pathogenicity. These viruses pose a significant threat to fish aquaculture, resulting in annual economic losses for the fish farming industry. Therefore, the development of novel, rapid virus detection technologies is essential for the prevention and control of ISKNV and MRV diseases. In this study, we developed a rapid, sensitive, and visual detection method for MRV and ISKNV using the RPA-CRISPR/Cas12a system. This method can detect as low as 1 copy/ul of MRV and 0.1 copy/µl of ISKNV, demonstrating excellent specificity and reproducibility. The detection can be performed at a constant temperature of 37-39°C, eliminating the need for complex equipment. The designed RPA reaction system is capable of performing reverse transcription of RNA, allowing for the detection of mRNA transcribed from the MCP gene of MRV and ISKNV in the sample. Furthermore, two probes were identified that can be observed without the need for excitation light. In conclusion, a field-suitable detection method for ISKNV and MRV has been established, providing a powerful tool for the prompt diagnosis of these aquatic pathogens and aiding in the prevention and control of ISKNV and MRV diseases.

KEYWORDS: Iridovirus, RPA, CRISPR/Cas12a, ISKNV, Ranavirus

Transcriptomic Reveal the Effect of Off Flavor Compound 2-Methylisoborneol (2-MIB) on Grass carp (*Ctenopharyngodon idella*)

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2-Methylisoborneol (2-MIB) is a common and widely distributed off flavor compound in water. However, the toxic mechanisms of 2-MIB on aquatic organisms remain largely unexplored. Here, grass carp fingerlings were exposed to different concentrations (0, 5, and 20 µg/l) of 2-MIB for 96 hours. The accumulation of 2-MIB in the dorsal muscle was measured. The histological analysis, ultrastructure observations and transcriptomic sequencing were conducted on the liver tissues. 2-MIB was found to accumulate effectively in the fish muscle, with a significant increase in accumulation as the exposure concentration increased. Histological and ultrastructure observations indicated that 2-MIB caused concentration-dependent inflammatory infiltration and mitochondrial damage in the liver. Transcriptomic analysis revealed lipid metabolism disorders induced by 2-MIB exposure in grass carp. Additionally, 5 µg/l 2-MIB affects the neurodevelopment and cardiovascular system of grass carp fingerlings through extracellular matrix (ECM)-receptor interaction and focal adhesion pathway. Furthermore, several pathways related to the digestive system were significantly enriched, implying that 2-MIB may impact pancreatic secretion function, protein digestion and absorption processes. These findings provide new references for the potential toxicological mechanism of 2-MIB on aquatic animal. In addition, the results showed that the presence of off flavor not only reduced the quality of aquatic products, but also had adverse effects on the healthy aquaculture. Therefore, it is necessary to take corresponding techniques or measures to remove off flavor in the follow-up study.

KEYWORDS: 2-Methylisoborneol, Lipid metabolism, Transcriptome, Oxidative stress, Mitochondrial damage

Development and Technology of Prawn Culture in China

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Prawns are important species in global aquaculture. Litopenaeus vannamei, Penaeus monodon, Fenneropenaeus chinensis and Marsupenaeus japonicus are cultured in China, and the total output in 2023 was 2.9 million tons. Among them, the output of L. vannamei was 2.29 million tons. This paper introduces the research progress in breeding new varieties, diseases prevention and control, and culturing modes of prawn in China. In breeding technology, the genetic information database of L. vannamei based on microsatellite markers has been established. The whole genome selection breeding technology, gene chip technology, and molecular design breeding technology of L. vannamei has been developed. So far, 24 new varieties were selected and bred, including 15 new varieties of L. vannamei, 6 new varieties of F. chinensis, 2 new varieties of P. monodon and 1 new variety of M. japonicus. In disease prevention and control, techniques were developed for detecting pathogens such as viruses, bacteria and parasites of prawn, and technologies of the production of prawn larvae free of specific pathogens (SPF) were developed. In 2023, more than 250 billion SPF prawn larvae were produced in China. Epidemiological characteristics of white spot syndrome virus (WSSV) was revealed, and effective biological control theory and technologies (WSS) were established, and polyculture technologies of prawn and fish based on the theory were developed. The microecological mechanism of prawn bacterial diseases outbreak was revealed in culture system, and high-yield culturing techniques of L. vannamei was established based on the mechanism, with the yield exceeding 75 tons per hectare. Great progress has been made in artificial feed, and the use of fish meal in feed has been reduced to less than 3%. In culturing technology, automatic feeding equipment for artificial feed was developed. A variety of culturing modes such as shrimp and fish polyculture mode, pond engineering culture mode, plastic shed farming mode, and indoor culturing mode have been established

KEYWORDS: Technology, Prawn culture, China

Vibrio parahaemolyticus Infection Mediates the Decline in the Abundance of Dominant Symbiotic Bacteria to Regulate the Diversity of Intestinal Bacterial Community in Shrimp

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The ecological mechanisms underlying dynamic changes in intestinal microbiota following bacterial infection and its interaction with host immune responses, although crucial for facilitating host defense against diseases, remain poorly understood. Here, we investigated the responses and interactions between the intestinal microbiota and host immune responses in Litopenaeus vannamei, a globally significant shrimp species in aquaculture, during Vibrio parahaemolyticus infection. Our findings revealed a substantial increase in both the richness and evenness of the intestinal community of shrimp following infection, while a noticeable shift towards a more heterogeneous community structure and an increased complexity of interspecific relationships. V. parahaemolyticus infection exerts a stronger selective pressure on the Candidatus bacilloplasma, which is the symbiotic bacterium and predominant genus in shrimp intestines. The significant increase in richness and evenness of intestinal communities, as well as the complexity of bacterial interspecific relationships following infection, may be attributed to niche vacancies resulting from a substantial decline in abundance of C. bacilloplasma. More importantly, the enhanced deterministic processes, such as host immune selection, played a more significant role in community assembly subsequent to infection, resulting in a substantial decrease in the abundance of *C. bacilloplasma* in shrimp intestines. This study advances our comprehension of the intricate relationship between intestinal microbiota and bacterial infection in shrimp, emphasizing the pivotal role of indigenous bacteria of intestinal habitat in maintaining host intestinal microbiota homeostasis.

KEYWORDS: Intestine microbiota, Shrimp, Litopenaeus vannamei, Pathogenic infection, Vibrio parahaemolyticus

Aquatic Animal Microbiome and Host Ecological Health Based on Microecological Koch's Postulates

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As the key "Blue Food" of food health security, shrimp is one of the most economically valuable species in the world and plays a key role in meeting the growing demand for high-quality protein. However, frequent occurrences of shrimp disease cause the farming industry to suffer huge economic losses annually. Increasing evidence has demonstrated that microbe-host interaction is the key issue of microecology. Moreover, the intestinal microbial community and environmental microorganisms are critical to the health status and growth of shrimp. With the multiple-omics, we are the first in the world to propose the "Microecological Koch's Postulates" and exemplify the solid evidence of the causality between intestinal microbiota dysbiosis and shrimp disease white feces syndrome (WFS), which developed from the centuries-old traditional Koch's postulates. Furthermore, the potential "intestinehepatopancreas axis" was revealed in lower invertebrate shrimp with an open circulatory system by analyzing basic characteristics of microbial composition and bile acid metabolism in shrimp intestine and hepatopancreas, with γ -diversity analysis, Source-tracker analysis, neutral model analysis and correlation network analysis. Using culture omics, genomics and microbiome to break through the culture bottleneck of uncultured microorganisms, for the first time in the world, uncultured intestinal symbiotic bacteria have been successfully isolated and cultured in arthropods and revealed their potential "double-edged sword" ecological function. Numerous studies have shown that there is a close link between the culture environment, intestinal microbiota and host health status. We systematically studied microbial community diversity in shrimp aquaculture pond ecosystems (SCPE) and enrich our understanding of the environment-intestinal microbiota-host health closely linked relationship, making it possible to be "the Central Dogma" for an anthropogenic aquaculture ecosystem. Based on microecological Koch's postulates, a healthy shrimp aquaculture ecosystem will be constructed to develop a new ecological strategy of One Health.

KEYWORDS: Shrimp microbiome, Host ecological health, Microecological Koch's Postulates, Shrimp intestine-hepatopancreas axis

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The Molecular Mechanism of Infectious Spleen and Kidney Necrosis Virus Manipulates the Hypoxia-Inducible Factor Pathway to Facilitate Virus Replication

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Infectious spleen and kidney necrosis virus (ISKNV), which belongs to the genus Megalocytivirus in the family Iridoviridae, could infect more than fifty fish species and cause huge economic losses in Asia. Our previous study found that hypoxia-induced the hypoxia-inducible factor pathway (HIF-pathway) to enhance the replication of ISKNV through promoting the expressions of viral hypoxic response genes, such as orf077r. In this study, the molecular mechanism of ISKNV manipulating the HIF-pathway to facilitate virus replication was investigated. ISKNV infection promoted the activation of the HIFpathway in vitro and in vivo. The activated HIF-pathway could promote ISKNV replication and vice versa. These observations suggested that ISKNV might actively manipulate the HIF-pathway. Co-immunoprecipitation results showed that ISKNV orf077r encoded protein VP077R interacted with the Von Hippel-Lindau (VHL) at the HIF-binding region of VHL, thereby VP077R competitively inhibiting the interaction of HIF-1α with VHL, leading to the suppression of HIF degradation and activation of HIF-pathway. Furthermore, VP077R interplayed with factor-inhibiting HIF (FIH), by which VP077R could recruit FIH and S-phase kinase-associated protein 1 (Skp1) to form an FIH-VP077R-Skp1 complex, subsequently promoting the ubiquitination-mediated FIH protein degradation and activating the HIF-pathway. These results suggested that ISKNV hijacked the HIF-pathway through VP077R, which released two "brakes" of this pathway (VHL and FIH) to facilitate virus replication. We speculated that hypoxia might initiate the "ISKNV VP077R-HIF-pathway positive feedback loop" to trigger the outbreak of ISKNV disease. This work would help to understand the interactions of environment-host-virus.

KEYWORDS: HIF-pathway, FIH, VHL, Hypoxia, Iridovirus

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Litopenaeus vannamei "Zhongxing No. 2": Innovative Molecular Breeding Practice based on IRF-SSR Markers

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Shrimp, Litopenaeus vannamei is the most widely farmed species in global aquaculture, with China being the largest producer, accounting for approximately 30% of global production. Current improvements in shrimp strains primarily rely on traditional breeding methods based on phenotypic traits, with the application of genotype-based selection in shrimp breeding being relatively limited. In our previous studies, we identified interferon regulatory factor (IRF) as a key gene involved in regulating antiviral and antibacterial traits in shrimp. The 5' untranslated region of the IRF gene contains a CT dinucleotide repeat polymorphism (Simple Sequence Repeat, SSR), with the number of CT repeats ranging from 10 to 26 among different individuals. The abundance of IRF expression directly determines the antiviral or antibacterial characteristics of the shrimp. Further research revealed that the shorter the CT repeat, the higher the expression of IRF, with higher IRF expression levels correlating with enhanced antiviral traits. Conversely, longer CT repeats result in lower IRF expression, which is associated with enhanced antibacterial traits. Based on this IRF-SSR molecular marker, we selected the IRF-(CT)25 genotype as a target. Using two genetically distant base populations as the parental stock, we conducted genotyping at this locus and selective breeding through crossbreeding. This approach resulted in the creation of a homozygous IRF-(CT)25/IRF-(CT)25 population, named "Zhongxing No. 2" of Litopenaeus vannamei. The antibacterial capability of "Zhongxing No. 2" was found to be 66.7% higher than that of unselected populations, demonstrating significant potential for widespread application and promotion.

KEYWORDS: Shrimp, Interferon Regulatory Factor, Simple Sequence Repeats, Molecular breeding

Nucleic Acid Sensing by STING Induces an IFN-like Antiviral Response in a Marine Invertebrate

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The cytosolic detection of pathogen-derived nucleic acids has evolved as an essential strategy for host innate immune defense in mammals. One crucial component in this process is the stimulator of IFN genes (STING), which acts as a vital signaling adaptor, connecting the cytosolic detection of DNA by cyclic GMP-AMP (cGAMP) synthase (cGAS) to the downstream type I IFN signaling pathway. However, this process remains elusive in invertebrates. In this study, we present evidence demonstrating that STING, an ortholog found in a marine invertebrate (shrimp) called Litopenaeus vannamei, can directly detect DNA and initiate an IFN-like antiviral response. Unlike its homologs in other eukaryotic organisms, which exclusively function as sensors for cyclic dinucleotides, shrimp STING has the ability to bind to both double-stranded DNA and cyclic dinucleotides, including 2'3'-cGAMP. In vivo, shrimp STING can directly sense DNA nucleic acids from an infected virus, accelerate IFN regulatory factor dimerization and nuclear translocation, induce the expression of an IFN functional analog protein (Vago4), and finally establish an antiviral state. Taken together, our findings unveil a novel double-stranded DNA—STING—IKKe— IRF—Vago antiviral axis in an arthropod, providing valuable insights into the functional origins of DNA-sensing pathways in evolution.

KEYWORDS: Shrimp, STING, IFN, Nucleic Acid Sensing

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Strategies for Mitigating Off-Flavors and Enhancing the Quality and Value-Addition of Pond-Cultured Fish

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As consumer demand for premium aquatic products continues to rise, the aquaculture industry faces ongoing challenges in managing off-flavors in freshwater fish, particularly in pond-cultured systems. These off-flavor compounds, notably geosmin (GSM) and 2-methylisoborneol (2-MIB), compromise the sensory quality of fish, negatively impacting marketability and leading to financial losses. This study explores both the environmental drivers of off-flavor formation in pond-cultured and strategies aimed at improving fish quality and value. We investigated the dynamic relationships between water quality parameters, algal community composition, and the accumulation of GSM and 2-MIB during the production cycle. Furthermore, post-harvest purification technologies were evaluated using a landbased temporary holding system designed to remove off-flavor compounds and enhance the sensory and textural qualities of fish fillets. Results showed that GSM levels were significantly influenced by total phosphorus (p<0.05, r = 0.72), while 2-MIB correlated positively with ammonia nitrogen, total nitrogen, and total phosphorus (p<0.05). The land-based purification system, using varied flow rates, effectively reduced 2-MIB concentrations (p<0.05), without significant differences across flow rate treatments. However, higher flow rates helped retain key sensory attributes of the fish, such as umami flavor and favorable textural characteristics like hardness and elasticity (p<0.05). This study underscores the importance of environmental management in preventing off-flavor formation and demonstrates the effectiveness of postharvest purification systems in enhancing the quality and market value of pond-cultured fish. These findings offer practical insights for optimizing post-harvest processing techniques to meet consumer expectations for high-quality, safe, and flavorful fish products.

KEYWORDS: Off-flavors, Value-addition, Pond-cultured fish

Transcriptomic Analysis Reveals the Role of Glycolysis Pathway in *Litopenaeus vannamei* during DIV1 Infection

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In recent years, shrimp farming has experienced significant losses due to the emergence of DIV1 (Decapod iridescent virus 1), an infectious virus with a high fatality rate among shrimp. In this study, we conducted transcriptomic analyses on shrimp *Litopenaeus vannamei* hemocytes following DIV1 infection and focused on the function of genes in the Glycolysis pathway during DIV1 infection. A total of 2197 differentially expressed genes (DEGs) were identified, comprising 1506 up-regulated genes and 691 down-regulated genes. These genes were primarily associated with Phagosome, ECM-Receptor Interaction, Drug Metabolism-Other Enzymes, and the AGE-RAGE signaling pathway in diabetic complications. KEGG pathway enrichment analysis of the DEGs revealed a noteworthy correlation with metabolic pathways, with a specific focus on glucose metabolism. Specifically, the Glycolysis/ Gluconeogenesis pathway exhibited significant upregulation following DIV1 infection. In line with this, we observed an augmented accumulation of glycolytic-related metabolites in the hemolymph following DIV1 challenge along with upregulation of the relative mRNA expression of several glycolytic-related genes. Moreover, we found that the inhibition of lactate dehydrogenase (LDH) activity through RNAi or the use of an inhibitor resulted in reduced lactate production, effectively safeguarding shrimp from DIV1 infection. These findings not only provide a comprehensive dataset for further investigation into DIV1 pathogenesis but also offer valuable insights into the immunometabolism mechanisms that govern shrimp responses to DIV1 infection.

KEYWORDS: Decapod iridescent virus 1, *Litopenaeus vannamei*, Transcriptomic analysis, Glycolysis

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Multi-omics Insights into Lipid and Fatty Acid Profiles in *Chlorella* pyrenoidosa Under Antibiotic (Streptomycin Sulfate) Stress

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Chlorella pyrenoidosa, valued in food industries for its rapid growth and nutrient richness, often requires antibiotics like Streptomycin Sulfate (STRS) in non-sterile large-scale production, impacting its productivity. This study explored STRS's effects on C. pyrenoidosa's growth and metabolism using a multi-omics approach. Results indicated that STRS inhibited growth but did not adversely affect carbohydrate, protein, or total lipid levels. Significantly, STRS enhanced the accumulation of α -linolenic acid (ALA), an essential n-3 polyunsaturated fatty acid for human and freshwater fish. Metabolomic, transcriptomic, and proteomic analyses showed an up-regulation in amino acid and lipid metabolism, particularly enhancing ALA synthesis by down-regulating of β -oxidation pathway. This study underscores the impact of STRS on C. pyrenoidosa's nutrient profile and its adaptive mechanisms to antibiotic stress. Future research should focus on reducing antibiotic resistance and refining cultivation techniques to enhance the sustainable production of valuable microalgal metabolites.

Keywords: Chlorella pyrenoidosa, Antibiotic stress, Lipid metabolism, α-Linolenic acid, Multiomics analysis

Characterizing Growth-Retarded Japanese Eels (*Anguilla japonica*): Insights into Metabolic and Appetite Regulation

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During field surveys and culture procedures, large growth disparities in Anguilla japonica have been observed. However, the potential causes are unknown. This study explored differences in digestive ability, metabolic levels, and transcriptomic profiles of appetite-related genes between growth-retarded eel (GRE) and normal-growing eel (NGE) under the same rearing conditions. The results showed that growth hormone (gh) mRNA expression in GRE was considerably lower than in NGE. The levels of total protein, total cholesterol, triglyceride, and alkaline phosphatase in GRE were significantly lower than in NGE. Conversely, levels of glucose, alanine aminotransferase, and aspartate transaminase were higher in GRE. The activities of glucose-related enzymes including hexokinase, pyruvate kinase, phosphoenolpyruvate carboxykinase and glucose-6-phosphatase were significantly lower in GRE. Additionally, or exigenic genes (npy and ghrelin) were dramatically downregulated, whereas anorexigenic genes (crh and pvv) were significantly up-regulated in GRE. These findings suggested that variances in growth hormone, metabolic activities, and appetite level could be associated with the different growth rates of A. japonica. The present research not only revealed the characteristics of the growth, metabolism, and appetite of GRE but also offered new perspectives into the substantial growth discrepancies in A. japonica, providing novel ideas for enhancing fish growth.

KEYWORDS: Japanese eel, Growth differences, Size uniformity, Appetite-related genes, Metabolism

ROS and Ca²⁺ Signaling Involved in Important Lipid Changes of *Chlorella pyrenoidosa* under Nitrogen Stress Conditions

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The changed mechanisms of lipid parameters (especially lipid classes and unsaturation of fatty acids) in microalgae are not completely well known under nitrogen stress. Therefore, *Chlorella pyrenoidosa* was exposed to 0, 0.5, 1 and 1.5 g/l NaNO₃ for 4 days. Then, the physiological and biochemical changes were measured. It was shown that the total lipid contents, neutral lipid ratios as well as their related genes (accDand DGAT) increased obviously while the polar lipid ratios, degrees of unsaturation as well as their related genes (PGP and desC) decreased significantly in nitrogen stress groups. The obvious correlations supported that gene expressions should be the necessary pathways to regulate the lipid changes in *C. pyrenoidosa* under nitrogen stress. The changes in ROS and Ca²⁺ signaling as well as their significant correlations with corresponding genes and lipid parameters were analyzed. The results suggested that ROS and Ca²⁺ may regulate these gene expressions and lipid changes in *C. pyrenoidosa* under nitrogen stress conditions. This was verified by the subordinate tests with a ROS inhibitor and calcium reagents. It also uncovered the clues of mutual interference between ROS and Ca²⁺ signaling. To summarize, this study revealed the signaling pathways of important lipid changes in microalgae under N stress.

KEYWORDS: Calcium ion, Lipid biosynthesis, Microalgae, Reactive oxygen species

Selective Breeding of Growth and Stress Resistance Traits for Turbot (Scophthalmus maximus)

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Turbot Scophthalmus maximus is an important commercial fish species in China. It is a type of cold-water fish with strict requirements for environmental temperature. The unsuitable high temperatures result in stress response against fish and cause low disease resistance, growth rate and reproductive activity. In order to expand the breeding range of turbot in China, it is necessary to extend the breeding period in Fujian in the south of China and achieve energy-saving and environmentally friendly farming in northern factories of China. Thus, the genetic improvement of turbot upper thermal tolerance is necessary to sustain the further development of the industry. We constructed a genetic linkage map of turbot using simple sequence repeats (SSRs) and single nucleotide polymorphism (SNP) markers. A total of 190 SSR and 8,123 SNP were assigned to 22 linkage groups (LGs) of a consensus map, which spanned 3,648,29 cM of the turbot genome, with an average interval of 0.44 cM. QTL mapping and validation analysis identified thirteen QLTs that are major effect QTLs, of these, 206 linked SNP loci, and two linked SSR loci were considered to have significant QTL effects. Association analysis for UTTs with 129 QTL markers was performed for different families, and results showed that eight SNP loci were significantly correlated with UTT, in which, markers could be helpful in selecting thermal tolerant breeds of turbot. For high temperature tolerance traits, considering that the survival rate of stress resistance indicators cannot evaluate individuals, we have established a stress resistance breeding method of "families selected using breeding value + individuals selected using molecular marker selection". Using this method, a new high-temperature tolerant variety of turbot named "Duobao 2" was developed. Compared with the general population, the weight of "Duobao No.2" increased by an average of 30.63% and the survival rate increased by an average of 26.70% during the high-temperature breeding period. The upper limit of high-temperature growth has been increased by 2 degrees, expanding the culture range and culture period in the south of China and achieving energy-saving and environmentally friendly factory farming in the north of China.

Keywords: Turbot, Scophthalmus maximus, Growth traits, Stress resistance traits, Selective breeding



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The Research of Nicotinamide and B-Arbutin on Reducing Melanin Content in the Skin of Leopard Coral Grouper (*Plectropomus leopardus*)

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Body color is an important economic characteristic of leopard coral grouper (*Plectropomus leopardus*). In this study, we tried to make the red colour more visible on the skin by reducing the melanin level, and aimed to investigate the possible mechanism of nicotinamide and β-arbutin on reducing melanin content in the skin of *P. leopardus*. 0.5% nicotinamide or 0.5% β-arbutin was added to the basal feed formulation to feed *P. leopardus* for 60 days. After nicotinamide or β-arbutin added feeding, the time for *P. leopardus* to maintain uniform body color was significantly longer. The melanin content in the skin of P. leopardus was significantly reduced, and the number of melanin particles was reduced. In the skin, the enzyme activities of superoxide dismutase (SOD) and catalase (CAT) decreased, and the content of malondialdehyde (MDA) increased. The mRNA expression of TYR, Sox10 and Mitf related to melanin synthesis and proliferation and differentiation decreased. The apoptosis-related gene Bax was upregulated, the Bcl-2 gene was down-regulated, and Bax/ Bcl-2 >1. The content of tyrosinase decreased and the content of melanin metabolizing enzyme increased, and the effect of nicotinamide was more obvious than that of β-arbutin. In summary, nicotinamide or β-arbutin added feeding increased the oxidative stress and the apoptosis level of the skin, increased the metabolism of melanin, decreased the synthesis and differentiation of melanin, thus reduced the content of melanin and the number of melanin particles in the skin. This study provided a new basis for the body color regulation of cultured P. leopardus.

KEYWORDS: Plectropomus leopardus, Nicotinamide, β-arbutin, Body colour, Melanin

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LRP6 Regulates Growth in *Litopenaeus vannamei* via the Wnt/β-Catenin Signaling Pathway

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Low-Density Lipoprotein Receptor-Related Protein 6 (LRP6) is a crucial co-receptor in the canonical Wnt/β-catenin signaling pathway, playing a fundamental role in various developmental processes, including cell growth, development, proliferation, and apoptosis. In this study, we characterized a homolog of LRP6 in *Litopenaeus vannamei*, named LvLRP6, and investigated its role in shrimp growth. Multiple sequence alignment and phylogenetic analysis indicated that LvLRP6 belongs to the invertebrate LRP6 family and shares conserved phosphorylation sites with LRP6 in other species. L. vannamei growth was considerably inhibited by dsRNA-mediated LvLRP6 knockdown, as shown by decreased weight gains in comparison to control groups. LvLRP6 functions as a positive regulator of the Wnt/βcatenin signaling pathway, enhancing the expression of key components such as LvGSK3, Lvβ-catenin, and LvTcf. Simultaneously, it represses the induction of LvMSTN (Myostatin), a negative regulator of muscle-related genes, while elevating the expression of Myosin, thereby promoting muscle growth and development. Subsequent research revealed that the promoter of LvMSTN contains TCF binding motifs. Overexpression of LvLRP6 or LvTcf reduced the promoter activity of LvMSTN, as shown by dual-luciferase reporter experiments. Additionally, LvTcf stimulates the expression of LvLRP6 and a number of Wnt ligands, which increases the activation of the Wnt/β-catenin pathway and strengthens the growth loop. Understanding the functional role of LvLRP6 in shrimp growth can provide valuable insights for genetic improvement and enhanced productivity in shrimp aquaculture.

KEYWORDS: Shrimp, LRP6, Wnt/β-Catenin, Growth, Tcf

The Significance of Research on Carotenoid Nutritional Requirements for Crustacean Aquaculture

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Carotenoids play a significant role in the nutrition and physiological of crustaceans. Crustaceans cannot synthesize carotenoids de novo but can metabolize and converse external carotenoids to meet the specific physiological and ecological adaptation needs during different stages. To date, research on the carotenoids nutritional requirements of crustaceans has primarily focused on the impact of adding different carotenoids to their diets on parameters such as growth performance, coloration regulation, antioxidant capacity, immune function, and stress resistance. However, there is still limited understanding of the metabolic pathways and regulatory mechanisms of carotenoids within crustaceans. This necessitates further research to uncover these aspects. Building on the comprehensive analysis and summarization of studies regarding the composition and distribution of carotenoids within crustaceans, the types and sources of external carotenoids, the effective utilization of external carotenoids by crustaceans, and the nutritional requirements of crustaceans for external carotenoids, this article proposes a deeper exploration of the metabolic pathways of carotenoids within crustaceans. It suggests identifying the key enzyme genes involved in carotenoid metabolism and elucidating their biological functions. This approach aims to advance our understanding of the metabolism and regulation of carotenoids, which are essential conditional nutrients for crustaceans, and provide a scientific basis for the efficient utilization of external carotenoids in crustacean aquaculture.

KEYWORDS: Carotenoids, Crustaceans, Nutritional requirement, Metabolic mechanism

Genotype by Temperature Interaction for Plasma Physiological Indexes in Turbot (*Scophthalmus maximus*) under Acute Heat Stress—Exploring a Method for Screening Physiological Biomarkers of Non-Toxic Stress in Aquatic Environments

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This study presents a method for exploring the genetic mechanism underlying the plasma physiological indexes under heat stress in aquatic environments and screening for reliable stress biomarkers based on split-split-plot analysis (SSP), additive main effects and multiplicative interaction (AMMI) analysis and genotype main effects and genotype × environment interaction (GGE) biplot analysis. The methodology developed was illustrated by applying it to a specific turbot heat stress case study. Five plasma physiological indexes (epinephrine, cortisol, alkaline phosphatase, superoxide dismutase and blood glucose levels) were measured in turbot (Scophthalmus maximus) under acute heat stress at four temperatures (18, 21, 24 and 27°C) for various exposure times (3, 6, 9, 12, 24, 48 and 72 hours). The SSP analysis showed that exposure time and temperature × gene interactions had significant (p<0.01) effects on the activity/content of turbot plasma physiological indexes. The AMMI analysis showed: (1) that at each exposure time, the genotype effect > the genotype × temperature interaction > the temperature effect; (2) that during whole experiment, the change trend of the contribution of the genotype × temperature interactions was similar to that of the temperature effect, and the changing trends of the contributions of the genotype × temperature interaction and the genotype effect were clearly completely reversed; and (3) that the 3–24 h period was the key period for the changes in the physiological indexes due to acute heat stress. The GGE biplot analysis showed that blood glucose and cortisol levels were reliable biomarkers and could be used as early warning markers for numerical simulations of physiological behavior.

KEYWORDS: Genotype, Temperature, Temperature × genotype interactions, Plasma physiological parameters, Aquatic environments, *Scophthalmus maximus*

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Nervous Necrosis Virus Capsid Protein Dynamically Modulate the Fish cGAS-Mediated IFN Signal Pathway to Facilitate Viral Evasion

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Nervous necrosis virus (NNV), an aquatic RNA virus belonging to Betanodavirus, infects a variety of marine and freshwater fishes, leading to massive mortality of cultured larvae and juveniles and substantial economic losses. The enzyme cyclic guanosine monophosphateadenosine monophosphate synthase (cGAS) is widely recognized as a central component in the innate immune response to cytosolic DNA derived from different pathogens. However, little is known about the response of cGAS to aquatic RNA viruses. This study found that Epinephelus coioides cGAS (EccGAS) overexpression inhibited NNV replication, whereas EccGAS silencing promoted NNV replication. The anti-NNV activity of EccGAS was involved in interferon (IFN) signaling activation including tumor necrosis factor receptor-associated factor family member-associated NF-kappa-B activator-binding kinase 1 (TBK1) phosphorylation, interferon regulatory factor 3 (IRF3) nuclear translocation, and the subsequent induction of IFNc and ISGs. Interestingly, NNV employed its capsid protein (CP) or Protein A (ProA) to negatively or positively modulate EccGAS-mediated IFN signaling by simultaneously targeting EccGAS. CP interacted with EccGAS via the arm-P, S-P, and SD structural domains and promoted its polyubiquitination with K48 and K63 linkages in an EcUBE3C (the ubiquitin ligase)-dependent manner, ultimately leading to EccGAS degradation. Conversely, ProA bound to EccGAS and inhibited its ubiquitination and degradation. In regulating EccGAS protein content, CP's inhibitory action was more pronounced than ProA's protective effect, allowing successful NNV replication. These novel findings suggest that NNV CP and ProA dynamically modulate the EccGAS-mediated IFN signaling pathway to facilitate the immune escape of NNV. Our findings shed light on a novel mechanism of virus-host interaction and provide a theoretical basis for the prevention and control of NNV

KEYWORDS: Nervous necrosis virus, cGAS, CP, ProA, UBE3C, Innate immune response

Effects of Temperature and Salinity on the Growth, Reproduction and Carotenoid Accumulation in *Artemia sinica* and Transcriptome Analysis

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Brine shrimp (Artemia), rich in carotenoids, are widely used in intensive aquaculture to supplement nutrients and enhance the coloration of farmed organisms. This study investigates the growth, reproduction, and carotenoid accumulation in Artemia sinica under varying salinity and temperature conditions. The results showed that temperature and salinity displayed significant interactions with survival, body length, and carotenoid accumulation in the body. The optimal survival and growth conditions of A. sinica (Bohai Sea Gulf) were a temperature range of 25–30°C and a salinity range of 30–50‰. High temperatures accelerated growth and sexual maturity at the expense of survival rates, while temperatures below 20°C prevented ovigerous development. Extreme salinity levels negatively affected survival and growth, though high salinity promoted sexual maturity. Carotenoids in A. sinica mainly accumulate as echinenone and canthaxanthin forms. Carotenoid accumulation decreased with increased temperature and salinity, and the temperature effect decreased with rising salinity. A. sinica cultivated at a salinity of 10% and a temperature of 25°C exhibits the highest carotenoid content. Transcriptomic analysis revealed that high temperatures primarily affected genes related to stress response and metabolism, while high-salinity regulated genes associated with ion balance and signaling pathways. These findings provide a theoretical basis for enhancing Artemia sinica aquaculture and optimizing cultivation conditions, offering novel insights into nutritional and environmental impacts on brine shrimp biology.

KEYWORDS: Artemia, Larval culture, Nauplius, Bio-capsule of carotenoids, Canthaxanthin, Echinenone

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Warming-Driven Migration of Enterotypes Mediates Host Health and Disease Status in Ectotherm *Litopenaeus vannamei*

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Global warming has threatened the all-rounded hierarchical biosphere by reconstructing eco-structure and bringing biodiversity variations. Pacific white shrimp, a successful model of worldwide utilizing marine ectothermic resources, is facing huge losses due to multiple diseases relevant to intestinal microbiota (IM) dysbiosis during temperature fluctuation. However, how warming mediates shrimp health remains poorly understood. Herein, a global shrimp IM catalogue was conducted via 1,369 shrimp IM data from nine countries, including 918 samples from previously published data and 451 generated in the study. Shrimp IMs were stratified into three enterotypes with distinctive compositions and functions, dominated by Vibrio, Shewanella and Candidatus Bacilloplasma, which showed an obvious distribution bias between enterotypes and diseases. The ratio of Vibrio and Candidatus Bacilloplasma was a crucial indicator for shrimp health. Moreover, temperature was the most driving factor for microbial composition, which potentially led to the migration of enterotypes, and high probability of white feces syndrome and low risk of hepatopancreas necrosis syndrome. Collectively, the warming-driven enterotypes mediated shrimp health, which exemplified the causal relationship between temperature rising and ectothermic animals' health. These findings enlarged the cognition of shrimp health culture management from a microecological perspective and alerted the inevitable challenge of global warming to ectothermic animals.

KEYWORDS: Migration, Disease, Ectotherm, Litopenaeus vannamei

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Identification of the Leptocephalus Larvae in the Western Central Pacific Ocean and Their Intestinal Microbiome Structure Analysis

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The present study employed DNA barcoding and 16S rDNA high-throughput sequencing techniques to identify the species and analyze the intestinal microbiota of leptocephalus larvae captured during the scientific expeditions conducted by the Songhang Research Vessel in the Western Central Pacific Ocean. The results indicated that among the 16 leptocephalus larvae captured, 14 were identified to species level, including species such as *Ariosoma majus* and *Thalassenchelys coheni*. Analysis of the intestinal microbiota structure revealed that the predominant microbial phyla in these larvae were Proteobacteria, Bacteroidetes, and Firmicutes. Notably, variations in the intestinal microbiota structure were observed among different species and capture locations. Furthermore, functional predictions of the intestinal microbiota suggested that microbial communities involved in amino acid transport and metabolism were most abundant, indicating a high demand for protein in leptocephalus larvae. This study provides valuable initial insights into the diverse composition of the intestinal microbiota in Pacific leptocephali, offering a reference for understanding their feeding habits and for research on starter feed for artificially breeding eels.

KEYWORDS: Leptocephalus larvae, Intestinal microbiota, High-throughput sequencing, Western-Central Pacific Ocean

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Comprehensive mRNA and microRNA Analysis Revealed the Effect and Response Strategy of Freshwater Fish, Grass Carp (*Ctenopharyngodon idella*) Under Geosmin Exposure

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Geosmin is an environmental pollutant that causes off-flavor in water and aquatic products. The high occurrence of geosmin contamination in aquatic systems and aquaculture raises public awareness, however, few studies have investigated the response pathways of geosmin stress on freshwater fish. In this research, grass carp were exposed to 50µg/l geosmin for 96 h, liver tissue was sequenced and validated using real-time qPCR. In total, 528 up-regulated genes and 488 down-regulated genes were observed, includes cytochrome P450 and uridine diphosphate (UDP)-glucuronosyltransferase related genes. KEGG analysis showed that chemical carcinogenesis-DNA adducts, metabolism of xenobiotics by cytochrome P450, and drug metabolism-cytochrome P450 pathway were enriched. Common genes from the target genes of microRNAs and differential expression genes are enriched in the metabolism of xenobiotics cytochrome P450 pathway. Two miRNAs (dre-miR-146a and miR-212-3p) down regulated their target genes (LOC127510138 and adh5, respectively) which are enriched cytochrome P450-related pathways. The results present that geosmin is genotoxic to grass carp and indicate that the cytochrome P450 system and UDP-glucuronosyltransferase play essential roles in biotransformation of geosmin. MicroRNAs regulate the biotransformation of geosmin by targeting specific genes, which contributes to the development of strategies to manage its negative impacts in both natural and artificial environments.

KEYWORDS: Geosmin, Transcriptomic, MicroRNA sequencing, Cytochrome P450, UDP-glucuronosyltransferase

Aquatic Food Supply and Consumption in China

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China's aquatic product production and consumption have experienced rapid growth over the past few decades. However, a substantial data discrepancy exists between supply and consumption data. By combining official statistical data with a national consumer survey, we close this data discrepancy and explore China's aquatic food supply, consumption patterns, and potential future scenarios. The research reveals that China's aquatic product edible yield ratio stands at a mere 61.1%, the lowest globally, attributed to the diversification of production and rise of aquaculture, especially low-edible-yielding molluscs. Notably, outof-home consumption accounts for one-third of total aquatic product consumption. While Chinese consumers show an increasing preference for aquatic products, consumption remains below recommended levels and is unevenly distributed due to demographic and geographical factors. Coastal regions, urban areas, and high-income groups tend to consume and spend more on these products. At global level, we found a negative correlation between a country's economic level and per capita supply with the edible yield ratio of aquatic products. In light of these findings, the research underscores the importance of developing policies to ensure effective aquatic product supply, promote efficient recycling of inedible parts, and guarantee equitable access to nutritious aquatic products for all Chinese citizens, regardless of their socioeconomic status or geographical location.

KEYWORDS: Food security, Aquaculture, Food away from home, Dietary changes, Consumer behavior



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Biofloc Technology Enhances Growth Performance, Antioxidative Activity and Intestinal Health of Immature Metamorphic Froglet (Hoplobatrachus rugulosus)

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Traditional tadpole farming methods, such as continuous flow systems, significantly contribute to environmental pollution by discharging nutrient-rich effluents that exacerbate water contamination. Biofloc technology (BFT) represents an eco-friendly aquaculture approach that enhances water quality management and nutrient recycling through microbial aggregates. The study aims to assess the potential of BFT on the growth performance, antioxidant defenses, intestinal morphology, and gut microbiota of Hoplobatrachus rugulosus tadpoles' culture during metamorphosis. The results indicate that the biofloc group achieved significantly higher cumulative metamorphic rates, body weight, and body length compared to the control group (p< 0.05). Enhanced antioxidant enzyme activities, including superoxide dismutase (SOD) and catalase (CAT), were observed in the biofloc group, accompanied by reduced malondialdehyde (MDA) levels (p< 0.05). Furthermore, improved intestinal villus structure, increased lipase and protease activities, and decreased amylase activity suggested enhanced nutrient absorption. Microbiota analysis revealed a significant enrichment of Proteobacteria and genera such as Citrobacter and Klebsiella in the biofloc group (p<0.05). Functional predictions further indicated increased thyroid hormone synthesis pathways, correlating with improved cumulative metamorphic rates. In conclusion, these findings highlight the potential of BFT to improve growth performance and physiological adaptations in amphibian aquaculture, providing a sustainable and innovative strategy for rearing tadpoles.

KEYWORDS: Biofloc technology, Hoplobatrachus rugulosus, Digestive enzyme, Intestinal microbiota, Antioxidant enzyme

OGDA 2.0: A Comprehensive Organelle Genome Database for Algae

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Algae are recognized as crucial biological resources, renowned for their extensive biodiversity and pivotal photosynthetic carbon sequestration capabilities, alongside their utilization as raw materials in food and medicine. Organelle is valuable for understanding the organism evolution, in terms of endosymbiotic events. But there is still a lack of databases on the understanding of algal genomes. Algal Organelle Genome Database is an updated resource focused on the algal organelle genomes, which comprises 973 mitochondrial genomes from 750 species in 10 phyla, and 1321 chloroplast genomes from 920 species in 11 phyla. OGDA 2.0 supports both basic and advanced queries at various classification levels, and also integrates a range of applications of structural variations, collinearity, and phylogeny. More functions have been added in to OGDA 2.0 since the release of OGDA 1.0, including the identification of missing and additional genes in the genome assemblies, primer design for algal genes, tRNA trefoil structure and protein tertiary structure analysis, and optimization of website interface. At present, OGDA 2.0 significantly expanded the gene pools, adding up to 118 mitochondrial genomes and 266 chloroplast genomes. This user-friendly platform underscores its value as a robust resource for algae research, facilitating seamless online analysis of algal organelle genomics.

KEYWORDS: Algae, Organelle genome data, Gene Function

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The Function and Application of Interferons in Controlling Viral Diseases in Aquaculture

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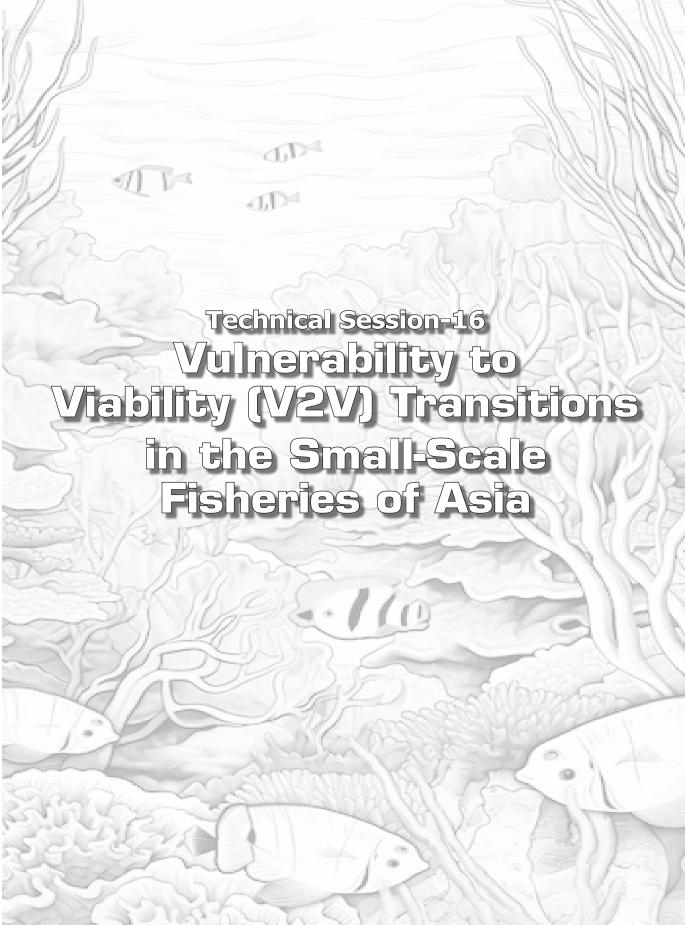
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Outbreaks of viral diseases cause significant economic losses to aquaculture industry. Understanding the antiviral responses of fish is vital to the development of effective measures for diseases control. Interferons are key cytokines that are produced during viral infection and play central roles in coordinating host antiviral responses. Based on their functions, receptors and signaling pathways: interferons are classified into 4 types. Type I, III and IV interferons activate antiviral effector genes, conferring resistance of host cells to viruses, while type II interferon mainly exerts regulatory functions in innate and adaptive immunity. Teleost fish possess type I, II and IV interferons, but lack type III. Although fish interferons possess limited sequence homology with their mammalian counterparts, they are structurally and functionally conserved. Fish type I and IV interferons display typical 6 alpha helical topology which is stabilized by 1-3 pairs of disulphide bonds, and interact with distinct receptor complexes to elicit cellular responses. They activate JAK/STAT signaling pathways, leading to the expression of antiviral genes and enhancement of resistance to viral infections. In the last few years, significant progress has been made in understanding the functions of interferons in fish and the signaling pathways they elicit. This talk will overview recent advance in interferon research and the applications as immune modulators in controlling viral diseases in farmed fish

KEYWORDS: Interferon, Viral disease, Farmed fish

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Vulnerability to Viability (V2V) Transitions in the Small-Scale Fisheries of Asia

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Small-scale fisheries are often characterized as vulnerable, and their viability is a key issue in fisheries governance. Vulnerability and viability are hard to define and these concepts have almost always been treated exclusively. Recent work emphasises that the inherent linkages between vulnerability and viability have largely remained unexamined. This session uses Vulnerability To Viability (V2V) Transitions as a novel approach to highlight their interconnected nature and the potential for vulnerable small-scale fisheries to transition towards viability. Our emphasis is on a three-dimensional view of V2V transitions that includes key measures such as changes in material, subjective and relational wellbeing, differential access to capitals (e.g., natural, financial, social) and shifts in resilience (e.g., adaptive and transformative capacity).

In this session, researchers from the V2V Global Partnership in the Asian region will present papers focusing on various dimensions of the Vulnerability to Viability (V2V) Transitions within the context of small-scale fisheries. These contributions will highlight that the V2V transition process needs to be understood not just in an economic sense but requires the inclusion of social, political, and ecological aspects of small-scale fisheries. As such, V2V transitions are multidimensional, complex, highly dynamic, and relative, the study of which needs to be inter- and transdisciplinary. An introductory paper will be presented by the session organisers. The session will emphasise that while small-scale fisheries will continue to remain vulnerable to multiple challenges (e.g., climate change), building on their existing strengths may be an effective strategy to increase viability. Further conceptual and methodological development of the V2V transitions approach is essential in this regard.

KEYWORDS: Vulnerability, Viability, Small-scale fisheries

Reimagining "Value" as Social-ecological Wellbeing in Dried Fish Value Chain

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The production and trade of dried fish are important sources of livelihood and employment for poor people engaged in the dried fish value chain. More importantly, half of them are women. Dried fish makes a significant contribution to the food and nutrition security of the poor because it is high in calcium and other vital micronutrients. Despite its importance, work on the dried fish value chain (DFVC) continues to focus on financial value creation and linear interactions among market actors that impede the recognition of human rights, justice, food security, and power across the entire value chain. Such a neoclassical perspective on DFVC tends to undermine the complex human-nature interactions that are contingent upon specific histories, people, places, and practices. Poor fishers and dried fish processors placed at the extractive end of the value chain hold low power in the market and remain vulnerable to changing social-ecological system dynamics. The paper through a mixed methods research framework, provides an empirical outlook of the dried fish value chain in relation to SES attributes in the context of the eastern Indian coast of the Bay of Bengal, including Odisha and West Bengal. The paper discusses value under the broader premise that it appreciates the diverse ways people derive value from the dried fish system. The analysis of value uses a hybrid framework of "social-ecological wellbeing" that takes into consideration both the theoretical understanding of social wellbeing and the social-ecological systems.

KEYWORDS: Dried fish, Social-ecological system, Social-ecological wellbeing, Value chain

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Justice and Equity for Small-scale Fisheries in the Post-Governance Transformation in Transboundary Sundarbans

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The development of the fisheries sector and the changes in governance over the years have squeezed out small-scale fisheries in the race for economic growth, resulting in unfair and unjust small-scale fisheries social-ecological systems. Although the majority of people rely on small-scale fisheries for their income, food and nutritional security, employment, and livelihoods, governments are more likely to favour industrial fisheries because of their costefficient production and high revenue. Drawing from the Interactive Governance theory (Kooiman et al., 2005), this study assesses outcomes, challenges, and opportunities for smallscale fisheries driven by the Transboundary Sundarbans (between Bangladesh and India) mangrove forest governance changes. The study involves case studies on both the Bangladesh and Indian sides of the Sundarbans. Historically, under hierarchical governance, small-scale fisheries in the Sundarbans have been marginalized, underrepresented, and undervalued. The current and ongoing governance actions (e.g., declaring protected areas and fencing the forest) further intensify the inequity and injustice for small-scale fisheries. The study also finds, to some extent, that the governance system has transformed from hierarchy to co-governance, allowing relevant stakeholders' (e.g., small-scale fishers) participation in the decision-making process. For instance, the government officially recognized and formed a co-management structure to increase participation in the Bangladesh Sundarbans. However, these initiatives require more effort and attention from the relevant stakeholders to increase their efficiency, functioning, and mechanisms. The study seeks the government's attention to the normative aspects of small-scale fishers, such as customs, taboos, mores, etc., in making just and viable communities.

KEYWORDS: Justice, Equity, Governance, Small-scale fisheries, Vulnerability to viability

Strengthening Social-Ecological Resilience in Chilika Lagoon: From Vulnerability to Viability in Small-Scale Fisheries

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Chilika Lagoon, Asia's largest brackish water ecosystem, presents a unique context for understanding the complex linkages between blue carbon ecosystems (BCEs), water quality, and small-scale fisheries (SSFs). However, these ecosystems face significant threats from anthropogenic pressures like overfishing, pollution, and unsustainable land use, which not only degrade ecological health but also adversely affect the livelihoods of local communities engaged in SSFs. The study explores the interdependencies between the ecological integrity of Chilika Lagoon and the social well-being of SSF communities whose livelihoods are intimately connected to the health of these ecosystems. By focusing on enhancing socialecological resilience, the research aims to provide actionable insights for conservation and sustainable management strategies, effectively guiding transitions from vulnerability to viability (V2V). The V2V framework emphasizes strengthening the capacity of vulnerable communities to adapt and thrive amidst environmental and socioeconomic changes. Utilizing qualitative research methods; including in-depth interviews with fishermen, community leaders, and policymakers, participant observation, and thematic analysis; the study offers a comprehensive examination of the resilience of Chilika's ecosystems and the SSF communities they support. This qualitative approach facilitated an in-depth understanding of local perspectives, traditional knowledge systems, and adaptive practices that are often overlooked in quantitative assessments. The results highlighted three critical dimensions that shape resilience in this context: community engagement, adaptive governance, and the ecological interconnections within the lagoon. Community engagement emerged as a cornerstone for fostering resilience, as the active participation of local stakeholders in decisionmaking processes leads to more effective and sustainable management outcomes. Adaptive governance refers to a flexible, learning-based approach to managing natural resources, which is essential in addressing uncertainties posed by climate change and other environmental pressures. The ecological interconnections within the lagoon, including the health of BCEs and water quality, are fundamental to maintaining the productivity and sustainability of SSF. By uncovering transformative pathways that strengthen both the ecological integrity of the lagoon and the viability of SSF communities, the research aligns with broader global efforts to foster sustainable fisheries and enhance social-ecological resilience.

KEYWORDS: Community engagement, Adaptive governance, Water quality, Ecological health, Biodiversity, Sustainable fisheries



Determining Adaptive Co-Management Applicability Within Small-Scale Fisheries in Indonesia: Transitioning Fisheries from Vulnerability to Viability

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Fisheries within Asia have complex human interactions affecting the environment, while also having diverse environmental interactions affecting humans. The management of capture fisheries is vital to ensure the sustainability of these complex social-ecological systems. Indonesia is an archipelagic country that is heavily reliant on small-scale fisheries for the production of fish for economic and livelihood prosperity. This study aims to determine the level of adaptive co-management indicators present within two marine fishing communities in Indonesia, determining if adaptive co-management could be successfully implemented within these communities, transitioning the livelihoods of fisherfolk from vulnerable to viable. This research study contributes to the sustainability literature on small-scale fisheries within Asia. The research design of this study is an explanatory mixed methods approach, employing surveys, followed by semi-structured interviews, coupled with firsthand observations and illustrations. Small-scale fishers were surveyed testing the adaptive comanagement indicators prevalent within their community. Critical leaders, government actors, and academic institutions were interviewed following surveys with fishers. The results of this research study indicate that adaptive co-management indicators are prevalent within fishing communities in Indonesia, suggesting that adaptive co-management could be successfully implemented. Additionally, results indicate that adaptive co-management is a viable management strategy to govern the complexity of interactions occurring within complex social-ecological systems, such as fisheries. Furthermore, results highlight the lack of institutional support and capital within Indonesian fishing communities, marking these areas as critical for future development.

KEYWORDS: Social-ecological system, Small-scale fisher, Adaptive management, Sustainability, Co-management

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Recognition Survey for Carbon Footprint Emission Estimation to Support Sustainable Aquaculture Tourism: A Case Study on Karimunjawa Island, Central Java, Indonesia

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This study aims to conduct a recognition survey of carbon footprint (CO₂) locations on tourism activities and calculate the estimated carbon footprint (CO₂) emissions generated from tourism activities (accommodation, transportation, and recreation) on Karimunjawa Island, Jepara Regency, Central Java. This study took place on Karimunjawa Island because these islands are known for their unique and beautiful island topography and a dominant residential area in the coastal or seaside area with a wealth of marine tourism that is attractive to foreign and national tourists. The research method applied in this study is a mixed method, which uses a recognition survey, in-depth interviews with stakeholder analysis as a qualitative approach, and the calculation of carbon emission estimates from tourism activities that have an impact on the coastal tourism environment as a quantitative approach. Tourism activities that are used as a reference for calculating carbon emission estimates are based on accommodation, transportation and recreational tourism. The results of the recognition survey study indicate that several points on Karimunjawa Island have high carbon emissions resulting in externalities that tend to be negative. In the recognition survey, information on potential locations with carbon footprints can be obtained, followed by carbon emission results and externalities for the environment affected by carbon emissions from coastal tourism activities.

KEYWORDS: Aquaculture, Carbon Footprint, Karimunjawa, Recognition Survey, Tourism

Strengthening Marine and Coastal Tenure: A Pathway for Integration of Rights, Governance and Responsibility for Coastal Communities

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Marine tenure systems, which govern rights and responsibilities over coastal ecosystems, are fundamental to the livelihoods, food security, and cultural identity of coastal communities, small-scale fishers, and indigenous peoples. As demands on oceans and fisheries are escalating, recognizing and strengthening these diverse tenure systems is a foundation of equity and stewardship outcomes. Despite numerous international commitments supporting marine tenure rights, implementation remains challenging. From fisheries and ocean conservation sectors, we observe a narrowing or reduction of rights to access and use. Whereas a more holistic "bundle of rights" also incorporates the rights and power to manage, to govern and to transfer. Indigenous and local views tend to be even more holistic, emphasizing the interconnection between rights, responsibilities, and nature. In this presentation I will discuss how advances can be made toward tenure security—the certainty that rights will be upheld by society and law. I examine how advances toward tenure security and fisheries goals require complementarity between legal frameworks, governance quality, and flows of funding.

KEYWORDS: Marine and coastal tenure, Governance, Coastal communities

Models of Governance: Inland Fisheries in Controlled Waters Vipul Singh*

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This paper explores governance models for inland fisheries management, drawing inspiration from historical case studies in Gangetic Bihar. Under British colonial rule, decommonisation processes transformed riverine waterscapes, restricting public access to rivers and ponds resources that had long sustained local culture and economy. In the transition from communal to privatized control, landowners acquired unprecedented rights over water bodies and fish stocks, reshaping the term julkar from a broad designation of water-related rights to one focused on private fishing rights by the early nineteenth century. This study proposes a Commons-Based Governance Model as a framework to address the complex legacy of colonial policies on inland fisheries. Key questions examined include: How did the colonial state's fiscal motivations shape legal approaches to fisheries? What socio-cultural impacts did this shift have on communities with deep cultural ties to aquatic resources? Analysis of legal cases and landmark judgments reveals a gradual colonial shift from initial rulings supporting public fishing rights to later decisions that favoured private claims, often in alignment with government revenue interests and at the expense of community rights. The Commons-Based Governance Model leverages these historical insights, advocating for collaborative management that respects public access, ecological sustainability, and equitable resource distribution. By incorporating community-led management principles and legal protections for public use, this model aims to support sustainable fishery practices that preserve both ecological and cultural values. This paper aims to contribute to current discussions on inland fishery governance, suggesting balanced frameworks that honour the ecological integrity and socio-economic importance of riverine waterscapes.

KEYWORDS: Governance, Inland fisheries, Controlled waters

Green Energy and Technology: A Framework of Intervention through Resilience for Vulnerability to Viability

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Vulnerability in socio-ecological systems can be addressed by external interventions on multiple fronts such as social, cultural, economic, policy, community, infrastructure, technology, and so on. On the other hand, the system can be made resilient either through its intrinsic strengths or acquired attributes. While two approaches to vulnerability and resilience look at the two as either two distinctive concepts (with overlaps) or as two sides of the same coin, in this paper, I propose to present a model that shows how a set of 'attributes' and their 'moderators' interact to define a system as either vulnerable or resilient. Next, through the use of case studies on Green Energy and Technology Intervention based on two projects, 'Socializing MSDs' and 'V2V Global Partnership,' it is proposed to demonstrate how (a) contexts and (b) interconnectedness among subsystems of any given socio-ecological system contribute to vulnerability/resilience status of the system. At the end, an attempt will be made to present a schematic pathway for assessing resilience and identifying optimal uses of resources

Keywords: Green energy, Resilience, Socio-ecological systems, Technology intervention, Vulnerability

Emerging Leaders, Evolving Entrepreneurs: Activating SDG 13 Through Inland Fishing in the Indian Sundarbans

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Spanning an area of 9,630 square kilometers, the Indian Sundarbans mangroves delta is a volatile island archipelago, experiencing multiple disruptive risks in the form of climate change, breaching of embankments, rigid forest bureaucracy, etc. The women are more severely exposed to physical-emotional barriers as the men migrate in search of better opportunities, leaving the former in the hands of socio-ecological penury. This presentation will deconstruct this mainstream declensionist narrative, demonstrating hopeful transitions from vulnerability to viability, more specifically gender empowerment and agency through inland fishing activities and experimentation carried out as part of a transdisciplinary process and initiative in the island village of Kumirmari, Gosaba Block. The empirics will validate how this bottom-up exercise and its impact on women as individuals and also members of self-help groups are playing an instrumental role in achieving key targets and objectives of SDG 13 (Gender Equity). Finally, the case study and the lessons drawn from it, will showcase that roadmaps for realizing SDGs in the coming years would require grounded, non-hierarchical and inclusive collaborations and engagement within diverse groups of actors (including women), collectively envisioning long-term viable and transformative change.

KEYWORDS: Emerging leaders, Evolving entrepreneurs, SDG 13, Inland fishing, Sundarbans

Addressing Resource Use, Governance and Equity for Small Scale Fisheries in Blue Growth — Case Study of Moheshkhali, Bangladesh

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According to the World Bank, the blue economy (blue growth) is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem." South Asia is undergoing rapid development in the blue economy sector, as experienced in Bangladesh, India, Sri Lanka, and others. What is clear, however, is that ocean equity (or socially just ocean use, and governance) is central if blue growth is to be viable. Blue justice needs to address historical injustice by adopting a comprehensive consideration of marginalized people in decision-making. We take a case study approach in applying the lens of blue justice on the impact that blue growth is having on small-scale fisheries in Moheshkhali island, Bangladesh. Due to the construction of a number of mega projects including a coal-based power plant, there have been several environmental and social damage to the island – coastal erosion due to dredging and removing soil, pollution from the construction centre, (both on land and water), and decline in fish catch. On the social side, there has been displacement, loss of livelihoods, restricted fishing grounds, loss of land for cultivation and loss of community cohesion. We try to address the following three questions in this case study - What are the challenges in addressing blue justice? How do we incorporate the voice and agency of small-scale fishing communities in addressing blue justice? What are the key policies at the local level for addressing blue justice issues?

KEYWORDS: Resource use, Governance, Equity, Small-scale fisheries, Blue growth

Participatory Approach for Managing Vulnerability and Risks in Sustainable Inland Small Scales Fisheries of West Bengal

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The integrated participatory approach was initiated in different Lower Gangetic Flood Plain wetlands of North 24 Parganas, Nadia, and Murshidabad districts of West Bengal, India, to increase the fish production and socio-economic development of small-scale fishermen communities of wetlands by ICAR-Central Inland Fisheries Research Institute, Barrackpore. It showed that fishers in the 40-50 age group were the most active and made up the most significant percentage (30.06%) of both the male and female fishers. However, it is found that women (7.18%) are not directly involved in fishing activities but indirectly support them by preparing and repairing nets and vending fish to market. Outside organizations can develop and implement effective management strategies that benefit the environment and those who depend on it by encouraging community participation and involvement. In these wetlands, the local fishermen have taken it upon themselves to install pens and release fingerlings of Indian Major Carps and exotic carps, thereby contributing significantly to aquaculture production enhancement. Within a year, they got 2-3 times better commercial food fish production with an annual growth rate of around 24.19%. Commercial fish production gives an INR 0.8-1.2 million increment in annual income depending on the wetland's area. Apart from that, the local marginal fishers also earn Rs. 250-1000 daily by capturing small indigenous fish with traditional crafts and gears. Around 16% of the small indigenous fish are caught for household nutritional security, while the remaining 84% is marketed at local markets for Rs. 100-250/kg. Over half of the fishers, 56.86% have their boat. Not only that, but an overwhelming majority of fishers, 76.47% have their fishing gear (cast net, traditional trap, or gill net). It has recently been advised that auto-stocked, high-value minor carp in these wetlands be adopted for improving income and for the conservation of small indigenous species. A system for effective communication and collaboration is necessary to build leadership and foster cooperation. This system will help community members identify challenges, plan, implement, monitor, and improve the management of inland fisheries, and strengthen the community. "Active participation" is vital to the success of this system, as it involves community members in all aspects of community mobilization and will help to create a brighter future for small-scale fisheries.

KEYWORDS: Sustainability, Participatory approach, Wetlands, Policy

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Social Ecological Vulnerability in Marine Protected Areas: Does Tourism Diversify Livelihoods of Local Fishers in Malaysia?

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The government of Malaysia has established several marine protected areas (MPAs) in offshore islands to protect overexploited fisheries resources. The tourism industry generates substantial revenue from the islands in Malaysia. Considering the numerous benefits of tourism activities to the well-being of local communities, we assessed whether local fisher households were able to diversify their livelihood strategy for better livelihoods. Several studies demonstrate that coral reefs and fisheries in MPA suffer from natural and anthropogenic disturbances mainly caused by increased tourism activities and pollution from land-based activities. This paper examines the impact of tourism activities on environmental degradation and diversify livelihood outcomes of small-scale fishers in MPAs of Malaysia. This study used paired comparison methods to elicit the perception of local stakeholders on activities harmful to marine habitats. Data was collected through face-to-face interviews with 200 respondents in the selected fishing villages in Peninsular Malaysia, using a structured questionnaire. The findings of the study show that local fishers were able to diversify their livelihoods through tourism-based employment. However, the results indicate that a major share of income generated from tourism is reaped by the wealthier groups who invested in the tourism business. The results of the study suggest that the transition from fishing into tourism leads to an uneven social and economic impact on livelihoods. Additionally, tourism users damage and threaten the resources in the MPA. The viability of the small-scale fisher's livelihood will require well-coordinated and participatory management that can involve the local community for resource conservation, provide fair access to resources and equitable distribution of benefits in the MPAs of Malaysia.

KEYWORDS: Marine protected areas, Environmental damage, Small-scale fisheries, Inequity, Livelihood diversification, Peninsular Malaysia

Governance Mismatch: Lessons from Anchovy Fisheries Management in Thailand

Suvaluck Satumanatpan^{1*}, Kungwan Juntarashote² and Ratana Chuenpagdee³

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Countries around the world develop fisheries policies that are in compliance with international instruments, such as the FAO Code of Conduct for Responsible Fisheries, and/or in alignment with global agreements, particularly those connected to conservation. Often, this results in policy reform that may or may not correspond well with the nature and characteristics of the fisheries and the local context. This is the case of Thailand with the Royal Ordinance on Fisheries (2015), which contains some articles that seem to contradict the mandate of the government to ensure sustainable utilization of fisheries resources and to support the livelihoods of small-scale fisheries. Such mismatch creates governability challenges, which need to be well-understood before they can be overcome. Following interactive governance, we examine the underlying causes of these challenges, using anchovy fisheries as a case study. Anchovies are important fish with a long history in terms of development and connection to culture and identity. We begin with the tracing of the history of large-scale and small-scale anchovy fisheries, examining the changes in the rules and regulations used for the management of these fisheries, and analyzing the extent to which they correspond with the nature and the characteristics of the fisheries, and whether they are conducive or inhibitive to achieve fisheries management objectives. We conclude with lessons learned and recommendations on pathways to enhance governability for small-scale anchovy fisheries in Thailand, with broader implications for elsewhere.

KEYWORDS: Governance, Anchovy Fisheries, Management

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Dried Small Fish as a Window into Vulnerability-Viability Transitions in Small-scale Fisheries

Derek Johnson*

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Out of the humble product of dried small fish, come many stories. Among others, dried small fish are a window into stories of markets, stories of eating, taste, and nutrition, stories of change, and stories of social and environmental relations. Dried small fish also point to current patterns of disruption and risk for small-scale fisheries while suggesting possible vibrant and meaningful futures for small-scale fisheries. Among those possible futures are how dried small fish might offer strategies for climate resilience. In this presentation, I draw on lessons from several international collaborations to reflect on dried small fish as a repository of lessons, and a point of reference for vulnerability and viability in small-scale fisheries, and in food systems more generally.

KEYWORDS: Dried fish, Vulnerability, Viability, Small-scale fisheries

Co-produced Climate Resilient Futures: Insights from Small Scale Fisheries of Coastal Andhra Pradesh, India

Bala Raju Nikku^{1*}, Srinivasu Kodi² and Siva Sankara Rao Mallavarapu³

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This presentation is based on ongoing participatory action research that uses co-produced community science approaches and the V2V framework. By doing so, we embrace a visioning process that applies a transdisciplinary approach to unpack the complexities of climateresilient fishing livelihoods. We present our initial findings that explored the intersections of access to fish catch, migration, livelihood, and tenure-seeking patterns of Jalari and other small-scale fishers and their stories of resilience from north coastal Andhra Pradesh. Many coastal villages, including eight towns in Andhra Pradesh State in India, fall under the Coastal Multi-Hazard Zone (CMZ), making them highly vulnerable to inundation due to sea erosion and climate change. The state has weathered more than 60 cyclones since 1975. In addition, the tenure rights of small-scale fishers are unsupported and unprotected due to encroachment by and competition with other fisher groups and corporate fishing. With the intersecting local-global-local processes, nurturing resilient small-scale fisher livelihoods is critical to achieving blue justice. The small-scale fisheries and their resilient livelihoods are essential for managing coastal habitats and other people whose livelihoods depend on the fishing value chain. We continue to explore the conventional science-policy-practice nexus to recommend and advocate for resilient futures for small-scale fishing communities. The presentation is an outcome of the ongoing work in progress in Andhra Pradesh through the participatory research conducted during 2023-2024, supported through the New Frontiers Research Funding Grant at Thomson Rivers University.

KEYWORDS: Resilience, Climate change, Blue justice, Andhra Pradesh, Small-scale fishers

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- Fisheries Extension
- Fisheries Economics

Diversification of Aquaculture

THRUST AREAS

- 2. Biodiversity Assessment and Conservation
- Application of Nanotechnology and Biotechnology
- 4. Nutraceuticals and Nutrigenomics
- 5. Genetic Improvement and Genomics
- 6. Climate Change and Adaptations

PATENTS GRANTED

Fish Drying Rack

(CIFE Eco-hatchery)

Tier System

1.

- 7. Improved Management of Aquatic Animal Health and Environment
- Assessment and Enhancement of Seafood Quality

Animal feed supplement for enhancing growth of

Ivermectin based medicated feed mix for treatment

of fish parasites and growth restoration in fishes

Portable FRP hatchery for carp seed production

Formulation of Fadrozole loaded nanoparticle feed

for efficient masculinization of Peocilia reticulata

Catfish hatchery and rearing of seeds under Three

for White Spot Syndrome Virus (WSSV)

9. Livelihood and Food Security of Marginal Farmers

TECHNOLOGIES

- CIFE-ARGUNIL: A feed mix for treatment of fish parasites and growth restoration in fish
- CIFE Test Kits for Aquaculture
- Floating Carp Hatchery for Reservoirs
- Timer-based power operated prototype water filtration system for aquaculture
- Prototype of automatic feeder for aquaculture
- Laminated Bombay duck
- Pangasius mince emulsion sausages Salt fermented Indian mackerel
- CIFE-Flavac: Inactivated vaccine against Flavobacterium columnare in fish
- 10. CIFE Gro: A herbal conglomerate to promote growth, mitigate stress and enhance immunity of fish
- 2. Feed supplement for improving reproductive health 11. Power Operated Solid-Waste Removal Device
 - 12. Sensor Based Automatic Aeration System for Aquaculture
 - Novel primers and a high throughput real-time assay 13. Solar cooler for fresh fish storage
 - 14. CIFE Vruddhi: A non-enzymatic nutraceutical conglomerate to promote growth, mitigate stress and enhance compensatory growth in fish
 - 15. Design of a Portable tubular photobioreactor with horizontal mixer. integrated harvesting system and artificial light panels

Pan India and

PRESTIGIOUS FELLOWSHIPS **AVAILED BY CIFE STUDENTS**

DST-INSPIRE Rajiv Gandhi National Fellowship Maulana Azad Fellowship ICCSR fellowship Indo-African Fellowship SRF and JRF of ICAR

UGC NET /SRF ICAR-Netaji Subhash International Fellowship

STUDENTS ACTIVITIES



Students Convention











ICAR-CENTRAL MARINE FISHERIES RESEARCH INSTITUTE





The ICAR-Central Marine Fisheries Research Institute (CMFRI) is the largest organization dedicated for marine fisheries research in the country. Established by the Government of India on 3rd February 1947 under the then Ministry of $\overline{\mathbf{Z}}$ Agriculture and the institute joined the ICAR family in 1967. Over the course of 75 years, ICAR-CMFRI has emerged as a leading tropical marine fisheries research institute in the world with research focus on both sustainable marine fisheries and mariculture. In marine capture fisheries, ICAR-CMFRI has been carrying out research towards the estimation of marine fisheries landings and fishing effort, stock assessments, taxonomy of marine organisms and the bioeconomic characteristics of the exploited stocks of finfish and shellfish. The Institute's multidisciplinary approach to research in marine capture and culture fisheries has led to its recognition as a premier research institute comparable to any well-established marine research organization in the world.









Artificial reef module deployment

Rajarshi Tandon Rajbhasha Puraskar 2020



CONSULTANCY SERVICES

Fisheries resources conservation and management, Artificial reefs deployment, Mariculture technologies, Marine ornamental fish hatchery technologies, Open sea cage culture, Fish stock assessment methodology, Impact assessment, DNA profiling and Bioprospecting

SEA RANCHING AT MANDAPAM (PALK BAY)



IDENTIFICATION/ ANALYTICAL SERVICES/ PRODUCTS

Identification of marine specimens, Water analysis, Sediment analysis, Tissue / feed biochemical analysis, PCR based diagnosis; Ornamental fish, Bivalve spat, Fish seed, Live feed, Phytoplankton / Zooplankton identification, Or namental fish feed, Farmed and depurated bivalve meat.

INTEGRATED MULTI TROPHIC AQUACULTURE (IMTA)



NEUTRACEUTICAL PRODUCTS TO COMBAT MAJOR LIFESTYLE DISEASES



垣 भा कृ अनु प - केंद्रीय समुद्री माल्स्यिकी अनुसंधान संस्थान ICAR - CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE



ABOUT CIFRI

The Institute strives for knowledge-based management of inland open waters such as rivers, estuaries, reservoirs, floodplain, wetlands etc. for sustainable fisheries, conservation of aquatic biodiversity, integrity of ecological services and to derive social benefits from these waters. Headquarters of the Institute is located at Barrackpore, West Bengal; the Regional Research Centers are located at Prayagraj, Guwahati, Bengaluru and Vadodara, with Research stations at Kochi and Kolkata. The Institute is ISO 9001: 2015 certified and provide world-class service standards.





Harvest from cage

Bountiful catch from pen

Riodiversity conservation

TECHNOLOGIES DEVELOPED

- Resource and yield estimation of inland fisheries
- System specific fish stock enhancement protocols for wetlands and reservoirs
- · Assessment of e-flow requirements for sustainable fisheries in rivers
- Models for predicting fishery potential of large inland water bodies
- Quality fish seed raising in pens in wetlands and reservoirs
- Cage culture for seed raising and table fish production
- Aquatic pollution monitoring, ecosystem & fish health management
- Waste to wealth insect based fish feed

REACH TO UNREACHED Capacity building program Empowering women Denefiting tribal fishers On-field demonstration



ICAR-CENTRAL INSTITUTE OF FRESHWATER AQUACULTURE



Established in 1987, ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA) has been addressing R & D programs in freshwater aquaculture sector of the country, with an objective of developing sustainable aquaculture systems of diversified finfish and shellfish. The Institute is also the Regional Lead Centre on 'Carp Farming' under Network of Aquaculture Centres in Asia-Pacific (NACA) operative under Food and Agriculture Organisation of United Nation (FAO).



MANDATE

- Basic and strategic research for the development of sustainable culture systems for freshwater finfish and shellfish
- Species and systems diversification in freshwater aquaculture
- Human Resource Development through training, education and extension

MISSION

Excellence in research for developing sustainable and diversified freshwater aquaculture practices for enhanced productivity, quality, water use efficiency and farm income

VISION

Making Indian freshwater aquaculture globally competitive through ecofriendly and economically viable fish production systems for livelihood and nutritional security



TECHNOLOGIES











DIVERSIFIED FISH SPECIES









FEED FORMULATIONS







Developed ELISA,
 Agglutination and PCR
 based diagnostics for
 common bacterial and viral
 diseases
 Vaccine against
 Aeromoniasis

4 Genetically Improved Fish Varieties				
22	18			
Commercialized	Commercializable			
technologies	technologies			
10	8			
Patents	Patents			
granted	filed			
2	1			
Designs	Design			
granted	in progress			
9 Trademarks granted				

Whole genome sequences of Rohu and Catla; and marker resources for freshwater fish species







Aquaculture Field School

Capacity Building Business Incubation

Development

Outreach

Outreach and Technology
Dissemination

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ICAR-CENTRAL INSTITUTE OF BRACKISHWATER AQUACULTURE



The ICAR-Central Institute of Brackishwater Aquaculture (CIBA) serves as the nodal institute for research and development and has played an important role in developing brackishwater aquaculture in India. With headquarters at Chennai, CIBA has Regional Research Centres at Kakdwip (West Bengal) and at Navsari (Gujarat) and experimental field station at Muttukkadu and Kovalam (TN). CIBA has in-house capacities to implement research in the frontier areas of aquaculture, genetics and breeding, nutrition and feed technology, biotechnology, molecular biology, aquaticanimal health, prophylactics and therapeutics, environmental and social sciences.



VISION

CIBA envisions as one of the world's foremost scientific research institute in brackishwater aquaculture through the pursuit of excellence in research & innovation that contribute modernization & development of sustainable brackishwater aquaculture

MISSION

Basic, applied research & providing technological backstopping for the development of sustainable brackishwater aquaculture suitable for Indian conditions, to ensure much-needed, nutritional security, employment, economic well-being & societal development

MANDATE

- Basic, strategic & applied research for technoeconomically viable & sustainable culture systems for finfish & shellfish in brackishwater
 Species & systems diversification in
- Species & systems brackishwater aquaculture
- Toactasrepositoryofinformationonbrackishwater fishery resources with a systematic database
- \bullet Human Resource Development, capacity building & skill development through training, education & extension

SIGNIFICANT ACHIEVEMENTS

- Captive breeding and seed production in seabass, milkfish, pearlspot, grey
 mullet, mangrove red snapper, goldlined seabream, silver moony, spotted
 scat, long whisker catfish, mud crab and five major shrimp species
- Indigenous cost-effective, functional and grow-out feeds for different life stages of the candidate fishes
- Farming technology for shellfish and finfishes in diversified rearing systems such as ponds, customized cages, RAS, biofloc based intensive systems, IMTA and brackishwater seaweeds
- Indigenous cost-effective kits for disease diagnosis and water quality assessment and microbial products for aquatic health management
- Whole genome sequencing of Flatehead grey mullet, Indian white shrimp, white spot syndrome virus (WSSV), Vibrio parahaemolyticus and Vibrio camphelli
- Frontline extension, livelihood development, economic and social impact of aquaculture and IT applications for dual-channel knowledge dissemination (vanami shrimpapps)

TECHNOLOGIES 54 Developed 45 Commercialized Transfered Collaborations with stakeholders 54 Entrepreneurship developed developed 11 states 193 MoUs signed Knowledge partnership

PRODUCTS DEVELOPED PRODUCTS DEVELOPED HI O 317 U - ÖÖÖLÜ GIRI VIGUULU GURUN GARAKISHWATER AQUACULTURE

ICAR-CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY





ICAR-CIFT is a technology Institute under Indian Council of Agricultural Research, which caters to the entire spectrum of isheries from harvest to post-harvest operations. The Institute provides technologies and services to fishing and fish processing industries in the areas of craft and gear, product development, packaging, waste utilization, nutrition, microbiology, biotechnology, engineering, quality assurance and extension.



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- Bycatch Reduction devices
- Carbon Footprint Reduction
- Value Added Products using fish/seaweed
- High-value byproducts
- Thermal & Non-thermal Processing
- Novel Food Packaging Techniques
- Rapid Detection Test Kits
- Aquatic Bioactive Compounds

- Seaweed Nutraceuticals
- Dietary Supplements
- Green Chemistry Process
- Antimicrobial Resistance
- Biomolecules from Aquatic Bacteria
- Molecular typing of pathogens
- Food Processing Equipment Design
- Renewable Energy Systems
- Refrigeration & Cold storage
- Waste management techniques

SERVICES OFFERED

- Novel technologies for harvest and post-harvest sectors
- New product formulation and testing
- Technology upscaling
- Setting up of food production lines / processing units
- Designing and equipping laboratories
- NABL accreditation / HACCP Certification
- Food safety and regulatory demand

STRENGTHS AND EXPERTISE

- ISO 17025 Accredited NABL Laboratories
- National Referral Laboratory
- National Reference Laboratory
- Agribusiness Incubation Centre
- Centre of Excellence for International **Training**

Join the Agribusiness Incubation Centre of ICAR-CIFT and get access to a wide range of technologies and value added business support services

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ICAR-NATIONAL BUREAU OF FISH GENETIC RESOURCES





BOUT NBFGR

- ICAR- National Bureau of Fish Genetic Resources was established in 1983 to undertake research related to the conservation of fish germplasm resources of the country.
- ICAR-NBFGR ranked 18 among all the ICAR research institutes (2019-20 & 2020-21 combined rating).
- Received the Sardar Patel Outstanding ICAR Institution Award for the year 2011 under small institute category.



MANDATE

- Exploration, characterization and cataloguing of fish genetic resource
- Maintenance and preservation of fish genetic resources for conservation andutilization of prioritized species
- Evaluation of indigenous and exotic germplasm including risk assessment and fish health







SALIENT ACHIEVEMENTS

- Database on fish diversity of India: Records of 3182 finfish species (Freshwater-915 Brackishwater-719 and • Developed sperm cryopreservation protocol for 39 fish Marine-1548) Discovered 49 fish species, 6 shrimps and 2 fish parasites new to science along with 9 redescription of fish species
- Documented first records for 10 fish species, 9 shrimps and 1 fish parasite
- Developed genomic resources including whole genome assemblies, expressed sequence tags and mitochondrial and genomic markers in Indian catfish, Clarias magur and Hilsa shad, Tenualosa ilisha as well as for commercially important traits like hypoxia and ammonia tolerance (Clarias magur), thermal tolerance (Mahseer) and muscle growth (Catla catla)
- Delineated genetic stock structure of over 30 fish & shellfish species using truss & molecular markers Whole genome of three commercially important fish species (Clarias magur, Labeo rohita and Tenualosa ilisha) and two fish pathogens (Tilapia Lake Virus, Aphanomyces invadans) deciphered
- Deciphered complete mitochondrial genomes of 28 fish
- Generated DNA barcodes of over 600 fish and shellfish species for identification
- Conidae and Strombidae families
- Microsatellitemarkers developed for over 50 important Indian fish species for genetic variation & differentiation studies
- · Captive breeding protocols developed for 20 ornamental

- fishes in collaboration
- species & viable hatchlings produced for 24 species using
- Sperm cryopreservation technology field validated in 38 hatcheries of 11 states for genetically diversified quality seed
- Established 7 germplasm resource centres in different parts of the country
- Developed diagnostic capability for OIE listed and emerging pathogens of finfishes (14), Shrimps (11) and Molluscs (6)
- Developed a formulation OoNIL for treatment and prevention of oomycete diseases in fishes
- Reported 9 fish/shellfish pathogens for the first time from the country
- Coordinating the implementation of Government of India supported National Surveillance Programme for Aquatic Animal Diseases (2nd phase) which has pan India coverage with involvement of partner centres
- Established National Repository of Fish Cell Lines, the world's largest fish cell line collection with 81 accessions and developed 44 cell lines from 29 commercially important food and ornamental fish species
- Molecular signatures developed for 55 molluscan species of Capacity development programmes undertaken for over 4300 stakeholders during last five years
 - Supporting River ranching under PMMSY by providing quality pure riverine fish seed for ranching in rivers through state fisheries departments









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ICAR-DIRECTORATE OF COLDWATER FISHERIES RESEARCH





BOUT DCFR

Coldwater fisheries has a great potential in generating rural income and providing food security to the economically underprivileged population residing in Indian uplands. To utilize the available resources and opportunities in the coldwater fisheries sector the involvement of Indian Council of Agricultural Research in this sector started during late sixties, which subsequently culminated in the creation of National Research Center on Coldwater Fisheries as an independent Research Center.



MANDATE

- To conduct basic, strategic and applied research in coldwater fisheries and aquaculture
- To act as repository of hill fisheries resources
- Human resource development through training, education and extension

MISSION

Tobecomea Centre of Excellence for assessing and managing coldwater fishery resources, development of technologies and models of hill aquaculture and formulating strategies for holistic growth of the sector

VISION

Coldwater fisheries and aquaculture to be an important economic activity in upland region for livelihood security and ecotourism



MAJOR ACHIEVEMENTS

- Fish diversity and health assessment of 13 rivers and 10 lakes in six hill states.
- GIS based maps of aquatic resources of 4 states (Arunachal Pradesh, Uttarakhand, Leh-Laddakh and J&K) for aquaculture suitability and fishery development
- Breeding technology for seven fish species of food (Schizothorax progastus, Schizothorax plagiostomus, Naziritor chelynoides, Bangana dero, Labeo dyocheilus, Chagunius chagunio, Neolissochilus hexagonolepis) & six fish species of ornamental (Barilius bendelisis, Garra gotyla, Garra lamta, G. annandalei, Barilius vagra and Schistura obliquofascia) value
- Commercialized seed production technology for endangered golden mahseer for conservation
- Polytank based multi-tier integrated fish farming model for mid-hill region
- Recirculating aquaculture system as a climate-resilient model & two backyard RAS models for intensive production of rainbow trout
- High-performance rainbow trout starter and grower feeds in PPP mode
- · Promotion of hatchery of carps, trout & mahseer in Northeast India
- Disease surveillance in rainbow trout and carp farms in hill states
- · Capacity building through training, education and extension















14TH ASIAN FISHERIES AND AQUACULTURE FORUM (14AFAF)

Theme: Greening the Blue Growth in Asia-Pacific

12-15 February 2025

Venue:

ICAR Convention Centre, NASC Complex, New Delhi, India

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- Asian Fisheries Society (AFS), Kuala Lumpur, Malaysia
- Indian Council of Agricultural Research (ICAR), New Delhi, India
- Department of Fisheries (DoF), Government of India, New Delhi, India
- Asian Fisheries Society Indian Branch (AFSIB), Mangalore, India

Associate Partners

- National Fisheries Development Board (NFDB), Hyderabad, India
- Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand
- National Mission for Clean Ganga, Ministry of Jal Sakti, Govt. of India
- Vulnerability to Viability (V2V) Global Partnership, SSHRC of Canada
- ICAR-Central Institute of Fisheries Education (CIFE), Mumbai, India
- ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi, India
- ICAR-Central Inland Fisheries Research Institute (CIFRI), Barrackpore, India
- ICAR-Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, India
- ICAR-Central Institute of Brackishwater Aquaculture (CIBA), Chennai, India
- ICAR-Central Institute of Fisheries Technology (CIFT), Cochin, India
- ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow, India
- ICAR-Directorate of Coldwater Fisheries Research (DCFR), Bhimtal, India
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