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Part One

AUGUST 1988

NATIONAL SEMINAR ON SHELLFISH RESOURCES AND FARMING

TUTICORIN

19-21 January, 1987

Session - I

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P. B. No. 2704, E. R. G. Road, Cochin-682 031, India

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Bulletins are issued periodically by Central Marine Fisheries Research Institute to interpret current knowledge in the various fields of research on marine fisheries and allied subjects in India.

Published by

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PREFACE

The marine molluscan resources of our country have been traditionally exploited along the coastal belt for edible, commercial, industrial and cultural purposes from ancient times. Although the bivalves such as clams, mussels and oysters have been serving the nutritional needs of a segment of coastal population besides contributing in a small way to the economy of these regions, it should be mentioned that the edible value of the meat of many molluscs was not taken serious note of in our country unlike in other Asian and Western countries. It is not because there was lack of awareness but primarily due to the disinclination and apathy of the majority of our population towards molluscan meat. The research thrust given by the Central Marine Fisheries Research Institute and other State and Central establishments brought about a fresh outlook to the problems of management and utilization of molluscan resources.

From the early seventies experimental culture of molluscs has been carried out not only by the CMFRI but also at some of the national institutions and universities. High production potentials, especially in the case of oyster and mussel have been indicated. Pearl culture has become a reality. More recently shellfish hatchery techniques have been developed successfully for large scale production of bivalve seed.

In order to bring together all the information available on molluscan resources and the results of research on farming technologies, and to discuss them for evolving an action plan for future development and management of these resources, a National Seminar on Shellfish Resources and Farming was organised by CMFRI at Tuticorin during 19-21 January, 1987. The papers presented at the various sessions reflect the advances made in molluscan fishery investigations and the present status of molluscan farming in our country. The limitations, constraints and gaps in our knowledge which are to be overcome in future have been brought to light by the Seminar. The proceedings of the Seminar with the papers presented and the recommendations made have been brought out in this publication.

I am grateful for the excellent co-operation and assistance given by various Institutions in making the Seminar a grand success. I am thankful to Dr. S. Jones, former Director of CMFRI, Dr. R. Raghu Prasad, Retired Assistant Director General, ICAR, Shri K. V. Rao, Retired Scientist of CMFRI, Shri M. R. Nair, Director, CIFT and Shri V. Ramalingam, Secretary, MPEDA for chairing the diiferent sessions of the seminar. I wish to place on record my deep sense of appreciation to Dr K. Alagarswami who helped in planning the Seminar and to Shri K. Nagappan Nayar and Shri S. Mahadevan for organising the Seminar at Tuticorin. My thanks are due to all Scientific, Technical and other staff of the Tuticorin Research Centre for the valuable service rendered by them.

P. S. B. R. JAMES
Director
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PROCEEDINGS

The National Seminar on Shellfish Resources and Farming was organised by CMFRI from 19th to 21st January, 1987 at Tuticorin Research Centre of CMFRI to focus attention on the important aspects relating to shellfish resources, their exploitation, farming techniques, seed production, marketing and utilization.

The Seminar was inaugurated by Shri R. Arumugham, IAS, District Collector, Chidambaranar District, Tamil Nadu. The inaugural function was presided over by Dr. R. M. Acharya, Deputy Director General (AS), ICAR, Dr. P. V. Dehadrai, Deputy Director General (F), ICAR, released CMFRI Bulletins on (i) Pearl Culture and (ii) oyster Culture - status and prospects on the occasion. Felicitations to the Seminar were given by Dr. S. Jones, former Director of CMFRI.

The Seminar which was spread over for 3 days consisted of six technical sessions ie. on (1) Management and development of shellfish resources; (2) Culture techniques and production; (3) Hatchery development; (4) Processing and product development; (5) Quality control of molluscan products; and (6) Marketing of molluscs.

101 papers were presented following the theme papers at each session highlighting the important subjects considered for the respective sessions. In the light of the papers presented and the comprehensive discussions thereof, the Seminar made specific recommendations on follow-up action to be implemented by the concerned agencies.

WELCOME ADDRESS

Dr. P.S.B.R. JAMES
Director, CMFRI, Cochin

Mr. Arumugam, District Collector, Chidambaranar district, Dr. R. M. Acharya, Deputy Director General (Animal Science) ICAR, Dr. P. V. Dehadrai Deputy Director General (Fisheries) ICAR, Dr. S. Jones, retired Director of CMFRI, Dr. R Raghu Prasad, retired Asssistant Director General (Fisheries), ICAR, Mr K. Virabhadra Rao, distinguished scientists, invitees and delegates.

I have great pleasure in extending a very warm welcome to Mr. Arumugam, I.A.S. who has kindly consented to inaugurate this National Seminar on Shellfish Resources and Farming at a very short notice since the Honourable Minister for Health, Tamil Nadu, Mr. P. U. Shanmugam, could not come here today to inaugurate the seminar. I extend a very warm welcome to him.

Dr. R. M. Acharya, Deputy Dirctor General (Animal Science) has kindly consented to preside over this function. As you know. Dr. Acharya has been looking after the Fisheries Institutions of ICAR for the past 6 years. I had the privilege to work under him. Although basically a renowned scientist in animal sciences, he has profound knowledge in fisheries. He was able to guide and advise the developmental activities of the fisheries institutions in ICAR. I have very great pleasure in welcoming him.

i extend a very warm and cordial welcome to Dr. P. V. Dehadrai who has very recently taken over as Deputy Director General (Fisheries) to the I.C.A R Dr. Dehadrai was till recently the Fisheries Development Commissioner for the country handling development programmes at the national level He held the position for 5 years and has recently come back to ICAR; he comes back with great experience at national level from the development side to link it with fisheries research now.

We are very happy to have Dr. S. Jones, former Director, CMFRI in our midst and I extend a very warm welcome to him. Although Dr. Jones retired several years ago, he is keeping in touch with the development of this Institute and I thank him on behalf of the Institute for his presence here today. I extend a very warm welcome to Dr. Raghu Prasad, retired Assistant Director General (Fisheries). Dr. Raghu Prasad has also been very actively associated with the Institute and we look forward to his advice and guidance in future too. We are very happy that Shri K. Virabhadra Rao is here today. He is the father of marine molluscan research in the country and the Institute was greatly benefitted by his work for many years. 1 also extend a hearty welcome to all the invitees, local dignitaries, other officials of the State/Central Government, Agricultural Universities, Fisheries Institutions and staff of our own Institute from different centres. I also welcome the Press who have been very co-operative with the Tuticorin Research Centre. We are very happy that the staff of the Doordarshan and All India Radio have come here for coverage of the function. I welcome them.

It will not be out of place if I take this opportunity to briefly explain the background and purpose of organising this seminar. You are all aware that Tuticorin is synoymous with the world famous fisheries for pearl oyster and the chank fisheries of this region.

Therefore, I thought it is proper and appropriate to hold this seminar at this particular venue. Earlier you might have had the opportunity to have visited this Research Centre. An excellent facility has been developed at this Research centre for molluscan research especially for pearl oyster and edible oyster and the credit naturally goes to Shri K. Nagappan Nayar and his colleagues who have toiled at this centre for the last 25 years or so. Iam also proud to say that Shri K. Nagappan Nayar will be shortly leaving this place on a special foreign assignment. Although I regret that he is leaving the Institute now, I am happy that he has been selected as an expert to advise the Bahrain Government on Marine Biology in general, and pearl oyster research in particular. It is a fitting tribute to his experience and knowledge on the subject and the centre should be proud of this particular achievement of the scientist. 1 congratulate him on this occasion, i very much wished that he should be available here to participate and organise this seminar and he has done excellently well.

The seminar has a special significance in that in spite of lot of achievements of this Institute especially in molluscan research for over 35 years, both on capture and culture fisheries, some of the technologies which have been developed still remain in the laboratories. I thought a seminar like this should focus the attention of all concerned on the results of research that have come out of this Institute so that the country can benefit by producing more protein food from this particular resource - molluscs. We have a wide variety of edible molluscs. We have varieties of ornamental nature. We have large sub soil deposits which form raw material for several industries. Unless steps are now taken at this stage to transfer the technologies for culture, the industry and the public enterprises cannot come forward to make use of them. Therefore, Departments and other organisations concerned with development, should join hands with the Research Institute and centres like this and make use of the results of research. The Marine Biological Association of India organised a symposium on Mollusca in 1968. That was the first consolidated thinking on molluscan research in this country. Experts from different parts of the world participated and made several contributions. A workshop on mussel farming was held by the Institute in 1980 at Madras, It is now necessary again to give a special thrust both on the capture and culture fisheries for molluscs and continue further work in areas which are specially identified for future research and development.

1 would also like to take this opportunity to mention a few words about the recent advancements in molluscan research and the gaps that remain to be filled in the field about which this Institute is very actively concerned with. Molluscs form a vital source of animal protein. We have to do a lot of work to survey the actual resource potential, whether in the coastal areas, estuaries or backwaters and project the quantum of total resources available for exploitation. Commercial farming has to be established as a regular practice. Farming technology is ready for many molluscs specially the edible oyster and the green mussel and large quantities of these animals can now be produced with the techniques so far developed. But we need to take them to the field and commercialise the results that have come out. In processing and marketing several experiments and trials have been conducted All these indicate that there is a great scope and potential for domestic as well as export market. The discussions and recommendations of the Seminar, I am sure, will throw light on these areas and indicate the action to be taken by the concerned.

The following specific areas of research would be conducted by this Institute in future. In the case of the edible oysters, identifying suitable areas for culture would be receiving our attention. We have done experimental oyster culture only in a limited scale. But this needs to be enlarged. Mortalities do occur in the culture systems. But we have to develop breeding techniques to raise disease resistant strains with better meat content and quality. The labour and material inputs need to be reduced by adopting modern techniques. The conditions for good growth of oysters might vary from one area to another. Therefore we have to try different methods, especially in deeper areas.

PRESIDENTIAL ADDRESS

Dr. R. M. ACHARYA
Deputy Director Genera/ (Animal Sciences), i.C.A.R., New Deifii

I am very happy to be with you this morning at the inaugural function of the National Seminar on Shellfish Resources and Farming being organised by the Central Marine Fisheries Research Institute, at its Research Centre at Tuticorin. We have put in tremendous research and development effort on agricultural production which has resulted in the green revolution and self sufficiency in cereal production, especially rice and wheat. We have not given similar attention to animal husbandry and fisheries. Considering the quality of the food that we eat, without food of animal origin, we can't think in terms of our food being very complete.

In coastal areas the fish, no doubt, is the animal food to most of the people in general. It is now considered costly and only eaten by people who can afford the higher prices But in coastal areas fish is a very important source of protein not only of the animal origin but of all the total protein. The Indian Council of Agricultural Research took over the Institute of Fisheries Research from Ministry of Agriculture in 1968 and it is satisfying to note that fisheries research receives sufficient attention. I understand that out of the 70 million tons of fish landed in the world, we land only a small share of around 3.0 million tons. But still we are the Seventh in the world in fish production either from the natural resources or culture. The shellfish harvested from the natural resources as well as from farming constitutes only a small percentage of the total output of 3 million tons Amongst the shellfish, oysters, mussels and clams are landed and are important. Developed countries like USA, Japan and U. K. contribute 80% of the total molluscan shellfish landed and produced through culture. The contribution from India in this regard has not been correctly evaluated. All along the Indian coasts, including estuaries, backwaters and lagoons, exploitation of these organisms has been traditionally carried out by small fishermen in a more subsistent manner rather than on a commercial scale. Therefore the quantity thus seasonally exploited, though considerable, has not been properly accounted for. There are several zones of our coastal areas where these resources abound but had remained unexploited due to general lack of interest of the local population to use the molluscan meat as an item of diet. The situation has been fast changing in recent years and the tempo of exploitation of these sea foods on commercial scale has gained momentum.

Apart from this, we in our country are not serious in organising farming enterprises as has been done in the countries like Japan, U. S. A, France, Netherlands, Spain and U. K. I understand that 17.23% of the world aquaculture production is accounted for by the molluscs. Therefore, during the past one decade, great emphasis has been laid on the assessment of the natural resources of edible molluscs as also in conducting experimental culture of few valuable species like mussel and oyster. As a result of these attempts valuable knowledge has become available and it is gratifying to know that the results of the investigations of the Research Institute especially at this Research Centre have shown that oyster culture and pearl culture can be undertaken as a profitable venture. Mussel and clam culture experiments are in the nascent stages but the results obtained so far are very encouraging. Growth of these animals under farming conditions has been found

The potential for markets either domestic or export has to be identified and commercial farming related with this. Pollution control measures perhaps need closer attention because the paralytic shell fish poisoning is well known the world over where molluscs are cultured. It can cause health hazards when extensive culture is taken up. Extension activities involved in propagating oyster culture need to be taken up, especially training in oyster culture techniques and taining in post harvest technology.

Coming to the pearl oyster there is a great potential for production of cultured pearls. The Institute has developed indigenous technology successfully The Southern Petrochemical Industries Corporation Ltd and the Tamil Nadu Fisheries Development Corporation Ltd have come forward to utilise the technology for commercial production of cultured pearls. It is going on smoothly and we are in constant touch with this particular enterprise. But it is not just the production of pearls alone. The raw materials that are needed have also to be produced in large quantities and I am most happy that the scientists of this Research Centre have developed a technology for breeding of pearl oyster, thus producing pearl oyster seed in large numbers. This great breakthrough has been achieved both in the case of edible oyster and pearl oyster. We are now able to produce large quantities of seeds so that commercialisation of cultured pearl production or edible oyster meat for food can be taken up by the entrepreneurs. The identification of other sites for pearl oyster culture remains to be done. Farming techniques may still have to be improved based on modern systems and materials towards reduction of the cost. Fouling and boring has been identified as one of the important areas where future research is needed.

Recently the Institute succeeded in breeding the black-lip pearl oyster which throws up ample opportunities for farming, especially in the Andaman and Nicobar islands and to a lesser extent in Lakshadeep also. This is another candidate species for pearl culture in addition to the species which we are at present dealing with. This initial work needs to be intensified, perfected and propagated, There may be other species but immediately we may not be focussing our attention on these, Occasionaly, heavy mortalities in the case of pearl oyster are observed. Therefore pathology and disease control need further study. The hatchery system has been developed at this Institute but the survival rates and rate of growth of larvae are still to be improved. Genetics, reproductive physiology, nutrition, pathology, water quality management, are other areas in the case of pearl oyster which need further attention.

I will not go into the various other techniques and processes which have been developed for the clams, mussel or window pane oyster and so on, but it is enough to say in brief that molluscan research in this Institute has taken great strides due to efforts of devoted scientists of this discipline who have been initially guided by scientists like Mr. K V. Rao and others. Today I am most happy to say that the Institute has reached such heights in molluscan research that emphasis is now needed to produce the meat or produce the cultured pearls commercially. This can only be done if a directed approach to this problem is made developing links with industry and the entrepreneurs. Here I would like to cite the example of Mr. John Motha's co-operation, assistance and goodwill to this Centre. In his farm the Institute achieved a production of over 2000 kg of prawns per hectare within six months. This is considered to be one of the best results in this area. After this initial success, there had been several enquiries from interested culturists-and we are trying to extend this knowledge and expertise to bring in prawn culture in large areas of productive and defunct salt pans so that more and more prawns can be produced in future.

In conclusion, 1 thank and welcome all of you who are present here, specially the District Collector, Dr. R M. Acharya and Dr. P. V. Dehadrai, for taking the time off from your busy schedule to attend the inaugural function.

to be much faster as compared to those in temperate countries. The production rate per hectare also appears to be better than what is reported from temperate waters. A significant achievement of this Institute is the success in pearl culture at Tuticorin which has now been taken up on commercial scale. Very recenly Central Marine Fisheries Research Institute has achieved a breakthrough in the technique of mass production of molluscan seed in hatchery laboratory at Tuticorin. These vital contributions have taken the country nearer to starting of culture of molluscs on a large scale. Molluscs, being gregarious, having high fecundity and capable of fast growth are ideal for mariculture. They can be kept alive for long duration and so could be transported alive for long distances.

I would like to point out that there are still several areas of investigations which remain to be tackled and the Institute's current research reflects these areas. In short, the projects of this Institute are oriented towards developing technologies which are sound and economical and which would lead to large-scale production

Proper assessment of areas where commercially important molluscs are found in dense population, their density, growth and reproductive cycles, environment in which they live, the economic importance of the species and their utilisation are the areas which need serious attention No doubt in earlier years people like James Hornell and scientists of the State and the Central Fisheries organisations have collected valuable information on these aspects. Extension of culture activities to different maritime States with modified techniques to suit the local conditions, popularisation of molluscan meat among the public, standardisation of techniques of processing the meat and market survey, both internal and external, to explore the marketing potentialities are all the areas which deserve serious attention.

Coastal aquaculture in India faces many constraints. One of the most important is the vagaries of the monsoon. Indian constline does not provide many sheltered bays and protected places for establishing coastal farms. Where they exist they are used for other economic activities. This calls for suitable techniques to organise coastal farming during the non-monsoon months both along the west and east coasts. Another problem needing attention is to examine carefully the areas subject to coastal pollution and to avoid establishment of farms in such areas The molluscs are easily affected by the quality of water since they are filter feeders and bio magnifiers of trace metals and organic compounds. In view of the possibilities of mollusc culture along some parts of our coast in the next few years it appears only logical that the fish farming interest in coastal areas are safeguarded by reserving certain areas for this purpose and assuring that no industrial establishments are located in the vicinity. Sooner or later we are bound to be confronted with legal aspects of farming as well as the right of holdership or leasing the coastal area for establishment of farms. In many countries definite laws exist in this regard. It is necessary to give some thought to this problem right now, so that the interests of the coastal farmers, traditional fishermen and other sea based activities do not. come in conflict with other developmental activities.

Let me also focus the attention of the scientists participating in the seminar towards the important role played by disease in marine farming. As at present we have not come across serious incidence of disease among the tended stock in the experimental culture system. The situation will be otherwise when we crowd the farm in greater density when conditions will arise resulting in a variety of diseases, primary or secondary in nature, leading to mortality of the farmed stock. This calls for shedding any complacency on our part and monitor and document instances leading to mortality, diagnose the causative factors and evolve suitable control or curative measures Disease diagnosis will thus have a pivotal role to play in our mariculture system.

Regardimg the management of the natural resources a word of caution seems to be pertinent in the context of the present day trend in the exploitation of shell deposits in the

estuaries and backwater areas. Mining for the deadshell for industrial purposes is extensively carried out along the west coast and to a certain extent along the east coast. Annually it is estimated that approximately 0.5 million tons of shells are thus retrieved from the natural settling ground of the seeds of the commercially important species like clams and oysters. It is feared that in the long run several such areas will be spoiled by indiscriminate mining and several favourable areas of natural population are likely to disappear. It is necessary that a rational policy should be formulated to observe either core zones or to declare sensitive areas as conserved. I am sure you are all aware of the efforts that theCouncil has more recently taken to reorganise fisheries research in the country especially looking into the importance of the brackish water aquaculture. A new Institute has been set up for brackish water aquaculture.

I am sure that the present seminar has attracted scientists and specialists in molluscan fisheries from all over the country. Close to 100 papers have been received from them, high-lighting resource potentials, prospects of farming, suggestions for progress of molluscan fisheries in our country and advances made in processing technology product development and in marketing. I have no doubt in my mind that the ensuing scientific discussions will be constructive and fruitful and will lead to broad consensus regarding the formulation of future strategies in the Research and Development aspects of this country. I am immensely happy to note that this Institute has brought two special bulletins one on pearl culture and the other on edible oyster culure dealing exhaustively with the results and advancements rtiade in our country in this particular area, i wish to compliment Dr. P. S B. R James, Director of the Institute and a former colleague. Dr. E.G. Silas, and other staff of this Institute for their achievements in the past and look forward to many more technological advacements this Institute is going to make. In conclusion I wish you and the seminar all success.

INAUGURAL ADDRESS

R. ARUMUGAM, I.A.S.
District Collector, V 0. Chidambaranar District.

Dr. R. M. Acharya, Dr. P. V. Dehadrai, Dr. S. Jones, Dr. P.S.B.R. James, Dr. R. Raghu Prasad, Mr. K. V. Rao, Thiru K. Nagappan Nayar, devoted band of scientists of CMFRI and the elite of pearl city

it is indeed a great pleasure for me to be associated with this seminar of national importance. I come here today with a student's curiosity to know more and learn more about marine shellfish resources and farming. This new district named after the great patriot V. 0 Chidambaranar has started functioning only 3 months before, having been inaugurated by the Honourable Chief Minister of Tamil Nadu on 20th October, 1986 and this district has many signal honours in terms of the location of gaint projects and industrial undertakings. But I consider, personally, the greatest blessing and endowment is its very long coast line and nature's bounty in the form of Gulf of Mannar which is world known for its natural wealth of marine resources.

India's contribution to the world sea food production has been increasing appreciably in recent years. India occupies seventh rank in the international map of fish production. All India marine fish production has been estimated to be 1.6 million tonnes of which the contribution of Tamil Nadu is about 2.3 lakh tons accounting for 14% of the country's marine fish landings. The role of Tamil Nadu in this national development is quite laudable as it occupies the third position in the marine fish landings of India. The coastal belt of Tamil Nadu is well known for molluscan fishery resources particulary for chank fishery, pearl fishery and ebible oyster beds. Our State ranks first for shell based industrial development and exploitation of natural resources of this group. Port Korkai which was located off Mukkanil the present coastal village south of Tuticorin, was well known for the export of Indian pearl, and other marine ornamental products to Rome and Greece from time immemorial of Pandyan rulers The present day progress made in shellfish industry appears to be much better than ever. Credit goes to the pioneer in this field namely late Mr. James Hornell, Marine Biologist and Director of Fisheries of the erstwhile Madras Presidency. He stressed the need for intensified study on molluscan wealth to realise its maximum production potential. His publications on molluscs are classical works.

We have fully realised the immense effects of 'Green revolution' in our country during this century. Now, the 'Blue Revolution' is fast catching up. I am glad to note that CMFRI at Tuticorin has been conducting multidisciplinary researches in marine capture fisheries with a view to suggest measures to increase marine fish production. We belonging to this new district indeed feel proud to consider this marine fisheries research centre at Tuticorin as a prestigious institution adding glory to the new district. The scientists here have made available a wealth of information on the biology and the fisheries characteristics of many commercially important fish and shellfishes. Widely appreciated and significant is the contribution of this Research Centre for the development of indigenous techniques for mariculture of finfishes, prawn, lobster, crabs, mussel, pearl culture and edible oyster. I congratulate the scientists of this Research Institute for the remarkable achievement made in the production of pearls and for success in the hatchery system at Tuticorin. The time has come to commercialise

this project into large scale production. Tamil Nadu Fisheries Development Corporation and the M/s. Southern Petrochemical Industries Ltd have already established an eminent organisation namely M/s. Tamilnadu Pearls Ltd. and it is heartening to note that the progress obtained in this venture is entirely on the basis of technology developed by this Institute. This Institute has trained officials from different maritime States and this sort of extension work is very much beneficial to the nation as a whole. It would be ideal if aquaculture system is combined with traditional fisheries with due considerarion to socio-economic aspects of fishermen community.

With the present rale of exploitation of marine food from sea and export, our country earns a very handsome foreign exchange of Rs. 400 crores in a year. A good demand exists for Indian cuttlefish. Soon steps should be taken for producing and exporting the meat of oyster and other molluscs so as to earn more foreign exchange. The aim of research is to face challenge—challenge of the future—and find solution

I may mention at this juncture that, based on the richness and the variety of marine organisms in the Gulf of Mannar as evaluated by the scientists of this Research Institute, the Government has set up a National Marine Park covering the islands of the Gulf of Mannar so that the pristine glory of the habitat is preserved. Tuticorin will be considered as the watch tower of this park zone to protect the valuable resources of the nearby islands

Continuous efforts have to be made for the proper assessment of natural resources of commercially important molluscs. Potential grounds within the EEZ including the far flung Andaman and Nicobar islands as well as Lakshadweep islands may be explored for optimum exploitation This may be a tedious and time consuming task, but I feel a joint effort with State Fisheries Departments, Research Organisations under ICAR, Agricultural Universities and other Biological Stations can attain the goal by sharing the expertise. I am sure the present seminar has been arranged with the aim of exchanging views on new findings and recent advances made and to examine prospects and problems connected with the future development of shellfish industry. No doubt this is the ideal place in the entire counry to concentrate on these aspects.

Gulf of Mannar as you all know is a treasure house for very wide variety of moHuscan group, including precious pearl oysters and auspicious *valampuri* chank. Experts from different coastal States who have assembled here may contribute much on the resources potentials. I personally feel that the Government sources should provide maximum opportunity to convene such seminars at short intervals as they are very essential for updating our knowledge and for achieving quick progress. I, as the District Head of the place, feel proud that this seminar is being convened here.

A perusal of the programme of the seminar and abstracts of different papers gives me very high hope that the deliberations of this seminar will be highly meaningful and will bring useful recommendations for the fast and profitable development of shellfish industry in our country Once again I wish to heartily congratulate the organisers and all participants of this Seminar for the very valuable contributions that are going to be discussed in the next three days I consider Tuticorin as a big marine treasure house and as the proverbial story goes we need an Allaudin's lamp to unravel these treasures I am sure the Central Marine Fisheries Research Institute and its very devoted band of scientists will act as Allaudin's lamp to unravel these treasure to the benefit of Bharat as well as the world. With these opening words I am indeed very glad and proud in inaugurating this National Seminar on Shellfish Resources and Farming. Wish you all success.

VOTE OF THANKS

K. NAGAPPAN NAYAR
Officer-in-Charge, Tuticorin Research Centre of CMFFil, Tuticorin

As the Convener of the National Seminar on Shellfish Resources and Farming, I have great pleasure in proposing the vote of thanl<s at the conclusion fo the inaugural function of the National Seminar. On behalf of the Central Marine Fisheries Research Institute and on my own behalf I express our very sincere gratitude to Dr. R.M. Acharya, Deputy Director General ^Animal Sciences), I.C.A.R., New Delhi, for kindly agreeing to our request and presiding over the inaugural function of the National Seminar today. I have pleasure in expressing our deep gratitude to Shri R. Arumugam, I.A.S., District Collector for kindly inaugurating the National Seminar. I express our most grateful thanks to Dr. P. V. Dehadrai, Deputy Director General (Fisheries), I.C.A.R. for kindly releasing the Bulletins on pearl culture and oyster culture.

I express my sincere thanks to Dr. PS.BR. James, Director, CMFRI for organising the National Seminar at this Research Centre and for giving a very cordial and enlightening welcome address. We are very grateful to Dr. S. Jones, former Director of the Institute and Chairman of the session on the Management and Development of Shellfish Resources for offering felicitations on the occasion of the inauguration of the Seminar.

1 thank Dr. R, Raghu Prasad, former Assistant Director General (Fisheries), I.C.A.R. and Chairman of the Session on Hatchery Development for Shellfish Seed Production for kindly coming over here for the inaugural function. I thank Shri K. Virabhadra Rao former senior Scientist of our Institute and the Chairman of the session on Shellfish Culture Techniques and Production for attending this seminar.

I thank Dr. G. Jegadeesan, Dean, Fisheries College, Tuticorin for his presence here and his co-operation and help in the seminar. I thank all the distinguished delegates of the National Seminar from various Institutions, such as Central Institute of Fisheries Technology, Cochin, Central Institute of Fisheries Education, Bombay, Integrated Fisheries Project, Cochin, Cenlral Agricultural Research Institute, Port Blair, Marine Products Export Development Authority, Cochin, National Bank for Agriculture and Rural Development, Bombay, Departments of Fisheries, Tamil Nadu and Gujarat, Centre of Advanced Studies in Marine Biology, Parangipettai, Marine Research Station, Ratnagiri, College of Fisheries, Mangalore, Tuticorin and Cochin and M/s. Tamil Nadu Pearls Private Ltd., for participation in the function.

Our gratitude are due to all the distinguished guests who have assembled here in response to our invitation. I thank all scientists of the CMFRI and other staff members of this Research Centre for their active co-operation and for making excellent arrangements for this function. I sincerely thank the members of the Press and Madras Doordarshan for kindly coming over here for the coverage of the inaugural function of the National Seminar on Shellfish Resources and Farming. I once again thank you all.

RECOMMENDATIONS OF THE SEMINAR

The following are the recommendations made by the Seminar on follow-up actions to be implemented by the concerne agencies

1. Realising the vast potential of the edible and industrial molluscan shellfish resources in India and noting the inadequacy of information and data on a number of resources, the Seminar recommends that quantitative and qualitative assessment and the level of optimum exploitation be made on all the exploited and potential resources along the coasts and in the EEZ including the Lakshadweep. Andaman and Nicobar islands.

2. A National Atlas for molluscan resources be prepared on a region-wise basis for the benefit of the public in general and the fishing industry in particular.

3. Recognising the need for rational exploitation, conservation and management of the molluscan resources, it is recommended that steps be taken to avoid degradation to the environmental natural habitats, keeping also in view the legitimate interest of the industries concerned. A National Advisory Body consisting of representatives of the fishing industry, Government departments and research organisations be constituted to go into the merits of each case where exploitation is involved.

4. Recognising that very high production is possible through farming of various candidate species of cultivable molluscs in our coastal waters and in the open sea and also taking into account the encouraging results obtained in the aquaculture techniques developed so far, it is recommended that farming practices be intensified in different regions of our coast to increase production and ensure an assured and continuous supply of the shell-fishes to domestic and export market.

5. Where the culture technologies are proving to be viable, it is recommended that pilot projects be taken up towards testing the techno-economic viability and popularisation of farming techniques.

6. It is recommended that steps be taken to conduct an intensive survey to identify suitable farm sites along our coasts for undertaking culture of appropriate species bearing in mind the species resources and environmental factors.

7. Considering the importance of natural seed resources of cultivable molluscs in our waters and being concerned about the wastage of such resources, the seminar recommends that proper techniques be developed for their collection and transportation for farming purposes.

8. The Seminar recommends that a very intensive survey of Andaman and Nicobar Islands and Lakshadweep be carried out to locate centres for hatchery development and suitable sites for culture of molluscan species of economic importance.

9. The Seminar considered that hatchery system of seed production is an important one which would help to overcome problems of fluctuating and unpredictable natural product-ion of seed of bivalves for culture purposes. For commercialisation of pearl culture and edible oyster culture, the hatchery system is most essential.

10. Since the success of hatchery mainly depends on water quality, the hydrolcgical condit-ions of the areas be considered before selection of sites for establishing hatchery.

11. The larval rearing technique for *vlllorlta cyprlnoides* var *cochinensis* by 'hapa'culture be further studied systematically for its viability.

12. Artificial encapsulated diet has been developed and tested as supplementory food for bivalve larvae for the first time in the shellfish hatchery, Tuticorin. It is recommended that careful study be undertaken to evolve suitable artificial diet for bivalve larvae and spat.

13. Though success has been achieved in the breeding and rearing of brown mussel *Perna indica* at Vizhinjam, the larval survival rate reported was poor. It is recommended that all the parameters be looked into for achieving a high survival rate and production.

14. The design suggested at the Seminar for a semicontinuous larval rearing system in the hatchery be considered for testing its suitability to hatchery operation.

15. Cost-benefit ratio of mollusc farming should be such that it should be acceptable to the producer as well as consumer It is suggested that this can be achieved by minimising the cost of production by adopting low cost technology wherever it is possible.

16. It is recommended that an extension service be set up to create confidence in the farmer on the marketability of the harvested product.

17. As molluscan shellfish culture is a new venture, adequate financial support be given by Government and financial institutions as loans, subsidies etc. Institutions like NABARD and IDBI could extend support to entrepreneurs taking up large scale molluscan culture and the scheduled and cooperative banks to small-scale shellfish farmers by giving loans at concessional rates of interest.

18. In post-harvest technology of bivalves, the products be prepared which will be acceptable to the local market and foreign market. Products like pickles, soup powder, canned clams and mussels in brine, oil, massala and tomato sauce and smoked and canned products will give an outlet for the bivalves in the market.

19. Depuration of harvested mussel, clam, oysters etc. be accepted as a code of practice for culture of shellfishes and depuration facilities be established at culture centres.

20. A higher limit of bacterial count be recommended for Indian standards for fresh and frozen molluscan products which will facilitate maintenance of the quality both for internal and export market.

21. Constant monitoring of the level of heavy metals, pesticide residues and bacterial load be carried out in the environment and in the fresh/processed products.

22. Eventhough the export market is confined to a small segment there is a growing demand for molluscs and molluscan products. It is recommended that India should take advantage of this demand. Once an item gains a foot-hold in the export market, it would give an automatic boost for production, processing and export.

23 Within India there may be a large market for molluscs. However, product awareness has not been created among the consumers. It is necessary to make available different molluscan products to suit the varied tastes in different parts of the country.

24. For developing domestic market for molluscan products a detailed market survey be carried out.

25. Suitable incentives be given to fishermen to land more of molluscan shellfish, simultaneously proper marketing infrastructure be developed to encourage fishermen to expand molluscan fishing activities.

26. Urgent steps are needed to encourage entrepreneurs to undertake large scale commercial culture making use of available technologies for the farming and production of shellfishes such as oysters, mussels and clams. This should be linked with marketing of frehs material and preparation of products acceptable to domestic as well as export market.

National Seminar on Shellfish Resources and Farniini

Session I

MANAGEMENT AND DEVELOPMENT OF SHELLFISH RESOURCES AND FARMING

1. ON MANAGEMENT AND DEVELOPMENT OF SHELLFISH RESOURCES
— Thome Paper

S. Mahadevan
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This paper is intended to review the present status of the molluscan resources of our country other than cephalopods and the existing management practices and suggest measures for an effective integrated approach to help in increasing the tempo of exploitation where it is in a low profile and recommend measures for conservation in Such cases and areas which need a hard look. Management should be conceived and understood not as a constraint upon natural exploitation but as an essential tool for the sound, sustained development of fisheries. Hence, management is an integral part of the developmental process.

Molluscs like oyster, mussel, and clam have been always known to the fishermen as nutritious and tasty. But many countries have discarded the exploitatibn of these till recently due to the priority given tb the fin fishes, prawns and crabs. In our country molluscan resources are aplently. Bui attention for exploitation, save for some zones of west coast had been very casual. In the all India fish landings of 1.4 million tonnes molluscs hardly occupy 1% status. Even this ismostly made up of cephalopods. The bivalves, except for mussels, do not find a place in the landing data. This does not mean other bivalves are not fished. Recent investigations on the status of molluscan fisheries in selected segments give us some precise information on the small-scale and seasonal fishing effort. Particular mention may be made of the mussel fishery of the west coast where it is known that mussel landings fluctuate between 2500 to 4000 tonnes annually. Similar^y clam fishery along> the ^^ggj coast in identified important clam fjshihg centres yields about 1500 tonhes of dam meat annually. The exact quantity is as y^j to be properly estimated The point is that proper assessment of the molluscan land-ings have not been done since there is no established assessmeritsystem for ascertaining these catches.

Fishery experts are of the opinion that to achieve greater production of.foodi from the sea in the next few decades ,it is going to be difficult to rely solely on intensive capture fishery operations alone in the Exclusive Economic Zone and Oceanic Zone These operations are fossil-fuel dependent and would be more expensive as time goes on. The current line of thinking is tpyy^rdj

promoting production of food resources of inshore forms which remain neglected due to disinterestedness or lack of knowledge of these forms and their potentialities. The acceptability of the molluscan meat as an item of diet has caught up amongst the Indian public and the present trends indicate very great interest in utilizing molluscan meat as diet, both exploiting ' natural beds and by trying to evolve suitable technologies in producing them by culture practices- These areas should receive greater attention and development. It is opportune for us to take note of this and strive to increase edible molluscan production. This can be done only by a greater understanding of the resources potentiality of all edible species and passing on the information to the fishing industry so that greater area coverage results. This will also make good use of the natural stock without allowing them to perish unutilized.

Along the 6100 km of coastline of India molluscan shellfish are valuable fisheries used either as food or source of lime, as decorative shells and in industrial purposes. 28 different species of bivalves and nearly 65 species of gastropods are of very great importance under these categories. Except for bivalves, gastropods are seldom exploited for the edible meat with the exception of chank. *Turbo* and *Trochus,* whose meat is utilised as food Fishermen have been exploiting marine aquatic organisms for tens of centuries but the edible molluscan resources have remained as an augmentation to finfish landings rather than to have achieved a major industry status. Realising the need for updating the status of our knowledge of the potentialities of the edible molluscs Central Marine Fisheries Research Institute launched a resources survey project in 1976 which enabled us to get a broad picture of the status of fishing in selected segments of our country. Due to several handicaps the project could achieve only a limited success, leaving a big gap to be filled. I feel that this work needs intensification in the next few years. Most of the information existing pertains to the coast of Tamil Nadu, Kerala and Kamataka. For States like Orissa, Andhra Pradesh, Maharashtra and Gujarat hardly any valuable information, qualitative and qu^ntitatfYP assessment of species and the population Is avaiable. The Institute with its capacity to provide expertise should take up the resources assessment at the regional or sub regional levels by collaborating with departments of fisheries and Agricultural Universities of the respective States. This work will enable us to get precise information of the areas of availability, population size, exploitable species and their seasonal stock recruitment to the fishery etc. A national molluscan Atlas should be prepared giving information on season of fishing, population size, species distribution and other relevant factors, region wise. This would help to improve the fishing for the edible molluscs particularly clams, mussels and oysters.

It is essential to enhance the capability of coastal states in stock assessement in order that they can determine the optimum catches of the living resources of the areas where they exercise the sovereign rights. Reliable and timely data and statistics on all aspects of fisheries are needed for planning, implementation and subsequent monitoring of fishery management and development. The natural capability to collect data and information on molluscs should be developed. Development plans should take account of all aspects of fishery sector,' not only harvesting, processing, marketing and material supply but also the development of the infrastructure, technology and human jesources to enable better exploitation, to increase the value added to the economy and to improve the employment opportunities. It is essential to note all those involved understand the social value of molluscan fisheries as a source of food, employment and profit. Hence, the need and the. desirability of using fishing methods and processes which do not jeoparadlse economic viability by exhausting the resources. Majority of the known edible and economically important species that are landed in India are nearshore forms, open coastal, estuarine or backwater species. The pearl oyster and chank and the other commercially valuable molluscs can be broadly termed as non-edible group (though not strictly so) inhabit subtidal and deeper zones of the sea. Hence, the method of fishing for these bottom dwelling, either free moving or those attached to the substrata.

though slightly different involve comparatively non-costly inputs. Mostly handpicking is done in the case of coastal and estuarine forms while in the case of forms in the deeper area skin diving is in vogue. Scope for modern-isation in fishing is therefore restricted to the non-edible group and hence can be considered easy and inexpensive operation otherwise. In the management of clam, oyster and mussel fishing the problem of overfishing does not seem to arise. On the other hand, there is scope for encouraging more fishermen and fisherwomen to resort to fishing of these.

The other method is to experiment with cultivable molluscs and establish farms to grow them. Musse's and oysters have been farm grown and found to grow faster than those in natural beds. The production rate per ha. is also very appreciable 300-400t/ha mussel and 135 t/ha of oysters. Intensification of the culture practices should be explored on all India basis by identifying suitable sites and viable techniques of growing in farms according to local conditions. This can contribute to other national objectives such as rural employment and earning.

Production of seed

a) *Utilisation of natural seed resources*

So far I have dealt with the fishabie stock and their assessment. I have not talked about the utilization of seed resources of these forms. The potential coastal water area available in the country include about 8.5 million ha. of productive inshore waters and 1.7 million ha. of estuaries, backwaters, brackish^water lakes and swamps. This includes two major backwater spreads in the west coast and two in the east coast. It has been assessed that there are about 100 estuarine and tidal inlet systems along our coast including the deltaic regions of the major rivers The settlement of the seeds of *Perna viridis, Meretrix casta* and *Crassostrea madrasensis* are commonly seen along the coastal areas in the slightly less saline areas of the estuarine system. Although these form the growing stock for th9 •iCRloited molluscs there are several regions where these seeds are subjected to fluctuations in environmental conditions resulting in large-scale mortality on account of seasonal exposure to reduced salinity conditions, siltation and constant exposure due to tack of enough tidal amplitude to permit sufficient column of water for survival. Thus enormous quantities of seed resources are known to go waste annually both in respect of niussel and oyster. As a matter of fact, the mussei settlement along the west coast in recent years has been found to be prolific but subsequent environmental incompatabilily of the areas of the spat settlement causes total destruction of these valuable seed stock It is necessary to plan proper utilization by process of transplantT ation of these to the agreeable areas so that a good fishery is established. These cap be utilised to serve as raw materials for farmjng in areas where natural raw stock is not found. No assessment of these potential stocks appear to have been so far made. It would be useful to identify important zones in each maritime state's coastal waters and conduct a detailed survey to assess the seed resources. These seeds, if transplanted to ideal growing conditions would help to enrich the fishery in the area of transplantation Thus what goes unutilized can be converted into protein giving marine resource

b. *Hatchery seed production*

Several countries spend huge amounts- in the establishment of hatchery system for the production of seed just because of lack, of adequate seed resources. In our country with bright future prospects for farming of oysters and mussels the seed respurces of these appea" to be enormous judging from earlier reports and through the results of directed research under-taken by the CMFR Institute,. In order to be preparad to meet future demandis the CMFR institute has made a breakthough in mass seed production of oysters in hatchery by developing a very good system of larval feed production to overcome the critical period of larval survival. This can be followed up in respect of mussels and clams also. It is difficult to establish a hatchery for each State because of cost involved- The hatchery at Tuticbrin should serve as a national molluscan seed production centre.

Management problems present themselves in greater dimensions In respect of the '«¥«fffffish

r«SQurces which are exploited On; cornmercipl lines not so much for edible value of thpir mefit but for their industrial importance. I have jn mind the pearl oyster, chank, *Trochus* apd *Tur^o* of Andamans and dead shell and subfoasil shfll deposit quarrying operations.

a) Chank

For centuries together the chank *Xanc^s pyrum* has been fished under the aegies pf sta^e monopoly in Tamil Nadu, Kei-ala and Qujarq^. The chank banglfe industry needs aboyt 2.p millfon shells anhualiy for supporting thp employment to artfsatts. The fisheries in Indip supplies only 2/3rd of the needs in good quality and size, of which the major share is from Tafnil Nadu, from Palk Bay and Gulf of Mfnnar coast. 1000 fishermen by skin diving are able to fish outchanks only up to 10 fathoms. It is k^own that beds extend beyond this depth which Can be effectively fished only by training them in SCUBA'diving and establishing service centres to cater to their needs in supplying accessories and filling atqualungs with compressed air sp that the efficiency in catches can be improved by reaching out to hitherto unexptoited beds. The size landed also will improve, it is true mechanised trawling gets as much as 100000 chanks annually as bye catch. But this is undesirable due to the damage caused to the natural habitats and in the possible destruction of chank egg capsules affecting recruitment to population. Observation of 'protected zone' and 'close season' during the trimester January to March which happens to be the breeding season are called for.

It is also necessary to ascertain the size at first maturity of chanks, both for male and female, so as to stipulate the size that can be safely fished. The present 55 mm diameter size is arbitrary and may have to be raised. The state government has its own political and labour considerations with regard to leasing out chank fishing rights and departmental supervision. Whatever the case strict vigilance and effective patrolling the chank beds appear to be necessary to prevent catches being clandestinely sold. These measures will improve the status.

Researches on movement of chanks, their migratory habits, breeding, rate of growth. longevity and laboratory production of baby chanks for sea ranching would help to expand the fisheries in future.

b) *Pearl oyster*

As for pearl oyster it is well known that there is irregular cyclic nature of fisheries. The last pearl fishery was in 1961 after which we had drawn blank. The reasons for poor fishery are far from human control undertaking culture pearl operations would help to produce pearls thus saving the country valuable foreign exchange. The Institute developed technology in this regard has been field tested and found to be a great success. The raw material seed available for farming has also been ensured by mass production of spat in hatchery at Tuticorin. The spat that could be produced annually can run to several billions. Portions of this can be broadcast over pearl' beds periodically and allowed to replenish the paars. The chances of natural pearl fishery can also thus enhanced. Researches on how best the spat so produced can be effectively transplanted by standardising the technique of ranching appear to be necessary. A start has been made on these lines and the results are being monitored and watched. The possibilities of the establishment of more number of pearl culture farms by identifying areas in different maritime states should be explored so that employment opportunities also can improve. At present, the nucleus for the implantation are imported. This problem has to be studied carefully with reference to the possibility of utilizing some of the large shells of bivalves like *Tridacna* and gastropods like *Turbo* sp. and Troc/JMS sp. of Andamans for making spherical nuclei of size from 3-8 mm dia.

c) *Turbo* and *Trochus*

Due to indiscriminate fishing for these shells in Andamans there seems to be a scarcity of shells. The status of these in fisheries has to be studied carefully so that restrictive action can follow. Our knowledge of the resources availability of these two is very restricted. A thorough survey of the beds and resources in the Andaman and Nicobar islands is very essential before planning for the future development.

d) *Shell quarrymg for lime and industry*

This practice has been in vogue for several centuries wherein poor fisherfolk collect the

dead shells from the coastal waters and estuarine regions and sell them to industry. It is estimated that annually about 2.5-3.0 lakh tonnes of clam subfossil deposit shells are quarried from Vembanad lake in Kerala by resorting to mechanical removal. Similarly dead shells are removed by fishermen from the beds in Ashtamudi Kodungallore, Kadalundi and Korapuzha river estuary (50000-600001 annually), in Kali river estuary in Karnataka (5000-10000 t annually) in Attankarai in Tamil Nadu (5000 t annually) at Sonapur estuary in Orissa (20001/ annually) ennore estuary, Tamil Nadu (1000 t), Buckingham canal and Pulicat lake (lOOOOt/annually). 2001 of window pane oyster shells in Kakinada; 100-1501 of the same in Gujarat State. Although this operation aims at the utilization of the buried shells remains very often the price fetched by the shell makes the fisherfolk and those interested in shell collection to remove, indiscriminately all live shells of clams, young and old. The operations done under the right of lease given by State Government is not only a potent activity in disturbing the habitat but also robs the fishermen of the long term benefit of utilizing the meat of the shells. It appears necessary to moderate the activities keeping in view also the interest of the industries concerned. Regulatory practices by declaring closed or protected zones in selected segments would help to increase natural population size giving greater scope for mulluscan meat production. A Joint National Consultative or advisory body consisting of concerned fishermen representatives, of industries, department of minor mineral mining, and State Fisheries should go into the merits of each case and decide the future.

Clams and oysters have been well received both in the internal and external markets. Nearly 500 tonnes of this meat has been exported annually. This indicates the area of product development and scope for marketing- As at present trade for molluscan meat is bright. This can be expanded by increasing marketing possibilities in exchange for fishing possibilities. Obstacles remain which prevent us from reaping full benefits from international trade. These include difficulties in the level of product, quality and quantity demanded by export market, limited trade information and contracts, tariff and nontariff barriers, restrictions of exports of raw material rather than finished products, low share in trade related services etc. There are also possible conflicts between the achievement of national nutritional goals and the objective of increased foreign exchange earning. Expansion of export trade in shellfish activity should be resolved by establishing priorities at the national level at the same time a well developed domestic market helps to reduce the high risks associated with industry based exclusively on export market. It is better to export final product than raw material as per the quality standards. Once this channel is steady and standardised the future holds out great possibilities for a spurt in the exploitation of these edible molluscs.

Disease

At present not much is known about the natural mortality in the molluscan beds Most of the great fisheries of world have experienced fluctuations in supply. Causes of such fluctuations have been much discussed but rarely determined precisely. Among the factors implicated in reduction in abundance are overfishing, inadequate food supply, disease, change in the environmental condition, drastic and sudden destruction of beds, toxins, predation and indiscriminate harvesting. It is necessary to document the reasons for large scale mortality of population. Whenever such instances are brought to notice it is essential, to correctly diagnose the causative factor and study the etiology and take preventive steps. Most of the management practices recommended the establishment of disease diagnostic sections to serve as extension media

I have indicated only broad strategies for future management and development of molluscan resources and I hope this Seminar will throw more light on the problems and constraints faced in molluscan fisheries development and recommend tangible steps to be taken for achieving greater production,

National Seminar on Shellfish Resources and Farming

Session I

MANAGEMENT AND DEVELOPMENT OF SHELLFISH RESOURCES AND FARMING

1. ON MANAGEMENT AND DEVELOPMENT OF SHELLFISH RESOURCES

—Theme Paper

S. Mahadevan

Central Marine Fisheries Research Institute, Cochin

This paper is intended to review the present status of the molluscan resources of our country other than cephalopods and the existing management practices and suggest measures for an effective integrated approach to help in increasing the tempo of exploitation where it is in a low profile and recommend measures for conservation in such cases and areas which need a hard look. Management should be conceived and understood not as a constraint upon natural exploitation but as an essential tool for the sound, sustained development of fisheries. Hence, management is an integral part of the developmental process.

Molluscs like oyster, mussel, and clam have been always known to the fishermen as nutritious and tasty. But many countries have discarded the exploitation of these till recently due to the priority given to the fin fishes, prawns and crabs. In our country molluscan resources are aplently. But attention for exploitation, save for some zones of west coast had been very casual. In the all India fish landings of 1.4 million tonnes molluscs hardly occupy 1% status. Even this is mostly made up of cephalopods. The bivalves, except for mussels, do not find a place in the landing data. This does not mean other bivalves are not fished. Recent investigations on the status of molluscan fisheries in selected segments give us some precise information on the small-scale and seasonal fishing effort. Particular mention may be made of the mussel fishery of the west coast where it is known that mussel landings fluctuate between 2500 to 4000 tonnes annually. Similarly clam fishery along the west coast in identified important clam fishing centres yields about 1500 tonnes of clam meat annually. The exact quantity is as yet to be properly estimated The point is that proper assessment of the molluscan landings have not been done since there is no established assessment system for ascertaining these catches.

Fishery experts are of the opinion that to achieve greater production of food from the sea in the next few decades it is going to be difficult to rely solely on intensive capture fishery operations alone in the Exclusive Economic Zone and Oceanic Zone. These operations are fossil-fuel dependent and would be more expensive as time goes on. The current line of thinking is towards

promoting production of food resources of inshore forms which remain neglected due to disinterestedness or lack of knowledge of these forms and their potentialities. The acceptability of the molluscan meat as an item of diet has caught up amongst the Indian public and the present trends indicate very great interest in utilizing molluscan meat as diet, both exploiting natural beds and by trying to evolve suitable technologies in producing them by culture practices. These areas should receive greater attention and development. It is opportune for us to take note of this and strive to increase edible molluscan production. This can be done only by a greater understanding of the resources potentiality of all edible species and passing on the information to the fishing industry so that greater area coverage results. This will also make good use of the natural stock without allowing them to perish unutilized.

Along the 6100 km of coastline of India molluscan shellfish are valuable fisheries used either as food or source of lime, as decorative shells and in industrial purposes. 28 different species of bivalves and nearly 65 species of gastropods are of very great importance under these categories. Except for bivalves, gastropods are seldom exploited for the edible meat with the exception of chank, *Turbo* and *Trochus*, whose meat is utilised as food. Fishermen have been exploiting marine aquatic organisms for tens of centuries but the edible molluscan resources have remained as an augmentation to finfish landings rather than to have achieved a major industry status. Realising the need for updating the status of our knowledge of the potentialities of the edible molluscs Central Marine Fisheries Research Institute launched a resources survey project in 1976 which enabled us to get a broad picture of the status of fishing in selected segments of our country. Due to several handicaps the project could achieve only a limited success, leaving a big gap to be filled. I feel that this work needs intensification in the next few years. Most of the information existing pertains to the coast of Tamil Nadu, Kerala and Karnataka. For States like Orissa, Andhra Pradesh, Maharashtra and Gujarat hardly any valuable information, qualitative and quantitative assessment of species and the population is avaiable. The Institute with its capacity to provide expertise should take up the resources assessment at the regional or sub regional levels by collaborating with departments of fisheries and Agricultural Universities of the respective States. This work will enable us to get precise information of the areas of availability, population size, exploitable species and their seasonal stock recruitment to the fishery etc. A national molluscan Atlas should be prepared giving information on season of fishing, population size, species distribution and other relevant factors, region wise. This would help to improve the fishing for the edible molluscs particularly clams, mussels and oysters.

It is essential to enhance the capability of coastal states in stock assessement in order that they can determine the optimum catches of the living resources of the areas where they exercise the sovereign rights. Reliable and timely data and statistics on all aspects of fisheries are needed for planning, implementation and subsequent monitoring of fishery management and development. The natural capability to collect data and information on molluscs should be developed. Development plans should take account of all aspects of fishery sector, not only harvesting, processing, marketing and material supply but also the development of the infrastructure, technology and human resources to enable better exploitation, to increase the value added to the economy and to improve the employment opportunities. It is essential to note all those involved understand the social value of molluscan fisheries as a source of food, employment and profit. Hence, the need and the desirability of using fishing methods and processes which do not jeoparadise economic viability by exhausting the resources. Majority of the known edible and economically important species that are landed in India are nearshore forms, open coastal, estuarine or backwater species. The pearl oyster and chank and the other commercially valuable molluscs can be broadly termed as non-edible group (though not strictly so) inhabit subtidal and deeper zones of the sea. Hence, the method of fishing for these bottom dwelling, either free moving or those attached to the substrata,

though slightly different involve comparatively non-costly inputs. Mostly handpicking is done in the case of coastal and estuarine forms while in the case of forms in the deeper area skin diving is in vogue. Scope for modernisation in fishing is therefore restricted to the non-edible group and hence can be considered easy and inexpensive operation otherwise. In the management of clam, oyster and mussel fishing the problem of overfishing does not seem to arise. On the other hand, there is scope for encouraging more fishermen and fisherwomen to resort to fishing of these.

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Production of seed

a) *Utilisation of natural seed resources*

So far I have dealt with the fishable stock and their assessment. I have not talked about the utilization of seed resources of these forms. The potential coastal water area available in the country include about 8.5 million ha. of productive inshore waters and 1.7 million ha. of estuaries, backwaters, brackish-water lakes and swamps. This includes two major backwater spreads in the west coast and two in the east coast. It has been assessed that there are about 100 estuarine and tidal inlet systems along our coast including the deltaic regions of the major rivers. The settlement of the seeds of *Perna viridis, Meretrix casta* and *Crassostrea madrasensis* are commonly seen along the coastal areas in the slightly less saline areas of the estuarine system. Although these form the growing stock for the exploited molluscs there are several regions where these seeds are subjected to fluctuations in environmental conditions resulting in large-scale mortality on account of seasonal exposure to reduced salinity conditions, siltation and constant exposure due to lack of enough tidal amplitude to permit sufficient column of water for survival. Thus enormous quantities of seed resources are known to go waste annually both in respect of mussel and oyster. As a matter of fact, the mussel settlement along the west coast in recent years has been found to be prolific but subsequent environmental incompatability of the areas of the spat settlement causes total destruction of these valuable seed stock. It is necessary to plan proper utilization by process of transplantation of these to the agreeable areas so that a good fishery is established. These can be utilised to serve as raw materials for farming in areas where natural raw stock is not found. No assessment of these potential stocks appear to have been so far made. It would be useful to identify important zones in each maritime state's coastal waters and conduct a detailed survey to assess the seed resources. These seeds, if transplanted to ideal growing conditions would help to enrich the fishery in the area of transplantation. Thus what goes unutilized can be converted into protein giving marine resource

b. *Hatchery seed production*

Several countries spend huge amounts in the establishment of hatchery system for the production of seed just because of lack of adequate seed resources. In our country with bright future prospects for farming of oysters and mussels the seed resources of these appear to be enormous judging from earlier reports and through the results of directed research undertaken by the CMFR Institute,. In order to be preparad to meet future demands the CMFR Institute has made a breakthough in mass seed production of oysters in hatchery by developing a very good system of larval feed production to overcome the critical period of larval survival. This can be followed up in respect of mussels and clams also. It is difficult to establish a hatchery for each State because of cost involved. The hatchery at Tuticorin should serve as a national molluscan seed production centre.

Management problems present themselves in greater dimensions in respect of the shellfish

resources which are exploited on commercial lines not so much for edible value of their meat but for their industrial importance. I have in mind the pearl oyster, chank, *Trochus* and *Turbo* of Andamans and dead shell and subfossil shell deposit quarrying operations.

a) *Chank*

For centuries together the chank *Xancus pyrum* has been fished under the aegies of state monopoly in Tamil Nadu, Kerala and Gujarat. The chank bangle industry needs about 2.5 million shells annually for supporting the employment to artisans. The fisheries in India supplies only 2/3rd of the needs in good quality and size, of which the major share is from Tamil Nadu, from Palk Bay and Gulf of Mannar coast. 1000 fishermen by skin diving are able to fish out chanks only up to 10 fathoms. It is known that beds extend beyond this depth which can be effectively fished only by training them in SCUBA diving and establishing service centres to cater to their needs in supplying accessories and filling aqualungs with compressed air so that the efficiency in catches can be improved by reaching out to hitherto unexploited beds. The size landed also will improve. It is true mechanised trawling gets as much as 100000 chanks annually as bye catch. But this is undesirable due to the damage caused to the natural habitats and in the possible destruction of chank egg capsules affecting recruitment to population, Observation of 'protected zone' and 'close season' during the trimester January to March which happens to be the breeding season are called for.

It is also necessary to ascertain the size at first maturity of chanks, both for male and female, so as to stipulate the size that can be safely fished. The present 55 mm diameter size is arbitrary and may have to be raised. The state government has its own political and labour considerations with regard to leasing out chank fishing rights and departmental supervision. Whatever the case strict vigilance and effective patrolling the chank beds appear to be necessary to prevent catches being clandestinely sold. These measures will improve the status.

Researches on movement of chanks, their migratory habits, breeding, rate of growth, longevity and laboratory production of baby chanks for sea ranching would help to expand the fisheries in future.

b) *Pearl oyster*

As for pearl oyster it is well known that there is irregular cyclic nature of fisheries. The last pearl fishery was in 1961 after which we had drawn blank. The reasons for poor fishery are far from human control undertaking culture pearl operations would help to produce pearls thus saving the country valuable foreign exchange. The Institute developed technology in this regard has been field tested and found to be a great success. The raw material seed available for farming has also been ensured by mass production of spat in hatchery at Tuticorin. The spat that could be produced annually can run to several billions. Portions of this can be broadcast over pearl' beds periodically and allowed to replenish the paars. The chances of natural pearl fishery can also thus enhanced. Researches on how best the spat so produced can be effectively transplanted by standardising the technique of ranching appear to be necessary. A start has been made on these lines and the results are being monitored and watched. The possibilities of the establishment of more number of pearl culture farms by identifying areas in different maritime states should be explored so that employment opportunities also can improve. At present, the nucleus for the implantation are imported. This problem has to be studied carefully with reference to the possibility of utilizing some of the large shells of bivalves like *Tridacna* and gastropods like *Turbo* sp. and *Trochus* sp. of Andamans for making spherical nuclei of size from 3-8 mm dia.

c) *Turbo* and *Trochus*

Due to indiscriminate fishing for these shells in Andamans there seems to be a scarcity of shells. The status of these in fisheries has to be studied carefully so that restrictive action can follow. Our knowledge of the resources availability of these two is very restricted. A thorough survey of the beds and resources in the Andaman and Nicobar islands is very essential before planning for the future development.

d) *Shell quarrying for lime and industry*

This practice has been in vogue for several centuries wherein poor fisherfolk collect the

dead shells from the coastal waters and estuarine regions and sell them to industry. It is estima ted that annually about 2.5-3.0 lakh tonnes of clam subfossil deposit shells are quarried from Vembanad lake in Kerala by resorting to mecha nical removal. Similarly dead shells are removed by fishermen from the beds in Ashtamudi Kodungallore, Kadalundi and Korapuzha river estuary (50000-60000 t annually), in Kali river estuary in Karnataka (5000-10000 t annually) in Attankarai in Tamil Nadu (5000 t annually) at Sonapur estuary in Orissa (2000 t/ annually) ennore estuary, Tamil Nadu (1000 t), Bucking-ham canal and Pulicat lake (10000 t/annually). 200 t of window pane oyster shells in Kakinada; 100-150 t of the same in Gujarat State. Although this operation aims at the utilization of the buried shells remains very often the price fetched by the shell makes the fisherfolk and those interested in shell collection to remove, indiscriminately all live shells of clams, young and old. The operations done under the right of lease given by State Government is not only a potent activity in disturbing the habitat but also robs the fishermen of the long term benefit of utilizing the meat of the shells. It appears necessary to moderate the activities keeping in view also the interest of the industries concerned. Regulatory practices by declaring closed or protected zones in selected segments would help to increase natural population size giving greater scope for mulluscan meat produc-tion. A Joint National Consultative or advisory body consisting of concerned fishermen repre-sentatives, of industries, department of minor mineral mining, and State Fisheries should go into the merits of each case and decide the future.

Clams and oysters have been well received both in the internal and external markets. Nearly 500 tonnes of this meat has been exported annually. This indicates the area of product development and scope for marketing. As at present trade for molluscan meat is bright. This can be expanded by increasing marketing possibilities in exchange for fishing possibilities. Obstacles remain which prevent us from reaping full benefits from intemational trade. These include difficulties in the level of product quality and quantity demanded by export market, limited trade information and contracts, tariff and nontariff barriers, restrictions of exports of raw material rather than finished products, low share in trade related services etc. There are also possible conflicts between the achievement of national nutritional goals and the objective of increased foreign exchange earning. Expansion of export trade in shellfish activity should be resolved by establishing priorities at the national level at the same time a well developed domestic market helps to reduce the high risks associated with industry based exclusively on export market. It is better to export final product than raw material as per the quality standards. Once this channel is steady and standardised the future holds out great possibilities for a spurt in the exploitation of these edible molluscs.

Disease

At present not much is known about the natural mortality in the molluscan beds Most of the great fisheries of world have experienced fluctuations in supply. Causes of such fluctuations have been much discussed but rarely determined precisely. Among the factors implicated in reduction in abundance are over-fishing, inadequate food supply, disease, change in the environmental condition, drastic and sudden destruction of beds, toxins, predation and indiscriminate harvesting. It is necessary to document the reasons for large scale mortality of population. Whenever such instances are brought to notice it is essential to correctly diagnose the causative factor and study the etiology and take preventive steps. Most of the management practices recomm-ended the establishment of disease diagnostic sections to serve as extension media

I have indicated only broad strategies for future management and development of molluscan resources and I hope this Seminar will throw more light on the problems and constraints faced in molluscan fisheries development and recommend tangible steps to be taken for achieving greater production.

2. DEVELOPMENT OF MOLLUSCAN FISHERIES IN INDIA

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ABSTRACT

The-Molluscan fisheries resources are constituted bythe adible and non-edible species. The former, excluding the cephalopods, comprise mainly the bivalves and the latter a variety of bivalves and gastropods- Development of the edible resources is linked with popularisation and acceptability of the meat as an item of food and the marketing of the meat or the products in the domestic and export sectors. The non-edible species contribute greatly to Industrial raw material in the form of extensive subfossil deposits in the estuarine, brackIshwater and coastal areas. Othe's of this kind support a lucrative ornamental shell and cultured pearl trades.

Production of various bivalves through simple indigenous culture techniques opened up avenues fcr development of these resources through training, transfer of technology and commercialisation of the methods.

Monitoring-of the harvesting of molluscan resources assumes greater importance with reference to rational exploitation and conservation. Dredging operations for subfotsll deposits cause destruction of spat and changes In ecological characteristics of the beds. Transplantation of seed available in nature and sea-ranching of hatchery produced teed of bivalves and gastropods need special attention for augmenting natural productivity. A review of the existing laws and conservative measures would contribute to rational exploitation of the moHuscan resources of the country.

The Molluscan fisheries resources of India constituted by a wide variety of edible and non-edible species occur in a wide range of habitats, typical of any tropical region. James Horneil the British biologist has exhaustively dealt with the Indian molluscan resources in his various publications and reports spanning over the period 1905 to 1951. The symposium on Motlusca conducted at Cochin in January 1968 by the Marine Biological Association of Ind'ra created interest for further research on rholluscan resources. Aspects of biology and fishery of oysters, mussels, clams and gastropods have been studied earlier (Rai 1928, 1932 and 1933; SetnaT933; Rao 1939; Jones 1950 and U73; Rao 1958 and 1969; Rao ef a/ 1962, Anon 1966; Gckhale 1963; Nayar and Mahadevan 1967; Narasimham 1969; Alagar-swami and Narasimham 1973; Jones and Alagarswami 1973; Mahadevan and Nayar 1973; Rasalam and Sebastian 1976; Nayar *et al* 1984; Narasimham *et al* 1984; Nayar dnd Rao 1985; Rao and Rao 1985. A comprehensive account of various molluscan resources have been given under the title 'Commercial Molluscs of India' (CMFRI 1974):

Molluscs are exploited from time immemorial, but of late, the exploitation rate has been found to be on the increase, especially in certain localised areas causing concern for planned development. Although the meat of molluscs is considered highly nutritious, it has limited market in the country at present. At best, they are consumed in coastal areas mainly by fishermen community and few others to a limited extent. With increasing demand for protein rich foods from the sea, the demand for molluscan meat injthe country has also been rising gradually and has even led to export markets in recent times.

The edible species (exclusive of Cephalopods which are not considered in this paper) comprise mainly of bivalves viz *Meretrix meretrix, M. casta, Katelysia opima. Villorita cyprinoides, Paphia malabarica, Anadara granosa. Solen kempi, Parna viridis, P. indica, Crassostrea madrasensis, C. gryphoides* and *Saccostrea cucullata* and few gastropods such as *Trochus niloticus, Turbo marmoratus, T. intercostalis, Xancus pyrum, Oliva gibbosa, Strombus canarium, Lambis lambis, Thais rudolphi* and others. The non-edible molluscs are represented by a variety of bivalves _and gastropods. While the edible varieties are directly used for human consumption in fresh

condition and also for export in the processed state, the non-edible varieties are used mainly for ornamental purposes.

The Andaman and Nicobar islands support a thriving licensed fishery for *Trochus niloticus* and *Turbo* spp mostly for ornamental purposes. Shells of a number of bivalves and gastropods are utilised by the ornamental shellfish industry at Mandapam, Rameswaram and Kiiakkarai (south-east coast) and elsewhere. The shells of both edible and non-edible varieties coupled with vast resources of sub-fossil deposits from the estuaries, brackishwater and coastal areas contribute greatly to industrial raw material for the manufacture of cement, calcium carbide etc. According to Rasalam and Sebastian (1976) th« sub-fossil shell deposits and fresh clam shells are utilised by cement industry to the tune of about 50,000 t annually from the Vembanad lake in Kerala; the calcium carbide industry consumes about 15,000 t besides the lime production in innumerable lime kilns. Rao (1983) reports that an average of 20,000 t of shell deposits are dredged annually with simple mechanical devices from the Kundapur estuary from 1975 onwards, major industries using these deposits being polyfibre, paper and rayon industry in 'Chemical recovery process' and plantation industry in the treatment of effluents and in neutralisation of soils of coffee and tea plantations.

Many estuaries, brackishwater and coastal areas abound in a wealth of moliuscan resources. But a precise knowledge of the natural resources is still wanting. This is due to the limited use to which the meat is put to. This again is linked with the food; habits of the population where the shellfish meat is frowned upon. Therefore, further development of the moliuscan resources would depend upon popularisation of the meat in the country as well as the export sectors.

In view of the recent demand for moliuscan meat and their products, the effect of fishing on the natural populations needs a closer scrutiny since the known beds which are in easy access are rapidly exploited. What is immediately needed is the proper assessment of exploited populations. Exploited shell fish resources do not find a place even today in the landing figures of the country. Recent investigations by the Institute provide some information on the standing stocks in some selected segments along the coast. The exploitation rate should be linked with the rate of regeneration including growth and biomass production. The settlement of spat and overcrowding in natural beds a'so need critical evaluation. In several parts of the country, the demand for raw materials for various industries from natural resources like subfossil deposits is ever increasing. The resultant dredging to recover shell deposits removes live clams as well as spats which would have settled down in such regions. Repeated dredging in the same area can cause extensive damage to the future settlement of spat thus leading to depletion of the resources. According to Rao (1983) continuous dredging in the Kundapur estuary which was yielding good quantities of live clams before the dredging operations, has completely destroyed the clam beds by disturbing the substratum thereby preventing fresh spat settlements. Moreover dredging results in heavy sedimentation which is not conducive for spat settlement.

Recent studies have indicated that various commercially important bivalves could be produced in commercial quantities through indigenous culture techniques. It has been demonstrated that it is possible to obtain high yields of bivalves in few months'time (Qasim *etal* 1977; Appukkuttan 1980; Kuriakose 1980; Narasimham 1980; Ranade and Ranade 1980; Rangarajan and Narasimham 1980; Silas er«A 1982 and Nayar and Mahadevan 1983). However, due to lack of necessary incentives and possibilities of marketing within the country and outside, the technologies developed have remained almost on an experimental scale only. Economically also, moliuscan culture is not as attractive as shrimp farming. Further development of moliuscan fisheries through culture would be successful only <wheh commercialisation of the results achieved through research are given serious consideration, coupled with identificatior^ and development of markets both within and outside the country.

While a number of technologies , have been developed tp produce bivalves in large scale (CMFRI 1983 a; 1983 b; 1986), further

survey for suitable areas for culture along the coast has to be conducted Seeds of commercially important species will have to be transplanted in suitable areas where they are not naturally available. Sea ranching programmes have to be taken up to replenish the natural stocks as well as to develop new beds.

With the possible increasing demand for production of molluscan meat through culture systems, the hatchery technologies already available will have to be improved and propagated

Monitoring of the harvesting of molluscan resources assumes greater importance with reference to rational exploitation and conservation. A review of the existing laws and conservation measures would contribute to judicial exploitation of the shellfish resources. Training and transfer of technology programmes need to be expanded to create an awareness of the importance of the molluscs In the economy of the country.

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3. CHARACTERISTICS OF CLAM RESOURCES OF VEMBANAD LAKE - A CASE STUDY

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ABSTRACT

The Vembanad lake, covering about 200 sq. km, it supporting a rich fishery of clams mainly constiiuted by *VillorIta cyprInoIdes* vac *Cochinensis* and the total production Is around 25,000 t/year- The lake is divided into s'x zones for studying the pattern of exploitation and seed production and the results are presented in the paper.

The effect of manual exploitation of aubsoil deposits ranging from 41,000 to 70,000 t/year and of dredging on the clam beds is also presented with comments on the development possibilities in the sector based on this case study.

INTRODUCTION

Vembanad lake, having about 200 sq km waterspread, is one of the major estuaries in India, and is supporting two major factories and a large industrial network in Kerala and Tamilnadu for their requirement of lime shell as raw material. The supply of lime shell from this lake is exclusively from clam shells in the form of dead subfossil deposits and also from the harvest of live *Villorita cyprinoides vat Cochinensis.* As this important resource has been threatened to the level of depletion because of the high rate of consumption, the Central Marine Fisheries Research Institute has initiated a detailed

investigation in 1979 on the exploitation of clam resources of Vembanad lake and its socio-economic implication and a detailed report (Achary1986) has been made on this subject and some of the major findings on the resource are presented in this paper. At this context, the earlier studies made by Kunjupanicker (1957) and Rasalam and Sebastian (1976) are worth mentioning.

FISHING AREAS OF THE LAKE

For studying the production potential of the lake, it was felt necessary to divide the lake into six zones having certain characteristics such as the exploited size of clams, the grouping of fishermen etc. since they belong to different co-operative societies functioning in the respective locality. The following are the areas included in each zone.

Zone I. Thevara, Kumbalam,Thekkumbhagom, Manakkunnam, Chembu, iKulasekharam, Arobr, Aroblcutty, Vaduthaia, Mattathilbhagom, Kuthiathodu.

^°"® "• Thycattusseri, Pallipuram east, Pallipuram west, Chenganda, Vayalar.

_, , .

Zone III. Thannrrmukkon North, Thannirmukkon South, Kokkothamangalam, Shertallay Municipal area Ward VI.

'^°"® '^" P°""3<^' Mannamcherry, Aryad north, Aryad south, Alleppay, Kainakarl, Pulimkunnu.

Zone V. Neduvila, Vaikom, Thalayazham, Vechoor north (north of bund),

Zone VI. Vechoor south (south of bund), Kaipuzha, Ayimanam, Kumarakom, Tiruvarpu, Nattakom.

The above zones are shown in Fig 1 '" detail.

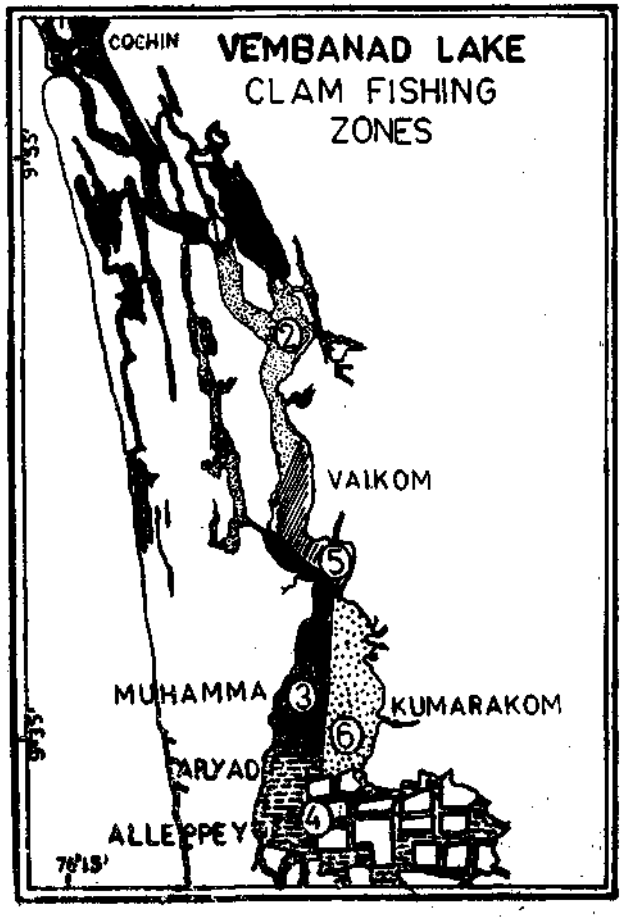

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Fig. 1 Map of VembanadlakB showing the clams fishing zones

METHODS OF STUDY

Fishermen belonging to the above zones collect their daily harvest of clams and dispose the catch through the societies to which they belong. So it was possible to get the realistic estimate of the clam! production by periodically visiting these societies and to collect the data on the different size groups exploited daily. In addition samples from the fishermen were taken directly from the canoes for the biological studies. Similarly the factories were visited periodically to collept information on their consumption of lime shell and other details A socio-economic survey also was conducted to evaluate the impacts of this fishery and to suggest measures for improvement. The results are summarised and presented in this paper.

EXPLOITATION OF LIVE CLAMS

Clams are harvested as an annual crop from this lake as well as the small Islands known as '"Thuruthu". It was observed that the average annual production of *ViUorita cyprihoides Vat Cochinens/s from the* lake was 21,490.5 t during 1979 to 1984. The details of ; production during different years are

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TABLE - 1. *Harvest of live clams from Vembanad lake by fishermen (Figures in tonnes for calendar year)*

Centre of collection Zone of Collection	Kuthiathoda I	Thycattusseri II	Muhamma HI	Aryad IV	Vaikom V	Vechoor VI	Total for the year	Remarks
1979	2591.75	5661.96	3255.86	3619.56	4153.50	195.50	19478.13	
1980	4087.36	6527.52	4061.86	3241.50	4195.00	512.26	22625.50	
1981	3508.34	4421.62	5727.20	5369.30	4742.00	610.18	24378.64	Mass
1982	3519.96	4937.50	5275.02	5344.24	4856.00	1052.34	24985.06	rnortality
1983	4283.60	4265.80	4650.42	4499.30	4373.00	1599.28	23671.40	and heavy collection
1984	4126.80	3644.00	1507.46	1524.94	2529.00	472.28	13804.48	°^ ^'^^" sized
1985Ja.to March	672.00	314.50	220.00	612.50	400.00	85.52	2304.52	clams (for Jan. to Mar. 85)

presented in Table I. The lowest production of 13,804.5 t in 1984 is found to be due to mass mortality and also due to heavy exploitation of small sized clams. Except in zone Vl the production is more or less stable but in zones III, IV and VI which are south of the Thannirmukkon bund the clam production has gone down considerably in 1984 due to the mixing of sub soil acidic water.

The exploitation of smaller size groups of clams is more than 50% in the northern most zone (zone I) and this group is supposed to be of the seed clam size. It is also one of the major reasons for low production in this zone and these clams can be utilized for culture by transplantation as practised in Thailand and other countries. Similar practice of fishing is observed in zone II also and these two areas are found to be highly productive for the seed clams. However, in zone III and IV which are south of the Thannirmukkon bund, clams above 15 mm size only are harvested and seed clam fishing is very rare.

EXPLOITATION OF SUBSOIL DEPOSITS

The subsoil deposit is known as "white shell" and the annual landings range from 41,445.04 to 69,305.98 t. The harvest is made by the fishermen from zones I, III, IV, V and VI and the details of annual exploitation is presented in Table 2 for the respective zones. The maximum collection of shells is recorded at zone III ranging from 13,029. 3 to 26,499.7 t. and the minimum at zone I ranging from 719.4 to 1012.5 t.

In addition to collection of shell directly from the lake, from paddy fields also huge quantities are exploited at zones IV and VI. At zone IV a maximum of 88,784. t. of shells were collected in 1984. However, the landing from zone VI by members of one of the societies is exclusively from paddy fields which are reclaimed and it ranges from 9,390 to 17955t. This adds as a subsidiary income for the fishermen in addition to their income from paddy and coconut plantation.

EXPLOITATION BY FACTORIES AND EFFECT OF DREDGING IN VEMBANAD LAKE

The Travancore Cements Ltd., Nattakom, Kottayam, the Travancore Electrochemicals, Chingavanam and the Pallathra Bricks and Tiles Ltd, Shertallai (at present the Kerala Construction Components Ltd) are the three factories utilising lime shell at an annual

TABLE 2. ***Harvest of subsoil deposits of clam shell from Vembanad lake by fishermen (Figures in tonnes for calender year).***

Collection Centre	Keinalcari	Muhamma	Kumarakom	Vechoor	Mattathil Bhagom	KaiPuzha-Vechoor	Grand total for the year
Zone of collection	IV	iII	VI	V 6 V I	1	VI	
1979	3950.80	15988.88	6541.46	7549.70	N. A.	17955.00	51985.84
1980	3605.74	17318.08	7531.56	8467.16	719.40	9390.00	47031.94
1981	4098.98	16305.46	6420.94	6763.26	837.74	13007.00	47469.75
1982	6161.54	22376.56	7939.70	7193.80	835.86	14836.00	59343.46
1983	3043.82	13029.26	6419.54	7293.16	727.76	10931.50	41445.04
1984	12941.74	26499.70	6816.06	6956.02	1012.46	15080.80	69305.98

average of 95,0001. The first two factories are collecting lime shell by dredging from the lake and the third factory is depending on contract labour. However the major consumption is by the Travancore Cements (about 50,000 t) followed by the Travancore Electrochemicals (about 41,000 t) and by the Pallathra Bricks and Tiles (4,0001.)

A study on the effect of dredging in Vembanad lake is also made during this period and heavy silting condition is noticed around the dredging area which is found to spread around 1.5 km radius from the dredge due to mixing of water, drift current and by wind actions. The suspended silt which does not settle within 24 h is found to be 0.155 g/l around the dredged area. For complete sedimentation, if undisturbed, it takes 40 h in the laboratory and it may take more time in the lake for settlement because the water is always disturbed. The penetration of light ranged from 15 to 25 cm during bright sunny days around the dredged area and in other localities it ranged from 50 to 80 cm. Observations also indicated that clam are surviving well beyond 0.5 km radius from the dredge area. The washed out sand and silt during the dredging make the lake's bottom uneven and also the superficial layer formed by the settlement of silt makes the layer very smooth, covering the settled larvae of clam which may lead to mortality of the larvae also. However, this is not affecting the total production of clam in the lake because the larvae are capable of moving to favourable conditions and are selective in forming the clam bed and when the total area of the lake is considered, the silted area due to dredging is negligible.

DEVELOPMENT POSSIBILITIES

The scope of improving clam production of the Vembanad lake is presented in detail in the study report (Achary 1986). The activities of the present Co-operative societies working in this area can be expanded by diversification and by channelising the development programmes of the state to these societies also. The details of diversification are presented elsewhere in one of the management papers presented in this seminar by the author. There is also the scope for starting additional societies at the northern parts of the lake and the practice of exploitation of undersized clams can be discouraged by creating a general awareness among the concerned which will help increasing the production of live clams.

ACKNOWLEDGEMENTS

The author is very grateful to Dr. P.S.B.R. James, Director, for his encouragements and to Dr. K. Alagarswami, Scientist S-3 and Shri S. Mahadeven, Head of molluscan division for their interest in this study.

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4. CLAM RESOURCes OF THE ASHtAMUDI LAKE, WITH SPECIAL REFERENCE TO *KATELYSIA OPIMA* (GMELIN) FISHERY

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ABSTRACT

The clam fishery rasourcts of ths Ashtamudi lake are supported by several species belonging to *VIllorIta, Katelysia, Meretrix* and *Paphia.* However, *VillorIta cyprInoides* and *Katelysia opima* contribute to the bulk of the resource. The extant of the major clam beds, the estimate of the present stock and the magnitude of the axIsting fishery suggest increased production. The exploitation and utilization of Kafe/ys/a op/ma, which has got great export potential, are dealt with in detail. Some steps for the judicious management of the clam resources are also suggested.

INTRODUCTION

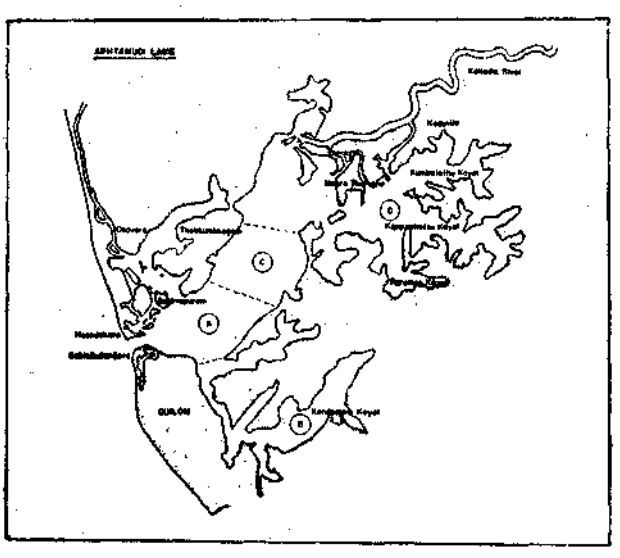
Among bivalve molluscs, clams form an important resource as meat for human consumption and as lime-shell in cement and calcium carbide industries. Very little is known about the clam resource of the Ashtamudi lake situated on the southwest coast of India and second only to the Vembanad lake in Kerala in area and clam production. The only study is that made recently by Appukuttan et al (MS) on *Katelysia opima* (Gmelin). The present paper gives a baseline information on the status of the clam fishery with special reference to the fishery and utilization of 'baby clam', *Katelysia opima*-

AREA AND METHODS OF STUDY

The Ashtamudi lake is situated between lat. **8'45'-9°28' N and long. 76°28'-77''17'E, It** has a waterspread of 32 km'and is connected to the Arabian Sea through a perennial opening, permitting an estuarine condition almost throughout the year. The Kallada river which joins at the northeastern part is the source o* freshwater to the lake.

To assess the present status of the clam fishery and its prospects, survey of the Ashtamudi lake [was undertaken in February 1984. For thiXthe entire area was divided into Mones, viz. Dais apuram, Ashtamudi mudflat (Neduvathu Thututhu), Kandachira Kayai and Kanjirakottu Ksyal (Fig. 1).

Areas of occurence of clams were first ascertained by enquiries with -regular clam



p.^ ,. ^,^ „, ^.^tamudi estuary.
A. Oalavapuram B. Ashtamudi mud flat C. Kanachlra Kayai o. Kanjirakottu Kayai.

pickers and also by observing actual fishing, T / i j- * Stations were fixed at a minimum distance of 200 m from each other. Water samples were collected for temperature, salinity, dissolved oxygen, phosphate, nitrite, nitrate and pH analysis. Wherever the depth was more than i m, water samples from the bottom were collected with a Casella bottle for estimating ^^ese parameters. Sediments from very shallow ^^^33 ^3,^ ^^^^^ ^.^^ ^3^^ 3^^ when the depth was more the sediment that came along with the clams in the clam sampler was collected for determining the nature of the

bottom. All the samples were analysed in the Mobile Laboratory.

A sampler designed by G. P. Kumaraswamy Achary was used for collecting samples of clams (Fig. 2, E). This is a hand-operated dredge having a rectangular iron frame 0.25 m long. There are small spikes on both the longer rims of the dredge. A 75-cm nylon netting of 10 mm mesh is tied to the frame. The codend of the net is open, which can be closed by tying a thread. A nylon rope is attached to the dredge for dragging it on the bottom. One haul with the dredge covering

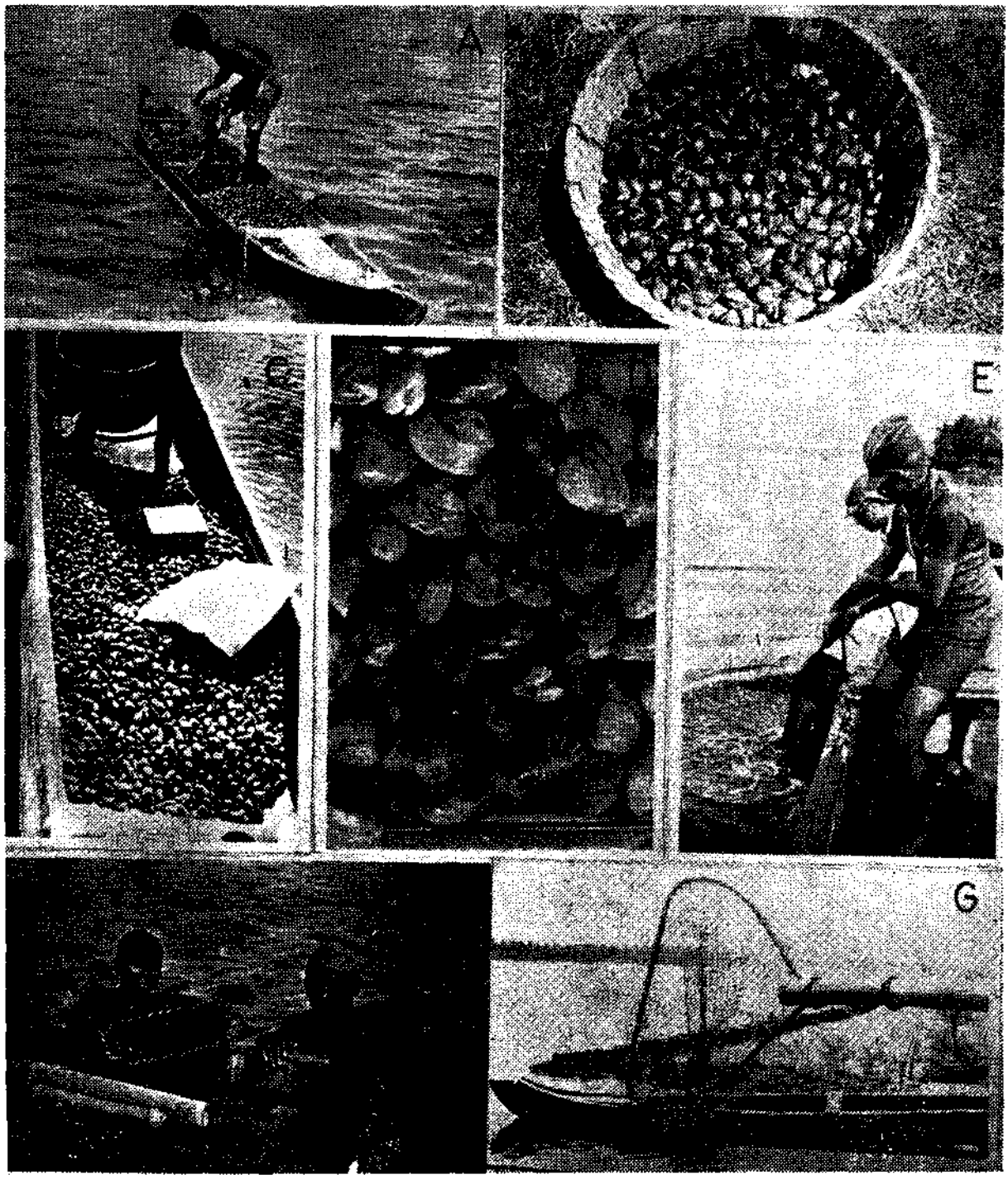


FIG. 2, A–G: A. A canoe full of black clam, *Villorita cyprinoides* from Kanjirakottu Kayal. B. Black clam, *Villorita cyprinoides*. C. Black clam for sale in the coastal villages around Ashtamudi. D. Baby clam, *Katelysia opima*. E. Clam sampler in operation. F. Divers unloading the black clam catch in to the canoe. G. Hand-dredge used for collecting baby clam.

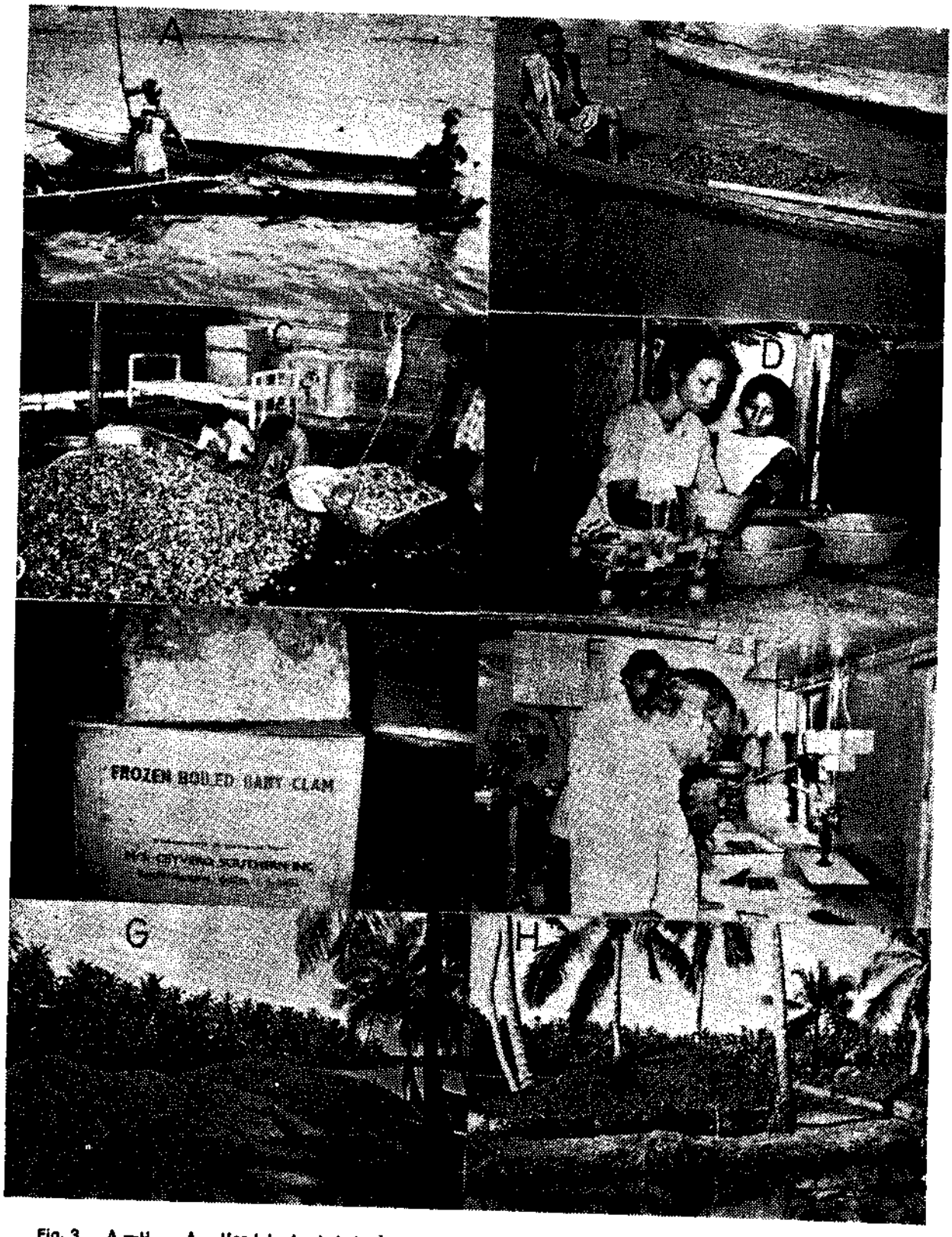


Fig. 3. A.—H. A. Hand dredge is being operated from the canoe for baby clam collection at Dalavapuram B. Baby clam is being taken to the processing shed. C. Grading the clams beforetaking them to the purification tanks. D. Grading the boiled and shucked meat. E. 2-kg frozen slab of clam meat for export. F. Analysing clam samples inside the Mobile Laboratory during survey. G. Baby clam shells stocked for industrial use at Neendakara. H. Heaps of black clam shells at Munro Thuruthu.

one metre distance gives the clams available in 0.25 sq. m area.

Apart from collecting clams with the dredge, samples were taken from the regular fishery for qualitative studies and for comparing with the sampler collections.

OBSERVATIONS AND RESULTS

A. Dalavapuram: Dalavapuram area (Fig 1 A) harbours a rich clam bed of about 15 ha which sustains regular fishery. The species of clams is *[Kate/ysia op/ma* (fig. 2, D); stray numbers of *Meretrix meretrix* and *Paphia* sp are also met with. Twelve stations were fixed in this area. The depth of these stations ranged from 0.5m to 3.5 m. The sediment was composed of coarse, medium and fine sand clay.

Water temperature varied from 29°C to 31.3°C at the surface and from 23.6^C to 31 °C at the bottom. Surface salinity range was 23-28.37oo and the bottom salinity 22-287oo- Dissolved oxygen varied between 3.06 ml/I and 5.10 ml/I for surface waters and between 3.40 ml/1 and 6.12ml/i for bottom waters. The phosphate values were 1.23-2.31 (ig/l for surface, 1.77-4.48 t*g/l for bottom; nitrate: 23.65-30.65 ^wg/l and 23.65-35.32 ug/l; nitrate: 20.01-70 /*g/l and 10-50.03 i^g/l ; pH: 7-8.5 for surface and 7.5-8.5 for bottom waters.

Fishing methods and fishery: Appukuttan et a! (MS) have given the different methods employed in clam fishing which vary from the simple, traditional, hand-picking to scooping and dredging (fig. 2.) The fishing is generally done at low tides for 3-4 h and till the'canoe is full with clams or the high tide begins. A canoe with 2 persons takes about 200-300 kg of clams per day. In the fishery for edible purpose, only the medium and large-sized clams are taken.

There is clam fishing throughout the year, with peak in February-March. During March-May 1982. there were 20 clam pickers and 40 canoes on an average per day. As the export demand for clam meat increased, the number of persons as well as canoes also increased, and on a single day in February 1984 there were 160 canoes with 271 persons fishing for clams.

Appukuttan et al (MS) gave the catch of *Kate/ysia opima* from Ashtamudi take during March 1982 to February 1983 as 5^436.5 t. There has been good fishing in subsequent years and though the exact catch figures are not available, judging from the demand for clam meat in the export trade, the present level of production is estimated at 6,000 t to 6,500 t. Based on the present survey it is estimated that the existing stock of *Katelysia opima* in this area is around 10,000 t.

Size range: The size frequency of *Kateiysie* op/ma collected with the sampler from Dalavapuram clam bed during February 1984 is given Fig. 4A. The size ranged from 5 to 44 mm with a dominant mode at 17 mm; there were smaller modes at 26, 35 and 41 mm. Since spawning takes place during December-February (Appukuttan et ai MS), there is a dominance of smaller size groups up to 20 mm. In the fishery the maximum exploited size is 30-40 mm.

Utilization: About 5% of the total clam production is consumed locally and the rest is being exported as frozen 'baby clam' Fig. 3 C, D, E). The export of clam meat which began in 1981 has reached 608.6 t, worth Rs. 7.6 million in 1983. The major buyer of Indian 'baby clam' is Japan; other importing countries are the U. A. E., U. S. A. and the Federal Republic of Germany.

During 1982-83 the price paid to the clam-picker varied from 20 to 40 paise per kg of whole clam, and Rs 3.50 to 7.00 for the meat; during the 1984 survey it was Rs. 1.25 and Rs. 7.50-12.00 respectively.

The bulk of the shells is taken to Tamil Nadu for the calcium carbide industry, and a small portion is used locally for producing lime (Fig. 3, G).

lVleretrix meretrix, locally called *'valla k^kka',* occurs in very small numbers along with *Katelysia opima,* especially in the upper reaches of this clam bed of Thekkumbhagom. The size range of the clam taken in the sampler

In February 1984 was 10-51 mm (Fig. 4 B). The dominant mode was at 20 mm with two smaller modes at 29 and 44 mm. The entire catch is used for local consumption. It is gathered that there was illegal dredging of white clam shells till about 1982 in the northern part of the Ashtamudi at the entrance to Chavara canal.

B. Ashtamudi Hudflat: The Ashtamudi mudflat is on the eastern side of the Dalavapuram bed, about 10 km from the bar mouth (Fig IB). It is a very shallow submerged mudflat, the maximum depth being about 1 m. The bottom sediment consists of coarse sand and mud. There was plenty of weeds on the bottom.

Only two stations were fixed in this zone, as there was no clam fishery. In both the stations the surface water temperature was 30°C, salinity 24-25%o and dissolved oxygen 3.40-4.08 ml/1; phosphate gave a single value of 1.77 t*g/1, and nitrite 30.65-32.99 (Jig/1. The pH of the water was 9.

The clam sampler was used at both the stations. There were a good number of *Modiolus* and dead shells of *Sanguinolaria.* A few seed clams *(Meretrix)* were hand-picked. However, adult clams were absent.

C. Kandachira Kayal: This zone is situated south of Dalavapuram zone.and consists of many narrow creaks and inlets. Six stations were fixed during the survey. The depth of these stations was 1 2m. The bottom sediments consisted of fine sand and mud. At some stations the sediments were black in colour, emitting strong smell of hydrogen sulphide because of extensive coconut retting.

The surface temperature ranged between 30.5X and 31.4°C. salinity 22-24% dissoloved oxygen 2.70-403ml/l, Phosphate was estimated at 2.31 (xg/1, nitrite 28.32|Jig/l and pH 8.5-9.

In the clam sampler collection, no live clams were collected except for plenty of *Modiolus:* dead shells of *Vi/iorita* and *Sanguinolaria* were hand-picked. It is learnt that previously there were live clams and small scale clam picking for domestic consumption.

Both white and black clams are brought In small canoes from Dalavapuram and Chavara areas and sold to coastal households. The price is about 25 paise for a measure by coconut shell which may Contain 50-60 small and 20-25 large clams. Sometimes women bring fresh clam meat to the market and sell at the rate of 40-50 a rupee.

D. Kanjirakottu Kayal: This is a very extensive area forming the eastern segment of the Ashtamudi lake which branches off into 3 arms, Kumbaiathu Kayal, Kanjirakottu Kayal and Perumon Kayal with their many creeks (Fig. 1D). This is a very rich ground for the black clam *Villorita cyprinoides,* locally called *'Karim/(a/(/(a'.*

Thirty-one stations were fixed in this zone and the depth of clam grounds was1-3.5m. The nature of bottom varied greatly from gravel to clay but mostly it was muddy with fine sand and clay.

Temperature ranged between 30°C and 32.8°C for surface waters and between 30.2°C and3l.5°C for bottom waters. Saline conditions prevailed even at the uppermost reaches of the take. Surface salinity range was 10.75-25%o and for bottom salinity 21-26%o Dissolved oxygen ranged between 2.72ml/l and 6.78ml/l for surface waters and between 0.34 ml/l and 6.12 ml/l for bottom waters. Other parameters estiniated are: phosphate 0.89 2.85 (Jg I for both surface and bottom; nitrite 30 65-32.99 l*g/l for surface and 28.32(J'g/l for bottom; nitrite 20.01 -30.02 /*Jgii* for surface and 20.01-40 (*g/l for bottom; pH 5-9 for Surface and 5-9 for bottom.

In the Manakkadavu area there is good *Villorita* fishery. During February-April which is the peak season, about 150 people do clam fishing here, and the fishing may continue up to June. Clams are collected either by hand-picking or with a rectangular or semicircular metal frame attached with a net-bag. The frame is dragged on the bottom, pushing the clam into the net. The catch is emptied into canoes or submerged baskets. The meat is sold to coastal households and also in the markets at Kundara, Kallada and nearby places. Women do clam-picking in very shallow waters. Many women who work in the nearby cashew factories go for

clam-picking when tiiere is no worl< in tlie factory. There are about 100 such women who pick clams both for domestic consumption andforsale.

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There is good demand for clam shell and 10 kg of shells fetch Rs. 1.25-1,50. Bigger canoes with 3-4 men are employed for collecting clams of all sizes. A heap of about 50 t of clam shells stocked for sale was observed in MunroThuruthu (fig 3 H).

The Kumbalathu Kayal of this zone is very rich in *Villorita* resource. Here also the peak fishing season is February-April, and from mid-June to October-November is the closed period. Over 150 people including 20-25 women go for clam fishing in good season. About 75-90 canoes are employed every day. Normally one person with a canoe takes about 100 kg of clams. People of all communities except Brahmins go far clam fishing and consume clam meat.

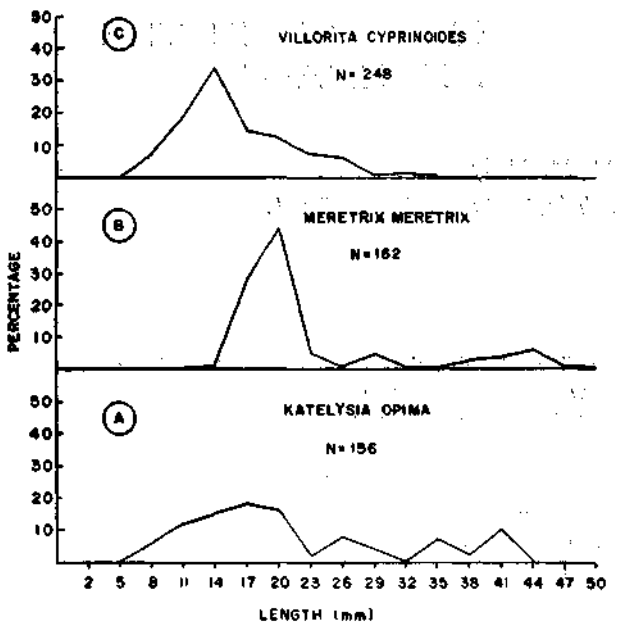

Fig 4. Length frequency distribution of clan)*.
A. *Katelysia opima* B. *Meretrix mtrttrix*
C. *Villorita cyprinoidBs*

Near Kumbalam on the southern bank of the Kumbalathu Kayal there is a lime kiln and a stocking place for shells. Recently collected clams are stocked under water in enclosures for completely decaying the meati^Thes% are rribstly very small clams cofllected for the shdlli^ Fishermen collect the shells in fcanoesind self to merchants at the rate of Rs. 1.60 per basket' of about 20 kg.

Based on a few day's observation during the survey, the ahntial prodiictidn is' estirttated at 5,600 to 6,000 t. thia dlarh bed is spnsad ih' about 50 ha though it is patchy at rhariy places' with very stray occurrence of cl^ms. The estimate of the present stock of *VHlorita cypflndi l(l*es is a;piinc^ 12,0QQt.

'" '*i's becl th^cjams ranged in lengtK ^''°'" ^ ^° ^'^ ""'^ ^'*^ ^ '^°'^® ^' 14 mm (^'9 * *->•

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REIVIAnNb

Nair et al (1983) have studied in detail the physicochemical features of water and nutrients of sediment of this lake. According to them the heavy flow of fresh water from Kaliada river an^o tliis^lake;minirTiises pollution by effluents frorp the punalur Paper iVlills,

With the beginning of export of clam meat in 1981 the, prpduction of *Katelysia opima has* increased but in, 1984-35 there was a lull in export demand and with this an indiscriminate fishing for small clams started for the shell for industrial purposes. This created an alarming situation but the export was resumed and the fisherrtien concentrated on 30-49-mm size clams suitable for ekport. Though the fisheyb'ien claim that there is a self-imposed restriction that under-sized clams should not be collected, such restrictions are Yiot often observed. During January-March period seed clams and young-ones are plemy, and to prevent their exploitation fron Dalavapuram area regulation of the mesh size of the hand-dr«dge to 30 mm is recom. mended.

At present thpre is no licensing system for fishing in Ashtamudi lake. Such a system as followed in the Vembanad lake (Rasalam and Sebastian 1976) can be considered for adoptipn for this estuary also for preserving the valuable clam resources.

Though there is every possibility of increasing the production of black clam *Villorita cyprinoides* from the estimated 50-ha bed/ indiscriminate fishing of smaller sizes (<20 mm) was observed in certain areas. Such practice should be put to an end.

Vigorous quality control of the clam meat processed for export should be maintained. A consignment sent during September-October 1986 was rejected by Japan because of the presence of traces of kerosene.

To augment production, farming *Katelysia op/ma* by transplantation of seed clams to suitable areas in the estuary is suggested.

Another suggestion is that the meat of black clam can be canned or pickled, so that the consumer demand will increase.

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ASSESSMENT OF CLAM RESOURCES IN THE ESTUARIES OF DAKSHINA KANNADA

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ABSTRACT

Clam resources In all the eight estuaries of Dakshlna Kannada, viz., the Nethravsthi, Gurpur, IVluiky, Udyavara, Swirna, SIti, Coondapoor and Uppunda were assessed during 1984. The total clam resources 'standing stock) of these estuaries are estimated at 4900 t. About 92% of this resource was found in the Mulky estuary. The clam resources were negligible and formed less than 1% in the Udyavara, Swarna, Site. Coondapoor and Uppunda. *Meratrix casta* js the chief species followed by *Paphia malabarica* and *Villorita cyprinoides.* Species-wise distribution of clams in different estuaries along with the environmental parameters and biological characteristics of different clam species are presented. Information on the utilisation and marketing is also given.

INTRODUCTION

Clams are the chief molluscan resources of the estuaries and back waters along the Kamatake coast. They are gaining importance In the economy and in recent times an export trade for frozen clam meat is being developed. Earlier works on the clam resources of this area are by Alagarswami and Narasimham (1973), Rao and Rao (1985) and Narasimham et al (>1986). Gopal et al (1975) and Rao (1983) jeait on shell deposits while Rao (1984) made observations on the clam fishery,

MATERIAL AND METHODS

The clam survey of the Nethravathi, Gurpur, Mulky, Udyavara, Swarna, Sita, Coondapoor

and Uppunda estuaries was conducted during April-May 1984, Salinity, oxygen, temperature, pH and sediment data were collected and analysed from each bed. Depending upon the extent of clam bed, the number of samples varied. If the area is under 5 ha, 5 samples were collected, and 10 samples/5-20 ha, 20 samples/20-50 ha, 30 samples/50-100 ha and 50 samples if the area is more than 100 ha. One square matre of the bed was sampled with the help of a galvanised iron frame, the sediment was passed through a 2 mm mesh to retrieve the clams. A portion of the sample was examined for biological analysis, like length frequency, condition index, and stage of maturity. The average weight of clam species in each bed was taken into consideration to quantify the clam resources in each bed. The extent of the clam beds was calculated based on length and average width of the bed. All the estuaries and clam landing centres of Dakshina Kannada were visited once in a month during 1983 to collect data on the quantity landed, species composition, number of persons involved and method of collection. These observations were supplemented with the the enquiries from the fishermen and merchants-

RESULTS

Nethravathi estuary: There were three beds covering 48 ha. *Villorita cyprinoides* was found in all the three beds (Table 1). The total standing stock was estimated at 75 t. Most of the clams were small sized. The substratum was sandy and salinity ranged from nil to 17ppt. The dissolved oxygen ranged from 5 to 5.7 ml/l and pH varied between 7.5-8.0. In this estuary clams are exploited by hand picking. During 1983, 149 t of *V. cyprinoides* and 233 t of *M. casta* were exploited. During the current survey *M. casta* were observed only in stray numbers. In 1979 (Rao and Rao 1985), *M. casta* were observed in good concentrations.

Gurpur estuary: The total standing stock of clams during April 1984 was estimated at 3451 (Table 1) in 72 *ha. P. malabarica* was the dominant species, followed by *V. cyprinoides* and *M. casta.* The substratum is sandy; salinity ranged from 26.16 to 35.5 ppt, dissloved oxygen from 4.1 to 5.1 ml/l and pH 7 5 to 8.0. The exploitation of clams was by hand picking, clam nets and shell-dredge. Shell-dredge was mostly used to collect *P. malabarica* as it was found in slightly deeper waters, near the mouth of the estuary. In 1979 (Rao and Rao 1985), *P. malabarica* was not observed. The estimated clam landings during 1983 (Table 2) from this estuary were about 1281 t, out of which about 50% were *P. malabarica.*

Mulky estuary: This is a small but very important estuary for clam resources with maximum stand-

TABLE 1. *Clam resources of Karnataka south zone (Dakshina Kannada). ApriUMay 1984 (in tonnes).*

Estuary	*M. casta*	*P. malabarica*	*V. cyprinoides*	*Total*
Nethravathi	@	—	75.426	75.426
Gurpur	84.2	164.82	94.800	343.82
Mulky	3663.00	744.00	@	4407.00
Udyat/ara	33.8	@	@	33.80
Swarna	@	—	@	@
Site	3.42	—	@	3.42
Coondapoor	18.8	@	—	18.8
Uppunda (Baindoor)	@	@	—	@
Total	3803.22	908.82	170.226	4822.266

@ indicates stray occurrence of the species.

TABLE 2. ***Species wise dam landings of the estuaries of Daicsfiina Kannada during 1983 (in tonnes).***

Estuary	*M. casta*	*M. meretrix*	*P. malabarica*	*v. cyprinoides*	*K. opima*	*Total'*
Nethravathi	233	—	—	149	—	382
Gurpur	307	—	600	374	—	1281
Mullcy	1814	—	578	—	—	2392
Udyavara	216	—	6	—	—	222
Swarna	—	—	—	15	—	15
Sita	362	8	—	2	5	377
Coondapoor	53	43	528	8	8	640
Uppunda	11	...	80	—	69	160
Total	2,996	51	1,792	548	82	5,469
/o	54.8	0.9	32.8	10.0	1.5	

ing stock when compared to other estuaries. The total standing stock during May 1934 was 4407 t, spread over an area of 232 ha, occupying almost one third of water spread of the estuary. M. *casta* was dominant followed by *P, malabarica.* Clams from this estuary are marketed in most parts of Dakshina Kannada. Here clams are collected by hand-picking and clam nets. The magnitude of clam landings from this estuary varied from 40 t to 951 t during 1978-82 (Rao 1934). However the landings have showed considerable improvement during 1932-84 and amounted to 1659 t and 31091 respectively. In general *M. casta* was the dominant species. The substratum is sandy; salinity ranged between 35.1 to 35.65 ppt, dissolved oxygen from 39 to 4.7 mi/1 and pH from 6.5 to 7.5.

Udyavara estuary: A 10 ha clam bed was located, with a standing stock of 34 t of M. *casta* (Table 1). In 1980 good stocks *of M. casta* and *P. malabarica* were observed (Rao and Rao 1285), During 1983 the clam landings were estimated at 222 t (Table 2) compared to 250 t during 1980. The substratum is sandy. The salinity ranged from 29.83 to 35.16 ppt, oxygen from 4.1 to 5.1 ml/1 and pH from 6.5 to 7.5.

Swarna estuary: This estuary joins the sea, after confiuencing with the Sita estuary. No recognisable clam beds were observed in this estuary. *V. Cyprinoides* and *M. casta* were available in negligible numbers. The estimated clam landings during 1983 were about 15tof *V. cyprinoides.* In 1979 also (Rao and Rao 1985) very poor clam resources were observed The sediment is sandy, salinity varied from 28.2 to 35.65 ppt; dissolved oxygen from 4.1 to 4.6 ml/1 and pH from 6.5 to 7 5. Sub-soil shell-deposits are exploited from this estuary on a large scale.

Sita estuary: In this estuary also, the clam resources were negligible. *M. casta* ware found in very low densities in an area of 9 ha. In 1979, Rao and Rao (1985) reported on good clam resources. The estimated annual landings of clams during 1983 were 377 t. The sediment is sandy; salinity ranged from 28.2 to 35.6 ppm, dissolved oxygen from 4.1 to 4.6 ml/l and pH from 6.5 to 7.5.

Coondapoor estuary: This is one of the biggest estuaries in Karnataka. However, very limited clam resources were observed. In 1979, moderate clam resources were observed (Rao and

Rao 1985). During 1983 the estimated dam landings (table 2) from this estuary were 6401, mostly comprising *P. malabarica.* Other clam **species observed are *M. meretrix, M, casta V.*** *cyprinoides* and *K. opima.* There is heavy sub-soil shell deposit exploitation in this estuary (Rao 1983).

The substratum is sandy, salinity ranged from 30.4 to 35.15 ppt; dissolved oxygen from 4.2 to 4.6 ml/I and pH value of 7 was recorded.

Uppunda estuary: This is the smallest estuary in Dakshina Kannada. No recognisable clam bed was observed. Few specimens of *P. Malabarica.* ***K. opima, M. casta* and *M. meretrix* were** collected. A total of 160 t of clams were landed during 1983 (Table 2). During 1980, Rao and Rao (1985) also observed very poor clam resources. The sediment is sandy; salinity ranged from 33.49 to 35.65 ppt, dissolved oxygen 4.0 to 4.1 ml/I and a pH value of 7 was obtained.

Conditior) index: The condition index based on pooled samples from all the estuaries of Dakshina Kannada are 9.35 for *M. casta* 14.45 for ***P. malabarica* and 10.09 for *I, cyprinoides.* It** shows that *P. malabarica* has more flesh, when compared to the other two species, particularly after 30 mm length. There were some variations in the condition index from estuary to estuary.

Maturity stages: Most of the clam species observed in these estuaries were in indeterminate condition. However few *M. casta* in the Mulky estuary wera in mature and spent condition. Similarly in the Nethravathi estuary about 29% of *V. cyprinoides* were in mature and spent condition.

Utilization and marketing:* Flesh of *P. malabarica and *V. cyprinoides* is used for gastronomic purpose. *M. casta,* when available in plenty, particularly between September-January period are exploited for their shells. The clams are marketed in fresh condition in diiferent villages of Dakshina Kannada.

REMARKS

The total estimated standing stock of clams in the estuaries of Dakshina Kannada was about 4800 t. *M. casta* is dominant (79%) **followed by *P. malabarica* (19%) and *V. cyprinoides* (2%). *K. opima* and *M. meretrix* were** observed in stray numbers. Rao and Rao (1985) estimated the standing stock of clams from these estuaries at 53000 t during 1979-80. The present estimate of standing stock is slightly lower when compared to the previoas assessment. This is mainly due to the poor clam resources in most of the estuaries; other than Mulky and Gurpur estuaries. Appearence of considerable stocks of *P. malabarica* in the Gurpur estuary indicates that the proportion of different species in a given estuary can undergo fluctuations over a period of time. When compared to the earlier study (Rao and Rao 1985) the variation in the individual estuaries of Dakshina Kannada, as a whole, is small, although fluctuations in the individual estuaries are wide. In general, compared to earlier study there is a significant increase in the proportion of P. *malabarica.* The near absence of *M. meretrix* and other species of clams in the Coondapoor estuary, where extensive sub-soil shell deposit exploitation is practised, is noteworthy (Rao 1983).

ACKNOWLEDGEMENTS

We are grateful to Dr. K. Alagarswami, formed Head of Molluscan Fisheries Division for encouragement. Dr. K. A. Narasimham, Officer-in-Charge, Kakinada Research Centre of CMFRI, for cirtically going through the manuscript and Shri D. Nagaraja for his Technical assistance.

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6. FISHERY AND RESOURCE OF GREEN MUSSEL, *PERNAVIRIDIS.* ALONG THE WEST COAST OF INDIA

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ABSTRACT

The green mussel, *Pema viridis,* constitutes a sustenance fishery in India, particularly along the Malabar Coast. The paper deals with the distribution, extent of mussel beds, exploited resources, total stock and the man power employed in the fishery along the Kerala coast from Calicut to Cannanors and Karnataka coast from Bhatkal to Majali. In the Callcut-Cannanore area fishery Is from August to June and the catch is estimated at 3043 t, 3074 t and 2596 t during 1981-82, 1S82-83 and 1983'84, respectively. The mussels tanged in length from 20-129 mm. The total man power employed Is assessed as 685 in the Callcut-Cannanore area, of which 325 are traditional full time mussel divers and the rest are part time mussel divers, The seed resources varied from 4.57 to 6.52 kg/m- In December 1983 and the size of the seeds ranged from 10-40 mm. There is no regular commercial fishery in the Bhatkal-Majall area. The paper also deals with the constraints and prospects for development of the mussel fishery.

INTRODUCTION

Hornell (1917. 1922) and Jones (1950, 1968) provided an account of the sea mussel resources of India. Later Jones and Alagarswami (1973) gave a more detailed account of the resources and magnitude of the mussel fishery. The settlement and colonisation by the juveniles of the green mussel and their resources on the stone embankments and groynes along the central coast of Kerala was delt by Nair et al (1975). The paper deals with the results of the investigations carried out on the fishery resources of green mussel along the Karnataka coast from Majali to Bhatkal and Kerala coast from Cannanore to Calicut during 1981-82 to 1983-84.

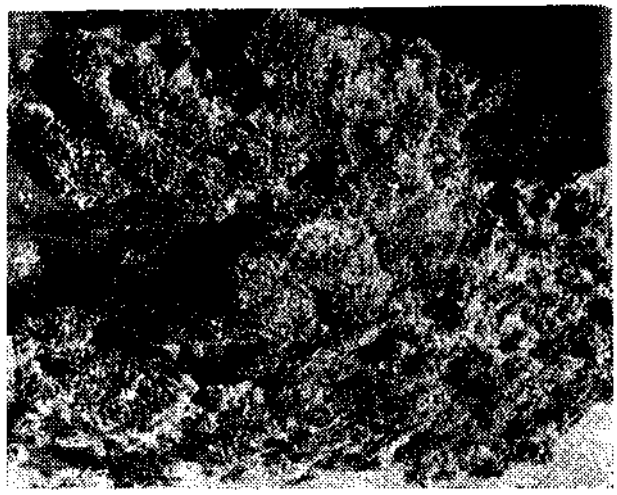

Fig. 1 : Natural mussel beds.

DISTRIBUTION AND EXTENT OF MUSSEL BEDS

The green mussel, *Perna viridis* is found attached to the intertidal and submerged rocks along the West Coast of India in varying densities (Fig. 1). Its distribution along the Karnataka Coast from Majali to Bhatkal is much dispersed and patchy. Mussel beds are found in Majali, Karwar, Kuramgat Islands in the Karwar bay, Binage, Chendia, Harwada, Gabithwada, Manjuguni, Tadri and Bhatkal. Mussel fishery, on a very low sustenance scale was noticed only at 3 centres namely Karwar, Harwada and Tadri. The total extent of mussel beds along this coast is estimated as 5 ha.

The Coast of Kerala from Cannanore to Calicut is the virtual mussel zone of India, where the abundance and exploitation are quite high. In this zone dense and extensive mussel beds are found in Azhikkal, Cannanore, Mythanappally, Koduvally, Tellicherry, Thalai, Mahe, Chombala, Mutungal, Badagarar

TABLE 1 *Extent of musssl beds and estimated annual production at different centres in the Cannanore Calicut area.*

Centres	Extent of mussel beds (ha)	Average weight of mussels per Sq.m (kg) (kg)	Total estimated stock (t)
Challlum-Calicut	80	3.0	2,400
Elathur-Kappad (poyilkavu)	75	2.25	1,687
Kollam-Thikkokdi	240	2.5	6,000
Badagara-Chombala	40	4.5	1,800
Mahe-Thalai	40	4.0	1,600
Theliicherry-Koduvally	80	3.0	2,400
Total	555	—	15,887

Thikkodi, Moodadi, Kollam, Kappad, Elathur' South Beach and Challium. Mussels occur on coastal rocks from intertidal zone to 4 km into the sea where the depth is about 12 m. Exploitation is normally restricted to the upper 5 m in view of the abundance of mussels upto this depth and limitation of physical endurance of the divers. The extent of the mussel beds from Cannanore to Calicut and the production from the natural beds are presented in Table 1 The estimates were made in September 1983. Total extent of the beds was estimated at 555 hectares, excluding the intertidal area due to the non-availability of mussels there at the time of observations.

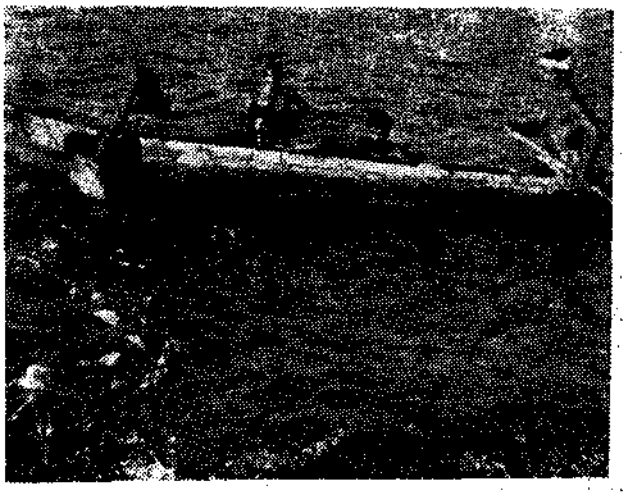

Fig. 2 : Mussel divers picking the mussels from the submerged mussel beds

MUSSEL FISHERY AND PRODUCTION

The mussel fishery along the Malabar and Karnataka coast is of a sustenance nature. The fishery has gained importance and an organised trade exists with a concentrated market in Ca cut. The musse divers reach the mussel beds either by swimming or by canoes (Fig 2) depending on the distance of the beds from the shore and collect the mussels either by hand picking or with sharp tool like chisel. Each diver has a net bag tied around his waist in which he keeps the collected mussels. Women and children collect mussels from the intertidal rocks (Fig. 3)

MANPOWER OR UNIT OF EFFORT EMPLOYED IN THE MUSSEL FISHERY

The average catch by a man per day's considered as one unit of effort, Karnataka coast from Majali to Bhatkal engaged in the mussel fishery on Paft time basis. In the Cannanore-Calicut persons are engaged full time and another 360 on part time (Table 2) . These persons hail from 16 centres and a maximum of 155 parsons from Elathur followdd by 153 from Calicut.

Fig. 3 : Women and children picking the mussels from exposed rocks.

TABLE 2 *The manpower employed in the mussel fishery in Cannanore-Calicut zone.*

Centres	Full time mussel divers	Part time mussel divers
Calicut (Challium & South Beach)	93	60
Elathur	110	45
Poyilkavu (Kappad)	—	12
Kollam	—	10
Moodadi	21	16
Thikkodi	30	15
Badagara	—	15
Muttungal	—	10
Chombala	29	35
Mahe	22	16
Thalai	—	20
Thellicherry	—	18
Koduvally	20	28
Mythanappally	—	20
Cannanore	—	25
Azhikkal	—	15
Total	325	360

PRODUCTION

The commercial exploitation of mussels along the Malabar and Karnataka coasts of India is carried out by means of canoes. Twenty six canoes are engaged in the Majali-Bhatkal area. In the Cannanore-Calicut zone 340 Canoes are employed. The logs were used in Thikkodi in 1981–82; but the number decreased to 3 in 1983-84.

The major mussel landing centres in the Cannanore-Calicut area are Koduvally, Mahe, Chombala, Moodadi & Thikkodi, Elathur, Challium & South Beach (Fig. 4). Fig 5 shows the monthly average production from 1981-82 to 1983-84 from the above landing centres. The season for the mussel fishery in this zone starts from August and last till June. There will be no mussel exploitation in July due to the south west monsoon. At Moodadi & Thikkodi, which is the most important mussel landing centre the season for mussel fishery is from November to May with peaks in January and March (122.16 t and 138 9 t). Challium & South beach rank second in importance with the maximum catches in December (169.7 t) followed by a minor peak in March (74.2 t). At Mahe the maximum mussel picking is in October (70.6 t) with a secondary peak in March (48.6 t) and at Koduvally it is in January (64.6 t). In Chombala the peak catches are in March (59.6 t). At Elathur the maximum exploitation is in November (45.3 t) with a secondery peak in May.

Fig. 4 : Mussel landing Centre, South Beach (Calicut)

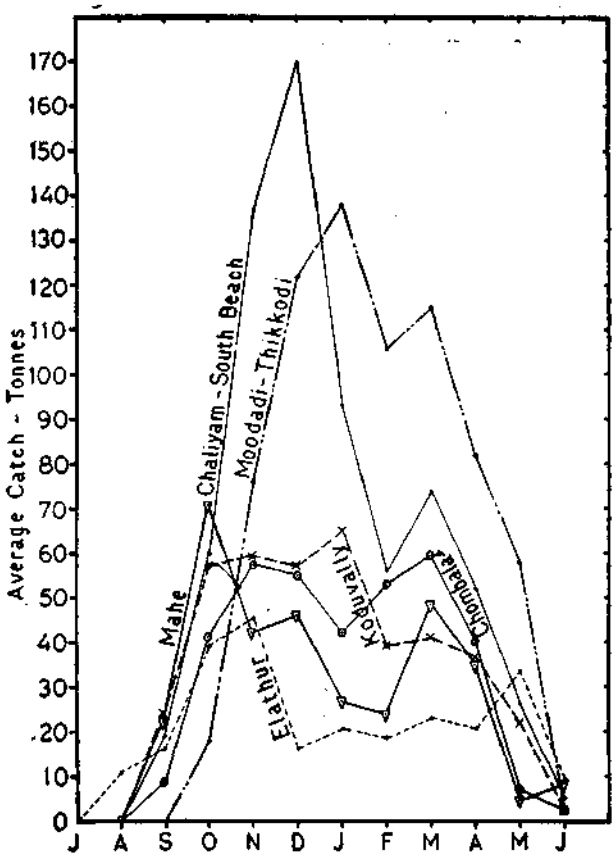

Fig. 6 : Monthly avaraga catch of green mussel during the fishery season from 1981-82 to 1983- 84 from different centres In tha Cannanore-Callcut area

In general the traditfonal full time mussel divers along the Malabar Coast are fromElathur. They move with their canoes to different centres for mussel picking depending upon the availability of mussels in the natural beds. In October their concentration is in Mahe. In December the mussel divers move to Challium & South Beach and Thikkodi, In January the exploitation is more in Thikoodi and Koduvally

The estimates of production, total effort and the catch per unit of effort in the Cannanore-Calicut zone for the years 1981-82 to 1983-84 are presented in Table 3. The production was estimated at 3043.0 t, 3074.2 t and 2596.8 t for the years 1981-82, 1982-83 and 1983-84 respectively. The corresponding effort expended to obtain the catch was 50377, 61005 and 58557 units. The catch per unit of effort for the above years worked out to 60,4,50.4 and 44.3 kg. The length of the green mussel expio-

TABLE 3 *Estimates of green mussel production (annual landing in tonnes), total annual effort and average catch per effort (in kg) during the years 1981-82 to 1983-84 in Calicut-Cannanore zone.*

Year	Catch in t	Effort	Catch per unit effort (kg)
1981-82	3043.9	50397	60 4
1982-83	3074.2	61005	50.4
1983-84	2596.8	58557	44.3

ited from different centres ranged from 20-129 mm (Fig 6) and the size of the bull< of the catches ranged from 50-90 mm. In March, smaller length groups ranging from 45-65 mm are also abundant along with the larger groups around 90 mm.

In the Majaii-Bhatkal area the fishing season is from April to June. The production from this zone is estimated as 36.5 t in 1982-83.

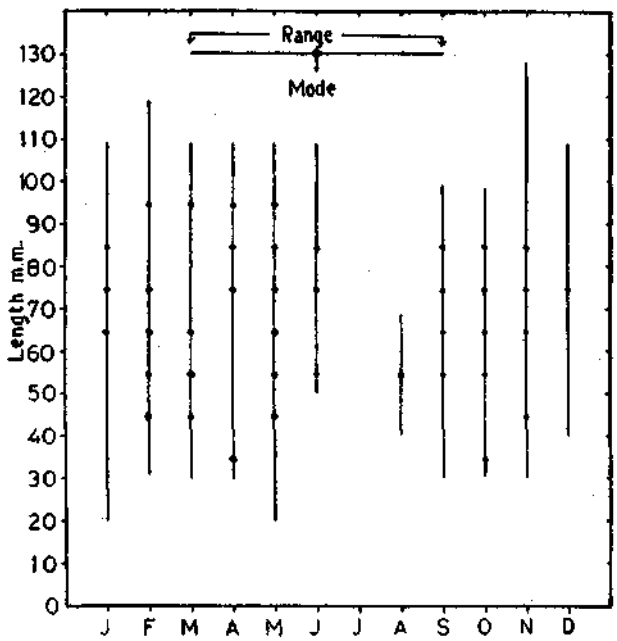

Fig. 6 : size range and model values of mussel Bxploltod during different months of the fishery season from 1981-82 to 1983-84.

j^e length of the exploited mussels ranged from 40-100 mm. The total stock trom a 5 ha area of mussel beds in this zone fs estimated at 2061.

TABLE 4 *The graenmusse/ seed resources from 7 centres along the Malabar Coast in December 1983.*

	Total number/m^	kg/m^	Length range (mm)	Mode (mm)
Challium	2055	4.90	14-40	25—29
South Beach	1547	4,57	20-40	25-29
Elathur	6225	6.25	10-35	20-24
Moodadi & Thikkodi	3750	5.72	12—36	20-24
Chombala	1715	4.90	12—40	25-29
Mahe	3595	6.52	12—38	25—29
Koduvally	2825	5.17	12—35	20-24

The total stock for the Cannanore-Calicut area of mussel beds in this zone is estimated at 15,887 t from an area of 555 ha of mussel beds (Table 1). The density per square meter ranged from 2 25-4.5 kg of mussels,

The mussel seed resources estimated from 7 centres in the Cannanore-Calicut zone in 1983 i? presented in Table 4. The density of seeds in the natural beds varied from 1547 to 6225 numbers per m^ weighing 4.57 to 6.52 kg and their length ranged from 10-40 mm. The maximum density in numbers was noticed at Elathur. In the Majali-Bhatkal area the mussel $eed was noticed at 3 centres namely Karwar, Harwada and Tadri in 1983. The total area of the seed bed was 150m2 at Harwada, BOm^ at Tadri and 20m^ at Karwar. The density of seeds varied from 6,000-10,000/m* in December 1983 and their length ranged from 8-16 mm.

DISCUSSION

It is seen from the earlier reports of Jones (1950, 1968), Jones and Alagarswami (1973) and Rao et al (1975) that the green mussel resources and their fishery along the west coast of India is restricted to a few rocky patches except in the Cannanore-Calicut zone along the Kerala Coast. The production of mussels from Ratnagiri to South Kanara was estimated as 15 5 t and from Calicut to Cannanore as 290 t (Jones and Alagarswami 1973). The present study showed an increase in production of two and a ^^'^ ^'"'"^^ ^^ ^^^ ^°''^^' ^"d ^®" ^'"'"^^ ^^ the latter area. Jones and Alagarswami (1973) estimated that 170 canoes and 10 logs are deployed m the Cannanore-Calicut zone for mussel picking. The present study showed considerable increase in the craft also. The *i'9h density of seed observed in the Cannanore-Calicut zone is encouraging for taking up l^rge scale mussel farming along this coast.

At present mussels are marketed fresh without depuration. Simple and effective depuratlon techniques should be developed to maintain the quality of mussels before marketing. There is also need for enlarging the consumer sector through vigorous extension drive of the proposed products so that the fishermen get better remuneration for the catch.

As the mussel resources are small the developmental effort in future should be towards increasing the production of mussels through farming, particularly in view of the fact that the yield by culture is very high (Kuriakosa 1980).

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7. ROCK OYSTER RESOURCES. OF BOMBAY COAST

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ABSTRACT

Ihe **results of a preliminary investigation conducted on the resource of the rock oyster *Saccosifea cucuJlata* ^'*om* two selected centres viz. Barldra andWorli Sea Face are presented and discussed. Information on the papulation density, size, predators, pasts and other associated organisms of the oyster and the general features of the oyster beda Is given. The total area of the oyster beds at both the centres is 87,500 mZ. The estimated standing stock of 5. ct/ci/Z/ara is 80.66 million in number and 3,35,125 kg in total weight. The estimated shell weight and meat weight are 2,80.825 kg and 33,075 kg respectively Oysters of siz9 range 7.00 mm to 55.00 mil with a mean length of 28.44 mm are represented in population. Adult oysters of 13-41 size groups formed 81 04%.The littoral concrete found along the coast is an ideal habitat for the settlement of the rock oysters.**

INTRODUCTION

Among the edible bivalves, oysters have a prime place due to the nutritive value and palatability of themeat. *Crassostrea madrasensis, C. gryphoides, C rivularis* and *Saccostrea cucullata* are the commercially important oysters of India. The contributions of Rai (1928, 1932), Awaiti and Rai (1931), Subrahmanyam et al (1949), Durve and Bal (1962), Jones (1968), Alagarswami and Narasimham (1973), Rao (1987) and Mahadevan (1987) give information on the oysters of Maharashtra. Rao (1987) stated that S. *cucullata* inhabits shallow coastal waters and creeks along both the coasts of India including Andamans and Lakshadwesp. Mahadevan (1987) reported that the population of this oyster found along Maharashtra and Gujarat coasts is exploited for food on a small scale. He further stated that our information on the extent of beds, population density and

magnitude of tha recruitment of 0/sters of India is still fragmentary. James (1987) emphasized the need to assess the oyster resource potential and collect information on the suitable areas for the culture of edible oysters for the benefit of enthusiastic entrepreneurs and agencies in states lil<e Kerala, Goa and Maharashtra where there is no data base for the same at present. *Saccostrea cucullata* occur along the rocky littoral zone of Bombay and form beds. A preliminary study on the population of this little known resource was conducted during January-March 1986 in order to enhance our knowledge in the management and development of this food species for the benefit of the coasta fisher folk.

MATERIAL AND METHODS

The extent of the oyster bed, standing stock, population density and size and ecology of the oyster have been investigated from two centres viz., Bandra and Worii Sea Face along the Bombay coast. The area of the oyster bed was determined by measuring the length and breadth during extreme low water spring tides and with the help of a map of the region. As oysters are found distributed continuously all along the rocky littoral zone the average breadth of the oyster belt was taken for the estimation of the total area of the oyster bed at both centres of the study. Tha oysters were sampled at every 100 m length of the oyster belt with a 25 cm.2 quadrat. One to 4 samples were taken from each station depending on the width of the oyster belt. The number, total weight (shell on), shell weight and msat weight of all live oysters in the sample were recorded and from this the average density/m^ was derived. The meat was weighed after draining all the water. Based on this data the standing stock, density and meat weight of oysters in the bed were estimated. Data on length, predators, pests and other associated organisms of oysters were collected. The length was taken as the greatest measure in an anterio-posterior direction of the shell of the oysters. A representative sample of 100 oysters from both the centres was analysed for sex and condition of the gonad in order to know the breeding of the oyster. A chisel, hammer, and sharp knife were used to remove the oysters attached on rocks. Gonads smears were examined under microscope. The survey was carried out at both the centres and the data collected for the period January to March 1986 were pooled for the estimation of different parameters. The general features of the littoral region were noted,

General feature of the oyster beds

^^^ ^^^ ^^^^^^^ ^^^^ ^^^^^ ^^^ ^^^3 on ^he oyster resources have been collected are situated on either side of the Mahim Bay along the coast (Fig 1) The tides are semidiurnal and the amplitude of spring and neap tides at Bombay is 3.66 m and 1.44 m.

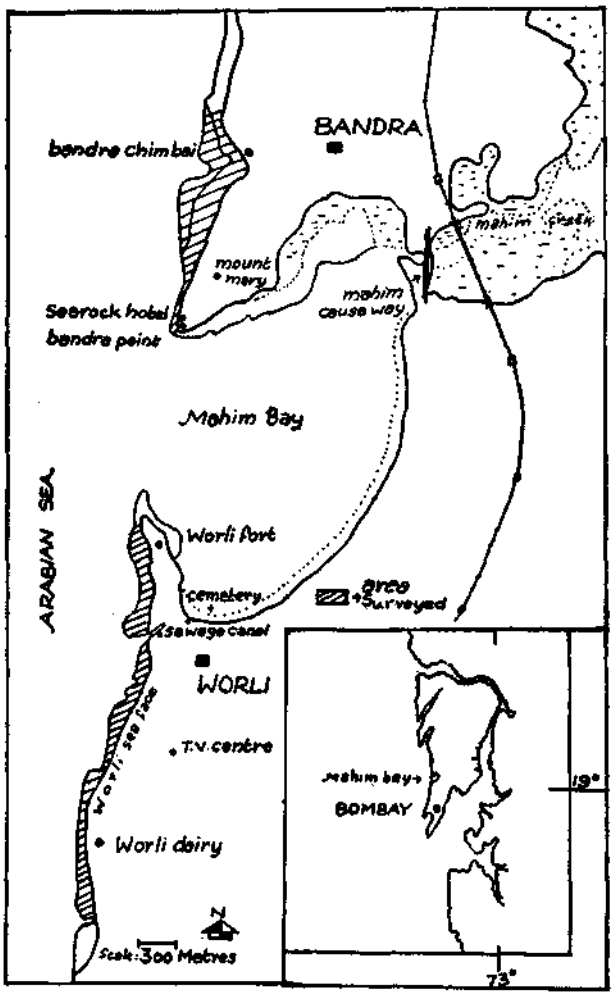


Fig. 1. Map showing the location of Bandra and Worll Sea Face, inset show* the position of Bombay and Mahim bay.

(°^ *Bandra Centre*

This centre extends from the Sea Rock Hotel at Bandra point on the seaward side to

fish landing centre opposite Bandra chimbai village (Fig 1). The length of the beach surveyed is 2.0 km. Beach rock of littoral concrete s found in ihe entire zone. The area is shallow and 25 to 400 m (Breadth) of beach is exposed during extreme low water spring tides. The wide area of the littoral zone is towards the Bandra-chimbai village. Embankments constructed by placing small to moderate sized granite stones serve as fish traps in the area. Rock pools mounds occur in the zone. Small rock mounds are seen near the boat channel. Rock platforms or terraces are common. It has been observed that the waste materials from an indigenous cloth dying work on the beach is let into the littoral zone near the Sea Rock Hotel and the sand and silt brought along ..,.,. ,u u- u . . r J • *u with the high waves get accumulated in the ...^ , „ J • . littoral zone and in soma areas oysters are partially covered with coarse sand. The silt over the area makes the oyster bed very slippery when exposed and the sharp shell edges of the closely settled oysters give cut injury while walking on the horizontal beds with barefoot. The average effective width of the oyster belt is 30 m. The rock oysters occupy an area of 6 h.

(bj Wor/i Sea Face

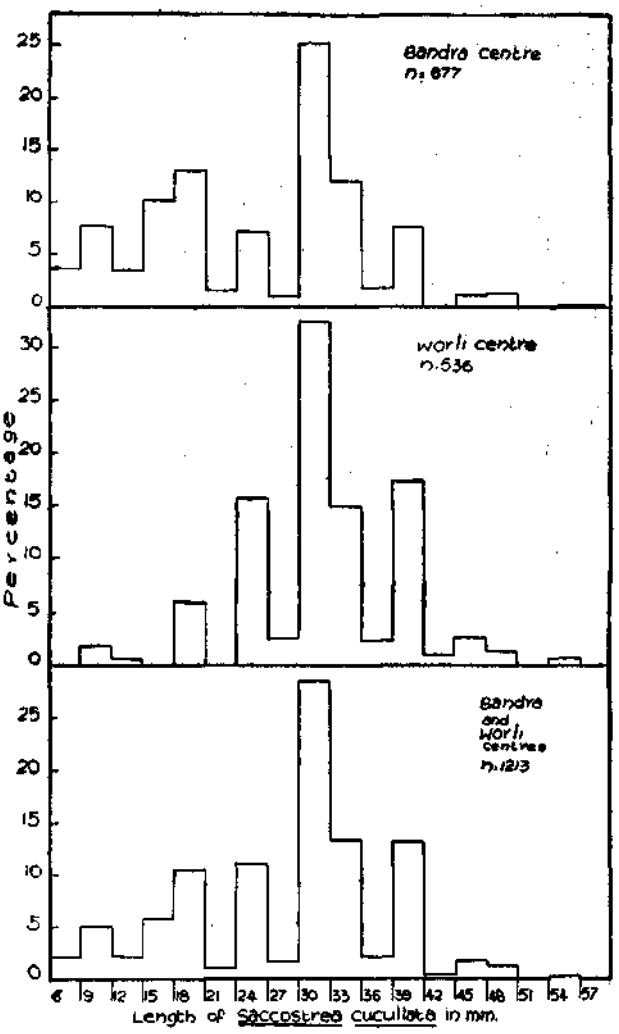
The area lies between Worii Milk Dairy on the beach and Worli fort on rhe southern bank of the Mahim Bay (Fig 1) The total distance is 2 75 k.m. The dark granite type beach rocks found all along the shore are like those noticed at Bandra Centre. A sea wall is constructed along the road and large granite boulders are noticed scattered over the area below it on the shore. The shore is steep and rock platforms or terraces are very few in the exposed littoral zone. A sewage canal opens into the beach opposite the cementry. An area of 20 to 200 m (width) of the shore is emersed during low tide. The average width of the oyster belt is 10 m. The total area of the oyster bed is 2.75 ha.

Saccostrea Cucullata *Population*

(a) Bandra centre

A single species of *oyster Saccostrea cucullata* forms bed at this centre. The density of *S. cucullata* varied from 576 to 1792/m2 with an average of 1062/m2. The number of oysters in the bed is 63,72,0000. The total biomass of oysters ranged from 1.57 to 5.89 k^4Tl2 with.an average of 4.38 kg'm2. The total biomass of oysters in the bed is 2,62,800 kg. The shell weight ranged from 1.25 toS.12 kg/m' with an average of 3,75 kg/mz . The weight of the-shell in the entire bed is 2,25,000 kg. The meat weight ranged from 0.22 to 0.64 kg/mz with an average of 0;40 kg/m^ . In the bed 24,000 kg of meat is present,

^^^ length of *S. cucullata* ranged from 7 to 50 mm with a mean length of 25.86 mm. The percentage frequency of oysters of different size groups is given in Figure 2. The 18-20 mm and 30-32 mm modal groups were prominent in the Population. The percentage of spats and young °y^*f^« °^ size range 6-17 mm was 38.55. ^^"'* °7f/„? of size range 21-41 mm consti-*"t9d 54.94%. The large sized adu t oysters of ,^ .^ 'r ^ . . "yoioio« 40-40 mm size group formed the rest.



pig. 2. Percentage fr.quency of S. *cucullata* in the oyster beds at Bandra and Worli seaface.

Oysters are not exploited from the bed. Sometimes the fisherfoli< scoop out the meat of large oysters from the cupped valve of the oyster by breaking the flat uter valve with the help of a sharp knife and use it as food. Immature, mature and partially spawned individuals of both sexes are met with in the population. The meat of the partially spawned oyster is thin, loose and watery. Ripe gonads are cream coloured and thick,

;.;yuQfh;. CQntfG

At rhis centre also *Saccostrea cucullata* is the only species found in the beds. The density of this oyster ranged from 256 to 1536/m2. with an average of 6l6(m2 . A total of 1,69,40,000 oysters are found in the bed. The total biomass of oysters in the entire bed is 72,325 kg. The shall weight ranged from 0.79 to4.99kg/m2 with an average of 2.03 kg/m^ The weight of the shell in the bed is 55,825 kg. The meat weight ranged from 0.14 to 0 66 kg/ m2 with an average of 0.33 kg/m^ . The meat weight of the oysters in the bed is 9.075 kg.

T. , ,. , o ,, ^ . , , , . • *rs* .

The length of S. *cucuHata* at Worl. Centre ranged from 9 to 55 mm with a mean length of 31.70 mm. The percentage frequency of each size group is given in Figure 2; 24-26, 30-32 and 39-41 mm are the prominent modal group*. Spats in the population was very insignificant The adult oysters of size range 24 to 41 mm form 85.26% of the population. The condition and nature of gonads are the same as observed at Bandra centre. Oysters are not fished from this area.

ECOLOGY

a) Settlement of oysters: The rock oysters *Saccostrea cucullata* firmly adhere to the littoral concrete and colonize the mid littoral zone and in some places invade the supralittoral fringe. The oyster belt is distinctly noticed at both the centres and their zonation pattern is the same at both centres. The oyster spat cement their left valve to the substratum and its shell assumes various sizes and shapes. The right valve closes the animal like a lid and the valves of the oyster are tightly closed when it is exposed during low tide. The shell valves are hard and stony but not heavy. The colour of the outer side of tiie sliell is liglit brown or dirty white and almost blends with the colour of the substratum on which it gets attached. IHigh density of oysters occur on exposed rocks and ijttoral platforms or terraces, especially at Bandra. The magnitude of settlement on protected or semi-exposed rocks of shoreward side and on polluted surfaces, as noticed near the sewage canal outlet at Worii, is very much less,

b) Predators: Thais tissoti. Bursa, granularis and *Drupa tuberculata axe* the predatory gastropods recorded, /-//a/s r/«of/is found wedged on rocks "«^'' ^^^ '°^*'d« '^^«' ^^ ''o*^ the centres at a density of 0.5 m2 at Worii. This snail is very inactive when exposed. The other two species ^'^ Pr^^ent at Bandra. Oyster drills are not found.

Pests and other associates

T^e acorn barnacle *Balanus amphitrite* is the ^^ief pest of the oysters. These animals are found attached on the beach rocks and shells of oysters in the midlittoral zone at both the centres. The average density of this barnacle is gSS/m^at Bandra and 3413'm^ at Worii. The shell ^^^^^^ ^^ ^he oysters occurring on the rock platforms in the littoral zone at Worii is fully covered by the barnacles and it is very difficult ^^ ^^^-^^^ ^^e oysters settled there. The conical barnacle *Cathamalus ste/fatu forms* a belt in the mid-littoral zone and sometimes invades the oyster belt on the littoral concrete platforms at ^^^ij geaface. Sanils like *P/anaxis sulcatus. Nerita sp^. Cerithium* spp and *Cellana radiate* occur on oyster bed. *P/anaxis sulcatus* is found in groups amidst oysters and on rocks. The littorinids like *Noditilorina* sp occupy the supralittoral zone. *Chaetomotpha* sp grows in the the pools of the mid-littoral zone at Bandra. The ^ ^ j skipper *(Boleopthalmus* sp) and *Therapon* sp are occasionally observed swimming in the ^0^^ pools in the oyster bed at Bandra centre. Polychaetes, small crabs, anemones and sponges ^^^g ^ig^ ^een seen from the littoral zone,

DISCUSSION

Rai (1928, 1932), Awati and Rai (1931), Subrahmanyam et al (1949), Alagarswami and Narasimham (1973), Rao (1974) reported about the exploitation and traditional farming of

S. cucullata and *Crassostrea gryphoides* in the shallow coastal areas and creeks of Bombay. The fishery for clams and oysters of Mahim Bay ceased due to water pollution However, the ecological conditions and water quality are relatively better in the coastal waters outside the Bay. (Govindan and Desai 1980-81). The existence of rich rock oyster beds at Bandra and Worii confirms that the quality of the coastal waters have not deteriorated so as to inhibit settlement and growth of the oyster in the littoral zone.

The total area of the oyster bed at both the centres is 8.75 ha. TheS. *cucullata* population present at Bandra and worli shows variation in density and size. The standing stock of S. *cucullata* at Bandra and Worli in a hectare is 1,06,20,000 and 61,60,000 in number and 43,800 kg and 28,300 kg in total weight (shell on) respectively. This shows that the oyster population at Bandra is 41.10% more in number and 39.95% more in total weight than at Worli. The meat weight is 4000 kg/ha at Bandra and 3300 kg ha at Worli. Thus the meat weight at Bandra is 21.21 % more than that of Worii. At Worli the percentage of small size groups (0-20 mm) oysters constituted 9.33% in the population while at Bandra they formed 38.55%. So the mean length of oyster population at Bandra (25.86 mm) is less than that of Worli (31.70mm). The percentage of meat in total weight of oyster at Bandra oyster bed is 9.13. The percentage of meat in total weight is higher (12.55) at Worli when compared to Bandra because of the higher percentage of larger size groups in the oyster population of worli. The probable reasons attributed to the high density of settlement of oysters at Bandra may be due to the availability of suitable substratum in the form of littoral rock mounds and platforms or terraces, the shallowness of the area, less intensive competitors for food and space and limited number of predators. At Worli the population of barnacle, *Balanus amphitrite,* the chief competitor for food and space is 396% more than that of Bandra centre. The conical barnacle *Chthamalus* sp is also found in abundance at Worli. As larvae of oysters form food of barnacles (Rajapandian and Rajan 1987), there might be high degree of oyster larval predation. A sewage canal directly pollutes the oyster bed at Worli. However at Bandra centre direct pollution source is less.

The density of S. *cucullata* recorded from Bombay appears to be very high when compared to their occurrence in some other locations along east and west coasts of India observed by Rao andSundaram (1972).

It is known that rock oyster is well adapted to the litoral mode of life. The oyster spat settled on the substratum in the litoral zone has no escape from its dwelling place and are subjected to all types of environmental stress of the zone Viz. exposure to air, high temperature during summer months, rains, humidity and water pollution. The oyster has to respond to these variables and ajust for its survival and growth. The oysters have to depend on the incoming tide for suspended nutrients and planktonic food. This filter feeder has also got the ability to filter the maximum quantity of food within a short time when the high waters cover the oyster bed. Awati and Rai (1931) concluded that spawning in *S. cucullata* is continuous except during monsoon period (June to September) and spawning during summer months is very intense. These authors have suggested that salinity and temperature may be responsible for the spewing of the species. The fluctuations in the salinity and temperature of the coastal waters of Bandra and Worli is less (Govindan and Desai 1980-81). The spawning of S. *cucullata* inhabiting the Shirgaon creek at Ratnagiri occurred from October to January (Nagabhushanam 1983). The maximum size of S. *cucullata* recorded during present study is 355 mm. There is no work known to the author on the growth of this species from India. Rai (1928) stated that S *cucullata* of Bombay grow to 3-4 inches in the natural beds and within a span of 4 to years reach a size of 4 to 6 inches in the transplanted beds. Saraiya and Chhaya (1983) recorded a length range of 32 to 117 mm for the *S. cucullata* inhabiting the littoral zone of Gujarat. *S. cucullata* found in the natural beds at Bombay show retarded growth. This condition may be due to the exposure during low tides., crowding of large number of spat in a small area and presence of foulers on the shells.

The prospects (Of developing a commercial fishery for S. cucuZ/afa appear very dim, The difficulty in harvesting these oysters from wild prevents the exploitation of this resource present in high concentrations along the coast It is of interest to note that this species is cultured in Some countries Aquapop (1982) reports that in French Polynesia the spat of S. *cucullata,* collected on *Tridacna* shells, are grown on some structures and reach a size of 60-80 mm in two years. Unar et al (1932) have observed 50 mm growth of *S cucu//ata wthin* a year in the grow out grounds of Banten Bay in Indonesia. The same species attains an average size of 45 mm in one year from 5 mm spat stage in an experimental farm at Sarawak, Malaysia (Oon et al 1982). The spat of rock oyster also could be collected from coastal areas of our country by using suitable cultches and grown on same material in unpolluted creeks.

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8. EXPLOITATION OF MOLLUSCAN SHELL DEPOSITS IN VIGAI ESTUARY AT ATHANKARAl

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ABSTRACT

Molluscin shell deposits are present In th* bed of Valgai estuary at Athankaral, on the southeast coast of India, which are being exploited intensively since 1978. The topographical and environmental feituras of the estuary, distribution and species composition of shell deposits, extent of resources, methods of exploitation, magnitude of production and utilization have been studied

The shell deposits are distributed In the bed of estuary over a distance of,4.63 km in the upper portion of the estuary. They are subfossil deposits 0 15 m-0.46 m In thickness and comprise predominantly of *Meretrix casta* vyhichare favoured as raw material in the manufacture of calcium carbide and In tannery Industry. Shells of other species in the deposits like *Cerithidea fluviatilis, Hemifusus cochlidium,-Area; Paphia ate.* are convarteci into lim^. The annual production of lime shells from the estuary Is about 5.500 t. The ramsval of larga numbers of live adults and seed clams of /tfsretnx casfa present In the upper layer of sediment along with the subfossil shells Is pointed, out and the need for preventing the destruction of live shellfish Is strassed,

INTRODUCTION

Molluscan shell deposits are distributed at several places along the east and west coasts such as Chiika Lake, Vembanad Lake, Sonapur, KakinadaBay, Pulicat Lake etc. and are expioitedforuse in the production of lime, cement etc. (Rao, 1969, Alagarswami and Narasimham, 1973, Rasalam & Sebastan 1976), The molluscan shell deposits are mainly subfossil deposits and are important as a resource as they yield shell lime and offer livelihood to rural people in the coastal areas where they occur. Since a very i^^g time molluscan shell deposits are known to 53 found in the bed of Vaigai estuary at Athankaral on the southeast coast of India and shells have been collected from therein by paople of the villages around, converted into

lime and sold for whitewashing or for use in construction of buildings. But the exploitation was on a very small scale and was only a subsistence fisheryuntilquite as recently as1978. Early in 1978 it was observed that the shell lime deposits in the bed of the estuary were intensively quarried and large quantities of shells were being collected annually thereafter.

In view of the economic importance of the lime shell deposits of the estuary it was felt necessary that topography of the estuary, the environmental conditions, the associated fauna and flora, distribution of the shell deposits, their exploitation, magnitude of shell production and utilisation are to be studied and the scope for future utilization of the resources discussed,

MATERIAL AND METHODS

Observations were made on the topography of the Vaigai estuary, the ecological conditions, the fauna and flora of the estuary and distribution and exploitation of shell deposits. Data on the magnitude of shell production were collected on observation days at the estuary and the total quantity removed, from the records of the Taluk office of the Revenue Department at Rarrvanathapuram. Information was also collected on the utilization of the lime shells,

TOPOGRAPHY OF VAIGAI ESTUARY

The Vaigai estuary is formed by the river Vaigai which originates in the Western Ghats and opens on the southeast coast into the Palk Bay (Dunna and Alagarswami, 1964) on the eastern side of the village Athankarai which is about 25 km. northwest of Mandapam Camp. The estuary runs almost parallel to the National Highway 49 and turns northwards 1.8 km. before the mouth to join the sea. The length of the estuary is 8.2 km and its width is 130 m upstream, 2C0-240 m in the lower reaches and a maximum of 356 m near the mouth (Rao et al 1987). The depth ranges from less than 1 m in the upper portion of the estuary to 2 m or more in the lower part.

ENVIRONMENTAL CONDITIONS

The estuary is connected with the sea except in the months April to June when a sand bar Fs formed near the mouth. In some years the mouth of the estuary gets closed much earlier in January due to accumulation of sand under the influence of strong winds and tides. The sediment is grey in colour and consists of clayey mud with an admixture of fine and medium grain sand in the upper and lower parts of the estuary. Near the mouth the sediment is largely sandy with a small percentage of fine mud. The water temperature of the estuary varies from 27.5°C to 37.5°C with the highest values in the summer months, April to June. Salinity of the estuary fluctuates over a wide range of 17.83°/oo to 71.2r/oo- The salinity values ate high in the summer months especially in the upper reaches when the estuary is cut off from the sea and there is progressive evaporation. A drastic drop in salinity to as low as 3-5°/oo takes place in some weeks during October-December as a result of discharge of freshwater from the Vaigai reservoir and irrigation canals following heavy rains.

FAUNA AND FLORA OF THE ESTUARY

The fauna of the estuary consists of mostly molluscs, fishes, prawns and crabs. Beds of the clam *Meritrix casta* are distributed from the upper reaches of the estuary upto a distance of 1.6 km from the mouth. Seed clams of *Mereitrix casta* occur in enormous numbers in the upper part of the estuary opposite Perungulam and south of it. Three beds of the oyster *Crassostrea madrasensis* each consisting of several patches and larger formations exist in the lower and middle portions of the estuary (Rao et al 1987). The small gastropod *Cerith/dea fluviatilis* is found in large numbers in the shallow parts of the estuary. Three species of prawns *Penaeus ind/'cus P. samisulcatus* and *Metapenaeus burkenroadi* and several species of fishes like *Himantura sp. Thrissocles* sp, *Tachysurus* spp, *Mugi/ cephalus, Tilapia mossambica* etc. occur in the estuary and are caught in drag nets called C/?/pp/va/a/forming a subsistence fishery. The flora consists of the sea-grasses *Cymodocea* spp and *Halophila ova/is* and the algae *Eneromorpha* spp, and *Polysiphonia* sp, the latter as encrusting flora on oyster beds.

DISTRIBUTION OF SHELL DEPOSITS

The shell deposits are distributed as a layer from a distance of 3.70 km from the mouth of the estuary up to the point midway between Perungulam and causeway over a distance of 4.63 km. These are subsoil deposits, 0.15 m-0.45 m in thickness and are located below a grey muddy sand sediment 0.6-0.9 m thick

Analysis of the composition of the shell deposits show that they consist exclusively of molluscan shells. Shells of the clam *Meretrix casta* form the predominant portion amounting to 75-90%. Next in importance to the clam shells are the shells of Cer/Y/i/Ws *fluviatilis a* common gastropod in the estuary. *C. fluviatilis* accounts for 3-24%. The rest consists of the shells **of species like *Area complanata. Paphia* sp, *Gafranum* sp, *Sanguinolaria diphos, Umbonium vestiarium, Bullia sp,* and *Hemifusus cocftlidium.***

The shell deposits in the estuary being 0.15-0.45 m in thickness, if it is assumed that they are on an average 0.30 m in thickness and since the length and width of the estuary over which the deposits are distributed are 4.63 km and 135 m, the standing stock of the subfossil molluscan deposits appear to be about 1,60,000 t. To determine the actual magnitude of the shell deposits a geological survey of the estuary is needed.

The source of the shell deposits are the **shells of *Meretrix casta* and *Cerithidea fluviatilis*** which are inhabitants of the estuary and after death were covered by sediment. The shells **like *Area, Sanguinolaria, Hamifusus* forming a** small component would have drifted into the area from the inshore waters.

EXPLOITATION

The exploitation of the shell deposits in the estuary was permitted by the Government of Tamil Nadu till a few years back through issue of licences by the Revenue Department on payment of seniorage. The Tamil Nadu Government propose to exploit the subfossil shell deposits present in the estuary directly. Shell merchants took licences fram the Taulk Office, Ramanathapuram and have the shells collected by persons including fisherfolk and agricultural labourers of the villages adjoining the Vaigai estuary at Athankarai

The lime shells are collected from the bed of the estuary using simple devices consisting of a crowbar and a bag like synthetic net tied securely to a semicircular or circular frame fabricated out of a tree branch The diameter of the frame varies from 30 cm to 50 cm and the length of the net is 90 cm to 180 cm The presence of lime shells is detected by thrusting the crowbar into the bed of the estuary If shells

TABLE 1. ***Percentage composition of the different molluscan shells found in samples of subfossil deposits of Vaigai Estuar/ at Athankarai (the fifth sample is one from discarded shells).***

	Samples				
	1	II	III	IV	V
Meretrix casta	88.29	79.54	74.93	89.67	52.78
Cerithidea fluviatilis	11.43	19.87	24.46	3.30	44.44
Area complanata	0.25	0.54	0 31	7.03	1.67
Umbonium vestiarium	—	0.01	0.15	—	0.69
***Bullia* sp**	003	0.04	0.15	—	0.42

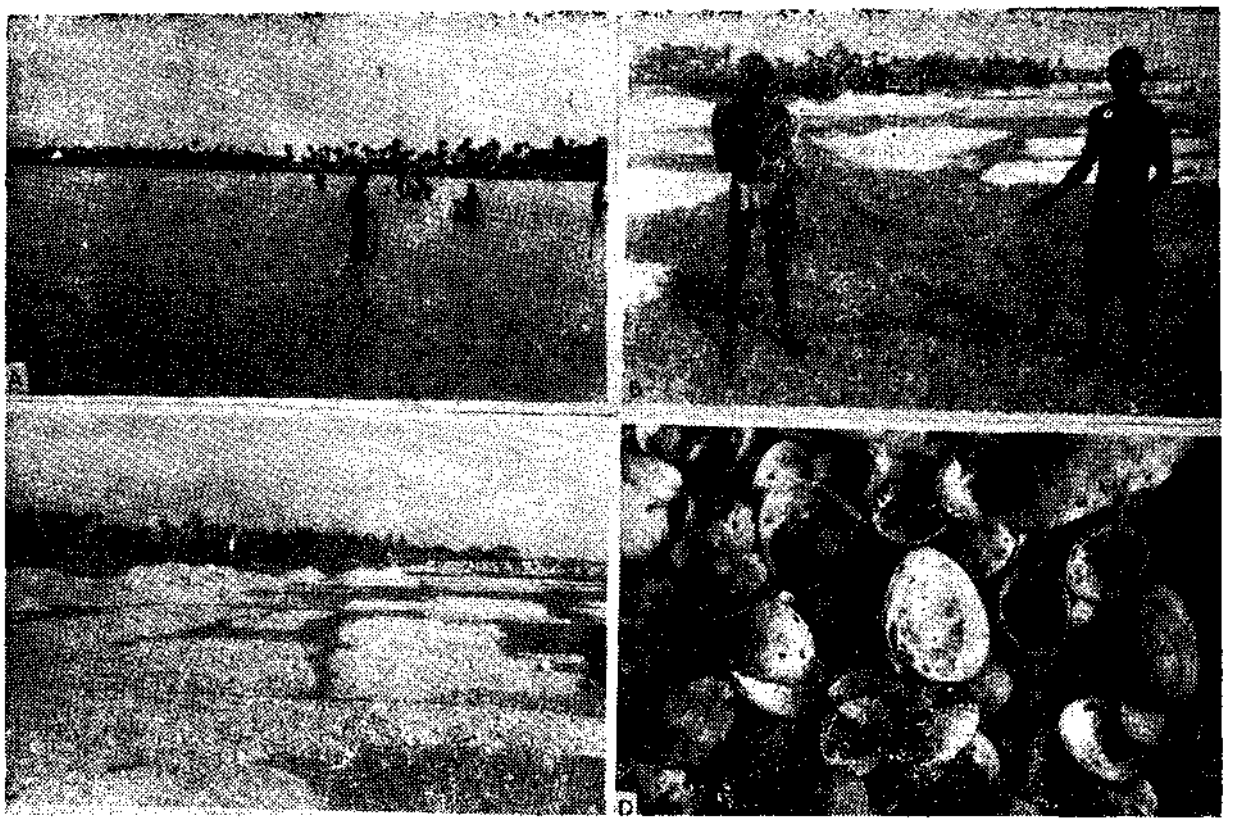

Fig. 1 A. Collection of shells from the Vaigai Estuary. B. Two workers holding the synthetic net used for keeping the shells taken. C. Shells gathered. spread and dried on the bank of the estuary before they are transported for utilization. D. A. close up photograph of the shell of *Meretrix casta*, *Cerithidea fluviatilis*, *Sanguinolaria diphos*. etc. forming the deposits

are present, a metallic sound is produced on pushing down the crowbar. On locating the shells, the muddy sediment present over the shell layer is pushed sidewards with hands and feet and shells collected with the bag net after rinsing them in the net by shaking the latter repeatedly. (Fig. 1 A-D)

Both men and women gather lime shells from the estuary. But the number of men fishing the shells is much more than that of women. 300 to 1,200 adults take part in fishing shells per day and out of these women number about 103-150. Men collect per day 10 to 12 bags of shells, each bag weighing 20 kg while women gather 5 to 6 bags. Children above the age of 7 or 8 years also collect shells found in the shallow waters near the banks of estuary and they gather about one or two bags of shells in a day. A bag of shells fetches Rs. 1 -50 for those who collect them. Sometimes large numbers of live *Meretrix casta* including seed clams are gathered along with empty shells, ^^^ ^^^^^ ^^^^^^^^ ^^^ ^p^^^^ ^^ ^^^ 1^^^^ ^j^^ stretches on the southern bank of the ggj^^^y gnd allowed to dry for a day or two in ^^^y^^^^ ^^^^^ ^^.^^ j^^y a^3 gj^^g^ ^,^gj ^^^^^^^ a coarse meshed sieve and later a fine meshed sieve to remove shell debris and sand. Oyster shells if present are removed as they are not favoured for use in the production of carbide,

MAGNITUDE OF PRODUCTION

^^^ ^^^^^^^ production of shells from the vaigai Estuary at Athankarai varies from 300 t to a maximum of about 600 t and the annual production from 3,100 t to about 6,500 t. The shells are gathered throughout the year except ^ j ^ ^ ^ ^^ere is rain. As rainfall is low and rest-fijjted to a short period especially during October-December, shell collection Is actively carried out in the estuary on the remaining days

of the year. The magnitude of shell production is also influenced by the offtake of the shells by the using industries.

UTILIZATION

The lime shells collected from the estuary are rich in calcium carbonate which forms 70-80% and they are used by factories manufacturing calcium carbide and in lime, sugar, poultry and tannery industries in Tamil Nadu. The lime shells are loaded in lorriesnear Nagachi village situated on the southern side of the Vaigai Estuary and transported to several places like Madurai, Tuticorin, Srivaikuntum, Arumuganeri, Paramakudi, Manamadurai, Aruppukottai Tiruchirapalli, Karur, Salem, Namakkal, Pudukottai, Dindigul, Pattukottai, Vaniambadi, Alangulam, Sivaganga, Padalam and Ranipet. In each lorry 6-10 t of shells are transported. The residual fragment and small shells, mostly *Cerithidea* are burnt in small kilns located in the neighbourhood, converted into lime and sold for use in construction and whitewashing of buildings. A basket of 10 kg of shell lime costs Rs. 5-6/-.

DISCUSSION

The observation made in this study indicate that considerable lime shell deposits exist in the Vaigai estuary. The magnitude of the shell resources may be much more than the approximate quantity mentioned. A systematic geological survey of the estuar/ is required immediately to estimate the quantum of exploitable resources.

The removal of large numbers of live clams and seed clams of *Maretrix casta* along with the shell deposits in some parts of the estuary should be prohibited by the State Government as it will affect recruitment of clam populations. After removing lime shells the pits are left as they are. This is harmful for the survival of clam populations. After collecting lime shells the pits have to be covered with the mud removed from them. Controlled exploitation will be very helpful to the flourishing of clam populations. Transplantation of seed clams in other shallow parts of the estuary where they are not found now will also help in the conservation of clams.

The Tanhil-Nadu Government has recently stopped the system of issuing licences to individuals to exploit lime shell deposits in Vaigai estuary. The state Government intends to plan and exploit the shell deposits. If the exploitation is carried out on sound lines, after a survey of the shell deposits, there appear to be good prospects for further exploitation of the lime shells in the estuary. There is growing demand for lime shells. Apart from use in carbide industry, lime shells could be used in several industries such as cement, paper, polyfibres, caustic potash and mosaic tile industries and as poultry feed. It is not desirable to mechanize quarrying of shells in Vaigai estuary as it will not be possible then to provide employment to the large number of the poor rural folk who could be gainfully employed in shell collection especially when they do not have other means of livelihood.

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9. MOLLUSCAN SHELL DEPOSITS ALONG PINNAKKAYAL—VALINOKKOM COAST AND THEIR EXPLOITATION

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ABSTRACT

Marine molluscan shell deposits are distributed at different places between Pinnal(ayal and Valmoltkom on the southwest coast of India and support a good shell lima Indutsry. The different areas where the lime shell deposits occur have been surveyed and the nature and extent of the deposits, the species composition, the methods of exploitation, magnitude of production, utilization and annual turnover are dealt with.

INTRODUCTION

Along the east coast of India molluscan lime shell exploitation is a means of livelihood to local people at a number of places (Hornell 1916; Jones 1970; Rao 1969; Alagarswami and Narasimham 1973; Rao 1974). Between Pinnakayal and Valinokkam on the southeast coast there are many places where molluscan shell deposits are being exploited commercially for various purposes. However studies have not been attempted in this subject. The distribution of the deposits, species composition, magnitude of exploitation and utilization have been studied in this work and the results are presented in this paper.

MATERIAL AND METHODS

The places where the shell deposits occur have been surveyed and data collected on the areas where they are distributed, depth at which they occur, the thickness of the deposits. environmental conditions, methods of exploitation, extent of production and the purposes for which they are utilized.

RESULTS

The shell deposits occur at Kovangad, Mariyour, Agaram and Valinokkam. The deposits are of recent origin formed in the post-pleistocene period.

Shell deposits at Kovangad

At Kovangad, located 16 km southwest of Tuticorin, shell deposits occur about 0.5 m ''^'ow the surface and are as much as 2.0 m ^^'"'^ ^"'^ ^'^ distributed over an area of about ^5 ha. The shells are found in black muddy sandy sediment.

Exploitation is by pushing rectangular wooden panels into the earth, removing mud 3"^^ sand present inside and collecting the *'i«"s- *Meretrix casta* are the predominant constituent of the deposits and forms about Q4%- Shell remains of *Crassostrea madrasensis. ^\r\dosNpaneoVs\et Placenta placenta, Sanguinolaria diphos, Anadara. Phaphia* and *Xancus pyrum* are also seen in the deposit. Marginal agriculture farmers of Kovangad and neighbouring area, engage themselves in this activity throughout the year except in northeast monsoon months i.e. October-December. 100-200 persons are involved in this vocation when they do not have work in fields. The state Govern- "lent leases out the right of exploitation in specific areas in different years to individuals, The lessees employ agricultural workers for the collection of shells. The workers are paid Rs. 1.50 per basket of shells. After collection, the shells are heaped in the adjoining areas. When sufficient quantities accumulate they are transported by lorries to industries such as Southern Petrochemical Industries Corporation, Sun Paper Mill, Seshasayee Paper Mill and others. The annual shell production varies from 300 to 400 t.

ShdII deposits at Mariyoor

The shell deposits in this area occur at a depth of 0.2 m to 1.0 m in sediment which is mostly sandy with some amount of silt. In the rainy months the area is submerged by rain water flow from the adjoining Kallar river. The deposits are the recent formations, lie scattered and not dense. Many of the area where the deposits occur have been taken on lease by salt companies for construction of salt pans. The loosely occurring shells ate removed by digging and hand picking when salt pans are prepared. Shells of oysters Crassosfrea mat/ra-*sensis.* 40-180 mm in length form bulk of the deposits The remaining portion consists of windowpane oysters,/WerefA/xcwfa and>»/7arfa«.

The shells are gathered by the labourers of the salt pans located at Mariyoor. When lorry loads accumulate they sell the shells to comp-anies in Madurai for conversion into lime, needed for building construction and poultry feeding. Exploitation is being carried out in this place since seven years and the annual production from this area varies from 150-2001.

Shell deposits at Agaram

The deposits are distributed in the areas adjoining the Pinnakayal estuary. These deposits also are recent formation and occur at about 0.3to 1 m below the surface in sandy muddy sediment. *M. casta* is the main compon-ent of the lime shell deposits, the rest con-sisting of *M. meretrix* and gastropod shells. The shell deposits are being exploited by digging the earth and hand picking. Shells are collected by agricultural workers of Agaram and neigh-bouring places and' transported by lorries to SPIC and paper mills. The annual production is about 150 t

Shell deposits at Valinokkam

The deposits at Valinokkam were exploited till very recently. The shells comprised of C. /narf/'ase/7s/s and to a lesser extent *Meretrix sp.* The shells were present in sediment which was mainly sand with some amount of silt. It is stated that previously as much as 60 t of shells Were gathered anhuaily'anid transported by lorries to Calcium carbide companies.

REMARKS

'» "laV ^e seen from the above account that molluscan shells occuring as subsurface deposits are collected regularly at the places mentioned. The lime shell deposits are of significant importance to the economy of the 'coastal rural areas as it provides mean, of livelihood to the people particularly when they d° "°^ have other occupation like fishing Or cultivation The shell deposits are distributed over large stretches at some of the places like Kovangad and Agaram. At present time we have no information on the quantum of shell deposits available for exploitation in the areas dealt with. In this context there is need for a proper survey to determine the magnitude of the deposits. It will be helpful in generating more employment to the economically weaker section of the population in the areas of the region and also result in increased production of the lime shells for which there is growing demand from various industries like lime, fertilizer, calcium carbide, cement and poultry.

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IO. POPULATION DENSITY OF THE WEDGE CLAM *DONAX CUNEATUS* LINNAEUS IN AND AROUND MADRAS COAST

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ABSTRACT

Donax cunoatus, papu\ar\y known as wedgt **clam i« • small mjltiooloured p3'9cyDod molluica occuring in dense population in the intertidal zone of the three exposed sandy beaches of the Madras coast namely Marina, Thiruvanmiyur and Mahabalipuram- The population density of the dams in ihe three beaches was studied from July 1982 to August 1984. The Marina beach supports a population 16 times greater in size and 14 times more dense compared to Mahabalipuram; 2.5 times ereatar in size and 2-3 times as dense as that of Thiruvanmiyur. Among the various environmental parameters studied be^ch slope s 'ems to play s significant role in the distribution and abundance of *D. cuneatus.***

INTRODUCTION

Wedge clams of the genus Oonax (Bivalvia: Donacidae) are typical inhabitants of sandy beaches in both temperate and tropical zones. They are interesting animals mainly because of their special adaption to live on wave-swept sandy beaches, Individual populations *oi Donax* ^ooM/have an unique ability to develop resurgences and are subject to sudden and devastating population crashes (Johnson 1968). In 1938. the clams were sa abundant on some southern California beaches that industries were developed for producing nector from the clams. But the industry collapsed in the period of a few weeks when the clams suddenly disappeared ^Johnson 1968). *Donax gouldii* of east coast of California were collected for the preparation of broth and poultry feed (Coe 1955). Do/70x has been basis of fishery in several parts of the world (Wade 1964), In India these clams are being consumed as food by the coastal population, especially the fishermen community during the period of rough seas (Nayar 1955). Although there are many reference to *Donax \n* the literature (Nayar 1955; Coe 1955; Edgren 1959; Wade 1964; Alagarswami 1966; Ansell et al 1972; and Mikkelsen 1981) most of them described their tidal migratory behaviour and biology. Hitherto there has been no comprehensive investigation on the population densities of *Donax* species except the works of Nayar (1955), Alagarswami (1966) and Ansell et al (1972) on the Indian coasts. The present study is therefore aimed at investigating about the population structure of the wedge clam *Donax cuneatus* inhabiting the sandy beaches at and around Madras of the south east coast of India

MATERIAL AND METHODS

Donax cuneatus were collected at fortnightly intervals from July 1982 through August 1984 from the intertidal zone of the three beaches, namely Marina, Thiruvanmiyur and Mahabalipuram on the east coast of India. To determine the distribution and density of population, transect method of sampling was adopted. At each station, six transect lines were sampled, Transect A, B and C were at 10 m intervals and D, E and F were 5 m apart. On each fortnightly visit, in each transect line, an initial sample was collected at a point of maximum wave recession during low tide by driving a 28.2 cm diameter stainless steel corer into the sand to a depth of 15 cm, below which depth the species had not been found to burrow. Additional samples were taken at 2 m intervals along the transect lines to the point of maximum wave advancement mark of the high tide. When the zone of clams was sighted, cores were taken dt I m interval until the zone was completely sampled. The sand samples were sieved through a I mm screen in the surf water

and the clams retained on the sieve were counted. Beach profiles were measured by triangulatton at i m interval from the-seaward limit of extreme high water spring tide to the base of the surf zone at the time of low tide. The mean particle size of the sand and uniformity coefficient were determined by conducting standard granulometric sieve analysis (Inman 1952;. Salinity of surf and interstitial water was estimated as per method given by Strickland and Parsons (1968).

RESULTS

Table 1 shows the fluctuations in the population density of clams at the three study areas. During the study period a total of 7342 specimens of *D. cunaatus* were collected from Marina, 2935 from Thiruvanmiyur and 467 from Mahabalipuram. Following Mikkelson (1981), the ratio of density per linear meter of beach at Marina, Thiruvanmiyur and Mahabalipuram was found to be 15.8 : 6.5 :1.0. At each location, there was very little difference in numbers collected per transect between those at 10 m intervals and those at 5 m apart. However, the breadth of the belt in which the clams were dispersed differed among the three beaches. In Marina it ranged from 4-5 m, in Thiruvanmiyur it was 3-4 m whereas in Maha^ balipuram the band width is only 3m. This difference is very well reflected or) the population densities of the clams. Thus, the taiio of density per square metre of beach at Marina, Thiruvanmiyur and Mahabalipuram was on an average, 14:5:1 (Table 1). These ratios are based on a monthly average of 452 individuals at Marina, 168 at Thiruvanmiyur and 27 at Mahabalipuram per linear meter of beach and mean densities of 135/m' at Marina, 51/m2 at Thiruvanmiyur and 9.5/m2 at Mahabalipuram (Table 1). However, at Marina the minimum and maximum densities recorded were 62/m2 (July 1982) and 495/m2 (July 1984) respectively At Thiruvanmiyur beach, while the minimum density recorded was *21 jm*^ (August 1982) the maximum was 108/m^ (October 1983). At Mahabalipuram the minimum and maximum densities recorded were 4/m^ (October 1982) and 17/m^ (May 1-983) respectively (Table 1).

Observations on the vertical distribution of *Donax* have revealed that the entire population appears to occupy a relatively stable zone on the beach, which appears to be in the mid water mark. Under normal conditions the clams ware not found to live in the high watefr mark as well as in the low water mark, although occassionally, during rough seas they wer^ scattered so high on,the beach or carried into water to lower levels. Shoreward from the maximum wave recession point, Do/7ax began to appear in the cores at about 6-^0 m from the wave recession point at Marina, 5-9 m at Thiruvanmiyur ,and 4-9 m at Mahabalipuram. After first sighting, the density in subsequent cores were increased rather ra^jidly to a peak and then decreased towards zero. It is also seen that there is significant difference in the vertical distribution, whereasuhe horizontal distribution shows vary little variation for all the three beaches.

The analysis of the sand particle indicated that the sands were predominantly of medium class. However, some variation in the mean particle size is evident: the midian pai'tidle diameter ranges between- 0,179 and^.499 mm, 0.204 and 0.221 mm and 0.223 and 0.252'mm at Marina, Thiruvanniiyur and Mahabalipuram respectively. The m$a.n particle siz« at <a4 the three beaches generally decreases while progressing up the beach face. The organic carbon in the sands of Marina beach is high (950-1980 (Ag/g), whereas, it is moderate at Thiruvanmiyur (730-1460 IJig/g) and low at Mahabalipuram (330-750 (^g/g)- The seasonal changes in temperature and salinity do not shovy.muQh variation among the three beaches. The pattern of oscillation in the surf and interstitial vyatei temperature is biomadal with 2 peaks in April-May and Octpber and 2 depressions in August and Decerriber-January. The annual variation in salinity is monocyclic with one peak during south west monsoon (May- August) and one depression during north east monsoon (October January).

	N/m² of area sampled			N/linear m of beach			MARINA Transects							
	Marina	Thiruvanmiyur	Mahabalipuram	Marina	Thiruvanmiyur	Mahabalipuram	A	B	C	D	E	F	Total	Cores
Jul. 1982	62	40	9	216	120	27	26	30	28	27	25	26	162	42
Aug.	129	27	11	387	95	32	25	26	22	20	26	27	145	18
Sep.	87	27	12	305	96	35	40	42	38	36	33	40	229	42
Oct.	66	30	4	232	107	13	35	26	28	24	29	32	174	42
Nov.	71	33	9	283	81	28	31	35	38	32	36	40	212	48
Dec.	84	34	13	336	103	40	22	18	19	26	16	25	126	24
Jan. 1983	111	37	11	333	111	32	44	45	43	36	45	37	250	36
Feb	65	45	7	291	136	21	37	34	37	40	37	33	218	54
Mar.	124	62	14	371	217	41	46	61	47	43	48	43	278	36
Apr.	126	68	12	377	175	37	46	52	43	47	49	44	283	36
May	180	70	17	541	211	51	42	36	35	30	44	27	203	18
Jun	79	59	9	315	205	27	38	42	43	34	46	35	236	48
Jul.	109	48	7	381	143	21	38	50	48	61	61	48	286	42
Aug.	85	40	9	296	141	19	43	33	40	30	35	43	222	42
Sep	154	63	11	384	188	28	47	47	42	50	56	46	288	30
Oct.	135	108	9	337	271	23	46	40	43	45	39	40	253	30
Nov	78	43	7	352	173	19	41	48	46	41	46	43	264	54
Dec.	122	67	8	428	267	20	51	54	51	64	44	57	321	42
Jan. 1984	86	46	7	381	163	19	60	57	48	41	38	42	286	54
Feb.	126	40	6	376	141	16	50	41	53	44	46	47	281	36
Mar.	65	45	8	228	159	23	26	25	30	26	34	30	171	42
Apr.	172	38	11	688	161	27	88	98	94	78	74	84	516	48
May.	266	60	8	797	151	25	107	95	102	114	88	92	598	36
Jun.	149	76	8	448	187	24	61	48	62	50	63	62	336	36
July	495	66	10	1485	261	24	105	91	87	76	96	102	567	18
Aug.	298	79	10	1192	317	29	73	79	78	73	67	77	447	24
Total							1268	1242	1236	1178	1197	1222	7342	978
Mean	135.5	51.1	9.5	452.3	168.1	26.9	48.8	47.8	47.6	45.3	46.0	47.0	282.4	38.6
S. D.	93.7	18.9	2.7	293.9	61 0	8 6	22.3	21.3	20 8	21.1	18.9	20.6	121.6	10.8
Coeff of Variation	69%	37%	29%	65%	36%	32%	46%	45%	44%	47%	41%	44%	43%	29%

DISCUSSION

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The present investigation undertal<en with *^ the main poulation density of the wedge cl^m D0/7.X c/jeams has provided many interesting results. Thezonation of *D. cuneatus* studied in the three beaches is similar with the clams distributed mainly in the mid water mark of the intertidal zone. In spite of such similarities in the zonation of their occurrence, the three beaches do show difference in their respective profiles. In Marina, the degree of beach slope is less and hence the intertidal expanse is more. On the other hand, the Mahabalipuram beach is more steep and hence, the intertrdal expanse is narrow, >4n intermediate condition is obtained • .u TU- • U U O •. j« in the Thiruvanmiyur beach. Such difference in ^^^ ^^^^^^ p^^^„^^ ^^^ ^^^1^^^^^ ^^ ^^^ ^^^^^y ^f ^ooax population. Thus, Marina beach supports a population o\ *D-cuneatus* 16 times greater in size and 14 times more dense compared to Mahabalipuram beach, 2.5 times greater in size and 2.8 times and 2 8 times as dense as that of Thiruvanimiyur beach. Nayar (1955) observed that a maximum of 475 clams *(D. cuneatus)* per sq. foot, area of beach. (5113 clams/m'} from Mandapam in south east coast of India.

and Numbers

THIRUVANMIYUR								MAHABALIPURAM							
Transects															
A	B	C	D	E	F	Total	Cores	A	B	C	D	E	F	Total	Cores
9	6	6	5	11	8	45	18	2	5	4	2	3	4	20	36
12	16	14	12	10	8	71	42	3	2	1	2	3	1	12	18
16	11	10	12	14	10	72	42	3	5	6	4	3	5	26	36
13	14	15	9	11	18	80	42	2	3	1	1	1	2	10	36
12	8	11	11	10	9	61	30	3	4	4	4	3	3	21	36
15	14	11	13	12	12	77	36	1	2	2	3	4	3	15	18
14	18	16	10	13	12	83	36	4	2	5	4	5	4	24	36
17	15	18	14	18	20	102	36	3	2	4	3	1	3	16	36
27	24	28	24	34	26	163	42	6	4	3	5	7	6	31	36
19	23	23	20	21	25	131	36	4	5	5	4	6	4	28	36
11	13	11	16	12	16	79	18	2	3	3	3	3	3	19	18
32	21	27	22	29	23	154	42	4	2	5	2	4	3	20	36
16	19	18	21	18	15	107	36	2	3	2	2	3	4	16	36
21	15	18	17	15	20	106	42	1	3	3	3	2	2	14	24
19	31	28	25	20	18	141	36	4	5	2	4	4	2	21	30
40	37	28	37	25	36	203	30	2	3	2	4	3	3	17	30
25	23	18	20	24	20	130	48	2	3	1	3	2	3	14	30
29	33	36	38	34	30	200	48	2	3	4	2	2	2	15	30
20	18	21	19	20	24	122	42	4	1	3	3	1	2	14	30
18	20	17	15	19	17	106	42	2	1	1	2	2	3	11	30
23	18	21	17	18	22	119	42	1	3	3	4	3	3	17	36
17	21	20	15	22	18	113	48	5	3	4	2	3	3	20	30
16	20	14	17	23	23	113	36	2	4	3	4	4	2	19	36
22	19	24	26	22	27	140	30	2	3	3	3	4	3	18	36
17	20	15	19	13	14	98	24	3	4	2	5	2	2	18	30
21	18	22	15	24	18	119	24	1	2	1	2	3	2	11	18
500	494	490	470	492	489	2935	948	70	80	77	82	81	77	467	804
19.2	19 0	18 8	18.1	18.9	18 8	112.9	36.5	2 7	3.1	3.0	3 2	3.1	3.0	18 0	30.9
7.0	7 0	6.9	7.6	6.9	6.9	38 9	8.5	1.3	1.6	1.4	1.1	1.4	1.1	5.2	6.5
36%	37%	37%	42%	36%	37%	34%	23%	48%	38%	48%	36%	46%	36%	29%	21%

After settlement of the spat, on the mid water mark a variety of environmental factors may influence the growing population. Essentially, the chief factors such as slope of the beach, sand grain size and wave action are interpendent Thus, the slope of the beach is decided by the wave action which in turn is responsible for the distribution of different grades of sand on the expanse of the beach. Generally, the coarser sands tend to produce steeper beaches and fine sands shallower beaches At Marina, the shallow beach and fine sand support a dense population; conversely, the coarser sand particles and steep beach at Mahabalipuram supports only a sparse populatjon. Thiruvanmiyur beach is neither too steep nor flat, thus providing suitable conditions for settlement and growth of the population. It is seen from the foregoing observations that the density of population depends much on the slope of the beach. Accrodingly, Marina with g less slopy beach favours the maximum spat settlement, whereas in the Mahabalipuram beach, the beach is steep, thus supporting only a sparse settlement of spat. Again, the Thiruvanmiyur beach is intermediary in character, thus

supporting a moderately dense distribution of spat.

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U. MANAGEMENT APPROACH FOR CLAM RESOURCES DEVELOPMENT IN INDIA

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ABSTRACT

Clam resource, both live and subsoil deposits, are categorised under minor minerals and as such the licencing and general policy decisions are being formulated by the Department of Mining and Geology of the respective states. Eventhough in the states like Kera'a, Karnataka, Maharashtra, Tamil Nadu and Andhra Pradesh the meat is consumed, major portion of the live clams are collected for utilising the shell for lime and related industries involving a high wastags of meat. There are co-operative societies functioning in certain parts of the country making the harvest and sale on a co-operative basis. Similarly large scale collection and destruction of seed clams are also observed in some of the areas and if properly conserved the produciion can be enhanced considerably. The developmental programme in this sector are to be taken up at the state and national levels. The paper deals with these topics in detail and suggests management programmes.

INTRODUCTION

A proper management approach for judicious exploitation and conservation of natural resources is necessary for all development programmes in a planned way to balance a continuous supply of raw material for the industry as well as for maintaining a uniform level of food production as far as our country's requirments are concerned. Our non-renewable natural resources like minerals and the renewable resources from agriculture, forestry animal husbandry and fisheries require dfferent management systems.

The clam resources of our country have a non-renewable phase as subsoil deposits at some centres and a renewable phase in various low saline water bodies of maritime states where live clams are harvested Based on this background the C. M, F. R. I. has taken up a case study of one of the major estuaries, the Vembanad lake, to evaluate the situation and suggest management measures which can be taken up by the administrative departments of the respective states to evolve management procedures for conserving the clam resources and si.nultaneousiy implemant programnss for improving the living standards of the fisherman involved with this resource.

IMPORTANCE OF CLAM IN THE INDUSTRY

Many Industries like cement, calcium carbide, textile, paper etc. and the manufacturers of lime based chemicals depend on lime shell for their requirments of raw materials, it is worthwhile to mention that those states which are not having deposits of lime stone naturallK depend on clam shells for their bulk requirments. It is observed that the production from the Vembanad lake is about 2,00,000 t annually comprising lime shell and live clams. The convertion rate af calcium carbonate by these animals is *yeti* high that from a lake area of about 200 sq km a production of more than 25,0001 of shells is achaived by the activities of clams in the Vembanad. Similarly depending upon the size of the estuary and the water conditions, all the estuaries in the country are contributing their share of clam production to the industrial network. Alagarswamy and Narasimham (1973) gave an account of the clam resource of the Indian coast and the earlier studies have bean revieA^ed Subsequently the studies by Rasalam and Sebastian (1976) on the lima shall fisheries of tha Vembanad lake have projected the potentialities of the resource in this locality. Nayar el al (1934) and Narasimham et al (1934) made detailed investigations on the mollu3can resource of Kali estuary and Kakinada Bay respectively, while Rao and Rao (1935) have preser^ted the

resource position of some of the Karnataka estuaries. A recent investigation by the author (Achary 1986) on the socio-economic impact of the clam resources of the Vembanad lake form the base of this paper.

The present method adopted by fishermen of many of the stales for collection and sale of shall is more or less very much unorganised and a proper organisation of these fishermen will naturally help them to make clam fishing as a regular employment.

UTILISATION OF CLAM MEAT : NEED FOR AN ORGANISED NET WORK

Even though clam meat is highly nutritious and is a source of cheap protein food, the meat is shucked only at certain parts of the country and utilised as food. Of late, the meat of *Katilysia* and *Paphia are* exported to foreign countries. The meat from *Villorita* fished in the Vembanad lake is estimated at 3,300 t and it is locally consumed. Similarly in Karnataka state, the meat of *Maretrix* is very much relished and there is a regular market in Katnataka and Goa for *Maretrix* along with *Katelysia* and *Paphia.* Huge quantities of *Maretrix* are exploited in live form in Kerala and the fishery is mainly for utilising their shell. A proper processing and marketing system is to be developed for avoiding the wastage of clam meat.

CONSERVATION OF SEED CLAMS

It is unfortunate to notice that the young clams below 15 mm length are heavily exploited during certain seasons in almost all areas of Vembanad lake. As high concentration of settlement occurs in clam beds of shallow areas, the fishermen are able to collect them in large quantities by using small mesh sieves. To study the intensity of seed clam collection from a specific area, observations are made on the fishery of clams of Vembanad lake and a comparison is made for the different zones. It is found that more than 50% of the catch from the zones north of Thannirmukkom bund is constituted by seed clams below the size of 15mm. Whereas in southern zones they collect clams above the size of 15 mm using sieves of larger mesh size and seed clam collection is very rare. In northern estuaries also seed clams are heavily exploited. However, the fishermen are becoming aware of the deleterious effect of this practice and there is improvement in the situation in some localities. If an organised clam culture programme is initiated it will augument the production of clams.

ROLE OF CO-OPERATIVES IN VEMBANAD LAKE

There are twelve co-operative societies working around the Vembanad lake, six for live clam fishermen and six for fishermen collecting shells from the deposits. The total membership of these societies is 4699 and except in case of one live clam society the others have a turnover of 3,686 to 4,909 t. The white lima shell societies have a turnover of 5,633 to 18,586 t except for one which is on the northern most part of the lake.

The main activity of these societies is collection and sale of shell. There is a co-ordination committee known as Action Council with representatives from each society to formulate general policies like fixation of price and collection of deposits like compulsory deposits, provident fund, medical, festival and other welfare funds etc. from the members. Two societies have their own boats to tow the canoes of fishermen to the fishing area and back to the depot where the shell in stocked. This reduces the manual labour and helps the fishermen to have more time for fishing There are also facilities for advance payment to the members which is recovered subsequently and also for payments from the reserve funds.

RURAL DEVELOPMENT PROGRAMMES AND CLAM INDUSTRY

The self employment and other welfare schemes under the Department of Fisheries, Industries, Agriculture, Animal husbandry, Harijan Welfare, Khadi and Village Industries Commission, Matsyafed etc. could be very well channelised to the clam fishermen if the co-operative societies can function as nodal centres (Flow Chart). For example, the Khadi & Village Industries commission has 25 schemes

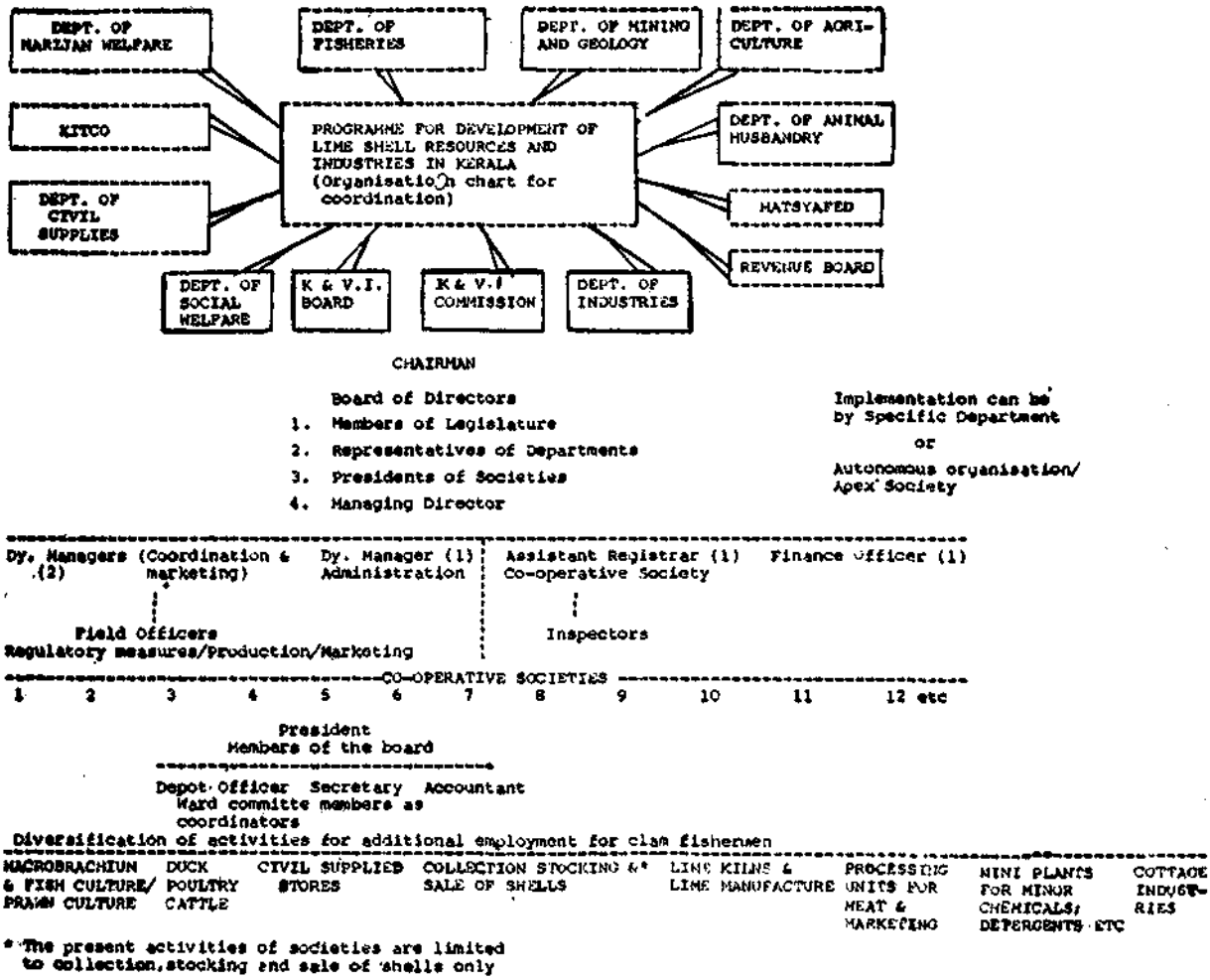

Fig. 1 Flow Chart

to provide self employment opportunities and of these thirteen are functioning at present for lime industry to support individual as well as group activities. It is observed that only very few societies of lime shell fishermen of Vembanad lake have availed this facility. If an agency to co-ordinate and channelise the development programmes through these societiesis set up, it will go a long way in improving the living standards of the fishermen.

AN APPROACH FOR FUTURE DEVELOPMENT

Th clam resource of our country need immediate attention for conservation and replenishment to meet future demands of the lime based industry. In addition, generation of additional employment opportunities and welfare programmes'for the fishermen also can be simultaneously tackled by establishing co-operatives for these fishermen and the activities ^,3^ ^e coordinated by autonomous agencies ^^ ^^ ^ ^^p^^^,^ ^.^^ ^, ^^^ administrative departments. A general programme is presented in the organisation chart which can be suitably modified according to the administrative facilities available for specific localities. The C.M.F.R.I.. C.I.F.T., MPEDA and the concerned departments will be in a position to formulate programmes by mutual consultation to make localised area development programmes and the base line studies made by the ^nstitute could be properly utilised, by consulting the specialist scientists in the respective field.

ACKNOWLEDGEMENTS

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12. EDIBLE OYSTER RESOURCES OF ENNORE ESTUARY AND MUTTUKADU BACKWATER, MADRAS

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ABSTRACT

Survey conducted of the standing crop of edible oyster *Crassostrea madrasensis* papulation in Ennore Estuary and Muttukadu Backwater Indicated the existence of beds in both areas- At Ennore, the oyster beds are located over a distance of 2 km extending to 1 km on either side of the railway bridge. An oyster bed present below the Ennore railway bridge is the largest with an area of 40 ha and the population of oysters is dense In its eastern portion. The other beds are small.

At Muttukadu, the oyster beds are present from the mouth of the backwater to the road bridge near Fisherman's Cove Hotel A bed on the western side of bridge is the biggest one In the backwater and Is 2.6 ha In area. Environmental factors play significant role in limiting the distribution of oysters in both areas.

Exploitation of oyster beds in Ennore Estuary and IVluttukadu backwater is limited. Shells are utilized for lime preparation and meat for local consumption.

INTRODUCTION

Oysters constitute one of the commercially important molluscan fishery resources, provid - ing both food for human consumption and raw material in lime and cement industries. Their importance as a fishery resource and the possibility of their cultivation have been high-lighted byAwatiand Rai (1931), Hornell (1910, 1917, 1922 and 1951), Rao (1958), Jones (1968), Rao (1974) and Nayar and Rao (1985). jhe oyster C. *madrasensis* is widely distributed gn the east coast of India, occurring in Sonapur backwaters in Orissa (Alagarswami and Nara-simham 1973), Pulicat Lake, Ennore (Hornell 1917), Muttukadu backwater, Sadras, Killai backwaters, Athankarai, Pinnaka/al and Tuti-corin (Rao, 1974). Although extensive beds of

C msdrasensis a'erdistributed along tfi4 coa&f, resources survey of the oysters has not been carried out till recently. A comprehensive knowledge about the distribution and a proper estimation of the standing stocks are essential for planning any large scale utilization of this resource and also for effective culture product-i-n. Therefore a survey was undertaken during September-December 1986 to study the general features, hydrological conditions, distribution and quantitative information on the standing stocks of oysters of Ennore estuary and Muttu-kadu backwater, and the results are presented in this account.

MATERIAL AND METHODS

A preliminary survey was made by inspect-ion of the oyster beds and the formation of patch6s iff the Enriore eStuary"ana\WuittiMadu backwater *by* diving and observations during low tide.

While the Ennore estuary was sampled at i6 stations spaced at an interval of 3C0:m, Muttukadu backwater was sampled at 19 stations located at 200m intervals. The structure and shape of oyster beds were noted. In each station, oysters were samp ed using a quadrat °"' »° determine the density of oysters for ^""^^ Percentages of live and dead oysters were estimated by weighing them separately in each sample. Based on the weight of the live oysters in 1 m2, the total biomass of the bed was calculated. Samples of live oysters yvere analysed for size composition and meat weight.

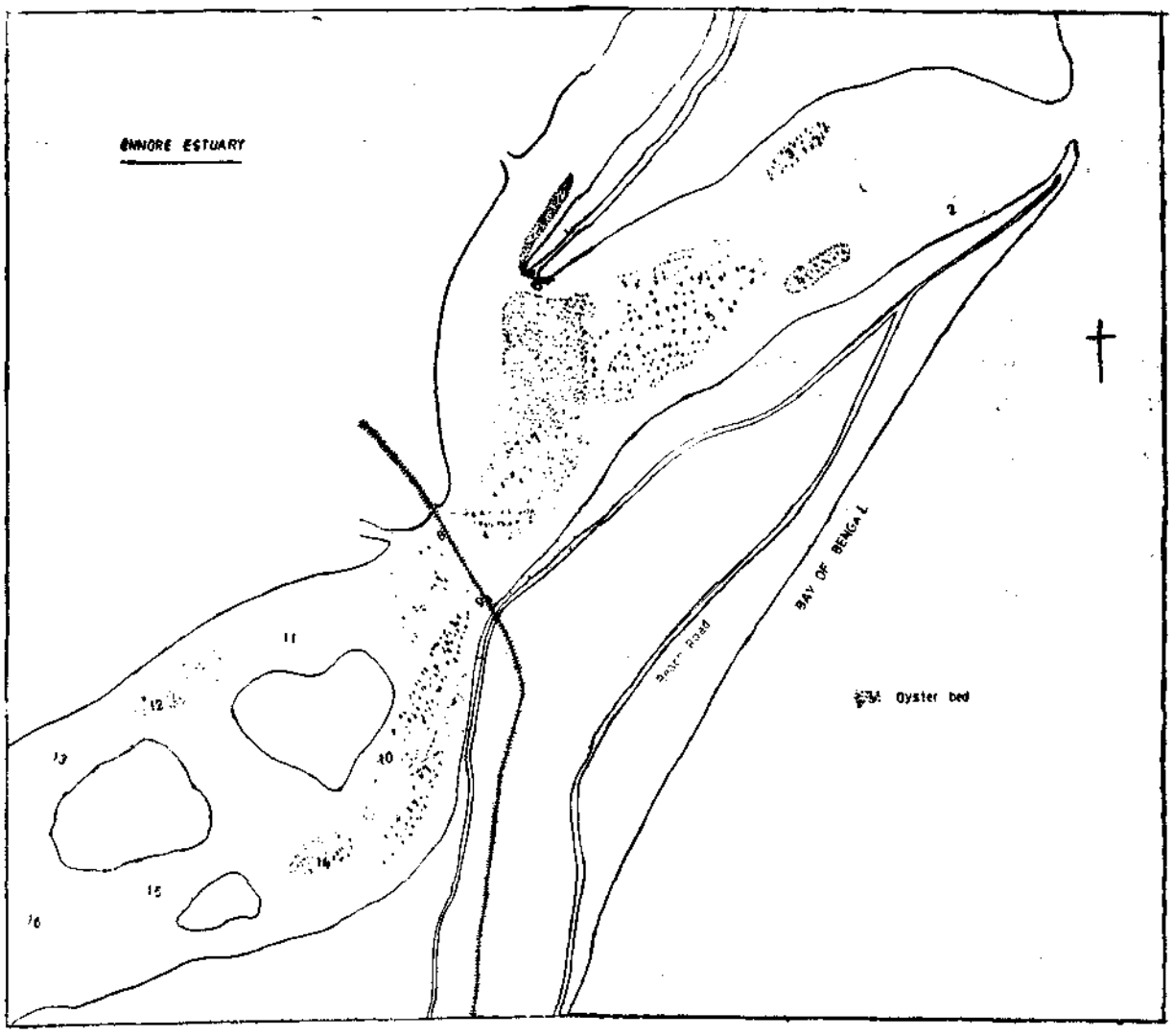

Fig. 1 Ennore estua.y showing survey stations and Oyster beds in the estuary

PHYSIOGRAPHY OF ENNORE ESTUARY

The Koratalayar estuary popularly known as Ennore estuary is situated at 13° 14' N and 80" 20' E and is about 15 km north of Madras. The estuary runs parallel to the sea coast and extends over a distance of 3 km in length and about 1 km in width with depth varying between 0.6 m and 3.0 m. The Koratalayar river forms the main channel for the estuary besides the Buckingham Canal (Raghunathan and Srinivasan 1983). The estuary joins the Sea at Ennore village. The bar mouth is kept open throughout the year due to the dredging operations by Ennore Thermal Power Station (ETPS) to draw a large volume of water from the estuary for cooling purposes. This results in regular mixing of sea water with the estuarine system.

LOCATION AND DESCRIPTION OF OYSTER BEDS AT ENNORE

Details regarding the location of stations and distribution of oyster beds are given In Fig 1, hydrographic data at various stations in Table. 1 and the estimated area of oyster beds, density by number a weight in Table 2- Of the 1 6 stations examined there were no oysters at stations 1^ 2, 11, 13. 15 and 16. At stations 5, 7, 8 and 9 the oyster beds were observed to be continuous.

The general description and the observations made on the oyster beds are as follows.

Oyster bed I. This small oyster bed was located about 600 m away from the mouth near the western bank in station 3 in the vicinity of the tourist spot. The bottom was of muddy and

TABLE 1. *Hydrography of oyster beds in Ernore estuary*

Station	Depth (m)	Nature of substratmum.	Salinity (s%o)	Temperature (oC)	Dissolved oxygen (ml/l)
1.	3 0	Sandy	32.80	32.0	4.2
2.	0.8	Sandy-mud	31.70	31.3	4.6
3.	1.5	Muddy	32.17	31.8	4.9
4.	1.2	Oozy-mud	30.38	30.3	3.9
5.	1.3	Muddy	30.95	31.0	4 0
6.	2.1	Granitd stone	30.52	33.0	3.8
7.	0 6	Muddy	31.01	32.9	3.6
8.	2.2	Concrete & mud	29.31	28.6	3.8
9.	1,5	Muddy	27.80	29.6	3.7
10.	1.2	Muddy	23.31	29.6	4.0
11.	1.4	Muddy	24.81	29.1	3.2
12.	0.5	Muddy	25.85	28.9	3.0
13.	1.7	Muddy	22.82^	28.8	3.1
14.	0.9	Muddy	24.62	29.1	3.8
15.	1.7	Muddy	25.25	29.2	3.3
16.	2 4	Muddy	25.53	28.9	3.2

TABLE 2. *The estimated area of oyster bed in Enriore estuary, numbers arid biomass of oysters and meat weight*

Station	Estimated area of bed (sq.m.)	Estimated density of oyster (No/m2)	Estimated total number	Estimated biomas of oysters (kg)	Estimated meat weight of oysters (kg.)
1.	—	—	—	—	—
2.					
3.	280	120	33,600	560	36,4
4.	200	152	30,400	1,360	63.9
6.	500	160	80,000	5,200	306.8
5&7.	4,00,000	356	14,24,00,000	1,80,80,000	10,769.2
8&9.	9,776	240	23,46,240	1,99,430	18,162.1
10.	32,760	92	30,13,920	2,88 288	—
11.	—	—	—	—	9,40,160.0
12.	1,500	168	2,52,000	16,200	1,075.2
13.	—	—	—	—	—
14.	2,480	172	4,26,560	21,824	1,331.2
15.					
16.					—
Total.	4,47,496		14,85,82,720	1,86,15,862	9,71,904.8

the depth varied between 8.5 m and 3.0 m during low tide. The oyster bed consisted of two closely positioned thick patches roughly ovate in shape, in all raeasuring 35 m long and 8 m wide with a total area of 280m2. The density of oysters in the total area was 120/m2 and the total biomass was estimated to be 33,600 oysters with a total weight of 560 kg and meat weight 36 4 kg. In this bed the live oysters formed only 31% of the population and they ranged in size between 24 and 51mm. About 17% of the oysters were of small size 20-29 mm. The other organisms found in the bed were a few *Balanus* sp and *Modiolus undulate.*

Oyster bed 11. In station 4 another smaller bed of the size 40 m in length and 5 m in width was located lying almost parallel to the eastern bank at a distance of 20 m from it. This narrow strip of oyster bed included a total are of 200m2 a total biomass of 30,400 oysters. The density was 152/m2 and the total meat weight 63.9 kg. The oysters ranged in size from i6 to d9mm. The modal sizes observed were 35-39 mm, and 70-79 mm. Although this is a smaller oyster bed, a good number of green mussels, *Perna viridis ^5-^45 mm* in size were present a^ong with oysters.

Oyster bed III. The oyster bed located in station 6 was of moderate size near the southern lock Of Buckingham Canal. The size of the bed is 53 m in length and 10 m in width. The shape of the bed was roughly rectangular. The bed, with thick clumps of pysters had ^ total area of 500m2, on the flat hard muddy substratum and heavy concentrations on the granite stones of the lock. The bed was partly exposed during low tide and the depth of water column was around 2.1 m. The oyster population and total biomass in the bed were 80,000 and 5,200 kg. The estimated meat weight of the live oysters in the bed amounted to 306 kg.

Oyster bed /v. This is the largest oyster bed with an area of 400,000 m* which extends from almost middle of the estuary tdwards the

railway bridge on the western side reaching upto a distance of 1 km. The bed extends from station 5 and covers the station 7. The general shape of the bed is roughly triangular with the broad base in parallel position to the eastern bank, one extension of the triangle on the east towards mouth, and another extension on the north upto the railway bridge and a third extension towards the northern lock. The dense concentration of oysters in this particular bed is of significance. The number of oysters present m the entire area was estimated to be ,42,40,000; with a concentration of 356/m2. The live oysters contributed to a meat weight of 9, 0,1 60 Kg and the total biomass of dead and live oysters was estimated to be 180,80,-OOO kg. The oyster population of the bed included individuals of the size range 86-189 mm at the northern portion of the bed and 20-122mm at the southern part of the bed. The modal sizes were 40-44 mm, 50-54 mm, 70-74mm, 80-84mm. 95-99mm and 165-169mm.

Among the other organisms associated with the oyster bed the distribution of green mussel, *perna viridis* was noteworthy Both adult and spat of the green mussel were found attached to the hard substratum provided by the oyster shells. The green mussels ranged in size between 16-137 mm. They were not found in dense clustures but distributed sparsely. In addition to this. *Modiolus undulata* and *M. metacalfi* were common among the oysters. The oyster borer, *Thaisrudolphi* was rare whereas the barnacle *(Balanus* sp) were seen attached to the live and dead shells of oysters in small numbers. A part of the bed gets exposed during the low tide especially at the northern extremity, at station 7.

Oyster bed V This bed extends between stations 8 and 9 at the eastern and western ends of the railway bridge. The depth range was between 1.5 m and 2.1 m. Heavy con-centration of oysters formed a broad strip of the bed at this site extending for about 340 m under the bridge. Good settlement of oysters was also seen on all the concrete pillars of the railway bridge. The bed area had a total expanse of 9,776 m* having a biomass of 1,99,-430 kg consisting of 23,46,240 oysters. The density of oysters fourid in an unit area was 240 numbers. The oyster population of the bed consisted of 42% live and 58% dead oysters. The oyster shells formed a strong solid substratum for the live oysters to settle over it. Live oysters ranged from 24 to 1 55mm in size with modal groups 40-44mm, 50-54 mm, 75-79 mm and 90-94 mm. The weaving mussel. *Modiolus undulata,* amphipods and alpheids were commonly met within samples taken from this bed.

Oyster bed VI. Running parallel to the south eastern bank of the estuary and located in between the large *thittu* (islet) and the bank were to long patches of oysters. Both patches occupy a total bed area of 32,760m2 having a total biomass 2,88,288 kg and total density of 30,13,920 oysters distributed at 92 numbers per 1 m2. Although this bed is large in area, the number of oysters present in unit area was less when compared to other beds. The oysters were of the size range 37-103 mm and the modes recorded at 50-54 mm and 85-89 mm. The estimated total meat of the oysters was in the order of 18,162 kg.

Oyster bed VII. This moderate size bed was located near the eastern bank and occupied a total area of 1,500 m^. The total population of 2,52,000 oysters had total weight and meat weight of 19,200 kg and 1,075 kg respectively.

Oyster bed VIII. The oyster bed was situated very close to the western bank at the southern extremity of the estuary and had a total spread of 2,480 m' with biomass of 21.824 kg and 4,26,530 numbers which had an estimated meat weight of 1,331 kg. The density per unit area was 172 oysters. Live oysters formed only 39% of the oysters in the bed. The size of oysters ranged from 19 to 81 mm with a prominent mode of 40-44 mm.

PHYSIOGRAPHY OF THE MUTTUKADU BACKWATER

The Muttukkadu backwater (Lat. 12° 49' N; Long. 80° 15' E) extends for a distance of 20 km from the mouth. The backwater runs at right angle to the coast for a distance of about 3 km and branches into southern and northern wings. The Mariculture Farm of

CM.F.R.I, is located as a separate extension of the backwater on the northern side, close to the mouth. The backwater is connected to the sea by a bar mouth, the width of which is variable from a few metres to 200 m in different months. The backwater is normally cut off from the sea during May-September; when a sand bar is formed During October-December, due to inundation by the freshes from the upper reaches, the sand bar gets eroded and the connection with the sea is restored.

The width of the estuary ranges from 800 m to 1050 m. The estuary is shallow, .the maximum depth being 2 m, in the middle of the channel, while in most of the areas, it is 1 m or less. Granite stones are found along the banks of the southern side. Due to limited fresh water supply, even during the monsoon, and limited flushing, the salinity of the backwater goes up appreciably during summer months, particularly in the Mariculture Farm and in the shallow areas of the open channel. Numerous salt pans lie along the southern side of backwater, the seepage of which also results in increase of the sainity.

OYSTER BEDS IN MUTTUKADU BACKWATER

Compared to Ennore, the distribution of oyster beds is limited in Muttukadu backwater. Of the 19 stations examined in this area, a thick bed of *C. madrasensis* was found at station 6, while scattered to moderate patches were noticed at a few other stations. Location of the different stations and the distribution of oyster beds are given in Fig. 2.

Oyster bed I This bed is located in stations in the middle portion of backwater. This is the largest bed located in Muttukadu backwater where the depth was between 1.5m and 2.0 m, depending on low and high tides. The bed has large number of dead eroded oysters forming the basis for attachment of successive generations and is exposed at low tide. The total area of the bed was 26,068 m^ with a population of 72,99,040 oysters at an average density of 280/m' . Estimated biomass of the bed was 4,17,088 kg which could yeild 23,-357 kg of meat. The size of oysters ranged from 22 mm to 139 mm with modal sizes of 35 mm, 105 mm and 125 mm.

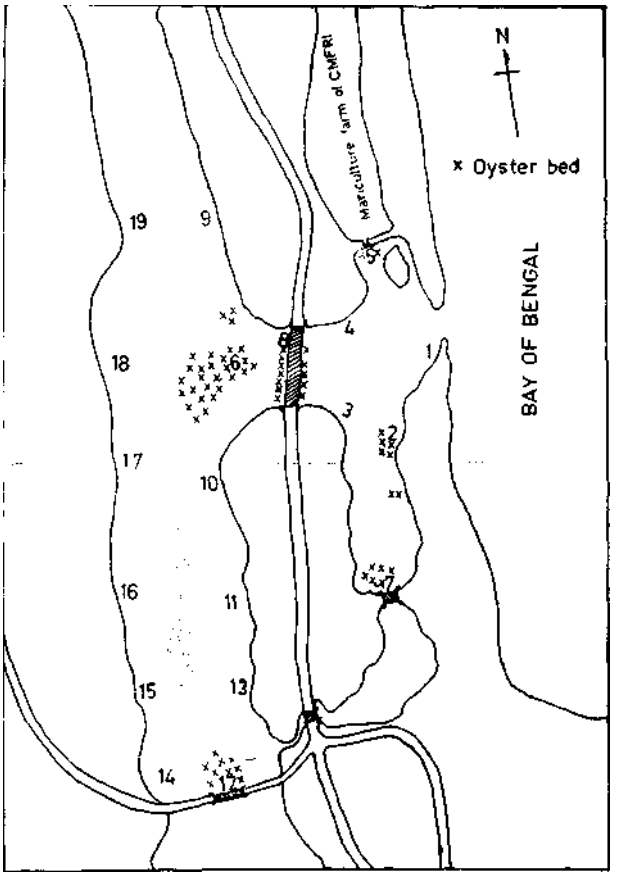

Fig. 2 Muttukadu Backwattr showing survey stations and distribution of Oyster beds

Oyster bed II. This bed was located at station 8 just below the bridge on the Madras-Mahabalipuram highway. The concrete pillars as well as the bottom ware observed to harbour oyster populations. A total area of 8,704 m^ was covered by the oysters at this area. An estimated number of 3,23,788 oysters were found at an average density of 372 numbers/ m2 . The size range was 25 mm to 128 mm and the modal size 45 mm. Total biomass of the bed was 1,01,184 kg with a meat yield of 6,091 kg.

Oyster beds at other stations were of limited quantity and were seen at stations 2, 5, 7, and 12. In all these stations, scattered granite stones form the base for the attachment of oyster spat. Details regarding the areas of oyster bed, biomass, density and meat weight are given in Table 3. In all, the oyster beds at Muttukadu covered an area of 36, 109 m^ and a biomass of 54,50,054 kg of oysters, with a meat yield of 30,938 kg. The total number of

TABLE • 3. *Estimated biomass, density, area of oyster bed (m^), and meat weight of oysters in IVluttul<adu Bacicweter*

Station	Estimated area of oyster bed (sq.m)	Estimated biomass of oysters (kg)	Numbers of oysters per sq m	Estimated number of oysters	Estimated meat weight of oysters *(kg)*
2	446	4,906.0	174	77,604	220.8
5	40	672.0	320	12,800	41.3
6	26,068	4,17,088.0	280	72,99,040	23,358.9
7	816	20,889.6	316	2,57,856	1,211.6
8.	8,704	1,01,183.8	372	3,23,788	6,091.3
12	35	266.0	60	2,100	16.3
Total.	36,109	54,50,054.4		79,73,188	30,938.2

oysters was estimated as 79 73,188 with an average of 221'm^ In almost all the beds, incidence of *Balanus* infestation was noticed.

GENERAL REIVIARKS

Quantitative survey of the edible oyster resources of Ennore estuary and IViuttukadu backwater has been attempted for the first time. Estimated total area of the Ennore oyster beds is 44.74 ha and the estimated oyster biomass was 18,616 tonnes with total meat weight of 971.9 tonnes. The oyster beds of Muttukadu are moderate with a total area of 3.61 ha having a biomass 5,450 tonnes and meat weight of 30.9 tonnes. The oyster beds at Ennore are fiat, uniformly distributed and often form continuous stretch extending even upto 1.5 km in distance. The oysters are also formed of thick formations. The oyster beds at Muttukadu occured in patches and found attached to the submerged stones or the concrete boulders of the road bridge. The oysters in the Ennore Estuary were found to be healthy whereas in Muttukadu the oysters appear to be stunted in growth.

The probable reason may be the maint-enence of sea connection with Ennore estuary throughout the year which provides ample food supply and other congenial conditions for growth and reproduction while exposure during low tides and closure of bar mouth during summer inihibits growth of oysters at Muttukadu.

Both at Ennore estuary and Muttukadu backwaters, oysters are found abundantly indicating the suitability of these areas for their existence. Hunter (1964) suggests that species in estuarine and backwater systems are relatively few because of the unstable environment. However, certain species which succeeded in colonizing the environment proliferate and are found abundantly. The existence of rich beds of oysters at Ennore and Muttukkadu substantiates this conclusion of Hunter (1964).

Rao *et al* (1987) have given a vivid account on the oyster resources of Athankarai estuary in which they have estimated a total biomass of 389 tonnes. The oyster beds occur in patches at Athankarai estuary. The oyster beds are much larger and extend ovar an area of 44.74 ha. In Muttukadu oyster beds occur in patches over an area of 3.61 ha.

The oyster beds in both the places are restricted to 2.5 km from the mouth- This is due to the prevailing brackish water conditions upto this distance by infiltration of sea water. Of the environmental factors such a salinity temperature, configuration of bottom, water level and availability of food influencing the survival and growth of sedentary benthic organisms, salinity appears to be the most' important (Rao, 1951, Rao and Nayar, 1956. (Desai and Krishnamurthy, 1967; Kurian, 1972) that limits the distribution of oysters within the area where brackish water conditions exists

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13. DISTRIBUTION OF MOLLUSCAN FAUNA IN PULICAT LAKE

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ABSTRACT

The Pulicat Lake was surveyed from the barmouth to Ougarajapatnam for molluscan fauna Extensive oyster beds occur in the southernmost region of the Pulicat Lake. Dense population of oyster beds wes'eco'ded at Kulathumedu and scattered distribution near the mouth, Moosimani lock. Kottaikuppam. Sriha'liiota and Ougarajapatnam on the northern side of the lake. Beds of the clams, *Meretrix* casfa and *Katelysia opima* was found arcund the small Islets lying between Gunakuppam and Kottaikuppam. Regular fishery for ci*ms exists in this area. Brds of Oonax spp occur near the bar-mouth of the lake. The button shell. L/mbon/um i/es^anum is distributed from the mouth of the lake uptT 1 km- southwards. *Cerithidea* (C) *cingulata* were also found to form extensive beds. Ihe distribution of the molluscen fauna in the lake is correlated with environmental parameter*.

INTRODUCTION

India has very valuable nnarine molluscan resources which has been widely used as food and source of lime, pearls in ornaments and some shells as medicinal constituents. During the past two decades detailed investigations have been made to study the commercially important molluscan resources Though there is good deal of information available on the resource potential of edible oysters, clams and mussels (Hornell 1908, 1916, 1917; Rai 1928 and 1932; Ranade 1964; Jones 1968; Aiagarswami and Narasimham 1973; Nair and Mahadevan 1974; Rao 1974; Rasalam and Sebastian 1974; Nayaret al 1984; Nayar and Rao 1984 and Sreenivasan 1985) except the works of Rao and Rao (1985) and Rao et al (1987) at Athankarai estuary on the quantitative survey on the resources of oyster beds, no information is available in regard to backwaters or estuary of east coast of India. Distribution of benthic fauna of Cochin backwater has been studied by Desai and Krishnamurthy (1961) and Kurian (1972),of Kali estuary by Harkantra (1975), and of Pulicat Lake by Chacko et al (1955), Krishnamurthy(l971)andRao(1974).Athorough knowledge on the natural resources of bivalve molluscs and their ecology is very essential for starting culture.

In the present paper an attempt has been made to give information on the distribution of oysters, clams, mussels ^nd other molluscan fauna in the Pulicat Lake based on a survey undertaken for this purpose.

MATERIAL AND METHODS

The Pulicat Lake was surveyod during January to April, 1980 for finding out the distribution of molluscan fauna. The edible oysters, clams and *Cerithidea cingulata* popu- '^t'on densities were estimated by using * ""^^'^ ^"^^rat at the sampling sites and the molluscs present in the quadrat were counted ^'"^ .'"""'^''^'^ ^°' ^ ^^j -^-^f^^-Samples were obtained at an interval of 200m at the Low ^^^^^ ^^^^ ^^WM), Mid Tide Level (MTL) and High Water Mark and additional samples were also obtained at a depth of 1 mètre in the lake to estimate the moluscan fauna. Totally 286 stations have been fixed and surveyed. Data collected for *Cerithidea cingulata* from 25 stations were pooled together and average was given in the taole against the villages. The extensive oyster and clam beds were surveyed ^y measuring their length, breadth and height. °ata on the size, weight, percentage of dead and live oysters were estimated in each bed ^ndthetotal oyster biomass was determined, ^^'^^ ^'^"^'^'"^ *^« °^^'^' ^'^"^ ^ ^"'^« ^^^ ""^^^^ ^^^ '"°««'^' ^« ' ^^'Q^^* determined and from ^'^'^ Percentage of meat weight was calculated (meat weight X 100)/ whole weight. Regula** observations were also made on the clam landings of the Pulicate Lake. Various environmental parameters such as salinity,

dissolved oxygen and temperature have been collected at all the sampling sites.

PHYSIOGRAPHY OF PULICAT LAKE

The Pul.cat Lake (Let: 13^26' to 13"43- North and Long: 80°03' to 80=18' East) is the second largest brackishwater lake or lagoon in India, lying almost parallel to the Bay of Bengal covers an area of 461 sq. km between Chingleput District of Tamil Nadu and Neliore District of Andhra Pradesh (Fig. 1). The lake is about 59 km north to south, the maximum width from east to west in the northern sector is about 19 km and the narrowest region of the lake is about 350 m between Dhonirevu and Monaikal. The southern end of the lake opens into Bay of Bengal by a narrow mouth or pass, closely north of Gunakuppam village. There are three small rivulets Swarnamukhi, Kalangi and Arniar, opening into the lake at its northern, western and southern ends respectively The Buckingham Canal, a navigable one, runs parallel between the lake and the sea opening into the lake at one point. There are two large islands, Venadu and Irakkam in the northern region of the lake. The average

The bottom of the lake is oozy mud in deeper parts and quartz sandy along the shores. The eel grass, *Enhalus koenjii* and *Halophila ovaJis are* the two common weeds found all over the lake At the southernmost part of the |,?ke, from Edamanikuppam to Annamalaichery tho seagrassess *Diplanthera uninerves,* and *Halophila avails,* the brown alga *Rosenvlngia intricata.* the green algae *Enteromorpha* sp, *Chaetomorpha* sp, *Gracilaria verrucosa. Acetabularia* and the green alga *Oscllllatoria* form the bulk of the weed bed.

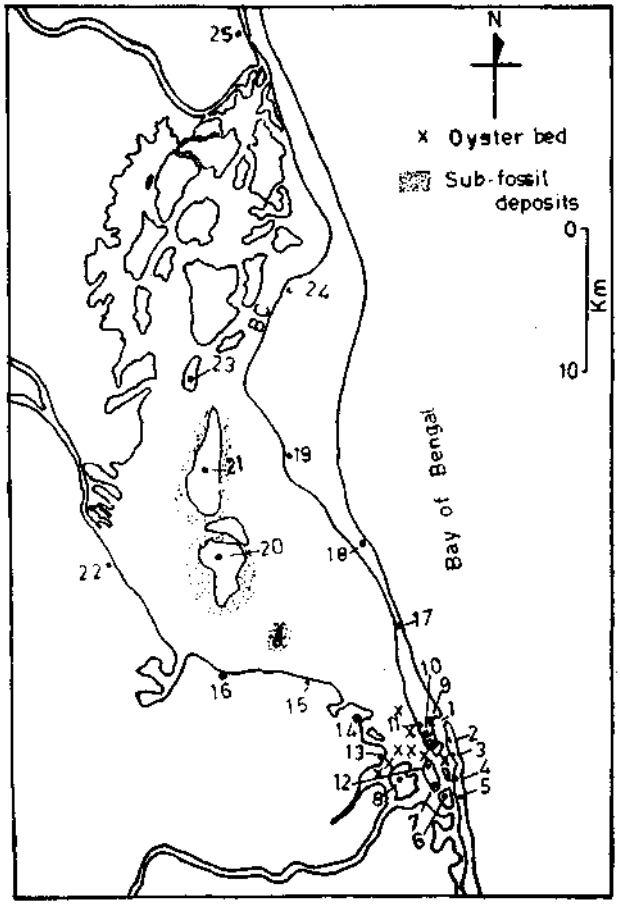

Fig. 1 A map of the Pulicat lake showing the stations and the oyster and subtossii beds

OBSERVATIONS

The survey of the Pulicat Lake revealed that the edible oysters and clams are the major bivalves that occur in vast beds and the gastropod *Cerlthidea cingulata* occur abundantly in the intertidal area of the southernmost region of the Pulicat Lake (Table 1). The distribution of oysters in the Pulicat Lake is illustrated in Fig 1. There are eleven oyster beds with a total area of 9.05 hectares.

OYSTERS

Kulathumedu / Sinnaparaval Bed

This is the largest oyster bed located about 4 km from the pass of the lake. There are 16 extensive patches of oyster beds and with a flat bed of scattered oysters extending to 84,003 sq m. area. Estimated oyster biomass was 13,01,565 kg and meat weight 72,893 kg. Density of oysters, size ranga, nature of bottom, percentage of live and dead oysters and hydrological conditions of the Pulicat lake are given in Tables 2 and *I* The height of the oyster bed varied between 15 cm to 120 cm. The oyster patches are oval, rounded or irregular and exposed during low tide. The oysters which live in patches adjacent to streams grow to longer size and majority of them were found alive. In flat exposed areas, empty oyster shells lay scattered every-where and on these

TABLE 1. *Distribution of moliuscan fauna in different areas of Pulicate Lake.*

Station.	POLECYPODS										GASTROPODS								
1. Bar-mouth	+	—	—	—	—	—	+	—	+	—	+		—.	+	—	—	—	—	—
2. Gunakuppam	—	—	+	—	—	—	4-	—	—	—	-h		—	+	—	—	—	+	—
3. Light Housekuppam											+	+	+						
4. Sttankuppam	—	—	—	—	—	—	+	—	—	—	+	+	+						
5. Koraikuppam	+	—	—	—	—	—	+	—	—	—	+		—						
6. Edamanikuppam	+	—	—	—	—	—	+	—	—	—	+	+	+	—	—	—	+	—	—
7. Pulicatekuppam	+	—	—	—	—	—	+	—	—	+	+	+	+	—	+	—	—	—	—
8. Kottaikuppam	+	+	+	—	+	+	+	-t-	—	+	+	+	+	—	+	+	+	+	+
9. Karimanal	4-										+		—	—	+	—	—	+	—
10. Dhonirevu	+	—	+	4-	+	—	+	—	—	—	+		—	—	—	—	—	—	—
1'. Moosamani Lock	+	—	+	+	+	—	+	+	—	—	+	+	+						
12, Kulathumedu	+	+	—	—	—	—	+	+	—	4-	+		+	—	+	+	—	—	—
13. Avirivakkam	+										+								
14. Annamaiaicherry	—	—	—	—	—	—	+	—	—	—	+								
15. Mangodu											+								
15. Sunnambukulam											+								
17. Arangam											+								
18. Pulianchery																			
19. Zonangipalayam																			
20. Irakkam																			
21. Venodu																			
22. Tada																			
23. Atakinithippa	+	—	—	—	—	—	-|-	—		—	+								
24. Sriharikota	+	—	—	—	—	—	+	—	—	—	+								
25. Durgarjapatnam	+						+				+								

-\|- Present — Absent

numerous oysters settled and they seem to be very stunted due to overexposure at low tide. The bottom was muddy in this region. The oysters in the bed are characteristically elongate, long and narrow in form and remarkably regular in growth. The oysters are very much crowded, gradually thinning out along the margins. Depth of water on each side of the bed varies between 0.8 to 1m during the low tide. The successive generations of oysters result in a thick bed.

The oysters exposed at low tides are devoid of fouling organisms and in the submerged oysters there was algal growth. 23% of the oysters were infested with *Polydora ciliata.* The coral boring bivalve mollusc *Lithophaga* burrows into the shell of dead oysters in this bed. Burrows made by *Lithophaga* were long and cylindrical in outline. Oysters also found infested with the boring sponge *Cliona* sp. The weaving mussel *Modiolus undulata* was very common. Gastropods *Thais rudolphi, the*

TABLE 2. *Tfie estimated area of oyster beds in PuHcat Lal<e, number and biomass of oysters and meat weight.*

Name of Oyster bed	Estimated1 area of oyster beds (Sq m)	Estimated number of oyster	Estimated biomass of oyster (Kg)	Estimated weight (Kg)
Bar-mouth	1,312	15,744	1,476	120
Koraikuppam	450	3,160	170	10
Edamanikuppam	1,200	16,600	889	60
Pulicatkuppam	19	3.876	209	14
Kottaikuppam	10	15,215	1,11	89
Karimanal	49	3,250	174	10
Dhonirevu	7	721	58	3
Moosamani Lock	925	2,23.850	12,436	659
Kulathumedu	84,000	2,50,32,000	13,01,664	72,893
Sriharikota	124	2,136	164	8
Kondurpalayam & Durarajapatnam.	2,400	40,800	2,203	1,153
Total.	90,590	25,35,6342	1320,575	75,019

TABLE 3. *Density of oyster, size range, nature of bottom, percentage of live and dead oysters and hydrologicai conditions in pulicate Lake.*

S/N0.	Nams of oyster	Numb8r/m2	Size range(mrri)	Mean size	Percentage Dead	Alive	Nature of bottom ,	Na'ure of oyster bed	Salinity S7o0	Tem. ve	Dissol-ved oxygen (ml/l)
1.	Bar-mauth	12	40-137	93 2	63.8	36 2	Muddy sand	Scattered	34.14	28.5	6.7
2.	Koraikuppam	7	36-125	87.2	35.4	642	Muddy	Scattered	34.40	29.0	56
3.	Edaminikuppam	13	42-127	78.0	368	63.2	Muddy	Scattered	34.40	29 0	6.4
4.	Pulicate	204	31-124	77 3	23.6	76.4	Muddy	Vertical	34.14	29.8	5.2
5.	Kottaikuppam	147	33-125	905	28.4	71.6	Granite stones	Vertical	35.30	28.6	54
6.	Karimanal	67	24-118	91.4	58.5	41.5	Muddy	Heaps	35.20	29.S	6.2
7.	Dhonirevu	103	21-134	72.6	39.4	60.6	Granite stones	Heaps	35.84	30.2	6.3
8.	Moosamani Lock	242	18-134	71.9	33.6	66.4	Muddy	Scattered	35.62	29.6	5.4
9.	Kulalhumadu	298	22-138	52 5	43.2	56.8	Muddy	Vertical horizontal	36.40	31.2	6-5
10.	Sriharikota	89	36-124	808	33.8	66 2	Granite stonea	Vertical	39.2	34.0	5.2
11.	Kondurpalayam & Dugarajapatnam	17	45-119	79.7	60 0	40.0	Muddy	Scattered	36.82	33.3	5.4

Hemifusus sp and the polychaetes *Marphysa* and *Eunice* sp were also found in the crevices of oysters.

Bar-mouth:

There is a small oyster bed exposed during low tide at about *i* km distance on the western side from the pass of the lake. The estimated area of this bed is 1312 sq.m. and the oyster biomass was 149 kg with 15,744 oysters. The meat weight obtained was 120 kg in this bed. The bed is on a sandy bottom and oysters are scattered everywhere^ The percentage of live biomass is lesser than dead oysters.

Korailiuppam

There is a small oyster bed here with oysters scattered over a wide area of 450 sq.m. with an average of 7 per sq. m. The size of oysters ranged between 36 mm and 135 mm. The live ones formed 64.2%. of total oysters The substratum is hard muddy. The estimated biomass was low, at 170 kg. total numbers 3,150, and meat weight at 3.7 kg.

Edamanikuppam

The oyster bed is widely spread with an average number of 13 oysters per sq. m. and estimated biomass was 889.2 kg in a total area of 1,200 sq. m. with a total number of 15,600 oysters. The size range varied between 42 mm and 127 mm and the percentage of live oysters was 63.2.

Pulicatlfuppam

Oysters are found attached to a concrete pillar and also on granite stones in the southern region of the Pulicat village. Total estimated area is 19 sq. m. and the live oyster biomass was 209.3 kg and the meat weight was estimated to be 13.9 kg. The size of oysters range between 31 mm and 124 mm. The maximum percentage of oysters were found in the live condition in this bed compared with other beds-

Kottaikuppam

There are six patches of oyster bed having a total area of 10 per sq. m., of which two were on the granite stones in the lock area and four small ones north of Kottaikuppam. The estimated total number of oysters was 15,215 and biomass 1,111 kg. The estimated meat weight was 89 kg. in this bed. Alongwith *Crassostrea madrasensis* which is the main species, the rock oyster *Saccostrea cucullata* is sparsely distributed in this area. The green mussel *Perna viridis. Modiolus undulata* and *Anomia* sp are also found associated with the oysters. The other four patches are small and spread over 49 sq. m. These are found on muddy bottom. Oysters were also sparsely found attached to small shells in some places.

Karimanal

This is a small bad consisting of four patches located in the bay like projection of the lake near Karimanal area which is about 2 kilometres from the mouth of the lake. The height of the bed ranges between 20 to 60 cm. The total area of the bed is 48.5 sq. m. a total biomass of 174 kg and meat weight calculated to be 88.9 kg with a total number of 3,250 oysters The percentage of dead oysters was calculated to be 58.5%, The bottom of the bed is muddy. The patches of oysters are partly buried in the muddy bottom and thereby a majority of the oysters were dead.

Dhonirevu

There is a small patch of oysters found on the western side of the village with a total area of 7 sq. m. having 103 oysters per sq. m. estimated to be 721 oysters in this bed. Estimated live biomass was 58 kg. The bottom consists of granite stones. The size of the oyster ranges from 21 mm to 134 mm with a mean length of 72.6 mm. The estimated total biomass was low, 55.4 kg.

I\/loosamani Lock

There are four patches of oysters attached to the granite stones of the lock. Oysters are also found scattered in this area. The total area of the patches is 925 sq. m The estimated number of oysters per sq. m. is 242 and total of oysters 22,32,450 are found. The size of oysters ranged between 18 mm and 134 mm with a mean length of 72 mm.

Sriharikota

The oysters are found attached to the granite stones of the road bridge in the Buckingham Canal. The total area of this patch is 124 sq. m. with 2,186 oysters having a biomass of 1 64.5 kg. The size range of the oysters was 36 and 124 mm with a mean length of 81 mm. Oysters were also found live on the dead shells on either side of the bridge.

Kondurpalayam and Dugarajapatnam

The oysters were sparsely distributed on the muddy bottom. Most of the oysters are attached to the empty oyster shells and were sparsely distributed. Thick patches of oysters were observed only in two places. The ^density of the oysters were calculated to be 89 per sq. m. and the estimated biomass was 2203.2 kg consisting of 40,800 oysters. The estimated wieght was 1,153 kg. The size range of oysters was 46 and 118 mm and mean size 80 mm in this area,

CLAMS

Rich clam beds exist at a distance of about 2.5 km from the pass of the lake. The total area of clam beds of the lake has been estimated to be 12.08 ha. and the total biomass 121 tonnes (Table 4). There are three islets existing in the lake between Kottakuppam and Gunakuppam from where fisherwomen hand-picked the clams for marketing. On the northern side of Kottakuppam up to Moosamani lock, the clams are sparsely distributed.

The density of clams was high around the islets in the lake area near Gunakuppam and another wide spread area adjacent to Kottaikuppam was also rich in clams. The total area of the bed approximately has been estimated to be 3.6 ha and 1.6 ha near the two islets near Gunakuppam with an average number of 270 and 140 clams per sq.m. The total biomass of clams was 67,557 kg. (Table 4) The size of the clams ranged between 17 mm and 40 mm. The clam bed was black muddy with 40 cm slushy bottom.

The Kottaikuppam bed is more or less triangular in shape which is exposed during low tide. The bed was rich in clams in the northernmost region and the density of the clams was gradually decreased on the southern side. There was growth of *Halophila ovalis-Chaetomorpha* and *Enteromorpna* sp at the bottom in the area. The total area of the bed is 2 ha with an average of 63 clams per sq. m. and biomass 19,932.9 kg. In the area lying between Dhonirevu and Moosamani lock also clams were sparsely distributed. The clams were found upto a depth of l .5 metres near Dhonirevu and at Moosamani lock. The areas of the two beds were 1.68 ha and 3.2 ha with average number of 28 and 10 clams per sq. m. The total estimated biomass in Dhonirevu and Moosamani lock were 7870 kg and 6,709 kg respectively.

OTHER BIVALVES

Beds of the clam *Katelysia opima* occur near the Kottaikuppam lock area. The density

TABLE 4. *Total area of the clam bed, total biomass of clams, numbers and mean weight of clams in Pulicat Lake.*

Name of the clam bed	Total area in hectare	Total Nos. per sq.m.	Mean weight of a clam	Total number of clams	Total biomass of clams (kg.)
Gunakuppam	3.60	270.4	6.94	97,34,400	67,557
Light House kuppm	1.60	140.0	8.53	22,40,000	18,937
Kottaikuppam	2.00	63.4	15.72	12,68,000	19,933
Dhonirevu	1.68	28.0	16.73	4,70,400	7,870
Moosamani lock	3.20	9.6	21.64	30,72,000	6,710
Total	12.08	511.4	69.76	167,84,800	121,007

of clams ranged between 1 to 9 ciams/sq.m. They lay usually buried in the muddy region. *Anadara granosa* is found between Dhonirevu and iVloosamanl lock. This species is found at a depth of 10 cm. The bottom of this area is muddy. The green mussel *Perna viridis* was present in small numbers at Kottaikuppam lock area where they occur along with the oysters. Two species of *Dofiax* occur in the sandy beaches at the pass of the lake. *Donax cuneatus* is the predominant species with a density of 50-270 sq. m. and *D. scortum* is rare in this locality. *The cora\ horet Litfiopfiaga* was found in the dead shells of the oysters. The weaving mussel, *Modiolus undulata* is very common in the oyster beds. Numerous shells of *Nuculana* sp were noticed at Sunnambukulam area during April, but live ones were not found.

GASTROPODS

Cerithidia cingulata occur at a distance of 2 km from the pass of the lake. The density of the *Cerittiidea* population was very low north of Gunakuppam area and high towards Light House Kuppam and Sattankuppam. Highest density of population was observed at Pulicat, Kottaikuppam, Karimanal, Lighthouse Kuppam, Sattankuppam and Dhonirevu. The population of *Cerithidia* sp. slowly decreases from Dhonirevu to Arangam on the eastern bank and similarly from Avirivakkam to Mangodu on the western bank. *Ceritf)idea* specimen were absent at Sunnambukulam, Zonangipalayam, Irakkam, Venadu and Atakinithippa. The salinity of this arsa ranges between zero during the monsoon season to 56%o in postsummer season.

TABLE 5. *Distribution of* Cerithidea cingulata *in tfie three intertidal areas of Pulicat Lake {No^jm^).*

	Station	High Water Mark	Mid Tide Level	Low Water Mark
1.	Bar-mouth			
2.	Gunakuppam	8	33	7
3.	Lighthouse Kuppam	579	1179	456
4.	Sattankuppam	354	801	381
5.	Koraikuppam	392	1031	332
6.	Edamanikuppam	46	315	56
7.	Pulicatkuppam	401	1229	318
8.	Kottaikuppam	259	1719	203
9.	Karimanal	891	1289	433
10.	Dhonirevu	199	1138	413
11.	Moosamani Lock	301	997	316
12.	Kulathumedu	685	1333	366
13.	Avirivakkam	230	657	280
14.	Annamalaichery	152	326	127
15.	Mangodu	193	394	284
16.	Sunnambukulam			
17.	Arangam	36	131	34
18.	Pulianchery			
19.	Zonangipalayam			
20.	Irakkam			
21.	Venadu			
22.	Tada			
23.	Atakinithippa			
24,	Sriharikota	67	249	55
25.	Dugarajapatnam			

The presence of *Cerithidi!.* sp was observed in the three parts of the intertidal areas. HWM, MTL and LWM. The highest population was observed in the Mid Tidal Level and the populations were comparatively less in the high water mark and low water mark. C *cingulata* is thickly populated on mat like formations of *Enteromorpha intestinalis.* They are very poor near the algae of *Halophila ova/is.* C. *cingulatum* ranged from 6 mm to 28mm in length at different stations and the most common sizes were 18-22 mm.

The gastropod, *Hymnaea* sp is very common in the weed infested areas. It usually occurs in large numbers where seaweeds are plenty. *Thais rudolphi. Hemifusus* sp and *Turbo* sp are the gastropods occurring in the Kottaikuppam, Karimanal and Pulicat areas *Nassa* sp and *Littorina* sp are the small gastropods which occur alongwith the *Cerithidea* population. The Scsphopod *Dentalium* sp is rarely found at Kottaikuppam lock area. Cephalopod *Sepiella* sp was caught in dragnets operated in the Dhonirevu area during April.

CLAM FISHERY IN PULICAT LAKE

The clams are regularly fished in this lake by poor fisherwomen residing at Athipattu, Minjur, Anuppampattu, Pakkam and Ennore. Clam fishing starts in January or February and continues till October-November. The best catches were observed during February-June. In the fishery females dominated throughout the period of observation. The clam meat is sold in the local market at the rate of Rs. 1/ per measure *(Azhakku Ca* 200gm)and the shells are left at the Shell Industry of the private entrepreneur for making them into shell grit. The shell industry owner used to supply one saree per year to the fisherwomen engaged in fishing.

EXPLOITATION OF SUB-FOSSIL DEPOSITS

Rich beds of sub-fossil deposits are found around Irakkam and Veynadu islands of Pulicat lake. Irakkam has a shell potential of about 1,000 ha of land and Veynadu has 800 ha of shell deposits. The annual yield of sub-fossil deposits was 33,4701 and 23,745 t respectively in the two areas in 1980. Expioltatfon Usually starts during the post-monsoon season in the month of January-February and extends till the onset of monsoon. The peak period of excavation was observed between April and June in both the islands. Each man engaged in shell excavation is paid by the lease owners at the rate of Rs. 8/- *parpora* (200 kg). The maximum percentage in the order of abundance was *Meretrix, Cardium, Tellina, Area, Pilar, Pecten, Umbonium, Ceritliidia* etc. Edible oyster shells are also collected for lime burning.

DISCUSSION

The survey brought to light the distribution of dense oyster and clam beds in tha southernmost region of the Pulicat Lake. Three were no molluscs beyond Arangam and Mangodu. The central part of lake beyond Veynadu island is completely dry during the summer season and inundated with freshwater during monsoon which does not favour the survival of brackishwater molluscs. The molluscan distribution was found in the northern region at Dugarajapatnam where there is another mouth. The Kulathumedu bed or Sinnaparaval bed as explained by Hornell (1908) alone constituted 98% of oysters. The density of oysters in the Pulicat oyster bed ranged between 7 and 298 oysters per sq. m. The highest densities of oysters were observed at Kulathumedu, Moosamani lock, Pulicat and Kottaikuppam whereas in all other beds the oysters are scattered. The size, total weight, meat weight etc., does not show much difference in beds. Among the dead and live oysters in all beds, the maximum percentage of live ones was observed at Pulicat, Kottaikuppam, Moosamani lock and Edamani. The lowest percentage of oysters were found at the Karimanal area since the oysters are partly immersed in mud.

Edible oysters were exploited during Hornell's time (1908) and they were sold to the Madras hoteliers for consumption. At present only shells are exploited by the local people for lime burning. Occsionally local fishermen collect the oysters for consumption.

Rao *et ai* (1987) has given that Athankarai estuary with a total area of 1.56 ha produced a total biomass of 388.9 t. In Pulicat Lake 9 05 ha has a total oyster biomass of 1320.6 t.

Hornell (1908) has observed eight oyster beds namely 1. Edamanikuppam, 2. Pulicat 3. Lighthouse kuppam 4. kottaikuppam 5. Sinnaparaval bed 6. Pudupettai bed 7. Karimanal and 8. Vannanthurai bed. The Lighthouse kuppam, Vannanthurai and Pudupettai beds are not found at present. These beds may have been destroyed due to natural calamities or covered by silt and sand. At present 11 oyster beds are present. The oyster beds at Koraikuppam, Moosamani lock, Sriharikota, Chonirevu and Dugarajapatnam are newly reported.

The rich beds of oysters, clams and *Cerithidaa* are found in the southernmost region upto which the tidal effect extends in the lake. The most important environmental factors influencing the distribution of oysters in the lake are salinity, temperature, configuration of bottom and the availability of food in the lake. Decline in the population density of these molluscs was observed in the middle of the lake, due to high salinity and also drying up of the lake, during the summer months. Salinity of the central part of the lake almost reaches freshwater conditions and temperature also simultaneously decreases during the monsoon season. Several workers have mentioned that benthic biomass is poor when the salinity is low (Desai and Krishnamurthy 1967; Kurian 1972). Contrary to the above point Harkantra (1975) has suggested that temperature plays a significant role in the distribution and abundance of the benthos. In the present ecological conditions of the lake, salinity and temperature showed very wide fluctuations during different seasons of a year, which determine the distribution of molluscan fauna.

Gopinathan and Qasim (1971) have mentioned that a major factor affecting the distribution of edible oyster in coastal estuary appears to be the siltation which resulted in turbid conditions. The tidal wave which enters during the cyclonic period along the Pulicat Lake plays a major role in disturbing the bottom configuration of the lake and also destroys the oyster and clam beds by covering them with sand and mud. The oysters found partly buried in the Karimanal inlet area support the view of Galtsoff (1960) that the presence of suspended matter on benthic oysters, prevents setting and survival of spat.

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14. RESOURCES STUDY OF THE CLAM *MESODESMA GLABRATUM* (LAMARCK) IN THE ISLANDS OF THE GULF OF MANNAR

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ABSTRACT

A survey of twenty Islands lying between Tuticorin and Pamban in the Gulf of Manner during 1977 indicated extensive beds ranging from 0.25 to I.SOsq.km of *Mesodesma glabratum* along the intartidal zones of these islands. The population density was very high in six islands nearer to Tuticorin and low In the Islands nearer to Pamban. It was estimated that the rich beds in Van Thivu and Upputhanni Thivu contained as much as 4,50,000 numbers each which is a seasonally renewable resource. At present this valuable resource remains unexploited.

INTRODUCTION

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Molluscan resources survey was undertaken in 1977 in the twenty islands of Gulf of Mannar as a part of programme carried out in connection with the setting up of a Marine National Park. The islands in the Gulf of Mannar had been subjected to intense human interference for the pastsevearal years. Exploitation in the islands had been concentrated on the live coral reef zone and associated fauna and flora. In the formulation of a conservation policy to put an end to the indiscriminate exploitation of the area it was felt essential to obtain qualitative and quantitative information on the existing marine Fauna and flora in this area. With this background a survey of these islands was undertaken by the Central Marine Fisheries Research Institute during 1977. During the course of this survey by CMFRI useful data and information have been collected. From available information it is known that a number of gastropod species populate in the coral reef zones in these islands but information about pelecypods is poor. During the course of this survey we came across a very interesting feature of the existence of large population of the clam *iVlesodesma giabratum* in the Intertidal areas of most of the islands. This clam is known for its edible meat Since the occurrence of this clam in the islands is not well known till now the population remains unexploited. The object of this paper is to highlight this aspect which it is hoped will be of value commercially Earlier Satyamurthi (1956) mentioned about the occurrence of live M *giabraturry* in the Krusadai ^"^ Shingle islands,

Survey

The islands in the Gulf of Mannar were surveyed during the period January to March '9^^, employing a 24 H P. motor launch M. L. Chippi for the sea trips. The survey covered Vanthivu in the south, near Tuticorin to Shingle Island in the north, near Pamban. The islands numbering 20 are grouped into I, II, III, and IV ^°*t* convenience: (I) comprising four islands (Van Tivu, Kasuwar Island, Karaichallai Island and Velanguchalli Island); (11) three islands. Upputanni Island, Puzhuvunnichalli Island and Nallatanni Island); (III) five islands (Anaipar island, Vallia munai Island, Appa Island, Thaliari Island, Valai Island and Mulli Island) and (IV) the rest viz. Musal Island, (Hare Island), Manoli Island, Manoliputti Island, Poomarichan Island, Pullivasal Island, Krusadi Island and Shingle Island (Fig. 1). Most of the islands are situated close to the main land. Sampling was carried out all along the intertidal zone in three areas viz. just below low water line, high water mark and between the low and high tide zones, Sampling was done at intervals of 10 m of the shore line in all islands. The results are as follows:

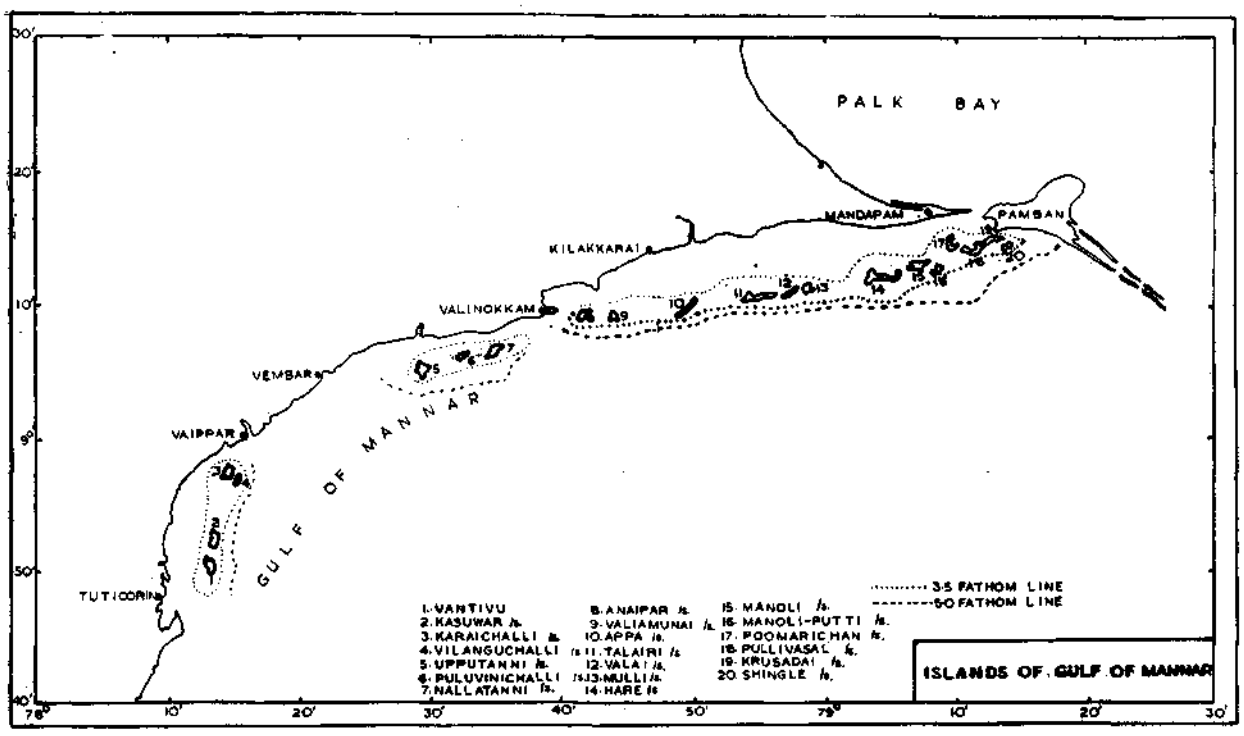

Fig. 1 Map showing the islands of Gulf of Mannar

Area of Availability of tlie clam Mesodesma galbratum *and density x)f population*

1. VanTivu : Available on the western side of the island for a length of 0.7 km. 300nos/m'.

2. Kasuwar Island Available on the western side of the island for a length of 0.7 km; 250 nos/m».

3. Karaichalii Island : Available on the western side of the Island for a length ICO nos'm^ .

4. Vilanguchalli Island : Clam abs«nt

5. Upputanni Island Sparsely populated on the western side of the Island covering a length of 0.5 km

6. Puluvinichalli Island Clam absent

7. Nallatanni Island : Sparsely populated

8. Anaipar Island Available on the western side of the island for a length of 0.6 km; 40 nos/mz.

9. Valiamunnai Island : Available all long the shore line i. e. 1170 m; 200 nos/m^.

10. Appa Island : Available all long the shore line i. e. 4840 m; 100 nos/m^.

11. Thalaiari Island : Clam absent

12.	Valai Island	Available all long the shoreline i. e 1889 m; concentration on the seaward side (east) of the island; 200 nos/m^.
13.	Mulli Island	Available on all along the shore line i. e. 1712 m. Thickly populated on the northern side of the island. Sparsely populated on rest of the shore line.
14.	Hare Island	: Available on all along the shore line i-e. 11520 m 100 nos/m^.
15.	Manoli Island	Sparsely populated; less than 5/m^
16.	Manoliputti Island	Sparsely populated; less than 5/mi.
17.	Poomarichan Island	Available on eastern, western and southern shore line. Absent on the northern side of the islard; 30 nos/m*.
18.	Pullivasan Island	Available on northern, southern and eastern shoreline of the island. lOOnos/m^.
19.	Krusadi island	: Available on all along the shore line i. e. 5193 m; 100 nos/m2.
20.	Shingle Island	'• Sparsely populated; less than 5/m^.

REMARKS

Judging from the above results it has been noticed that although the clam beds exist in many of the Islands, they are abundant only in the islands situated in between Tuticorin and Vembar It is interesting to note that the beds are situated in the islands where the sand has smaller proportion of comminuted shingles and reef fragments. The distribution pattern of the clams also shows variation in density in the three mtertidal zones. The area which is always bathed with sea water on the water front harbours greater density (165/m*). The zone within the high water mark is sparsely populated (9.5/m^) and the zone below the low water mark is less dense (nos. 48.5) than the middle zone.

The population consists predominantly of individuals in the size groups between 20-30 mm. The maximum size observed in the population was 50 mm in length. Small gj^ed dams are more in the middle zone, jf,^ ^^g^ ^^ ,he clam is found to be ^0% ^^ ^^e total weight (30-35 mm group), ^^ ^^^^^^^ ^^.^ ^ 1 ^ ^ .^ ^^^ ^^.^.^^^ ^^ j , ^ ^ j ^ ^ ^ ^ ^^^^^^^ estimated that there is a standing stock of nearly 3 million clams in all ^^^ .^^^^^^^ ^pa^j ^^^^ ,^,3 ;^„o^„ edible value ^, ^^^ ^^^^ ^^ ,^.^ ^,^^ ^j,^ ^j,^,, ^^^ ^^^ j , ^ ^^^^^^^ ^^ ^^^ j^^^^^^.^, ^^^^^^^^

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^....v,..., ,r,-r,i. *r^ -r* ,«,ro ~*r^.* „ • SATYAMURTHI, S. T. 1956. The mollusca of Krusadai Island (In the Gulf of Mannar), II. Scaphopoda, Pelecypoda and Cephalopoda. *BuJ/. Madras Govt. Mus. (New Ser.) Nat. Hist Sect.,* 1 (2), Part 7. pp. 135-137.

15. STATUS OF THE PEARL OYSTER POPULATION IN THE GULF OF MANNAR

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INTRODUCTION

The five volumes of Herdman (1903-1906) on the "Report to the Government of Ceylon on the pearl oyster fisheries of the Gulf of Mannar" and the treatise of Hornell (1922) on "The Indian pearl fisheries of the Gulf of Mannar and Palk Bay" are the works of scientists who had mastery over the subject of pearl fisheries of the Gulf of Mannar on both the Indian and Sri Lankan sides. Subsequent to 1922 the only major contributions, aside the routine survey, have been the use of dredge for fishing of pearl oysters on the Sri Lankan side (Sivalingam 1958) and the survey and charting of "Pearl and chank beds of Gulf of Mannar" on the Indian side by Baschiere-Salvadori and his Indian associates introducing SCUBA-diving for the first time as reported in First through Third Report to the Government of India (FAO 1960, 1962 a, b, Mahadevan and Nayar 1967).

The fragmentary information on the pearl fisheries of Gulf of Mannar as gleaned through the travelogues of Marco Polo and Ibn Batuta, the glory as sung by the Tamil poets of Sangam Age, the scanty records maintained since 1663 by the European rulers and works of Herdman (1903-1906) and Hornell (1922), and all that scientific investigations that followed indicate without any doubt that the pearl oyster resource of the Gulf of Manner is the most fluctuating one among the molluscan resources of the World. The causes for these fluctuations have been listed severally in the above-cited works, all of plausible explanations. However, how these have accountably worked, singly or in combination, in any one situation of depletion has not been investigated thoroughly. Perhaps the fact that the Gulf of Mannar pearl oyster resources are on beds down to about 20 m depth and as far away as about 10 n. miles from the shore and that no direct observation are practically possible during June through September when major physico-chemical and biological population changes take place on account of monsoon conditions have been the real problems in not understanding the phenomenon of fluctuations.

jhig paper gives an account of the pearl oyster resource position during the period 1975.36. It indicates the need for further specific scientific investigations to understand the dynamics that work in favour of or against ^^e building up of fishable stocks on the pgg^i banks

PEARL FISHERIES

Production of pearl oysters m the natural beds of the Gulf of Mannar had been an irregular feature. Even forty years of barrenness ^^^ observed in some periods. Records show that there were 18 pearl fisheries since the *1*^^' ^^OO- The recent series of pearl fishery ^as conducted from 1955-61. The pearl oyster beds situated in between Vaipar in the north a"d Manapad in the south had been the most productive ones where most of the pearl fisheries had been conducted in the past, During the last series of pearl fishery, pearl banks of this region had been fished (Table 1). It is evident that the Tholayiram paar "where more oysters reach the full maturity of three or four years needed for the reasonable production of pearls" had been the main source of oysters for the entire period of the fishery. Next in importance was the Kudamuthu faar followed by Karuwal paar. The number p oysters per diving unit ranged from 1603 in 1957 to 26^79 in 1958 (Table 1).

TABLE 1. *Pearl fishBrias of Gulf of Mnnar (f955-61 Series) After Sivalmgam {W61) and l\Aaftadevan ar\d Nayar (1973)*

Year	No. of dives	No. of oysters fished	Oysters/ Unit of effort	Size of oysters (mm)	Estimated age	Paars fished
1955	759	35,08,967	4,623	..	3^	Tholayiram, Sa/athonpathu
1956	457	21,29,058	4,659	55	3	Tholayiram
1957	733	11,75,214	1,603	55-65		Tholayiram, Kodamuthu, Karuwal, Pudu, Rajavukku Chippi Sothicha
1958	805	2,14,76,514	26,679	60-75		Thoiayiratn, Kodamuthu, Karuwal, Poonthottam, Rajavukku chippi Sothicha
1959	1896	1,64,28,298	8,665			Tholayiram, Kodamuthu, Karuwal, Poonthottam, Rajavukku chippi Sothicha
1960	1821	1,58,29,263	8,093			Tholayiram, Karai Kodamuthu, Kodamuthu
1961	1350	1,53,96,928	11,405			Tholayiram, Kodamuthu

POST FISHERY CONDITION OF PEARL BANKS

In the northern sector of the pearl banks including Fernando, Nagarai, northern and central part of Tholayiram, Salvadori (1960) has found the settlement of oysters to be 132/sq. m during December 1958 to may 1959- The settlement was 74 in the central sector which includes the paars such as southern part of Tholayiram, Kuthadiar, Melonpathu, Vadaonpathu, Sayathonpathu, Pulipundu, Kudamuthu and north Karuwal and, in the southern sector, which includes Tiruchendur and Manapad group of paars, large quantities of both adult and young oyster settlement were observed.

Mahadevan and Nayar (1973) reported that, subsequent to the pearl fishery of 1955-1961, the pearl banks were having very few oysters, most of them having been fished, remaining perished or eaten away by predators. During the year 1961-62, Tholayiram, Karai Keluthi and south Tholayiram paar had one oyster per square yard (Sambandamurthy 1966) and the pearl oyster population was "rare" in the northern paars including Devi, Cruxian, C thundu, Authurai Arupagam and Vanthivu Arupagam. No oyster was available in the 15 pearl banks inspected during 1962-63 (Chacko and Sambandamurthy 1969). The pearl banks off Rameswaram, Thondi and Kilakarai were not productive during 1'965 (Rajendran and Chandrasekharan 1969.)

STATUS OF PEARL OYSTER POPULATION IN THE RECENT DECADE

Survey of the pearl oyster beds of the Gulf of Mannar during 1975-1985 by the Central Marine Fisheries Research institute further confirmed the fluctuations in the population of pearl oysters from year to year and oaar to paar. The beds surveyed extended from Vaipar periya paar in the north to the Karuwal paar in the south. This Central division has been the most productive in the past and 39 out of 40 fisheries that had taken place between 1663 and 196i, had been in the paars located in this division. For the sake of convenience, the paars of this division are divided into (i) the northern group (near shore, depth less than 7 fathoms) and (ii) southern group (depth 8-10 fathoms).

Thepeari banks included in the northern group are Vaipar periya paar, Devi paar Fernando paar, Nagarai paar, Utti paar Uduruvi paar, Paduthamarikan paar, Cruxian parr, Vanthivu arupagam paar and Karai paar. The year-wise collection of pearl oysters from this group is given in Table 2. The maximum number of oysters coHected from this group was during 1981-82 at the rate of 35.7 oysters per diving minute. The minimum was during 1980-81 with a total of only 45 oysters for 1090 diving minutes.

TABLE 2 *Oyster collection from Nortfiern group of pears (1975-1985)*

Season	Diving effort (mt«)	No of Oyster *P. fucata*	Average Size (mm)	Paars surveyed
1975-76	1526	165	24.5	Devi, Paduthamarikan, Fernando, Vanthivu arupagam, Kurichan, Nagarai, Vaipar Periya, Karai. Otti and Uduruvi.
1976-77	3507	5748	33.9	Devi, Paduthamarikan, Vanthivu arupagam, Kurichan, Naflarai
1977-78	3530	9720	247	Devi, Kurichan
1978-79	5896	33417	34.8	Devi, Vaipar Periya
1979-80	1784	9171	32.0	Devi, Kurichan, Nagarai, Vaipar Periya
1980-81	1090	45	196	Devi, Paduthamarikan, Fernando, Vaipar Periya
1981-82	2785	99568	29.5	Kurichan, Nagarai
1982-83	2676	36461	47.7	Kurichan, Nagarai
1983-84	823	260	22 0	Devi, Fernando, Kurichan, Nagarai, Paduthamarikan
1984-85	2380	10890	30.5	Devi, Fernando, Kurichahv Nagarai, Vanthivu arupagam

TABLE 3. *Collection of Oysters from Southern Group of pBars (1975-1980/*

Season	Diving effort (minutes)	No. of Oysters *P. fucata*	Average size (mm)	f^aars surveyed
1975-76	3650	820	24.0	Tholayiram, Kodamuthu, Koothadiar, Poonthottaiti, Karuwal, Sayathu Kudamuthu, Karai Kudamuthu, Outer Kudamuthu, Sayathonpathu, Vadaonpathit
1976-77	1755	2240	37.0	Tholayiram, Kudamuthu, Koothadiar, Pulipoondu, Poonthottam, Karuwal, Sayathu Kudartluthu
1977-78	277	428	29 8	Tholayiram, Kudamuthu
1978-79	1332	233	37.4	Tholayiram
1979-80	538	2302	40.0	Tholayiram, Kudamuthu, Pulipoondu, Poohthottam, Kafuwal

The southern group surveyed included ThoJayiram, Kuthadiar, Pulipundu, Poonthottam, Karuwal, Kudamuthu, Sayathu Kudamuthu, Karai Kudamuthu, Outer Kudamuthu, Sayathon-pathu, Vadaonpathu and Melonpathu. A maximum number of 4.3 oyster per diving minute was collected during the season of 1979-80 from this group of paars. Except during 1976-77 and 1977-78 when the collect-ion exceeded 1 oyster par diving minute, it was far less in the other years (Table 3).

AGE AND SIZE OF OYSTERS

In the northern group of paar, the mean length of oysteis collected during 1975-1985 ranged from 19.6 mm in 1980-81 to 47.7 mm in 1982-83 (Table 2). Only during 1976-77 to 1979-80 and 1982-83, the maximum size of oysters exceeded 50 mm. But their contribution to the collection was less than 5.5%. In the southern group of paars, tha mean length of oysters ranged from 24.0 to 40.0 mm (Table 3). Even though oysters of 50 mm and above were collected during 1976 to 1980, the percentage of occurrence of the large oysters was less.

CAUSES OF FLUCTUATION OF OYSTERS OF THE NATURAL BEDS

Several factors have been suggested by various workers as the causes for the destruction of pearl oysters in the natural beds. Shifting of sand by the bottom currents caused by south-west monsoon, ravages of natural enemies, the most destructive of which were fishes such as *Batistes* sp, *Lethrinus* sp, *Serranus* sp, *Tetradon, Rhinoptera javanica* and *Ginglymostoma,* smo-thering and boring molluscs, boring sponge, boring worms, star fishes, crabs, octopus and fouling organisms. Overt ishing, over crowding anddiseases were the other causes attributed for the depletion of stock from the beds (Herd-man 1903). Hornell (1916) had witnessed the total destruction of immense beds of young oysters within a period of a few weeks by the predatory fishes. Devanesen and Chidambaram (1956) suggested that overfishing, predominance of females and paucity of males as the probable causes tor depletion. Moray eels and octopi occupied in great number the beds of the young oysters (Salvadori 1950). The growth of A7oo'/o/ys population on the pearl oyster beds was cited as the cause of destruction of spat on the beds (Mahadevan and Nayar 1973). Con-siderable mortality to the young oysters was caused in the beds by the predatory gastropods (Chellam et al 1983).

CONSERVATION MEASURES

Revival of pearl oyster populations in the natural beds may ba possible only with a series of favourable seasons. Hornell (1916) was of the opinion that there were three distinct sources of spat supply for the replenishment of the paars of the Gulf of Mannar, Of these, mutual dependence between the pearl banks of Indian and Sri Lankan coasts was considered to be the most important one. Transplantation of young "strikes" or broods of oysters from useless or unreliable paars to areas that give better living and growing conditions (Herdman 1906), maintenance of "breeding reserve" in the Tholayiram paar (Devanesen and Chidam-baram 1956), development of hollows in the pearl oyster beds by filling with rocks to provide better anchorage (Salvadori 1960) and spat collection by suitable spat collectors during intense spawning months (Mahadevan and Nayar 1976) were some of the measures sug-gested in the past to improve the pearl oyster population on the natural beds.

Sea-ranching of pearl oysters

The successful development of hatchery technology in India for production of pearl oyster spat (Alagarswami et al 1983) is an important development and production of required quantity of pearl oyster spat has become possible in the hatchary. As high as 1.3 million spat could be produced under moderate conditions in one of the rearing experiments in the experimental hatchery at Tuticorin.

The "barrenness" of the pearl oyster beds of the Gulf of Mannar after the last pearl fishery series of 1955-61 has made it necessary to think in terms of sea-ranching the excess spat as an attempt to repopulate the natural beds themselves. For this purpose Vanthivu

arupagam paar in the Gulf of Mannar, one of the nearshore beds, was initially selected. Spat from the hatchery were allowed to settle on materials such as old fish net, velon screen and monofilament. These were placed in a rectangular basket (90x 60 x 15 cm), covered with old fish net, and placed on the paar. The spat would crawl out and disperse themselves after awhile. A total of 7,78, JOO spat of *Pinctada fucata* were sea-ranched between December 1985 and January 1987. Efforts are underway to monitor the sea-ranched spat.

NEED FOR A FRESH LOOK AT THE RESOURCE

As already pointed out, several hypotheses have been put forth in the past to explain the irregular nature of the pearl oyster resources of the Gulf of Mannar. However, detailed scientific investigations on the appearance, survival and dis-appearance of the stocks on the beds are yet to be made. There appears to be a need for afresh look into the whole problem. The aspects of research that should receive attention in future are identified as follows:

Exploitation: It would appear from the records of the pearl fisheries that the pearl oyster has been considered as a revenue earning resource and haste has been the order of the day to fish them out rather than rational exploitation. The norms declared that only oysters of three years or older should be removed from the beds during a fishery and the younger ones should not be removed, or returned when brought ashore, cannot be expected to be practised by the divers who are after the quantity of harvest rather than quality of the oysters fished given the nature of sharing of the collections. Inspection of beds after a fishery series had been ended had always revealed the barrenness of the beds. Would that mean that the beds have been over-exploited or plundered beyond the level of renewability? This question can be answered only after marked beds with plentiful oysters are left unexploited and allowed to go through their natural cycle and subsequently monitored. This does not seem to have been done as the motivation in the past has solely been the revenue.

Environmental: A lot has been said about larval drift and mutual dependence of pearl oyster beds of India and Sri Lanka. So far, no reliable records are seen in the literature on having identified the pearl oyster larvae in the oceanic waters where the beds are located. Only very recently, the pearl oyster has been successfully bred in the laboratory and the larval characters established. With this information, it should be possible to identify the pearl oyster larvae and trace their movements in the open sea. Peaks of larval occurrence in the Gulf of Mannar over the Indian and Sri Lankan beds have to be followed concurrently in order that the mutual dependence theory is accepted or rejected. This also envisages detailed studies on the seasonal current patterns at the larval moving depths in the gulf between India and Sri Lanka Also quantitative observations would be required on the sand drift over the pearl oyster beds, which is stated to be responsible for the mortality.

In addition to testing of the above historical hypotheses, there is need to investigate the more recent phenomena such as the effect of industrial pollution, the changes brought about by the intense bottom-trawling operations on the beds, as also the effect of floods due to occasional heavy monsoon which brings down the salinity by several ppt. The coast of Gulf of Mannar is the seat of several industries which discharge their effluents, toxic or non toxic, in one form or another. Although the pearl oyster beds are located offshore, the effluents would be dispersed by currents and microlevels of pollutants would reach the pearl oyster beds in the column and/or bottom waters. This has to be monitored and bio-assay studies made on the tolerance and lethal limits of pearl oyster for specific industrial pollutants.

The paars are the natural haunts of quality perches and, in the recent years, bottom-trawling operations by the commercial fishing boats have intensified on the pearl banks and adjacent areas. It is known that such activity can change the ecology of sea bottom over a

period of time. How far this would affect pearl oyster settlement and sustenance is to be ascertained through investigations on the beds.

Hornell (1916) had already indicated the possibility of floods affecting the population through dilution of sea water over the beds. There has been at least one such instance of drastic reduction of salinity in coastal waters off Tuticorin due to unusual heavy monsoon (Alagarswami and Victor 1976). Experimental work has shown that dilution up to about 15ppt can be tolerated by oysters for a short spell but not of longer duration Monitoring of such dilutions, when they occur and their effect on the population would be necessary in future.

Unit stocks: Is the pearl oyster population in the Gulf of Mannar a homogenous one? Hornell (1916) has pointed out that oysters of certain beds were always stunted and useless as a resource for pearl production. Alagarswami and Chellam (1977) noticed certain differences in morphometric characters of the oysters in different paars by statistical analysis. The data of the recent decade show that, in the shoreward paars, the oysters collected during several months in the same season (October-May) and during consecutive years do not show a natural progression of growth and the populations of these paars remained at modes ranging between 25-35 mm. Would this indicate that there are different stocks of *P. fucata* with different growth characteristics or that those settling on the shoreward paars would not progress beyond the 'stunted' size? If oysters on all paars are of the same stock, what are the factors responsible for stunting their growth on certain paars? These are some important questions that remain to be answered.

Biological: Mention has already been made of the planktonic larvae of pearl oyster. Investigations are required on the short pelagic life of the larvae in relation to the environment in the open sea and to monitor their distribution and abundance. Particularly important is to locate the pediveliger stages. Settling of pearl oyster preceded by the exploratory "wandering" phase of the larvae to locate suitable substrata and the ideal conditions for spat setting should be studied critically.

The stomach contents of pearl oyster from natural beds invariably include items such as bivalve eggs and larvae, and copepod appendages which cannot apparently be digested (Chellam 1983). Only studies on the mechanism of functioning of labial palps which are supposed to discriminate the particulate matter wafted by the ciliary currents, and physiology of digestion can throw light on this so-called "wasteful" feeding behaviour. The microalgal population in the different paars has to be studied in detail to understand the food availability for the oyster.

The natural enemies of pearl oyster have been listed in the literature from the time of Herdman (1903-1906) to recent times. These are the predators (fish, starfish, gastropods and octopus), the foulers (barnacles, ascidians etc.) the borers (polychaetes and sponges) and the mat-forming weaving mussel. In a syn-ecological situation, there is co-existence of various organisms, the level of each component being kept optimal through natural processes. The pearl oyster, however, appears to be one of the most passive organisms in this complex with no means of defence against those which disturb them in one way or another and, hence, it falls an easy prey. While soma information on individual aspects of animal association on the beds is available through the works of Mahadevan and Nayar (1967, 1974, 1976), it is yet to be studied with the pearl oyster as the central point and how the other biological communities interact with the pearl oyster population in the natural situation and how the adverse processes are overcome when the pearl oyster builds itself up as a dominant community.

Oyster *(CrassostreajOstrea)* beds in several parts of Europe, America and Japan have been, at various times, subject to widespread devastation by diseases. Such beds do not easily

rebuild for several years and, therefore, transplantation is resorted to. Specific to pearl oyster, *P maxima* of Australia has recently been affected by disease and the stocks had reduced. An instance of mass mortality of *P. margaritifera* in Sudan is also on record. Does a similar phenomenon works in the case *oi P. fucata* of Gulf of Mannar? The pathobiology of pearl oyster is yet to be touched upon and this is a subject which needs serious consideration.

Sea-ranching is being attempted in the Gulf of Mannar with a view to finding out the feasibility of repopulating some of the beds. It is a regular commercial practice to sea-ranch abalone in Japan. Monitoring the result depends on locating the exact sites where the pearl oyster has been ranched. But the Conventional method of locating the paars has not so far been helpful in this effort. A vigorous programme on this should include improvement in the technique of locating actual sites and continuous follow up. The spat that are ranched may be marked appropriately to distinguish them from the natural population. If done successfully, this work can also provide very useful data on many aspects of biology of the species.

Vear-rouAJrf oAseAi/af/ons; June-September (south-west monsoon) has remained a blank period in pearl oyster research as no observations could be made on the resource or environment due to the turbulent conditions of the sea and lack of clarity over the paars. Like-wise, observation is hampered during several short spells in November-January due to north east monsoon. Changes in the life of the pearl oyster take place during these periods such as gameto-genesis and spawning, larval production and drifting and physiological adaptations to changes in environmental parameters. A comprehensive investigation on the pearl oyster resource cannot exclude such periods. Sampling and observation techniques have to be developed for year-round study without which a total picture cannot emerge.

In future, with the additional knowledge that might be acquired through the above investigations if put through, the pearl oyster resource, as and when it builds up, should merit management and judicious exploitation and not a hasty step to fish it out for the sake of a paltry revenue.

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16. STUDIES ON THE PEARL OYSTER POPULATION IN PEARL OYSTER GROUNDS OFF TUTICORIN IN THE GULF OF MANNAR

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ABSTRACT

Details of the inspection of pearl oyster grounds and pearl oyster collection (mainly *PInctada fucata)* for the period from 1977 to 1986 are presented In this paper. The favourable season for diving operations in this area normally sets in from October and and* In May in the subsequent year. During 1977-1986 forty four pearl banks or Paars' in the Gulf of Manner were inspected. A record number of 4,42 321 P. fucafa were collected during the year 1985-1986, followed by 3,19,718 in 1984-1985 and 2,10,955 in 1981-1982. In 1981-1982 Utti paar supported the collections mainly by contributing 94.28% of the total oysters gathered. During 1984-1985 Devi paar (24.68%), Fernando paar (20.93%), Cruxian paar (24.10%) and Kara! paar (29.39%) together contributed 9810% of the total collections. In 1985-1986 season' from Cruxian paar alone, 94.34% of the P-/ucafa were collected SCU iA-diving was effectively employed along with skin diving during 1984-1985 and 1985-1986 seasons.

INTRODUCTION

The natural pearl fishery in the Gulf of Mannar could not be conducted with any predictable regularity and only 38 fisheries were held during the period from 1663 to till date. The last fishery was held in 1961 and thereafter no pearling was done due to paucity of fishable oyster population in the beds. Tamilnadu Government Fisheries Department carries out regular pearl bank inspections to ascertain that any eventual settlement goes unnoticed. From 1974 inspections were conducted with an eye on collection of oysters for farming and cultured pearl production in their research scheme, then for the Pilot Project and finally for Tamilnadu Pearls Limited, which is a commercial culture pearl producing venture.

TOPOGRAPHY

The rocky bottom of the sea wher* the pearl oysters occur are 'Pearl Banks' or 'Pearl beds' which are locally called 'Paars'. They are found from Pamban in the North (78° 18' E Long and 9° 15' Lat) and ending with Manapad in the south (78° 15' E Long. 8° 15' N Lat). Regionwise it is divided into northern, central and southern divisions In all there are 83 charted pearl banks (Hornell 1922). The pearl oyster beds in the central division have considerable importance, since all the fisheries of the last two centuries have been confined to this division. The depth of the beds ranges from about 12 m to 25 m and the area varies from small beds of size 0.5 sq. km to huge stretches of 23 sq. km. (Rajendran et al 1976). Majority of the pearl banks are marshalled roughly in line parallel with and at a distance of approximately 10 km to 15 km from shore (Hornell 1922).

MATERIAL AND METHODS

This account is based on the data collected during the pearl oyster collection trips made during the period from 1977 to 1986.

Mechanised boats, boat craw, skin divers and SCUBA divers, a paar mandadi (Rock pilot) and manducks were engaged in the above work. The pearl banks located by transit bearings of land marks and also by sounding the depth and nature of the sea bottom by paar mandadi.

TABLE 1. *Pearl bank survey and pearl oyster collection during 1937 -1986.*

Sl. No.	Year	No. of Paars Cov-ered	Total No. of Trips rriade	No. of oysters Collected *P. fucata*	Flat oysters	Total oysters Collected	No. of Oysters Collected/ Trip (Average)	*Skin-Diving* No. of Dives	No of Oysters Total	Average No. of Oysters Collect-ed/diva	*SCUBA - diving* No. of dives	Total No. of Oysters	Oysters per dive
1.	77-78	12	46	8,795 (83.42%)	1,748 (16.58%)	10,543	229,20	1212	6995	6.77	92	3,548	38.57
2.	78-79	9	41	6,813 (87.50%)	973 (12.50%)	7,786	189.90	1088	4985	4.58	101	2,801	27.73
3.	79-80	6	10	400 (89.89%)	45 (10.11%)	445	44.50	295	237	0.80	20	208	10.40
'*•	80-81	17	44	1,716 (92.56%)	138 (07.44%)	1,854	42.14	644	349	0,54	39	1,505	38.B9
5.	81-82	2	56	2,10,966	—	21,10,965	3,767.23	6900	210695	30.57	—	_	—
6.	82-83	1	34	33,612	—	33,612	988.59	4250	33612	7.91	_	—	—
7.	83-84	19	61	10,962 (76.02%)	3,457 (23.98%)	14,419	238 37	4397	14419	3.28	_	-	-
8.	84-85	16	230	3,19,718 (87.76%)	44,571 (1224%)	3,64,289	1,683.87	20452	239686	11.72	618	1,24,603	201.62
9.	85-86	19	200	4,42 321 (91.16%j	42,810 (8.84%)	4,85,131	2,425,65	4390	73840	16.82	1,606	4.11,291	273.10
				10,35,302 (9169%)	93,742 (8 31%)	11,29,044	1.563.77	43628	585088	13.41	2,376	5,43,956	228.94

TABLE - 2. *Pearl oysters collected with reference to diving effort in tha pearl beds surveyed during 1977 - 1986.*

Si. No.	Name of pearl bed	No. of trips	Oysters coliected p. fucata	flat oysters	Scuba dives	Sl<in dives	Depth in Metres.
1-	Devi	174	1,00,503	16,355	512	15,712	12-15
2.	Devi Karai	49	1,17,025	16,622	268	2,523	12-14
3.	Fernando	45	66,938	8,712	66	6,306	11—13
4.	Padutliu marikkan	2	Nil	Nil	Nil	64	11—13
5.	Paduthu marikkan ''•''undu	1	Nil	Nil	Nil	20	11-13
6.	Vaiparperia	8	1,575	96	6	609	12-14
7.	Vaipar Karai	12	145	110	Nil	619	11—13
8.	CruxianTundu	7	Nil	Nil	Nil	10	11—13
9-	Cruxian	176	6,10,706	51,340	1,374	5,021	12-18
10.	Vanthivu Arupagam	7	Nil	Nil	4	276	10—12
11.	Nagarai	15	58	2	11	547	13—14
12.	Pethai	2	3	Nil	Nil	92	13-15
13.	Utti	102	2,32,629	Nil	4	7,533	14-17
14.	Uduruvi	1	Nil	Nil	Nil	50	,14—17
15.	Kilathi	5	Nil	Nil	Nil	119	13—14

1	2	3	4	5	6	7	8
16.	Athuvai Arupagam		Nil	Nil	Nil	50	14
17.	Melasthi		Nil	Nil	Nil	20	7- 9
18.	Paasi		Nil	Nil	Nil	17	14--18
19.	Patharai		Nil	Nil	Nil	105	14--18
20.	Athombathu		Nil	Nil	Nil	20	16--18
21.	Karai	3	Nil	Nil	Nil	29	10--11
22.	Tholayiram	37	3,181	383	101	1,250	15--21
23.	Koothadiyar	4	3	Nil	Nil	155	15—16.5
24.	Vada Onbathu	2	Nil	Nil	Nil	50	15-16.5
25.	Saithonbathu	9	737	Nil	9	232	15—16.5
26.	Pulipoondu	11	41	Nil	4	483	15—16.5
27.	Nenchurichan	1	Nil	Nil	Nil	10	15--18
28.	Melaonbathu	2	75	Nil	Nil	40	16--17
29.	Rajavukku Chippi Chothicha	2	4	Nil	Nil	36	16--18
30.	Kudamuthu	6	45	Nil	Nil	381	14--16
31.	Saith Kudamuthu	6	6	Nil	3	195	14--^16
32.	Pudu	1	Nil	Nil	Nil	16	17--19
33.	Kadayan	1	Nil	Nil	Nil	30	14--16
34.	Kanava	1	5	Nil	Nil	20	14--16
35.	Karai Karuval	3	3	Nil	Nil	101	16--18
36.	Velangu Karuval	6	1,110	110	3	136	16--18
37.	Poonthottam	6	27	Nil	3	163	14--18
38.	Sandamaram Kovil Piditha	1	30	2	Nil	290	13--18
39.	Tundu	4	453				
40.	Narikuzhi	1	Nil	Nil	Nil	40	12
41.	Kanika	1	Nil	Nil	Nil	40	8
42.	Kondal	1	Nil	Nil	Nil	40	12
43.	Naddn	1	Nil	10	Nil	40	10
44.	Kothandaraman Kovil Piditha	1	Nil	Nil	Nil	40	5

After fixing the paar the divers start diving operations at regular interval. A diver can cover approximately 3 sq. yds. only, per dive (Mahadevan and Nagappan Nayar 1973). The collected oysters were cleaned, measured and kept in troughs containing sea water. From the collected data an assessment of the pearl oyster population, and average collection per dive were estimated. At the end of the days operation, the collected oysters were transported to the pearl oyster farm.

OBSERVATION

During 1977-1986, 722 trips were made and 44 pearl oyster beds were inspected. Of these only few beds were found to be productive. *Pinctada fucata and flat* oysters were collected from them, though the flat oysters were in small numbers. Fairly good number of *P. fucata* were collected from Devi paar (1,00,503), Karai paar(1,17,025), Fernando paar (66,938), Cruxian paar (5,10,706) and Utti paar (2,32,629. Other *Pinctada* spp (flat oysters) were collected from Devi paar (16,355), karai paar (16,622), Cruxian paar (51,340) and Ferando paar (8,715) as shown in Table 2, while a few other paars were sparsely populated many others were found to be barren (Table 2).

A maximum of 4,42,321 *P fucata* were collected during 1985-1986 followed by 3,19,718 oysters in 1984-85 and 2,10,965 numbers in 1981-82. 44,571 flat oysters were collected during 1984-85 and 42,810 numbers were collected in 1985-1986. Of the total collection; *P. fucata* eonstituted 91.69% and the flat oysters constituted 8.31% (Table 1)

An average of 30.57 oysters were collected per skin dive for the period 1931-1982 followed by 16.82 in 1985-1936. The average oyster collection per skin dive for the entire period was 13.41. In SCUBA diving a maximum collection of 273.10 oysters was achieved in 1985-1936. This was followad by 201.62 oysters per dive during 1984-1935. The averaga collection of oysters per man hour or per cylinder was 228.94 for the period from 1977-1986.

REMARKS

Going through the history of pearl fishery in Gulf of Mannar, it is interesting to observe that repopulation of the beds takes place after long barren periods. After the 1928 pearling, the next fishery could be declared only in 1955 which extended till 1961. Surveys and collection operations conducted during the past 25 years indicate that the spat fall on beds was irregular and subject to great fluctuations. In 1970's the settlement of pearl oysters in oyster grounds was not profuse and there had been marked decrease in density of oyster population as reported by Mahadevan and Nayar (1976).

From Table 2 the productive paars during the period 1977-1986 can be identified. At times the paars that have received good spat fall too are rendered unproductive by certain natural calamities that destroy oysters on large scale. Utti parr, Cruxian paar and Fernando paar which harbour good number of pearl oysters (Table 2) belong to the category of pearl beds where spat fall occur frequently but the oysters rarely survive to reach the pearl bearing stage to support fishery. However these pearl oyster beds are traditionally known for supporting commercial pearl fisheries. (Rajendran et. al., 1976)

With the introduction of SCUBA diving for intensive pearl oyster collection programme, from 1984 to 1986 the pearl oyster collection improved much as is evident from Table 1. With this diving apparatus one diver can remain for an hour under water. During the period 201.62 (1984-1985) oysters were collected per man hour and 273.10 oysters were collected in 1985-1886. Earlier SCUBA diving was employed effectively and an improved system of survey and charting of pearl oyster beds was introauced (Baschieri Salvador! 1960, 1961.) The FAO (1962) recommended the continuations of such surveys.

The flora in the paars include *Gracilaria, Hypnea* sp, *Po/ysiphonia* sp, *Caulerpa* sp. *Hallmeda* sp and *Sargassum* sp as observed by Varma (1960).

The nature of the bottom of the pearl banks observed is given in Table 2A some banks are covered with sand, and few others have broken coral bits.

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17. CHANK FISHERY OF PORTONOVO COAST

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ABSTRACT

Chank fishery of Portonovo relies mainly on catches from mechanised trawlers and to a limited extent catches from gillnets. A total of 56,539 chanks were landed during May 1976 to December 1977. May-July were observed to be more productive than others In a year. *Xancus pyrum* var. *obtusa,* commonly known as "Patti" variety was landed at this centre. Marketing was dealt by middlemen, since there was no government procurement. Chanks ranging in length from 51 mm to 270 mm and in diameter from 20 mm to 129 mm were common. Landings of undersized chanks ranged fiom 1 to 14% while worm infested chanks formed 0 to 24% of the catches in various months. For establishing a regular fishery for chanks it is suggested to carry out a survey of beds off Portonovo and also to Introduce regular diving with modern diving equipmants.

INTRODUCTION

Of ail the commercially important molluscs of India, the sacred chank, *Xancus pyrum* Linnaeus is the most exploited. The fishery for the chank has been known since time immemorial from the south east coast of India. Extensive details about the distribution exploitation, utilization and biological aspects of the sacred chank in Indian and Ceylon waters are available in the works of Hornell (1914, 1915 and 1916), Gokhale (1960), Mahadevan and Nayar (1966), Nayar and Mahadevan (1973 and 1974). Jonklass (1973) and Appukuttan (1980). Pillai and Devadoss (1974) reported on the occurrence of X. pyAU/n in large quantities, off Portonovo. Since no detailed information on the catch, size composition and distribution, worm infestation on the chanks and economics of fishery from this centre was available, a study was undertaken in May 1976 and the results of the observations are presented in this account.

MATERIAL AND METHODS

The data presented in this account is for the period from May 1976 to December 1977. Chanks landed by trawls and bottom set gill nets were sampled once a week. The quantity landed for the day was obtained from fishermen, who collect the chanks from the boats and sell them to merchants. Length (measured from the tip of the shell to the drawn siphonal canal) and maximum ^.^^^^^ ^^ ^^^ ^^^„ ^^^^ measured by sharp ^^^^^^ ^.^.^^^^ ^^ ^^^ ,^^^.^g ^^^^^^ ^^^^^ ^^ ^^^^ .^^^^^^ ^^^^^ ^^^^ ^^^^^ ^^^^ ^^.,^ measuring the chanks. Value ^.^ ^^^^^^ ^^ ^^^ ^^^^^^ 1^^^^^ ^^ ^^^ ^^^^^^ ^^^ ^^^ ^j^^i^^^ ^^^^ merchants.

OBSERVATIONS

Catch

^ total of 56,593 chanks were landed during 20 months of observation. All of them were landed by nets only and no diving operation was done at this centre during the entire period of observation. Major catches came from trawl nets operated from mechanised boats and a limited quantity from the ''^^^"^ «^* 9"" "^^ ('"^^''^ " " ^ ^ T^^^'"^^' ^«'^'") ^he trawlers at Portonovo operate normally in the south east direction between Portonovo and Pazhaiyarai at 10 to 25m depth. Normally chanks were available only in the "^^^ operated close to the shore, known as "Karai madi" locally (shore net), at a depth of 10 to 15m. The bottom set gill nets operated only in depths varying from 5 to 10m. Therefore, it can be inferred that the distribution of the chanks at Portonovo area was more between 6 to 15m depth.

Month-wise landings of *X. pyrum* with the number of trawlers operated during the period of observation is given in Table 1. During 1976, the landings of chanks was observed to be high in July. In May, August and September the landings were moderate. In October, due to the stoppage of operation of mechanized boats, on the advent of monsoon, the catch dwindled to 725 and there was no catch in subsequent month. In 1977 also, the catch showed similar trend. The above observation indicates that maximum catch of the chanks was obtained during May-July, probably due to operation of more number of fishing units during these months Pillai and Devadoss (1974) observed a similar trend in 1971-72 also.

TABLE 1, *Chanks landed at Portonovo duiing 1976-77.*

Month	Number of chanks	Number of trawlers
May 1976	1356	581
Jun	No landings	750
Jul	2129	1133
Aug	1790	2596
Sep	1290	638
Oct	725	969
Nov	No fishing	
Dec	No fishing	
Jan 1977	2015	504
Feb	2473	607
March	2740	465
Apr	1050	1388
May	24025	2325
Jun	7230	1653
Jul	1870	1275
Aug	2465	1473
Sep	3210	800
Oct	2302	465
Nov	No fishing	
Dec	No fishing	

Fishery value

The variety of *X. pyrum* landed at Portonovo is *X. pyrum vat. obtusa* (commercially known as 'Patti") and is of inferior quality. In the chan k industry, it is referred to as ''Gharbaki" (Nayar and Mahadevan 1974), which is not much suitable for cutting bangles. Therefore, they do not fetch high price. A chank in commercial size is called as 'Piece'. A piece was sold at Rs 2 to 5 depending on the size, but this rate was highly fluctuating from week to week. Undersized and worm-infested chanks were normally rejected by the merchants, but, at times, two or three of tham were counted as one piece and purchased. Therefore, the number of chanks landed and amount realised did not show any correlation. The value of chanks landed in each month is given in Table 2. A total of Rs 64,128 was the cost of chanks landed in 1977 alone, paid at the fishermen level by the merchants. There was no monopoly procurement by Tamil Nadu government during the above years.

TABLE 2. *Value of chanks landed at Portonovo during 1917.*

Month	Value in rupees
Jan 1977	3879
Feb	4293
Mar	6664
Apr	1398
May	19375
Jun	10815
Jul	3069
Aug	4534
Sep	5680
Oct	4425
Nov	
Dec	

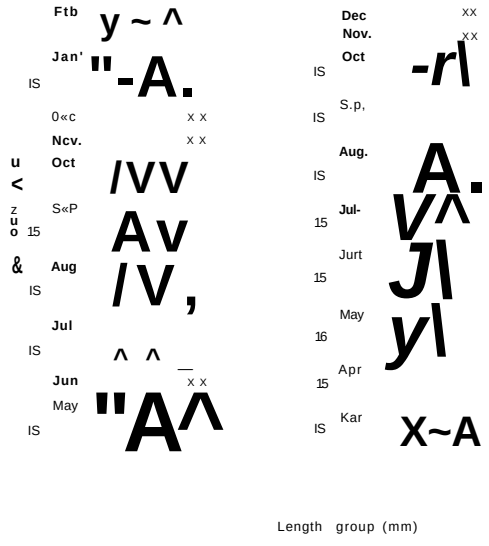
Four chank merchants, who were the agents of larger companies based at Kilakarai and Cuddalore were monopolising the chank trade. They made arrangments with local fishermen to collect chanks netted in the mechanised and non-mechanised boats. These

fishermen used to purchase the chanks from the boat crews and then sold them to the merchants with a gain of 50 paise per piece. The chanks, so collected, were allowed to purify for a week before cleaning and transporting. The shell and the operculum only were recovered, while the flesh was rejected totally.

Though the chanks were landed regularly year after year there was no proper licensing till 1977. During that year, the Assistant Director of Fisheries, Government of Tamil Nadu at Cuddalore, imposed a license fee of Rs. 10 per motor boat and also for every fisherman and merchant, considering them as divers. By this system, the government could realise about Rs. 600 in that year. Subsequently, from 1980 onwards, the Tamil Nadu Government introduced monopoly procurement of chanks from fishermen, thus forbidding totally the private trade.

Length distribution

To study the major length groups of chanks in the catches, they were assorted into 10 mm groups (eg., 50-59 mm, 60-69 m) and their percentage composition was found out. The data is presented in Fig. 1.



FIO' 1> Length composition of X. *pyrum*

Total size range in the fishery was from 51 mm to 270 mm. The modal size groups were: 120-129 mm and 170-179 mm in May 1976; 110-119 mm and 170-179 mm in June; 120-129 mm and 170-179 mm in August; 110-119 mm and 140-149 mm in September; 120-129 mm and 140-149 mm in October; 120-129 mm and 150-159 mm in January 1977; 110-119 mm and 130-139 mm in February; 120-129 mm, 130-139 mm and 140-149 mm in March; 90-99 mm, 110-119 mm and 180-189 mm In April: 120-129 mm and 140-149 mm in May; 70-79 mm and 120-129 mm in June; 120-129 mm and 190-199 mm in July and August; 90-99 mm and 120-129 mm in September and 120-129 mm and 140-149 mm in October. A length group of 270-279 mm was found only once in September 1976. From the above data, no definite conclusion can be drawn on the progression of th« modal groups in the population. This might be due to the limitation of sample, which was mainly dependent on the fishery sample.

Diameter distribution

For estimating the landings of undersized and commercial sized chanks and also to have an idea of the diameter range and major groups in the fishery, the chanks were grouped into 10 mm diameter groups. Monthly percentage composition of various diameter groups are presented in Fig. 2. The major diameter groups found in different months were: 60-69 mm in July, August and October of 1976 and also in January 1977, February and April; 70-79 mm in May and September of 1976 and May, June, July and August of '77: and 80-89 mm in October of both the years and also in March and September '77.

Chank below 60 mm in diameter, were considered as undersized in the trade. Such chanks were normally returned to the sea. But some greedy fishermen used to bring them and utilize in lime burning also. The under-sized chanks were absent in the months of August and October '77. However, in the same year, in Apri| 24% of the chanks landed were under-sized. Details of landings of the under-sized chanks

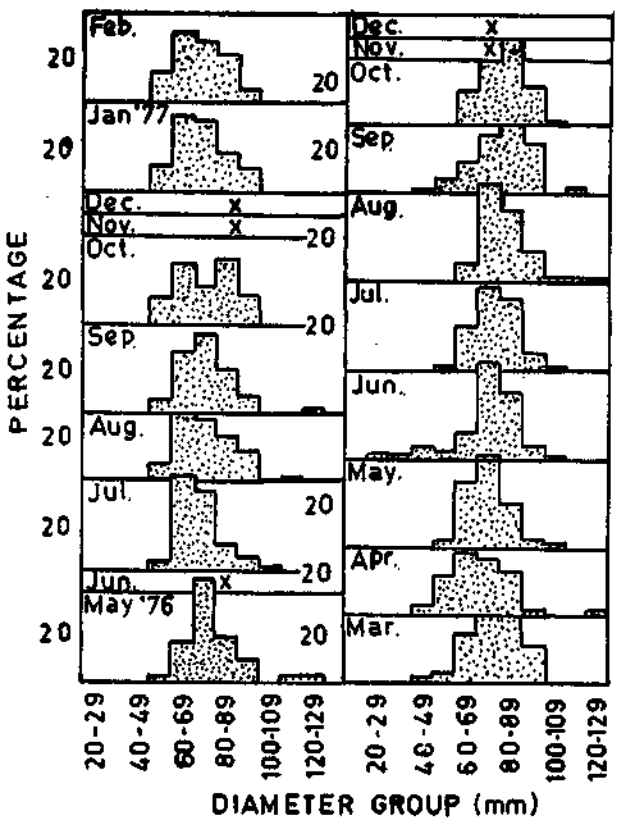


Fig. 2. Diameter frequency of *X. pyrum*

TABLE 3. *Percentage of undersized chanks landed at Portonovo.*

Month	Undersized chanks landed (%)
May 1976	2
Jun	—
Jul	4
Aug	8
Sep	6
Oct	11
Nov	—
Dec	—
Jan 1977	11
Feb	14
Mar	4
Apr	24
May	3
Jun	12
Jul	1
Aug	0
Sep	8
Oct	0
Nov	—
Dec	—

are given in Table 3. The present situation, however, was not as alarming as observed by Pillai and Devadoss (1974), when a normal range of 20 to 38% of the chanks landed were under-sized.

Worm infestation

Being gregarious in nature and large sized, the chank attracts a large number of fouling and boring organisms particularly polychaetes and sponges. Worm-infested chanks are unfit for cutting into bangles and therefore rejected. To estimate the extent of damage caused by worm-infestation, observations were made on the sampling day. Monthly variation in the percentage of infested chanks is given in Fig. 3. Except in October '76, in all other months, the infestation was common. A maximum of 24% was noted in September '77 and it was observed that no definite pattern could be recognised in the incidences of infestation.

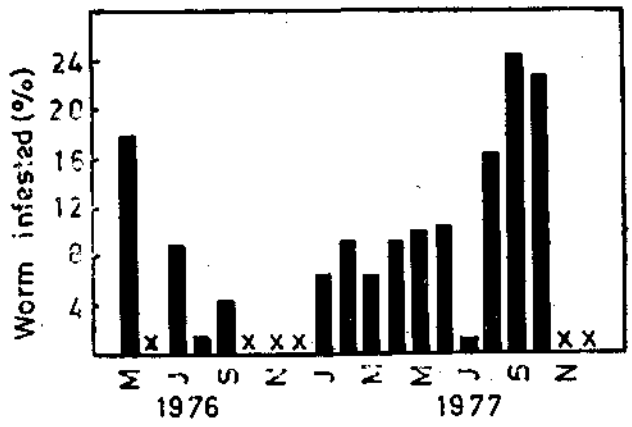


Fig. 3 Percentage of worm infested chanks

GENERAL REMARKS

From the foregoing account it can be seen that the chank landings at Portonovo cannot be considered as a minor fishery. The catch figures showed a declining trend, when compared to that of 1971-72, when more than 1 lakh chanks were reported as having been landed in one year (Pillai and Devadoss 1974) the present figures mark a decline. Indiscriminate

landing of both under-sized and normal-sized in the earlier observation might have boosted the figure, while, reduction in the number of under-sized chanks might have resulted in the decline in the catches during the present study.

Nayar and Mahadevan (1974), while giving an exhaustive account on the distribution, fishery from various regions, methods of fishing, commercial uses of chanks, exploitation and also the future prospects, suggested for a survey on the occurrence of chanks along both the coasts of India. They have also advocated for improving the present skin diving by adapting SCUBA. Jonklaas (1973), on the otherhand, feels that instead of SCUBA diving, introducing grabs would be of more useful in exploiting the resource. At present, there is no diving for chanks, beyond north of Rameswaram, since there is totally no knowledge about the extent and nature of chank beds. Therefore, there is an immediate need for surveying these areas for exploiting the chank resources. The present observation also indicates that a lucrative fishery can be established In this area, by acquiring more knowledge on the chank and chank beds.

ACKNOWLEDGEMENTS

I gratefully acknowledge Dr. P. S. B. R. James, Director, Central Marine Fisheries Research Institute, Cochin for his kind encouragement. I thank Dr. K. Alagarswami, Head of the Molluscan Fisheries Division of the Institute for review of the paper.

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18. CHANKS CAUGHT BY THE RESEARCH VESSEL CADALMIN IV FROM TRAWLING GROUNDS IN GULF OF MANNAR

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Central Marine Fisheries Researcti Institute, Cochin 682 031.

ABSTRACT

The Sacred Chank. *Xancus pyrum* was caught in bottom trawl net operated by the Research Vessel CADALMIN IV in different areas in Gulf of Mannar. The areawisa, depthwise and monthwiss catches of the chanks. the ecological conditions from where they were ob'ained, size composition of the chanks and length-weight relationship have been-atudi«d. Maximum number of chanks were caupht from trawMng grounds off Tiruchendur cnast. The highest numbers were recorded in the period Oecember-IViarch- The chanks ranged from 25 mm to 117 mm in nwximum shell diameter end 54 mm to 202 mm in length. In the trnwUng grounds from where the chanks were netted the bottom was muddy sandy with rocky patches hare and there and the other fauna found were polychaetes, crabi gastropods, bivalves, starfishes, sea urchins, sea lillies, cephalopods etc.

INTRODUCTION

The Sacred Chank, *Xancus pyrum* forms dense beds off Tuticorin coast and supports an important fishery. (Hornell 1914, Mahadevan and Nayar 1973). The chanks are distributed in the area at depths of 11 to 27 m. The bottom where the chank beds are found has been stated to consist of very fine sand and sometimes coarse sand and some of the areas are partly rocky (Hornell 1922, Mahadevan and Nayar 1974). Chank fishing is done along the Tuticorin coast during November-May when the water clarity is good. The disposition of chank beds in the area has been surveyed for the first time by Hornell (1922) and recently by Mahadevan and Nayar , - g ^ , .

During the course of exploratory fishing conducted by the Research Vessel CADALMMM IV of the Central Marina Fisheries Research Institute based at Tuticorin, in Gulf of Mannar off Manapad-Valinokkam coast with bottom trawl net in 1982, chanks were netted on several occasions from different fishing grounds. Data were collected on areawise, depthwise and month-wise catches of the chanks; ecological conditions where they occur, the size composition of the chanks and length-weight relationship. The results obtairwd are presented in this paper.

MATERIAL AND METHODS

Data have been collected on the number, length, maximum shell diameter and weight of chanks caught in the different fishing areas and depth zones in which bottom trawling ^vas conducted in Gulf of Mannar with CADALMIN IV as part of the experimental fishing programme of Central Marine Fisheries Research Institute. The sediment in the different areas was collected with a grab, dried and sieved using standard sieves. The fauna and flora occurring in the sea bottom from where chanks were netted were collected from the trawl catches and identified Direct underwater observations were carried out by one of the authors (Pon Siraimeetan) off Tiruchendur coast, Tuticorin Harbour area and Tholayiram paar using SCUBA equipment The length-weight relationship of 155 chanks measuring 54 mm ^Q 202 mm in length was studied.

RESULTS

Araawise distribution

Bottom trawling was conducted in ten fishing areas in Gulf of Mannar between Lat. 8° and 9° N and Long 78°E. Of the total of 155 netted chanks, 23 2% (36 chanks) were obtained from area 8-78/3B, off Tiruchendur coast and the next two areas from where

highest number of chanks were got are 8-78 4C, in Punnakayal trench and 8-78/5B, immediately south of Tuticorin, close of Tuticorin Harbour. 11% of the chanks were netted from area 9-78/1C, off Valinokkam coast. The number of chanks fished form other areas surveyed was much less and they accounted for 5.8 to 1.2% (Fig. 1).

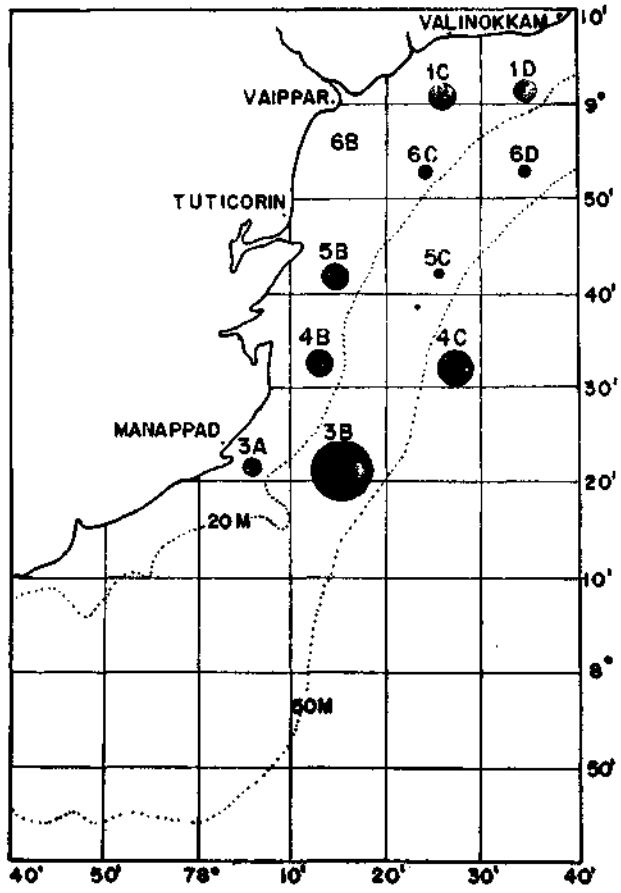


Fig. 1. Relative abundance of chanks caught in trawl net from different areas in Gulf of Manner

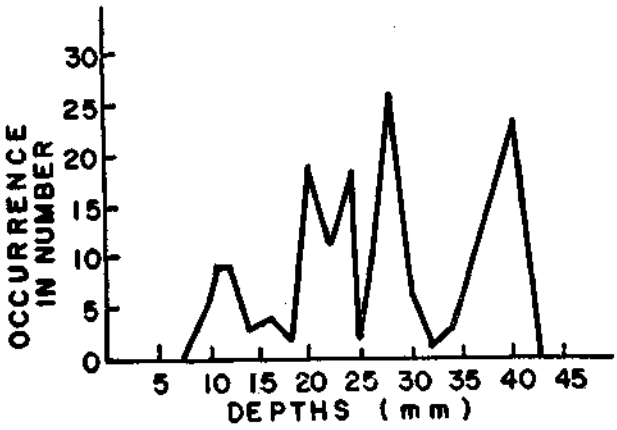


Fig. 2. Occurrence of sacred chank in different depths in Gulf of Mannar

Depthwise distribution

The depths of the fishing grounds surveyed varied from 10 to 40 metres and chanks were recorded upto a depth of 40 metres (Fig. 2). The maximum occurrence of chanks, 16.8% (26 chanks) was from a depth of 28 metres and the next was at 40 metres, 14.8% (19 chanks) and 24 metres 11.6% (18 chanks). The percentage composition at other depths varied from 6.5% to 0.6%.

Monthwise distribution

The highest number of chanks were obtained in January, 1982 (16.8%) and the next best months were March (13.5%), December (13.5%) and February, 1982 (12.2%) (Fig. 3). The catches were less in the other months and accounted for 9.0% (April) to 2.6% (September). The months in which the best catches of chanks were netted by the Research Vessel coincide with the fishing season off the coast.

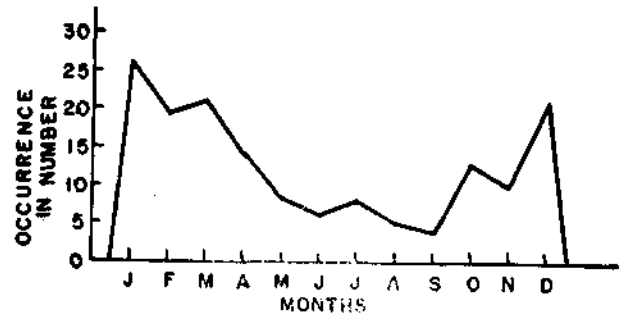


Fig. 3. Occurrence of sacred chank in trawl net in different months in Gulf of Mannar.

Ecological conditions

In the area 8-78/3B where the largest number of chanks were obtained, the dominant component of sediment was fine sand, mud and silt and there was a good amount of shell pieces of bivalves, *Turritella* etc. and small quantities of coarse and medium grain sand. In the areas with the next best catches 8-78/4C and 5B also fine sand and silt formed the bulk of sediment and shell debris and medium sand were a characteristic

feature. In the other areas the sediment was similar to the latter two areas with the shell debris and coarse sand often less.

In the trawling grounds from where the chanks were netted several live molluscs like the bivalves *Tellina coarctata, Mactra mera* and live gastropods *Babylonia spirata, Mirex virqineus, Hemifusus cochclid/urrir Oliva nebulosa, Calliostoma tranquebarica, Clanculus microdon' Conus amadis, egg* capsules of sacred chank, egg ribbons of *Tonna dolium* and *Natica tigrina.* , ,. , . . , _ . J egg clusters of M^rex rrapa holothur.ans, sand dollars, sea urchins, cr.no.ds, sponges, sea anenones sea fans, corals, stomatopods, the crabs *Portunuspe/agicus, Charybdis* sp, *Ocypoda* sp and hermit crabs were recorded The species of algae *Gracilaria foliifera. Halimenia* sp and *Sargassum* sp and *Lithothamnion* and the sea grass *Cymodocea* were represented in the fishing ground. In addition, empty shells of several bivalves *Area complanata, A. fusca, Cardita bicolar Pecten plica, Pinctada fucuta, Tellina* sp *Pteria* and the gastropods *Oliva gibbosa* and *Turritella acutangula* were distributed over the bottom On one chank collected during January, a pearl oyster *Pinctada fucata* and a sea anamDns *Anemonia* sp were found attached

A variety of fishes like rays, skates, sharks, *Lutianus, Lactarius lactarius, Sillago sihama, Chirocentrus* sp *Leiognathus* spp, Carangids, *Siganus* sp, *Saurida tumbil, Pseudorhombus, Lates calcarifer, Pseudosciaena diacanthus, RachycentTon* sp *Cynoglossus, Pellona Thrissocxles, Anchoviella commerson. Scomberomorus, Therapon jarbua, Nemipterus, Plotosus, Platycephalus* spp *Tetrodon* sp, gobids, the prawns *Penaeus semisulcatus, P. indicus, Parapenaeopsis uncta* and *P. maxillipado,* the lobsters *Panulirus homarus, P. ornatus, P. versicolor* and *Thenus orients lis,* the squid *Loligo duvaucelii,* the cuttlefish *Sepia elllptica* and *Sepiella inermis and octopods* etc. were caught in the trawl net catches.

Direct underwater ecological observations

Underwater ecological observations made with SCUBA equipment revealed that the **bottom at the three grounds where studies were conducted was sandy muddy with rocky** patches here and there. The chanks were seen moving slowly at the bottom with the foot very much expanded They took a zigzag course in their movement pausing occasionally over the bottom, brown or grey coloured muddy sandy sediment. The chanks also burrowed into the sediment,

Size composition

, ^^^ '^"9*^^ °^ '^^ ^^^^"^^ ^^"^^^^ ^^""^ ^^ mm to 202 mm and the dominant length groups were 100 119 mm (35.5%) and 120-139^^(310/^). The size groups 140-159 mm ^^^ 80-99 mm accounted for 12 3% and 11% respectively (Fig. 7). The other size groups ^^^^ ,^33 ^^^^^^ ^^^ 3^^^ 3 ^^^g^ ^f (,6% to 4 5°/ (Fia 4)

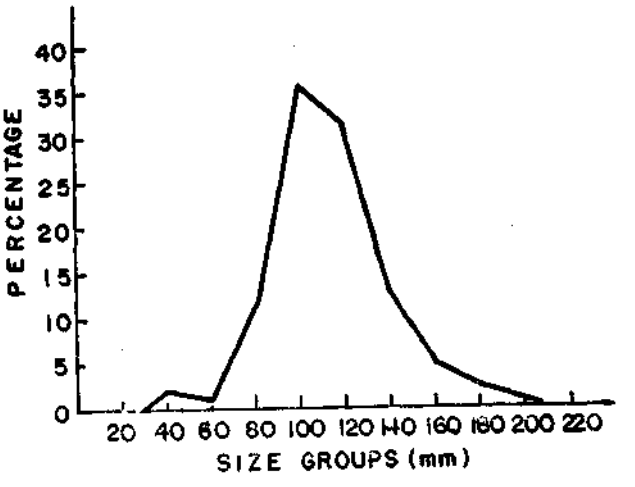
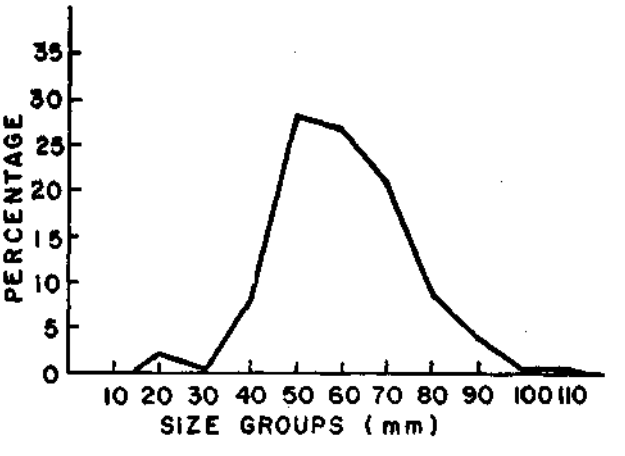


Fig. 4 Length frequency distribution of sacred chank netted in trawl net in Gulf of Mannar.



pg_ 5 Miximum shell diameter frequency of sacred chank obtained in trawl net in Gulf of Mannar.

Chanks with maximum shell diameter 50-59 mm formed 27.7% followed by 60-69 mm and 70-79 mm size groups which amounted to 27.1% and 21.3% respectively. The two shell diameter groups 80-89 mm and 40-49 mm accounted for 8.4% and 7.7% respectively and the other size groups represented less than 1% to 4% Fig. 5

Length-weight relationship

The length-weight relationship of *Xancus pyrum* based on 155 specimens of the length range 54-202 mm was calculated as.

$W = 0.000093284 L^{3.11369}$ $(r = 0.76189)$

where W is weight of chank, L, length of chank and r correlation coefficient.

To test whether the exponent value i. e. 3.11369 differs significiantly from 3, t test was applied and it was found that the calculated t value was 1.59 at 153 degrees of freedom indicating that there is no significant departure from 3 (Fig. 6).

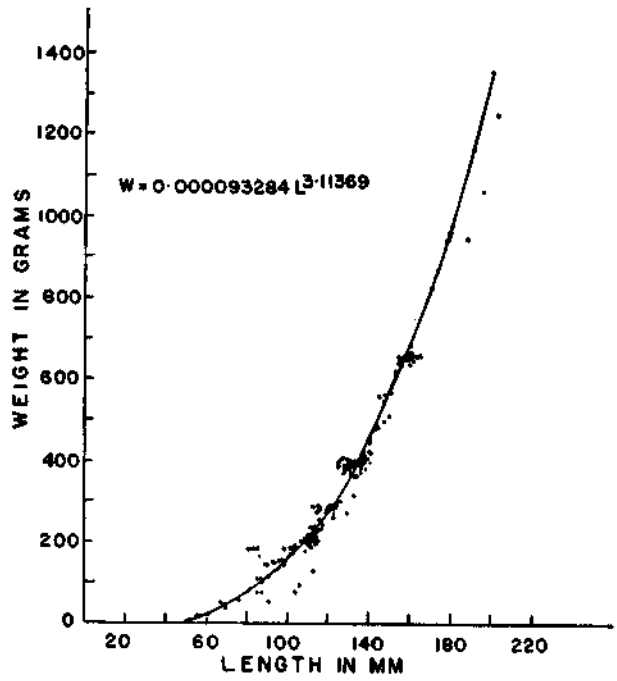


Fig. 6. Lengthweight relationship of sacred chank netted in trawl net in Gulf of Mannar.

DISCUSSION

It is noteworthy that the highest number of chanks were netted in bottom trawl off Tiruchendur coast which is one of tho richest grounds from where chanks are collected by skin diving. This area has a depth of 24–28 m which is the maximum depth upto which skin divers go due

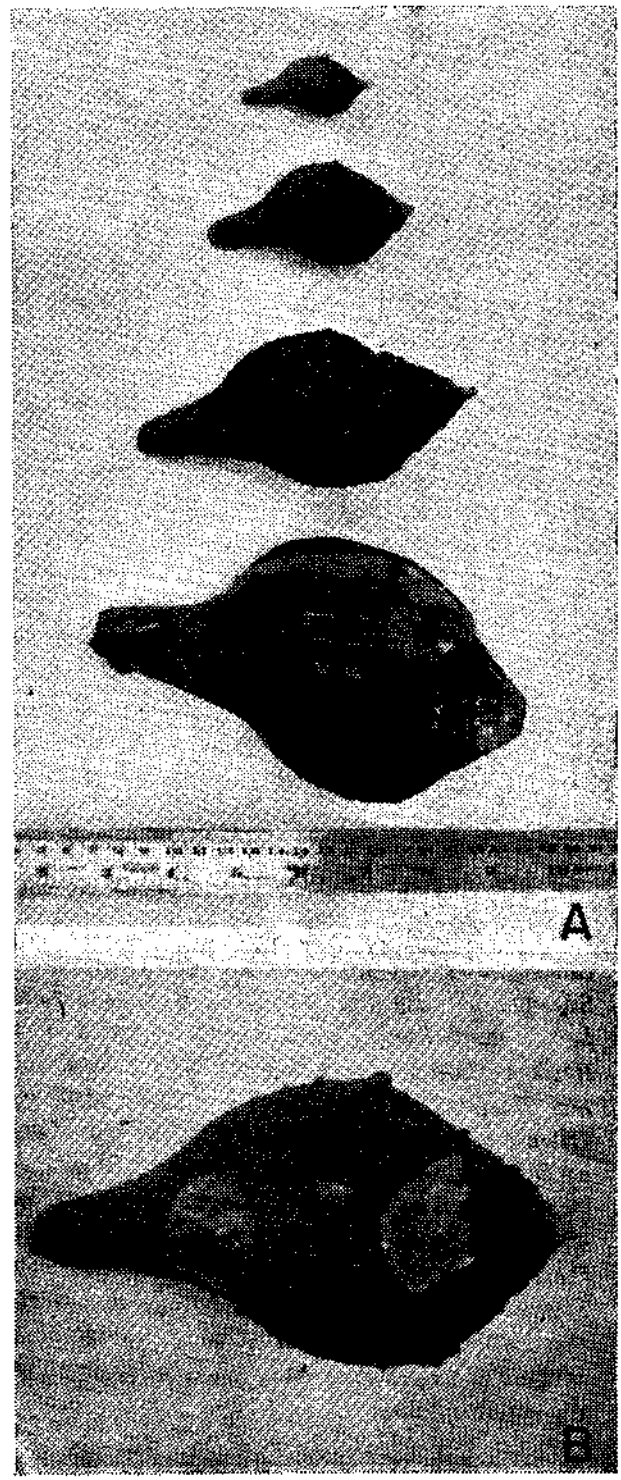


Fig. 7A. A Sacred chank, *Xancus pyrum* of different sizes caught by R. V. CADALMIN IV in Gulf of Mannar. B. *Xancus pyrum* with pearl oyster *Pinctada* and sea anemone *Animonia* sp.

to practical limitations. A good number of chanks, 17.4% of the total chanks obtained by trawling has been netted from the Punnakayal trench 8-78/4C, an area with depth 20-25 m where diving for chanks is not done due to the presence of a channel running at the bottom under the influence of a water current from the Punnakayal Estuary into the sea. The bottom in this area is uneven and there is a rich fauna and flora of diverse species. Hitherto chanks were known from waters of depth upto 27-28 m (Mahadevan and Nayar 1974). The present study has revealed for the first time that the sacred chanks occur at a much higher depth of 40 m, in the fishing area off Manapad and southwest of Valinokkam.

The areas where chanks have been netted in the present work are muddy with fine sand and mud as regular feature. The sediment of the bottom of the areas trawled is similar to that reported by Horneli (1922) and Mahadevan Nayar (1974).

There is a growing demand for shells of the sacred chank in India from the bangle industry as well as for use in workshop and the present production is not sufficient. In this context there is an urgent need for making a resources, survey of the chanks in Gulf of Mannar using SCUBA equipment and assess-r,nVnt of the abundance of the chanks in its entire distributional area.

' In commercial trawling carried out in Gulf of Mannar throughout the year off Manapad-Valinokkam coast young chanks 20-25 mm in shell diameter are often netted and suffer destruction. The egg capsules of chanks are also frequently caught in trawl nets in January-March. This should be prevented by legislation prohibiting the capture of such very small size chanks and egg capsules which will be very helpful in conservation of the species.

ACKNOWLEDGEMENTS

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19- COMMERCIAL FISH TRAWLING OVER PEARL AND CHANK BEDS IN THE GULF OF MANNAR-A NEW DIMENSION TO PROBLEMS IN SHELL FISHERIES

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ABSTRACT

Examination of the mechanised boat landings at Tuticorin during 1984-86 and 1985-86, of the sacred chank *Xancus pyrum* revealed that nearly 30.000 numbers of these sheila have been landed on an aveiage in a year during these two years. The paper gives an analysis of the catches, size range of the chanks landed, areas fished and indicates the need for conservation policy to protect the natural beds from being disturbed.

INTRODUCTION

The dichotomy in the physico-chemical, flora and faunistic constitutents of the habitat of pearl oyster and chank has been revealed from the studies on the ecology of the pearl and chank beds by SCUBA diving (Mahadevan and Nayar 1966, 1968, 1974). The survival of the sedentary pearl oyster appear to be intricate as they are constantly exposed to the adverse effects of the discharges of different riverine systems along the Gulf of Mannar, violent currents, long swells which throws the bottom silt in suspension with the consequence that the area constitutes a negative force. Further, extensive predatiqn by animals like octopuses and echinoderms has also been observed. On the other hand, thqugh the survival of chanks appear to be better by their free living and well protected thick shells with camouflaging colouration of the periostracum which suits the muddy colour of the sandy bottom, the vulnerable stage is considered to be during early development as the young ones during their development in the sedentary egg capsules are rooted to the sandy bottom, constantly exposed to the vagaries of nature. Added to these, the human interference by extensive trawling over the pearl and chank beds for the exploitation of commercially important fishes and prawns which are abundant in these beds poses a new threat to the problems already explained to in the shell fisheries.

With the aim to explore this problem the present study on the commercial fish trawling over pearl and chank beds was initiated in July 1984 at Tuticorin. This paper deals with the quantum and quality of chank landings by commercial trawlers, the availability of chank resource beyond the conventional fishing grounds and as well the effect of trawling over pearl and chank beds.

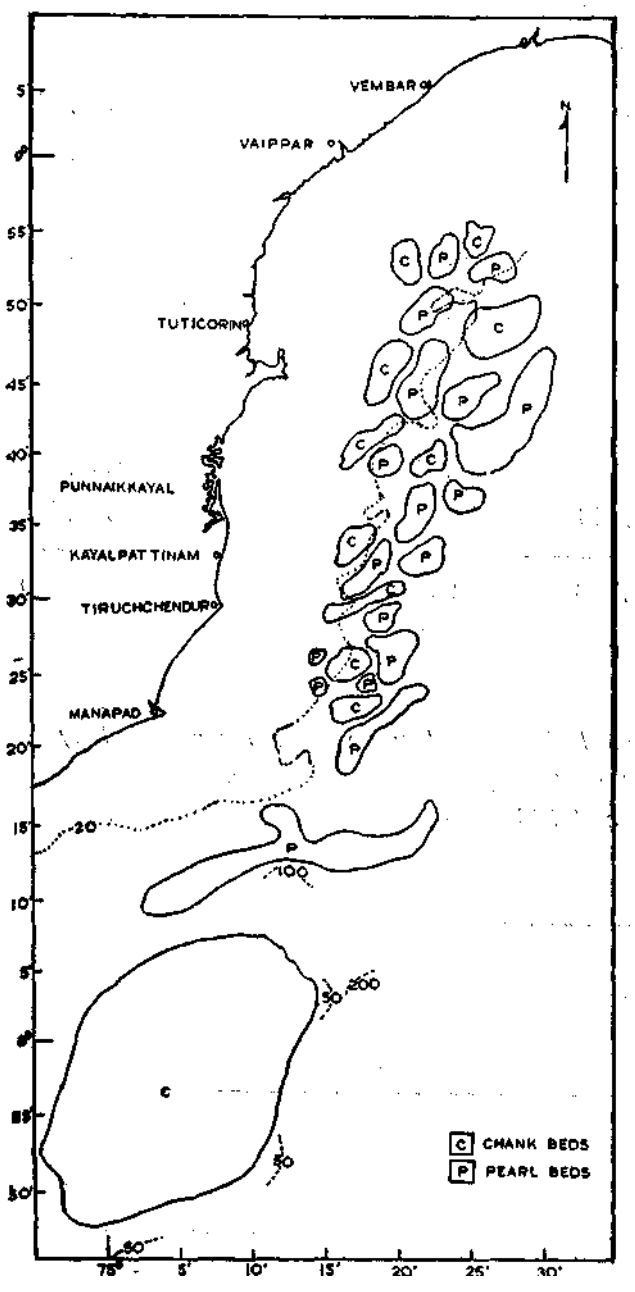
METHODS

Weekly observations were made at the Tuticorin fishing harbour on the catch composition of trawlers. The number of chanks landed by a sample of minimum 10% of the boats was recorded and the length, breadth and weight were recorded at the chank godown of the Tamil Nadu State Fisheries where these chanks are procured by the Department for fixed price. The number of chanks landed were raised to the total units operated on that day and then to the month. Detailed enquiry was also made on the area and depth of fishing arid other relevant informations. In addition to this the data on the chanks landed by diving, different nets and confiscation were obtained from the Tamil Nadu Fisheries Department at Tuticorin.

FISHERY

The methods of fishing for chanks is chiefly by skin diving, and the chanks $fd

randomly caught in hooks & lines, gill and trawl nets also. The important chank and pearl beds in the Gulf of Mannar are shown in Fig 1. The total annual chanks landed during season and non-season from 1971-72 to 1982-83 are given in Table 1 where in the season refers to diving season and the non-season, the period in which chanks are landed by gill and trawl nets. On an average annually 5,96,175 chanks are landed in which 5,68,921 are landed during season and the rest during non season. The full sized good chanks (ie., 64 mm and above) constituted 4,91,016 and the rest 99,030 were wormed and under-sized are landed by skin diving and 5% are landed by nets as the chank catches in the nets are incidental and none of the gears aim at catching shanks exclusively.



•^'•^J- J''tv'/'T'"°T''''"-''*''''^ -
and chank beds along Tuticorin coast from Vambar in the north to Manapad in tha South.

During 1984-85 and 1985-86 as seen from the Table 2 wherein the details of chank landing are given, a total of 3,55,305 chanks were landed by diving and 55,638 were by nets. As the chanks fetch a good price from the private procurers the fishermen try to smuggle good chanks and the Department keeps a check on this by consiscating such chanks. A total of 12,783 chanks were consfiscated during 1984-85 During 1985-86, a total of 90,553 chanks were landed by diving, 52,775 by nets and 2,630 were confiscated. The monthwise total netted chanks and the chanks landed by trawl nets at Tuticorin during these two years are given in Table 3, The length, breadth and weight of the chanks were computed and thB length-weight relationship *for Xancus pyrumis* Log W-. 3 5940 + 2.8475 Log L. The analysis of variance of the above said three factors are shown below.

Source variance	Degrees of freedom	sum of squares	Mean square
Individual factors	156	4.3	0.02756
Samples	2	34.8	17.4000
Total	158	39.1	

$$F = \frac{17.4}{0.02756 - 631.8»'}$$

F ratio 5% 1%
••Highly significant 3.06 4.75

T+wf«i«Bhisftly-sl«mficant correlation between s / o
these three factors.

TABLE 1. *Total chink landings in Tuticorin during season and non-season* ***from 1971-72 to 1982-83.***

Year	Season		Non- season		Total	
	Full size	Under size & Wormed	Full size	Under size & Wormed	Full size	Under size & Wormed
1971-72	1,08,189	6,354	14,061	6,351	1,22,250	39,367
1972-73	3,70,763	1,01,161	1,252	554	3,72,015	1,01,715
1973-74	3,56,532	1,03,334	2,189	1,385	3,58,721	1,04.719
1974-75	5,48,393	1,26,850	10,587	2,324	5,58,930	1,29,174
1975-76	4,755	8,980	7,605	4,420	12,360	13,400
1976-77	No fishing		9,071	16.289	9,071	16,289
1977-78	No fishing		10,416	19,408	10,416	19,408
1978-79	10,11,345	1,95,540	8,265	7,112	10,19,610	2.02,652
1979-80	7,87,815	1,58,376	13,081	9,732	8,00,896	1,68,108
1980-81	7,51,145	1 79,991	26,722	21,957	7,77,867	1.01.948
1981-82	7,64,459	1,13,272	31,076	26,741	7,95,535	1.40,013
1982-83	10,11,178	1,18,672	43,546	32,898	10,54,724	1.51,570
Average	4,76,210	92,711	14,623	12,431	4,91,016	99,030

TABLE 2. *Total number of different sizes of gdod chanks and wormed chanks obtained by diving, net operations and confiscation, their percentage composition during 1984 • 85 and 1985 - 86.*

SIZE	1984-85						1985-86					
	DIVED		CONFISCATEO		NETTED		DIVED		CONFISCATED		NETTED	
	Number of chanks	%	Number of chanks	%	Number of chanks	%	Number of chanks	%	Number of chanks	%	Number of chanks	%
Below 64 mm	15,786	4.4	641	5.0	4,552	8.0	8,361	9.2	139	5.3	3,136	5^9
64 to 70 mm	1,67,135	47.0	3,160	45.6	26,405	46.6	43,098	47.6	858	32.6	25,584	48.5
Above 70 mm	88,936	25.0	7,811	61.1	9,463	16.7	23.879	26.4	1,249	47.5	7.10817.3	
Wormed	83,448	23.6	1,171	9.2	16,218	28.7	15,215	16.8	384	14.6	14,947	28.3
TOTAL	3,55,305		12,783		66,638		90.553		2,630		52,775	

TABLE 3. *Monthwise total netted chanks and chanks landed by commercial trawlers at Tuticorin during 1984-85 and 1985 86.*

MONTH	1984-85		1985 86	
	Total netted chanks	Trawlnet chanks	Total netted chanks	Trawlnet chanks
July	7,323	3,938	7,043	3,882
Aug.	12,087	7,782	6,576	3,275
Sep.	9,573	6,210	1,355	828
Oct.	6,845	3,705	8,581	5,035
Nov.	1,763	820	749	480
Dec.	868	550	3,036	1,845
Jan.	4,379	2,015	249	105
Feb.	1,262	695	1,083	785
Mar.	2,531	1,620	1,855	1,020
Apr.	1,370	798	11,464	6,810
May	3,928	1'895	7,834	4,340
June	4,709	2,025	2,950	1,225
TOTAL	56,638	32,053	52,775	29,630

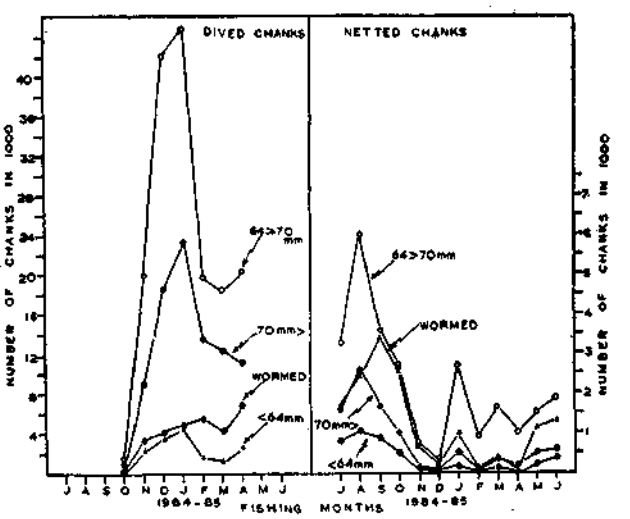


Fig. 2. The monthwise chank landings by diving and nets in Tuticorin during 1984-85.

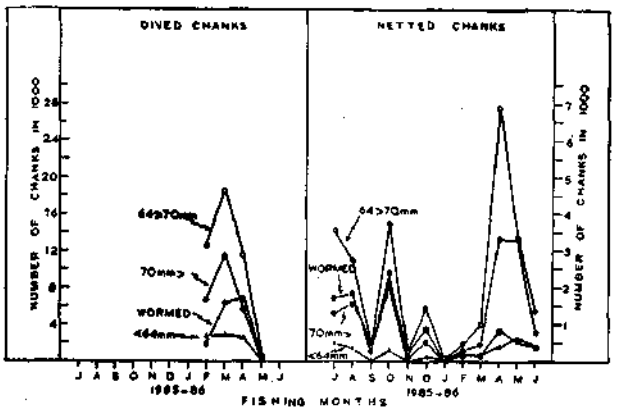


Fig. 3. The monthwise chank landings by diving and nets in Tuticorin during 1985-86

DISCUSSION

Chank landings by mechanised trawlers have not been reported in detail so far. Trawlers do not aim to exploit the chanks and they form an insignificant bye catch which comparatively do not fetch good and continuous return for the boat owners. Mostly the fishing hands share the earnings from the chanks among themselves as an incentive. The chanks measuring 64 mm to70mm ware landed in good numbers, whereas above 70 mm and below 64 mm were landed in less numbers(Table2). Chanks measuring below 64 mm do not fetch any price and are returned to the sea alive. Therefore, the fishermen do not bring smaller chanks ashore. Comparatively the wormed chanks are more in the netted catches as there is no selection (Fig 2 and 3). Among the netted chanks the trawlers landed an annual total of 32,053 and 29,630 during 1984-85 and 1985-86 respectively (Table 3). The peak period of landing is during July-September when the most of the trawlers which are fitted with higher horse power Leyland engines operate off Manapad for mainly prawns, During the other months the chank landing is comparatively low (Table 3).

^^^ occurrence of chanks beyond 20 m ^^p^^ ^^^^^ .^ ^^^ ^^l, ^^^^^ ^^ ^^^ ^kin ^^^^^^ ^^ ^ot ^g^t^^^g generally beyond 20 m (jgpth. Nayar and Mahadevan (1973) have well documented the distribution of chanks and various chank beds beyond 20 m depth within Lat 8° 25'N to 8° 55'N Longitude 75° 15'Eto 78° 35'E in Gulf of Mannar. Present observation also reveals the availability of chanks upto 40m

depth as per the trawler operations in the Gulf of Mannar especially off Manapad where it is reported that good quality chanks are available in depth greater than 20 m. However, the objective of this paper is not to advocate for chank fishing by trawlnet but to highlight the quantum of incidental chank landing by trawlnet and to bring out the possible damage caused by trawling over pearl and chank beds.

The trawling operations necessitate dragging of the net over the bottom causing considerable disturbance and dislocation to the upper crust of the sea floor. This act with particular reference to the chank habitat would cause the food supporting layers for the chank to be affected. Naturally the adult population would suffer. It has been observed by Mahadevan and Nayar (1966) that during the trimester, January-March the chank breeding is intense during which act several males surround one female in the act of copulation. This appears to be a natural process and requisite for laying of egg capsule as the copulation goes on. Trawling during such time in the area would definitely displace these aggregations, interfering with the natural process in the completion of the life cycle of the animal. Even the potential spawners happen to escape such disturbance to complete the process successfully and lay the egg capsules, subsequent sweeping of the foot ropes with sinker chains of the trawlnets appear to cause severe damage to the egg capsules. The sandy beds where the egg capsules are planted are the habitat for the prawns and different fishes also. Most of the trawler units operate for prawns usually off Manapad and during the other seasons for fish off Tuticorin. These grounds are exposed to trawling and consequently enormous numbers of egg capsules are believed to be uprooted thus bringing down the recruitment of the chanks due to high mortality rate at the young stage.

SUGGESTIONS

This study reveals the occurrence of chanks beyond the conventional diving areas and corroborates the findings of Nayar and Mahadevan (1973) in Gulf of Mannar. Therefore, it is felt essential that an intensive survey may be carried out along the coasts to assess the potentiality of this resource by systematic SCUBA diving

Further studies are suggested on the biology, growth, spawning, recruitment, mortality rates, stock position and maximum sustainable yield in addition to various factors which influence the production of chank to formulate proper fishing management regulations.

However, in the mean time the landing of undersized chanks may be further checked by insisting that the smaller chanks should be brought alive to the chank procuring yard and removal of the flesh from smaller chanks should be banned. Further, each diver may be provided with a plastic gauge to check the size of the smaller chanks in the sea itself. In addition to this possession of under sized chanks, dead or alive, by any one may be declared as illegal. These regulations do not involve much monetary expenditure. This may be expected to bring down the fishing mortality of the smaller sized chanks and enhance the chank production.

Though trawling over the chank beds have been recorded to produce adverse effect on the production of chank, considering the economic value of the trawl fishery it is beyond imagination to ban trawling on these grounds. However, by thorough study on the spawning to identify the potential spawning grounds, atleast regulation of trawling of these areas may be thought of by observing closed season during the spawning season ie., during January to March.

Considering the economic value, studies on the captive breeding and development of proper hatchery technique may be attempted

with the view of restocking the depleted waters if necessary, though such a situation has not arisen yet.

Exploitation of chanks beyond the skin diving area may be taken up by introducing SCUBA diving, the advantage of this method has already been highlighted by Nayar and Mahadevan (1973).

CONCLUSION

The sacred chank *Xancus pyrum* distributed along the coasts of Indo-Ceylon sub-continent is commercially exploited to greater extent in Indian coasts. About one million chanks are landed every year from Indian waters which 50% is contributed from Tuticorin coast in Gulf of Mannar. As much as 95% of the catch is landed by skin diving and the rest by nets. The chank landings by trawlnets in Tuticorin is about 30,000 in a year during 1984-86. Considering the commercial value of the chanks, it is suggested to regulate the trawling on the important spawning areas by observing closed season during the breeding season, say from January to March, to conserve this resource at least from the adverse effect of trawling on the recruitment of this resource.

ACKNOWLEDGEMENTS

I wish to express my deep sense of gratitude to Shri. S. Mahadevan, Scientist S-3 for his keen interest in this study. But for his guidance I would have not been able to bring out this paper successfully.

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20. DYNAMICS OF INDIAN CHANK FISHERIES

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ABSTRACT

The demand for chanks from the bangle industry in West Bengal had persisted at about 25 million chanks per year from the early part of this century to the present. The present supplies, which meet only about 40% of the demand, come mainly from the Gulf of IVIannar. The average annual stock in the Gulf of Mannar is 2.0 million adult chanks of which 44-83% are exploited. The initial stock size, however, varies from year to year, and hence, there exists different levels of optimum yields for different Initial stock sizes. Chank fisheries in Palk Bay and the Coramandal coast yield annually an average of 49,000 chanks and 24.600 chanks respectively while in Kerala the average annual yield is 20,100 chanks. The average annual stock of chanks in the intartidal Gulf of Kutch is 25,000 of which only 30.6% is exploited, but additional catch is possible only for the 60 80 mm diameter size chanks as the *y* 81 mm diameter size groups ate already well exploited. There is prospect for increasing the present supplies by introducing SCUBA diving in 20-30 m deep grounds in the Gulf of Mannar and by exploiting the Gulf of Kutch beyond the Intettidal zone.

INTRODUCTION

The demand for the Indian sacred chank *(Xancus pyrum)* from the bangle industry in west Bengal has remained at about 2.5 million chanks per year from the early part of this century to the present (Hornell 1914; Ghazi 1962; Mahadevan 1987). The present supply, which meets only about 40% of the demand, is contributed by Tamilnadu (96%), Kerala (3o/„) and Gujarat (1 %). Bulk of the catch in Tamilnadu comes from the Gulf of Mannar. This account summarises the fishery for chanks in the above states and its dynamics in the Gulf of Mannar and the Gulf of Kutch and examines the prospects for augmenting the present supplies.

MATERIAL AND METHOD

The data for the study was collected from the records of the Departments of Fisheries of the states where chank fishery exists. Standard methods were employed for the stock assess* ment of chanks (Beverton and Holt 1957; Schaefer 1957; Jones 1981; 1984; Devaraj MS; Devaraj and Smita MS).

RESULTS

Gulf of Mannar {Tamiinadu) : There are about t«" '"ajor chank beds (each comprising at """^ber of smaller beds, named after the pearl oyster beds they surround) extending from off Vaipar to off Tiiuchendur, exploited from Tuti-corinasthe base. Similarly, there are obout ^'^e major beds extending from off Rameswaram *° °" '^^'"^^'- exploited from Ramnad as the ^'^^- '^^^ '^'^^"^ ^'"^^ ^'^^^"^ *^°'" 6 to 27 m or even beyond, but chanks are more abundant in 16 to 20 m depths (Hornell 1914; Moses 1923; Mahadevan & Nayar 1966; 1967). Over 95% of the catch is taken by skindiving in depths of up to 20 m from November/December to March/ April, while the rememing comes from incidental catches taken in various fishing gears, especially trawls. Taxonomically, the Gulf of Mannar chank is called the acufa variety ('X. p/ru/n var. *acuta)* of which there are three races, namely ,^,/^^^,^ ;„ ,^^ .^uticorin beds and *kilaicarai* and ,,^,,^,*ram* in the Ramnad beds (Hornell 1914.18).

The growth data from chank marking experiments (Sambanda Murthy and Chacko 1969), the maximum recorded size of 113 mm

maximum shell diameter (MSD) and the incubation period of 0.115 year (Devanesan and Chacko 1944) formed the basis for fitting the following von Bertalanffy growth function according to the forced Gulland-Holt plot method (Pauly 1983).

$$D_t = 119\,(1 - e^{-0.0948\,(t + 0.116)})$$

where Dt is the MSD in mm at age fin years. The theoretical life span is about 51 years (for 119 mm), the observed maximum life span is 31.5 years (for 113 mm) and the fishable life span 14 8 years (for 90 mm). The size at first capture (Dc) was 57.15 mm MSD from 1876 to 1977, 60.325 mm MSD from 1978 to 1985 and 64 mm MSD since 1986. The minimum size of 58-60 mm MSD at first maturiry (D^) for males is close, to Do while the D^ of 70-80 mm for the males IS much higher than D, (Devanesan and Chacko 1944; Mahadevan and Nayar 19OD).

During 1978-79 to 1984 85, the average annual yield of chanks of < 60 mm MSD. 60-69 mm MSD and 70-90 mm MSD was 5.59%, 56.57% and 37.54% respectively. The annual total mortality coefficient r^; was extremely low at 0.0548 (being less than even *M; vide infra)* \n 1978-79 as the fully recruited 60-69 mm MSD group in the catch was only marginally higher than that of the > 70 mm MSD group. Barring this, Z during 1980-86 ranged from 0.1323 in 1981-82 to 0.2403 in 1980-81, with the mean at 0.1736. The natural mortality coefficient *(M)* was estimated to be 0.0921 by Cushing's (1968) method (Devaraj 1983). The fishing mortality coefficient *(FJ* during 1980-86 ranged from 0.0402 in 1981-82 to 0.1482 in 1980-81, with the mean at 0 0815. The annual exploitation ratio ff; for 1980-86 ranged from 0.3039 to 0.6167, with the mean at 0.4483.

The Tuticorin fishery for the period 1876-77 to 1985-86 is divisible into six phases: 51 years from 1876-77 to 1927-28, 18 years from 1928-29 to 1945-46, 13 years from 1947-48to 1959-60, 14 years from 1960-61 to 1974-75, 5 years from 1978-79 to 1982-83 and 3+ years from 1983-84 to 1985-86 (the present) during which the average annual catch was 180,714; 410,622; 823,301; 324,558; 890-102 and 324,802 chank8(only good adult chanks > 60 mm MSD. free from any destruction by borers are included) respectively. The average annual yield doubled successively in the first three phases, suggesting proportionate increases in the area fished and the effort deployed. But It declined rather abruptly in the fourth phase (when the average annual yield of 324,558 chanks was much less than half the average annual yield of 823,301 chanks for the previous phase) possibly due to overexploitation. It is therefore likely that the production limit has been reached in phase III itself, and hence, the optimum yield may lie at some production level between the average annual yield of 410,622 chanks for the second phase and 823,301 chanks for the third phase. The fishery evidently would not be able to absorb as many gkindivers as have participated annually in phase III. The average annual yield during the fourth phase was so low (324,558 chanks) that the fishery had to be suspended continuously for three years from 1975-76 to 1977-78 betwen the fourth and the fifth phases. The ^as distinctly evident in the abrupt increases in the catch to the all-time maximum of over a million chanks (1.05 xlO") in the first year (1978-79) of phase V while the minimum in »his phase was 778,132 chanks (i980-81) and the average 890,102 chanks. But obviously due to overfishing, phase V lasted only for five years and gave way to the present and the sixth phase characterised by the steady decline in yield (103,915 chanks in 1985-86).

During 1969-70 to 1974-75 an average of 34 canoes operated per day for 104 diving days with about 6 crew per canoe, realising an average effort of 23,017 diverdays per year. During 1978-79 to 1985-86, an average of 67 canoes operated per day for 111 diving days ^j^h about 5 crew per canoe, realising an average effort of 39,418 diverdays per year The catch of good adult chanks ranged from 9 ^Q 20 per diver per day during 1969-87, but declined to 3 in 1985-86.

The Ramnad fishery for the period 1978-79 to 1984-85 landed an annual average of 172.940 good adult chanks (> 60 mm MSD) with an annual average effort of 9,608 diver-

days (about 20 canoes per day for 70 diving days witli 6 or 7 crew per canoe). Tlius, for the 1978-85 period, the average annual yield from the entire Gulf was 900,838 chanks comprising 80 8% from the Tuticorin fisher/ and 19.2% from the Ramnad fishery. The average annual effort of 50,601 diverdays was also accounted for by the Tuticorin and Ramnad fisheries in the ratio of 79:21, which is about the same as for the yield. The average annual stock (P) estimated by dividing the annual yield (/) by the annual exploitation ratio (f) for the entire Gulf was 2.01 million chanks.

It has been observed that the restoration of the stock that is reduced by a certain level of effort (/) in one diving season rarely takes place along the same line of increase or decrease, but mostly along different lines, in the interval of about an year between two successive diving seasons. This may be explained by the fact that the revival of stock through growth and recruitment between successive diving seasons does not keep pace with the removal of chanks by the fishery. As a result, every season starts with an initial stock that is poorer than that in the previous year, until such time when the stock is made to recoup by suspending the fishery for an year as in 1884-85, 1946-47 and 1965-66 when fishing was apparently not very intense, and for as long as three years from 1975-76 ;o 1977-78 after a period of overexploitation (phase III) and stock depletion (phase IV).

Since there exists different levels of initial *P,* there must be different levels of maximum sustainable yield (MSY), and for this reason, the fishery cannot operate with a single MSY as its objective. They//for the first few days of diving, whic is a good index of initial stock size, can form the basis for determining and adjusting effort according to stock size for the rest of the season, so that the fishery could stay on the MSY appropriate to the given level of initial stock size. A progressive decline in *P* has been found to provoke a proportionate decline in effort, and hence, a deline in yield. But *yjf* also declined almost invariably with declining /, reflecting thereby the progressive decline in the initial *P.* The Schaefer model, built on the principle of a rather monotonia decrease *In yjf* with increasing/, could not, tiierefore, be applied in its original form to the chank fishery data. Increase in *yjf* with increasing / may happen in the initial learning phase of a newly developing fishery, but not jn the age old chank fishery operating since tj^e immemorial. The stratified Schaefer model, introduced in this study, seeks to resolve the problem of *yf* decreasing in tune with the decrease in / owing to the occurrence of initial P in different strata. This model identifies the various strata where *yjf* values distribute themselves as monotonically decreasing functions of /. The successive strata, thus identified. were seen to run more or less parallel to each other and represented different strata of initial stock size,

in the case of the Tuticorin fishery, six strata of stock abundance were apparent in the plot of j/Z/against / for 1978-86, with the MSY ranging from 143,016 chanks for stratum VI to 1,064,079 chanks for stratum I ^^^ ^^e effort (fn,sy) ranging from 18,768 diverdays for the former to 51,195 diverdays for the latter. The constant *a* in the relative yield equation *ylf~a-bf* is an index of initial *p* at the beginning of the diving season, Thus, changes in *a* are indicative of changes in initial *P,* but the rate of decrease in /// with increasing /described by 6 has been found to be nearly the same for the various strata of abundance,

The plot of annual yield against year for over hundred years for the Tuticorin fishery reveals the existence of a production cycle of four years with apeak, a valley and a peak at intervals of two years. The relatively poor parent stock at the production valley seems optimum enough to bring about high or even maximum recruitment so that there could follow apeak after the valley. Obviously, there exists a Ricker (1954; 1975) type bell-shaped stock-recruitment relation. In recent years, however substantial increases in yield and the resultant overexploitation have widened the interval between a production valley and peak to five years, with yields progressively declining to rock bottom levels. Therefore, the fishery is better closed for one to three years (depending on the level of depletion). Two years after

every peak so as to restore the stock to reasonably high levels.

In the case of the Ramnad fishery for the period 1978-85, five strata of stock abundance were evident from the plot, of /// against /, with MSY ranging from 69,160 chanks for stratum V to 350, 488 for stratum I for effort ranging from 6,494 to 14,619 diverdays.

MSY (=32/46) and fmsy {= a/2i&) values could be determined in advance at the beginning of the diving season for different levels of a, and the fishery regulated accordingly. The parameter a, for this purpose can be determined by substituting the /// and /values for the first few days of a diving season in the relative yield curves for the two fisheries given below.

Tuticorin fishery : Y/f = a - 0 000401 f
Ramnad fishery : Y/f = a-000164 f

Since the fishery by skindiving is limited to a depth of 20m, SCUBA diving may be introduced in 20 to 30 m deep grounds in order to augment the present yield.

Palk Ba\i {Tamllnadu) : Unlike in the Gulf of Mannar, there is no organised fishery for chanks in Palk Bay. The fishery, comprising only incidental catches in various fishing gears, is very insignificant, the annual yield of good adult chanks 0 60 mm MSD) in 1978 85 ranging from 15,061 in 1984-85 to 123, 061 in 1982-83, with the average annual yield at 48,986 chanks. Size composition and effort data are not recorded for this fishery, and hence, stock assessment and MSY estimates could not be made. The Palk Bay chank, described as A. p/m/77 var *obtusa* race *tn/rupa-/aqua/,* is inferior in quality to the races of chanks in the Gulf of Mannar.

Coramandal coast (Tamllnadu): Like in Palk Bay, there is an incidental fishery for chanks in the districts of Tanjore. South Arcot, Chengalpat and Madras and the Union Territory of Pondicherry, which together constitute the Coramandal coast. However, catch data is available only for the Tanjore district between Point Calimere and Pudukuda where the annual catch of good adult chanks (> 60 mm MSD) during 1951-64 ranged from 11,832 in 1954-55 to 44,981 in 1958-c9, with the annual average at 24,489 chanks.

The traditional fishing gears which land chanks include boat seines and crabnets, and the important landing centres include Tranque-b^,^ Pudupattinam, Sinnangudi, Kaveripattinam, Melamookavai and Thirumullaivasal. Since the 3^^^,^ of commercial bottom trawling in the sixties, large number of chanks are being taken ;„ ^^^^^^^ j„ 14,0 30 m depths along the Coramandal coast, particularly between Thirumullaivasal and Portonovo (Mahadevan Pilla and Devadoss, 1974). Of the two races of chanks occurring along the Coramandal coast ^ *PY'^"'^ '^^' °*^"** '^^^ coramandal* is inferior while X. p/m/77 var *obtusa* race *nayinathivu* is quite comparable to the Gulf of Mannar races,

Kerala The government leases its fishery rights by auction to the fishermen. Skindiving forms the main method of exploitation along the Trivandrum district where the important bases include Poovar, Vizhingam, Kovalam, Val.athura and Poonthura villages. Crabnets '^"d small quantities of chanks from Poovar to Q"''°"- At Vizhingam, 15 to iO units of longlines, each 250-500 m long with 500 to 1000 hooks (No. 6 or 8) are being operated for chanks since 1976 for about 25 days a year, with an average of obout 45 chanks per day per gnit. The operation, repeated 2 or 3 times g day, involves dragging the longlines along the chank beds for hooking the chanks by their f^ot. Inshore shirmp trawlers also land chanks regularly from Sakthikulangara to Cochin throughout the year with peak from July to December. During the period 1964-80, the annual catch of chanks ranged from about 4,750 in 1975-76 to 44,670 in 1979-80, with the average at 20,138 chanks. Of the three varieties of chanks known to occur along the ^^^^1^ ^^^^^ ^ ^^^^ ^^^ *giobbosa. X. pyrum* var *comorinensis* and *X. pyrum* var *acuta),* the variety *acuta* forms the bulk of the catches (Appukuttan ef. a/. 1980.

Gulf of Kutch (Gujarat) . The fishery is limited to the intertidal zone, in spite of indications of good potential beyond this zone. The annual catch of good adult chanks (> 60 mm MSD) during 1974-84 ranged from a meagre 2,572 in 1977-78 to 13,066 in 1974-75, with the annual average at 7,717 chanks comprising 39% of 60-80 mm MSD group, 50.19% of 81-100 mm

MSD group and 10.81% of > 100 mm MSD (upto about 115 mm MSD) group.

The Gulf of Kutch variety *(acuta)* is the same as that occurs in the Gulf of Mannar. Therefore, the growth equation for the Gulf of Mannar stock was used to determine the age composition of the catch from the Kutch, and ti,».*„ ,K , *, xu ,y ^ therefrom, the value of Z. The annual Z ranged X «..-,/No. -«-,« «« «-,^«, . .^^^ «.. from 0.1708 in 1979-80 to 0 2384 in 1980-81 except in 1982-83 when it was 0.0972; the mean annual Z was 0.1 725. Considering M to be the same as for the Gulf of Mannar stock, /^ was found to range from 0.0787 in 1979-80 to 0.1463 in 1980-81 and £ from 0.4608 in 1979-80 to 0.6137 in 1980-81, with the mean £ at 0.5201 (excluding 1982-83).

The annual stock of adult chanks (> 60 mm MSD) ranged from 7,880 in 1977-78 to 53, 018 in 1974-75, with the annual average at 25,234. Thus, the average annual yield of 7.717 chanks represent 30.6% exploitation of the stock of >60mmMSD chanks. However, . . . rro«..„, . the actual exploitation ratio was 52.01% since ,_____"', , „ °„^ only in 1981-82 and 1983-84, the 60-80 mm MSD group formed the fully recruited group in the catch while in all the other years the 81-100 mm MSD group formed the predominent portion of the catch. The stock of > 81 mm MSD group chanks was about 9,050 and the » u t /l -tr\-i u l < .u- . „ „„«.,•- catch of 4,707 chanks of this group represents 52% exploitation, indicating thereby little , ... scope for expanding the fishery in the intertidal zone for the > 81 mm MSD group and some prospects for increasing the catches of the 60-80 mm MSD group.

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21. ORNAMENTAL SHELL INDUSTRY OF RAMANATHAPURAM COAST

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ABSTRACT

As many as twelve shell craft Industries established at KeelaVaral and Ramaswaram cater to the demand of the internal and external market of ornamental shells in India and abroad. Several species of molluscan shells which occur in the Gulf of Mannar and Palk Bay constitute the raw materials for these industries. Apart from very rare SPECISS, 15 important species are regularly exploited for this purpose. The Genus /.a/n^/s commonly known as'Spider conch' is very Important among them by virtue of its abundance. Of the 9 species of *Lambis* known from India, only 3 species art abundant in this coast Exploitation of these shells are mostly by skin diving and to a limited extent by trawl, gill and drag nets employed mainly to catch finfishes, lobsters and crabs.

This paper mainly deals on the ornamental, curious and religious values of molluscan shells, their Industry, types of shells and species used by tne industry, varied products, marketing, employment opportunities and certain aspects of costs and earning of the industry.

INTRODUCTION

Eye catching, striking contrast colour pattern and varied shapes are the features which have aroused the curiosity of man towards the molluscan shells. The initial curiosity lead to finding out many ways of usefulness of these shells starting from using them initially as vessels for keeping food and water to using them as ornaments of high value. The Ramanathapuram coast is a rich area inhabited by just common species of molluscs as well as hard to get species of high rarity. Majority of the molluscan species that have been reported all along the south east coast of India are known to occur in Ramanathapuram coast. The availability of a variety of shells in good abundance has led to the development of a typical ornamental shell industry at Keelakarai and Rameswaram. It is realised that documenting various aspects of this industry is highly essential for the proper development of the industry.

MATERIAL AND METHODS

Periodical visits were made to important shell industry centres to collect data on different species of molluscs used in industry, places of collection, specieswise cost, total number of manpower engaged in the industry, details of marketing through retail and wholesale outlets. Important molluscan shell landing centres were visited once in a week to collect data on the collections, fishing methods, fishing ^^^^^^ ^^ ^^'^' "'"P'"^"^ ^"'^ ^'^'^'"9 9'°""ds. Enquiries ^"'"'^ '"^^^ ^^ ^^^ manufacturing centres on the details of articles made and their cost. Chank '^"^^'"9 data were collected both from shell industry and Tamil Nadu State Fisheries Department,

SHELL INDUSTRY

The entire shell industry may be divided into 1) the raw material production 2) product- '»" °f ornamental shells and shell products and 3) marketing.

Raw material production The raw materia s include the shells of different shapes and sizes belonging to the following genera *Oliva, Cypraea, Natica. Cerithidea, Pterocera. Gafrarium, Strombus, Babylonia, Conus, Murex, Cymatium, Turco, Merita, Marpa, Turbinella Lambis, Pyrene, Umbonium, Dentalium, Area, Velata, Littorina, ^^'«' Fistularia. Traphezium. Fusinus. Cymbium, Cancellaria, Faciolaria, Turbinella. Cassis, Bursa, Phalium, Tonna, Drupa, Buttia, Thais etc.* Among these shells it is estimated that 1,75,000 shells of 3 species of *Lambis* are fished annually and each shell fetches Rs 1 to 3/- for the fisher-

men. The fishing for the chanks is the monopoly of the State Government and the merchants get the chanks when the catches are auctioned by the Government every year.

The methods of exploitation of these shells depend on the size, behaviour and habitats in which they occur and maybe divided intol) hand picking in shallow waters 2) skin diving in deeper waters 3) hand dredging and 4) by different types of nets. Moderately small shells like *Oliva* and *Cypraea* are usually collected by hand picking in the intertidal rocky zone during low tides. Exposed coastal muddy flats and near-by islands are the habitat wherein a variety of colourful dead shells and live specimens are collected during low tides. Chanks, *Turbinella pyrum* are usually landed by skin diving done upto 20 m depth range in Palk Bay and Gulf of Mannar. Hand dredging with a common type of triangular net fastened with a long pole called 'Arachal' or 'Kachan' is done in areas like Devipatnam, Sundaramadayan, Vedaiai, Marakkayarpatnam, Mandapam and Pamban to collect small sized gastropods like *Pyrene* during October to April every year. These nets are set at the bottom at 2 to 3 m depth and dragged with the connected pole for a distance of about 10 m by hand. Then the net is lifted out of water and emptied of its contents. The main aim of operating this net js to exploitiny molluscan shells, whereas other nets like gill nets such as bottom set gill net, nanduvalai and singivalai which are employed to catch finfish, crabs and lobsters, ignd gastropods like *Pterocera, Trochus* etc. in good numbers as they are caught incidentally, A wide variety of shells like chanks, species of *Gafrarium, Strombus, Babylonia, Conus, Murex, Cymbium, Harpa* etc. form a portion of the by catch in trawl nets operated for shrimps and fish.

TABLE 1. *Procurement and sales-rate of corrimerclally important shells by shell industries of Keelakaral & Rameswaram*

Species	Vernacular name	Purchase rate	Sales rate	Quantity
Turbinella pirum	Sanku	There are 11 sizes viz. Fo: 0; 1,2,3,4, 5,6,7, AR and 8 (Re 1/- to Rs. 3/- depending upon the size)	Rs 3/- to Rs. 50/- depending upon the size.	per piece
Pterocera lambis	Aiviral Sanky	Rs 1/- to Rs. 3/- depending upon the size	Rs 2.50 to Rs. 5.00/- depending upon the size	
Umbonium vestiarlum	Poochi Koodu	Rs 1/-	Rs 2/-	Per litre
Oliva spp	Kovanchu	Rs 5/-	Rs 15/-	,,
Dentalium sp	Vellai Mooku	Rs 6/-	Rs 8/-	
Arca spp	Sippi/Kilinjal	Rs1.50/-	Rs 2/-	
Cymatium pileare	Pillayar Sanku	Rs 2/-	Rs 3/-	per piece
Tibia spp	Ezuthani	Rs 0.40/-	Rs 0.75/-	
Babylonia spp	Puramuttai	Rs 2.00/-	Rs 4.00/-	per litre
Conus spp	Vazhvi Poo	Rs 0-10/-to RsO-75/-	Rs 0.25/-to Rs1.50/-	per piece
Cypraea spp	Sozhi/Mani Mowri	Rs 0.05/-to RsO.10/-	Rs 0.12/-to Rs. 0.15/-	

Species	Vernacular name	Purchase rate	Sales rate	Quantity
C0/7US spp (Glory of India)	Vazhzi Poo	Rs 100/-(This shell is not polished; polished shell does not fetch good price)	Rs 400/-	
Strombus spp	Veranjan	Rs 0.40/-	Rs 0.75/-	
Fistu/aria spf>	Sihappu Mulli	Rs0.15/-	Rs 0.30/-	
Trapzium sp	Kuthurai IVlulli	Rsl.50/-	Rs 2.00/-	
Fusinus sp	Vellai Chaval	Rs0.30/-	Rs 0.40/-	
Harpa sp	Sarpa Koodu	Rs 2.00/-	Rs 2-50/-	
Cymbium melo	Suvappu pathiram	Rs 3.00 to Rs 5.00/- depending upon the size	Rs6toRs. 10/- depending upon the size	
Cancel/araia spp	—	Rs 4.00	Rs 6.00	per litre
Fascio/ar/a spp	—	Rs0.15	Rs 0.25/-	per piece
Mures rmosus	Yanai IVlulli	Rs 3 to Rs. 10/-	Rs 5/-to 25-00	
M. florifer	Karuppu Kullai	Rs 1/- to Rs. 2/-	Rs 3/- to Rs. 5.00	
M. muteramos/s	Katta sanku	RsO.10/-	Rs 0.25	
M. triremis	„	Rs 0.50 to Rs 1.00	Rs 1.00 to Rs. 3.00	
M. haustelium	Vellai Poodu			
M.adj'ustus	Karupplu Mulli			
Pterocera Chiragra	Aru viral sanku	Rs 1/- to Rs. 4/-	Rs 5/- to Rs 15/-	
P. aurantia	Silanthi sanku	Rs 1/-to Rs. 2/-	Rs 2/-to Rs 5/-	
Cassis madagascarensis	Mattu Thalai	Rs 10/-to Rs 30/-	Rs 30/-to Rs. 50.00	
Cypraea reticulata	Sozhi	Rs 1/- to Rs 1.50	Rs 2/- to Rs 4-00	
C. *talpa*	Anil sozhi	Rs 2.00/- to Rs 3.00	Rs. 4.00/- to Rs. 6.00	„
Operculum of *Turbo*	Ravanan Vizhin	Rs 3-00/- to Rs. 5/.	Rs. 6/- to Rs. 10.00	per liter

Shell divers, shell collectors, beach combers and those who collect shells from boats and launches sell their collections either to shell procurers who act as agents of shell industry or directly to the shell processors in the industry. Different species of molluscan shells, their procurement rate and market rate of finished product by the shell industry are given in Table 1. The important centres where the shells are processed are Pamban, Mandapam, Vedalai, Periapattinam, Devipattinam, Thirupalakkudi, Mullimunai, Karankadu, Thondi and Sethubavachathiram. Shell are also being procured from Tuticorin, Cuddalore, Andaman and Nicobar Islands. On an average Rs 4,00,000 of raw materials are used in the industry,

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After drying the shells in the open for 3 to 5 days, they are soaked in fresh water for 2 to 5 days in cement tanks, depending on the size and quantity of the shells. This enables removal of dirt and decayed soft parts of the animals. Then the shells, whether big or small are placed in bleaching powder solution or bleaching liquid for 24 h in cement tanks

constructed for this purpose, followed by immersing the shells in caustic soda solution in another tank for one h. Depending on the thickness, colour and quantity of the shells, they are polished by allowing them to remain in 5% Hydrochloric acid from 10 seconds to 4 minutes

Ornamental products

In view of the increase in demand for ornamental molluscan shells there has been a wide diversification, producing novel items such as table lamps, lamp shades and domes, dolls, garlands, pendents for chains, necklaces, ear-drops, beads for the neck, hair pins, fantasy flowers sculptures of Gods and Goddesses, agarbathi stands, bangles, flower vases, shell screens for windows and door curtains etc.

Marketing

There are as many as 12 shell industry units of which 3 are at Keelakarai and 9 at Rameswaram which manufacture the ornamental shells and market them throughout India. The market outlets in India are Bombay, Calcutta, Delhi, Mathura, Haridhwar, Lucknow, Purl, Ayodhya, Kanyakumari, Madras, Dwarka, Hyderabad, Bangalore and Agra. The shell and shell products are exported to countries like USA, U K., Australia and Austria. The annual turn over of the shell industry amounts to Rs 10,00,000.

FIG 1. A shell shop.

GENERAL REMARKS

^^^ ecological habitat surrounding Mandapam-Rameswaram coastal belt is ideally suited for the settlement and growth of a variety of gastropod and bivalve shell species. The island system m the Gulf of Mannar provides suitable areas serving as breeding ground for many of the gastropod shells which form the important components supporting the shells industry at Keelakarai and Rameswaram area.

The craftsmanship m the shell industry is age old and dates back to the historic time when recorded to nurture the then craftsmen of shell people in the society, some of these are still available in «ome national museums and temples. The causative factors which prompted the development of the shell industry into a well established one are manifold such as mere whimsical curiosity to religious sentiments, Curiosity tempted man to collect the gorgeously multicoloured shells and then he found some uses of the shells, initially as utensils for keeping food and water. Even now beggars use the shells of *Cymb/um melo* as 'beggar's bowl'. Later the aesthetic sense prevailed to find ways and means of using them as ornaments, The use of sinistral chanks and dextral chanks in temples testifies to the religious sentiments attached to chanks.

Keelakarai is purely a shell processing and shell ornamental manufacturing centre and there are no retail or wholesale outlets for the public. On the other hand Ramesweram thrives not only with the shell and shell ornamental production but there are as many asseventy shell shops located in and around the Rameswaram temple. Being a very important religious place, Rameswaram attracts pilgrims and tourists from all over India and abroad and these shops cater to the need of these pilgrims and tourists. The shells and shell ornaments vary in cost from as low as Rs 1.50 to as costly as Rs 400 and a sinistral sacred chank costs anywhere around

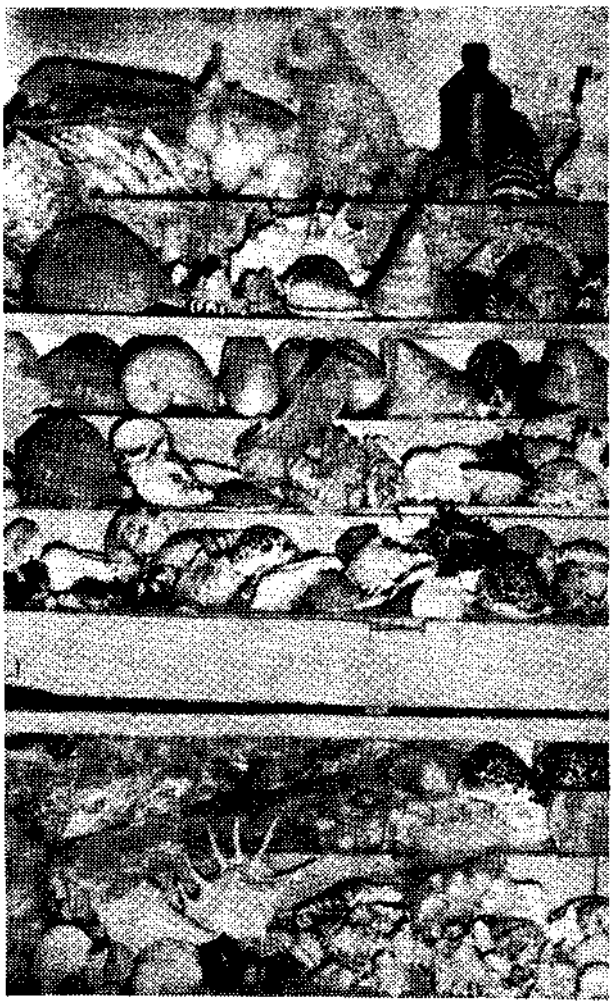

FIG. 2. Shells on display.

to Rs. 5000 to 10000 depending onits size and perfection.

The shell craft industry at Keelakarai and Ramnad offer livelihood for nearly 250 shell-craftsmen apart from the fishermen, shell procurers and the shell shop owners. Each craftsman earns around Rs. 15 to 20 a day. Some of the craftsmen work as shell collectors and procurers also and the shell crafting work is seasonal during May to September. Exploitation of the shells is not regulated and there is no organised fishery exists except for chanks. Therefore, it is suggested that systamatic studies on the biology and population dynamics of these species are suggested for rational exploitation of these resources. This industry thrives mostly as a cottage industry along this coast. Further training in the cranfsmanship and financial support to certain extent for the procurement of advanced mechineries may improve the standard of the products which may attract a wider market in India and abroad. This may be achieved through organising a co-operative societies in the industry and the financial assistance may be extended by the Government or through banks. This may improve the economy of the industry in addition to increase the employment opportunity in the coastal area of Ramnad district.

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22. ON THE HABITAT,. HABITS AND FOOD OF *LAMB IS LAMB IS'* AND *HEMIFUSUS COCHLIDIUM*

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ABSTRACT

***Lambis lambis* and *Hemifusus cochlidium* are two important marina gastrapods of commercial value in India, whiich occur at several places along the southtast coast and are exploited for their shell*. The habitat, habits and food of these gastropods occurring in Gulf of Mannar off Kayalpatnam, 30 km south of Tuticorin have been studied. The two species occur at depths of 2-12 fathoms in sandy muddy habitat with rock<y outgrowths and are netted in bottom set gill nets *(singi valai)* laid for lobster*. Direct observations have been made on their habits by SCUBA diving. The gastropods burrow in the sandy muddy bottoma and sometimes climb over rocl(s and coral stones found in the area. The food of the two gastropods is similar and consists of ploychaetes, small crustaceans and bivalve molluscs. The nature of sediments, the fauna and flora occurring along with the gastropods in their habitat and the behaviour of the two species in laboratory has been studied.**

INTRODUCTION

Shells of a number of species of ornamental molluscs belonging to the Class Gastropoda with beautiful shells inhabit the coastal waters of India, including Andaman and Lakshadweep Islands (Nair 1974). These marine gastropods are fished in many parts of the world for food, bait, for their shells or manufacture of lime. *Lambis lambis* and *Hemifusus cochlidium ate* of commercial value in India and occur at several places in large numbers along the southeast coast and are exploited for their shells. The two gastropods are collected, and the shells are cleaned, polished and sold as curios.

Hornell (1914,1917, 1922 a, b, 1949 a,b,c and 1951) studied the molluscan resources of Indian coasts, especially those of composite Madras State, and published accounts of the distribution, habitat, fisheries and utilization of several gastropods of commercial value. Satyamurthi (1952) studiedthe gastropods from Krusadai Island, Gulf of Mannar and Rao (1958, 1969) stressed the importance of the shellfish. their fisheries and the shell-craft industry which has got great scope in India since it is possible to export the products to other countries, also.

The present paper gives an account of the diagnostic charactern, distribution of the two gastropods, *Lambis lambis* and *Hemifusus* cocMWwm, their habitat, habits,size-composition food and bottom fauna and flora present in the area where these gastropods occur.

MATERIAL AND METHODS

The inshore areas from Rameswaram to Manapad in the Gulf of Mannar on the southeast coast of Tamil Nadu are the important grounds *\n wh\ch Lambis lambis andHemlfusus cochllcfium* occur in large numbers. Samples of Z../awA/* and *H. cochlidium* netted at depths 2-8 fathoms in bottom set lobster gill nets *(singi valai)* at ^ayalpattinam, 30 km south of Tuticorin were transported alive to field laboratory and kept j^ fjbreglass tanks to study their diagnostic characters and habits in laboratory. Their habits in the natural habitat were also noted ^y jj^ect observations using SCUBA diving apparatus by one of the authors (Pon Siraimeetan)

Feeding experiments were conducted in the laboratory and it was studied whether *Lambis lambis* and *Hemifusus conchlidium* feed on live polychaetes and chopped clam meat, To study the feeding habits in the natural

habitat, a total of 70 *Lambis lambis* of the size range 110 mm-186 mm (length) and 56 *Hemifusus conchlidium* of the size range 71 mm-112 mm (length) were collected alive from bottom set gill nets which are mainly operated for lobsters at Kayalpattinam. The outer hard shells of the live animals were broken without causing any injury to the animals. The live animals alone were immediately preserved in 5% formalin and the gut contents examined.

Tests were conducted to study the survival of *L. lambis* and *H. conchlidium.* Healthy animals of the two species reared in sea water were kept outside water separately and their survival tested at every 24 h intervals Bottom sediment samples were collected from the grounds inhabited by the gastropods off Kayalpattinam. The sediment samples were preserved in 5% formalin and bottom fauna and flora presented in them were identified Experiments were also conducted to find out the response of the two gastropods species to light. The animals were kept in sea water in large plastic tanks and light was focussed in a limited area in the tank. Observations were made on animals at frequent intervals and their movements if any away, towards or away from light were recorded.

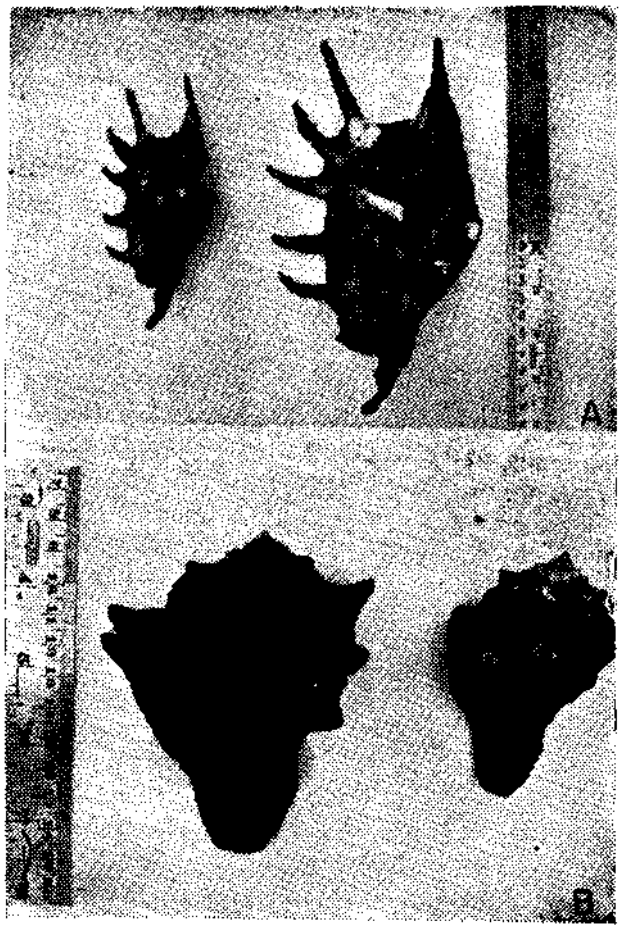

Fig 1. *Lambis lambis* **(A) and** *Hemifusus cochlidium* **(B) caught in lobster net** *(Singi valai)* **off Kayalpatnam, Southeast coast of India.**

DIAGNOSTIC CHARACTERS AND DISTRIBUTION

Lambis lambis (Linnaeus)

The shell is large, spindle shaped, moderately heavy and covered by a brown horny periostracum. Body whorl has angular shoulder with well developed nodules near the suture; some nodules are present lower below on the whorl. Surface of body whorl coarsely sculptured with closely set spiral ridges; on the whorls of spire ridges are closely set together. Outer lip of aperture broad, extends upwards over the surface of spire and is prolonged at its outer edge into seven elongated finger-like grooved processes. Columella and interior of shell smooth, bright and white or buff coloured. Outer surface whitish with brown markings. (Fig. 1.A)

This species is distributed from East Africa to Micronesia and eastern Melanesia. In India '* occurs from Tuticorin to Pondicherry. Ths fishing season for this species is from April to October in Palk Bay and from November to February in Gulf of Mannar. Common Names; EngliBh—Five fingered chank, Tamil—Aivirali or Aiviral sangu.

Hemifusus cochlidium (Linnaeus)

Shell large, thick and pear shaped. Surface periostracum. Spire short- Whorl predominantly angularly shouldered. The shoulders particularly those on the body whorls bear well developed outer-posteriorly compressed tubercles. Whorls of spire sculptured with fine, spiral ridges; only a small number of thin spiral ridges are present

on the body whorl. Aperture is elongated and columella border concave. Anterior canal moderately elongate. Outer surface of shell dark orange red and columella and interior of aperture light yellowish red (Fig. 1, B).

The species is distributed in coastal waters including trawling grounds of Palk Bay and Gulf of Mannar. The fishing season of this species is the same as that for *L. lambis.* Common names: English—Red chank, Tamil—Mulli, Nagamulli sangu, Segappu mulli, Erathi mulli.

HABITAT

Lambis lambis and *Hemifusus cochlidium* are found to occur along the southeast coast of India and they are abundant in the shallows of Palk Bay and Gulf of Mannar. They inhabit the sandy and muddy areas and are very common at depths of 6-12 fathoms.

In the Gulf of Mannar, off Kayalpattinam the two gastropods occur in areas with sandy muddy bottom at a depth of 2-8 fathoms which are about 2.5-10 km from the coast. The fauna are rich in these areas and comprise of various groups like polychaetes, amphipods, bivalves, corals, sponges, holothurians, hydroids, gastropods, isopods, crabs, hermit crabs, echinoderms and fishes.

HABITS

Lambis lambis The animals are active, shallowly burrowing in sand or gravel and graze on animal matter present in the mud as mentioned by Morton (1979), They can be recognized at the bottom by the presence of five spiny digitate processes of the shell. They move quickly by the active muscular movements of the foot.

Hemifusus cochlidium This species crawls slowly with the help of its foot over short distances leaving a mark on the bottom. It usually inhabits sandy muddy habitat with rocky outgrowths with benthic animals which form their main food. The species soon attaches itself sometimes to the substratum firmly with its thick and broad foot.

OBSERVATIONS

The two gastropods were reared in rectangular fibreglass tanks (210 X 110 X 50 cm) with sand at bottom to a height of 3 to 4 cm. The animals were observed at intervals and their behaviour was noted.

Lambis lambis The animal is seen with protruded optic tentacles, prominent eyes and proboscis. It retracts these organs if disturbed. The proboscis is tubular in shape dark brown in colour and retractable. The animal moves from one place to another by step by step movements by vigorously shifting the foot by which the front side of the animal is lifted up and the animal progresses by a series of forward runs. At every step it stops for a short time. Within 2-3 minutes *L. lambis* moved sideways along the walls of the rearing tank and covered a distance of about 55 cm in 8-10 steps. The track left behind by the animal in the sand consists of thin, narrow and zig-zag lines like the marks left by the feet of small birds on land.

Hemifusus cochlidium The animal usually rests in one place with protruded proboscis. The latter is tubular in shape, dark brownish red in colour and is movable. It moves clockwise, anticlockwise as well as in downward and upward directions. The animal retracts the proboscis inside if touched or disturbed. Some animals are seen attached to the walls of the tank below the water level and at times above the water level with the help of their thick muscular foot. On attachment the animal expends its muscular foot on the front and back sides and moves slightly in clockwise and anticlockwise directions. The animal moves slowly on the muddy bottom by the muscular movements of the foot leaving a characteristic track in the sand which is narrow, curved or straight and looks like a narrow channel.

Direct underwater observations made with SCUBA diving apparatus revealed that the bottom where the two gastropods occur was sandy muddy with rocky outcrops. The bottom

is covered with a mixture of coarse and medium sand of pale brown colour with plenty of broken shell bits. Very often the two species of gastropods were overgrown with seaweeds, barnacles, egg masses of gastropods etc. The gastropods burrow in the sandy muddy bottom and sometimes climb over rocks and coral stones found in the area.

FEEDING EXPERIMENTS

Individuals of the two species of gastropods of identical size were kept separately in rectangular plastic tanks (65 x 45 x 30 cm) with sand at the bottom to height of 10-15 cm. The tanks were filled with sea water to a level of 5 of the tank and a known quantity of feed was given daily at a fixed time. The rejected food material was collected and weighed next day. The experiment was repeated with live, polychaete feed and chopped clam meat.

Lamb/'s lambi's Two animals of the size 158mm and 155 mm in length were used in this study. The animals were kept separately and 5.0g of live polychaetes was given to each animal daily. The results indicated that the animals have consumed SSyo of the live polychaetes daily out of 5.0 g provided.

Later the same animals were given 5.0g of clam meat daily. The animals showed poor response to clam meat and consumed 16% of the meat daily out of 5.0 g.

Hemifusus cochlidium Two animals of size 108 mm and 110mm in length were used. The animals have taken 42% of the live polychaetes daily out of 5.0g. But they have not fed on clam meat and a total rejection to clam meat was noted.

FOOD OF THE TWO SPECIES COLLECTED FROM OFF KAYALPATTINAM

The gut contents of *L. lambis* and *H. cochlidium* netted in bottom-set gill nets were examined and the food of the two species was found to be similar. The animals are carnivorous and fed chiefly on polychaetes, bivalves, small crustaceans, foraminifers, isopods and gastropods. Sandgrains, polychaetes and digested matter were the daminant items found in the guts of Z. *lambis* and *H. cochlidium* (Table. 1)

TABLE 1

Percentage occurrence of food in the gut contents of L. \arr\b'is and H. cochlidium *netted in bottom set gillnets {singi valai).*

Food	*Lambis lambis* %	*Hemifusus cochlidium* %
Sand grains	34	46
Polychaetes	25	12
Digested matter	22	24
Bivalves	7	10
Small crustaceans	6	4
Broken shell bits	4	—
Foraminifers	1	1
Isopods	1	—
Gastropods	0.6	3

SURVIVAL

Normally the gastropods can thrive for a certain period outside seawater. In order to study the survival of the two species outside sea water, six series of experiments were conducted at 24 h, 48 h, 96 h, I20h and 144 h intervals. The two gastropods were kept separately in cleaned glass tanks without water and at the end of each experiment the animals were put under sea water to test their survival by close observation. The experiments were repeated for each series of time interval.

Lambis lambis Individuals of the size group 142-145 mm in length were used. The study revealed that till 120 h the animals were alive, slightly active and retracted foot inside but at 144 h, they were confirmed to be dead.

Hemifusus cochlidium In this study specimens of size 98-100 m were used. The results indicated that the animals were alive till 96 h, and were confirmed to be dead at 120 h.

BOTTOM FAUNA AND FLORA

Bottom sediment samples were collected from the lobster grounds at depths of 2-7 fathoms off of Kayalpattinam from where the gastropods occur. The mud samples were washed with water several times and the washings were filtered through sieves. The fauna thus filtered was sorted out and identified.

The bottom fauna consisted mostly of sponges, calcareous algae, bivalve shells, coral pieces, oyster shells, amphipods, polychaetes Amphioxus, isopods, hermit .crabs (juveniles), decapod larvae, pteropods, ostracods, foraminifers, *Alphaeus* and caprellids and the flora comprised mostly of the algae *Sargassum* spp, *Hypnea* spp and the sea grass *Cymodocaa.*

Some observations were also made in the laboratory to find out the response of the two gastropods to light. The animals were kept separately in sea water in large plastic tanks and light was focussed In one corner of the tank. The experiment was started by placing the animal opposite to the lighted area and the movements of the gastropods were observed at frequent intervals.

Lambis lambis These always showed movement towards light. They moved from the shade place to lighted area when tested repeatedly.

Hemifusus cochlidium It was interesting to note that these animals exhibited very limited movement and did not show movement towards light.

EPIFAUNA AND EPIFLORA

Barnacles, polychaetes, sea-anemones and •ggmasses of some molluscs are often seen attached on the surface of the two gastropods Algae such as *Gracilaria, Hypnea, Padina* and *Sargassum* are also seen as epiflora attached to the outer surface of shells of these gastropods.

REMARKS

The foregoing observations show *L. lambis* are more active than *H. cochlidium.* The five fingered chank does not have foot attaching mechanism. But in the case of the latter the animal gets attached firmly on the surface and moves very slowly.

The two gastropods showed some response to live polychaete feed than clam meat. Analysis of the gut contents revealed that the food of the two gastropods collected from the lobster gillnets is similar since they live and feed in the same habitat. The predominant items among diet of the two species are polychaetes, bivalves and small crustaceans.

L. lambis exhibits positive phototropism and moves towards light from shaded area But *H. cochlidium* does not prefer to move towards lighted area.

Analysis of bottom mud samples collected from the sandy muddy habitat indicate that the bottom fauna present in itie natural habit plays a vital role by forming the food of the two gastropods.

Except in the case of sacred chank, *Xancus pyrum* (Mahadevan and Nayar 1966) and a few others (Hornell 1949 a, b, c) which has been studied to a limited extent, the habits and biological aspects of gastropods of Indian region have receivwi very little attention. A thorough study of the behaviour and biology of gastropods of Irulian seas which are of commercial importance is needed to have a better understanding of the populations which are exploited commercially.

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23. STUDIES ON THE BIOLOGY OF THE DOG-WHELK *NASSASTOLATA* (GMELIN) OF PORTONOVO WATERS

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ABSTRACT

The morphology, anatomy and sex ratio of the mud snail *Nassa stolata* (Gmalln) were studied. The species, being a facultative omnivore. feeds mainly on dead animals and the digestive system Is suited to this mode of feeding. The radula is of rachiglossate type and is well suited for tearing and rasping. The female reproductive system Is mors complicated than that of male- Studies on sex ratio clearly show the prepondarence of males over females. The males mature at a size of 12.1 mm female* at 12.5 mm.

INTRODUCTION

Studies on the functional morphology and anatomy of neogastropods are few. These groups of animals by virtue of their several advanced chracters lil^e internal fertilization, facultative omnivorous feeding habit, and highly developed sense of chemoreception have been studied by Peile (1922, 1936), Graham (1939, 1941, 1949), Fretter (1941), Jennerand Chamberlain (1955), Oisson (1956), Fretter and Graham (1962), Marcus and Marcus (1959,

1962), Brown (1959) and Ponder (1970, 1972, 1973). Among nassarids the European species *Nassarius obsoletus* has been studied by several authors (Bergman and Graham 1975; Scheltema 1956, 1962, 1964, 1965; Pachenik 1978). Knowledge on the sex composition and sexual dimorphism is of vital importance in understanding the population structure of any animal community. However information on the tropical nassarids is almost nil. The present study is aimed to throw some light on the morphology, anatomy and sex ratio of *Nassa stolata* collected from the Vellar estuary (Lat. ir29'N; Long 79°46'E).

MATERIAL AND METHODS

The animals were collected from the benthc region of the Vellar estuary (Fig 1). Theanimal was removed from the shell by breaking open it or boiling m mild alkaline solution. Length, width and height of the shell and operculum were measured with a vernier calliper. Dissections were carried out both on live and preserved animal to study anatomy and drawings were made with camera lucida. The radula was studied by dissolving the tissues of probosis in 10% sodium hydroxide. The radular ribbons were mounted on a clear glass slide with a drop of 4% acetic acid and the drawings were made. In the present study an attempt was also made on this animal whether this species

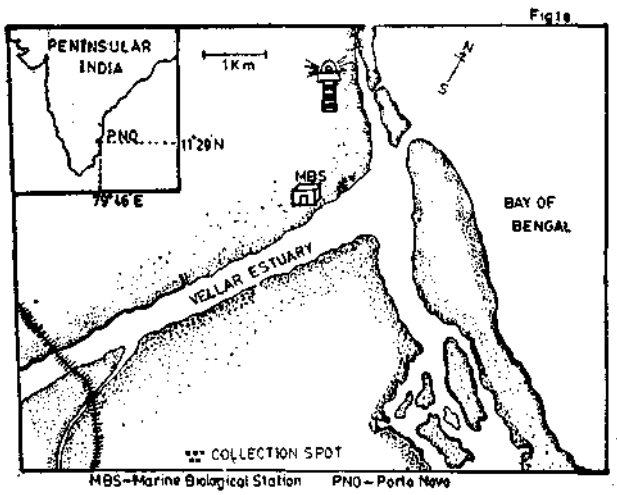


Fig. 1 Map of the Vellar estuary showing the collection area.

ing the chl-square test. The size at first maturity was observed by gonadial smear examinations and by histological sections following the pocedures of Alagarswami (1966) and Nagabhusanam and Mane (1975).

RESULTS

Shell and Operculum Morphology

globosely increased spires. The aperture inside. The inner surface of the outer lip has small ribs which are not well pronounced. A short siphonal canal is present in the anterior part of the shell. The shell surface has strong transpiral ribs which make it rough, Columella is without marked callus thickenmg. The shell is dark brown with bands. The she I measured about 6.9 mm in width and 4.0 mm to 5.4 mm in height. The whorls are 6 to 7 in number,

The operculum is elongately ovate with a terminal nucleus and measures about 2.5 mm to 3.0 mm in width and 3.0 to 4.5 mm in diameter. It has teethed margin and closely fits the aperture when the foot is retracted,

Head. Penis, Tentacle (Fig, 2 A-B)

The head is light red; the tentacles are moderately long with dot like eyes near the base. The probosis protrudes from below the tentacles at the tip of which the mouth is present. The penis which is tugged in the mantle skirt below the right cephalic tentacle is laterally compressed and light yellow in colour throughout, with a wedge-shaped swollen end which bears the penial opening.

Pallial complex

i. Male (Fig 2. C)

The pallial complex contains the penis and anus on the extreme right side. The rectum parallels the pallial region of the male genital duct and opens through anus at the region where the base of the penis joins the head.

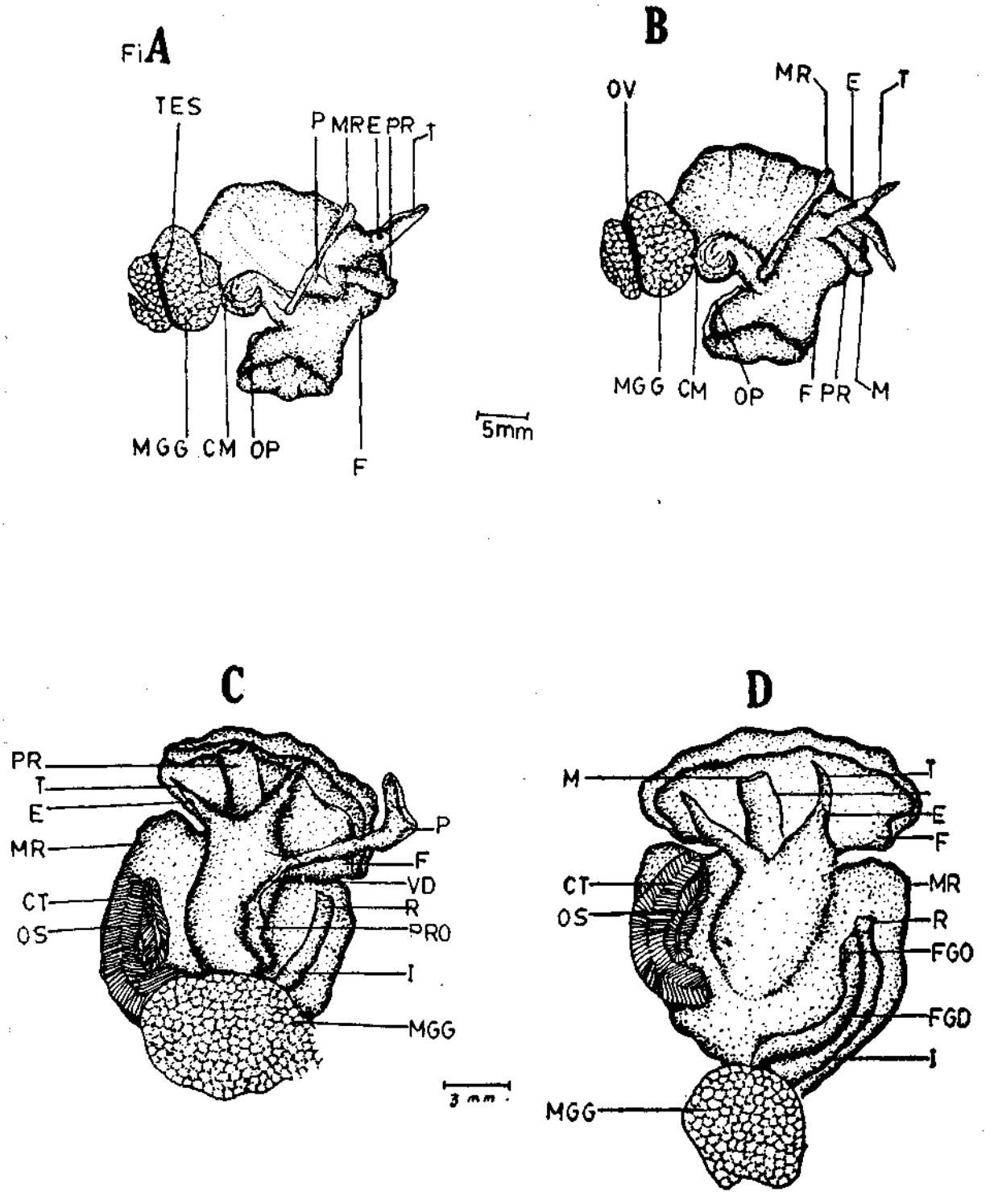


Fig 2. A: Male removed from the shell; B: Female removedfrom the shell; C: Pallial complex (Male); D: Palial complex (Female).

Description of figures (common figs. 2, 3 & 4)

A - Anus; AA - Anterior Aorta; AG • Albumen Gland; AO - Anterior Oesopliagus; BC — Buna Copulatrix: C -Capcum; CCM - Cerebral Comnissure; CG - Capsule Gland; CM - Columellar Muscle; CT - Ctenldium; E - Eyes; F • Foot{ FGO - Femsia Genital Ouct; FGO • Female Genital Opening; GL - Gland of Leiblein; GS - Gastric Shield I • Intestine; IG - Intestinal Groove; LAT • Lateral Tooth; M - Mouth; MAT - Major Typhlosaol; MGG - Mid Gut Gland; MIT • Minor Typhlosole; MO - Mid Oesophagus; MR - Mantle Roof; OD - Oviduct; OEO - Oesophageal opening; OP - Operculum; OS • Osphradium; OV - Ovary; P •-Penis; PO - Pedal Ganglion; PEO - Penial Duct; PO - Posterior Oesophagus; PR-Probosis; PRO-Prostats; R-Rectum; SV-Seminal Vesicle; T - Tentacle; TES • Testis; VD - Vas deferens;

The anterior region of the prostate lies in the pallial region.

ii. *Female* (Fig. 2, D)

The rectum runs next to the pallial oviduct, which lies on the extreme right side of the animal, and opens just below the female genital pore. Because of the presence of reproductive glands like albumen and capsule gland, the pallial oviduct is quite prominent than the rectum and can be seen by the transparency of the mantle when the animal is removed from the shell. The bipectinate osphradium and ctenidium occupy the left of the animal. The siphon becomes confluent with the mantle edge at the base of the osphradium. The kidney and heart lie in the posterior region of the mantle cavity and adjacent to each other.

Animal removed from the shell

Male (Fig 2, A)

The head-foot region which includes the tentacles with eyes on it and the mantle cavity are seen just after the animal is remsved from the shell. The mantle cavity extends from the head to the point where the visceral mass begins. The visceral mass Includes the posterior oesophagus, stomach, mid gut gland and testis The foot is pigmented with black spots. A pair of posterior tentacles are present at the posterior end of the foot which is clearly visible when the animal is crawling. The foot, when fully extended, may reach upto two third of the body length. The mantle skirt is thin, transparent and unpigmented throughout. Most of the organs housed within the mantle cavity can be recognised owing to its transparency. A large laterally compressed penis can be seen tugged into the mantle skirt.

Female (Fig 2 B)

The female shows a great degree of similarity to males in head-foot region except for the penis. In females, columellar muscle which occupies the ventral portion of the animal is white and wedge-shaped. At the posterior region where the oviduct enters into the pallial complex, albumen gland can be seen with the receptaculum seminis next to it- Near the anterior end of the pallial oviduct the capsule gland and bursa copulatrix are present. Running parelled with all these structures is the rectum **which opens outside by the anus.**

The viscera! mass is constituted largely by midgut glands. The midgut gland is dark green in colour and encircles the stomach except for a small portion on the ventral side. The inner-side of the apical whorl is occupied by the ovary which is orange in colour,

Anatomy

Digestive system {Fig 3 A)

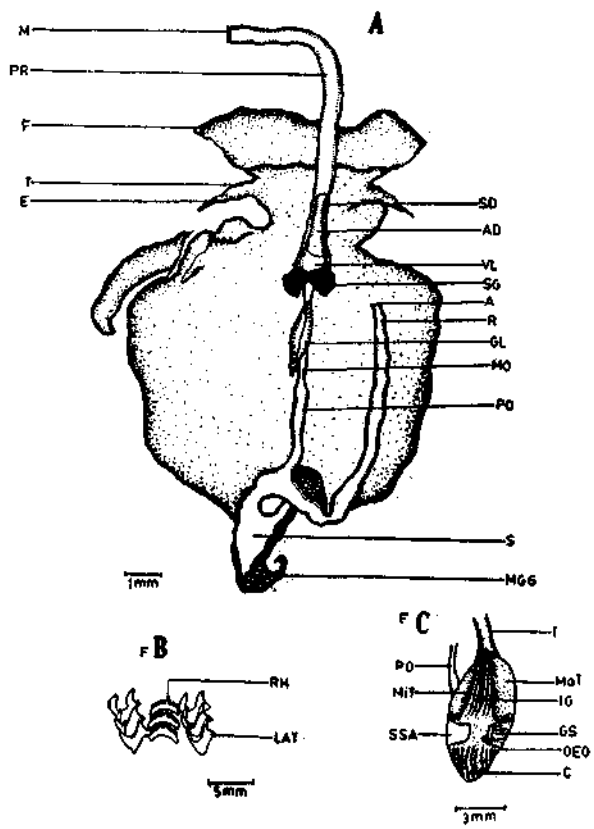
• *Pr H '*

'• ^^0'^°^'^

The protrusible probosis which forms the anterior buccal region is pleurembolie type gnd it enables the animal to feed on food materials at some distance The mouth is at the tip of the probosis, inside which lies the radula.

//. Radula (Fig 3, B)

The radula is located in the radular sac which lies ventral to the anterior oesophagus. It contains about 71-83 transverse rows of ^^^^^ and measures 3.5 mm in length and 0.31 ^^ •^^ ^idth. The radula shows the typical



p.^g ^. Di,^,,,^^ .howing the digestive system; g. ^he tr.nsver., row of r.dui.r teeth;

C: Cutopened view of the atomach.

rachiglossan pattern with one central and two marginal teeth. The central tooth contains 12 cusps.

///. Salivary glands

A pair of horse-shoe shaped, white coloured salivary glands are present on the dorsal side of the midoesophagus closely intermingling with each other. The ducts of the salivary glands passes anteriorly lateral to the anterior-oesophagus and opens into the mouth at the tip of the probosis

iv. Gland of L eiblein

The gland of Leiblein is brown in colour and measures 2 5 to 3.0 mm in length. It is a single, elongate organ which tapers to a point with undulated margin, which may be due to the lobrilar nature of the gland. The gland of Leiblein is close to the dorsal side of the oesophagus and ends halfway of the mid-eosophagus.

\^. Valve of Leiblein

The value of Leiblein is a cone shaped structure which marks the beginning of the mid-oesophagus. It measures about 1.2 to 1.5 mm length. It preventsthe reverse passage of the food into the anterior-oesophagus (Graham 1941) .

vi. Oesophagus

The oesophagus can be divided into anterior, mid and posterior oesophagus. The anterior, oesophagus is included in the probosis. At the lateral sides of the anterior oesophagus runs the salivary duct which opens into it near the mouth at the tip of the probosis. The beginning to the mid oesophagus is marked by the presence of valve of Leiblein where the gland of Leiblein opens. Then the oesophagus continues as the posterior oesophagus before enters into the stomach midventrally.

vii. Stomach (Fig 3, C)

The stomach Is a 'V shaped tubular sac with oesophagus and intestive [occupying the respective side of the 'V. The stomach has the greatest diameter in the middle and measures about 2.5 to 3.0 mm with its ends tapering to a point. The stomach is enveloped by the mid-gut gland except on the ventral side.

The stomach can be divided into anterior stomach which contains major and minor typhlogoles with intestinal groove between them and posterior stomach which contains no crystalline style but Brown (1959) reported the occurrence of one in *Nassarius obsoletus.* The midgut gland opens into the stomach by two groups of openings on the ventral floor. The posterior stomach is occupied by the cerecum.

viii. Intestine and Rectum

After leaving the stomach the intestine passes forward, slightly curved to the right side near the kidney and passes along the pallial wall It is wide at the beginning but reduces in diameter as it approaches the rectum. The rectum opens on the right side of the mantle roof.

Reproductive system

In *N. stolata* sexes are seperate. Males can be readily distinguished by the presence of the long penis. In both male and female the genital system starts with the gonadial tissue in the apical whorls of the animal and ends by their opening in the mantle roof. The male genital system is comparatively simpler than the female system.

/'. Male (Fig. 4, A)

The yellow coloured testis spreads over the mid gut gland in the ultimate and penultimate whorls. It is made up of numerous follicles and small ductules which join to form the genital ducts.

Immediately after leaving the testis on the posterior side, the vas deferens is thrown into numerous convolutions which form the seminal vesicle. The seminal vesicle, which ends just before the mantle cavity starts, is followed by a closed duct, yellow in colour

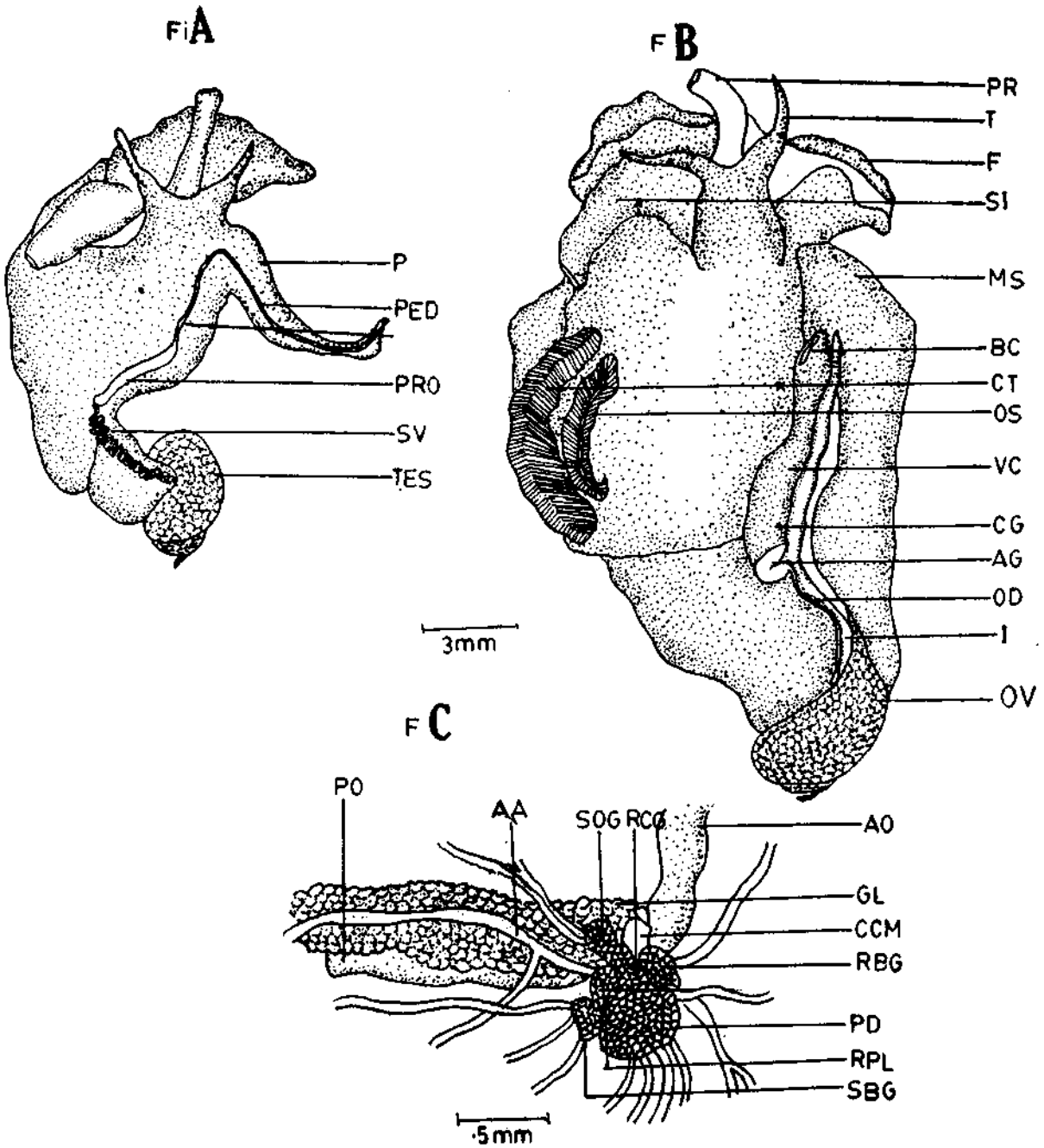


Fig 4, A: Dissection showing the male reproductive system
B. The female reproductive system
C: Dissection showing the nervous system.

with black streaks on the edge named as the prostate. It runs parallel to the rectum on the right side of the mantle cavity. The prostate is followed by the anterior vas deferens which terminates near the base of the penis. The penis IS a dorso-ventrally flattened structure below the right cephalic tentacle. The penial groove runs in the centre of the penis to the tip where it opens outside.

//. Female (Fig 4, B)

The light yellow coloured ovary les on the last two apical whorls. The oviduct emerges from the ovary, runs on the columellar aspect and joins with the albumen gignd by a small curve. The creamy white, inverted 'V shaped albumen gland constitutes the first part of the pallial oviduct. It opens into the ventral channel of the capsule gland.

The seminal receptacle is present between the capsule and albumen glands and opens at the junction on the dorsal side. The ducts of the ingesting gland usually act as a seminal receptacle storing the orientated spermatozoa (Ponder 1973).

The white coloured capsule gland occupies the greater part of the pallial oviduct. The ventral channel from the ventral side of it leads upto the junction where the ingesting gland opens into the albumen gland. The terminal part of the capsule gland ends as the vestibule and vagina. The ventral channel has two ciliated folds running over them. Ventral to the capsule gland and vestibule is the bursa copulatrix.

Nervous system (Fig 4, C)

The nervous system of *N. stolata* is of a "Concentrated" type with the ganglia around the anterior oesophagus forming a circum - oesophageal ganglionic ring. The ring is constituted by a pair of buccal ganglia, a pair of cerebal ganglia which are dorsal in position, a pair of pleural ganglia which are lateral in position and a sub and supra oesophagel and a large pedal ganglion. The nerves from these ganglia innervate various body parts.

Sex ratio

The male to female ratio in different months of the year (December 1982 to November 1983) is given in Table 1. It is clear from the results of the chi-square test that males dominate in all the months except November and July 1983 during which the females are dominant. The preponderance of males over females is well pronounced in March and May 1983 but the ratio is almost equal in December 1982 and February 1983. Despite few fluctuations the sex ratio was comparable in different months of the study period. The sex ratio of males and females were pooled to know their distribution among different length groups and the results are presented in Table 2. The dominancy of males over females is generally well pronounced in the larger size groups whereas in smaller size groups the females are dominant. The sex ratio calculated for the period of 3 years from 1982 to 1984 is enumerated in Table 3. In ail the

TABLE 1. *Sex ratio in* Nassa stolata *during different montfis (1982).*

Month*	Males	Famales	Ratio of males to females valua	Chi square valua	D.F.
Dec 1982	58	57	1.02:1	0.005	1
Jan	61	36	1.69:1	6.44	1
Feb	57	54	1.06:1	0.08	1
Mar	69	38	1.82:1	8.98	1
Apr	66	46	1.43:1	3.571	1
May	67	40	1.68:1	6.813	1
Jun	60	45	1.33:1	2.1428	1
Jul	53	57	0.93:1	0.1455	1
Aug	56	49	1.14:1	0.47	1
Sep	42	35	1.20:1	0.64	1
Oct	44	35	1.26:1	1.031	1
Nov	39	44	0.89:1	0.30	1

TABLE 2. *Sex ratio in* Nassa stolata *at different lengtti groups.*

Length groups	Males	Females	Ratio of male to female
7.6-8,0	3	5	0.60
8.1-8.5	6	5	1.20
8.6-9.0	7	8	0.88
9.1-9.5	10	8	1.25
9.6-10.0	8	11	0.73
10.1-10.5	6	3	2.00
10.6-11.0	2	3	0.67
11.1-11.5	1	4	0.26
11.6-12.0	5	5	1.00
12.1-12.5	6	2	3.00
12.6-13.0	28	21	1.33
13.1-13.5	44	36	1.22
13.6-14.0	95	76	1.25
14.1-14.5	106	58	1.83
14.6-15 0	146	125	1.17
15.1-15.5	87	76	**1.14**
15.6-16.0	89	64	1.39
16.1-18.5	18	16	1.13
16.6-17.0	9	4	2.25
17.1-17.5	2	1	2.00

TABLE 3. *Sex ratio in* Nassa stolata

Year	Males	Females	Ratio of males to females	Chi-square value
1983	614	479	1.28:1.0	16.67
1984	367	301	1.22:1.0	6.52
1985	269	204	1.32:1.0	893

Significant at 0.1% level.

three years the male : female ratio was not 1:1 as hypothesized but the males are dominant in all the three years.

The monthly gonadial smear observations shows that the first indication of sex cells appear in males at the size of 12.1 mm and in females at 12 5 mm. The sex cells are incipient below 10 mm in both the sexes examined. Scheltema (1964), in his study on *N. obsoletus,* found that the animals attained sexual maturity at 12.0 to 14.0 mm length. Which is higher than the values found in the present study.

DISCUSSION

The shell in most neogastropods is large, usually fuseform, rather heavy and has a long anterior siphonal canal and the animal can be withdrawn into it completely. The presence ofcolumellar plaits provide additional surface for the attachment of columellar muscle in Turbinellidae and in some Faciolariidae are absent in *N. stolata.* The shell of female is larger in size than that of males which clearly indicate their sexual dimorphism which is the case in *Buccinum undatum* also (Hallers-Tjabbers 1977). The shallow lines which are present in the upper whorl near the body whorl of some *Nassa* spp are absent in *N. stolata.*

The head region conforms in most of the details with other neogastropods. The eyes are directly situated on the tentacles unlike *Alcithoe* spp which contain eyes on a short papillae (Ponder 1970). The penal duct like all neogastropods is sealed although open condition occurs in a few form like *Tudicula* (Abbott 1959).

In the families (Mitridae, Vexillidae, Marginellidae) that are modified far burrowing, the mantle cavity is placed for back on the right side (Ponder 1973). This type of arrangement is lacking in *N. stolata* which inhabit soft substrata. Some nitriform neogastropods like *Strigetella panpercula* have a large brown osphradium and a slightly longer ctenidium (Ponder 1972).

The digestive system of *N. stolata* is well suited for its food habits. This animal which mostly feeds on dead animals has a long pleurembolic probosis which enables it to reach the food at some distance. The radula shows lesser number of teeth which is well suited for tearing and rasping (Ponder 1973). The value of Leiblein which is the characteristic feature of neogastropods performs the important function of preventing food from returning to anterior oesophagus (Graham 1941).

The stomach of *N. stolata* is best modified according to its food habit. The two major regions of the stomach with its major and minor typhlosoles digest the flesh of dead organisms and the indigestible particles are being sorted out. Though the crystalline style was found to be absent in *N. stolata,* Brown (1959) reported the occurrence of one in/V. *obsoletus.* In general organisation of the reproductive system *N. stolata* follows the neogastropod pattern described by Pretter (1941). The prostate gland of this species is of closed type. Some primitive neogastropods like *Alcithoe arabica* contain open prostate glands as reported by Ponder (1970).

As the neogastropods evolved, the pallial groove became fused into a duct along its entire length (Pretter 1946). Wu (1973) has noted the existence of 3 types of prostate glands in Muricidae. Among the neogastropods, *Colus stimsoni* alone has a prostate which enters the body and coils among the lobes of salivary gland (West 1978). The penis of muricids and

buccinids are wide, blunt and considerably flattened dorsoventrally and the penis of nassarids, columbeilis and turrids are wide, tapering to a point and flattened or tubular, in addition to serve as an intramittant organ, penis also helps to hold the partner during copulation. The anterior vas deferens which is coiled in *Nassarius incrassatus* (Houston 1976) is almost straight <n this species.

The female reproductive system of *N. stolata* agrees well with the description given by Fretter (1941) for *N. reticulatus.* Johansson (1957) in his account on the reproductive system of *N. incrassatus* reported the occurrence of both seminal receptacle and ingesting gland which was later disputed by Honston (1976). But both these structures are found in *N. stolata* Houston (1976) observed in *Neptunea antigua* the division of the seminal receptacles into two sacs on each side of the ventral channel. But in the present study no such division in seminal receptacle could be established. Like all neogastropods the capsule gland occupies the largest part of the pallial oviduct.

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24. AGE AND GROWTH IN *TELESCOPIUM TELESCOPIUM* L

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ABSTRACT

In length frequincy analysis, model were traced for • pe'iod of two years and the growth was found to be 55 and 95 mm for I and 11 years respectively. Growth determined by months mode curve indicated that *T. telescopium* can grow upto 62, 85 and 110 mm in the I, II and III year respectively Growth assessed by probability plot was found to be upto 23,57.5, 91 and 108 mm in the 0, I II and III year respectively. Integrated method showed growth rates of 60, 92 and 111.6 mm respectively in the I, II and III year of life. Employing von Bertalanffy's growth equation It was found that it can grow upto 57.5, 91 and 108 mm respectively in the I, II and III year of life. The empirical length at different ages found by von B^rtalanffy's growth equation showed general agreement with the growth estimates *i others.

INTRODUCTION

The results of age and growth studies go a long way in proper management of fisheries constituted by commercially important organisms. In Porto Novo, *Telescopium telescopium* is used for making lime. No information is available on the age and growth of this organism. Hence the present study.

MATERIAL AND METHODS

Specimens were sampled for a period of one year from January to December, 81 in the Vellar estuary (lat. 110 29 N; long. 790 46'E). Length of the shell was measured with a vernier caliper nearest to 0.1 mm. Shells with wornout upper whorls and broken lips were discarded. As no sexual dimorphism could be discerned externally, no effort was made to study the age and growth sexwise. Age evaluation was done by length frequency analysis (Petersen. 1891), months mode curve (Devaraj, 1977; Sriraman, 1978) and probability technique (Harding, 1949; Cassie, 1954, and growth evaluation by integrated method (Pauly, 1983), von Bertalanffy's growth equation (Von Bertalanffy, 1938) and Ford-Walford graph (Ford, 1933; Walford, 1946). For studying the length-weight relationship, the live total weight of the snail was determined after cleaning the shells of adhering encrustations and sediment particles. The weight was taken nearest to 0.1 mg using an electrical balance. Hare also as the sex could not be made out externally, no effort was made to study the length-weight relationship sexwise,

RESULTS

Age evaluation

^^"9*^ frequency distribution for the period January to Decembej, 1981 is shown in the form of histograms (Fig.1). Probably due to the extensive breeding habit of this animal, modes appeared every month. Among them the egrliest mode in the length group of 6-10 mm in November (a) was traced to 61-65 mm group again in November recording a growth of 55 mm in 12 months time. Thus it grows to 55mm in 1 year. The mode m the

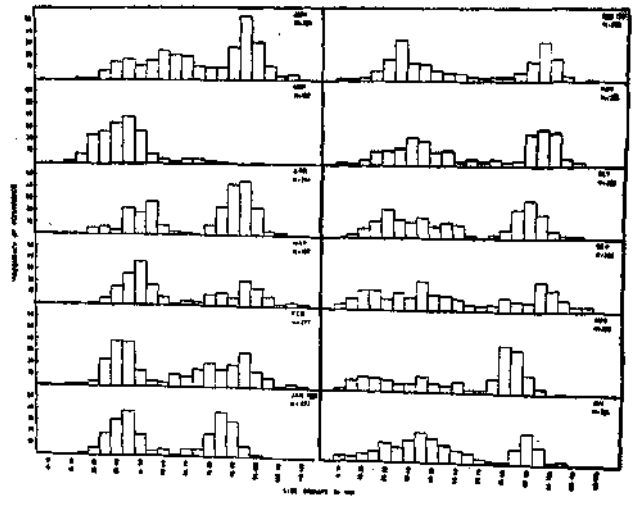

Fig. 1 Length frequency histogram of *Telescopium telescopium*

length group 51-55 mm in November (b) was traced to 91-95 mm group again in November showing a growth of 40 mm during the second year. So by the end of second year it grows to 95 mm size. Further modes could not be .

The progression of modes through sucessive months along series of trend lines, representing the rate of growth of various broods is summarised in Fig. 2 and 3. Mean growth based on the value of various broods and the missing values found from the fitted line can be read from the figure. As per the findings of this method, the size attained was 52, 85 and 110 mm in the pi^^

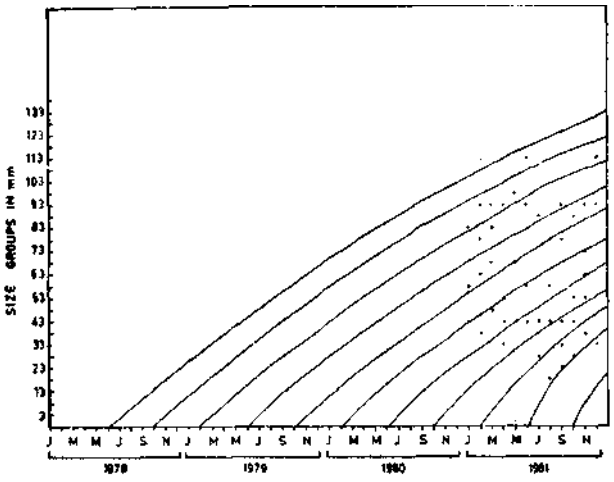

Fig. 2 Scatter diagram of months mode fof *Telescopium telescopium*

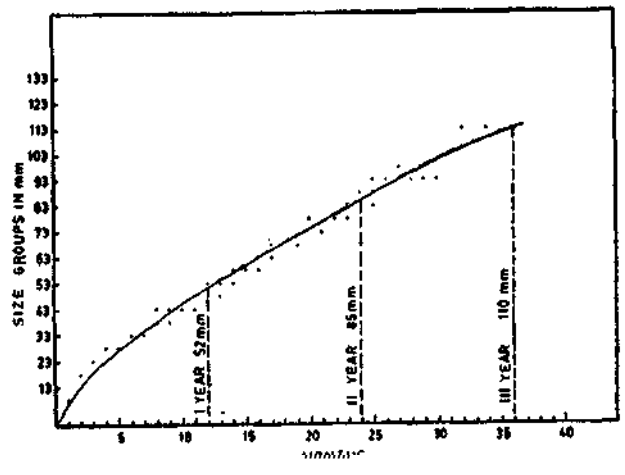

fig. 3 *Gro'*,\.h oi Telescopium telescopium* based on icatter diaoram of months mode

I, II and III year respectively, The time involved between sucessive brood origins could also be derived. It can be seen that there were 3 broods in a year.

In the probabilityplot, the curve showed points of inflexion at 20, 70 and 99 (Fig, 4). 't was found that the I modal value representing the'o'year class was 23 mm. The II, III and '^ "^odes at 57,5, 91 and 108 mm represented ^he I, II and III year age groups recpectively.

Growth evaluation

In integrated method (Fig. 5), the curve in figure interconnect most of the peaks and thus was helpful to estimate the growth parameters of this species. It showed a growth of 60, 92 and 111.5 mm respectively in the I, II and III year of life.

Making use of von Bertalanffy's formula the growth equation was calculated and presented below:

$$Lt = 125.5190\ (1\text{-}e\text{-}o.6783\ (t\text{-}0.0967)$$

The theoretical growth curve is presented in Fig. 6b. From this growth curve, it can be observed that the I year animals attain 57.5 mm, II year ones 91 mm and III year ones 108 mm Through Ford Walford graph, Leo was determi-. ned as 125 mm (Fig. 6a).

The regression line fitted to the length weight data. (Fig 7) showed a linear relationship between these two variables. It can be seen from the figure that the points are very close to the line and hence can be presumed that there is a close relationship between length and weight. The correlation coefficient value was found to be highly significant (0.978 $P < 0.001$). The regression equation can be expressed as follows:

$$\log W = -0.4150 + 2.6268 \log L$$

DISCUSSION

Determination of age and growth based on a Single method has its own limitation especially

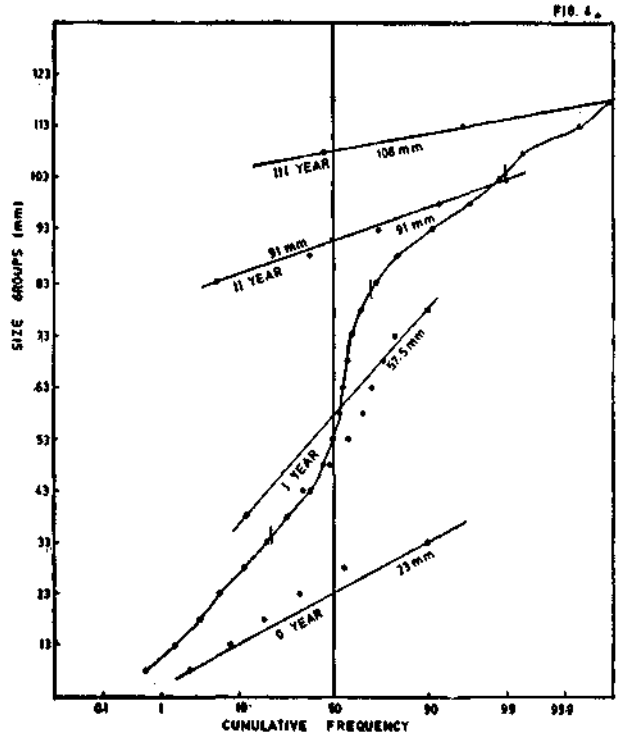

Fig. 4 Probability plot of *Telescopium telescopium*

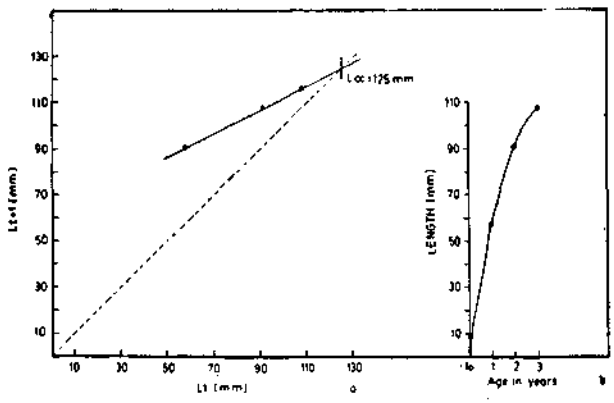

Fig. 6 a. Ford Walford plot of *Telescopium telescopium*; b. Theoretical growth curve

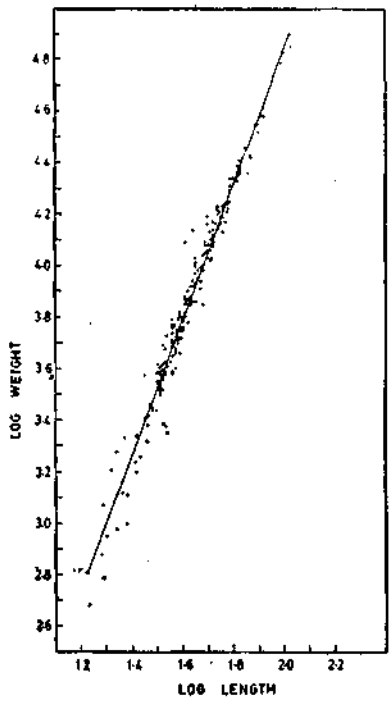

Fig. 7 Length-weight relationship of *Telescopium telescopium*

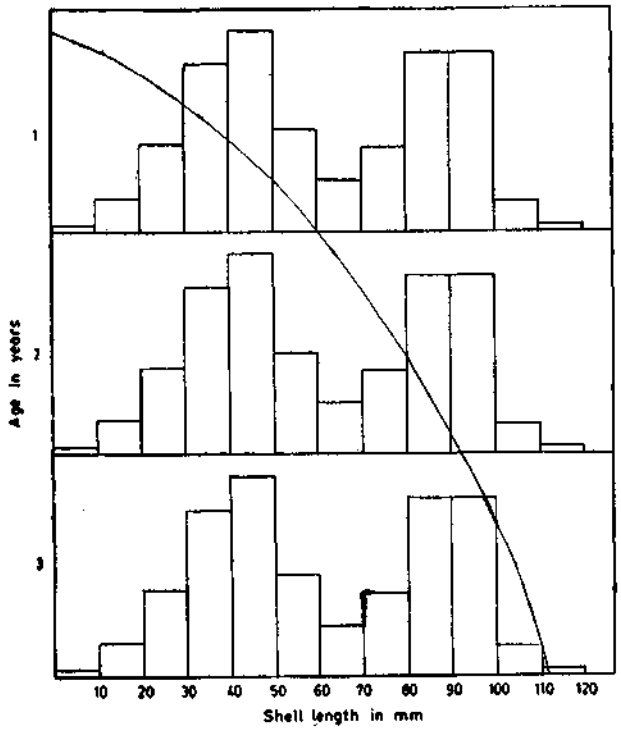

Fig. 5 Integrated method of *Telescopium telescopium*

when the determination of age and growth is through indirect method or through statistical analysis as this. So, presently age and growth data in *T. telscopium* have been analysed in six different ways so that the outcome of one will act as check and control over the other. For easy comparision, the results of age and growth are

presented in label 1. Age and growth estimated showed that the information derived agree more or less The empirical length at different ages made by von Bertalanffys growth equation shows some agreement with the other estimate showing that, in the length ranges studied, the theoretical growth equation adequately describes actual growth. As there is no any sexual dimorphism in *T. telscopium,* age and growth were not studied separately sexwise

TABLE 1. *Mean shell length fin mm) attained* 6y Telescopium telescopium *in different years of life as found out by various methods.*

Method	Years 0	i	n	m
Length frequency	—	55	95	—
Months mode	_	52	85	HO
Probability plot	23	57.5	91	108
Integrated method	-	60	92	111.5
von Bertalanffy's	-	57.5	91	108

Comfort (1957) estimated the longevity for a number of gastropods and found it to range from 1 to 20 years. Generally temperate and polar species live for more years than tropical animals. In tropics few studies have been done on the age and growth of gastropods. Sadasivan (1947) based on his studies suggested that the longevity of *Cerithidea cingulata* a species closely related to *T. telscopium* as around 5J years. Balaparameswara Rao (1976) found the longevity of *Cellana radiata* to be around 5 years. Sreenivasan (1985) studied the age and *grovjth 0^ Cerithidea cingulata,* and found it to live for 4 years. Presently T. *telescopium* is found to live for 3 years. Thus compared to temperate and polar regions where some species live for as many as 20 years, tropical species are ephemeral, in the present study age and growth has been studied in *T. telscopium* through indirect method Direct information regarding rate of growth and variations during different seasons and ages will give a correct picture. Therefore experimental studies in this line involving marking experiments should be done and such studies will add quite a lot of valuable clue to the phenomenon of age and growth in this animal.

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25. FISHERY AND THE POPULATION DYNAMICS OF THE BLOOD CLAM *ANADARA GRANOSA* (LINNAEUS) IN THE KAKINADA BAY

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ABSTRACT

The blood clam, *Anadara gtanosa* is fished throughout the year in the Kaklnada Bay by fishermen residing in 15 villages. During 1978-81. at Yatlmoga Kakinada) the blood clam catch, effort and catch per unit effort varied from 104 to 222 t, 3414 to 6295 man-days and 30.4 to 35.3 kg/man day respectively. The instantaneous rates of total (Z), natural (M) and fishing (F) mortality rates are estimated at 3.9,1.3 and 2 6 respectively- In the presently exploited population, other parameters estiinated are the age at recruitment (tr) = 0.29 yr, age at first capture [to] = 1-0 yr and the maximum age [ta] = 5.62 yr. At present the yield in weight per recruit [Yw/R] is about 9-5 g; It Increases with increase In F and it is less for greater values of tc. It is suggested that at the current level of F, maximum Yw/R value of 10 42 g is possible if tc is reduced to 0.6 yr.

INTRODUCTION

The blood clam is second in importance among a dozen species of molluscs fished in the Kakinada Bay. While a general account on these fisheries is available (Narasimham 1973) there is no information on the population dynamics of this clam. Hence the present work was taken up.

....r-r-m.. ...~ ...-.^..^..n

MATERIAL AND METHODS

Out of 15 landing centres, Yetimoga was selected because of year round fishing at this centre and its proximity to the fishing ground enables the fishermen to return daily to the village with catch. Further, since the fishing ground and the fishing method are the same at all these Centres, the trends at Yetimoga can be taken as representing the catch trends at other centres. During 1978-81 weekly observations were made at this centre On each observation day, the catch of *A. granosa* and the effort expended were recorded. Men. women and children pick the clams by hand. As the clams burrow in the soft muddy substratum they are not visible to the eye and selection is not exercised when catching them. The effort was standardised in terms of man-days which is the average effort put in by a man to catch the molluscs during a single low tide The efficiency factors of a woman and child were estimated at 0.64 and 2.28 respecti- ^^.^ Q^ ^^^ observation day, a random sample ^^ ^^3 ,^g ^^ ^,3^5 ^^^ measured for length to ^^^ ^^^^^^^ ^^ 3^^ ^^,3 g^^pl^ ^^.g^, recorded ^^ ^^^ ^^g^^g, ^ ^^^^^^^ ^^^ ^^^^3, estimates ^^ ^^^^^^ gfj^^t and length frequency were obtained from the data collected on the obser- vatlondays.

The total mortality rate (Z) was estimated by the methods of Beverton and Holt (1955), Jones and van Zaiinge (1981) and Pauly (1983). The natural mortality rate (M) was estimated by the Beverton and Holt (1957) method. The regression coefficient in the length-weight relationship of *A. granosa* in the Kakinada Bay is 2.6212 (Narasimham 1985) and it was found to be significantly different from 3. Hence the yield in weight per recruit was calculated by the Beverton - Holt (1957) model as modified by Jones (1957).

^L._ picucDY

A. granosa is exploited in 46.6 sq. km area in the southern and western sides of the bay where the maximum depth is 1.8 m at low tide.

At Yetimoga, in 1978 a total of 103.9 t of blood clam were landed by expending 3414 man-days which gave an average of 30.4 kg/ man-day. The monthly catches varied from 0.9t in January to 18.0 tin September (Fig 1). Apart from September, another peak in the catches was observed in March. The catch per unit effort (c. p. u. e.) varied from 14.7 kg in January to 40.4 kg in July.

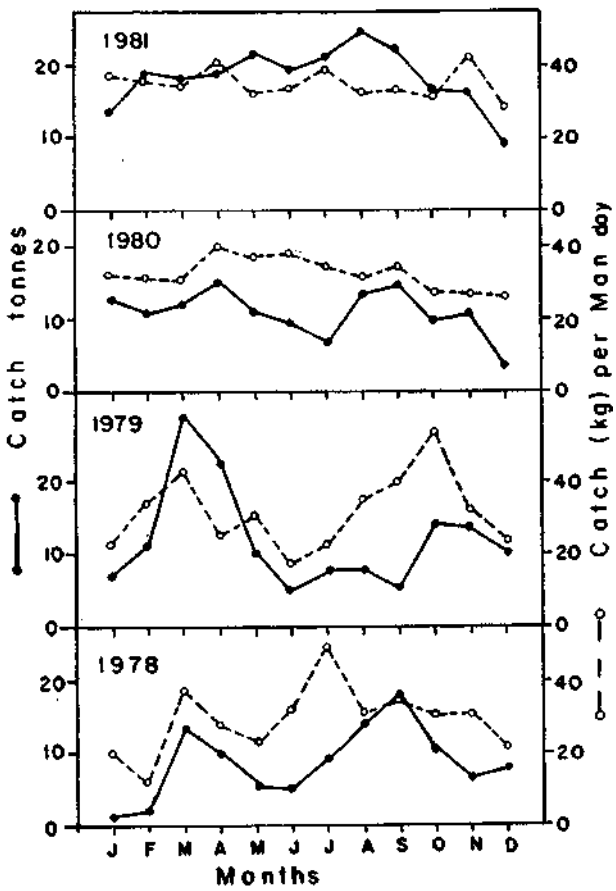

Fig 1. Monthly catches and catch rates of *A. granosa* during l978-81at Yetimoga.

In^^l979 there was an increase in the total catch (144.7 t) and effort (4715 man-days) when compared to the previous year but the c. p. u. e. at 30.7 kg hardly showed any variation. The monthly landings varied from 5.1 tin June to 29 t in March (Fig 1). The catches were considerably high in March-April and October-November. The c. p. u. e. was low at 17 kg in June and reached a maximum of 53.7 kg in October.

Compared to the previous year, in 1980, there was a slight decline both in the total catch (129.6 t) and effort (4C02 man days) while a slightly higher catch rate of 32.4 kg was recorded. The monthly catch (Fig 1) varied from 3.7 t in December to 15.2 t in April, The catches were high in April and again in August-September. The c. p. u. e. ranged from 27.2 kg in December to 39.8 kg in April.

Substantial increases in the catch (221.91), effort (62£5 man-days) and c. p. u. e. (35.3 kg) were observed in 1931. The monthly catches varied from 8.9 t in December to 24.91 in August (Fig 1). The catches were high in all the months except in December and January The c. p. u. e. fluctuated [between 29.3 kg in December and 43.9 kg in November.

The data, pooled for the 4 years, showed heavy catches in IVlarch-April, slight fall in May-July, good catches in August - September and a trough in December - January.

POPULATION DYNAMICS

The length range of the catch during the 4 years was 15.0-71.2 mm (Fig 2).

Growth parameters The parameters of the von Bertalanffy equation for growth in length in *A granosa* from the Kakinada Bay were estimated as Lcc =. 73.4 mm, K =. 0.5816 (on annual basis) and to = -0.4088 year (Narasimham 1985).

Estimation of total mortality (Z) rate

a. *Beverton and Holt method* The length at first capture (Lc) was taken as 41 mm since it was observed that this is the smallest length that is fully represented in the catches during three years (Fig 2), The mean length was calculated as 45.5 mm in 1978, 45.0 mm in 1979,45.4 mm in 1980 and 45.0 mm in 1981. From these values, Z was estimated at 3.60 in 1978, 4.13 in 1979, 3.70 in 1980 and 4.13 in 1981 (Table 1). The average for the 4 years was 3.89.

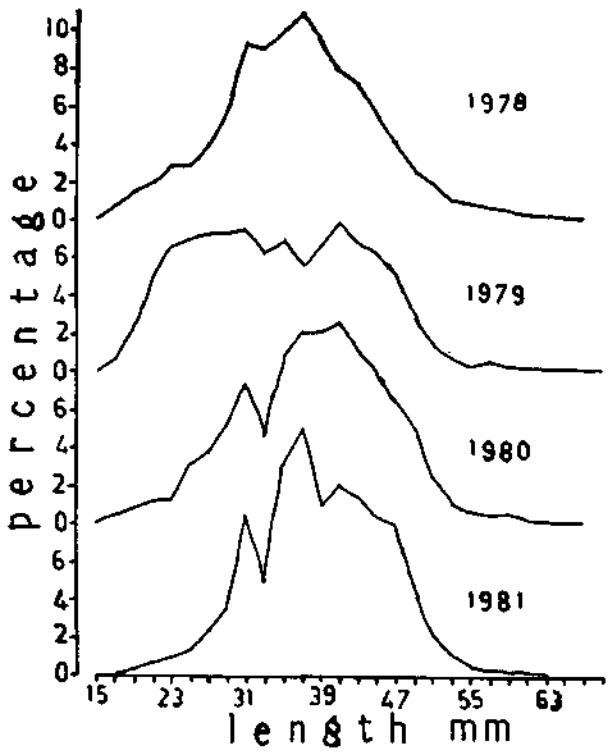

Fig 2. Annual length-frequency distribution of *A granosa* during 1978-81.

TABLE 1. Estimates of Z by different methods in A. granosa.

Year	Beverton and Holt	Jones and van Zalinge	Pauly's	Average
1978	3.60	2.99	2.95	3.18
1979	4.13	3.12	5.60	4.28
1980	3.70	2.96	3.63	3.43
1981	4.13	4.65	5.49	4.76
Average	4.89	3 43	4.42	3.91

b. *Jones and von Zalinge method* In 1978, Z was estimated at 2.99, in 1979 at 3.12, in 1980 at 2.96 and in 1981 at 4.65 (Fig. 3) with an average of 3.43.

c. *Pauly's method* During 1978-81, Z was estimated at 2.95, 5.60, 3.63 and 5.41 respectively (Fig 4) with an average of 4.02.

The Z estimates by different methods (Table 1) show that the results are comparable. The average Z for 1978-81 was estimated at 3.91.

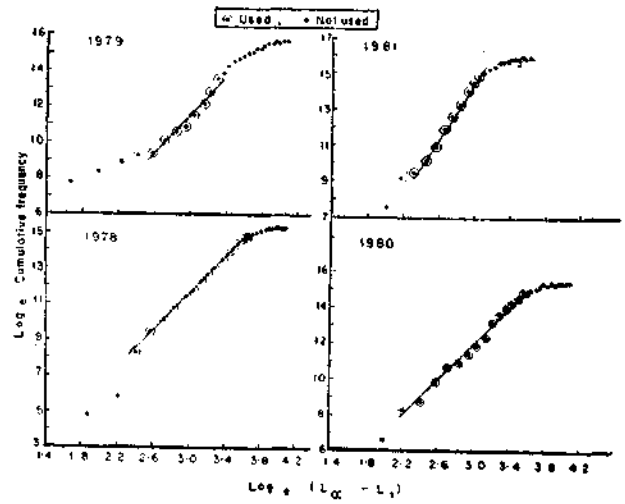

Fig 3. Estimation of Z in *A. granosa* during different years by the method of Jones and von Zalinge.

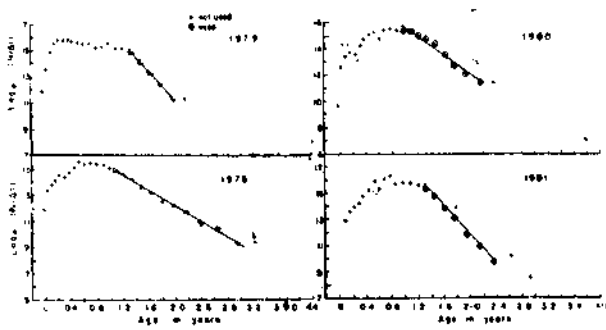

Fig 4. Estimation Z in *A. granosa* during different years by the catch curve method of Pauly.

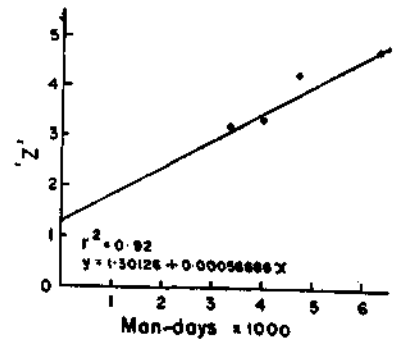

Fig 5. Plot of coefficients of total mortality in different syears against the corresponding effort in *A. granosa*.

Estimation of M andF The regression of the annual average Z (Table 1) against the corresponding effort for the 4 years (Fig 5) is described by the equation

Y^ 1.30126 +0.000566859 X

where Y - Z, X = effort in man-days and M = 1.30126 or 1.3.

Yield per recruit in weight The value of Woo ..,«„ «^»:.v,«*«j *iinc u*r- l j.u was estimated at 119.5 g by taking Leo and the length-weight relationship of the species The smallest length in the catch was 1 5 mm and this was taken as length at recruitment (Lr) whose age (tr)' was estimated as 0.29 yr. The length at first capture was 41 mm and the age at first capture '(to) was estimated as 1 yr. The largest clam in the catch measured 71.2 mm and the maximum age (ta) was estimated as 5.62 years.

The yield in weight per recruit (Yw/R) against F, keeping M constant at 1.3 and considering three values of tc at 0.75, 1.00 and 1.25 years, show (Fig 6 A) t at Yw/R increases with increased F, without showing a fall. It is also observed that Yw/R is less for greater values of tc- Under the current values of F and tc (2.6 and 1.0 year respeciively) the yield per recruit is about 9.5 g and the same is about 10^3 g v.ith the same t. and with F at 5.1^ It IS thus clear that any increase in F (i. e. fishing etfort) would give only marginal increase in the yield which may not be remunerative, though the same does not affect the stock adversely.

Yie d in weight per recruit against toby , . . . ,^ , "^""P'^^ ^ '"^ ^ "°"'^'"* ^' '^^ """'«"» '«^«' ^ ^ ° ^ ' '^^'^ ^ ^^ ^^'^ maximum yield of 10.42 g is obtained vvhen tc is 0.6 yr. Hence reduction of tc from the present one year to 0 6 year would give maximum yield under the current fishing mortality rate,

ni^ri icQinisj

Broom (1983) estimated the average instantaneous rate of total mortality (Z) as 1.88 j„ ^^^ ^aj^^^^, ^^^ two artificially seeded populations of *A. granosa* in Malaysia. The two components of this mortality were not estimated ^y him. This value is considerably lower than j^^^ ^glue of 3.9 obtained in this study.

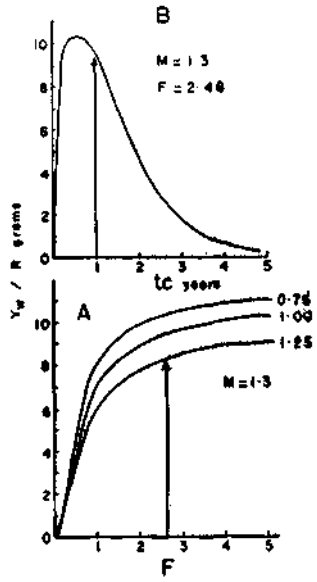

Fig 6. Yield per recruit (Y„/R) of *A. granosa.* **A. As a function of Fishing mortality rate (F;. Numerals** are the values of age in years at first capture. Vertical line represents the current F. B. As a function of age **at first capture. Vertical line** repiesents the current tc.

It was shown that at present the age at first capture is one year (Lc = 41 mm) and a reduction to 06 yr (Lc = 32.6 mm) would give maximum yield per recruit. The length at first maturity in/4. firz-anosa is 20 mm in males and 24 mm in females (Narasimham 1985). Therefore reduction of tc from one year to 0.6 yr would ensure that the clams would spawn at least once before they are fully recruited to the fishery and hence there will not be any problem of recruitment overfishing at some higher level of etfort.

The total stock of *A. granosa* in the clam bed in the Kakinada Bay during March-April 1983 was estimated at about 6000 t (Narasimham *et. at.* 1984) and the actual landings at 2000/ year (Silas *et. al.* 1982). This suggests that there is considerable scope to step up production collecting the clams by hand (which [jp^j^g ^^e catching efficiency) and the low market demand for the clam meat insulate against over fishing. However, any change in the pattern of fishing such as the introduction ^f *dtedge* or Other mechanical gear is likely to affect the stock adversely.

ACKNOWLEDGEMENTS

I am thanl<ful to Dr. E. G. Silas, form»r Director, for encouragement and to Dr. K. Alagaraja. Scientist S-3 and Head of Fishery Resources Assessment Division, CMFRI for suggesting improvements in an earlier draft of the paper.

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26. BIOLOGY OF THE BLOOD CLAM, *ANADARA RHOMBEA* (BORN) IN KAKINADA BAY

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ABSTRACT

A. rhombaa **occurs in small qusntities in the Kakinada Bay and is incidentally collected while fishing foi the moie abundant *A. granosa*- Males attain maturity at 22 mm and females at 24 mm length. It spawns during December-April (rarely in May) and major spawning Is indicated in Januaiy-March. A single or two reproductive cycles occur during the spawning period. Increase in the ambient water temperature and salinity seem to induce spawning The proportion of males and females during dif'etent months, years and also in different length gioups generally conforms to 1:1 ratio. The average monthly condition index (CI) expressed as percentage of wet flesh weight in total weight, vsries from 9 6 to 15 7. The CI does not vary in relation to length. It is high before or at the beginning of spawning and low when majority of the clams hive released bulk of the gametes. In the post-spawning period the CI Is again high, probably due to the accumulation of body reserves. The estimatad values of the parameters of the yon Beitalanffy growth equation ate Lco'=90.2mm, K = 04573 per year and t" = "0 6315 yr. *A. rhombea axxa'ms* 47.4,63.1 and 73.1mm on completion of 1, 2 and 3 years respeotivaly. Various morpho netric and length-weight relationships are studied-**

INTRODUCTION

The blood clam, >^ r/}0/w6ea occurs in stray numbers in the Kakinada Bay and is caught incidentally while fishing for 4. flrra/josa. Except for a study on maturity, spawning and sex ratio from Porto Novo backwaters by Natarajan and John (1983,) there appears to be no other published information on the biology of *A. rhombea.*

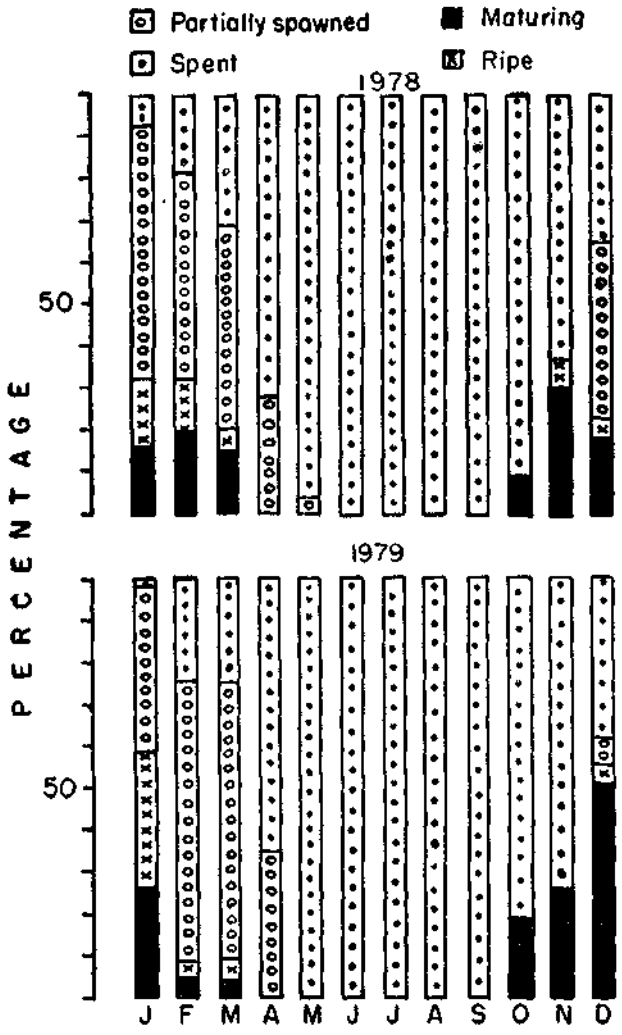
MATERIAL AND METHODS

Fortnightly samples of about 25 clams were collected during 1978-81 from the fishermen catches and supplemented by grab collections. Spawning and sex ratio were studied by examining the gonad smear in 1944 clams and gonad sections of 360 clams of the length range 33-89 mm. Standard histological techniques were followed to cut 7-10 mm thick gonad sections and stained with Delafield's haematoxylin and eosin. Ropes (1968) was followed in the categorisation of the maturity stages except that his -early active- and 'late active- phases were clubbed under the maturing stage. Length at first maturity was studied by examining the gonad sections of 84 clams measuring 13.5-28.8 mm and collected in March 1979 when there was a peak spawning. The test of variance of homogeneity (Snedecor and Cochran 1967) was applied to test the significance of differences in the proportion of males in the monthly samples. It was next ascertained by the Chi-square test whether the observed monthly sex ratio differed from the theoretical 1:1 ratio. This test was not applied if the number of specimens was below nine. The condition index was calculated as percentage of wet flesh weight in total weight. The condition in relation to length was studied in 75 clams measuring 41-80 mm and collected ,-. * u,. in-jn u .u,. during October 1979 when there was no spawn- '"9-, Age and growth was studied by growing 56 clams of length range 9.0-82,5 mm for one *V^^'* "" dealwood boxes measuring 50 cm x 50 cm x 15 cm and divided into 9 compartments, ^^^^ compartment was filled with sediment obtained from the clam bed, a measured clam ^as introduced in it and the box was placed in the clam bed. Further details were given by Narasimham (1983). The values of Leo and to in the von Bertallanffy growth equation were estimated by the Manzer and Taylor (1947) P'ot The relationship between length and other body measurements was studied by fitting the regression equation of the type Y= a-I-bX; where required logarithmic transformation was

applied. The dry meat weight of the clam was recorded after keeping the flesh in hot air oven for 48 h at 80°c±1. All linear measurements were taken to the nearest 0.1 mm with a vernier calipers and weight data recorded to the nearest mg in electric balance.

SPAWNING

January-September 1978 During January-March maturing (Pl. la, Pl. 2 a) and ripe (Pl. 1 b and c, Pl. 2 b and c) clams formed 14.8-19.4%o and 5.6-16.0% respectively (Fig. 1). The number of partially spawned clams (Pl. Id, Pl. 2d) was high at 60% in January followed by February-March (about 48%) indicating major spawning in these months. In April the partially spawned clams formed 27.3% and they released bulk of the gametes; in May their number was reduced to 4.2% indicating the completion of the reproductive cycle. The spent clams (Pl. 1e, Pl. 2 e) increased progressively from 8% in January to 95.8% in May and all were spent in June-September.



Flo 1. Monthly percentages of different «,aturity .t.ge. in A. rftomdea during 1978-79.

October 1978-September 1919 Maturation was initiated in October and during November-January maturing clams formed 17.5 to 33.9% (Fig.l). There was spawning during December-April when 34.5-67.3% of the clams showed partially spawned gonads. There was major spawning in January-March. The gametes were mostly released by March-April. The spent clams increased from 1.9%o in January to 65.5% towards the close of the reproductive cycle in April and in the following five months all were in spent stage.

October 1979-September 1980 Maturing clams increased from 18% in October to 81.6% in January (Fig 1 and 2) and in the following three months they formed 10-20.4%. The distribution of partially spawned clams shows that spawning was initiated in December and it continued till April with peak activity during February- March. Spent clams were absent in January and their number gradually increased to 58.3% by April; in May-September all were in spent state.

October 1980-October 1981 Maturing clams first appeared in October 1980 andtheirnumber increased to 70% by December and declined to 6.4% in January (Fig 2). Spawning commenced in December, touched peak in January when 68.1% of the clams were in partially spawned stage. The spent clams showed a reduction from 68% in October to 4% in December and a slight increase to 19.1% in January.

The sharp increase of maturing clams from 4% in January to 59.2%, in February (Fig 2) indicates the commencement of another reproductive cycle within the spawning period. The maturing clams declined to 16.7% in March and were absent in April. There was spawning In February-April and the follicles were almost **«'"P*y «* the close of April. All the clams were** in spent stage during May-October 1981.

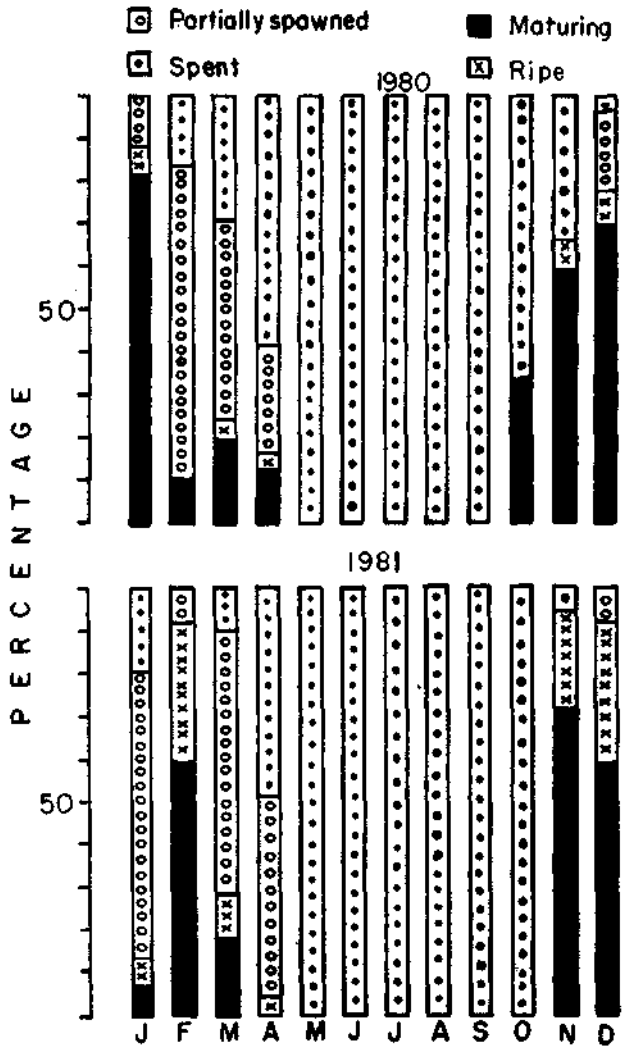


Fig 2. Monthly percentages of different maturity stages *A. rhombea* during 1980-81.

November - December 1981 Majority of the clams had maturing gonads in these two months (Fig 2) and spawning commenced in December.

LENGTH AT FIRST MATURITY

The gonad was not developed in 14 and 16 mm length groups (Table 1). In the next group, 7 clams were in indeterminate stage and three were maturing males. In the 22 mm group majority (62.5%) were mature males and in 28 mm group all the males were mature. Partially spawned and spent males were first observed in 24 and 28 mm length groups respectively. In males the length at first maturity was taken as 22 mm.

TABLE 1. *Percentages of different maturity stages in length groups in A rhombea.*

Length mm	Sex	N	Maturing	Ripe	Partially spawned	Spent/resting
14	Indt	6	—	—	—	—
16	Indt	8	—	—	—	—
18	Indt	7	—	—	—	—
	Male	3	100.0	—	—	—
	Female	—	—	—	—	—
20	Indt	4	—	—	—	—
	Male	8	100.0	—	—	—
	Female	—	—	—	—	—
22	Male	8	37.5	62.5	—	—
	Female	2	100.0	—	—	—
24	Male	6	16.7	66.7	16.7	—
	Female	2	50.0	50.0	—	—
26	Male	9	11.1	33.3	55.6	—
	Female	5	20.0	40.0	40 0	—
28	Male	10	—	30.0	50.0	20.0
	Female	6	16.7	33.3	33.5	16.7

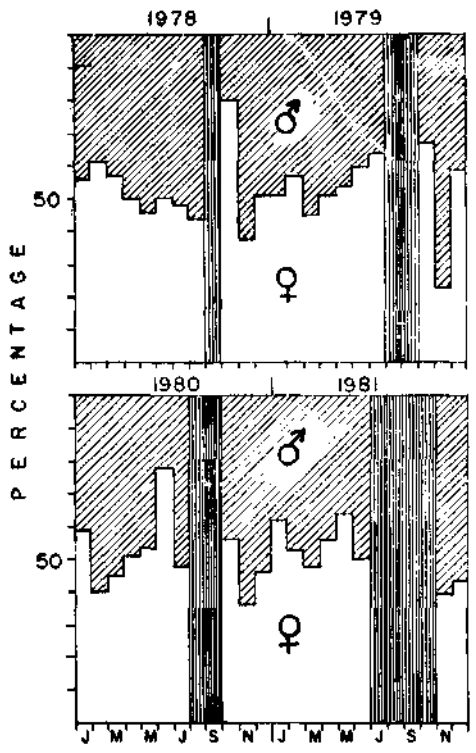
Indt = Indeterminates.

Females were first observed in the 22 mm length group (Table 1) and in the next length group 50% of them were mature. Partially spawned and spent stages occurred for the first time in 26 and 28 mm length groups respectively. Thus females attained first maturity at 24 mm length, at a slightly larger size than males.

SEX RATIO

During April-December of different years the sex of some or all the spent adult clams examined could not be determined as they passed into indeterminate (resting) phase. In September 1978, August-September of 1979 and 1980 and July-October 1981 all the clams were indeterminates (Fig 3).

Females outnumbered males in most of the months f'Fig 3). The test of heterogeneity for variance showed that at 5% probability the Chi-square values during different years are



Flo 3. Monthly peroentagw of malM and ftmiLs during different years in >t. r/iom/)sa. (Long vertical line* show the months when all the clamS examined could not be sexed).

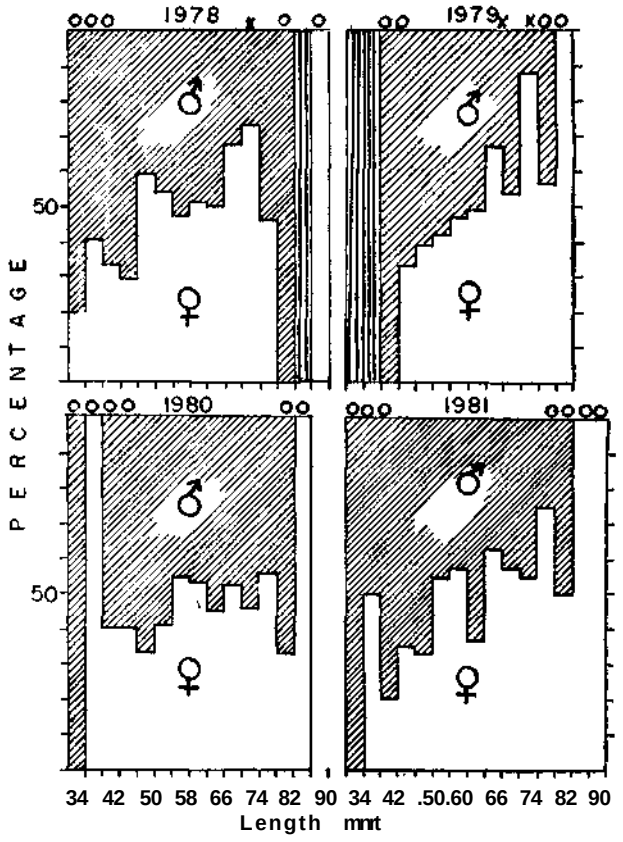


Fig *A.* Sex ratio in different length gioups during 1978-81 in A. fhombea [Vertical lines indicate absence of date, circles mdicate that Chi-square ,est not conducted due to small sample size. **Crosss indicate Chi-squire value significant at** ^/^ probability.]

. .,. ,» , , „v -r. *r^,* • ^ . **not Significant (Table 2). The Chl-square test** on the monthly sex ratio (October 1978 test **not conducted) revealed that only in June 1980** the ratio differed significantly at 5% from the theoretical 1 : 1 ratio during the four year study

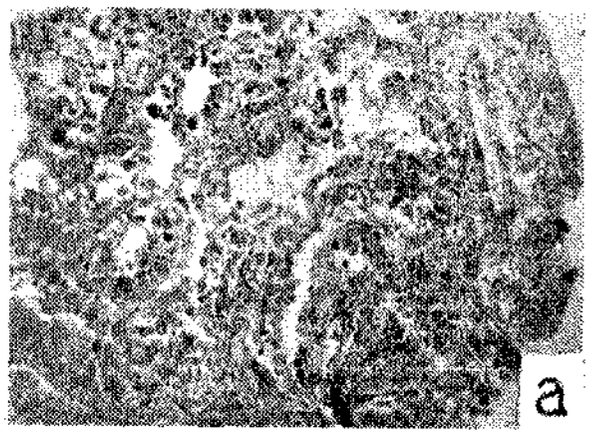
^ •"

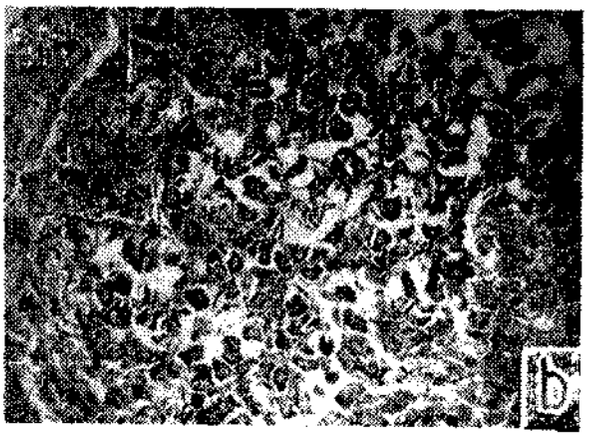
TABLE 2. *Test of homogeneity {XI) for proportion of males in monthly samples of* A. rhombea *during 1978-81*

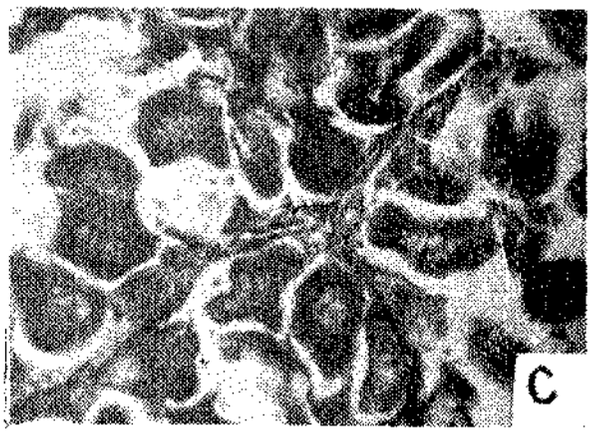
^»°'"	d^	X'	Significanc* at 5%
1978	10	6.04	Not significant
1979	9	8 68	"
1980	9	12.75	„
1981	7	7.46	,,

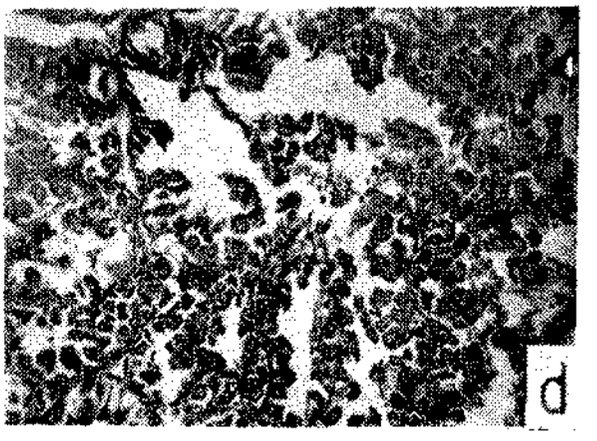
The data on sex ratiD in relation to length (Fig 4) showed that in 1978, malas were dominant in 34-46, 58 and 78 mm length groups: they formed 100% in the 82 mm group. in the remaining length groups females out-numbered males (in 62 mm group the ratio T"' '"'"^ !." |^' ^° ""^ ^'""^ °"'^ °"^ ^^"^^'^ *oocuueA).* The Chi - square test showed that the male: female ratio was not significantly different from the expected 1 : 1 ratio at 5% except in the 74 mm group when females dominated The data for 1979-81 indicated the same trend wz dominance of males in smaller

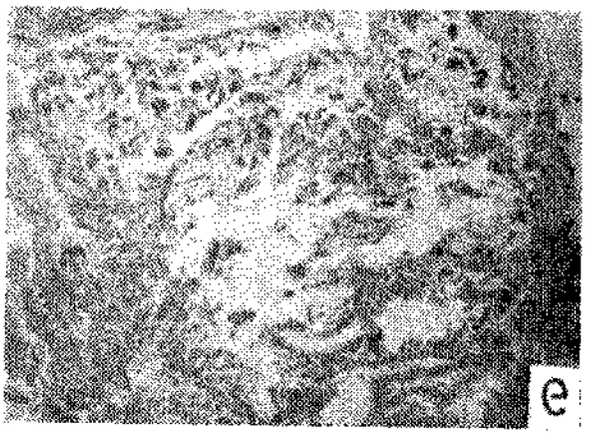
length groups, female dominance in the rest of the length groups with few exceptions and all the clams in the 83 and 9D mm groups were females. The XMest showed that during thasa three years the male : female ratio was not significatly different from the expected 1 : 1 ratio at 5% in ail the length groups for which the test was conducted excepting the 66 and 74 mm groups in 1979.







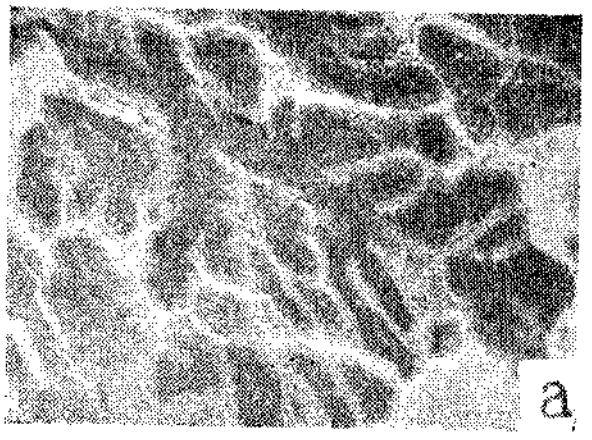


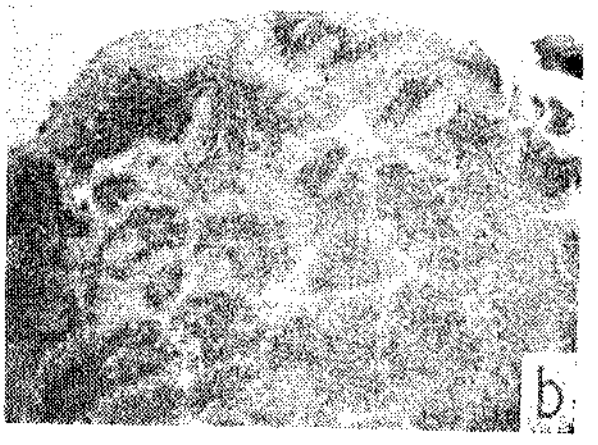


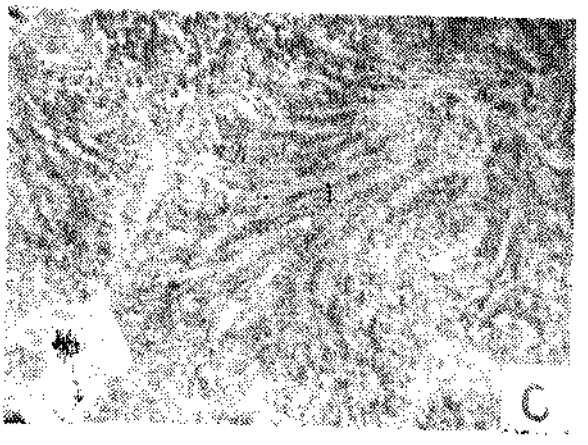
200μ
a,b,d,e

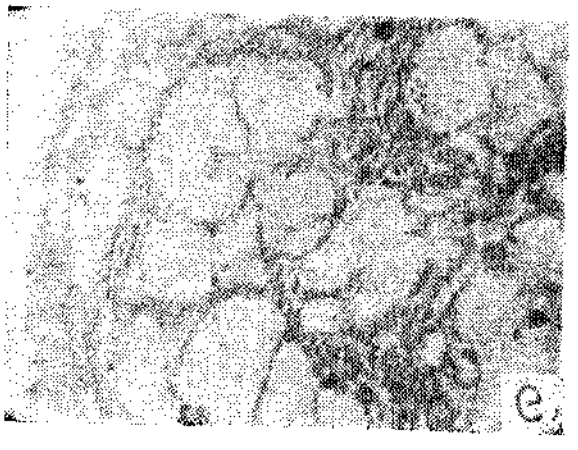
50μ
c

PLATE 1 (Female) a. Maturing stage showing developing oocytes of various sizes.
b. Ripe stage with densely packed ova and some ova appear free in the enlarged follicles.
c. Ripe stage at higher magnification. The ripe ova are polygonal in shape, diameter ranges from 49 to 61 mm and the nuclei measure 22-33 mm.
d. Partially spawned stage with some ripe ova in some follicles while other follicles are empty.
e. Spent stage with residual ova undergoing cytolysis.









200μ
a,b,d,e

50μ
c

PLATE II (Male) a. Maturing stage showing many developing follicles.
b. Ripe stage showing many follicles densely packed with spermatozoa.
c. Ripe follicle at higher magnification. Mature sperms arranged in radial streaks with tails towards the centre of follicles.
d. Partially spawned stage with moderate quantity of spermatozoa in some follicles while other follicles aremostly empty.
e. Spent stage with many empty follicles and residual spermatozoa.

Though deviations in the sex ratio were observed in one month and on three occasions in different length groups, since they are few and may be due to sampling variation, it is concluded that the male : female ratio conforms to 1 : 1.

CONDITION INDEX

Condition index in relation to length. The individual values of the condition index in the sample varied from 9.3 to 17.4 and in each length group the range of variation and the mean were more or less the same over the length range studied (Fig 5). Analysis of variance showed that the CI between the length groups is not significantly different at 5% (Table 3). In other words the CI does not vary with growth.

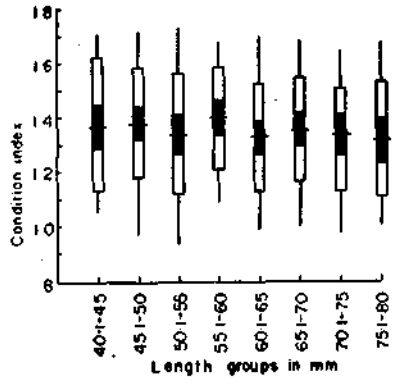


Fig 5. Condition index in different length groups in *A. rhombea*. The vertical line (not depicted in the area showing S. E and S. D) shows the range, the small horizontal line the mean, the shaded and open boxes together one standard deviation and the shaded box alone one standard error on either side of the mean.

TABLE 3. *Analysis of variance to study the significance of differences in condition index between different length groups in* A. rhombea

Source of variation	d f	S. S.	M. S	F
Between size groups	7	4.68	0.6686	0.152
within groups	67	293.85	4.3858	
Total	74	298.53		

F (d f 7, 67) 5% = 2.15

Seasonal changes in the condition index. The average CI during different months varied from 9.6 in June 1980 to 15.7 in November 1978 (Fig 6) with an average of 13 2.

In 1978 the CI steadily declined from January, touching the lowest value in April (Fig 6). Thereafter, notwithstanding the slight fall in August, it remained fairly high. During 1979 the CI was high in January, low in March-April, steadily increased to touch high values in July-September and November - December, excepting for a slight fall in October. The CI was high during January-March 1980, low during April-September, increased in October and remained high during November-December. In 1981, the CI was high during January-February, low in April-June and it remained high during July-December except for a slight fall in September.

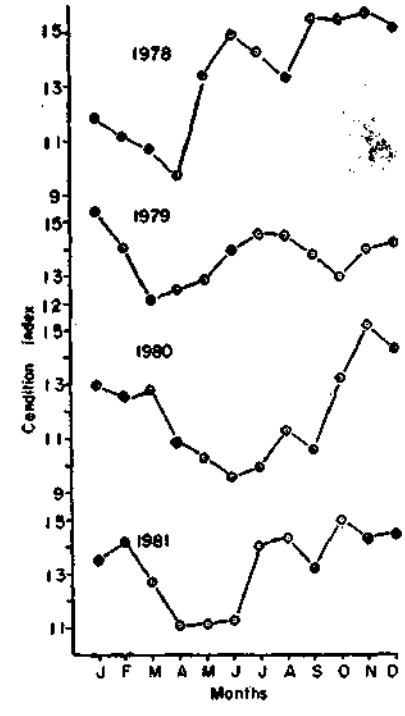


Fig 6. Monthly average condition index based on wet flesh weight in *A. rhombea* during 1978-81

The trends in the CI values during different years are comparable, barring a few exceptions. In January the CI was high, low in April-May and was fairly high in the second half of the year.

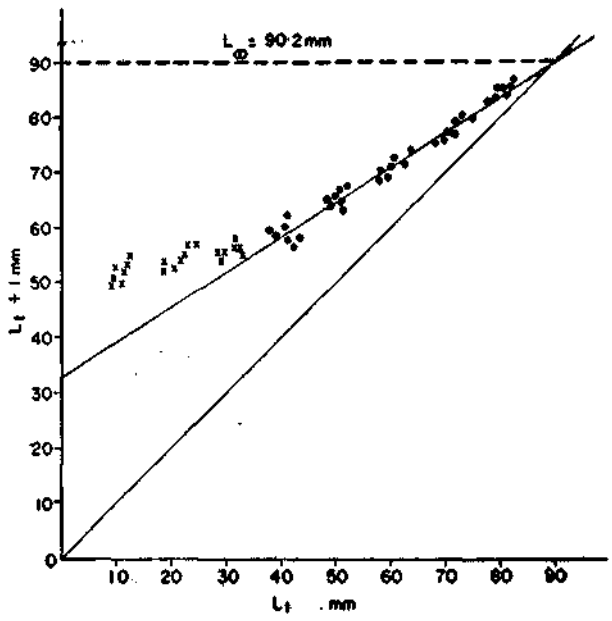


Fig 7. Manzer and Taylor plot using growth data of 56 individuals of different lengths of *A. rhombea* Data by crosses not used in fitting the regression equation.

AGE AND GROWTH

Growth of clams in boxes The average growth rate of the clams during a year varied from 0.36 to 3.44 mm/month depending upon the initial size (Table 4). Clams of 10.8 mm average length introduced in the box on 29.3.1979 have grown to 33.2 mm in 3 months, 43.2 mm in 6 months, 46.7 mm in 9 months and 52.1 mm in one year (Table 4, S. No 1). Similar data are available for the remaining clams but their age when first introduced in the boxes is not known. While there is no information available either on the duration of the larval development or the growth of spat of *A. rhombea* it is known that the larvae of allied species, *A. granosa* settled after 21-22 days after fertilisation and the growth of the spat in the first 1-2 months was slow (Wong and Lim 1985). By taking the larval life as 3 weeks and another 9 weeks for the spat to attain 10.8 mm length it follows that from fertilisation *A. rhombea* grows to 10.8 mm length in 3 months. The observed average lengths in the succeeding months are shown below and also as a broken line in Fig 8.

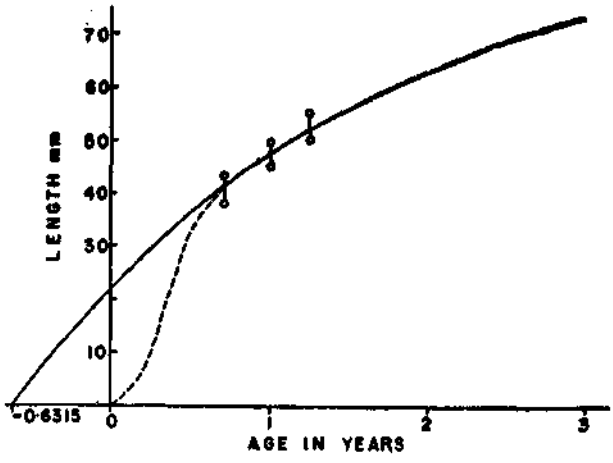


Fig 8. The von Bertalanffy growth curve in *A. rhombea*. Broken line represents the average growth of a class of the length range 9-12.3 mm and circles connected by vertical bar the range in the growth of individual clams studied in boxes.

TABLE 4. *Quartely average growth in length (mm) in* A. rhombea *grown in boxes*

S No.	Length range	No.	29.3 1979	30.6 1979	28.9 1979	30.12 1979	29.3 1980
1.	9.0-12.3	7	10.8	33.2	43.2	46.7	52.1
2.	18.7-24.6	,,	21.4	37.8	46.7	50.0	54.6
3.	28.4-32.8	,,	30.7	42.1	49.3	51.9	56.2
4.	38.1-43.4	,,	40.9	49.5	54.3	56.1	59.1
5.	48.7-52.2	,,	50.4	56.8	60.9	62.6	65.3
6.	58.0-64.1	,,	60.7	66.0	68.4	69.5	71.2
7.	68.2-75.0	,,	71.2	74.6	76.0	76.6	77.7
8.	78.3-82.5	,,	80.4	82.4	83.5	84.0	84.7

._Q j	Z	4	5	Q	J	g	g
^QPtf^s							
Averaoe length mm	10.8	18.5	25.6	33.2	36.9	39.1	43.2

In one year the above clams attained 46.7 mm and m 15 months 52.1 mm length (Table 4, °' ''

Estimation of tf^eparameters of tf^esionBertalanffy growtf, equation. The Manzer and Taylor plot of L,+i against Lt of the 56 clams (Fig 7) showed that the growth data of the first 21 clams (Table 4, S. No. 1-3) do not fall in line with the values of the other 35 clams. Hence the regression line was fitted for the points pertaining to these 35 specimens (Fig 7). The values of Loo and K were estimated as 90.2 mm and 0.4573 per year respectively. By taking the length of 15 months old clams as 52.1 mm the lengths at successive ages were estimated from the Manzer and Taylor plot. Using these data the value of to was estimated as -0.6315 yr. The von Bertalanffy growth equation in/l. *rfiombaa* IS written as

$$L_t = 90.2\ [1-\exp\ [0.4573\ (t+0.6315)]$$

where L is length in mm at time t. From this equation the estimated lengths at ages 1-5 are 47.4, 63.1,73.1, 79.3 and 83.3 mm respectively. The growth curve (Fig 8) fits well to the observed data from about the 7th month onwards. The largest clam in the collections measured 89.7mm (estimated age 10 years) and this length is close to the L, value obtained,

Relative growth during different quarters The average percentage increase in length of individual clams during the first quarter (29.3.79 to 30.6.79> was the highest at 48.0, followed by 25.6 and 10.6 in 2nd and 3rd quarters respecti- ^"'y- " ° ^ ' ^ " ^ ' '^^ ^"^ ^"^^*"^ ^'9'^'"^"^ ^^^'^' 9'°^^^ "^ ^^2% ^""^P^'^^ to the preceeding ^"^^*"- "^^^ '"'^'•"*'' ^'^"'^ °^ accelerated growth following a period of slow growth.

MORPHOMETRIC AND LENGTH-WEIGHT RELATIONSHIPS

The various parameters studied and the relationships .obtained are given Table 5. The r values varied from 0.9358 to 0.9976 indicating high degree of correlation between the parameters studied. The b values in the length-weight relationships varied from 2.5053 to 2.9367.

DISCUSSION

Natarajan and John (1983) stated that ^- *r/iombea* spawns during February-September in the backwaters of Porto Novo, in the Kakinada Bay the spawning season in this species is restricted to five months during December-April (rarely in May) with one reproductive cycle (rarely two). It is well known.

TABLE 5. *Estimates o/tfia paramatars for morphomstric and /angth-waigfit (aftar logarithm! transformation) regression equations in* A. rhombea. *Length (X) is taken as the Independent variable-*

S. No.	Dependent variable	Size range mm	Numbers	a	b	r
1.	Height	9.0-89.7	136	3.6180	0.7030	0.9958
2.	Width	9.0-89.7	136	2.9964	0.6962	0.9953
3.	Hinge	9.0-89.7	136	0.8760	0.6274	0.9938
4.	Total weight	9.0-89.7	148	-3.2465	2,9367	0.9976
5.	Shell weight	25.1-89.7	100	-3.3303	2.8973	0.9513
6.	W«t meat weight	25.1-89.7	100	-3.3860	2.5053	0.9892
7.	Dry meat weight	41.6-84.1	125	-4.5384	2.8848	0.9358

that the duration of the spawning period varies in a species occurring in different parts of its geographtc range (Ropes and Stickney 1955 and Seed 1976). Sastry (1979) reviewed the various exogenous and endogenous factors which influence the reproductive cycle in bivalves. Among them temperature and salinity received greater attention, In/4. rAo/nAea spawning took place in a few individuals in December but majority of them spawned during January April. During these four months temperature and salinity in the clam bed showed increasing trend (Narasimham 1985). Similar observations were made by Nagabhushanam and Talikhedkar (1977) in *Donax* cy/jeafus and Nagaphushanam and Mane (1975) in *Katelysia opima* from the Ratnagiri area.

In some bivalves gametogenesis occurs immediately after the completion of spawning (Loosanoff 1953 and Nagabhushanam and Man© 1975) while in others gametogenesis does not occur immediately after the spawning and the sexuality of fhe bivalve is lost (Rao 1967 and Boyden 1971). The present study reveals that /I. r/70/77i6e» belongs to the latter category. Natarajan and John (1983) also observed that at Porto Novo this species passes on to an indeterminate stage after the completion of spawning.

According to Natarajan and John (1983), *A. rhombea* attains first sexual maturity when 21-25 mm long and males mature earlier than females though they did not give the lengths at first maturity for the sexes separately. The present study confirms the above obssrvations.

At Porto Novo, the overall male:female ratio in *A. rhombea* \NSiS 1.27:1 and in male dominated months the sex ratio was significantly different from 1:1 (Natarajan and John 1983). These authors also found that males were dominant in the 20-50 mm length range and females in 55-60 mm length range. However, in the Kakinada Bay tha male: female ratio conforms to 1:1 in all the months and and length groups, barring a few exceptions.

In some bivalves the condition index iu relation to length/volume was found to vary (Baird 1958, Hickman and lllingworth 1980 and Narasimham 1934). In *A. rhombea* the condition index did not vary in different length groups indicating that the proportion of meat weight in total weight is uniform during growth. The condition was high, just before or at the beginning of the spawning and it was low immediately on completion of the spawning. Similar observation was made in other bivalves also ^Durve 1964, Ansell et. al. 1964 and Alagarswami 1966;. Sastry (1970) observed increase in the body weight of scallop *A»quipe-cten irradians* during the post-spawning period and attributed this increase to accumulation of nutrients in the body. It was observed that during the post-spawning period, *A. rhombea* passes into indeterminate phase with no gonad development; during this period high condition was observed and this may be due to the accumulation of body reserves.

Following tha work of Manzer and Toylor {'1947;, who plotted the individual lengths of recaptured lemon sole against their lengths when tagged one year previously, some authors ('Hancock 1965; Theisen 1973) have called the plot of Lt-Hi against against Lt of *individuals* of different ages as Manzer and Taylor plot. I differs from the more usual Ford-Walford plot (Ford 1933;Walford 1946) which employs the *mean* lengths at each age. Theisen (1973) observed that in *M/ti/us edulis* the growth curve (in length) is of sigmoid form and that the von Bertalanffy growth equation gave the best fit to the observed length data pertaining to above 1/3 rd of the maximum length. He wrote "Probably the sigmoid growth curve is common to most lamellibranchs, and hence the von Bertalanffy growth equation should not be used to present the growth of lamellibranchs under about one third of the estimated maximum length." (p. 72). The growth curves for weight and length of many organisms are sigmoid (Crisr 1984) and among the bivalves sigmoid growth curves ware observed by Stevensan and Dickie (1S54) Ansell and Parulekar (1978) and

Broom (1982). In the present study also the growth curve in length was found to be of sigmoid form (Fig 8) and the von Bertalanffy growth equation describes the growth *A. rhombea* well when fitted to the length data of the clam, measurino above 32.8 mm length onwards-

Retardation of the growth rate, in bivalves due to low salinities is know in Indian waters (Rao 1952, Rao ef *si* 1964 and Mane 1976). During the period when *A rhombea* was grown in boxes the variations in the monthly average temperature were small (27.8-33.5°c) whereas salinity showed much wider range (13.69-34.40 ppt); the lowest salinity value was obtained in November 1979 followed by 15.30 ppt in December '79 Narasimham 1985). The slowes. growth of 10.6% of the annual growth in *At rhombea* was observed during the quarter ending December 1979 and this may be due to the low salinities in November-December.

Patel and Patel (1974) described the length-breadth (referred to as width in the present, study), and length-height relationships, in *A rhombea.* These authors have neither mentioned the scale in which ttie measurements were taken nor the length range of the material examined. They obtained the equation W = 0.35L2.74to describe the length-total weight relationship. Both the elevation and slope of this equation were found to be beyond the 99% confidence limits of the parameters obtained in this study.

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27. AGE AND GROWTH OF *M£RETR/XCA-STA* ***(CHEMNITZ)*** IN VELLAR ESTUARY, PARANGIPETTAI

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ABSTRACT

Age and growth of *Meretrix casta* (Chemnitz) in Vellar estuary was studied from April 1975 to March 1976, Employing length-frequency method growth of *M. casta* at the end of I year was found to be about 24.0 mm. Months mode curve showed that this clam attained growth of 23.2 mm, 38.4 mm and 49.2 mm at the end of 1,11 and III year respectively. Growth estimated by probability plot method was 23.0 mm in 1 year, 38 3 mm In II year and 50.6 mm in III year.. The life span of M. *casta* was found to be 3 years in Vellar estuary.

INTRODUCTION

Salih (1973), Parulekar (1973) and Harkantra (1975) have reported the rates of growth in *tiAeretrix casta* (Chemnitz) from the west coast of India while Abraham (953), Durve (1970, '73) and Sreenivasan (1980) reported the the growth of *M casta* from the east coast of India. *M. casta* being an economically important bivalve in Vellar estuary (Lat.11°29'N; Long. 79°46'E) was studied by various methods from monthly collections of this clam made from April 1975 to March 1976. Clams were measured to the nearest 0.1 mm by Vernier Calipers and the length was the greatest measurement in antero-posterior axis parallel to the axis of the hinge.

OBSERVATIONS

Lengtti-frequency mettiod

The total length range of/If. *casta* collected was from 1 mm to 60 mm and the clams were grouped into 3 mm class intervals. The length frequency distribution (Fig 1) was bimodal for most months and unimodal or multimodal only in a few months. The mode at 1-3 mm size in April 1975 shifted to 4-6 mm in May, 10-12 mm in June, 13-15 mm in August and 16-18 mm in October, thus attaining a mean growth of 17mm in six months. The same group can be traced to 22-24 mm in February 1976. A new mode appeared in March 1976 due to fresh settlement of spat. Thus growth at the end of 1st year was found to be about 24.0 mm. Among the larger size groups, the growth pattern was difficult to trace because of frequent back shifts in the modes,

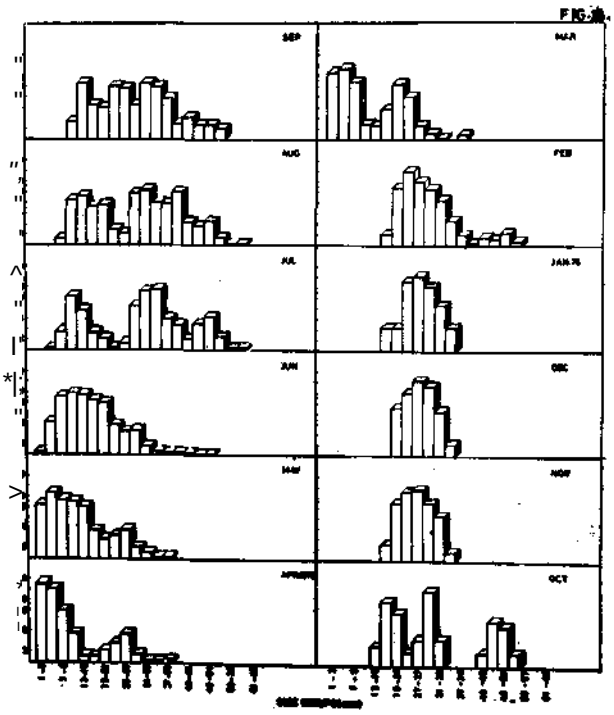

Fig. 1. Length frequency histograms from April 1975 to March 1976.

Month and modes curve

Modes recognised in the length-frequency data for various months were represented in the form of a scatter diagram of mod«s for *lVl.* casfa following the method used by Devaraj

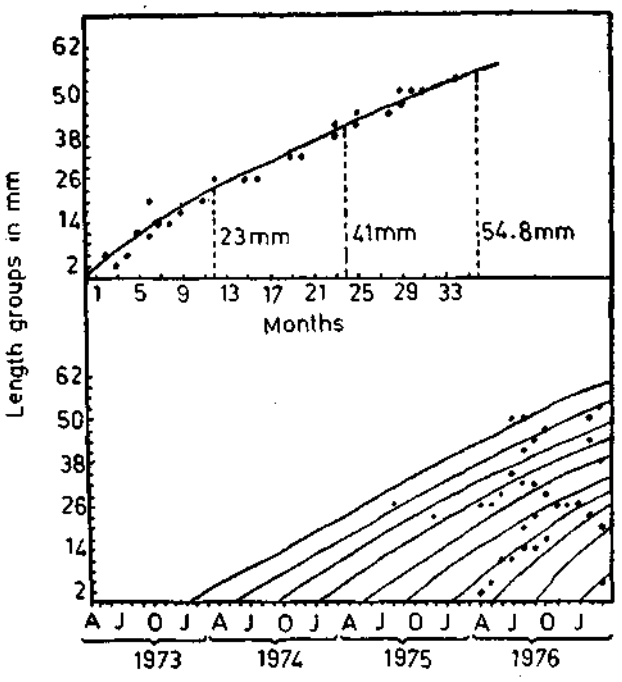

Fig. 2. Monthly distribution of length frequency and modal values.

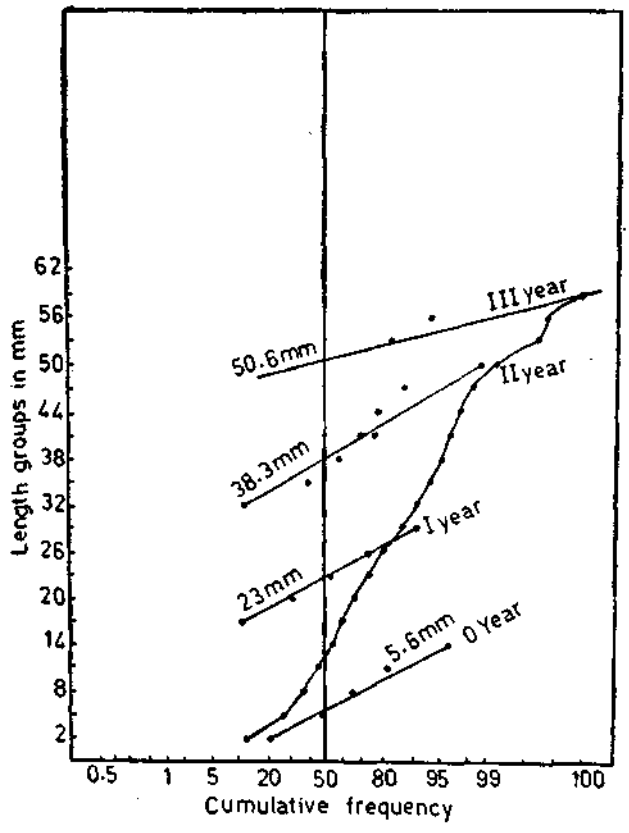

Fig. 3. Probability plot curve showing length attaintd in different year groups

(1977), Sriraman (1978) and John (1980). The progression of modes through successive months, along the series of trend lines representing growth of various broods is summarised in Fig 2 and the fitted trend lines therein represent growth in *M. casta.* From the graph, it was possible to trace 3 broods in a year. The growth of *M. casta* traced from observation was 23.2 mm, 38.4 mm and 49.2 mm at the end of 1,11 and III years respectively.

Probability plot method

The length frequency data can be interpreted again by another method known as probability plot method of Harding (1949) and Cassie (1954). This method has been used to find the modal values of different year classes. Sometimes, certain year classes may not be represented in the collected samples and Petersen method will give erroneous results. So, in such cases, the probability plot method is used for seperating the polymoda! length-frequency distribution into modal lengths of different year classes. The probability plot drawn for *M. casta* is given in Fig 3 and shows that 0 year class measures 5.6 mm while I, II and III year classes attains 23.0 mm, 38.3 mm and 50.6 mm respectively.

DISCUSSION

In Japanese waters, Hamai (1935) found that growth was cyclical and confined to the period May to September in *Meretrix meretrix* and he reported a growth of 20 mm, 32 mm and 44 mm respectively for 9, 21 and 33 months. In India, Abraham (1953), who studied growth of *M. casta* in Adayar estuary at Madras on the east coast found that growth was suspended twice atleast in a year and he reported a growth of 29.5 mm in 9 months, i. e. 3.3 mm per month. Salih (1973) reported a growth rate of 3.7 mm per month (i. e. 33.5 mm for 9 months) in one case (earlier brood) and 3.2 mm per month (i. e. 35.4 mm for 11 months) in another case (later brood) of *M. casta* occurring in Cochin bar mouth on the west coast of India. Further studies on the west coast of India by Parulekar et al. (1973), in estuaries at Goa and by Harkantra (1975; in Kali estuary at Karwar, Karnataka, showed a

growth rate of 2.7 mm and 2.9 mm per month in *IVl. casta* occurring in these places.

Durve (1970), who studied the growth of *iVl. casta* in the marine fish farm at IViandapam reported a monthly, average growth of 0.79 mm and he attributed this slower growth rate in the fish farm at Mandapam to high saline conditions which is not a natural habitat of this clam. Sreenivasan (1980) who studied the growth of *IW casta\n* vellar estuary by transplantation, recorded, a growth of 34.0 mm in 13 months. In the present study, the growth of. *M casta* in Vellar estuary was found to be 23.0 mm during the I year, 38.3 mm at the end of the II year and 50.6 mm at the end of 111 year. Growth of *M. casta* was slower when compared to growth rates reported by other workers. The slower growth rate found in *M. casta* occurrmg m Vellar estuary can be due to various hydro-biological factors prevailing in Vellar estuary which may differ in other places studied by others.

Senior author thanks Dr. K. Sriraman, Dr. V. Sivakumar and Prof. Ramamoorthi Emeritus Scientist for their valuable help

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28. BIOLOGY OF *MERETRIX CASTA* (CHEMNITZ) AND *PAPHIA MALABARICA* (CHEMNITZ) FROM MULKY ESTUARY, DAKSHINA KANNADA

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ABSTRACT

***Meretrix casta* and *Paphia malabarica* are the major species contributing to tlie clam fisheries of the iMull<y estuary. Studies on age and growth indicated that *M. casta* attains 46.6 mm and *P. malabarica* 48.1 mm in one year The von Bertalanffy growth equation is fitted for both the species. iV^ost of these clams do not survive t3 the second year. Length-weight relationship of both species and other dimensional relationships of *M. casta* are worked out. The major spawning season of *M. casta* and *P. malabarica* are Septtmbar-lVlarch and October-February rtspectlvely. In *M. casta* females are significantly dominant btyond 30 mm Itngth. This species attains first maturity at a length of 17mm-iHigh condition index in both the species coincided with paak spawning period. An analysis of rings on the shells of *M. casta* indicated that they are not useful in age determination. Various aspects of the biology of the above two species are discussed in relation to the ecological conditions of the Mulky estuary.**

INTRODUCTION

Clams are the most important estuarine moHuscan resources of Karnataka. Among them *Meretrix casta* rChemnitz) and *Paphia malabarica* (Chemnitz) contribute 88% and *A%* respectively in the Dakshina Kannada (Rao and Rao 1985).Theclamfishery of of the Mulky estuary in Dakshina Kannada was reported by Rao [1984]. Although there is some information on the resource characterstics of clams, information on t+ie biological aspect is scanty. The work on the biology of /\^. *casta* \s mainly from the estuaries of east coast (Abraham 1953, Durve **1964,** 1970 and Sreenivasan 1983). No published information is available on the biology of *Paphia malabarica.* Some aspects of the biology of these two commercially important clam species from the Mulky estuary are dealt ^®'®"

MATERIAL AND METHODS

Samples of *M casta* and *P. malabarica* **were** collected weekly during low tide from the Mulky estuary. For this purpose, the sediment containing the clams from the clam bed was i,wiiium iiy 1110 ^-la o lu passed through 1 mm mesh seive. The length of *M. casta* ranged from 5-43 mm and *P. malabarica* from 5-51 mm. The observations were made during 1979-82 on *M. casta* and 1983-84 on *P. malabarica.* Length-weight relationship and other dimensional relationships ^^^^ calculated by the least square method. ^^^ ^^-^ purpose, the linear measurements were takg^ upto 1 mm accuracy, and weight to 0.01 g precision. The differences in the distribution of males and females were tested by the Chi-square (X^) test. Three maturity stages viz, maturing (developing) mature and spent were considered. The condition index was deter-^jned as percentage of wet meat weight in the total clam weight. For this purpose after operving the clams, excess moisture from the meat was removed with a blotting paper and the meat weight recorded to an acuracy of 10 mg. The Qulland and Holt (1959) method was followed j^ gge and growth studies. Clams measuring g ^^ 4^ ^^ ^^.^ studied in detail with regard to the number of rings, length at which they were found and the period of ring formation. As there were not much variations from year to year, the data collected during different years y^ere pooled on monthly basis.

RESULTS

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Physiography and environmental conditions

Mulky estuary is formed by the confluence of Sambhavi and Pavanji rivers near Mulki

about 30 km north of Mangalore (Rao 1984). This estuary has a waterspread of about 750 ha and receives about 4000 mm rainfall annually, out of which about 85% occurs during the south-west monsoon (June-September).

The salinity is generally high and stable during December - May (29-33%J and low during September-November [17.5-247oJ- During June-August when the flooding of the estuary is maximum, the salinity is very low [<5°/oo]- The water temperature ranged from 27.4° C to 32°C and followed the same pattern, as that of salinity [Fig. 1]. The sediment is predominantly composed of medium and fine sand [Rao and Rao 1985]. The estuary is very shallow and during low tides, major parts of the estuary are exposed. The maximum depth at low tide is 3 m. The clam beds are mostly located in the shallow areas; *P. ma/a-barica* is found in slightly deeper waters, close to the mouth of the estuary generally separated from *M. casta.*

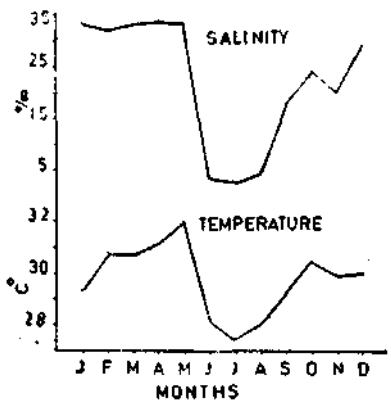

Fig. 1. Temperature and saiinity pattern of Mulky estuary. (1979-82 monthly average).

Dimensional relationships

The relationships can be described by the following equations.

M. casta:

Length-weight relationship:

logW== -3.7333+3.1478log L(r=0.9959,

The parabolic equation is

W=0.000184799 L ^'^'B

Length-height (depth) relationship;

H=-1 7775+0.8025 L (r =• 0.9882)

Length-thickness relationship:

T=-4.3286-f0.S706 L (r= 0.9842)

In the above regression equations, the correlation coefficient is close to 1, showing high degree of correlation between the parameters studied (Fig 2). The length, height, thickness (LHT) of Af, *casta* are in the ratio of 37X28 5X20.5, as compared to 37X32.25X22.75, ^.^^^ ^^^ Cornell (1917) *for Meretrix casta war o^um,* from Mangalore.

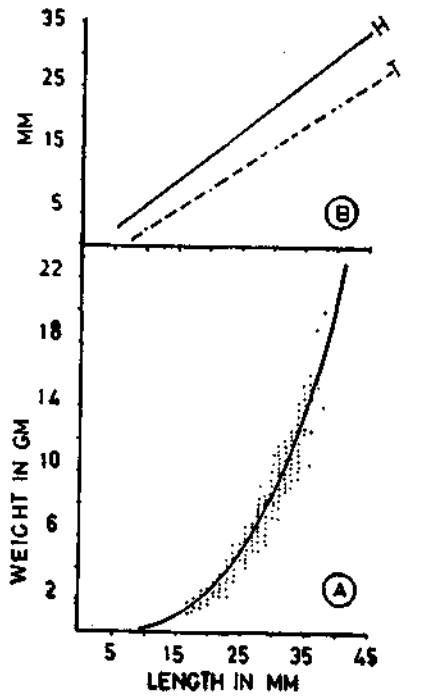

Fig. 2. Lenoth-weight (A) Thiclcnets (T) and Height (H) relationship (B) in *M. casta*

The length-weight relationship of *P.malaba-rica* may be described as

^ W^-3.9121 -h3.2640 log L (r=0.9921)

a

The parabolic equation is

W=0.000122443 L smtt

'" *P malabarica,* the weight increases at a higher rate in relation to length, when compared *to M. casta* (Fig. 3).

^^,

Generally the clams are exploited from about 20 mm length onwards. The modes could be traced only for short intervals of time, a maximum of 35 days. They could not be traced continuously over the whole length

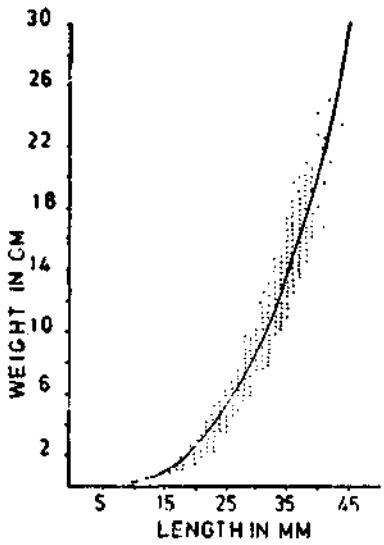

Fig. 3. Length-weight relationship in *P. malabarica*

range of *M. casta* and *P. malabarica*. The Gulland and Holt (1959) method allows age determination by the tracing of growth at short and irregular time intervals. The growth rates derived at different mean lengths are plotted to fit a regression equation by the least square method.

M. casta

Growth rate (Y)=0.2720-0.0051 Length (X) (Fig 4A)

The intercept *a* and sloge *b* provide the values of *K* and $L\infty$ through the relationship

$K = -b = 0.0051$/day

$$L\infty = \frac{a}{k} = 53 \text{ mm}$$

Following Pauly (1983) t_o in the von Bertalanffy growth equation is derived as - 49 days. Hence the von Bertalanffy growth equation for *M. casta* may be written as

$$Lt = 53\,(1-e)^{-0.0051\,(t+49)}$$

According to the above equation *M. casta* attains a length of 36.5 mm in 6 months, 42.6 mm at the end of one year (Fig 4B). It may be mentioned here that according to Abraham (1953) *M. casta* grows to 43 mm in one year in the Adyar estuary. The largest specimen of M. *casta* in this estuary measured 43 mm in length.

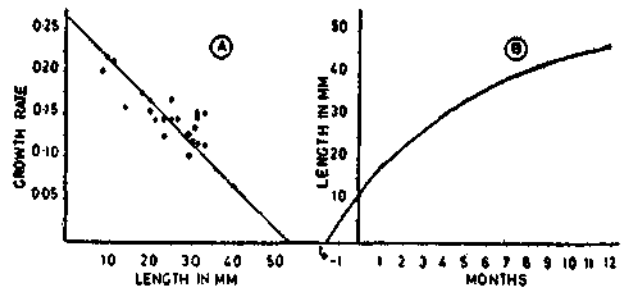

Fig. 4. (A) Regression of growth rates on length and (B) von Bertalanffy growth curve of *M. casta*

P. malabarica

In this species the regression of growth rates on length (Fig 5A) may be described as:

Growth rate (Y) = 0.2343 - 0.0039 Length (X)

The values of growth parameters derived are

$L\infty$ = 59 mm, K = 0.0039/day and t_o - 62 days

The von Bertalanffy growth equation for *P. malabarica* is written as

$$Lt = 59\,(1-e^{-0.0039\,[t+62]})$$

The estimated length of *P. malabarica* are 36.3 mm in 6 months, 43.1 mm in 9 months and 48.1 mm in one year (Fig 5B). The largest specimen of *P. malabarica* recorded in the collections is 51 mm.

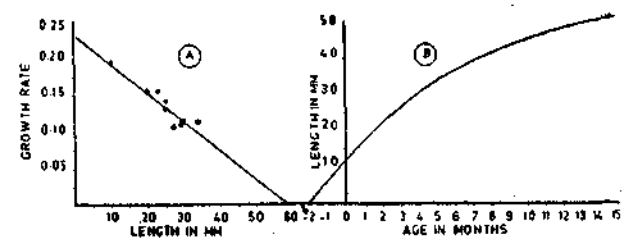

Fig. 5. (A) Regression of growth rates on length and (B) von Bertalanffy growth curve of *P. malabarica*

Maturity and spawning

M. casta: Developing and mature clams were noticed from 15-19 mm group onwards, which may be considered as size at first maturity (17 mm). According to Abraham (1953) the size at first maturity was 11 mm. Mature *M.*

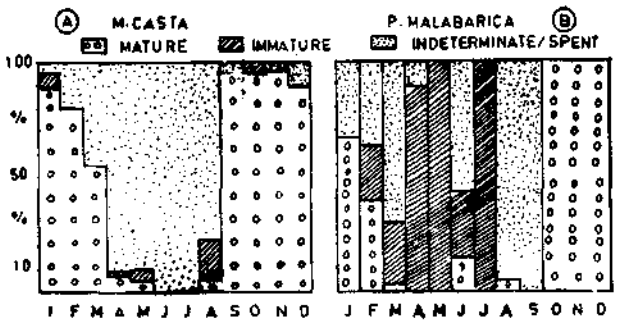

Fig. 6. Dtstribution of mature (A) *M. casta* and (B) *P. malabarica* in the Mulky estuary.

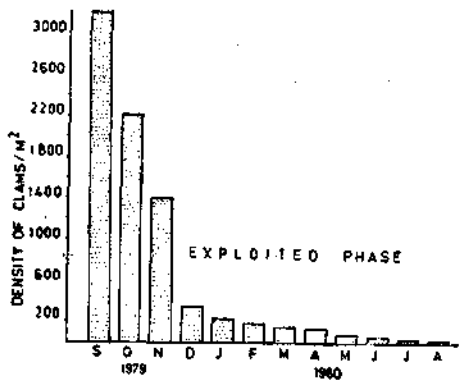

Fig. 7. Changes in the density of clam population in the clam bed *M. (casta)* during course of 12 months.

casta were observed from August to May. Majority of the specimens were in mature condition during September - March period, which may be considered as the spawning season (Fig 6A). Indeterminate clams were available almost througout the year. Although mature clams were available from September to March in appreciable numbers, seed clams were available during September - December and April-May periods only, indicating that major spat settlement takes place only during these two periods. The clams that settle during September-December period contribute to the fishery (Fig 7), whereas those that settle during April - May are subjected to heavy natural mortality during the monsoon.

P. malabarica : Mature gonads were observed in clams measuring 20 mm onwards. Mature *P. malabarica* were abundant from October to February, which can be considered as the spawning season (Fig 6B). Mature specimen were also observed during March, June and August in few numbers. Unlike in *M casta*, immature specimens were available in considerable numbers from April to July. Thus the spawning season of *P. malabarica* is short, when compared to *M casta*.

Sex ratio

The sexes of *M. casta* were almost equally distributed (Table 1) except in August when

TABLE 1. *Sex ratio and Chi-square (X^2) values of M. casta (1979-82 pooled) and P. malabarica 1983-84 pooled)*

	M. casta				*P. malubarica*			
MONTH	Males	Females	Total	Chisquare	Males	Females	Total	Chisquare
Jan	100	98	198	0.02	26	24	50	0.08
Feb	88	72	160	1.60	32	16	48	5.33*
Mar	73	54	127	2.84	19	10	29	2.79
Apr	6	10	16	1.00	35	32	67	0.13
May	13	15	28	1.14	29	21	50	1.28
Jun	1	4	5	1.80	64	11	75	37.45*
Jul	—	—	—	—	62	13	75	32.00*
Aug	56	27	83	10.13*	4	—	4	4.00*
Sep	92	101	193	0.42	—	—	—	—
Oct	76	79	155	0.05	10	15	25	1.67
Nov	54	62	116	0.55	9	16	25	1.96
Dec	51	49	100	0.04	10	15	25	1.00

* Significant at 5 °/₀₀

there was a significant male dominance. In other months the X^2 values showed no significant deviation from the expected male to female ratio of 1:1. In *P. malabarica* there was male dominance during February, June, July and August months (Table 1) which is significant. The sex ratio in relation to length showed that at 30 mm and beyond, females out-numbered males in *M. casta*.

Condition Index

The condition index of *M. casta* ranged from 8.4 in May to 16.0 in September (Fig 8A). There was a trough during April–June, when most of the clams were in spent or indeterminate condition. The index was high during September-December. Coinciding with spawning activity. The pea crab (*Pinnotheres* sp) infestation was at its peak (65 to 100%) during April-June (Fig 8A), indicating that high pea crab infestation may also be a probable reason for the low condition index obtained in *M. casta*. In *P. malabarica*, the condition index (Fig 8B) ranged from 11.8 in May to 14.3 in February. It began to increase in October through February, coinciding with the major spawning period. Then it showed a decline till May. Again there was a small peak in the index in June, which coincides with a minor spawning.

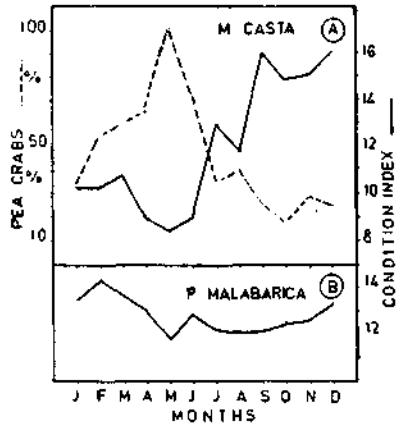

Fig 8. (A) Condition Index and infestation of Pea-crabs in *M. casta* (B) condition index in *P. malabarica*

Rings on shell

Rings varying in number from 1 to 4 occurred on the shells of *M. casta*. These rings are generally in the form of thin grooves in the antero-posterior direction. The rings are variously termed as disturbance rings (Orton 1927), growth rings (Rao 1951) etc. The smallest clam in which ring was observed measured 9 mm in length. Single ring was found at a length range of 9-32 mm (mean 20.7 mm). The second ring occurred at lengths 15-36 mm (mean 27.8 mm), third ring at lengths of 24-41 mm (mean 34.0 mm) and the fourth ring at lengths of 32.41 mm (mean 36 2 mm). (Fig 9)

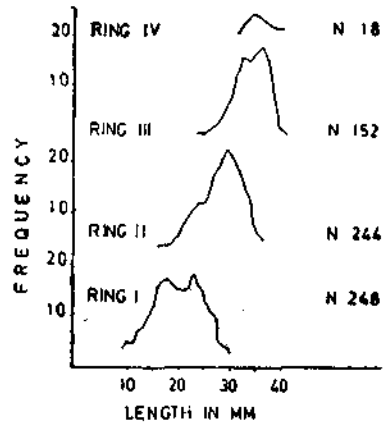

Fig 9. Distribution of rings on the shells of *M. casta* (n = number measured)

It was also observed that the ring formation was not confined to any particular month or season. Also these rings could not be related to any particular age units. They appear to indicate some physiological changes in the clam, like reproductive activity. It is of interest to note that the mean length for the formation of first ring is closer to the size at first maturity.

DISCUSSION

According to Hornell (1917) *Meretrix casta* found in the estuaries of west coast are similar to those occurring on the west coast of Malay Peninsula. On both these coasts the rainy season is prolonged and rainfall is heavy compared to the east coast of India. West coast *M. casta* have shown morphometric adaptations such as the more pointed out line of the posterior angle of the shell etc. They have been elevated to a species viz., *Meretrix ovum* (Hanley). However, Hornell (1917) opined that the differences between the east coast

and the west coast specimens of *M. casta* are insufficient to warrant separation as a distinct species, but advocated to consider it as a variety, namely *Meretrix casta* var *ovum* (Hanley). The length, height and depth (LHD) proportions given by Hornell (1917) and those obtained in this study show that, in the present case the body is more linear and streamlined. Hence the growth in length may be rapid.

According to Rao and Rao (1960) *M. casta,* measuring 17 mm and 24 mm, transplanted in a fish farm in the iVlulky estuary, reached 32mm, and 36 mm respectively in 4 months. These growth rates are almost similar to the results obtained in this study. The growth rates obtained in the present study in *M. casta* are faster than those given by Abraham (1953), Durve (1970) and Sreenivasan (1983). Such disparity in the growth rates may be due to the differences in the envitonmental conditions.

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29. FEEDING BEHAVIOUR OF THE GREEN MUSSEL, *PERN A VIRIDIS* (LINN.) IN LABORATORY

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ABSTRACT

The rate of filtration and feeding on six species of diatoms by the green mussel *Perna viridis* Linn In the laboratory has been studied. The number of cells removed per hour depended upon the size and suspension density of the diatom cultures- Generally the mussel was found to eliminate more than 50% of the filtered cells as pseudofaeces. The rate of ingestion was enchanced when the suspension density and cell size were less. Eventhough large quantities of pseudofaeces were produced when suspension density was increased, the actual ingestion of food was not affected by call concentration. The maximum filtration rate [341.43] ml hour -'g m —1 was noted in *Thalassiosira fluviaiillis* suspension. The relation between the rate of filtration and call size and density of the suspension was studied and discussed.

INTRODUCTION

Efficient production of culturable bivalve molluscs in controlled environments require exact information about the rate of feeding and particle transport. Clams and oysters subsist mainly on particles filtered from the surrounding water, which they pump through the gills. An extensive literature deals with the results of microscopical examination of the content of the digestive tract, to estimate the relative significance as food of the various types of organic matter present in bivalves (Allen 1921, Coe 1948 Coe and Fox 1944, Savage 1925, Vervey 1952).

The volume of water from which particles are removed in a given period is termed the filtration rate [Fox etal1937]. Generally the filtration rate and pumping rate are not same, because the retention of prticles by bivalves is rarely 100% efficient [Jorgensen 1955], the pumping rate is usually greater than filtering rate. The ingestion of food by bivalves mainly depend on the filtration rate, but various other factors also control the ingestion rate. Some of the particles filtered by the gills are eaten, while others are rejected as pseudofeces. The ejection of feces and pseudofeces are known as biodeposition.

Although there is considerable information concerning the filtration and pumping rates of bivalves, little consensus regarding rates of feeding or ingestion is available. Under experimental conditions different types of organisms and different mixtures of organisms Qf various size result in different rates of filtration and possibly of feeding (Loosanoff and Engle 1947; Rice and Smith 1958; Smith 1958; Allen 1962; Davids 1964j. Rice and Smith (1958) conducted the major study of *Mercenana mercenaria.* They supplied the clams with the four species of algae tagged with ^^p jn unreplenished suspensions, Allen (i962) studied the filtration rate, ingestion rate and biodeposition of s^p labelled *Pheodactylum* by for species of bivalves. The total biodeposition of three species of bivalves in relation to suspension density was studied by Haven and Morales-Alamo (1966), and found that the density of suspension determines the rate of filtration, pseudofeces formation and rate of food ingestion Walne (1970) investigated the food value of different species of algae in culture. AM [1970] investigated the filtration rate and biodeposition of *Hiatella arctica* by using two species of micro algae in different cell densities. Tenore and Dunstan [1973] studied the rates of feeding and biodeposition of American oyster by using four species of phytoplankton, viz., *Thaiassiosirapseudonana, Skeletonema costatum, Dunaliella tertiolecta* and *Nitzscfiia closterium.* Tenore et al [1973] studied the food chain dynamics of the oyster, clam and mussel in an aquaculture food chain.

Epifanio [1976] studied the nutritional requirements of juvenile and adult bivalves. Foster-Smith [1975] investigated the assimilation efficiency of three species of bivalves by using of *Phaeodactylum* sp and found that the assimilation mainly depend upon the rate of ingestion. The rate of removal of four species of algae from suspension by the oyster *Crassostrea virginica* was determined by Epifanio and Ewart [1977] and found that the filtration rate was influenced by the suspension density and cell size of the algae. Malouf and Breese [1977] measured the effects of algal concentration and larval density on the growth of larval oysters in a flow through feeding system.

Salzwedel [1979] quantitatively estimated the production of pseudofeces and feces by *Tellina jabula.* For long term bioaccumulation studies with suspension feeding mussels, Boetter-Jensen and Dahlgaard [1981] designed an apparatus to maintain phytoplankton cell concentrations at a constant level. Wilson [1983] studied the retention efficiency and pumping rate of *Ostrea edulis* in suspension of *Isochrysis galbana* in relation to cell concentration. Urban and Pruder [i 933] compared the growth of *Crassostrea virginica* at five algal ration levels for a period of 3 weeks Berry and Schleyer [1983] estimated the assmilation efficiency of/'eA/7a/DeA/7a on a natural diet of particles <lOO!*min diameter. Col well et al (1984) has developed microencapaulation techniques for artificial food to rear bivalve molluscs in recirculating system.

The food value of unialgal diet and mixed algal diets to juvenile oysters were determined, and mixed algal diet proved to be good for juvenile oysters (Romberger and Epifanio 1981-)

MATERIAL AND METHODS

Six species of diatoms (Table 1) were cultured in the lab. condition by using, f/2 medium (Guillard and Ryther 1962) made up in aged and filtered sea water with the salinity adjusted to 287oo and sterilized by autoclaving. All the six species of diatoms came from clones isolated from Vellar estuary (11°29'N; 79°49'E) and maintained in laboratory. For the feeding experiments, mass cultures of each species were developed. The cultures were shaken periodically to keep the cells in suspension. Continuous illumination at 4000 lux was supplied by 40 W'cool white' florescent lamps for 16 h in a day and temperature ranged from 28-30°C. Cell counts were made with Haemocyrometer (Neubauer improved double ruling' Fein optic. Made in GDR). Algae used in the experiment were from cultures that had reached the stationary phase to avoid the multiplication during the experimental period.

TABLE - 1 . *The algal species used for the experiment and their size in laboratory culture.*

SI. No.	Species of diatoms used	Cell size (A m	Suspension density cells/ml (x10*)
1.	*Chaetoceros gracilis* Schutt non pant	3-5	45 to 500
2.	*The lass iosira fluviatilis* Hust	8-10	7 to 100
3.	*Skeletonema costatum* (Grev.) Cl	7-9	10 to 100
4.	*Thalassionema nitzschoides* Grun	3-5 dia. 15-25 leng,	6 to 55
5.	*Chaetoceros didymus* Ehr	10-18	3.8 to 25
6.	*Streptotheca tamesis* Shrubs	22-30	1.8 to 10

The green mussel *Perna viridis* individuals of same age groups [the wet weight of the whole animals ranged from 2.0 g to 3.1 g] were collected from the field, washed free of epifauna and flora and acclimated in the laboratory aquarium tanks. During the acclimation period the animals were fed with cultured diatoms-mixed form. Prior to the experiment, the animals were allowed to starve for about 12 h. On the day of expeiiment they were removed from the acclimation tank, washed free of adhering debris, blotted free of excess water and weighed. Then the animals were placed in the experimental tank and the algal suspension of known concentration was added. Table 2 shows the cell concentrations of the suspensions used for the experiments. The algal suspension was continuously agitated by mild air bubbles to

TABLE 2. *Rate of filtration and feeding of P.v* iridis *in different suspension density of <aigae.*

1.	C. *gracilis*	2.5	45	232.2	59.00	202.00	104.50	22.60
		3.1	75	241.0	64.40	483.90	180.80	11.68
		2.2	200	250.0	60.00	1040.00	500 00	5.50
		2.4	500	128.0	58.80	1451.50	640.00	3 66
2.	*T. fiuviatilis*	2.5	7	278.5	22.50	26,24	19.50	46.16
		2.8	15	341.4	44.00	101.00	51.10	30.10
		2.1	40	252.0	53.10	141.80	92.80	27,24
		2.0	50	181.40	62.60	118.80	90.70	34.51
		2.0	100	157.50	6500	250.00	157.50	20.63
3.	*S. costatum*	2.7	10	155.5	36.30	5.60	15.55	86.54
		2.5	35	172 0	82.00	68.00	60.20	54.49
		20	60	149 2	81.00	98 80	89 50	45.25
		2.7	100	148.0	136.00	256 20	148.00	34.68
4.	*T. nitzsctioides*	2.4	6	108 0	10 08	5.00	6.48	6702
		2.0	15	122.5	16.60	7.90	12 25	67.76
		2.3	25	128,0	26.50	47.10	32.00	36.01
		25	55	92.2	25 00	102.OJ	50.72	1976
5.	*C, didymus*	2.1	3.8	1179	6.40	3.01	4 48	68.00
		2.3	8	129 9	10 90	12 00	10.39	45.61
		2.5	10	106.4	9.50	17 00	10.64	35.71
		2.5	25	83.5	14.50	37.70	20.83	27.78
6.	*S. tamesis*	2.0	1.8	131.7	3.80	0.94	2.37	80.16
		2.5	5	176.7	10.06	12.00	8.82	45.60
		2.6	7.5	182.0	11.85	24.32	13.65	32.76
		2.1	10	113.3	9.10	14.70	11.33	38.23

avoid diatom settling. The resulting concentration of the diatom suspension was determined by using haemocytometer for each 15 minutes intervel of feeding. In each 15 minutes after sampling, a new suspension of diatom was added to maintain the original concentration.

During the experiment the production of pseudofeces and feces were removed from the tank and collected in a beaker to minimize the chances of reingestion by the mussels. All the feeding in the laboratory at the room temperature of 28°C ± 2°C. The salinity of the feeding suspension was28±1°/oo' and the pH was 7.9 ± 02. The control cultures of diatoms of the same age kept in the experimental condition showed no growth in the experimental duration.

The collected pseudofeces were resuspended in known volume of sterile water and the cell numbers were counted. Then the total number of cells cleared from the suspension was calculated. The rale of filtration was calculated by using the formula F = R/C (Epifanio and Ewart 1977) where 'F' is the filtration rate in ml/h/g whole weight, 'R' is the mean number of cells removed from suspension per gram whole weight per hour and 'C is the number of algal cells per ml in suspension.

RESULTS

Rate of Filtiation

The total number of cells removed from the suspension appeared to be related to the size of the algal cells and the suspension concentration (Fig ') The filtration rate was high in small celled diatom suspensions and decreased towards the increase of diatom cell size. The maximum number of cells filtered in unit time was clearly less for the larger algae, *Streptotheca tamesis, Chaetoceros didymus* and

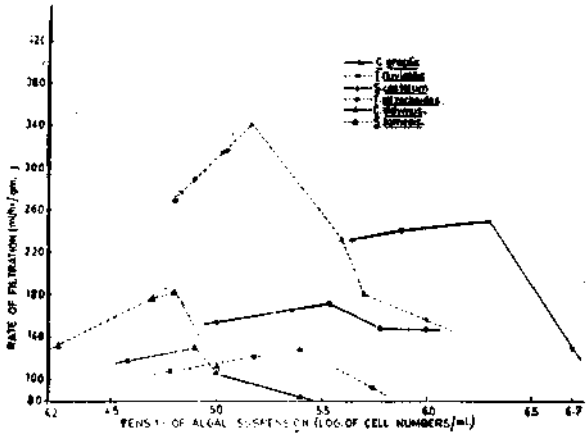

Fig. 1. Mean filtration rate as a function of density of algal suspension in P. *vindis.*

Thalassionema nitzschoides than the other three species (Table 2). The highest value of filtration density of 1.5x106 cells/ml of *Thalassiosira fluviatilis.* Rate of filtration was the lowest (83.5 ml/h/gm) when fed on *C. didymus* at 2.5x10« cells/ml. In all the algal suspensions, the filtration rate was relatively low in low cell densities and gradually incressed up to a particular concentration and then declined with the further increase of suspension concentration. A sudden decline of filtration rate was observed in *Chaetoceros gracHiis* and S. *tamesis* suspensions due to high suspension density [Table 2]. Eventhough fhe filtration rate was reduced with the increase of suspension density in all the experiments the number of cells removed per unit time increased with the increase of suspension density [Fig 2]. The following is the order of filtration rate observed for the six species employed: *T. fluviatilis* > *C. gracilis* > *S.tamesisySkeletonema costatum}C. didymus* > *T. nitzscftoides.* It is interesting to note that the rate of filtration of 5./a/WM/s was slightly higher than that of *S. costatum* eventhough the cell size of the former species is larger than the latter But the mean number of cells of S. *tamesis* removed by the mussel was lower than that of all the other forms.

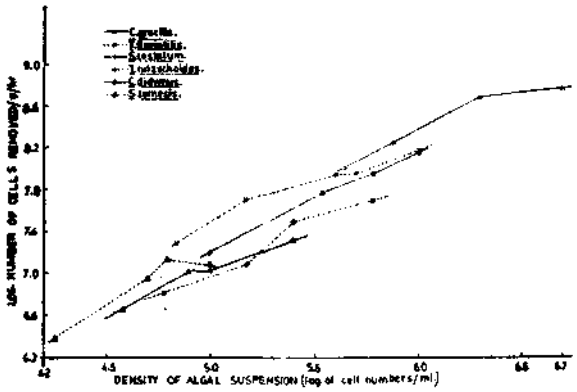

Fig. 2. Rate of removal as a function of algal suspension in *P. viridis*

Food Ingestion and Pseudofeces Production

The rate of food ingestion also varied with respect to the algal cell size and suspension density. In low Suspension density, most of the filtered cells were ingested and the vice versa was observed in high concentrations, The filtered cells rejected were eliminated as strings of pseudofeces. But in most of the cases the actual amount of cells ingested was "ot affected, by concentration. The least amount of filtered cells were ingested when fed on C. *gracilis.* More than 75% of the filtered cells were eliminated out as pseudofe. c^s even in the lowest suspension density [4.5 xlO"] and only 226% was ingested. The ingestion rate gradually decreased and only 3.66% was ingested at the highest suspension density [5 x 10» cells/ml]. The mean number of cells ingested by the mussel was more or less same (60.55 ± 2.6 x 10^ cells h) in all the suspension densities. More than 50% of the filtered cells of *T. fluviatilis* were ejected as pseudofeces and 46 16% was ingested at the lowest suspension density used. The pseudofecal production increased with the increase of suspension density and 20.63% was ingested at the cell density of 1x10^ cells/ml. The actual number of cells ingested by the mussel

was 22.5 X 10»/h and SSxIOo/hper animal a the lower and higher cell densities respectively.

The highest ingestion rate was observed when fed on *S. costatum.* In the lowest suspension density [1 x 10» cells/ml] 86.54% of the filtered cells were ingested. The remaining was [13.46%] ejected out as pseudofeces. But the percentage of ingestion was decreased to 34.68% in the highest concentration of alga, cells (1 X 10« cells/ml.) The actual number of cells ingested was more or less same in the concentrations 3.5x106 and 6 x 10^ cells/ml. But the values were slightly lower and higher in the extreme suspension densities.

The cells of the other 3 diatoms, *T. nitzschoides, C. didymus* and S. *tamesis* were effectively ingested at the lowest concentrations. Eventhough the cell sizes of these diatoms are larger than the other three, the ingestion rates were relatively high. As in other cases, the pseudofecal production was enhanced when the suspension density increased. Eventhough the number of cells removed from the suspension was increased with the increase of suspension density, the percentage of filtered cells ingested decreased. The mean number of cells ingested shows a complicated pattern with respect to the suspension density. The number of cells ingested by the mussel ranged from 10.08 x 10^ to 26.5 X 10« cells/h per animal in *T. nitzschoides,* 6.4 X 10« to 14.5 x 10« cellsyh per animal in *C. didymus* and 3.8x108 to 11.85 x 10" cells/h per animal in *S. tamesis.*

DISCUSSION

Rate of Filtration

As many workers have emphasized, the pumping rate in bivalves is a function of the concentration of particles present in the suspension. The present study reveals that the filtration was very much decreased due to the increase of suspension density and cell size. Mostly the diatoms of small cells were efficiently cleared by the mussel. When the cell concentration was low, the efficiency of retention was high. The retention efficiency mainly depend upon the cell size, suspension density and the relative effect of the bivalve. Loosanoff and Engle (1947) observed that the cells of flagellate *Euglena* of 60M. could easily pass through the gills, sometimes only 15% were strained from the suspension, and maximum retention was 80%. But the cells of *Chlorella* [5 (*] were retained by the gills, varyingly from 0 to 85%. Tammes and Oral [1955] observed widely varying retention of particles less than 30-40 *v*-by mussels. The retention efficiency of the mussel *I\/lytiius edulis* on blood corpuscles of 7-8/x varied from 0 to 98%. Jorgensen (1966) reported that very high concentrations can evoke supression or deterring responses in suspension feeders. Davids [1964] found a reduction in particle retention of mussels at concentration of */V/'fz5c/?/a* above 1 x 106 cells/ml. Epifanio and Ewart [1977] reported that the total number of cells removed from suspension was related to the size of the algal cells. They observed that the maximum number of cells filtered was clearly less for the larger algae than for the smaller ones. Further, they found that the rates of filtration was inversely related to the concentration of particles in suspension. However Ballantine and Morton [1956] claimed that *Lasaea rubra* cleared suspensions of *Chromulina pusiHi* (1 to 2 ^) and *Prorocentrum micans* (30-40(A) with equal rates independent of the size. The results of the present study closely agrees with the results of Epifanio and Ewart [1977].

Food Ingestion

Although there is considerable information concerning the filtration rates of bivalves, less is known about their actual feeding rates. In the present study, the results presented in the Table 2 shows that considerable amounts of filtered cells were ingested in low suspensions concentrations [Fig 3]. The ingestion rate was found to be high in S. *costatum* and low in C. *gracilis.* Considerable amounts of *S. tamesis* also was ingested. Matthiessen and Toner [1966] calculated that adult oysters growing near Martha's vineyard, Massachusetts could not possibly eat more than 1.1 xlO' algal cells/ animal/day. Tenore and Dunstan (1973) showed that both clams and oysters fed most efficiently at food concentrations of 2 x 10^ cells.ml.

Eventhough the filtration rate was affected by high suspension concentration, the actual

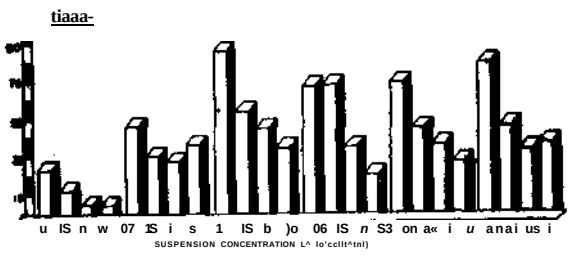

Fig 3 Number of cells ingested in relation to percentafle of total ceils filtered in *P. viridis.*

number of cells ingested was not affected (winter, 1973). The findings of the present study closely agrees with Winter's (1973) concept. The table 2 shows that the percentage of filtered cells ingested decreased with the increase of suspension, concentration, since copious amounts of pseudofeces were produced when the suspension density increased. It is evident that *Perna viridis* apparently have a maximum rate of ingestion in low cell concentration.

Some other factors also govern the ingest on rate of bivalves. Loos^noff and Engle(19l7) and Floyd (1953) reported that th"? depressed feeding rate of oyster on *Chlorella* was due to the external metabolites present in the filtrate. The absence of silt with the algal diet reduced the clearance rate and ingestion rate in *l\/lytHus edulis* (Kiorbe et al 1980) Walne (1970) found that the higher the concentration of *Dunaliella,* the lower the growth rate of oysters i e. the food ingestion was reduced The results of the present study shows that the number of cells ingested was slightly increased when the suspension concentration increased. In *T. nitzschoides,* the number of cells ingested was found to be doubled in high concentration. Navarro and Winter (1982) also observed similar results in *l\Aytilus chilensis.* In these cases, the digestion would be partial, and the high ingestion rate however counter balanced by a significant decrease in assimilation efficiency (Navarro and Winter 1982).

The differences in ingestion rate of various diatoms may be due to the nutritive value of the species and sorting mechanism of the bivalve. Loosanoff (1949) and Menzel (1955) described ciliary mechanisms which they believed may be responsible for sorting certain particles containing perhaps the more nutritious material in the food strained off the gill. Jorgensen (1949) found that when the rate of uptake of graphite suspensions of 4 to 5 (^ particle size was compared with that of flagellate cultures of *D. inornata* and */ galbana* of similar particle size, the filtration rate of flagellate cell was greater. However, the ingestion of palatable or nutritious particles may stimulate filtration. Epifanio (1979 b), and Romberger and Epifanio (1981) reported that the difference in growth rate in oysters when fed with various species of algae was due to the relative digestability of the algae. So it is believed that the mussel *P. viridis* is havir.g some selective mechanism to avoid less nutritive materials. The least ingestion rate of C. *gracilis* might be due to the poor palatable or nutritive quality of the species

Generally S. *costatum* and *T. fluviatilis* are considered to be good sou'ce of food to bivalves. The high feeding rate of *Perna viridis* on *S. costatum* proves the same. Tenor and Dunstan (1973 argued that the oysters fed on *Ttialassiosira pseudonana* a nd *Isoctirysis galbana* have grown well. This was due to the high rate of ingestion and assimilation. Ukeles and Wikfors (1982) reported that the growth of oysters was rapid when fed with *Thalassiosira.* Dean (1957) compared the food value of S *costatum* which field observations had indicated to be a good food to bivalves The present investigation also proved *S. costatum* as a good source of food to *P. viridis.*

The three species of diatoms 7'. *nitzschoides, C. didymus* and S. *tamesis* aslo seem to be equally good food source to *P. viridis,* fjnce the ceils of these forms also ingested considerably. Walne (1970) stated that with some variations, that algae which were good or bad foods for one species of bivalve ware of similar value to the other species of bivalves also.

Pseudofeces Production

All the particles filtered on the gill surface are carried by ciliary currents to the labial palps and so to the mouth or to the mantle edge to be rejected as pseudofeces, Table 2 shows that

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the production of pseudofeces increased with the increase of suspension concentration. Loosanoff and Engle (1947) using a continuous flow system, added *Chlorella* suspension to seawater and estimated that the pseuodfeces

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30 FISHERY AND BIOLOGY OF THE WINDOWPANE OYSTER *PLACENTA PLACENTA* L- IN POSHITRA, GULF OF KUTCH

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ABSTRACT

During April 1986 to March 1986 a preliminary survsy was undartaken to study fishary and b'ology of windowpane oyster in the Gulf of Kutch, covering three centres V|z. 1. Poshitra, 2. Goomara, 3. Raida. The population density was from 3 to 9/m2 at Poshitra, I6/m2 at Goomara and 2/m2 at Raida. Aspects of the fishery and biology of the windowpane oyster are dealt and suggestions for the management of the resource are made.

INTRODUCTION

In the Gulf of Kutch, extensive windowpane oyster beds exist in the Pindhara Bay, particularly on its Southern side. Horneil (1909) gave an account on the anatomy, distribution and utility of/'/ace/7tep/ace/7f«. Mosses (1938) dealt on the pearl fishery while Varghese (1976) and Sarvaiya (1982) described the windowpane oyster fishery of Pindhara Bay in the Gulf of Kutch. This study updates the information on fishery and biology of the windowpane oyster of this region.

MATERIALS AND METHODS

Temperature of the surface water was taken with a thermometer. Salinity was determined by Mohr method (Barnes 1959).

Observations were made on existing fishery. Survey of windowpane oysters was carried out by random quadrant method at three places viz. Poshitra, Goomara and Raida, A 1 m x 1 m wooden quadrant was used. Fifty or more or less quadrants according to the size of an area were measured and population from each quadrant was recorded, summed up, averaged and then population from different areas was calculated.

For biological study, windowpane oysters were collected by hand picking from the intertidal zones of Poshitra, Goomara and Raida. A total of 655 windowpane oysters of length range 7.5-16 cm were studied. They were measured antero-posterior direction for breadth and dorso-ventral axis for length. Weight was taken by weighing it on balance. A total 110 windowpane oysters were analysed for gut contents study, jhe gut contents of the oysters were preserved j^ 5 o^ formalin and examined under microscope A total 655 numbers of windowpane oysters were dissected for gonadial study, JVlorphological study of gonads was carried out by seeing colour and physical texture. For detail study, gonads were observed under microscope, Pests and commensals of oysters vvere recorded,

RESULTS AND DISCUSSION

Distribution

Windowpane oysters were available from Bey-Balapurto Sachana. (Hornell 1909, Moses ^938). In the present study it was observed that the natural grounds of the windowpane oysters are restricted from Poshitra to Chudeshavar, covering a coast line of 90 km. The extent °^ the Windowpane oyster bed at Poshitra, Goomara and Raida was observed at 20, 60 and 5 ha respectively. These days windowpane oyster fishery is extensively carried out at Goomara due to the richness of grounds there and also due to the limited natural stock at Poshitra region,

Besides, it was reported by fishermen that good quantities of windowpane oysters are available at Jakhau area.

Description of beds

The windowpane oysters inhabit muddy bottom of Pindhara Bay and near by areas. This area is shallow and horseshoe shaped. It is protected by contiguous elevated lands and plain salt pans, developed in Rann Bay. The bottom is an admixture of sand and clay particles. The oysters usually lie with their convex side resting on the substratum. The oysters occur from intertidal zone to a maximum 4m deep waters. The common fauna in the beds are the mud crab, *Scylla serrata,* gastropod, *Cerittiidea fluviatilis* and tube dwelling plychaete, *Eunice tublfex.*

Hydrography

Salinity of water over the windowpane oyster ground ranges from 30-37°/o„ and temperature 19°-33° C.

Observations on fistiery

General accounts of the windowpane oyster fishery of the Gulf of Kutch have been well documented by Varghese (1976) and Sarvaiya (1982). However, additional observations on fishery are discussed briefly hereunder. Windowpane oyster lease and leasee is fixed by Commissioner of Fisheries, Gandhinagar for a fixed period by accepting highest tender. Fishermen are drawn from Behan Bara, Nana Asota, Mota Asota, Ajad, Virpur, Pindhara, Gopi and Dwarka in addition to other centres, Koli Community is also involved in fishery. Camps are also established at Bhada, Kurchli, Pindhara, Goomara and Ajad. Materials like gunny bags, threads, bamboo poles etc. are supplied by the leasee for camp establishment. The fishery is throughout the year due to short period of lease and high tender. Fishery is started from 11th phase of moon. Kimarakot, Rozi, Raida, Chudeshvar, Ajad are fishing centres. Monthly 50 lakh oysters are exploited 7.5 cm (5%), 7.5-10 cm (20%), 10-12 cm (39%) and 12-16 cm (36%) are sizes of oysters harvested commercially. Thus, it was observed that 25% oysters exploited are undersize against the size (11.4 cm) prescribed by Fisheries Dept.

Payment at the rate of Rs 18-20/g of pearl dusts is made to fishermen in cash on every fortnight after weighing pearl dusts at different camp sites on 6/7 phase of moon. Similarly to machhawa owners at the rate of Rs 300-375/ fortnight. No payment for shells is made to fishermen.

Since the last few years oyster tender, collection of pearl dusts and shells collected commercially are recorded increasingly.

Fishing craft

Local machhawas are used for the transport of men from camp sites to fishing grounds and then back to bring their catches. These are non-mechanised sailing boats, Overall length of the boats ranges from 6- 8.5 m and breadth from 1.70-2.40 m. Besides, many fishermen use wooden contaptions of 0.70-0.80 m x 0.90-1.5m for propulsion in the mudflats.

Fishing gear

Fishermen collect windowpane oysters by hand-picking in shallow water and by diving and hand picking in deeper waters.

The catch is emptied into a bag known as "Gumbha". It is approximately 0.60-1. m in length and 0.76-0.91 m in width with mesh size of 3"-4" and made of monofilament.

Survey of Placenta placenta *beds*

At Poshitra different sites covering 20 ha were surveyed and the windowpane oyster population was estimated at 12,00,000 numbers. The density varied from 3-9 no/m^ with an average of 6 m^.

At Goomara, survey of 60 ha was undertaken during December and the windowpane oyster population was estimated at 90,00,000 giving a density of 15/m2. During survey it was observed that the number of dead shells of young windowpane oysters was thrice the numbers of live oysters.

At Raida, 5 ha area was surveyed and the total population was estimated at 1,00,000 giving a density of 2/m2. The low density was due to heavy exploitation.

Biology of windowpane oyster

Length - weight studies

The length-total weight relationship was derived by using the formula W= (A) (Bx), where W is the weight of the oyster in g, B is the length in cm, and A and X are constants. The logarithmic transformation of the formula gives a linear regression. The constants A and X were estimated by the usual method of least squares. The relationship is given by the following equation.

Log T. W. = — 2.0809 + 2.2516 log L

Similarly the length-animal weight relationship is given by the following equation.

Log A. W———1.9303 + 1.9762 Log L

Length-breadth studies

The length-breadth relationship is given by the following equation.

Log B = 0 4471 + 0.9249 log L

Based on the growth data given by Pearson (1912) the age structure of the windowpane oysters show that they are 5-27 months old and 7-11 month old oysters were dominant.

Gut contents

Phytoplankton namely *Nitzchia* Spp, *Navicula* Spp, *Pleurosigsma* spp, *Chaetoceros* spp. and *S/ceietonema* spp were observed.

Conadial study

It was noticed that the windowpane oyster is diacious. In each sex, the gonad appears as regular mass of yellowish tissue largely covering the organs of alimentary canal.

The gonad in the male appears smaller than in the female. Morphologically sexes are distinguished by colour when viewed against light. Male gonad is soiled yellow whereas female gonad appeared orange. Eggs are orange yellow and measure almost 45 *v-m* in diameter.

Mature males were observed from June to March (Table-1). Majority were nwture during September-December and then the number decreased from January-March.

TABLE 1. *Showing gonad study*

Sex and Maturity	Apr. 1985	May	Jun,	Jul.	Aug.	Sep.	Oct.	Nov.	Oec	Jan. 1985	Feb.	Mar.
MALE												
1. I mature	74%	76«/o	-									
2. Partialy mature	26o/o	24%	20%		-	24%	-	-	-	-	-	_
3. Mature			44%		57%	53%	79%	67%	73%	41%	38%	22%
4. Spent		-	26%		43%	23%	21%	33%	27%	59%	62%	78%
FEMALE												
1. Imature	50%	30%										
2. Partialy mature	50%	50%	33%	-								
3. Mature		20%	67%	-	**67%**	**60%**	**67%**	**67%**	**66%**	**38%**	**30%**	**20%**
4: Spent					33%	-	33%	33%	34%	62%	70%	80%

Females were mature during May-March. : However, majority were mature during August-December and their number declined in the following 3 months. These observations are generally in agreement with the spawning period mentioned by Hornel! (1909) and Mosses (1938).

First maturity observed at the 11th month age (Length 108 cm) of windowpane oyster. Age is derived by following Pearson (1912) length-breadth relationship with age.

Pests and commensals

The polychaetes, *Polydora* and *Eunice tubifex* and rock oyster, *Saccostrea cuculata* were found on the shell surface of windowpane oysters. The crab. *Pinnotheres placunae* is present in the body of windowpane oysters and is a commensal (Hornell and Sohthwell1909).

SUGGESTIONS FOR THE MANAGEMENT OF THE RESOURCE

1. Majority of males and females were mature during Sept-December. They should not be exploited during peak breeding season.

2. Undersize oysters below 11.4 cm were fished out in large quantities (25%). It should be stopped Even if they are harvested, they should be relaid with the convex side downwards in the fishing ground.

3. Present study reveals that windowpane oysters occur in between Poshitra to Rozi point (near Chudeshyar). They should be transplanted to nearby areas in order to establish new beds.

4. Before leasing out windowpane oyster fishery, a spot survey should be undertaken to estimate the abundance of oysters in the beds.

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31. REPRODUCTION IN EDIBLE BIVALVE SHELLFISHES OF RATNAGIRI COAST

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ABSTRACT

Clams, oysters and mussels are regularly fished and marketed at different places in Ratnagiri district throughout year, rarely in peak of monsoon. The annual reproductive cycles of three species of edible clams *Paphia laterisulca, Katelysia opima* and *Meretrix meretrix,* the oysters *Saccostrea cucullata* and C. *grypholdes* and the green mussel *Perna virldis* of the Ratnagiri coast have been studied. Maximum gonad index occurs during June-August and November-February in *P. laterisulca,* June-September and January-February In *K. opima* and February-August In *M. meretrix.* The histological studies revealed spawning m *P. laterisulca* during mid September-Match with two peaks • once in October-November and another In February-March. Spawning in *K. opima* occurs during October-November and March-April. *M. meretrix* spawns only during October-November. S. *cucullata* spawns during October-January, and C, *grypholdes* during October-November. *P. virldis* spawns during late July-early September. The difference In such spawning periods of these shell-fishes have be°n attributed to the change* In salinities in the respective habitats with the secondary cffecta of temperature on the gonads- The results are discussed in the light of species adjustment to the fluctuating environment and biochemical-phyiiology,

INTRODUCTION

Research work on the biology and fishery of edible bivalve shellfishes contributing to the substantial catches was started comparatively recently in India. There have been considerable preliminary and some detailed investigations on various species of local importance, and the results obtained are of some help to make effective attempts in management and conservation measures. Some of the notable contributions from various parts of the Indian coast are on clams (Rao 1952; Abraham 1953; Durve 1964a; Alagaraswami 1966; Rao, 1967), on mussels (Paul 1941; Jones 1951; Rao et al 1975), and rock oysters (Paul 1942; Venkataraman and Chari 1951; Rao 1951,1 956, Rao and Nayar 1956; Durve and Ball 961; Durve 1964b, 1965) and on cockles (Narasimham 1969).

Along the coast of Maharashtra State with its vast coastal areas and creeks, muddy bays, rocky inshore regions, estuaries and backwaters, edible shellfishes are common and offer an attractive field for fishery enterprise. Clams, oysters and mussels form regular fishery of considerable local importance along the coast. In Ratnagiri, along the coast. the following species of bivalve shellfishes are fished throughout different seasons.

the clams — *Paphia laterisulca, Katalysia opima* and *Meratrix meretrix'.*

the oysters — *Saccostrea cucullata* and C. *grypholdes:*

the cockles — *Anadara granosa.*

The Kalbadevi, Sakhartar, Sh.rgaon and Bhatiaestuar.es and creeks, and Ratnagir. bay on the outskirts of Ratnagiri are excellent shell-

Considering the abundant distribution and local market in Ratnagiri we have undertaken to study several aspects of eco physiology and neuroendocrinology of these shellfishes since ^g-^Q (pjagabhushnam et al., > 1972; Mantale ^^ g, 1972; Nagabhushanam and Mane 1973, .,975 1973; Mane 1974 a, b, 1975 a, b, 1978; Mane and Nagabhushanam 1975, 1976, 1979, 1983; Mane and Bidarkar 1976; Talikhedkar et al 1976; Mane and Dhamne 1980), Here we report comparative data on the reproductive biology of these edible shellfishes from Ratnagiri coast,

MATERIAL AND METHODS

P. laterisulca (35-45 mm), *K. opima* (32-37 mm) and *M. meretrix* (45-50 mm) from Kalbadevi

estuary, C-cucw//«fa (35-40 mm) from Shirgaon creek, C. *gryptioides* (80-90 mm) and *P. viridis* (70-80 mm) from Bhatia creek were collected monthly at regular intervals. The gonads of the animals were fixed in Bouin's fluid and histological sections taken as described elsewhere (Mane 1973; Bidarkar 1974). The gonads of the clams, *P. laterisulca, K. op/ma and M meretnx* were studied by the determination of gonad indices by volume displacement method or on wet weight basis (Giese 1969). During the collection of shellfishes from the respective beds salinity and temperature data were collected.

RESULTS

The shellfish in spawning condition are plump and in prime condition for use. After spawning the gonad is much reduced in size and once again occupies much of the visceral mass. Thus it is natural that as the size of the gonad increases with the ripening of the sex products, the gonad is expected to vary in size and weight. Therefore, the gonad indices have shown that the maximum increase in the index occurs from June to August and again from November to February in *P. laterisulca,* from June to September and January to February in *K. opima,* and from February to August in *M. meretix.* In the other periods the index for each species remains low (Fig. 1).

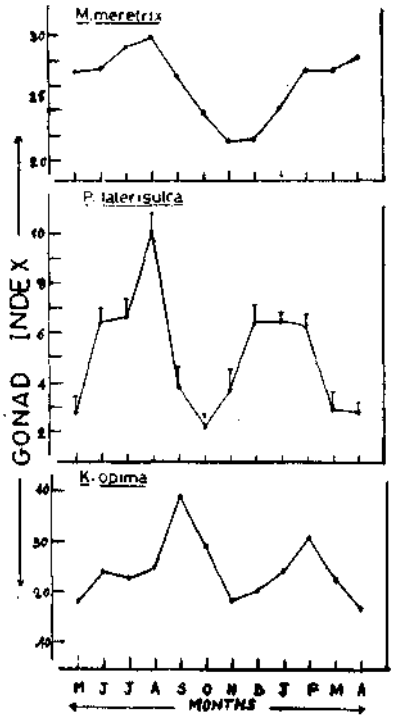

Fig. 1. Variations In the gonad indicM of the clams from Kaibadevi estuary, Ratnagiri.

. , u ^

The histological preparations of the gonad tissues of each species show following conditions:

^ Spawning in this clam starts ^^^^ ^^^^^^^ representing partial shedding of ^^^ ^^^^^^^ ^^^ .^ November spawning is more ^^ ,^^^ complete as majority of the clams have 3,^^^ gametes showing spawned-out condition ^^ ^^^ g^^^^g ^^^^ unspawned gametes left in the follicles after spawning undergo cytolysis ^"'^ ^^^ follicles start budding young developing sex cells in December. From the beginning of January till February few clams show active gametogenetic activity in gonads. A part of population reaches mature condition in March and begin to spawn till April. Those spawned show cytolysis of unspawned gametes. From June to September the gonads show development of the sex cells in follicles. Later almost all clams become sexually mature and ready to spawn in October,

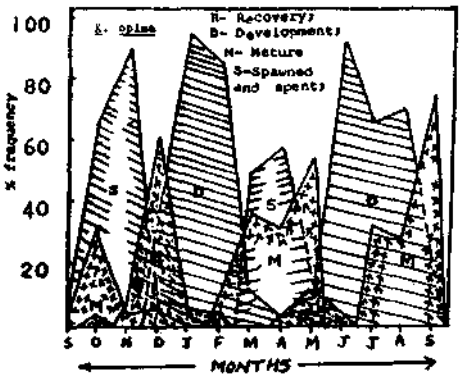

Fig. 2. Ssasonal gonadal changes In K, *opima.*

P. laterisulca (Fig. 3) This clam has a prolonged spawning season extending from mid September to the end of March with two peaks - one in October-November and the other in February-March. Active gametogenesis takes place in May and June, and by the end of June the whole population reaches peak of maturity which is maintained till mid September. The spawned out individuals from the first peak immediately enter into a phase of redevelopment in December and attain maturity within 4 to 6 weeks i. e. upto January. A few clams Continue to spawn in December and January but at low intensity

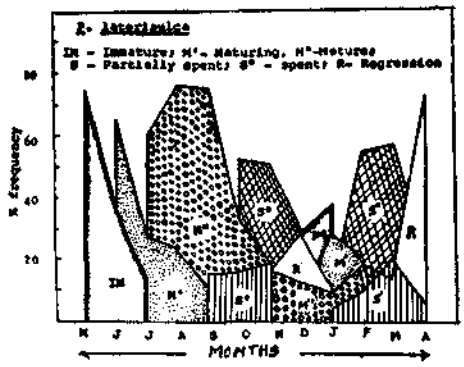

Fig. 3. Seasonal gonadal changes in *P. laterisulca*.

and immediately after spawning they enter into a phase of rematuration. After second peak of spawning majority of the clams pass into recovery condition in April before entering in gametogenetic activity.

M. meretrix (Fig. 4) Immediately after the close of monsoon i. e. in September the clams begin to spawn and majority of the clams are spawned-out in October and November. After the spawning, the gonads undergo recovery representing the cytolysis of unspawned gametes left in the follicles. Gametogenetic activity in the

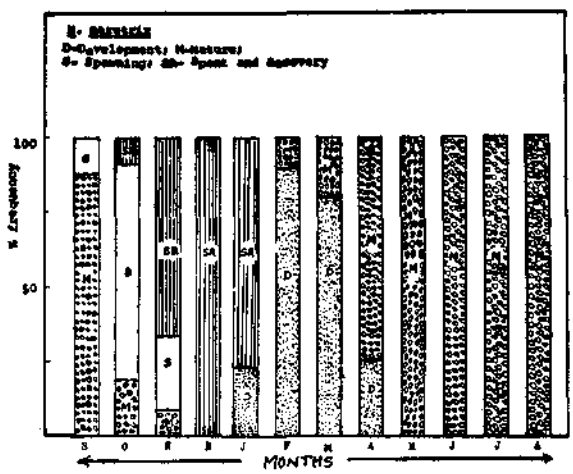

Fig. 4. Seasonal gonadal changes in *M. meretrix*.

gonad tissue begins in January and continues till February. Further development leads to the mature condition of the sex products in April. The clams maintain this condition till August end, i. e. throughout the monsoon and begin to spawn in September.

C. cuculiata (Fig. 5) After completion of spawning in January, both the sexes pass in to recovering stage. The follicles begin to shrink in size and get replaced by the connective tissue in February. The phagocytic cells appear in large number within the follicles. The follicles disappear rapidly and the gonad tissue enter neutral condition (difficult to differentiate the sexes) in March. When the reorganization of the gonad tissue begins, a few oysters in April show reappearence of the follicles with stem cells which are going to develop the young sex cells. The gametogenetic activity continues in May and June and in July both the sexes become sexually mature showing follicels fully

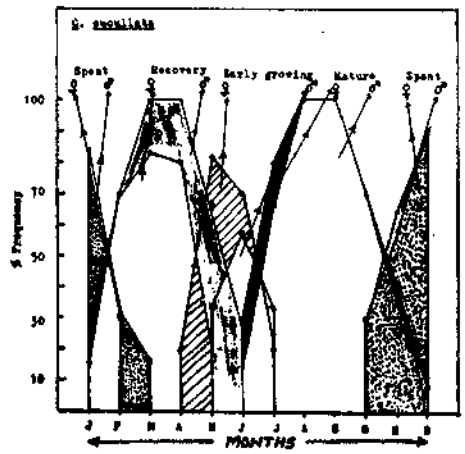

Fig. 5. Seasonal gonadal changes in *C. cuculiata*.

enlarged and packed with reproductive elements. The interfollicular vesicular tissue as well as the connective tissue between the gonadial layer and the gut are reduced to the bearest minimum. In some of the oysters maturing condition still persists showing continuous budding of the sex cells. In August and September both the sexes remain in mature condition and almost entire population becomes sexually mature. Spawning begins in October, a few oysters showing partially spawned-out condition of the gonad tissue. From November onwards till January many oysters spawn showing spawned-out condition. Immediately, after spawning, the sign of disintegration of the reproductive elements appears in the population of the oysters in February. This ultimately leads to the neutral condition as described earlier.

C. fifAyp/»o/£/es (Fig. 6) Most of the oysters become sexually mature in June but still in a few oysters the gametogenetic activity progresses. Gradual development leads to the extensive proliferation of the follicles accompanied by rapid growth of the sex products in large numbers. By July all the oysters reach a fully mature condition which is maintained

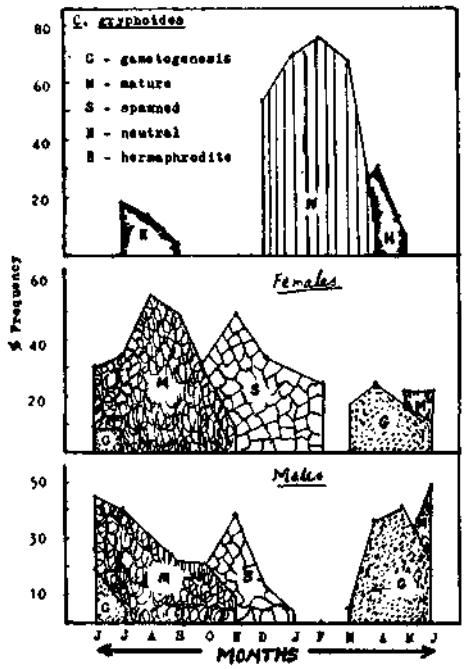

Fig. 7. Seasonal gonadal changes in C. *gryphoides.*

till September. During mid-monsoon (first fortnight of July) a few hermaphrodite individuals appear. The germinal epithelium proliferates fresh oogonia in all the follicles and lumina contain almost ripe sax products. Spermatogonia and spermatocytes are not seen. In a few oysters, the follicles contain maturing oocytes and traces of mature sperms in the lumen of the follicles. Thus, hermaphroditism inthis oyster is regarded as the transitional phase m the change of sex from male to female. immediately, at the close of monsoon (in the first fortnight of September) a few oysters begin to spawn. More than half of the population spawns in October. By November oysters spawn more or less completely. From the first fortnight of December the follicles and the gonad ductules start shrinking considerably. The vesicular tissue cells surrounding the follicles become large, flattened and bladder like with hyaline cytoplasm but some of them close to the follicle walls and the walls of the ductules are much condensed in size. The cells in amoeboid form with granular cytoplasm take up phagocytic function. These cells infliter through the walls of the follicles and accumulate in large number within the lumina. With subsequent development in the gonad the oysters pass to neutral condition (difficult to differentiate sexes) in February. Indistinguished sexes at the early gametogenetic activity appear in the first fortnight. During the second fortnight sex differentiation is marked by the slight expansion of the gonad tissue and appearance of oogonia and spermatogonia in females and males, respectively. With the development of the sex products, the gonads of the oysters become fully mature by May. Few females show unspawned eggs in February. The relict female gametes instead of undergoing resorption still remain in the lumina of the follicles and the follicle walls start proliferating fresh oogonia i.e. the sex products of the opposite sex which in turn, by series of divisions, give rise to spermatocytes and spermatids. In April these hermaphrodites occur in the samples and show gradual degeneration of unspawned sex products in follicles. It can be said that as spawning in female oysters is either late or prolonged (in partial State) and the vigourous differentiation of the male phase (some what premature) results in the occurrence of bisexual condition. In this hermaphroditism the change of sex is from female to male,

p ^j„-^/g (pjg 7) j^e disintegration of the unspawned gametes of the previous spawning ^tgrts in March showing recovery in gonad, *j^^^* characteristic of sex differentiation is lost 3,^ the follicles begins to shrink in size. They 3,3 simultaneously replaced by the developing . . r.u . • • connective t.ssue. Phagocytes appear m large """"er w.thm the follicles. Thus the follicles fapidlv disappear and the mussels enter in neutral stage. Most of the mussels are in neutral stage in April. In May very clear hermaphrodites are seen. The histological sections show well developed ova and sperms. In the sections of one of the mussels the gonadal follicles close to the periphery have shown large ripe ova, oogonia and developing ova of small

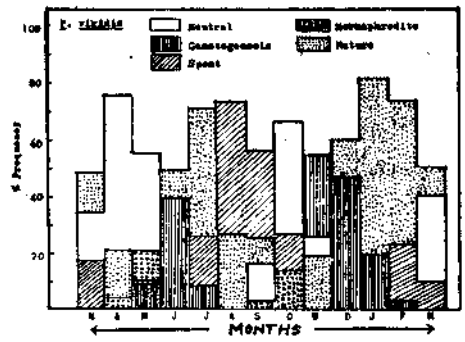

Fig. 7. Seasonal gonadal changes in *P. viridis*.

size in connection with the follicle layer. In the deeper regions the ova gradually diminish in size. The germinal cells actively proliferated fresh oogonia in all the follicles. The lumen was almost packed with well developed spermatozoa but there were no spermatocytes close to the follicle wall. In the sections of other few mussels, the formation of ova had taken place to a greater extent than in the proceeding one. Well developed ova were seen not only alog the peripheral region but also deeper down the follicles. The sperms were either altogether absent as in the follicles of the top layers or very sparse deeper down the follicles. The active proliferation of the female sex cells and the entire absence of the fresh spermatocytes in these mussels show that the change of sex is from male to female. The rare occurrence of the individuals with the reproductive elements of both the sexes is an indication that hermaphroditism is not a regular feature. As the germ cells stop proliferating components of one sex and give rise to those of other sex, hermaphroditism is said to be a purely transitional phase. Gametogenetic activity in males commences by about end of May and in females by beginning of June. It reaches its peak in both the sexes towards the end of June resulting rn full ripe gonad follicles. In the beginning of July the gonads of both the sexes become fully enlarged and packed with reproductive elements. The interfollicular vesicular tissue as well as the connective tissue betweenthe gonadial layers get considerably reduced. By third week of July spawning commences. A few partially spent oysters show shrinking of gonad follicles and the vesicular tissue surrounding them enlarges Within the follicles small amount of unspawned gametes are retained. Samples collected subsequently during August and early September showed increasing number of fully spawned-out mussels. In late September and October for the second time the disintegration of unspawned gametes takes place, vary similar to that had taken place in early summer, resulting in occurrence of large number of mussels in neutral stage. Few mussels in hermaphroditic condition are observed in late October. The presence of large unspawned eggs in the lumen of the Collides and numerous spermatogonia along */\® follicular wall suggest a change of se;^ from female to male. Reorganization of gonad tissue starts by the beginning of November with very fapid proliferation of oogonia in some and spermatogonia in others. Asa result follicles are found to spread out and the vesicular tissue reduces leading to mature condition of the sexes The number of fully ripe males and females increase in January. In February a few mussels show the beginning of spawning showing the occurrence of partially spawned-o"* males and females. This spawning can be said to be a minor one since only a few mussels >n the population release gametes partially In March disintegration of the reproductive products begins in the population of mussels leading ultimately to the condition described earlier in March,

USSION

From Indian waters both continuous and discontinuous spawning seasons in bivalves have been reported and regarding the nature of their reproductive cycles even the same species from one locality is known to differ from those of different locality in their reproductive seasons. For example, *Meretrix casta on* the east coast spawns twice in a year during April-May and again in September (Hornell 1922). whereas the same species spawns several times in a year in Adyar estuary (Abraham 1953) and Mandapam Camp (Durve 1964a). On the other hand, another species *M. meretrix* in Kalbadevi estuary, Ratnagiri,

along west coast begins to spawn in September and continues till November (according to the present study). *Donax cuneatus* on Madras coast and those in the Palk bay has only single reproductive cycle, although in the former locality the breeding is relatively much longer (Nayar1955). In contrast to this, Rao (1967) in the same wedge clam reported prolonged spawning from January to June on Madras coast. Alagaraswami (1966) in *Donax faba* also reported prolonged spawning on Mandapam Camp coast. *Donax cuneatus* in Mirya Bay (Talikhedkar 1975) shows close similarity in the reproductive cycle with the same species in Palk Bay (Nayar 1955) and on Madras coast (Rao 1967), although the clams from later locality are known to breed for a much longer period. \n *Katelysfa op/ma only one* spawning season occurs in Adyar estuary, Madras (Rao 1951) but the same species in Kalbadevi estuary, Ratnagiri spawns twice in a year.

One of the most important questions in the problem of reproductive cycles is, what mechanism regulate gametogenesis and spawning in Indian marine bivalve molluscs? The studies on the environmental factors, like salinity and temperature in the reproductive study areas by the above workers and many others have shown that under tropical conditions of Indian coast, the water temperature does not fall as m temperate waters and the temperatures remain comparatively high throughout the year except for few degrees drop in winter. The complex of physical variables in the environmem influence and the timing of events in the reproductive cycles of marine invertebrates .s well documented (G.ese 1959). In terriperate regions gonad development and reproduction in marine bivalves have been correlated with the wide range of temperature fluctuations (Posgay 1930; Loosanoff and Nomejko 1951; Loosanoff and Davis 1952; Dickie 1953; Wilson and Hodgkin 1967). On the other hand, in tropical regions the reproductive cycles of many marine bivalves have been correlated with fluctuations in salinity (Paul 1942; Rao 1951; Durve 1965; Alagaraswami 1966).

The low salinity in monsoon in Kalbadevi estuary affects the activities of the clams. The filtration rate and oxygen consumption decrease because for most of the period tliey remain with shell valves closed, though they could tolerate considerable low salinity in monsoon than summer (Mane 1974a, 1975a, b; Dhamne and Mane 1976; Mane and Dhamne 1980). Due to unfavourable conditions gametogenesis and maturation take place at slow rate, and through monsoon the gonads of the clams reach plump condition. As the salinity of the estuary increases with the temperature after the close of monsoon, the plump clams receive favourable environment and spawning begins. Spawning continues till almost all the gametes are released, With further increase in temperature and salinity followed by rematuration process in the later season the gonads of clams reach plump condition in early summer - the period when the clams are subjected to optimum temperature when spawning begins. It is of course very difficult to determine all the environmental factors con-^'°^^""Q ^he reproduction in bivalves in natural conditions, but it is the salinity change playing an important role in determining the physiolog'^a' activity of the clams with other factors counteracting on them.

Regarding oysters from Indian coast, the first record by Hornell (1910) showed that spawning in Madras back water oyster coincides ^.^^^ ^^^^^ ^^j^^^,, ^^ ^^^ north-east monsoon which begins in October. Later in 1921, he suggested that as the rainy season differs on the two coasts of India, there is a corresponding divergence in the spawning maxima (Hornell 1922,. R30 (1951, 1955) found the optimum ^^y^^.^^ requirements of 22.26°Uor the develop-^.ent of eggs under laboratory conditions and f.^her confirmed this by field observations. He ^^^^ suggested that the spawning in C. *madrasens/s* does not take place unless the optimum Salinity IS reached by the influx of rainwater, by the evaporation of sea water or by the opening ofthebar in Ennore backwater. In 1951, he indicated that besides the attainment of the salinity to the optimum level, there may be other unknown environmental factors or the presence of some suitable chemical influencing spatfall in case of *C. madrasensis.* Durve (1965) observed that spawning in *C. gryphoides* in

Kelwa backwaters, Bombay, did not take place at 28.58°/oo but following heavy rain the salinity decreased to 13.15 7„„ and the oysters began to spawn in July. He considered that the optimum level of salinity reuqirements for spawning in C. *gryphoides* might be between 28.58 and 13.15°/„o and as the spawning season advances (in monsoon) the oysters become more responsive to stimulation and spawn even in lower salinities than in the beginning of the spawning but the reason for this, he was unable to ascertain. His observations have further shown that spawning in females was more related to the lowering of the salinity than in males, as the females spawned earlier than males, which spawned till November when the salinity increased appreciably. According to our present findings, C. *cucullata* in Shirgaon creek spawns with the rise in salinity (after rainfall) and moderate temperature. The spawning reaches its peak in November and December. In February and March with the rise in temperature and salinity, the spawned out gonads recover at a faster rate and gametogenesis proceeds actively to reach mature condition by July. This condition is retained till the close of monsoon. The present findings on *C. gryphoides* in Bhatia creek shows difference in the spawning periodicity from that of the same species in Kelwa backwater on Bombay coast. This may be due to the physiologically different races of the oysters along the west coast, as suggested by Loosanoff (1933) for C. *virginica* from Long Islands Sound and Texas. During August the salinity of the Bhatia estuary lowers as much as 18°/„„ at which time *C. gryphoides* do not show any spawning activity. Further in September as the salinity raises to 23.5 7^„ spawning commences and continues till November with the rise in salinity to 28.7 7oo at the time majority of the oysters spawn. Those oysters, in particular females, which have spawned in late October do not spawn any more in December when the salinity increases to 31 7oo and the temperature of the water increases. Thus it can be seen that spawning in these oysters takes place only when the salinity ranges between 23.5 to 31 7„„. Regarding the temperature of the creek water, the fluctuation is ony between 22" to 33° C the lowest being in January and highest in May. During the spawning period (from September to November) the temperature fluctuates from 27° to 28.5°C and during the course of prespawning, at the time when all the oysters are fully mature, the temperature ranges from 29°C in June and 26.5°C in August. This indicated that temperature might not have any influence on maturation and spawning in these oysters. These observations are in agreement with the earlier findings of Rao ^'951; on *C.madrasensis* of Madras and of Durve ^1965^ on *C. gryphoides* from Bombay coast.

Thus once a shellfish population has reached maturity, spawning may be triggered through interaction between the organism and external factors that induce gamete release, if all mem. bers of the populations are mature and react simultaneously to the factors inducing spawning, gametes may be released synchronously and a short breeding period results (in oysters, Rao 1956; Durve 1965; in mussels, Parulekar 1982; from present study). Therefore, synchrony in spawning appears to depend on a critical state of maturity within an individual and among members of the population, as well as their representatives to the exogenous factors inducing gamete release. Once animals are mature a variety of factors seem to induce spawning.

Studies on *Perria viridis* from Goa coast by Rao (1975) have shown that in the green mussel breeding takes place throughout the year with maximum larval abundance in October and November and with lesser abundance again in March. Our study on green mussel from Bhatia creek indicates spawning from July to early September. The mussels on Goa coast also spawn during this time. Since many mussels in Bhatia spawn during this period they pass in to neutral stage in the subsequent period. Those mussels reaching fully mature condition in the gonads in January respond to high salinity and temperature, and spawn from February to beginning of March. Many mussels fail to spawn perhaps due to considerable increase in salinity and temperature unfavourable to them to spawn. On the Goa coast the temperature of the sea water is somewhat lower in summer than at

Ratnagiri though the salinities in both the areas remain high. The study by Rao (1975) on Goa coast is based on the older and younger mussels of the population separately. They have found restricted breeding in both; in older ones taking place from July to December and in smaller ones from January to April. Thus the population as a whole, the mussels on Goa coast are said to have breeding almost round the year with maturation process continuing almost simultaneously. In our study only the adult mussels belonging to 70 to 80 mm in shell length have been studied. It would be interesting to study breeding in the older and smaller populations of mussels of Ratnagiri coast separately.

However, the physiological variations in populations of a species exposed to different environments could either be a phenotypic response of a single genotype or could be truely genetic (Prosser 1955). Comparision of physiological responses of geographically separated populations of marine animals have shown variations in the adaptive capacity but in many cases the difference has been phenotypic. Hence variations in the reproductive activity, if any, may therefore be adaptive for continuity of populations in geographically separated areas. Spawning is a protracted process in a number of species of bivalve shellfishes. Several peaks within breeding periods lead to an extended breeding seasons. When different age groups in a population spawn at different times, an extended breeding season is observed. More data on the influence of various exogenous and endogenous factors controlling gametogenesis, growth and maturation of gonads and spawning are needed to understand the reproductive cycle.

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32. REPRODUCTIVE BIOLOGY OF THE WEDGE CLAM, *DONAX CUNEATUS* LINNAEUS

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ABSTRACT

Donax cuneatus **of Madras coast has a distinct annuai reproductive cycle. Almost In all tha clams the gametoganic cycle starts in November-December. Spawning commences in February and extends upto July with intermittent extrusion of gametes. Subsequent to spawning, the Initiation of gimetogenesis does not commence immediately but begins after a distinct inactive period of three months. Temperature and salinity influence the breeding of the clams.**

INTRODUCTION

The reproductive biology of marine molluscs has been studied in India extensively during the last three decades. Though considerable work has been done on the gametogenesis of a few commercially important bivalve molluscs such as edible oysters, green mussel, clams like /Were-*trix casta and Katelysia opima* (Rao 1950, 1956; Durve 1964, 1965; Rao 1975). Our knowledge on the reproductive biology of the genus *Donax* is scanty. Nayar (1955) has made observations on the stages of maturity and breeding of *Donax* cwneafus of Palk Bay. Alagarswami (1966) has studied in detail the reproductive cycle of *D faba* of Mandapam coast and Rao (1967) of *D. cunea*-rws of Madras coast. In this work Oonax cunea-fws were collected from three places along Mad-ras coast and the annual reproductive cycle studied.

MATERIAL AND METHODS

To study the reproductive cycle of *Donax cuneatus,* samples were collected on fortnightly intervals from three stations namely Marina, Thiruvaniyur and Mahabalipuram along the Madras coast. Following collection, the clams werebroughttothelaboratory, shucked and the soft bodies were taken out. After noting the macrostructure of the gonad, the sex and stages of maturity were ascertained by examining fresh smears of gonad under microscope. Gonadal tissues were fixed in Bouin's fixative and 10% neutral buffered formaldehyde. It was then processed for paraffin embedding. The sections were cut at 6m thickness and were stained in Ehrlich's haematoxylin and counterstained with ^^^.^ J^^^ gametogenic cycle of *D. cuneatus* ^^g j^^j^^^ j^^^^^ ^^ ^^^^ ^^.^^^.^ ^^^p^^^ ^^ Tranter (1958), Alagarswami (1966), Rao (1967), Dinamani (1974) and Nagabhushanam and Talikhedkar (i977). in all, a total of 6116 clams were examined and studied for the reproductive cycle.

RESULTS

|^ £, *cuneatus* from the histological examination of the gonad five stages of development could be distinguished (Pi. 1, 2, and 3). The criteria by which these stages were defined are gjven in Table 1. in stage la (early active phase) the gonad is small, inconspicuous and colourless In stage I b (late active phase) the gonad become slightly larger in size, thick and firm, jj^e gonad is colourless and transparent. In stage II (Ripe phase) the gonad is full and plumpy and attain the maximum size, creamy in colour with very little connective tissue sorrounding it. In stage 111 (Post spawned phase) the gonad is f'abby, loose in consistency, slightly greyish in colour and few phagocytes are present among gonadal cells. In stage IV (Spent phase) the 9°"^^ is transluscent and shrunken. Relict oocytes and phagocytes are present. In stage V (Indeterminate) the follicles are completely collapsed. Sex cannot be differentiated by smear examination.

Annual reproductive cycle

The percentage frequency of gonadal phases in different months was observed in males and

TABLE 1. *External features, histological and cytological details of gonadal phases in* Donax cuneatus

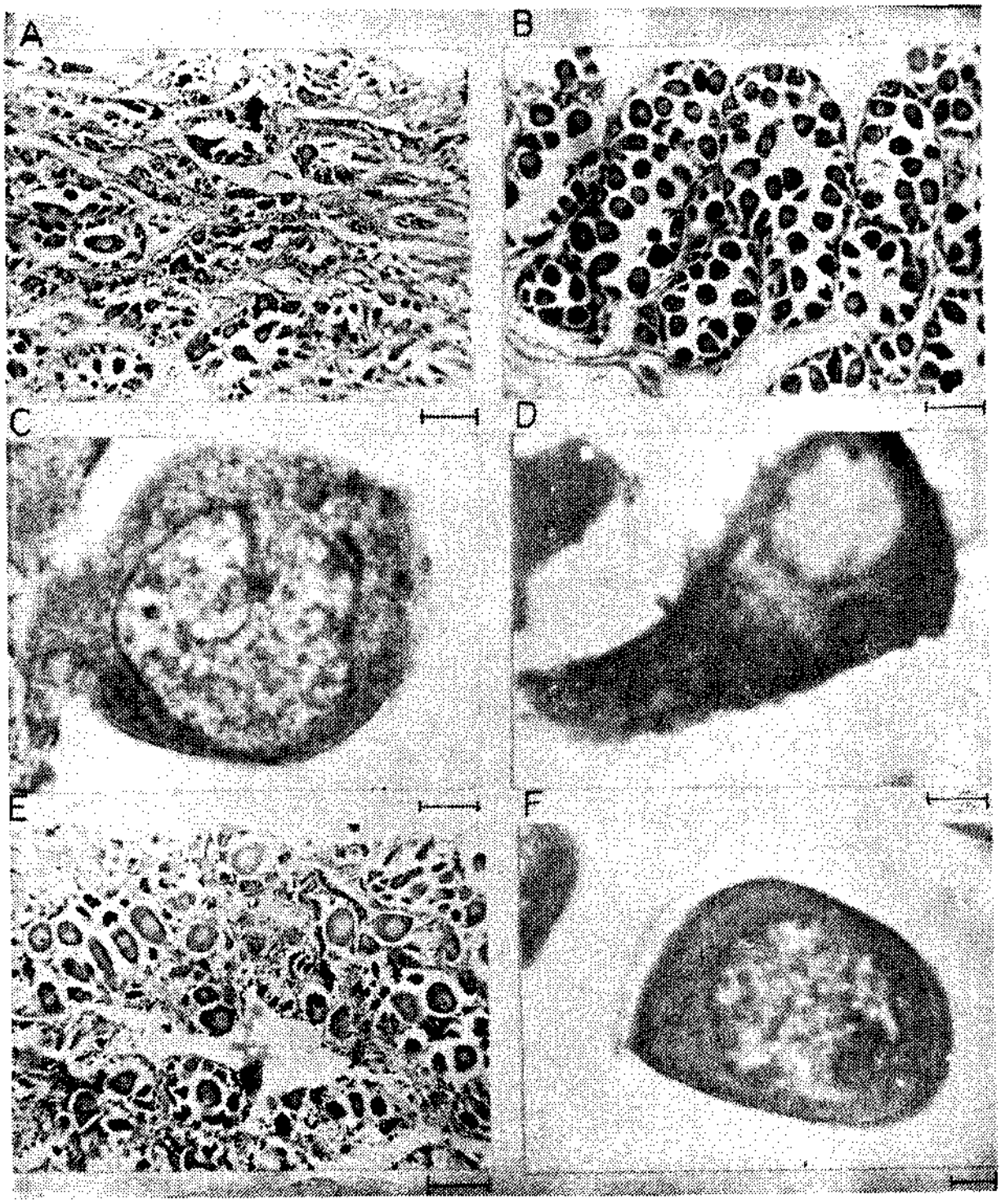
Gonad phase	Male	Female
1 a Early active	Increase in gonad size limiting the digestive gland to a restricted space; gonad somewhat flabby. Follicles contain mainly spermatogonia and spermatocytes; no spermatozoa.	Gonad size increases restricting the digestive gland to a limited space; gonad somewhat flabby; oogonia arising from stem cells in the follicle wall; a few attached to primary oocytes; no free oocytes
1 b Late active	Gonad thicker and firm, follicles larger and becoming packed together. Follicles contain predominantly spermatids and spermatozoa; characteristic swirling pattern of spermatozoa, with tails towards lumen. Follicles do not occupy entire gonad area.	Gonad thicker and firm, follicles larger and packed closely. Secondary oocytes are attached to the follicle wall by slender stalks. Few free oocytes in the lumen with distinct nuclei. Follicles increase in size.
II Ripe	Gonad becomes creamy in colour and full and piumpy. Bunches of spermatozoa with tail oriented towards the large follicle lumen. In fully ripe specimen, spermatozoa fill up the lumen.	Gonad becomes creamy and piumpy. Predominantly, large free oocytes in the lumen with distinct nucleus and nucleolus, rounded to oval; follicles are closely packed without interspace; no interfollicular tissue seen.
III Post spawned (Partially spent)	Gonad flabby and loose in consistency. Colour greyish; many follicles discharged; mass of spermatozoa separated from follicular walls; phagocytes present in the interfollicular space.	Gonad flabby and loose in consistency. Colour turned to greyish. Many follicles discharged. Few phagocytes present among gonadal cells.
IV Spent	Gonad loose and translucent. Follicles collapsed; residual sperms and phagocytes present.	Gonad loose and translucent. Residual oocytes occasionally present. Follicles collapsed, but relict oocytes present
V Indeterminate	Indeterminate phase is characterised by collapsed or shrunken follicles, with indifferent germ cells lining the walls in the early stage. Phagocytes distinctly present.	

females separately at all the three stations. However, the frequency of gonadal phases showed insignificant differences between the three stations. Hence the data for all the three stations were pooled together and presented in Table 2.

Gonadal condition in pre-monsoon

July

The gonad appeared loose and translucent. The gonads of both sexes were in the spent condition. The percentage frequency of partially spawned phases were 12.6 and 21,3 in bot^j



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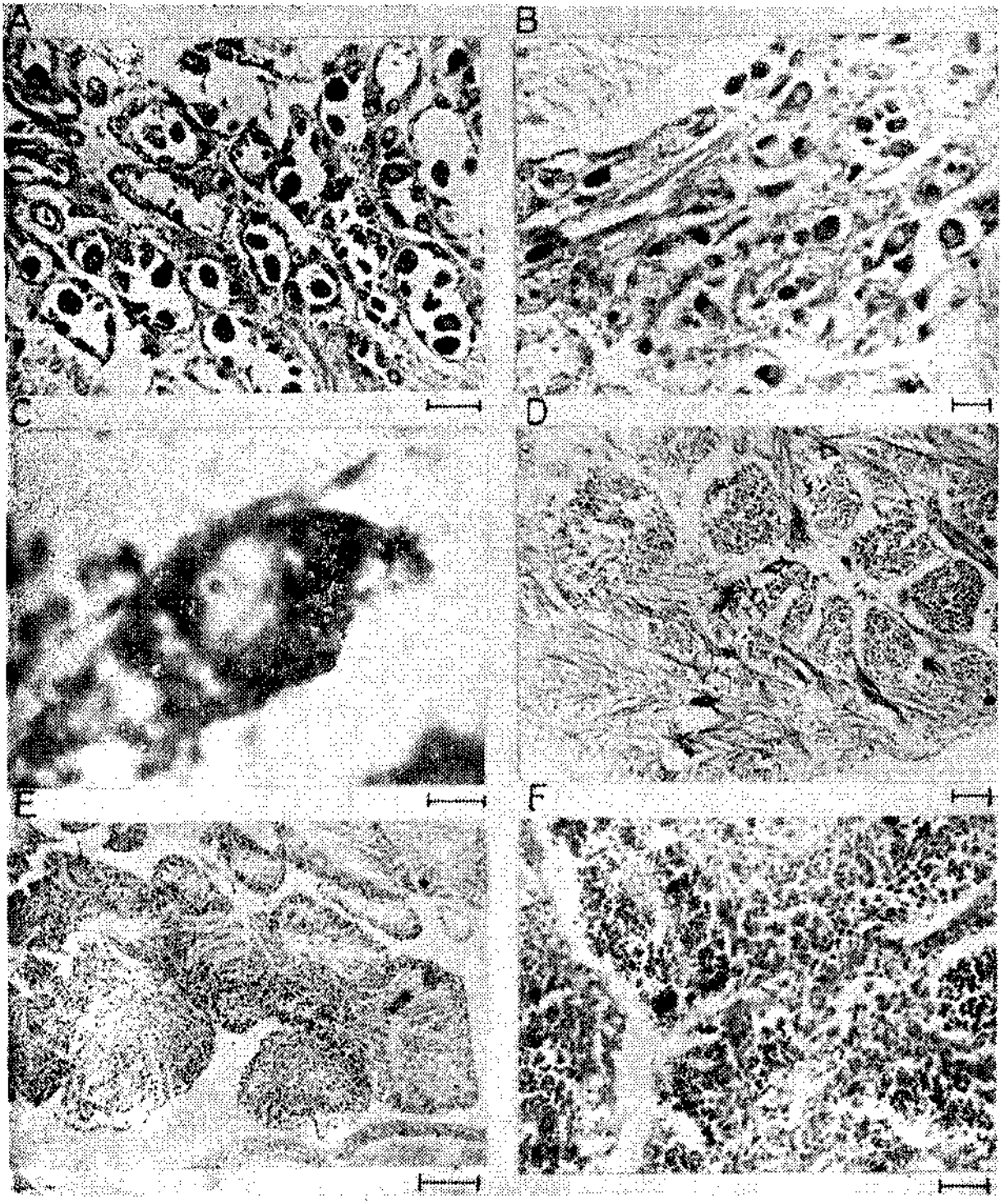

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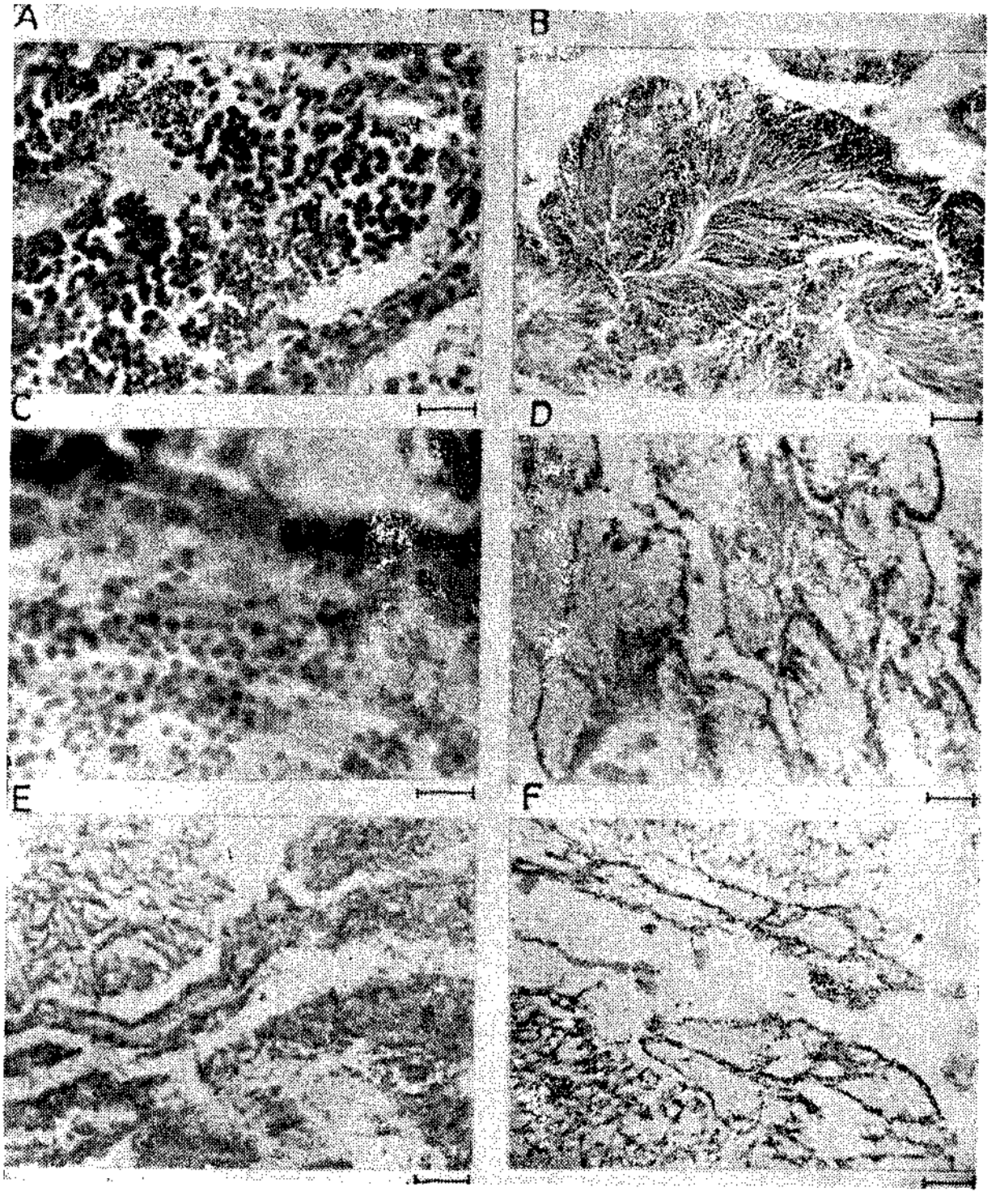

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PLATE I. A. Cross section of the active phase ovary of *Donax cuneatus* showing the proliferation of oogonia and oocytes. Bar represents lOO(Ji. B. Cross section of the ripe phase ovary showing fully packed follicles. While few of the oocytes are attached to the inner wails of follicles by stalk like connections, majority of the oocytes are free. Bar represents 100/*. C. Magnified oocyte of ripe phase ovary. Nucleus with nucleolus is noticed Bar represents lO/i. D. Magnified stalked oocyte of ripe phase ovary. Bar represents 10 i^. E.Cross section of post spawned phase ovary showing unspawned oocytes, shrunken follicle cell noticed. Bar represents 80 \^. F. Magnified oocyte of post spawned phase ovary. Bar represents 10 *v-.*

PLATE II. A Cross section of the spent phase ovary showing contracted follicles containing some relict ova. Bar represents SO/'. B. Cross section of the spent phase ovary showing the process of cytolysis of oocytes. Bar represents 80 M. C. Magnified degenerating oocyte showing the disintegration of nucleus and the process of cytolysis. Bar represents 10 Z'. D. Gross section of the early active phase testis showing divisions of spermatogonia upto secondary spermatocytes. Bar represents 100 Z'. E.Cross section of the late active phase testis showing clusters of spermatids outside the core of spermatozoa. Bar represents 100|it. F. Magnified late active phase testis showing the occurrence of Spermatocytes, spermatids and spermatozoa. Bar represents 50 *[>•.*

PLATE III. A. Magnified late active phase testis showing the occurrence of spermatocytes, spermatids and spermatozoa. Bar represents 10 [A. B.Cross section of ripe phase testis showing streams of spermatozoa arranged more or less radial columns with their tails radiating towards the centre of follicular lumen. Bar represents 100 t^. C. Magnified ripe phase testis showing the tailed spermatozoa. Bar represents 10 (A. D. Gross section of post spawned phase testis showing the shrunken follicles. Bar represents 100 i^. E. Cross section of spent phase testis showing the highly shrunken follicles with empty follicular space. Bar represents 100//. F. Gross section of gonad in sexually indeterminate phase. Bar represents lOOl*.

TABLE 2. *Percentage frequency of gonadal phases in Monthly Samples of* Donax cuneatus *from Marina, Thiruvanmiyur and Mahabalipuram (pooled data) during the period July 1982 to August 1984.*

Month		MALE Gonadal phase					FEMALE Gonadal phase				
Year		I	II	III	IV	V	I	II	III	IV	V
July	1982			24.05	47.66	28.29			25.78	45 93	28.29
Aug				8.60	44.90	46 49			6.77	46 73	46.49
Sep					23.00	77.00				23.08	77 00
Oct		16.72				83.28	16.72				83.28
Nov		56 84	22.97			20.19	60.78	19.02			20 19
Dec		9.36	79.81	6.91		3.92	16.73	72.60	6.76		3.92
Jan	1983	5.12	58.97	24.83		11 08	6.14	54.85	27.92		11.08
Feb		1.04	28.70	65.87	2.30	2.08	1.19	32.54	60.40	3.80	2 08
Mar			13.09	70.18	13 28	3.45	1.17	15.81	62.01	17.56	3.45
Apr			5.30	47.32	46 29	1.10		8.72	56.00	34.18	1.10
May			1.59	35.88	61.79	0.73		3.33	38.73	57.21	0.73
June				17.57	77.14	5.29			27.36	67.35	5.29
July				8.89	50.50	40.61			6.55	52.83	40.61
Aug				2.57	46.44	50.99			2.10	46.90	50.99
Sep					10.57	89.43				10.57	89.43
Oct		1.68			1.12	97.20	1.06			1.12	97.82
Nov		56.28	4 89			38 84	55.46	5.70			38.84
Dec		28.11	64.29	5.84		1.76	32 66	61.27	4.31		1.76
Jan	1984		76.64	19.98	0.47	2.90		82.49	14.61		2.90
Feb			24.63	65.87	9.50		1.52	18.90	70.58	9 01	
Mar			15.14	71.48	13.39		2.38	16.18	67.14	14.30	
Apr			3.33	61.81	34.86			1.89	65.78	32.33	
May				47.31	52.69				47.77	52.23	
June				13.65	86.35				16.66	83.34	
July					92.49	7.51			92.49	7.51	
Aug					18.56	81.44			18.56	81.44	

I = Active phase; II = Ripe phase; III = Partially spawned phase;
IV = Spent phase; V = Indeterminate phase.

males and females respectively. On the other hand in males the spent phase increased to 61.5% as against 52.5% in females. The percentage of indeterminate phase was 26.2 in both males and females. The fully spent clams were characterized by the presence of negligible numbers of residual oocytes and spermatocytes and more of vesicular tissue and condensed connective tissue. The follicles collapsed and the follicle lumen showed varying degrees of emptiness. In the spent gonad unshed oocytes or spermatozoa which were large in number in the lumen were in the cytolysed condition.

August

In this month majority of the clams had entered the indeterminate phase. The percentage of spent males and females was 39 and 44 respectively and that of the indeterminate clams was 56. The follicles were completely disrupted leaving a hieroglyphic appearance, In this stage

the gametes which were not yet released undergo resorption by being enveloped with connective tissue around the follicles. A large number of invading phagocytic cells appeared. During this time, the nucleus disappeared, the cytoplasm oozed out, the oocytes disintegrated, becoming transparent, and the constituents of the gametes were resorbed completely. When the process of cytolysis and resorption was completed, the follicles became empty. The gonad became translucent. It was at this stage that the sex of the individual become indeterminate.

September

In September the percentage frequency of indeterminate phase gonads was on the increase (72%) when compared to spent phase gonads which constituted only 28%. The residual reproductive elements were completely resorbed and the follicles were very much shrunken.

Gonadal condition in Monsoon

October

Though the percentage of gonads in the indeterminate phase increased furthermore to 88%, gametogenesis had commenced in 12% of the clam; the intensity of activity was considerably low when compared to the peak period of activity. In general, the indeterminate phase clams did not show any marked difference from those observed in the previous month. In the indeterminate phase, no trace of the follicular tissue was found and the gonad was completely resorbed.

November

The gametogenic activity initiated during the previous month became intense and as a result, the percentage of clams in the active phase increased to 54 in males and 66 in females. Only 5% of the clams were in the indeterminate phase. Due to active gametogenesis, about 40% of males and 27% of females had entered the ripening phase.

In the active phase, pronounced enlargement of follicles was due to the rapid increase of their size. In the testes, the reproductive follicles contained a large number of early stages of spermatogonia with spermatocytes and a few spermatids radiating into the lumen of the follicles. The gametogenic activity in the females proceeded rapidly. The number of follicels in the ovary increased and small oocytes with rounded distal ends protruding into the lumen, the other end being attached to the follicular wall by a slender stalk. A few follicles still in the process of proliferation have young oocytes in the follicular wall. In the ripe phase the gonads became plump and full and form the major part of the visceral mass. The follicles were enlarged and packed with reproductive elements.

December

As a result of the rapid growth of gonadal follicles during the previous month, the gonads had become full and plump and form the major part of the viscera. The percentage of ripe gonads in both males and females was 70 and 71 respectively. Concurrently, 20% of males and 21% of females had entered the partially spawned phase.

The follicles in the males as well as females were closely packed with ripe gametes without any interspace, the vesicular connective tissue being completely obliterated. Ripe male gonads were characterized by streams of spermatoza, with their tails directed towards the lumen. In the ripe female gonad, follicles filled the whole gonad with very little interspace between them. Large numbers of nearly round oocytes with distinct nucleus and nucleolus were found in the lumen of follicles.

Gonadal condition in post-monsoon

January 1983

In January, majority of the clams still remained in the ripe phase. The percentage of ripe phase gonad in both males and females were 53 and 43 respectively. The gonads in the partially spawned phase did not show any variation from those observed in the previous month. Clearly, there was a mild spawning activity in December; however, the ovary remained in the same condition till the end of January, 1983.

February

Spawning had become very vigorous, as evident from the appearance of a larger percentage of clams in the post-spawned phase. The gonads in the ripe phase showed a decrease from the previous month, as spawning started vigorously. The percentage of postspawned gonads increased to 62 and 74 in males and females respectively.

In the postspawned phase, the gonads gradually became flabby and slightly loose in consistency, showing a dull greyish colour indicating the commencement of spawning. Later on, the follicles became shrunken resulting in a marked reduction in the number of gametes within the lumen. The unspawned oocytes remained attached to the follicular wall; however, they were smaller in size. In some follicles of male gonad, the lumen appeared empty due to the discharge of spermatozoa.

March

Spawning had reached the peak as evident from the appearance of a large percentage of clams in the postspawned phase. The percentages of partially spawned gonads in males and females were 72 and 74 respectively.

Gonadal condition in summer

April

The percentage of postspawned gonads still remained high. However, the /appearance of a larger percentage of spent phase gonads in this month indicated that the spawning activity was still vigorous. The partially spawned phase gonads which formed 72% males and 74% females during the previous month declined to 47% and 58% respectively. Nevertheless the spent phase clams constituting 10% males and 4% females during the previous month increased to 40% and 25% respectively.

May

In May, spawning had far advanced and majority of the clams were found to be in the spent phase as indicated by the slow fall of postspawned phase gonads of both sexes. The percentage of spent phase gonads of males and females was 49 and 58 and that of postspawned ones was 40 and 25. The fully spent gonads appeared loose and translucent. The lumen contained residual oocytes and spermatozoa. The follicles were collapsed in some case, while in others, faint lines indicating the presence of follicular walls. Phagocytes appeared in large numbers both inside and outside the follicles. They cytolysed and devoured the remnants of undischarged residual gametes.

June

Spawning continues further and the clams in spent phase increased in number The percentage of spent phase gonads of males and females increased to 75 and 71 respectively. The fully spend gonads were characterised by the presence of a negligible number of residual gametes.

The same pattern of reproductive cycle was observed during the subsequent year from July 1983 to August 1984 with minor variations in the time, intensity of gametogenesis and spawning. Between July and August 1983 the major rity of gonads continued to remain in the spent phase. At the same time, the process of cytolysis and resorption was over in 40% of the gonads. Thereafter, these clams had entered the indeterminate phase. By September and October the residual reproductive elements were all resorbed and the sex of individual became indeterminate. From November onwards, gametogenic activity was initiated and the clams entered the active phase. In December and January as a result of the rapid growth of the follicles, the gonads had become fully ripe commensurate with the reproductive cycle for the corresponding period in 1982 and 1983. From February to May, spawning was vigorous as evident from the larger percentage of postspawned gonads. By June and July, spent phase gonads were on the increase owing to the continuation of the spawning activity. By August, the residual gametes were all absorbed and the clams entered the indeterminate phase.

It may be seen from the foregoing account that *D. cuneatus* of Madras coast follows a definite pattern of annual reproductive cycle with a prolonged breeding period extending from January to July. The gonadal changes were cyclical with well-defined phases of gametogenesis such as ripening, spawning and regression. Gametogenesis commences between October and November. Ripening took place mainly In December-January, spawning activity continues from February to July, entering into the Indeterminate sexual phase from August-September.

DISCUSSION

D. cuneatus exhibits an extended annual breeding cycle, in which the initiation of gametogenesis does not commence soon after spawning, but begins after a distinct inactive period of three months. Interestingly, the time taken for the completion of gametogenesis is shorter than the spawning season. Spawning does not occur in one stroke but intermittently over a long period (Rao 1967; Mane and Nagabhushanam 1976). This strategy in spawning is helpful in the reduction of intra-individual competition among the young ones.

A comparision of data on the reproductive cycle of *D. cuneatus* inhabiting different beaches on the east and west coast of India reveals difference in their breeding cycle, especially with reference to spawning season. In the west coast, the spawning season of *D. cuneatus* extended from October to January (Nagabhushanam and Talikhedkar 1977) and on the south east coast it was from January to April (Nayar 1955). On the Madras coast as mentioned earlier, the spawning season extends from January to July. Rao (1967) has also recorded almost a similar spawning season, January to June in the species on the Madras coast. In marine invertebrates resorting to broadcast fertilization, the time of release is very important as the embryonic development is accomplished within a very short period and the larvae are planktotrophic. Therefore, the survival of larvae depends very much on the environmental conditions obtained at the time of spaivning. A subtle difference in the spawning season of *D. cuneatus* in various parts of the Indian coasts lends support to this supposition. An analysis of food preferences for these larvae in different beaches may throw new light on this aspect.

Whereas the causative factor for differential spawning period may be related to larval survival, the environmental factors such as the temperature and salinity may constitute the proximate stimulus for gametogenesis and spawning. In temperate regions many workers have shown a close relationship between fluctuation of the habitat media of marine invertebrates and their gonadal conditions. There, the chief spawning stimulus, in the case of oysters, is the rise in temperature (Loosanoof and Davis 1950).

The low surf water temperature recorded at Madras coast from November 1982 (27.6°C) to December (26.2°C) and November 1983 (27.4°C) to December 1983 (26 2°C) coincides with the period of active gamete development and ripening in D. *cuneatus.* During the period of peak spawning the temperature which triggers spawning lies between 27.6°C (February) and 28 2°C (March) in 19?2 and 26 rc in (February) and 27.5°C in (March) in 1983. The temperature in the preceding months of spawning was observed to be 25°C in January 1982 and 25.5°C in January 1983 This clearly indicates that a slight fall in the temperature during November and December indicates gamete development and ripening of gonad in *D. cuneatus.* A slight increase in the temperature during February and March induces the clam to spawn and this activity continues upto July. The data of Nayar (1955) and Rao (1967) show that in *D. cuneatus* spawning takes place whan the temperature is on the ascent. Therefore, the temperature appears to be an important factor regulating the gametogenesis and spawning in *D. cuneatus.* However, Nagabhushanam and Talikhedkar (1977) are of the opinion that temperature may not influence the spawning of this clam in the west coast.

Another important variation in the sea, under the influence of monsoon rains, is salinity. In the present investigation the low surf water salinity recorded on the Madras coast during October-December coincided with the period of active gonad development and ripening in *D. cuneatus* and a sudden increase in th6

salinity during February and March triggers the clam to spawning which continues till July. Thus in *D. cuneatus* active gametogenesis takes place in both sexes when the temperature and salinity are low and spawning occurs when the temperature and salinity are higher.

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33. SEASONAL VARIATIONS IN THE BIOCHEMICAL COMPOSITION OF *MERETRIX CASTA* (CHEMNITZ) OCCURRING IN VELLAR ESTUARY

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ABSTRACT

Seasonal variation in bioclietnicsl composition of *Meretrix casta* (Chemnitz) occurring in VeUar estuary (Lat. 11°29' N; Long 79°46' E), S. India was carried out monthly for a period of *one year* from April '75 to March '76.

Gonad recorded high percentage of carbohydrates (5.2%-9.4%) than the other body components (viz- mantle, adductor muscle, gills, foot, siphon and digestive gland). Gonad also recorded the highest protein value of 74.4% but mean monthly values showed that mantle had higher percentage of protein (60.5%) than other body components.

Digestive gland had high percentage of lipid (mean 3.05%) than the other body components. Digestive gland appears to be storage organs for fat and protein. Of the seven body components studied, gill showed *very* low percentage of protein (47.07%), carblioydrate (1.45%) and fat (1.73%).

Protein content of gonad registered an increase before spawning and decrease after spawning. Thus, protein content of gonad shawed seasonal changes associated with the annual reproductive cycle-

INTRODUCTION

Biochemical composition of bivalves were studied by several workers in India (Venkataraman and Chari 1951; Durve and Bal 1961; Joshi and Bal 1965; Kasinathan 1963, '64a, b, '67; Rahaman 1965, '66; Saraswathi and Nair 1969; Nagabushanam and Deshmukh 1974; Wafer 1974; George and Nair 1975; Salih 1979; John 1980; Lakshmanan and Nambisan 1980; Jayabal and Kalyani 1986). The seasonal changes in biochemical composition of body components VIZ. mantle, adductor muscle, foot, gill, gonad, siphon and digestive gland in *Meretrix* casfa (Chemnitz) were studied from April 1975 to March 1976 and the results are presented ^^^^

MATERIAL AND METHODS

From the Vellar estuary 20 to 25 mature specimens of *M. casta* in size between 28-30mm were collected monthly and adopting standard procedure and precautions, biochemical estimations were carried out on dried tissues of the whole animal and other body components. Five estimations were done in each case and the average was taken. Protein was estimated employing Biuret method of Raymont et al (1964) while the procedure of Dubois et al (1956) was followed for determining the total carbohydrate content- Chloroform-Methanol extraction method of Foich et al (1956) was adopted for the estimation of lipid content of the tissues.

OBSERVATIONS

^ *protein*

Protein content varied from 50.4 to 63% for the whole animal (Table 1). The highest value occurred in May while the lowest value j^ November and December. High protein values recorded in May and August could be correlated to the intense breeding activity of the clams during these months

Protein in the gonad tissue varied between 50 4 and 74.4%, Highest value observed in ^pril could be due to intense proliferation of gonad and low value in May due to spawning activity. Another peak value in August (70.8%) coincided with secondary peak of breeding activity and low values in subsequent month due to spawning.

Protein in mantle tissue varied from 49.2 to 67.2% but mean monthly values showed higher percentage or protein (60.5%) than gonad. In

TABLE 1. *Seasonal variation in protein level (%) in tlie whole anintal and different body components of* Meretrix casta *for the year 1975-16.*

Month		Whole animal	Gonad	Mantle	Adductjr muscle	Digestive gland	Foot	Gill	Siphon
Apr	1975	54 6	74.4	57.6	54.0	50.4	46.8	45.6	43.2
May		63.0	50.4	67.2	55.2	51.6	49.2	46.8	46.8
Jun		56.4	52.8	62.4	60.6	57.6	58.8	45.6	52.8
Jul		54.0	61.2	64.8	62.4	49.2	56.4	54 0	44.4
Aug		61.2	70.8	66.0	58.8	63.6	49.2	46.8	48.0
Sep		60.0	51.6	68.8	52.8	62.4	48.0	50.4	45.0
Oct		54.0	52.8	63.6	61.2	52.8	62.8	44.4	45.6
Nov		50.4	51-6	52.8	58.8	51.6	51.6	43.2	46.8
Dec		50.4	52.8	49.2	54.0	54 0	51.6	43.2	45.6
Jan	1976	57.6	55.2	58.8	56.4	58.8	52.8	48.0	49.2
Feb		60.0	64 8	61.2	60.0	55.2	54.0	50.4	46.8
Mar		56.4	70.8	63.6	58.8	62 4	51.6	45 6	50.4
Mean		56.5	59.1	60.5	57.8	55 8	51.9	47.0	47.0
S. D.		388	8.50	515	3.04	4 84	3.29	3.09	2 59

mantle, during the dry season (January to July) when there was active feeding and synthesis, the protein values were more. During monsoon (October to December), when food becomes scarce, protein values were low.

Protein value varied from 52.8 to 62.4% in adductor muscle and from 49.2% to 63.6% in digestive gland. In adductor muscle, highest value was recorded in July and lowest in September. In digestive gland, highest value occurred in August and lowest in July. No definite trend in protein values could be seen in these two body components.

Protein content ranged from 46.8 to 58.86% in foot and from 43.2 to 54.0% in gill. During breeding peaks and monsoon periods, the values were lower and there was a subsequent build up later in these tissues. Siphon registered low protein values ranging from 43.2 to 52.8% and did not show any specific trend.

b. Carbohydrate

Carbohydrate content of the whole animal ranged from 3 6 to 6.8% in different months (Table 2). The values were low during monsoon months and high in other months- Carbohydrate content of gonad varied from 5.2 to 9.4%. Highest value was observed in May and the lowest in June. During the primary peak of breeding activity (April-May) the values were higher and immediately after there was a decrease in June. Later there was a build up with secondary breeding peak. Then again the values declined during the monsoon period.

Carbohydrate content ranged from 2.2 to 5.6% in digestive gland, from 2.1 to 4.5% in mantle and from 1.5 to 3.4% in adductor muscle during different months. Highest value was observed in May and the lowest in November and December. High carbohydrate value in May could be correlated to intense breeding activity and the values declined during the monsoon months.

Carbohydrate content varied from 2.1 to 3,4% in siphon, 1.3 to 2.5% in foot and 1.0 to 2.1% in gill. Gill recorded the lowest amount of carbohydrate and the values did not show any trend.

c. *Lipid*

Lipid content of the whole animal was generally low and the values varied from 2.0 to 5.2% in different months (Table 3). Higher values observed in April-May could be correlated with primary breeding peak. After this intense period of breeding, the values declined.

TABLE 2. *Seasonal variation in carbofiydrate level (%) in the whole animal and different body components of* Meretrix casta *for the year 1975-76*

Month		Whol* animal	Gonad	IVantle	Adductor muscle	Digestive gland	Foot	Gill	Siphon
Apr	1975	5.00	8.10	3.70	2.70	4.10	2.50	1.30	3.00
May		6.80	9.40	4.50	3.40	5.50	1 80	1.10	3 40
Jun		4.40	5.20	2,70	2.40	3.00	1.80	2.10	3.10
Jul		4.20	6.00	3.80	3.00	3.60	2.30	1.90	3.30
Aug		4.20	6.80	4.10	2.90	3.80	1.80	1.4X)	2.90
Sep		4.20	6.80	3.80	3.00	3.4o	2.10	160	2 50
Oct		4.10	6.20	3.40	2.00	3.50	1.30	1.20	3.00
Nov		3.80	6.00	3.20	2.00	2.20	1.70	1.00	2.40
Dec		3.60	6.00	2.10	1.50	3.30	1.50	1.30	2.70
Jan	1976	4 80	7.90	2.40	2.40	3.60	1.30	1.50	2.10
Feb		4 90	8 00	3.10	2.60	3 60	1.70	1.70	2.80
Mar		5.00	8.20	3.80	2.80	3 80	1 90	1.30	3.00
Mean		4.59	7.06	3.38	2.56	3.62	1.81	1.45	2.85
S. D.		0.77	1.19	0.68	0.51	0.73	0.35	0.31	0.36

TABLE 3. *Seasonal variation in lipid level (%) in the whole animal and in different body components in* Meretrix casta *for the year 1915-76*

Month		Whole •nimal	Gonad	Mantle	Adductor muscle	Digestive giand	Foot	Gill	Siphon
Apr	1975	4.60	3.60	2 50	2.00	4.40	2 50	2.30	2.00
May		5.20	4.50	3.20	2.10	4.00	2.30	2.10	2.30
June		3.80	2.50	2.70	2.10	3.80	2.70	2.50	2.50
Jul		3.20	2.70	2.70	2.00	280	2.40	1.80	2.00
Aug		3.00	2.60	2-80	1.80	3.00	2.70	1.60	1.80
Sep		2.60	2.70	2 50	1.90	3 20	2.10	1.80	1.70
Oct		2 20	2.50	2 00	2.00	2.60	1.80	1.20	2.C0
Nov		2.00	2.30	1.80	1.40	2.40	1.90	1.00	2.10
Dec		2.00	2.50	2.00	1.50	2 20	2 JO	1.50	1 80
Jan	1976	2,00	360	2 70	1.70	2.60	2 50	1.50	1.70
Feb		2.20	2.70	2.50	2.00	2 80	2.10	1.80	1.90
Mar		2.80	3.00	3 00	2.10	2.80	2.40	1.60	2.10
Mean		2.97	2.85	2.53	1.88	3.05	231	1.73	1.99
S. D.		1.C2	059	0.40	0.23	0.65	0.28	0.41	0.23

Lipid content varied from 2.3 to 4 5% in gonad, from 1.8 to 3.2% in mantle from 1.4 to 2.1 % in adductor muscle and from 2.2 to 4.4 in digestive giand. Digestive gland had high percentage of lipid content (mean 3.05%) than other body components. The values were higher during intense breeding months and subsequen-tly there was a decline.

The Variation in lipid content was between 1.8 and 2.7% in foot, 1.0 and 25% in gill and 1.7 to 2.5% in siphon The values did not show any trend.

DISCUSSION

Ansell et al (1964) in *Venus mercenaria* and Giese (1969) in *Tivela stultorum* reported that biochemical composition did not show any seasonal change and varied considerably at different times during the year. Ansell et al (1964) reported that gonad and digestive gland had greater percentage of carbohydrate and fat while Giese (1969) found high carbohydrate content in gonad and high lipid content in digestive gland. Later Ansell (1974 a, b,c) found that protein nitrogen increases to pre-spawning maximum in *Abra abra* and *Lima hians* while lipid and protein nitrogen levels decrease during spawning period.

Durve and Bal (1961) in *Crassostrea gryphoides Josh*\ and Bal (1965) in *Katelysia marmorata* and Nagabushanam and Deshmukh (1974) *m Meretrix meretrixiound thai* glycogen content was related to gonad development and increased during active gametogenesis. Venkataraman and Chari (1951) reported that fat content in *Meretrix casta* increased during gonad development.

Salih (1975) reported that glycogen and protein content showed a steady fall during premonsoon period and an equally steady raise during the postmonsoon period while the trend was opposite in the case of fat. John (.1980) noted a decline during spawning period in lipid and protein values in *Anadara rhombea* and stated that the digestive gland served as a storage organ of fat. Lakshmanan and Nambisan (1980; observed a significant negative correlation between carbohydrate and protein in *Villorita cyprinoides* var. *cochinensis* and *Meretrix casta.*

In the present study high percentage of protein was found in the mantle than in any other organ. Further, it was found that gonad and digestive gland had respectively high percentage of carbohydrate and fat than other organs. Ansell et al. (1964) also reported that gonad and digestive gland showed respectively high percentage of carbohydrate and fat than any other organ. As reported by John (1980) in *Anadara rhombea* digestive gland may be serving as a storage organ of fat in *i\4 casta* also.

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34. A STUDY ON BIOCHEMICAL GENETICS ON *CHASSOSTREA MADRASENSIS* OF COCHIN

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ABSTRACT

To determine genetic differences between geographic populations of *Crassostrea madrasensis,* studies on the protein band pattern in four tissues namely, adductor muscle, gills mant'e and digestive divert'cula was determined by polyacrylamide gel electrophoresis. The interpopulation differences observed in protein expression are discussed in relation to biochemical genetic characterisation of C. *madrasensis.*

INTRODUCTION

Many marine bivalve species are known to exhibit genetic polymorphism at a number of loci (Wilkins 1975; Ahmad et al 1977, Skibinski et al 1978, Beaumont & Beveridge 1984). In oysters, the presence of genetically variable enzymes has been indicated by the studies of Wilkins and Mathers (197''), Mathers et al (1974), Schaal and Anderson (1974), Buroker et al (1979 a, b) and Buroker (1933). Most of the above studies have been carried out on specific enzymes. Attempts to identify polymorphic loci from general protein zymograms have been carried out only on a limited number of bivalve species eg., *Ostrea lurida* (Johnson *et a\ }972), Saxidomus giganteus* (Johnson and Utter 1973), *Crassostrea gigas* (Buroker et al *^975) and Chlamys opercularis* (Beaumont and Gruffydd 1975, Beaumont 1982 a, b).

A biochemical genetic study has been recently initiated to identify polymorphic loci in *the \n6\an ed\b\e oyster Crassostrea madrasensis,* by which genetically distinct stocks of oyster can be identified from different locations along Indian coasts. This report describes the result of preliminary investigations carried out to determine the basic protein zymogram of adductor muscle, mantle, gills and digestive diverticula. The presence of two polymorphic loci have also been shown.

MATERIAL AND METHODS

Specimens of adult *C. madrasensis* (shell height 41-70mm) used in the electrophoretic analysis were collected from the Vypeen bar mouth jetty at Cochin. Live oyster were maintained in the laboratory without feeding for a maximum period of one week. The oysters were dissected for the specific tissues required in the analysis. The tissue samples were homogenized in double distilled water, centrifuged at 10,000 rpm for 15 minutes. Disc electrophoresis as described by Davis (1964) was followed using 10% acrylamide and 5% bisacrylamide. The gels were stained for general protein using 0.25% Kenacid. Very faint bands and those bands not observed in all the gels were excluded from the general pherogram pattern The relative mobility (rf) of each band to that of the marker dye front was calculated and the general protein pherogram was drawn on the basis of mean rf values of gels from a minimum of 12 individuals for each tissue. For determiniing the presence of polymorphic loci, electrophoretic analysis of the adductor muscle of 20 individuals were carried out. From each individual, three samples were analysed. The most intensely stained bands were marked 4x and the remaining bands comparatively graded as 3x, 2x and 1x.

RESULTS

Tissues specific variations in the general protein pherogram were observed with regard to ^^^ """^^er of bands, their relative position, thickness and staining intensity (Fig. 1, Table 1). In the adductor muscle, 9 bands were observed in all individuals. Compared to the other tissues, in the adductor muscle there were less variations between individuals with regard to staining intensity and thickness of bajnd*. The

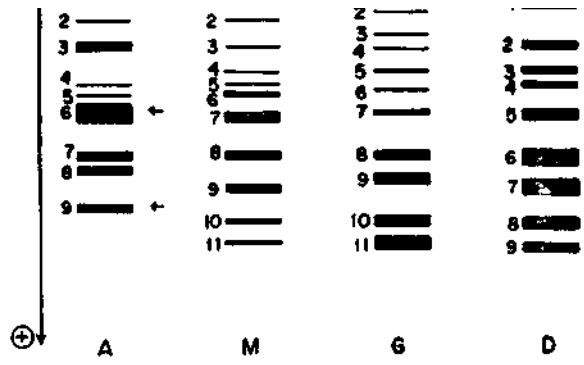

Fig. 1. Electropherogram in the adductor muscle (A), mantle (M), gonad (G) and digestive diverticula (D) in *Crassostrea madrasensis*. →+ indicates the direction of protein migration. Arrows at 6th 9th band in adductor muscle indicate polymorphic loci. O indicates the origin.

11 bands observed in the mantle tissue had more or less the same *rf* values in all individuals, but there were variations in staining intensity and thickness. These variations were marked for bands 4, 5 and 6. In the gill and digestive diverticula there were 11 and 9 bands respectively. In both tissues there were variations in staining intensities between individuals, but not in the thickness of bands.

(A, B and C) monomeric system. The most common type (BB) was a single band with *rf* value of 40.6 ± 1.45. Two other two banded phenotypes (AB, BC) were observed at this position (Fig. 2). The staining intensities of the 2 distinct bands in AB and BC system were half of BB band indicating that BB is the homozygous state and the other two phenotypes (AB and BC) are the heterozygous state. The homozygous AA and CC bands were not observed. Of the 20 individuals, AB phenotype was

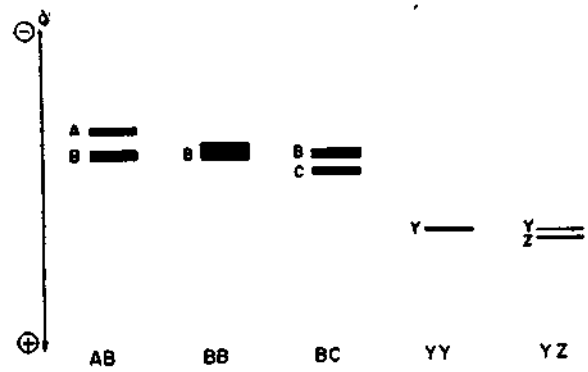

Fig. 2. The phenotypes observed at band 6 (AB, BB, BC) and band 9 (YY, YZ) in the adductor muscle of *Crassostrea madrasensis*. (→+ indicates direction of protein migration. O indicates the origin.)

TABLE 1. *Staining intensities (X), thickness (T in mm) and relative mobilities (rf) of the protein bands in different tissues of* Crassostrea madrasensis.

Band No.	TISSUES											
	Adductor muscle			Mantle			Gills			Digestive diverticula		
	X	T	rf	X	T	rf	X	T	rf	X	T	rf
1.	3	+	7.4	3	+	7.2	2	+	7.2	1	+	11.3
2.	2	+	13.7	2	+	13.9	1	+	12.1	3	0.5	21.7
3.	3	1	21.4	3	+	20.8	1	+	18.2	2	0.5	28.4
4.	1	+	30.8	2	+	27.8	1	+	21.8	2	0.5	32 2
5.	2	+	33.8	1	+	31.2	4	1	27.4	3	1	40.5
6.	4	2	40.6	2	0.5	34.2	1	+	32.9	2	2	52.9
7.	3	1	51.2	2	1	40.6	2	+	38.4	2	2	61.1
8.	1	1	55.1	2	1	51.2	2	1	51.2	2	1	69.4
9.	1	0.5	64.3	2	1	59.7	2	1	57.5	2	1	75.7
10.					1	68.2	1	1	68.6			
					1	1	1	1	74.5			

4 x — Dark
3 x — Medium
2 x — Light
1 x — Faint
+ bands less than 0.25 mm thick

observed in two individuals and BC in one individual indicating that B and C alleles occur at low frequencies in the population. The tissues from the AB and BC individuals were again electrophoresed with that of the common type to confirm the observed band patterns. At band 9 with rf values of 64.3 ± 1 26, in 50% of the samples two banded phenotype (YZ) was observed. But, unlike band 6 which in its homozygous state (BB) is 2 mm thick with a staining intensity of 4x, band 9 as a single band is 0.5 mm thick with a staining intensity of Ix. Further the interspace between the two bands y and z is small. Therefore, the presence of polymorphic system at band 9 cannot be said with certainty as indicated for band 6.

DISCUSSION

Of the four tissues tested, adductor muscle is the best tissue for detecting polymorphic loci since the variations between individuals with respect to staining intensity and thickness is minimum. Of the remaining tissues, the mantle tissue is the least suitable. In all tissues other than band 1 and 2 the coefficient of variation in rf values was less than 6% indicating that the general protein pherogram observed in the present study is repeatable under identical electrophoretic conditions. The differences in staining intensities between individuals could be partly due to the differences in the duration of starvation between individuals- The electrophoretic variants observed in adductor muscle protein of other molluscs have been either due to geographic variation (Johnson and Utter 1973, Beaumont 1982a) or due to differences in size classes tested (Beaumont 1982b). Due t& the low frequencies of alleles A and C and the small sample size, the effect of size class cannot be tested in this study. The present study, besides giving the tissue specific protein pherogram has indicated the presence of polymorphic loci. The actual allelic frequencies at those loci and the presence of other polymorphic loci can be substantiated by examining a larger sample size.

ACKNOWLEDGEMENTS

The author is immensely thankful to Dr. P. S. B. R. James, Director, C. M. F. R. Institute for the keen interest and encouragement he has shown in this study.

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35. ON THE CHROMOSOMES OF A BIVALVE, *ANADARA RHOMBEA*

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ABSTRACT

Study of chromosomes of bivalves is technically difficult. Spermatogonia and spermatocytes, oocytes, and cleavage stages of the fertilized eggs are more favourable than the somatic tissues of the adultss for the study of chromasomes. Hypotonic treatment, prior to fixation, is an essential pre-treatment for obtaining well-spread chromosomes. 1he study of the chromosomes of a bivalve, *Anadara rhombea,* from the Porto Novo waters, has been the first of its kind in an Indian bivalve. Oiakinet'C and first m^taphase stages from 'squash' preparations of testis show that In male 2n •= 28 in this species; the sex chromosomes, if any, are not distinguishable.

INTRODUCTION

A survey of the literature on the chromosomal cytology of the molluscs available upto 1978 (when the study reported here was undertaken) will reveal the relative paucity of information on the chromosomes of this group despite the fact that molluscs constitute the third large phylum in the animal kingdom (Fretter & Graham 1962); among molluscs, very few bivalves have been studied cytologically. Lillle's (1901) study on the egg of i//?/© is the earliest

known on the chromosomes of a bivalve, based on its maturation, fertilization and cleavage. Other works on the chromosomes of bivalves include those of; Ahmed and Sparks (1967 a) on oysters, clams and mussels, Ahmed and Sparks (1967 b) on *Ostrea* and *Crossostrea,* Ahmed and Sparks (1970) on two spp of *MytiJus;* leyama (1975J on three spp of Pteriomorpha: leyama and Inaba (1974) on ten spp of Pteriomorpha; Keyl (1956) on the mussel, *Sphaerium;* Kobayashi (1954) on two spp of *Ostrea:* Longwell et al (1967) on *Crossostraa;* Menzel (1988) on nine families of marine bivalves; Menzel and Menzel (1965) on two spp of *Mercenaria* and their hybrids, and Ropes (1972) on the surf *clam. Sp/'su/a.* It will be obvious from this list that there was no work on Indian bivalves till 1978.

MATERIAL AND METHODS

The specimens of *Anadar* rhombea* were kindly provided by Dr. George John who was then working in the Centre of Advanced Study in Marine Biology, Porto Novo, on the Biology *oi Anadara spp.* The specimens were obtained from Vellar estuary. Somatic tissues from the ctenidia and midgut gland, and the germinal material from the testis were used for this study. Testis proved to be the most favourable material for the study of chromosomes. Fragments of live testis were subjected, for 30 minutes, to hypotonic treatment prior to fixation; filtered estuarine water was diluted with an equal quantity of distilled water and this was used as the hypotonic fluid. The fragents were then fixed in Clarke's fluid or Newcomer's fluid, and stained in lacto-propiono-orcein or acetic-orcein. The chromosomes were studied from 'squash- preparations which were dehydrated in ethanol and mountedin euparal.

The slides were examined in an Olympus trinocular research microscope under oil immersion objective of N. A. 1.3 and with Kohler illumination; camera lucida sketches were drawn with a table top magnification of 3200 dia.

OBSERVATION

Th6 chromosomes were studied from spermatocytes undergoing first meiotic division; cells in diakinesis and I metaphase provided satisfactory preparations. The hapioid number of chromosomes in *A. rhombee* was found to be 14 in males (Fig 1). The chromosomes are metacentric and form 1^ bivalents. There is no localisation of chiasmata, there being proximal, interstitial and distal chiasmata. The meiotic behaviour of the chromosomes does not show any peculiarity. It was not possible to distinguish any sex chromosomes based on the morphology and behaviour of the chromosomes,

Fig. 1. Chromosomes of *Anadar, rhombea.* Squ«h preparations of testes fixed, after hypotonic treatment, [„ Clarl<e's fluid and stained in lacto-proplono-orcein. Cameia lucida sicetches; magnification: 3200 X.
Bivaients of a ceiiin diakinesis; n = i4.
^- ^'^"""" °' • "" '" ' "'«"Ph"e; n = u,

DISCUSSION

"^^^ dearth of information orr the chromo- ^°"^^^ °^ bivalves is in all probability due to the technical difficulty of obtaining good preparations of well-spread chromosomes; molluscs, '" S^"^"^'' ^nd the bivalves, in particular, have their chromosomes (which are in some spp large in number) in the relatively small volume of their nuclei. The conventional methods of 'Chromosome preparations, employed m t h e ^^^^y of most other invertebrates, are not adequate for the investigation of the bivalve chromosomes; it is absolutely necessary to subject the tissues to hypotonic treatment in order to swell the nuclei and to disperse the chromosomes so that they are spread well while squashing, without an overlapping of the chromosomes. Besides diluted natural medium, 1 % aqueous solution of sodium acetate or 0.4% aqueous solution of potassium chloride maybe used for hypotonic treatment of the material; 20 to 30 minutes in the hypotonic fluid will suffice; the tissues may then be fixed and stained; squashes can be prepared from such material and they will show a good number of well-spread chromosomes for observation.

Regarding the choice of favourable material for the study of chromosomes, in the experience of the present author, it is better to choose germinal material from the males or females during active gametogenesis. The most favourable materials for chromosomal studies are the spermatogonia and spermatocytes in the males, and the maturation stages of the oocytes in the females; cleavage stages of the fertilized eggs provide good mitotic chromosomes. Somatic tissues of the adults, such as the ctenidia or midgutglands, do provide mitotic stages, but are not as good as the gametocytes or the early stages of cleavages. For instance, Alagarswami & Sreenivasan (MS) found that the oocytes of pearl oysters were the most favourable for a study of the chromosomes; more than even the testis, the oocytes provided excellent stages of maturation in which the chromosomes were distinctly discernible. Cleavage stages in the oysters were not very useful in their studies

Patterson (1969) had reviewed the chromosome numbers of the bivalves and stated that the haploid numbers ranged from 10-23. Later work has indicated that the lower haploid number is 7. Among the bivalves cytologically investigated, the family Ostreidae have been the most irivestigated; except in tvvo spp of *Ostrea,in* all other spp *ofOstrea* and *Crossostrea* which belong to this fam ly, the haploid number has been recorded to be 10. In every family of the bivalves, the haploid number is constant for all the genera. Thus, the haploid number for the family Arcidae has been reported (leyama 1975) to be 14. In *Anadara rhombea,* which belonges to Arcidae, the haploid number has been found by the present author to be 14 Thus, the present observation confirms the constancy of the familial haploid number.

ACKNOWLEDGEMENTS

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36. ECOLOGICAL ENERGETICS OF THE ROCK OYSTER *SACCOSTREA CUCULLATA* (BORN)

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ABSTRACT

The energy budget partitioning in tlie rock oyster *Saccostrea cucullata* (Born^ has been described and based on this the functional iniportance of these oysters In the astuarins ecosystem has been discussed.

It has been found that a large amount of consumed energy (c *= 100%) Is diverted to the maintenance cost (R = 31.26%). However, at this cost the soma (S) energy Incorporation is only 9.74% while the gonadal (Q) energy output is only 6.51% of the 'C In addition to the gonadal output, 40% of 'C energy is passed to the trophic system back in terms of faeces and urinary excreta (F + U) and 2.49% of the energy !• totally eliminated (E) from the population on account of fishing and predation

INTRODUCTION

The present studies, contextual to modern developments in ecology, emphasizing the importance of energy and energy flow in evaluating the relative importance of species population to the functioning of an ecosystem, concern with the ecological energetics of rock oyster, *Saccostrea cucullata* (Born) in Kalbadevi estuary at Ratnagiri (Maharashtra;.

The energy flow studies in populations of marine and estuarine bivalves have attracted attention of many workers especially where they provide a commercial fishery and contribute significantly to the energy budget of a benthic community. The notable investigations include, studies on oyster, CAa5S0rfrea *virginica* by Dame (1972 a, b, 1976) *Choromytilus meridionaiis* by Griffiths (1981 a, b) *I\Aercenaria mercenaria* by Hibbert (1977 a, b), *Scrobicularia plana* (Da Costa) and *Fissurela barbadensis* (Grnelin) by Hughes (1970, 1971) scallop, *Ch/amys islandica (0. F. MiWet)* by Vahl (1981 a, b) oyster *Ostrea edulis* (L) by Rodhouse (1978, 1979) and *Tellina tenuis* (Da Costa) by Trevallion (1971)

The intertida popu ations of ndian rock oyster SaccosfAea *cucullata* are the typical of tidal estuarine ecosystems common to many coasts of Indian peninsula. In Kalbadevi estuarine ecosystem *Saccostrea cucullata* forms the popular food item in poor class communities. However, inspite of these being the Important members of the estuarine community, the Information concerning their significance to the estuarine ecosystem is nil. While there have been few studies on their biology (Nagbhushanam and Bidarkar 1975, Rajgopal eta! 1976, Mane 1978, D'Silva 1979, Asif 1979, 1980), the present studies report for the first time the quantitative examinations of these oysters' populations in relation to the incident potential energy per unit measure of the ecosystem and the efficiency with which this energy is being utilised by these oysters for various life activities and functions,

MATERIALS AND METHODS

The oyster community was sampled at low ^.^^^^ ^^ /^^^^ ^ ^^|^^/^^^ ^^^ip ^, ^^^^^ ^^ Kalbadevi estuary. At the beginning of sampling programme, a matrix of 120 (6x20) spots was determined on this shore and 4 spots were chosen monthly at random. A 0.25 m' grid ^gs then placed on the chosen spots and the ^eat contents of all the oysters within these quadrats were dissected out and individually packing in small glass vials containing sea water were transferred to the laboratory for further processing. On bringing to the laboratory the samples were dried to constant weights at 70°C temperature for 96 h. All biomass data ^. * . »u j *• • u» xu- thus refers to the oven dry tissue weights. The data obtained from 4 quadrats was pooled together for various analyses. The samples of 1 square metre were considered sufficient in size to reflect population functioning. For physiological experiments live oysters were required. These were the solitary individuals growing over small shingles.

The determination of energy budget was done by following I. B. P.

notation : C - P + R + F + U

where

C = Energy content of the food consumed.

P = Production i. e. energy incorporated by the population in new tissues and garnets and is, therefore, a sum of somatic production 'S' and 'G' which is the energy released into the environment as spawned garnets. Alternatively,

P = S + G + E where,

S = Any net change in energy content ot the standing crop.

G = op. cit.

E ⇐ The energy content of all individuals eliminated from the population due to various causes, such as predation etc.

R =" Energy dissipated from the population as metobolic heat, represented by respiration and is commonly measured by the oxygen consumption of the animal.

F = The part of 'C which is not absorbed but Is passed out of the gut as faeces.

U = Energy eliminated by secretion of unwanted materials or exudates such as mucus and dissolved organic matter (Rodhouse 1979)

Further, the amount of energy consumed which is utilised (assimilated) by the bivalve can be calculated as below:

$$A = C-(F + U)$$
$$=:P + R$$

and has been called as energy flow by Smalley (1960). This is the energy of assimilation (Trevallion 1971, Hughes 1971, Dame 1972 b 1976 Perkins 1974, Johnson 1976, Hibbert 1977 a, Ansel I et al 1978 Rodhouse 1978, Wu and Leving 1978, Wu 1979, Griffiths 1981 b) It is termed by Engleman (1966) as gross production. The net production according to him is C-(F + R).

The various parameters incorporated in the equation above were determined as follows. *'S'*- the somatic production by Ricker (1968) method, 'G' the reproductive output by the methodology described by Hibbert (1977 a, b) and 'E'the elimination by the method of Ansel I etal (1978). The energy dissipation (R) was estimated by measuring the oxygen consumption rates of oysters by standard laboratory experiements with volumetric estimations of dissolved oxygen, and converting the rates of oxygen consumptions into heat productions. For 'C and 'F i U since the independant measurements of feeding and biodeposition rates in the field were lacking, consumption 'C was determined as the amount of food consumption required to produce the energies of assimilation, assuming that food is assimilated at the 60% average efficiency as suggested by Miller et al (1971), i. e.

$$C= A/0.6 \text{ where}$$
$$A=P + R$$

and'F + U'asC-(P+R)

The energy budget was finally completed by converting the weight values (milligrammes) into energy values (kilocalories) by multiplying by 3.39566 (Vijayaraghwan et al 1975, Rajgopal et al 1976) and millilitres oxygen consumption values into energy values (kilocalories) by multiplying by oxycalorific coefficient 0.00482.

RESULTS AND DISCUSSION

The investigations carried out presently were on a representative oyster population sample covering an rock area of one square metre and the time unit was one year. Only the parametres in connection with the energetics of this population are presented here and the results are assumed to represent the characteristic of the whole oyster population system present in the estuary.

The energy utilization or the flow of energy through *Saccostrea cucuUata* is given below represented by the complete energy budget determined with units in Kcal/m7year which serves as a summary of population energetics.

C,	energy consumption	17968.29	Kcal.
A,	energy assimilation	10780.98	„
R,	metabolism energy	5617.79	„

F+ U, faeces & urinary energy loss	7187.31	
S, growth energy	1750.19	„
G, gonadal energy .output	1169.35	,;
E, energy to predators	2243.65	„
P, S + G T E i.e. production	5163.19	„

This complete energy budget can be used to examine the pathways of energy through population and hence to evaluate the role of *Saccostrea cucullata* in the community at the Kalbadevi estuary.

Large amount of consumed energy (C = 100%) is diverted to the maintenance cost (i. e, R = 31.26%). At this cost the soma (S) energy incorporation is 9.74% while the gonadal (G) energy output is 6.51% of the 'C. In addition to the gonadal output, the 40% of 'C' is passed to the trophic system back in terms of faeces and urinary excreta (F+U). The energy that is eliminated (E) from the population on account of fishing, predation and mortality is 12.49% and out of 60% of the energy assimilated (A) by the species 52.1% (R/Ax 100) is required by it for the incorporation of 16.33% of the energy as soma (S/A x 100), into the standing biomass and 10.85% of the energy as the gonadal output (G/A x 100). The 'S +G' together amount to 27.18% of 'A' and the elimination (E) is 20.82% of (A) (E/A x 100).

The ecological energetics budget available in literature may be compared with the energetics budget submitted here. The values reported in literature for C, S, G, P, R and F + U for various bivalves are given in Table. The original values have been converted to percentages of the energy consumed (C) with latter taking as 100% to facilitate comparison.

In bivalves the 'F-|-U' loss may be 14.00% to 94.22% of the consumed energy. It is interesting to note that in majority of bivalves the 'F+U' loss amounts to around 40% of the energy consumed. Tho examination of data in **Table 1 points out that *Saccostrea cucullata is*** an example of feeder with exploitative strategy like all these bivalves listed in this Table, except for the Bivalvia Los Maritas, only in which the energy loss amounts to 34.65% of energy utilization (F-|-U/PxIOO). Bivalvia Los Maritas shows extremely high efficiency ratios and appears to be adopted to conservationalist strategy, reducing energy losses to minimum.

The ratio of growth energy (S t G) to assimilated energy (A) is called the growth efficiency. The growth efficiency value for ***Saccostrea cucullata*** **may be compared with** the growth efficiency values reported in literature (Table 2) *Saccostrea cucullata* appears to have relatively high growth efficiency compared to ***Mytilus californianus, Scrobicularia plana*** **and** *Modiolus demtssus,* while it is close to a range **of values for *Donax vittatus, Bivalvia* San Luis' Bivalvia Las Maritas, *Tellina tenuis and Ostrea edulis.* For *Mytilus edulis, Mytilus Chilensis. Perna viridis, Pectinopecien yessoansis* and *Crassostrea virglnica* wide range of growth** efficiency values have been reported.

However, in *Saccostrea cucullata* besides 'F+U'loss of 7187 31 Kcal, fishing predators and mortalities (E) remove an estimated 2243-65 Kcal of energy and further with 'G' as 1169-35 Kcal, this all together amount to 10600.31 Kcal or 59% of the energy consumed (C) by these oysters, and therefore, inspite of the species relatively high growth efficiency, the above channeling of energies may probably be leading to it's inefficient survival and spread in the locality.

However, this may be only speculative, if the ecological efficiency of Sacco^rAfis *cucullata* is compared with the ecological efficiencies of other bivalve species of the same locality. The ecological efficiency is defined by Slobodkin (1962) is:

$$\frac{\text{Ec^Yield (P=S-^G-^E)}}{\text{Food intake (C)}}$$

For *Saccostrea cucullata* it comes to 0.2873. Based on the available information on primary productivity of the waters at the locality and on the filtration rate in *Mytilus {Perna) viridis* (Ranade 1977) and *Meretrix* sp (Durve 1963) and length- weight relationship (Kowale' Personal communication) of latter, the consumption of energy in Kilocajories (using calorific coefficient values given by Vijayraghavan et al 1975) required to produce the same amount

TABLE 1. ***Energy partitioning in bivalves from different Localities***

SPECIES	S	G	P	R	F + U
1. ***Donax incarnatus*** Anselletal, 1972	-	-	8.49	51.23	40.28
2. ***Donax spiculam*** Anselletal, 1972	—	-	6.17	53.81	40.02
3. Bivalvia San Luis Edwards 1974 a	-	-	19.76	40 22	40.01
4. Bivalvia San Luis Edwards 1974 b	—	—	15.55	44.44	40.00
5. Bivalvia Los iVlaritas Edwards 1974 a	—	-	4040	45.60	14.00
6. Bivalvia Los IVlaritas Edwards 1974 b	—	—	17.52	42.47	40.00
7. ***Scrobicularia plana*** Hughes 1970	-	-	12.40	47.60	40.00
			14.56	45.43	40-00
			12.64	2.37	84.98
			12.60	48.19	39.21
			14.56	45.60	39.83
			12.63	47.40	39.97
8. ***Tellina tenuis*** Travel l ion, 1971	—	-	16.77	43.23	40.00
			14.32	45.67	40.00
			26 50	33.49	40.00
9. ***Donax vittatus*** Anselletal 1972	—	—	18.71	41.29	40.00
10. ***Modiolus demissus*** Kuenzler, 1961	—	—	18.21	42.21	39 67
11. ***Choromytilus meridionelis*** Griffiths, 1981 a, b	1.40	6 87	8.27	12.35	79.36
12. *Chlamys islandica* Vahl. 1981 a	0.49 to 22.58	2.58 to 10.21	10.72 to 25.16	34 83 to 49.29	40.01
13. ***Chlamys islandica*** Vahl, 1981b	1.76	0.36	2.12	3-58	94.22
14. ***Ostrea edulis*** Rodhouse, 1979	4.45	3 82	8.27	20 18	7153
15. ***Mercenaria mercenaria*** Hibbert 1977 a, b	11.50	9.79	21.29	38.70	40.41
16. ***Crassostrea gigas*** Bernard, 1974	0.59	29.67	30.26	29.73	40.00
17. ***Crassostrea virginica*** Dame, 1976	21.21	4.11	25.32	34.67	40.00
18. ***Crassostrea meridionalis*** Griffiths, 1981	5.98	23.82	29 80	30.20	40.00
19. ***Perna viridi's*** Shafee	-	—	33.78	26.24	39.98
20. ***Mytilus Chilensis*** Navorro, 1982	—	—	33.74	26.99	39 27
21. ***Saccostrea cucullata*** Present studies	9.74	6.51	28.74	31.27	40.00

TABLE 2. ***Growth efficiencies of bivalves from different localities***

	SPECIES	GROWTH EFFICIENCY'	AUTHORITY
1.	***Donax incarnatus***	14.22	Ansell et al 1972
2.	***Donax splculum***	10.29	- d o -
3.	Bivalvia San Luis	32.94	Edwards, 1974 a
4.	- " —	25.92	- d o
5.	Bivalvia Los Maritas	46.98	Edwards, 1974 b
6.	- " —	29.20	— d o -
7.	***Scrobicularia plana***	20.67,2073 21.04,24.20 24.27,94.21	Hughes, 1970
8.	***Donax vittatus***	31.18	Ansell, et. al 1972
9.	***Modiolus demissus***	**30.14**	Kuenzler, 1961
10.	***Chlamys islandica***	17 86 to 41.94	Vahl, 1981 a
11.	***-'•—***	**37.19**	Vahl, 1981 b
12.	***Choromytilus meridional is***	40.11	Griffiths, 1981, a, b,
13.	***Ostrea edulis***	29.07	Rodhouse 1979
14.	***Mercenaria mercenaria***	35.49	Hibbert, 1977 a, b,
15.	***Crassostrea gigas***	5044	Bernard, 1974
16.	***Crassostrea virginica***	42.21	Dame, 1976
17.	***Crassostrea meridionalis***	**49.67**	Griffiths, 1981 b
18.	***Perna viridis***	56.28	Shafee, 1979
19.	***Mytilus'jchilensis***	55.56	Navorro, 1982
20.	***Saccostrea cucullata***	27.18	Present studies

* calculated values based on various data of respective authority.

of yield as that was for *Saccostrea cucullata* per square metre annually can be calculated and by dividing the yield by consumption the ecological efficiency is obtained. The ecological efficiency values for the three different species come to:

Mytilus {Perna) viridis	8.8999
***t\AeritriY,* sp**	70.6891
Saccostrea cucullata	0.2873

It will be seen, at once it becomes clear that the clams are severalfold efficient utilizers of the available energy at the Kalbadevi estuary, next to which come mussels and the rock oysters are found to be least efficient in using the available energy resources. The very high ecological efficiency of clams is truly reflected in their very high productions in this estuary. It is reported that 227.27 tons of the species are harvested every year (Ranade 1964). Production of mussels per square metre has been calculated as 7050. 45 g (Ranade 1977) which is strongly in contrast to present species production of 818.21g m/'.

In *Saccostrea cucullata* very large amount of Soma energy Is lost in the form of elimination (Table 3) the main cause being the human fishing activities. However, our laboratory studies indicated high tolerance capacities of these oysters to low salinity grades, survival for two weeks in fresh water has been noted. Similarly, the desiccation experiments have also proved that the short term atmospheric exposers had no effect on oysters, causative of any mortality in them. From the data collected on fishing and natural mortality, it is roughly concluded that about 80% elimination maybe due to fishing activities and remaining 20% may be attributed to the other factors (unpublished data).

That the fishing mortality affects the population structure, growth and production has also been observed by Okera (1976) in his studies on *Senilia senilia.* He found that, he could collect cockles only less than 22 mm in the Sierra Leone river estuary. He observed that predators other than man contribute little relative to total mortality of the cockels.

TABLE 3. *Frequency distribution of different groups sfiown as percentage of tfie total number of individuals collected during the study period of one year.*

Sl. No.	Weight (Mgs) Groups	Number of Individuals	Percentage %
1.	101—120	588	11.88
3.	121 — 140	729	11.55
4	61—80	582	Q 29
5	81 —100	213	3 37
6	101—120	588	931
7.	121 — 140	567	8 98
g	141 —160	503	7 97
9.	161—180	363	575
10.	181 - 200	121	1.92
13	241 - 260	223	3 53
14.	261 —280	251	2 39
15	281 — 300	4R	n 71
16*	301 — 320	96	i'<^9
18.	341 —350	70	1 11
19.	361 — 380	48	0 76
20.	381 —400	11	1 17
21.	401 —420	48	0 76
22.	421 — 440	37	Q 59
23.	441 — 460	23	0.36
24.	461 — 480	21	0 33
25.	481-500	13	0-21
27	521-540	in	niR
28.	541—560	9	a i 4
29.	561-580	13	0^21
30.	B81 - 600	1	0.02
31.	601-820	4	006
32.	621—640	4	0.06

In Kalbadevi estuary almost any specimen of *Saccostrea cueullata* of 280 mg and above sizes is prone to be harvested (Table 3). Such a situation however, is not in itself a stable and for the population to be maintained over a indefinite period would require a continuous recruitment of the bivalves. The *Saccostrea cucu/tata* seed oysters were present throughout the year. This oyster showed a continuous breeding pattern. However, the new recruits probably get only few chances to breed and their gonadal output (G= 6.51 %) is apparently ineffective in generating the required scale of recruitment of the species for population growth and spread in Kalbadevi estuary.

The heavy harvesting in effect maximises removal of reproductively the most valuable individuals in population. Consequently, the stability of the resource is being endangered by the present harvesting practices. The fishery should leave the age categories of highest reproductive values in an unharvested portion of the population in order to increase the productive potential of the population.

Considering the salient features of the data presented here in terms of energy, it must be the energy partitioning in *Saccostrea cucuilata* is suggestive of less functional importance of the species in the estuarine ecosystem at Kalbadevi. The energy utilization by this tropical oyster shows that these bivalves minor role in the functioning of this estuarine ecosystem. Although some growth energy is essentially srored for long periods of shells, large amount of energy produced in the form of tissues is utilised by humans as a food resource.

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37- BIOCHEMICAL CHANGES IN THE OYSTER *CRASSOSTREA MADRASENSIS* (PRESTON) WITH MATURATION

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INTRODUCTIOJNJ

Central IVIarme Fisheries Institute has perfected the technique of culturing the common edible oyster *Crassostrea madrasensis* (Preston). Venicataraman and Chari 1951 had studied the fluctuation in biochemeical composition in the whole oyster meat for different months in the naturally growing oysters of Ennore, Madras. In the presenr paper a study has been made about the biochemical composition with maturity in male and female oysters cultured at Tuticorin, Tamil Nadu.

METERIAL' AND METHODS

The edible oyster, *Crassostrea madrasensis* were collected from the Institute's Farm at the Tuticorin Bay. The oysters were carefully opened and gonadial smear examined microscopically. The stages of maturity were divided into five namely, immature, maturing, ripe, spent and indeterminate. In the indeterminate stage the sexes were not distinguishable. Since oysters attain first maturing by the first year, such older oysters were catagorised as indeterminate, which were either in post spent stage or in the process of sex change. In the immature stage sex could be distinguished. In the maturing female and male oysters the developing stages of the gametes were easily distinguishable but the gametes were not fully ripe. The eggs were elongated and dense. In the ripe stage eggs were free, less granular and oozing; in the males the sperms were easily distinguishable. In the spent stage the gonads were generally brownish, watery and a few unreleased gamets could be observed here and there which were in the stages of absorption.

Fromeachoyster, mantle, gills and adductor muscle were carefully dissected out. The rest of the tissue has been taken herein as visceral mass. Tissues of 3-5 oysters of particular stage were pooled, of which a part was used for the determination of moisture by drying at 55° C in a hot air oven and the rest were minced and from this weighed portions were talcen for the determination of lipid, protein and carbohydrate, The tissues used for moisture estimation were used for the determination of ash by incineration at 600° C in a muffle furnace,

Protein was estimated by biuret method a^er Gornall et al (Dawson et al 1969). Determination of total carbohydrate was carried out by anthrone method (Umbreit et al 1959) and lipid by Folch's method.

RESULTS AND DISCUSSION

The data obtained are given in tables 1 -3. The values for moisture and ash though significantly varied between the tissues, for the sartie tissue did not fluctuate very much and so were pooled together. In visceral mass the moisture content varied between 77.93% to 82.62%, and the high moisture content was observed in oysters which were in spent stage, Venkatarman and Chari (1951) have found the total moisture content to vary between 76.67o/„ to 85.04% f^^ naturally growing whole edible oyster of g^^ore, Madras, Further these authors dried the sample at 105° C. The same authors have a'so found the ash content to vary from 0.52% ^o 2.06%. Lipid content was found to vary with maturation but for the same stage, between the sexs, differences were not significent; therefore the data were pooled stage-wise and

TABLE: 1 *Organwise moisture and ash content /'" percentage.*

	Moisture	Ash
Mantle	79.50	6.1
GJH	81.11	6.6
Adductor muscle	78.00	5.6
Visceral mass	77.95-82,62	3.9

average taken. In different organs the lipid content fluctuated between 0.20% to 2.20%. The lowest values were obtained in the mantle tissue and the highest in the visceral mass during ripe condition. Venkataraman and Chari (1951) did not study the fluctuation with maturation but they found for the whole oyster meat the fat content to vary between 1.36%-3.07% during different months.

TABLE: 2 *Percentage lipid content In different stages.*

	Imma-ture	Matur-ing	Ripe	Spent	Indeter-minate
Mantle	0.21	0.25	0.30	0.20	0.20
Gill	0.73	0.78	0.86	0.74	0.71
Adductor muscle	0.80	0.82	1.00	0.90	0.83
Visceral mass	1.00	1.61	2.20	1.20	1.91

Protein content was found to be minimum (809%) in the gills of immature female oysters. The highest values (16.00%) were observed in the visceral mass of ripe males. Oysters which were in ripe, spent and indeterminate stages contained higher percentage of protein. Among the tissues adducter muscle showed lesser fluctuation between stages of maturity (11,63%-15.77%). Venkataraman and Chari (1951) have found the protein content in the whole oyster ^ggt to vary seasonally between 5.72% to 13.31'..

The percentage of total carbohydrate content in the tissues varied between 0.9 to 8.6. The higher carbohydrate content was met with in the mantle and in the gills. Visceral mass in the maturing and ripe oysters contained lesser percentage of carbohydrate. For the whole oysters meat the carbohydrate (glycogen) content varied in different months between

TABLE:3 *Protein and carbohydrate content* (%) *in various tissues wtth maturation in male and female oysters.*

	Male				Female				
	Immature	Maturing	Ripe	Spent	Indeterminate	Immature	Maturing	Ripe	Spent
PROTEIN									
Mantle	12.46	10.71	16.24	13.00	15.58	11.76	17.90	15.01	12.52
Gill	10.57	9.77	13.93	12.04	12.85	8.09	11·53	11.82	12.89
Adductor muscle	11.90	15.77	14.92	12.03	11.40	13.24	14.23	15.00	11.63
Visceral mass	14.32	10.56	16.00	15.82	15.05	13.22	14.82	12.01	12.84
CARBOHYDRATE									
Mantle	3.3	4.9	7.0	3.0	1.1	2.6	8.6	5.2	0.6
Gill	1.9	5.9	4.1	2.7	1.0	2.9	2.5	2.6	2.7
Adductor muscle	1.1	4.5	3.4	2.5	0.9	1.6	1.9	5.0	3.1
Visceral mass	4.9	2.5	1.5	2.0	3.1	5.3	1.1	2.0	5.3

0.44%-5.85% (Venkataraman and Chari 1951). The higher variation between the present worl< and that of Venkataraman and Chari (1951) is due to the fact that in the present work total carbohydrate content was measured while the earlier workers determined the glycogen content only,

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38. BIOTIC POTENTIAL AND ENVIRONMENTAL RESISTANCE OF BIVALVES OF MANGALORE COAST

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ABSTRACT

Blotic potential and environmental resistance of seven sgecles of bivalves inhabiting Mangalore coast have been quantified from data gathered during the pa^t 15 years. Ths species examined are the oysters *Crassostrea madrasensis* (Preston), *Saccostrea cucullata* (Von Born), the clams *Meretrix casta* (Hanley), *Katelysia opima* (Gmelin) *Villorita cyprinoides* (Gray), Donax *incarnatus* (Gmelin) and the mussel *Perna viridis* (Linnaeus) Components of blotic potential are described in terms of distribution and density, growth survival, longevity, age, size at first maturity and production. Environmental resistance was delineated by examining spawning', settlement, survival crowding, over-growth, fouling and mortality. Data on these aspects have been presented and discussed.

Blotic potential of estuarine species of bivalves was higher than that of marine species. In the estuaries, the main limiting factors were silting, heavy flooding, extremely low salinity levels during the south-west monsoon, lack of substrata for settlement and other causes of mortality. In the marine habitat, exposure, desiccation, overcrowding, lacIc of settlement space, competition for food and space, overgrowth, predation, surf action and mortality limited realisation of full biotic potential. A multidjsclplinaty approach to problems in bivalve population ecology has been lacking till now and this paper stresses the need for work on these lines.

INTRODUCTION

Knowledge of its biotic potential and environmental resistance is an important pre-requisite for the development of a strategy for management of a living species resource. Factors that limit abundance, distribution in space and time, life and activity have been studied in many living marine bivalves. But a comprehensive approach to examine a species resource from its biotic capability and to delineate how the environment resists the full componentof biotic potential from being realized in a natural habitat, has been lacking in the case of marine bivalves except in the oyster *Crassostrea virginica* (See Mackenzie 1981). In the present paper an attempt has been made to examine these two aspects as completely as possible In the sedentary phase of seven species of bivalves inhabiting the coast of Mangalore.

MATERIAL AND METHODS

Seven species of bivalve molluscs inhabiting the Mangalore coast formed the material for the study. These were the oyster *Crassostrea madrasensis* (preston), the clams *IVleretrix casta* (Hanley) and *Katelysia opima* (Gmelin) inhabiting the Mulki estuary (lat. 13°5' N; long, 74°46' E), the oyster *Saccostrea cucullata* (Von Born) and the mussel *Perna viridis* (Linn) inhabiting the Someshwar coast (lat. 12°47'N;

long. 74°5rE), the clam *Villorita cyprinoides* (Gray) inhabiting the Netravathi-Gurupur estuary (iat. 12°50'N; long. 74°50'E) and the wedge clam *Donax incarnatus* (Gmelin) inhabiting the Panambur shore (Iat. 12°57'N; long. 74°48'E). The data have been collected during various periods between 1971 and 1936.

Environmental parameters have been studied by analysing water samples for physical and chemical characteristics usingstandardmethods. Data on distribution, density and biomass production have been gathered by quantitative sampling using appropriate quadrants of 25, 50 or lOOcm^ size. Growth was studied by length frequency or Pauly's integrated method (paully 1983) using data on shell length. Data on longevity, survival, age, size at maturity and mortality were calculated from the basic shell length data recorded. La, K and t^ were calculated by Von Bertalanffy's growth equation (Von Bertalanffy 1938). -Reproductive activity was examined by the methods described by Joseph and Madhyastha (1982,1984). Data on settlement, survival, crowding, overgrowth, fouling and interrelationship with other organisms were quantified from field and laboratory observations carried out during the study period.

RESULTS AND DISCUSSION

Crassostrea madrasensis

Although C. *madrasensis* is distributed in all the five major estuaries of Dakshina Kannada coast, dense populations appear only in the Mulki and Hangarakatta estuaries. Within the Mulki estuary, the oyster beds extend from the bar mouth to 4 km upstream. Distribution is patchy, individual oysters are found lying at the silty bottom. Population density ranged from 0 to 8 oysters/m2, the average being 2/m» [mean biomass, (wet weight) 18 g/m»]. The average growth rate was 9.15 cm and 5.05 cm during the first and second years. The age at marketable size (7 cm) was 9 months. The Von Bertalanffy growth parameters were: Loo = 32.8 cm, K=0.0524, and 1^= —1.3 quarter year. Lmax in Mulki estuary was 28.4 cm. The population age structure showed dominance of zero and 1 year olds in the population. The minimum size at first maturity was 12-14mm in male and 24-26 mm in female. Above 30-32 mm shell lengh, there was no relation between size and stage of maturity. The sex ratio of the oyster was near 1:1. During the somatic growth phase (June-September) the indeterminate oysters dominated, at times constituting as much as 100%. No hermaphrodite or transition stage was noticed.

Environmental parameters seem to have a great influence on the activity of *C. madrasensis.* During the course of a year, two distinct phases of activity could be observed. A period of active somatic growth coincided with the southwest monsoon (June-September) which was characterised by low levels of ambient salinity (S%X15°/oJ. During October-May a period of sexual activity, gonadal growth, maturation and spawning coinciding with the buildup of ambient salinity to levels >157oc,- Spawning was observed between S°/„„ 25 and 36°/oo. Salinity shifts appear to play a regulatory role in synchronizing gonadal activity and spawning of this species. Spat settlement pattern showed two periods of peak settlement in Nov. ember January and March-May. There was no settlement during August-September. The mean rate of growth of spat was 2.1 cm, 1.4 cm, 1.0cm, 1.0 cm, 0.7 cm and 1.0 cm during the first six months respectively. The young oyster reached a size of 7.2 cm after 7 months of growth on suspended cultch. Crowding and overgrowth resulted in poor spat growth and survival. Fouling by barnacles, polychaetes, and spat of *Saccostrea* sp, boring by *Polydora ciliata* and parasitization by the trematode *Bucepfialus* accounted for the bulk of the biological components of environmental resistance. The major fouling organisms were 3 species of algae, 1 species of sponge, 2 hydrozoans, 7 bryozoans, 14 species of crustaceans and 6 species of molluscs. 3 spp of crabs and 2 spp of oyster drills formed the chief predators. The important parasites were *Polydora, Bucepfialus, Tylocephalum* and *Ostrincola.* Mortality was related to predatlon, parasitization, overgrowth by competition, suffocation due to heavy silting, shell fracture during spat growth, biological factors and other causes.

Saccostrea cucullata

The rock oyster *S. cucullata* forms an important component of the fauna of the surf

beaten rocky shores at Someshwar. Heavy spat fall and competition for space result in overcrowding of oysters as a result of which large flattened blocks of oysters with stunted growth form dense patches along the intertidal belt. The density ranged from 15 to 320 oysters/m^ [mean biomass (wet weight) 30 g to73g/m2]. The mean wet weight ranged from 1.67 g (August; to 3.64 g (May) in males and from 1.68 g (September) to 3.14 g (May) in females. Oysters ranged in size from 3.0cm to 7.1 cm shell length, the majority being in size ranges between 4.0 and 5.5 cm. Growth was fast immediately after settlement, but later reduced or negligible because of overcrowding and over growth on adjacent oysters. Heavy surf action on the shore altered the shell shape resulting in flattened individuals. The majority of oysters in the population belonged to the zero year group. The size at first maturity was 3.2 cm in female and 3.5 cm in male oysters.

Environmental effects were observed on the settlement, shell shape, growth, spawning, survival, fouling and mortality of the oysters. Sexual maturity was attained during April-May. Spawning commenced in June and extended till December with two peaks during June-September and November-December. The spawning season coincided with reduction of ambient salinity to 33.3°/„„ — 29.78°/„„. The male: female ratio was 1 :1.34 with a few hermaphrodites (167oo)- Among the environmental factors, settlement level, desiccation, overcrowding and overgrowth were the dominant ones which prevented the oysters from realising their full biotic potential. Fouling by other organisms was limited; the common foulers were barnacles and three spp of algae.

Meretfix casta

The clam *M.casta* forms the most important component in the bivalve population in all the estuaries of Dakshina Kannada. Large quantities are landed throughout the year. These clams are distributed throughout the estuarine stretch in th» Natravathi-Gurupur, Mulki, Udyavara and Coondapur estuaries. The average standing crop values (wet weight/m^) in the various estuaries are: Netravathi-Gurupur 174 g/m*, Mulki 956 g/m^, Udyavara 863 g/m', and Coondapur 1024 g/m2. The estimated values of Ymax are: Netravathi-Gurupur 661 t, Mulki 2581 t, Udyavara 1592 t and Coondapur 8110t. In all the estuaries higher densities were recorded during the pre-monsoon (Jan- May) period The population mainly consists of zero year class The average size of *M. casta* in the four estuaries are: Netravathi-Gurupur 29.6mm, Mulki 30.7 mm, Udyavara 26.7 mm and Coondapur 29.6 mm, Mulki 30.7 mm, Udyavara 26.7 mm and Coondapur 29 8 mm.

All the estuaries showed considerable variations in ambient salinity during the course of a year. The salinity ranged from almost fresh (0.2°/<,3) during monsoon to typically marine (36.00%(,) conditions during summer. Some mortality occurred during the monsoon period due to low salinity and heavy silting. The spawning season was prolonged, extending from October to May with several peaks fn between. Settlement of spat was characterised by patchiness. Heavy spatfall was noticed during November-December. Survival rata of spat was very high as they were not affected by crowding, overgrowth and fouling. Estuarine crabs and catfishes were the common predators of newly settled spat. Three parasistes/ commensals were observed; these were the creb *Pinnotherus,* the copepod *Conchylirus* and the trematode *Bucephalus.*

Katelysia opima

Biotic potential of *K. opima* was studied in Mulki estuary where this species is distributed in good quantities. The distribution was limited to silty areas near the bar mouth. The mean density ranged from 30 g to 533 g/m^. The estimated value of Ymax was 10351. Mean size of *K. opima* was 34.1 mm (range 10.5 mm to 48.7 mm) in the feral population. La was 52.8 mm, K=0.1049 and to= - 2.40. Differential rates of growth were observed between the two broods within a year class. The September brood had a faster growth rate than the April brood. Bulk of individuals in the population belonged to zero year group. The average life span of the clam was *Ca* 2y. The minimum size at first maturity was 20mm.

Resistance by the environment to the biotjc potential of *K. opima* was apparent in the

survival of clams during the low saline south west monsoon. Large scale mortality of clams inhabiting all areas in the estuary except regions close to the bar mouth was a regular feature. About 90% of standing crop was prolonged, from December to May. Settlement was sparse and patchy. Survival of young clams appear to be related to the nature of the bottom and ambient salinity. This species was least affected by problems in fouling and crowding. The parasites recorded were *Pinnotheres* and *Bucephalus.*

Villorita cyprinoldas

The upper reaches of the Netravathi-Gurupur estuary supports a moderate population of *V. cyprinoides.* The bottom was sandy with very coarse sand dominating (40.7%) the sediment. Population density ranged from 8 to 82 individuals/m^. Moment estimates of K (Reddy 1983) ranged from 0.0812 to 3.3214. Biomass ranged from 4.11 g to 44.14 g (wet weight)/m2 and 1.06 g to 9.94 g (dry weight)/ m2. The highest biomass values were during December-March. A fast rate of growth was noticed; the clams reaching 17.0 to 19.0 mm in 3 months, 24.0 mm in 6 months, 28.5 mm in 9 months, 31.5 to 32.0 mm in 12 moths and 35.0 mm in 16 months. The Von Bertalanffy growth parameters were L a = 38.96mm, K= 0.1289, and to =-1.74.

The ambient salinity showed a variation from 0.447„„ to 13.257„„ between October and March. Gametogenic pattern and spawning ware closely related to salinity cycles. Gametogenesis commenced during October-November and resulted in first spawning in December. Spawning season extended till late March with peal< activity during February-early March. Spat fall was observed from November onwards. The sex ratio was near 1:1 and no hermaphrodite was recorded. No metazoan associates or parasites were noticed in this species. Also, there were no fouling organisms. This population formed a more or less single species community. Heavy flooding and silting during the peak of the south west monsoon caused mortality in both small and large-sized clams.

Donax incaxnatus

Extensive beds of the wedge clam *Donax incarnatus* are found all along the sandy shores north of New Mangalore Port. The biotic potential of this species was studied at a locality on the sandy shore at Panambur. The substratum was formed of fine sand (Krumbein 1939) which formed 75.09% to 94.2% of the sediment. The population density ranged from 89 to 39446 individuals/m'. The peak density was during January and the least during April. Biomass values (whole wet weight) ranged from 124g/m2 (April) to 1892 g/m» (January). Biomass (dry tissue weight) ranged from 6.55 g/m2 (October) to lOOOSgm' (January). The size of clams ranged from 14.7 mm (May) to 20.7 mm (April). > 90% of individuals during periods of peak abundance belonged to newly settled spat. The monthly rates of growth during the first 12 months were 5.19 mm, 4.06 mm, 3.00 mm, 2.48 mm ,2.59 mm, 2.01 mm, 1 71 mm, 1.56 mm, 1.78 mm, 0.52 mm, 1.0 mm, 1.0 mm and 0 30 mm respectively. The whole population belonged to individuals of less than 1 year age. Lm«x was 26.1 mm. The von Bertalanffy growth parameters were. La = 30.94 mm, K = 0.162 and to - 0.04

Breeding in *D. incarnatus* took place mainly from November to February. Heavy settlement along the surf zone resulted in very high population density. Effect of the environment's resistance was clearly manifested by the sudden and very heavy mortality of newly settled spat. Population density ranging from 14342/m* in November to 39446/m' in January resulted in heavy crowding which probably caused high mortality. Also, settlement in the surf zone resulted in exposure to high sand temperature (32.2°C to 35.0°C) and desiccation. This also would have caused high mortality of newly settled spat. Thus, the survival rate of newly settled spat was as low as 0.44% at the end of the breeding season.

Perna viridis

The green mussel *P. viridis* forms mussel islands on the intertidal rocks at Someshwar. Heavy settlement results in large patches having a thickness range of 2.1 cm to 6 0 cm. The population density ranged from 2388 individuals/m2 (May) to 44075 individuals/ m' (October). The range in biomass (whole wet weight) was from 1772.2 g/m^ (October) fo 12794.8 g/ m' (February). The size of mussels ranged from 1.2 mm in October to 80.6 mm in May.

Small sized mussels formed the bulk of the population during October-December. Mussels reached a mean length of 34 25 mm at the end of 12 months' growth. The Von Bertalanffy growth parameters were: Loo = 41 93 mm, K= 0.1518 and to - - 0 038

The spawning of mussels commenced in January. Intermittent spawning was observed in February and May to November. Heavy spatfall occurred during January-March and September The sex ratio was close to 1 :1 with no hermaphrodites in the population- Settlement intensity was very high. Inspite of heavy crowding, spat and juvenile mortality were very limited. Competition for settlement space was very high, resulting in several layers of mussels carpeting the rocky substrata. As growth proceeded, mussels relocated themselves within the mussel islands. 40 species of fouling and associated organisms were recorded in the mussel island community. Mortality was low in the population. However, loss of mussels from the bed due to severe wave action was commen.

From the foregoing account of the biotic potential and environmental resistance of seven species of bivalves, the following conclusions could be drawn. The study has demonstrated that a concerted effort could identify the important aspects of a species' biotic potential and delineate the environment's resistance. Biotic potentials of the estuarine species are fairly high). In the estuary the limiting factors are heavy flooding and extremely low salinity levels during the south-west monsoon, heavy silting, lack of clean shell substratum for settlement of larvae and mortality due to predators, competition tor settlement space and parasites. Fouling, crowding and overgrowth were important factors affecting the survival of freshly settled spat in the estuary. The biological components of environmental resistance were fairly high in the estuary, thus preventing the fuU complement of biotic potential from being realised. In the marine habitat, the main componenfs of environmental resistance were overcrowding, overgrowth, lack of settlement space, severe wave action, predation and mortality due to desiccation. Survival rate of spat in species like *D. incarnatus* was as low as 0 44%. Levels of ambient salinity played an important role in regulating reproductive activities and also affecting growth rates. The study shows that removal of limiting factors in g species population by the careful application of specific methods can enhance production '^»««- '^^'^ '^ ^" important point to be con- ^'^^'^'^ '" management of mariculture practices, Such an approach would open up the possibi- "ty of increasing production through mariculture several folds than that at present,

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39 NEUROENDOCRINE REGULATION IN LAMELLIBRANCH MOLLUSCS

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ABSTRACT

Gametogenesis and spawning in lamellibranch molluscs may be controlled by either exogenous or endogenous factors. Though the factors like salinity or temperature in such studies have been widely elaborated by various workers, the endogenous regulation stilt remains in its infancy. Our experimental studies, based on the classic histological staining of the neurosecretory material, have revealed neurosecretory cells in the central ganglia of lamellibranch molluscs. The tinctorial properties of these cells may vary from species to species. The pyriform (pear-shaped) neurosecretory cells from cerebral ganglia revealed such endogenous regulation system affecting the release of sex products. There exists four successive stages in the passage of neurosecretory product within the sell body- This has been extensively worked out in case of Perna i/>/cy/S from Ratnagiri coast. The data have been correlated with the gonad maturation stages and spawning.

INTRODUCTION

Reproduction in Indian lamellibranch molluscs has been studied extensively. Much of the literature is concerned with reports on annual breeding period. Reproduction is cyclical, and it may be annual, semiannual, or continuous. Reproductive phases such as gonad development, spawning and fertilization, and development and growth, functioning continually in coordination with seasonal environmental changes, produce the pattern characteristic of a species in a given area. The timing and duration of reproductive activity may be determined through interaction between endogenous and exogenous factors. The synchronization of breeding periods with the environmental conditions most favourable for the development and growth of the progeny is obviously significant for reproductive success. Though voluminous publications on the reproduction in lamellibranchs from Indian coastal wateis exist, little attention has been given on endogenous regulating system during gonadal maturation and spawning in these animals. In this report we cover the work carried in different laboratories in abroad and India, including our laboratories on the endogenous regulating system during gonadal maturation and spawning of these molluscs.

In bivalve molluscs, nervous system and hormonal apparatus are not sharply separated and no endocrine glands have so far been encountered. It is, therefore, possible that hormonal activity is restricted to the nervous system itself. Thus, nervous system and hormonal system are interrelated structurally and functionally, which is supported by the fact that the secretory cells occur in ganglia of these molluscs. The nervous system plays a role in neurotransmission as well as in the synthesis and discharge of secretion. Neurons secrete both neurohumors and neurohormones. Studies on neurohumors have involved their chemical nature (Milton and Gosselin 1960; Sweeney 1963; Zs Nagy et al 1965; Paparo 1972; Stefano and Aiello 1975), their control of ciliary activity (Aiello 1962, 1970; Paparo and Aiello 1970) and their influence on oxygen consumption (Moore et al 1961; Moore and Gosselin 1962).

Neurosecretion in bivalves has been reviewed by Gabe (1965,1963), Lubet (1966, 1973), Martoja (1972), and Golding (1974). The development of subject has been hampered by the presence of shell, by the diffuse distribution of the neurosecretory cells, and by the ignorance of the chemical nature of the neurohormones Presence of neurosecretory cells has been demonstrated by classic histological studies on a number of species. Their number and location vary among species. Neurosecretory cells are located in cerebral and visceral ganglia. In higher lamellibranchs, neurosecretory cells are less numerous and more localized. These cells are generally found in the dorsal caps of cerebral ganglia and the dorsal cell layar of

visceral ganglia (Lubet 1965a, 1959; Nagabhu. shanam 1963, 1969; Nagabhushanam and Mane 1973; Mane 1986) The neurosecretory cells were found to be less numerous in the cerebral ganglia than in the visceral ganglia. The presence of neurosecretory cells in the pedal ganglia is controversial, However, Gabe (1955) and Lubet (1955a) conclude that they are absent in *My til us edulis* or *M galloprovincialis,* but Umiji (1969) in *Perna perna* and Nagabhushanam et al (1972) in *Mytilus (Perna) viridis,* have recorded them as present on the pedal ganglia. The neurosecretory cells have been reported to occur in all gangliaof freshwater mussels *Unio tumldus* (Fahrmann 1961). *Dreissf;na polymorpha* (Antheunisse 1963), *Lamellidens marginalis* and *L. corrianus* (Muley 1985).

In most species neurosecretory cells are small or medium-sized, with an approximate diameter of 20 (^m. Neurosecretory perikarya are avoid or pyriform. The general histological features are similar to those of plasmochrome cells, but neurosecretory perikarya can be distinguished by the marginal position of the Nissl bodies and the presence of acidophilic secretions in the cytoplasm (Gabe 1955, 1966). Different catagories of neurosecretory cells have been distinguished, based on their size and morphology. In *M. edulis* and *Chlamys varia* some neurosecretory cells are pear-shaped, unipolar, and upto 25 ^m, while others are small and multipolar (Lubet 1959). Pear-shaped (type I) and oval-shaped (type II) neurosecretory cells were distinguished in *Crassostrea virginica* and *Meretrly. casta* (Nagabhushanam 1963, 1969) and *Katelysia opima* (Nagabhushanam and Mane 1973). Different categories of neurosecretory cells have also been reported in the freshwater mussel, *U. tumldus {Fehrmann* 1961).

The appearance and position of neurosecretory products within the perikarya vary with the stage of the neurosecretory cycle (Lubet 1955a, b; 1959; Gabe 1966; Gabe and Rancurel 1958; Blake 1972; Nagabhushanom et al 1972). In some cells neurosecretory granules are few, while in others they are abundant and remain discrete. In still other cells, neurosecretory products are present in lumps or pools. The discharge of neurosecretory products is characterized by cytoplasm and the presence of small quantities of secretory products between the vacuole and axon hillock (Gabe 1966). Signs of axon transport are not very distinct in marine bivalves. Neurosecretory products have been observed in the axon hillock and proximal parts of the interganglionic paths of the axon, but they disappear in the neuropile and are not seen in the communicative branches, commissures or nerves leaving the ganglia. Endocrine glands or neurohemal organs have not been identified in bivalve molluscs. Umiji (1969) has reported that a neurohemal area exists on the cerebral commissure of *P. perna.*

The.transport of neurosecretory substances by axons, intermediate cells, and possibly glial cells has been suggested by Lubet (i955b) and Umiji (1969). Several authors have suggested that glial cells play a role in storage and transport and that glial cells and epineurons can function as neurohemal organs (Fahrmann 1961; Antheunisse 1963). However, the chemical nature transport, and fate of neurosecretory products is not clearly established in bivalves.

Cyclical activity in neurosecretory cells was observed by histological studies on C. *varia* and /W e£/w//s (Lubet 1955a, 1559), *Splsula solid!-sslma, M casta. Yoldia* sp. *Modiolus demissus* and *Mullna lateralis* (Nagabhushanam 1963, 1969), *K. opima* ^Nagabhushanam and Mane 1973), *P. perna* (Umiji 1969), and *Argopecten* (= *Acqu/pecten) irradlans* CBlake 1972). Seasonal changes in cyclic activity have been related to the reproductive cycle. However, Welsh and Antheunises (1963) have pointed out that the reproductive cycle is usually seasonal and in turn related to such environmental factors as temperature, food abundance, and light.

Investigations by Lubet (1956,1959) demonstrated distinct annual neurosecretory cycle in the pear-shaped neurosearetory cells of the cerebral ganglia in temperate species, *M. edulis* and *M. galloprovinclalls.* The annual neurosecretory cycle and gametogenesis cycle in these mussels appear to be closely correlated. Secretory material is accumulated in the cerebral ganglia during gametogenesis, and the evacuated from the cells vyhen the gametes become fully mature. The small multipolar neurons and the neurosecretory cells of the visceral ganglion in these mussels showed continuous activity

thoughout the year. These observations were confirmed in oyster C, *virginica* by Nagabhushanam (1963, 1964). In oysters the activity of type I cells varies during the year; the neurosecretory material accumulates in January and reaches a maximum In March. The number of cells containing secretion decreases between April and September; the cells are emptying between October and December. In freshwater mussel, *D. polymorpha,* the neurosecretory material begins to accumulate in the cerebral ganglia in autumn; maximum activity takes place during winter. A period of inactivity occurs in summer. In the visceral ganglia, the cycle is similar to that in the cerebral ganglia, but emptying takes place during summer (Antheunisse 1963). Blake (1972) examined the effect of temperature and starvation on neurosecretory activity and oogenesis in *Argopecten (= Aegu/pecten) irradians* population from Massachusetts, U.S.A. The annual cycle of neurosecretory activity of the population was divided into five stages based on changes in size, granulation, and vacuolization of the neurons. The neurosecretory cycle stages were found to coincide with the following stages in oogenesis .• stage I, vegetative or resting stage with primary germ cells; stage II, oogonia and early oocytes; stage III, cytoplasmic growth phase; stage IV vitellogenesis and maturation; stage V, spawning. For the first 12 months, the neurosecretory cycle and reproductive cycle of the population were highly synchronous. Both cycles showed significant correlation with seasonal changes in temperature but not with each other.

in adult population of the tropical bivalve, /f. op/ma from the west coast of India, gametogenesis, followed by spawning and resting phases, occurs twice each year. Neurosecretory product begins to a accumulate in the type I cells with the initiation of gametogenesis and reaches a maximum when the animals are mature (Nagabhushanam and Mane, 1973). Secretory granules in the neurosecretory cells decrease with spawning and are not seen in resting animals. The neurosecretory cycle and reproductive cycle closely parallel each other (Fig 1). In another adult population of the bivalve *Crassostrea gryphoides* from the west coast, gametogenesis, followed by maturation and spawning, occurs once in each year but a phe-

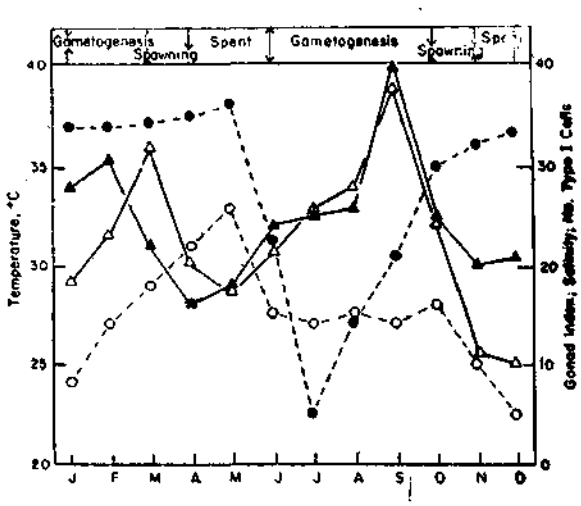

Fig. 1 . Reproductive cycle and the number of Type I cells containing neurosecretory granules in *Katelysia opima* relative to changes in temperature and salinity. ○, temperature (°C); △, gonad index; ●, salinity (‰; ▲, number of Type I cells.
(From Nagabhushanam and Mane 1973, 1976; modified)

nomenon of sex reversal has been reported during July and September and again in April and May (Mane and Nagabhushsnam 1976). Secretory granules in type I cells increase during August with mature gonads and by November most of the type I cells containing secretory granules decreased with emptying of gonads. From February onwards once again the type I cells with secretory granules increase in number. This clearly indicates parallel relationship in

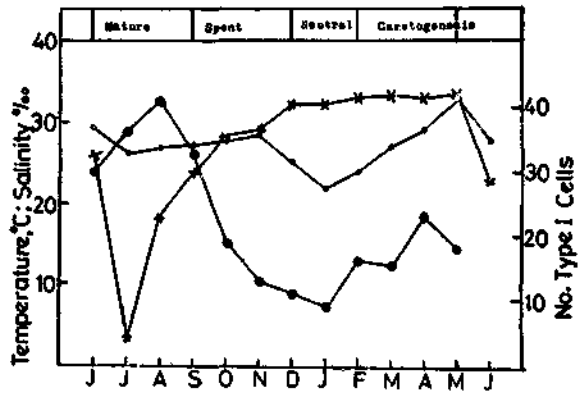

Fig. 2. The number of Type i cells containing neurosecretary granules in *Crassostrea gryphoides* relative to changes in temperature and salinity
#, temperature (°C); X, salinity (%);
., number of Typ. i cis
{From Mane and Nagabhushanam 1976; modified).

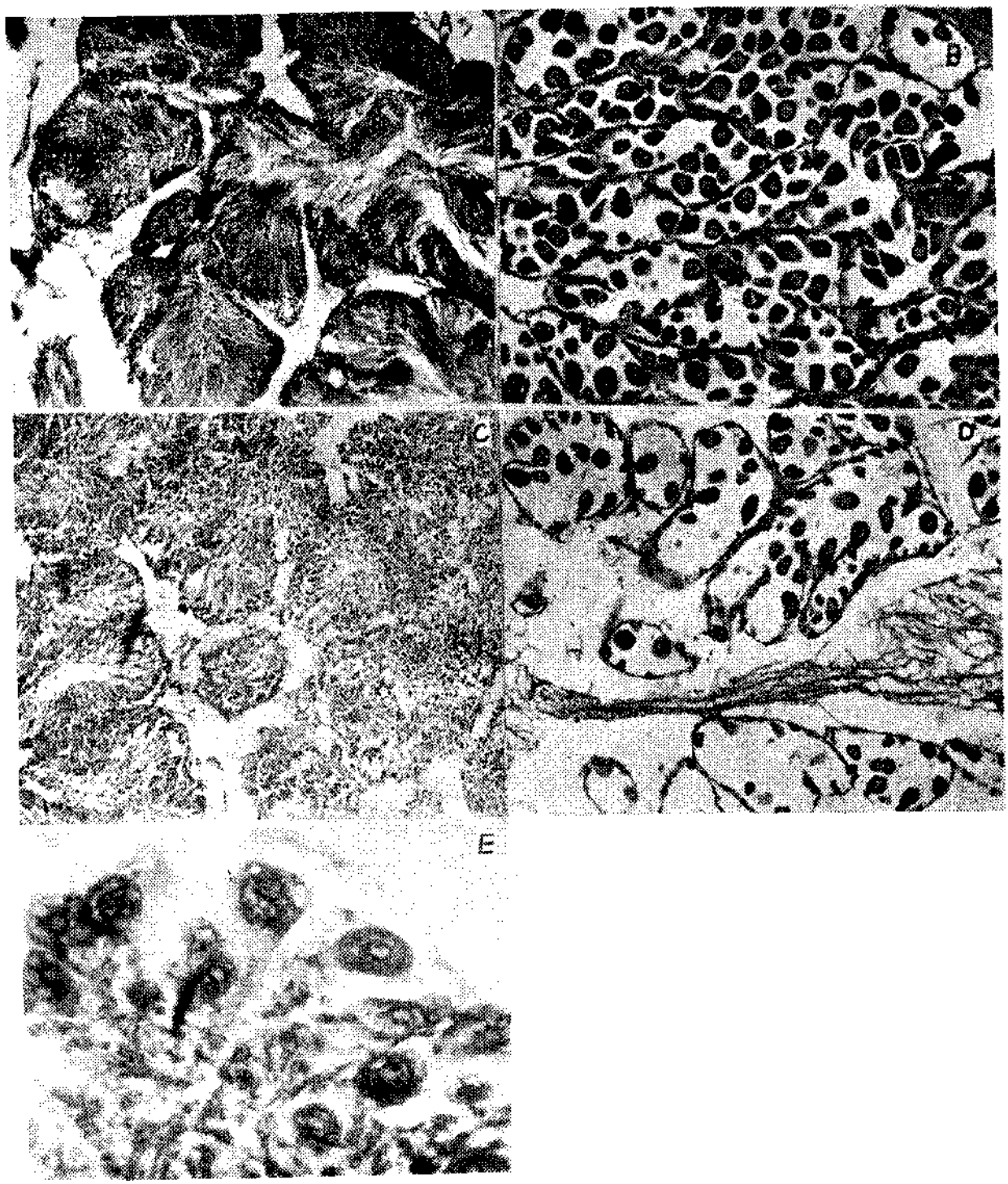

Plate 1, a-e. Effect of removal of cerebral ganglia in March in *Katelysia opima* on gametes from mature gonads. A, non-operated male; B, non-operated female; C, operated male; D, operated female; E, cerebral ganglion showing neurosecretory cells. (magnification X 400)

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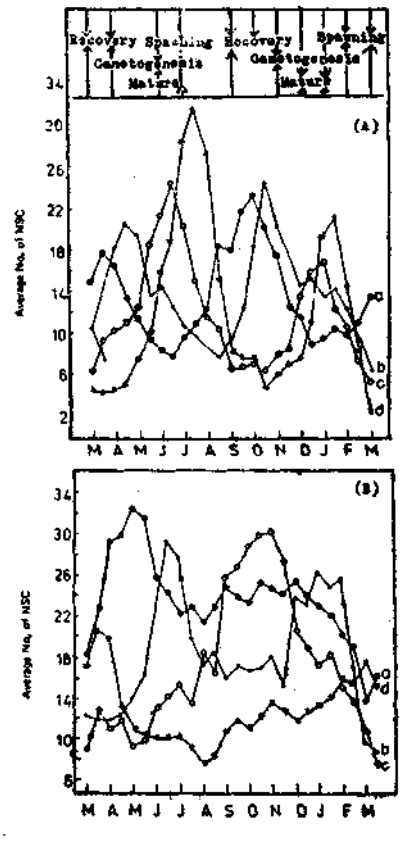
neurosecretory cycle and reproductive cycle but the authors could not ascertain the role of type I neurosecretory cells during sex reversal since only a small population was in hermaphroditic condition (Fig 2)

Based on the situation of neurosecretory granules in the pear-shaped cells, in another tropical species *M. (= P) viridis* Nagabhushanam etal (1972) determined successive stages of the neurosecretory cycle. Four stages recognized are, a) cells with uniform dispersed granules, b) cells with permuclear concentration of granules, (c) cells with accumulation of granules in the axon hillocks, and dj cells with granules in the proximal part of the axons. The authors found that the functioning of the neurosecretory cells in the same individual is not strictly at the same time but in any chosen individual most of the neuro-secretory perikarya are more or less in the same stage. Thus, it has been suggested that the secretory granules first appear throughout the cytoplasm, then concentrates around the nucleus, followed by accumulation in axon hillock and in the proximal part of the axon. On the basis of these findings Mane (1986) reported seasonal changes in the stages of the neurosecretory cycle of cerebral and visceral ganglia *ofP.viridfs.* Stage (a) is distinguished by the scattered neurosecretory material in the cytoplasm when compared with other stages and this stage is found in maximum number of neurosecretory cells during post-monsoon and early part of summer, especially during October and April. Stage (b) is the intermediate stage wherein the neurosecretory material gets concentrated around the nucleus. This stage dominates in the cells during late summer and late post-monsoon. Stage (c) is distinguished by the accumulation of neurosecretory material in the hillock and this is seen in maximum number of cells during early monsoon and early winter. Stage (d) is so-called end phase of the neurosecretory cycle in which the neurosecretory material is found not only in the axon hillock but also in the proximate part of the axon. The maximum number of cells in this stage are found in late monsoon and late winter. This cycle showed that immediately after the reproduction maximum number of neurosecretory cells in stage (a) occur in April and October, thereafter stage (b) reaches peak in May and November and during July and January stage (c) dominates followed by stage (d) in August and February, Thus, discharge of neurosecretoy material is much increased just before and during spawning. In visceral ganglia the neurosecretory cells also show the maximum of various stages succeeding each other during the seasons of the year. Stage (a) and stage (bj have maxima during late summer and early monsoon and winter, whereas stage (c) and stage (d) during post-monsoon to early summer Comparing the seasonal secretory stages of the neurosecretory cells from cerebral ganglia with visceral ganglia difference exists in the discharge of neurosecretory material during monsoon and late winter,whereas in visceral ganglia discharge continues to early summer (Fig 3).



pjg, ths average number of dorsal neurotecretoty cells of cerebral ganglia (A) and visceral ganglia (B) i" *Perna viridis* in successive stages i-4 during **different months relative to changes m gonadal condition. a, stage 1; b stage 2; c, stage 3; d, stage 4. ^^^^ N.g.bhu.hanam et .1 1972; Nagabhushanam and** Mane 1976; Mane 1986; modified;.

Demonstration of the role of neurosecretion in the reproduction of bivalves has been difficult with standard surgical procedures Bilateral ablation of cerebral ganglia during the resting phase and at the beginning of gametogenesis delays gametogenesis in *M. edulis;* the few gametes formed may undergo lysis before spawning (Lubet 1959, 1965). Removal of ganglia at latter stage of gametogenesis accelerates gamete maturation. After ablation of ganglia during the resting phase the amount of RNA and lipid IS decreased and glycogen is increased in gonadial connective tissues. Antheunisse(1963), who worked with freshwater animal *Dreissena polymorpha.* has suggested that prematutre spawning may be a function of the intensity of the operative shock when ablating the ganglia. Antheunisse concluded that, in spite of a parallelism between the neurosecretory and reproductive cycles in this species, a direct causative relationship did not operate. Umiji (1969) has found that ablation has no effect on follicle development nor on the mtrafollicular connective tissue. Removal of cerebral ganglia in March, just before spawning, of *K. opima* show release of gametes; females are much more responsive than males and immediately release gametes (Nagabhushanam and Mane 1973) PII, a-e. Similarly, ablation of cerebral ganglia in oyster, C. *gryphoides* in July at the time of mature gonads also release gametes (Mane and Nagabhushanam 1976). In *P. viridis,* a large number of mussels operated in late June and early July at the time of mature gonads release gametes after cerebralelectomy, in contrast to those operated during previous and next period (Mane 1986). Operation of mussels in similar way in late winter give spawning reaction in few mussels compared to those operated in monsoon. The author further stated that comparing the spawning reaction in cerebralelectomized and visceralectomized mussels, the latter do not Show accelerated spawning as cerebralectomized ones. Although cerebral ganglia appear to secrete neurosecretory substances during gametogenesis, it is impossible to decide the mechanism is nervous or hormonal in nature. If the activities of the neurohormones are important, removal of an internal inhibition, such as the neurosecretory product of the cere bral ganglia, may allow the animal to become receptive to external stimuli which then induce the release of the gametes,

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40. CYCLIC ACTIVITY IN THE DIGESTIVE DIVERTICULA OF *SUNETTA SCRIPT A* IN ACCORDANCE WITH TIDES

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Centre of AdVanced Study in Mirine Biology Parangipettai - 608 502

ABSTRACT

Feeding and digestion in bivalves are considered to be continous and simulatnsous. The tide influenced physiological changes in the digestive diverticula of *Sunetta scripts* on the basis of histological observation was studied. The shape of the disgestlve diverticula changes in accordanca with the tidal level. The niaximum pH value in the mantle cavity was recorded at high tide (7.46) when the animal was covered by the almost static tidal water, the constancy in the pH of the mantle cavity was due to the renewal of the water in the mantle cavity. At lowtida the pH gradually comes down to 6.87 du* to the exposure of the animal and the subsequent non-renewal of water in the mantle cavity.

INTRODUCTION

The effect of tidal cycle on the physiological state of the digestive diverticula of the bivalve molluscs is known since the work of Yonge (1926a). Though the overall function of digestive diverticula of bivalves remains a matter of controversy, this organ has been the subject of investigation for over 100 years. Feeding and digestion processes in bivalves are considered to be continuous and simultaneous (Yonge 1923. 1926 a, b; Owen 1966; Purchon 1968). Mansour (1946) and Mansour gek (1946) described the possibility of intracellular digestion in the lamellibranchs.

The rhythmic activity of the digestive diverticula in different bivalves has been studied by different authors. Some important works are by Morton (1956, 1969, 1970a, d, 1971, 1977), McQuiston (1969) and Langton and Gabbot (1974).

Perusal of the literature clearly shows that the information on the influence of tidal cycle on the function of digestive diverticula of bivalves is very meagre except a few like Shahul Hameed (1984) in *Crassostrea madrasensis* and *Anadara rhombea.* The present attempt is aimed at studying the tide influenced physiological changes in the digestive diverticula of *Sunetta scripta* on the basis of histological observations.

MATERIAL AND METHODS

The specimens of S. ^Crz/J^a were collected at the intertidal region near the mouth of Vellar estuary. The collections were carried out at **an hourly interval starting from low tide to** low tide extending over a period of 12 h. For every hour two specimens were collected. Immediately the pH of the mantle cavity was measured by using a BIOCHEM pm 79 model pH meter. Then digestive diverticula was dissected out and fixed in Aqueous Bouin's solution. The materials were brought to the laboratory and embedded in paraffin wax. 8-10(i sections were taken and stained in Delafield Haematokylin with Eosin as a coun-.g^g. jj^

RESULTS AND DISCUSSION

The maximum pH value (7.46) was recorded at hightide when the animal was covered by the almost static tidal water; the constancy in the pH of the mantle cavity was due to the renewal of the water in the mantle cavity. Similar observation was also reported by Morton (1970a) in C.erfu/a. At lowtide the pH gradually comes down to 6.87 due to the exposure of the animal and the subsequent non-renewal of water in the mantle cavity (Fig 1).

^ During lowtide the water in the mantle cavity is not replenished and the metabolic activity depletes the Oj and increases the CO2 level. As a result the pH value of this non-replenished water falls down. This phenomenon was also observed by Morton (1970a) in *C. edula.* Proceeding hightide replenishes the water due to which the PH increases again.

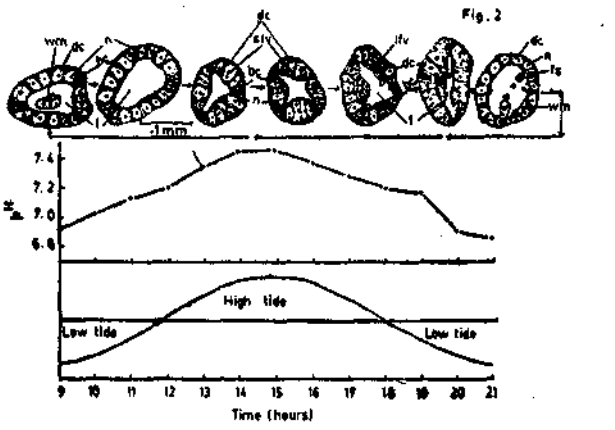

Fig. 1 Below: Mantle cavity pH in accordance with tidas. Above: Showing tha different siagss.of the d ge.tivediverticula; be — basiphii ceiis; do—digestiva cells fs-fr.gm.ntation spherule.; i-ium.n **lfv — large food vacuoles; n — nucleus; sfv-sm.ll food vacuoles; wm - waste material.**

Inspection of sectioned digestive diverticula of *S. scripta ftxed* at hourly intervals over the tidal cycle revealed that the structure of the tubule underwent rhythmic histological changes in accordance with the state of the tide,

Just before the hightide, the cells of digestive tubules were flattened (Fig 1). It showed two types of cells (a) the digestive cells; (b) the basophil cells (Sumner 1966a) or 'Young cells' (Yonge 1926) The. basophil cells stained much darker than the digestive cells; nuclei were located basally in the digestive cell and the lumen ^f the tubule was large. During hightide the digestive cells became swollen slightly and were ^^^^ cuboidal (or) columnar in form due to the absorption of food material arriving in the lumen ^f ^^^^ diverticula from the stomach (absorptive pj^gse). The number of nuclei in the 'nest of young cells' increased apparently. After hightide the lumen of the tubule reduced and the food materials were readily observed in vacuoles of the digestive cells Shahul Hameed 1984).

^^ lowtide the tubules were different in condition and the bulges at the base of the digestive cells projected into the haemocoel due ^o the breakdown of food materials in the digestive cells. The distal surface of the degistive cells became swollen and was loaded with indigestable wastes called

fragementation spherules. It has been reported by Morton {1969b) in *Dreissena* that the distal portion perhaps produce a fragmentation spherules and the proximal portion passes these into the haemocoel with food and waste materials.

At a later stage spherules were being budded off from the distal surfaces of the digestive cells in this case the nests of young cells had apparently oriented towards the lumen of the tubules. As a result the length of the digestive cells was mostly reduced and the orientation towards the lumen of the tubule was lost. Approximately 4 h after lowtide the digestive cells are reduced in length as well as in number and only few nuclei were seen. The basiphill cells could not be distinguished from digestive cells. The lubules were in the disintegration phase. Just before the high tide the tubules showed significant increase in the size and number of the digestive cells. The basiphil cells were recognisable in small groups with a few cells (regenerative phase).

The structure of the tubules essentially similar to that described in the early hjgh tide of the previous tidal cycle indicating the cyclic nature of the events.

In S. *scripta* the tidal cycle is related with the activity of digestive diverticula. Morton (1969a) opined that the animal when submerged by the tide the food is absorbed in the digestive diverticula during hightide and intracellular digestion takes place within the digestive cells.

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41. SEASONAL VARIATION IN THE ABUNDANCE OF WOOD BORING MOLLUSCS IN VELLAR ESTUARY, SOUTHEAST COAST OF INDIA

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ABSTRACT

Woodan blocks of *MangHera indica,* each 30 x 5 x 5 cm in size and 650 cm^ surface area, were exposed in the tidal zone of the Vellar Estuary at various positions from January 1981 to December 1981. The season of the settlement of wood-boring molluscs was determined by exposing the blocks for 1 month at a time, and the rate of growth and the dominant borers were studied by exposing the blocks for 3 to 12 months.

***Martesia striata* Linne, *Teredo furcifera* von Martens, *Bankia carinata* (Gray), *Bank/a campanellata* Moll and Roch and *Lyrodus pedicellatus* Quatrefages were the common species encountered in the test blocks. Intensive settlement was seen during Summer (Aprii-June) and post Monsoon (January-March) periods.**

INTRODUCTION

Twenty nine species ofteredinids and four species of phoiadids are known to occur in Indian waters. The ability of these borers to attack, damage and eventually destory the wood in brackish water areas are well known, especially along the south east coast of India (Santhakumari and Nair 1975) Ecology of IVlarine Wood borers in Cochin Harbour was studied in detail by Nair (1965). Nair and Saraswathy (1971) have reported on the biology of wood-boring teredinid molluscs. Nair and Dharmaraj (1979) have dealt with aspects of vertical distribution and rate of attack. Very little infor-

^^^j^^ ^^^^3 ^^ ^^^3^ ^^^^^^^ ^^ ^^^^ ^^3^

coast species. Only preliminary surveys have been made for wood borers at Godavary Estuary (Qanapathi and Rao 1959), Mahanadi estuary ^gubba Rao 1968), Krishna estuary (Rao et al 1957) and at Veliar-Colleroon estuarine system ^Nair and Dharmaraj 1980 b). The present g^udy was carried out for one annual cycle (January to December 1981) to determine the seasonal variation in the abundance of wood boring molluscs in the Vellar Estuary.

MATERIAL AND IVIETHODS

Study area

Vellar Estuary is situated on the east coast of India at 1l°29°Nand long 79°46°E. River Vellar originates from the Servarayan Hills of the Salem District (Tamil Nadu, India) and opens into Bay of Bengal at Portonovo. The river mouth is narrow and shifts to a considerable extent during monsoon, depending on the influx of fresh water. This estugrv is a main landing centre from where the indegeneous mechanised and non-mechanised crafts like plank built boats, catamarans and canoes are operated. Considering the wide use of different types of wooden crafts in this estuary it was selected as the experiment site to study the abundance of wood borers by exposing wooden blocks.

Settlement of the wood boring molluscs was determined by exposing untreated *Mangifera indica* blocks (5 x 5 x 30 cm) with a surface area of BBOcm^. These blocks were conditioned for a period of fifteen days by soaking in filtered estuarine water (Nair 1962). Subsequently, two series of experiments were conducted simultaneously. •

Under Series A, every month, one string with 2 blocks was tied vertically to rectangular frame, anchored with a stone at the bottom of the estuary. The wooden blocks were spaced at a distance of 1.5 m in such a way that the top most one was at the mid intertidal level and the other at the bottom of the estuary about 50 cm above the substratum.

In B series, three sets of blocks each with two units, were immersed at the same time and taken out one set by one during the post monsoon period (January-March). In the same way another 9 sets were employed during summer (April-June), premonsoon (July-September) and monsoon (October-December). This would give an idea of the settlement for the respective period of immersion from one month to three months during each season and also show the monthly settlement of the animals.

After removal of test blocks, surface debris and fouling organisms were scraped off so that the number of borer apertures on the wooden surfaces could be counted under a binocular microscope as followed by earlier workers (Nai 1965; Tsunado 1979). The blocks were cut into pieces randomly and the animals were collected for identification. Blocks which appeared free from attack were also cut into pices to confirm the complete absence of wood borers.

Scraped debris and fouling organisms were washed and the fouling complex were weighed in an electric balance to know the accurate biomass of fouling growth in a particular panel.

Water samples were collected twice a week, irrespective of tides. The bottom water was collected using Knudsens water sampler and the temperature was recorded with a standard thermometer, that was calibrated in advance. Salinity was estimated by Strickland and Parsons method (1968). Light penetration was measured in terms of the visibility with the sechi disc.

TABLE-1. *Environmental factors affecting the settlement of wood boring Molluscs in Vellar Estuary for the period January 1981 - December 1981*

Month	Water T»mp (°C)		Sallnlty (ppt)		Olssolveid Oxygen		Suspended Solids		Rain fall
	Surface	Bottom	Surface	Bottom	Surface	(ml 02/1) Bottom	Surface	(mg/1)/ Bottom	(in mm)
Jan	30.1	29.6	26.51	27.01	5.10	3.78	23.03	22.2	67 5
Feb	30.6	30.0	26 81	27.51	3.06	2.27	20.73	14.4	NIL
Mar	32.0	30.2	30.51	32.01	362	2.83	25.7	19.8	0.2
Apr	32.2	30.7	33.51	34.01	4.42	3.51	6.8	4.9	0.1
May	33.0	31.2	34.01	34.80	5.10	4.64	11.7	7.9	77.8
Jun	33.2	32.0	34.51	35.01	272	2.26	8.1	5.2	22.5
Jul	29.5	28.0	31.51	32.51	3.17	3.06	27.1	22.9	199.6
Aug	29.1	27.0	28.51	29.50	5.90	5.78	25.7	21.8	140.3
Sep	28.5	26.0	28.0	28.51	4.76	4.53	15.5	11.7	44.1
Oct	25.0	24.5	0.529	1.029	4.52	4.31	51.6	44.2	536.5
Nov	26.5	25 2	10.520	13.020	3.62	3.44	29.1	27.6	153.7
Dec	24.5	24.0	9.02	11.200	4.20	4.01	57 08	41.4	276.1

RESULTS

Variations in salinity, temperature dissolved oxygen and suspended solids in surface and bottom waters are shown in Table 1. Salinity and temperature values were higher during summer and premonsoon seasons and lower during monsoon. Surface water temperature values were close to that of the atmospheric temperature. The differences between surface and bottom water temperature rarely exceeded 1°C. Higher light extinction co-efficient values were noticed during the monsoon season owing to the turbid nature of the water column. The suspended detritus matter varied in different seasons and was affected by upland run off, tidal currents, winds and boat traffic. The highest turbidity was attained in surface waters during October (51.6 mg/l) and December (57.8 mg/l). Particulate load decreased to a minimum of 8.1 mg/l during June and then rose to 27mg/1 during July. In the bottom waters the turbidity level decreased from 44.2 mg/l in October to 4.9 mg/l during April.

The fouling organisms like diatoms, barnacles, oysters, modiolids, crabs, annelids, alpheids, copepods, amphipods and isopods were found to occur on the blocks.

Five species of molluscs belonging to genera *Martesia, Teredo, Bankia* and *Lyrodus* were found to occur in the blocks. The monthwise number of these species recorded are shown in Fig 1.

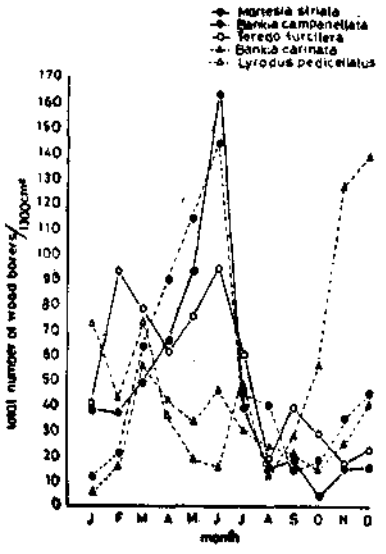

Fig. 1 Seasonal variation of different species of Marine wood borers at Vellar Estuary during January 1981 to December 1981.

Among the five species, the order of dominance was *Lyrodus pedicellatus, Bankia campanellata, Teredo furcifera, Martesia striata* and *Bankia carinata* repectively. *Martesia striata* has only one peak period of abundance during summer and the winter peak is not evident, where as *Lyrodus pedicellatus* has a highly pronounced winter peak of abundance and in summer the abundance of this species comparatively very poor. Among the rest of the three species *Bankia campanellata, Teredo furcifera* and *Bankia carinata* have a summer peak of abundance in the order in addition to a less pronounced winter peak

The monthly settlement of the five species in intertidal and bottom blocks are given in fig 2. The settlement of all the species in the bottom blocks are heavy uniformly with the seasonal variations among the species in different seasons.

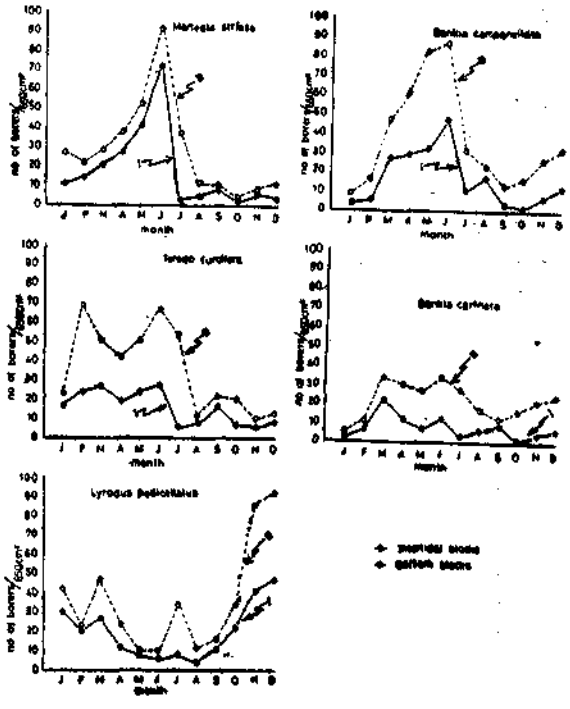

Fig. 2 Distribution of Marine wood borers in Intertidal and Bottom blocks in different seasons.

The quarterwise cumulative abundance of wood boring molluscs obtained in the long term experiments are shown in Table 2. The rate of attack among the species in different quarters are very much evident and *Teredo furcifera* is the

TABLE 2. *The quarterwise cumulative abundance (Number of specimens) of Wood boring molluscs in long term wooden blocks in Vellar Estuary during 1981.*

Block No	Month	*Martesia striata*		*Teredo furcifera*		*Lyrodus pedicellatus*		*Bankia campanellata*		*Bankia carinata*	
		I	B	I	B	I	B	I	B	I	B
B1	Jan	11	27	17	23	30	42	4	3	2	4
B2	Jan - Feb	21	34	30	32	17	37	7	15	6	17
B3	Jan – Mar	56	92	62	182	34	67	52	162	7	49
B4	Apr	18	22	19	42	12	24	29	61	12	30
B5	Apr - May	62	77	32	123	16	21	54	132	21	47
B6	Apr - Jun	112	129	92	215	15	33	71	164	29	64
B7	Jul	2	37	6	54	8	34	11	31	2	28
B8	Jul - Aug	9	17	17	21	11	20	29	40	7	19
B9	Jul - Sep	16	29	41	72	21	38	31	52	11	21
B10	Oct	2	2	7	12	22	34	1	7	1	5
B11	Oct - Nov	8	14	14	21	64	121	9	32	13	27
B12	Oct - Dec	11	24	20	31	87	157	11	79	15	52
	Total	328	504	357	828	337	628	305	778	226	363

dominant species. As already pointed out *Teredo furcifera, Martesia striata, Bankia campanellata* and *Bankia carinata* have summer peak period of abundance in the order mentioned and *Lyrodus pedicellatus* has a highly pronounced peak period of abundance in winter. The differential settlement of *Teredo furcifera* in the bottom blocks is very high when compared to the other three species. Such a difference is very low in *Martesia striata*. The settlement of *Lyrodus pedicellatus* is very high in the bottom blocks during winter.

The effect of fouling growth over the wood boring molluscs in intertidal and bottom blocks are shown in Fig 3. The fouling growth was observed to be very high during January and this declines in subsequent months till December with an exception during July. The effect of the light intensity on the settlement of wood borers both in intertidal and bottom blocks are shown tn Fig 4. The moderate value of K (Light extinction co-efficient) during January tends to decline in February and April and

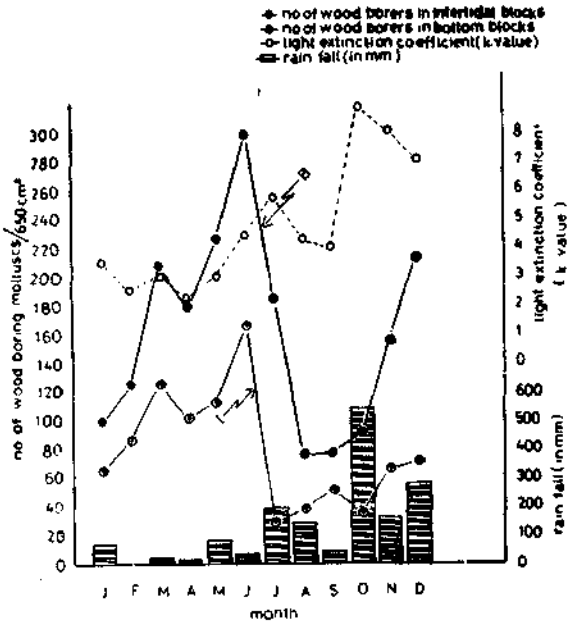

Fig. 3 Effect of Fouling growth over the settlement of molluscan larvae in intertidal and bottom blocks.

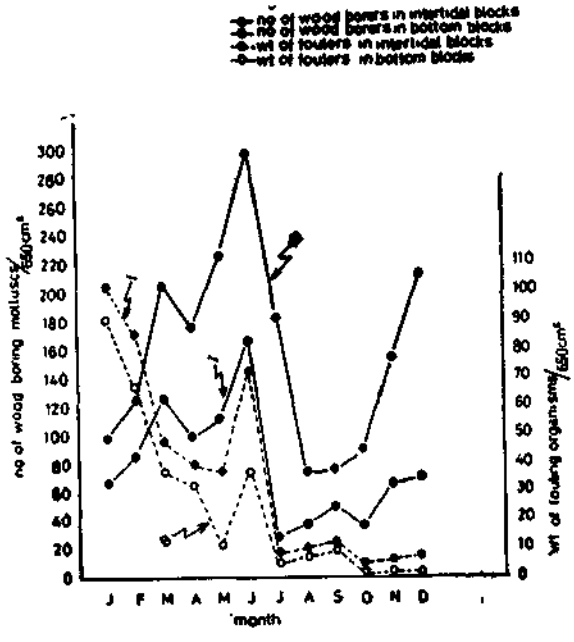

Fig. 4 Effect of Light intensity over the settlement of wood borers in intertidal and bottom blocks.

increases up to October with slight decline in August and September.

DISCUSSION

Generally wood boring molluscs are seen to attack during high saline conditions. The greater settlement of *Teredo furcifera, Martesia striata* and *Bankia camjpanellata* during summer in B series (Table 2) may be due to the intrinsic interspecific compatibility of the species in subsequent months, and also availability of 'Micro flora' as food which is known to be an essential prerequisite for speedy borer infestation (Becker and Kohlmeyer 1958). Further, as time advances the activity of marine fungi and bacteria would have converted the cellulose of the timber blocks into cellubiose, thus rendering the wooden blocks feasible for easy attack (George 1963).

Studies on the life history of shipworms also revealed that the rate of settlement and growth varies with temperature, salinity and availabilty of food (Turner and Johnson 1971). in the present observations the influence of temperature and salinity over the abundance of the wood boring molluscs is evident from the analysis of variance as both surface and bottom water temperature and salinity have very high significant correlation. The reason for the lower settlement of the mollusc wood borers during premonsoon and monsoon seasons may be due to the change in temperature, rapid currents due to heavy rain, sudden decrease in salinity, and also the accumulation of silt over the blocks. The experiment on the salinity tolerance of larvae of *Teredo furcifera* had shown this species iseuryhaline as it tolerate salinity from 0.2 ppt to 34 ppt (Nagabushanam 1963). However, as observed in the present study and in other estuarine regions of Kerala coast also the *Teredo* species settled well on the test panel during the hot saline coditions (Santhakumari and Nair 1975).

Martesia striata appeared on the test blocks throughout the year, with a peak in the summer months (Fig 2). During this period (April, May, June) the lower settlement of other molluscan borers might be due to the feeding of this species on the veligers of other molluscan borers, as reported by Ganapati and Nagabhushanam (1955) the presence of veligers in the gut content of *Martesia striata.*

The difference in the intensity of attack of *Martesia striata* in the intertidal and bottom blocks are very minimum. Better survival of this species may be due to its ability to tolerate wide range of salinity and high temperature as seen from the studies on the larvae of *Martesia striata* (Boyle and Turner 1976) and on adults of *Martesia striata by* Nagabhushanam (1955).

Teredo, Lyrodus and *Bankia* activity in Vellar estuary is as severe as that *of Martesia* sp. *Teredo furcifera* and *Bankia* spp have been observed to settle intensively in the bottom blocks during summer and *L. pedicellatus* during winter. Walden et al (1967) observed that the *Bankia* larvae were abundant mainly at the bottom and spread to the surface in declining numbers. The higher abundance of the wood boring molluscs in the bottom blocks may be due to the influence of different environmental factors specially the light intensity and suspended solids, as the less intensive light has been found to favour the settlement of these wood borers as observed by Isham et al (1951) in *Teredo pedlceliata {- T. bartscfii)* and Owen (1953) in *Teredo norvegica.*

As the fouling growth is concerned, except in summer during other seasons it is observed that the settlement of wood borers is negatively correlated with the fouling growth. Nair (1962) observed that the dense fouling growth, retarded the settlement of larvae of wood borers. The high fouling rate on the wood surface reduced the available area for the subsequent settlement of the shipworm larvae on wooden blocks (Radhakrishnan et al 1983). Extensive accumulation of barnacles was observed to affect the settlement of veligers of the wood borers adversely in the intertidal block. Johnson et al [1936] have reported that the fouling organisms like barnacles, bryozoans, tunicates and mussels feed extensively on the shipworm larvae and specially the basal plates of barnacles prevent the penetration of shipworm larvae into the wooden blocks.

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42. SEASONAL ABUNDANCE OF BIVALVE AND GASTROPOD LARVAE IN THE PLANKTON OFF TUTICORIN COAST

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ABSTRACT

Estimation and identification of tlie commercially important molluscsn larvae occurring in the planl(ton collected from inshore waters off Tutlcorin coast during 1976-1985 indicated their abundance in space and time. It is of practical significance to determina the fluctuations in the larval populat-ion and settlement of many of the bivalves iilce the pearl oyster. The occurrence of bivalve and gastropod larvae exhibit two distinct modes during February-April and September-December indicating the peal(spawning seasons of these groups. In certain years, anothsr prominent occur-rence of molluscan larvae was noticed during June-July. A maximum of 98.5% of bivalve larvae were recorded in February, 1976 and 91.8% of gastropod larvae during June, 1976. The distribut-ion pattern of molluscan larvae and that of other planktonic organisms and the relationship with hydrological factors are discussed. Several larval forms have been identified from the collections indicating the significence of Tutlcorin as an important molluscan resources zone.

INTRODUCTION

An accurate appraisal of the relative pro-ductivity of the area and the resultant variation in zooplankton stocks which directly support pelagic population might be possible through intensive hydrobiological studies. Such studies help in forecasting the situations developed in the environment that may affect the commer-cially important resources. Compared to the published information available on hydro-biology of the Gulf of Mannar (Chacko 1950; Prasad et a l 1952; Prasad 1954, 1956, 1958; Jayaraman 1954; Chacko and Malu Pillay 1962; Prasad and Nair 1960). Natarajan (1957) has described the larval development of some prosobranchs from the Palk Bay and Gulf of Mannar. Our knowledge of the plankton of Tutlcorin coast is limited to a few preliminary observations by Chidambaram et al (1951); Sambandamurthy (1962); Sudhakar and Chandrasekaran (1968). Recently, Marichamy and Pon Siraimeetan (1984) have described the distribution of zooplankton in this region in

relation to hydrological and meteorological features. The present paper attempts to describe the gross qualitative and quantitative variations of bivalve and gastropod larve distributed in the inshore waters with reference to environmental conditions and general inter-relationship of zooplankton based on the data collected during 1975-1985.

MATERIAL AND METHODS

The methods of collection of plankton samples, the area covered and the enumeration of the various components are the same as those described by Marichamy and Pen Siraimeetan (1984). Simultaneously, the hydrological factors were studied and the data collected on different sampling dates were pooled month-wise and the trend of seasonal variations were analysed on the basis of combined values of all the years of study. The fluctuations in the plankton are discussed in terms of monthly averages. Facilities enabled recording of some organisms upto generic level only. Measurements of different stages of molluscan larvae were taken using a micrometer scale and the features of larvae were compared with published information. Rainfall data were collected from the meteorological centre, Tuticorin Harbour Project.

ENVIRONMENTAL FEATURES

Among various hydrological parameters examined such as temperature, salinity, dissolved oxygen content, pH and nutrients, the data of highly influencing factors like rainfall, temperature and salinity alone were analysed and presented to examine their probable effect on the distribution of larve. The data collected on these aspects during 1975-85 were pooled monthwise since there was no difference in the trend of seasonal changes between the years. The results are presented in Table 1.

The surface water temperature closely followed the trends of atmospheric temperature and exhibited two peaks in a year. Sea temperature steadily increased from the winter low level and reached the maximum in May (30.5° C) and then declined upto August (27.2° C). The fall in surface temperature in coastal waters was due to the active south west wind. The secondary peak was observed during September-October and subsequently it declined. This observation is in confirmity with the earlier findings in Gulf of Mannar by Chacko (1950), and Marichamy and Pon Siraimeetan (1984). The values of salinity also exhibited a clear bimodal oscillation, more or less following the variations of temperature in the course of the year. Two maxima were recorded in April and October. The fall in salinity from November onwards was due to rainfall. However, in certain years the fall in salinity was not so prominent because of the failure of north east monsoon. The data on rainfall give a general picture for the region, but variations were noticed from year to year. Maximum record of 369.5 mm was noticed in November 1982, where as in the corresponding month of 1981 it was 34 mm. The average rainfall was generally high in northeast monsoon period, October-December. In November the average for the entire period was found to be 169 mm. Rainfall was noticed in April in certain years and average recorded was 34 mm.

DISTRIBUTION OF BIVALVE LARVAE

Pubished information on the collection of egg masses of planktonic molluscan larvae in the study of breeding habits are known from the contributions of Hornell (1921), Gravely (1942), Annandale and Kemp (1916), Panikkar and Aiyar (1939), Panikkar and Tampi (1949) and Nataraj (1957). The bivalve larvae were separated from the plankton collections and

TABLE 1. *Seasonal variations of temperature, salinity and rainfall in Tuticorin coast*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature "C	25.8	27.2	29.7	31.4	30.5	29.7	29.2	27.2	28.8	28.9	27.9	27.4
Salinity %.	32.41	33.20	33.63	34.23	33.44	34.13	34.13	34.18	33.87	34.00	32.78	32.75
Rainfall mm	13.6	27.4	18.7	34.0	19.5	2.2	3.9	1.3	9.3	89.0	169.5	77.8

TABLE 2. ***The percentage composition of bivalve larvae in zooplankton during 1975-85***

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1975	6.5	75.0	2.6	0.9	0.3	3.6	5.6	0.9	1.2	0.9	2.4	0.5
1976	—	98 5	0.01	0.3	0.2	0.5	0.2	001	0.01	0.12	0.2	0.01
1977	0.1	0.3	98.4	0.5	0.02	—	—	0.03	0.02	—	0.1	0.6
1978	1,0	3.2	0.5	32,1	0.5	59.0	2.1	—	—	0.5	—	1.1
1979	193	3.2	13.1	19.7	41.0	—	3.2	14.8	—	205	1.3	0.8
1980	0.1	02	2.5	90.5	—	—	—	0.2	5.5	0.1	0.1	0.7
1981	—	—	2o.4	25.8	3.8	—	19.5	3.8	7.5	—	1.2	12.0
1982	1.0	2.0	18.1	4.0	—	2.0	1.0	28.2	—	34.2	80	1.5
1983	—	14.3	16.8	1.4	9.1	5.0	21.5	—	24.1	6,0	0.8	1.0
1984	0.2	0.1	0.1	2.1	4.0	1.6	3.4	44.6	2.5	24.1	15.8	1.4
1985	10.5	3.1	2.4	0.1	—	0.1	0.6	—	14.6	—	19.3	49.3

their percentage composition in general zooplankton are presented in Table 2. It may be seen that a very high percentage of bivalve larvae ranging from 75-98.5% was recorded in the period February - April during 1975-1980, although they occur alround the year. Maximum bivalve larvae of 59% was the predominent item in June 1978. A secondary peak in the occurrence was noticed during July in 1981 and 1983 whereas this secondary mode of larval occurrence was noticed in the month of October in 1979, 1982 and 1984.

The bivalves occurring in high percentages as well as in most of the samples collected round the year were examined further to see the larval stages and size, and were compared with the data in previous work. The details of this study are preseeted in Table 4. *Mactra mere.* ***Avicula vexillum, Modiolus*** **sp;** ***Crassostrea*** *madrasensis* and *Mactra* sp were noticed in umbo and spat stages. The larvae of the first two species were found in swarms in the collections during February-March season in most of the years revealing the spawning season of these bivalves. The larvae of *Mactra mere* were present throughout the year. The shelled larvae of *Avicula vexillum* resemble those of the pearl oyster *Pinctada fucata* and are known as 'false spat' (Hornell 1922). They were very common in the collections made during December-February and the average size was DVM 280 *IJ.* and APM 337 ^ in umbo stages and 1588-1648(1 respectively in spat stage. **The larva of** ***Crassostrea madrasensis*** **measured** at the average size of DVM 351 *v^* and APM 422 *V-* were common in the collections made during October. This species is known to breed

TABLE 4. ***Larvae of Bivalves***

Name of the species	Stage	Size of larvae Minimum DVM /i	Minimum APM *V-*	Maximum DVM (A	Maximum APM (A	Average DVM /i	Average APM *V-*
Mactra mere	Umbo	200	200	560	590	389.2	399.2
Avicula \iexillum	Umbo	250	290	310	370	280.	336.7
Modiolus **sp**	Spat	1025	1025	2525	2525	1775	1800
Crassostrea madrasensis	Plantigrade	350	420	352	424	351	422
Mactra **sp**	Umbo	230	270	300	280	265	275
Avicula vexillum	Spat	450	575	2950	2975	1588	1648

througout the year with 2 peaks in April-May and September-October and there are a good number of natural beds in the intertidal regions and creeks along Tuticorin coast.

DISTRIBUTION OF GASTROPOD LARVAE

The percentage composition of gastropod larvae in zooplankton collections are presented in Table 3. It can be seen that gastropod larvae occur in high percentage, 56-82%, during February - April, indicating the spawning season of this group of molluscs. A secondary peak in the occurence was noticed in December. A swarm of gastropod larvae numbering 92,256 in a 10 mts surface haul, accounted for 92% in the collection made in June 1976. tn the rest of the months, gastropod larvae were noticed but in negligible percentages.

The gastropod larvae were present almost through-out the year as well as in good percentages. They were identified and the details of size of the larvae measured, are given in Table 5. *Murex virgineus, Oliva* sp, *Turritella acutangula, Turriteiia* sp., *Nerita aibicilla Pota - mides cirigulatus (Cerithidea fluviatilis)* were the common forms present in most of the collect-ions. Larvae of *lVlurex virgineus* was present in the collections round *the* year with peak in March. Natarajan (1957) observed that the breeding season of this species was during

TABLE 3. *The percentage composition of gastropod larvae in zooplaniiton during 1975-85.*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1975	8.2	61.1	4.0	1.0	0.8	8.6	5.0	1.3	2.2	3.0	4.0	0.8
1976	—	4.4	0.7	1.1	0.3	91.6	0.3	0.2	0.5	0.2	0.6	0.1
1977	0.9	6.0	81.5	3.9	0.1	0.4	0.2	1.4	1.5	—	0.5	3.6
1978	2.8	1.1	3.4	56.1	—	6.8	19.5	—	2.2	2.8	—	5.7
1979	22.0	10.2	12.6	4.2	6.0	—	3.9	34.3	—	3.6	1.2	2,0
1980	1.4	6.9	11.5	59.7	—	0.5	—	0.5	5.7	29	3.3	7.6
1981	—	—	12.6	6.9	11.1	—	4.1	7.6	13.3	—	0.9	43.5
1982	3.0	2.3	11.1	4.1	5.8	2.6	0.6	18.1	—	16.3	33.8	2.3
1983	2.7	11.0	43.4	0.1	0.5	1.0	0.7	—	3.0	27.2	5-3	5.1
1984	1.9	4.9	3.0	2.9	2.5	37.2	1.5	18.4	3.5	2.7	7.9	13.6
1985	18.2	9.4	55.4	0.2	0.1	—	1.8	0.4	5.7	—	1.9	6.9

TABLE 5. *Larvae of gastropods*

Serial No.	Date	Station No.	Depth mt	Name of the specias	Stage	Minimum DVM^	Minimum APM(X	Maximum DVM(Jl	Maximum APMjA	Average DVM (i	Average APMfx
1	30.3.77	6C	20	*iVIurex virgineus*	Advanced veliger	375	225	2125	1525	746.9	493.8
2	//	<»	//	*Oliva* sp	,'	2500	1050	2500	1050	2500	1050
3	11.4.80	4C	24	*Turritella acutangula*	//	350	225	700	325	557.5	292.5
4	/ t	it	tr	*Turritella* sp	/ /	425	200	475	275	450	237.5
5	19.11.82	58	12	*Nerita aibicilla*	veliger	275	225	875	625	543.8	437.5
6	31.3.83	60	20	*Cerithidea fluviatilis*	//	275	200	475	350	427.8	309.7

November-March and May-July and also stated the likelihood of continuous breeding round the year. The descriptions given for the various stages of larval development are comparable with the larvae examined in the present study. The average size of the larvae was DVM 747 *fi* and APM 494 t^. *Oliva* sp in slightly advanced stage was also recorded in March. *Potam/'des cingulatus {Certithidea fluviatilis)* larvae were next in importance in abundance round the year with peaks in March and June The larvae measured 275-475 in DVM and 200-350 ^ in APM. Sadasivan (1949) has made detailed studies on the rate of growth, duration of breeding period etc. from Madras. Natarajan (1957) has recorded the spawn masses of this species during January-September and the present observations indicate that the spawning season of this species in Tuticorin coast is also the same as in Mandapam area. The maximum concentration of gastropod larvae noticed in April 1980 was due to the presence of *Turritella acutangula* and *Turritella* sp, and the larvae with average size of DVM 557 *v-* and DVM 450 ^ respectively were examined. *Epitonlum scalare* were found in a few samples. The larvae of *Nerlta albicilla* measuring 544 [A in DVM, were noticed round the year, with a peak in November indicating the spawning season. Natarajan (1957) has given the descriptions for the newly hatched veliger of this species and the features of the larvae of present collections are in confirmity with the descriptions.

DISCUSSION

The richness of molluscan fauna in Gulf of Mannar has been recognized by several earlier workers. Natarajan (1957) had identified 33 species of prosobranchs and studied their early larval history from Mandapam area. Seasonal variations in the surface temperature and salinity show similarity in general trends. A bimodal cycle in the distribution of these major factors was noticed. Two maxima were observed during April-May and September-October and the minima during August and January. The same trend has been noticed by a number of earlier workers from this region (Malu piliay, 1962; Freda Chandrasekaran and Sudhakar 1968; Marichamy and Ron Siraimeetan 1984). Thorson (1940) opined that in the reproduction of prosobranchs of all oceans there is a tendency for the pelagic development to be totally suspended in the deep sea and is restricted to shelf fauna and that starting from the Arctic and Antractic where the pelagic development is suppressed there is a gradual increase of the same towards the trophic shelves where it is the highest. Panikkar and Aiyar(1939) and Paul (1942) have observed different types of both continuous and discontinuous breeding in marine and brackish water animals of Madras area. Natarajan (1957), Marichamy and Pon Siraimeetan (1984) observed the same trend of breeding habits from the Gull of Mannar. No direct effect of temperature and salinity on breeding activity was found since most of the molluscan groups breed intermittently in an extended period. However, Rao (1951) observed the influence of salinity and temperature on the intensity of breeding in *Ostrea (= Crassostrea) madrasensis.* The monthly averages of the diurnal variations in the minimum and maximum temperature were observed to have a direct influence to the gonadal development, spawning and setting of edible oyster spat (Rajapandian and Rajan 1983). The maintenance of larval population in a given region depends upon a balance of dynamic factors, the drift of the water and its interaction with the environment as well as upon the rate of reproduction and mortality of population under the environmental conditions (Prasad, 1954). Alagarswami andChellam (1976) observed a seasonal trend in the setting of the *Avicula vexlllum* during April-June and *Crassotrea* sp during May-June. The occurence of the above two bivalve larvae in the plankton collected from this zone was noticed more or less in the same period confirming the spawning seasons of the species. Similarly, they have observed the occurrence *Modiolus* sp in large numbers during July and in the present observation, the larvae ot this species was recorded in June. The determination of breeding seasons of the gastropods examined in the present study is in agreement with the findings of Nataraj (1957). In general, the occurrence of bivalve and gastropod larvae exhibit two distinct modes during February-April and September-December

indicating the peak spawning seasons. Copepods and Lucifers were noticed in negligible percentages when molluscan larvae were predominent in the collections.

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43. INCIDENCE OF *PERKINSUS MARINUS* IN *CRASSOSTREA MADRASENSIS*

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ABSTRACT

Perkinsus marinus (Dermocystidium marinum) commonly known as "Dermo" is one of the causative pathogens for widespread mortalities in oysters. In the natural population of oysters at Tuticorin, oyster tissues cultured in fluid thioglycollate medium with dextrose fortified with antibiotics were found to be Infected with ***P. marinus.***

This is the first time that this pathogen has been reportsd from Indian waters. The incidence of infection in oysters ranged from 10 to 60%. The weighted incidence ranging from 0.05 to 0.35 indicates the very light level of Infection.

INTRODUCTION

It is not uncommon to come across reports of diseases of contagious or noncontagious nature occuring among oysters in the natural beds. The noncontagious diseases are caused by the physiological malfunction of organ due to unfavourable environmental condition. The infectious diseases are mostly microbial origin, occasionally due to parasites also. Unfavourable environmental conditions lower the resistance of the oyster paving way for secondary infections by facultative pathogens. Three major causative organisms for the widespread mortalities in the east coast of United States oyster populatin are *Peridnsus marinus, Minchinia nelsoni* and *M. costalis.* (Andrews 1979 Sinderman 1970). *Marteiiia refringens* and *Bonamia ostrea* are known to cause mass mortality along the coast of France. The epizootic disease caused by *F. marinus* occurs m the warm season, causing mortalities in the Gulf and South eastern coastlines of United States (Mackin 1962). It caused havoc in the Pearl Harbour, Hawaii, during 1972, in which mortalities to 90 - 99% of the stock occurred in the oyster *Crassostrea* wirfh/mca (Frederic et al 1973). The examination of monthly sample of oysters C. *madrasensis* collected from natural oyster beds around Tuticorin during 1984-85, brought to light the incidence of *P. marinus* In them. The level of Infection being very light, no mass mortality occurred. But this is the first time that *P, marinus* has been detected in India.

MATERIAL AND METHODS

Methods for detecting P. *marinus* by microscopic examination of fresh tissue or stained sections of the tissue are difficult and time consuming. Therefore, the effective method of culturing them in thioglycollate medium, widely "'^^ in determining the incidence as well as the '"^^"s'ty °\ \:^*iBcX\on* was followed. The organisms do not multiply in the medium,

Dehydrated fluid thioglycollat. (29.3 gm) ^.^^ ^.^^,„^j ^^^^^ ^^^.^^ 2*o*l„ of sodium chloride was used as the medium. lOmi of the medium was taken in a culture tube (15 x 125 mm of 10 ml capacity) with screw cap. Before planting the tissue, the medium was fortified with 200 units of mycostatin and 200mg of Chloromycetin per ml of the medium in order tosupressthe bacterial growth (Ray 1952).

Ffom July 1984 to June 1985, twenty oysters were collected each month from the oyster bed at Tuticorin. They were cleaned and their length measured to the nearest mm. Small pieces (5 x 10 mm) of mantle (near palp) and rectal tissue of the oyster were planted in the culture tube. These tubes were incubated for seven days at room temperature. The jncubated tissues after wiping out the medium in a tissue paper, were placed on a slide with 2 or 3 drops of diluted Lugol's iodine solution, The tissues were teased into small bits and examined microscopically for green, blue and blue-black spheres. Depending upon the number of cells present in the tissues, oysters

were grouped as very light, light, light to moderate, moderate, moderate to heavy and heavy infection and assigned arbitarary values of one half, one, two, three, four and five respactively. The sum of these values divided by the number of individuals in the sample indicated the weighted incidence which combines incidence and estimated intensity of infection provides better index of the degree of infection (Ray 1954b).

DESCRIPTION

'Dermo'is a small nearly spherical spore like body, the size ranging from 2 to 25(A. The most distinctive feature is the presence of very large partially eccentric vacuole which usually contains one large, polymorphic retnngent inclusion body or "vacuoplast" occupying greater portion of cell body (Ray and Chandler 1955).

Dermo" was considered to be Rhinosporidian; under Endomycetalsj (Mackin 1962) considering its mycotic type of infection produced. Mackin and Ray (1966) renamed it as *Labyrinthomyxa marina* because of some gliding cells with iabyrinthulid "tracks,' Plasmodia and vegetative division in propagation. Later not finding any Iabyrinthulid characteristics, Perkins (1976) indicated that D./nsr/nym is a protozoan in the sub-phylum Apicomplexa because of the apical complex consisting of conoid, polar ring, rhoptries and micronemes. In addition to the apical complex, zoospores and trophozoites of ^^^ oyster pathogen possess microspores. Subsequently it was redesignated as *Perkinsus marinus* by Levine (1978).

RESULTS

The number of cellsiin^the infected oyster tissues ranged from 1 to 5 per piece of sample (P'O'1 a and b), with size ranging from 15 to 100|A Cells of size 35 to 50|JI were common. In JulV' 1984 rectal tissue of an oyster had thirty five cells with a maximum size of 100(J>. Clusters ofcells having 9 to 17 cells were observed (Fig.1

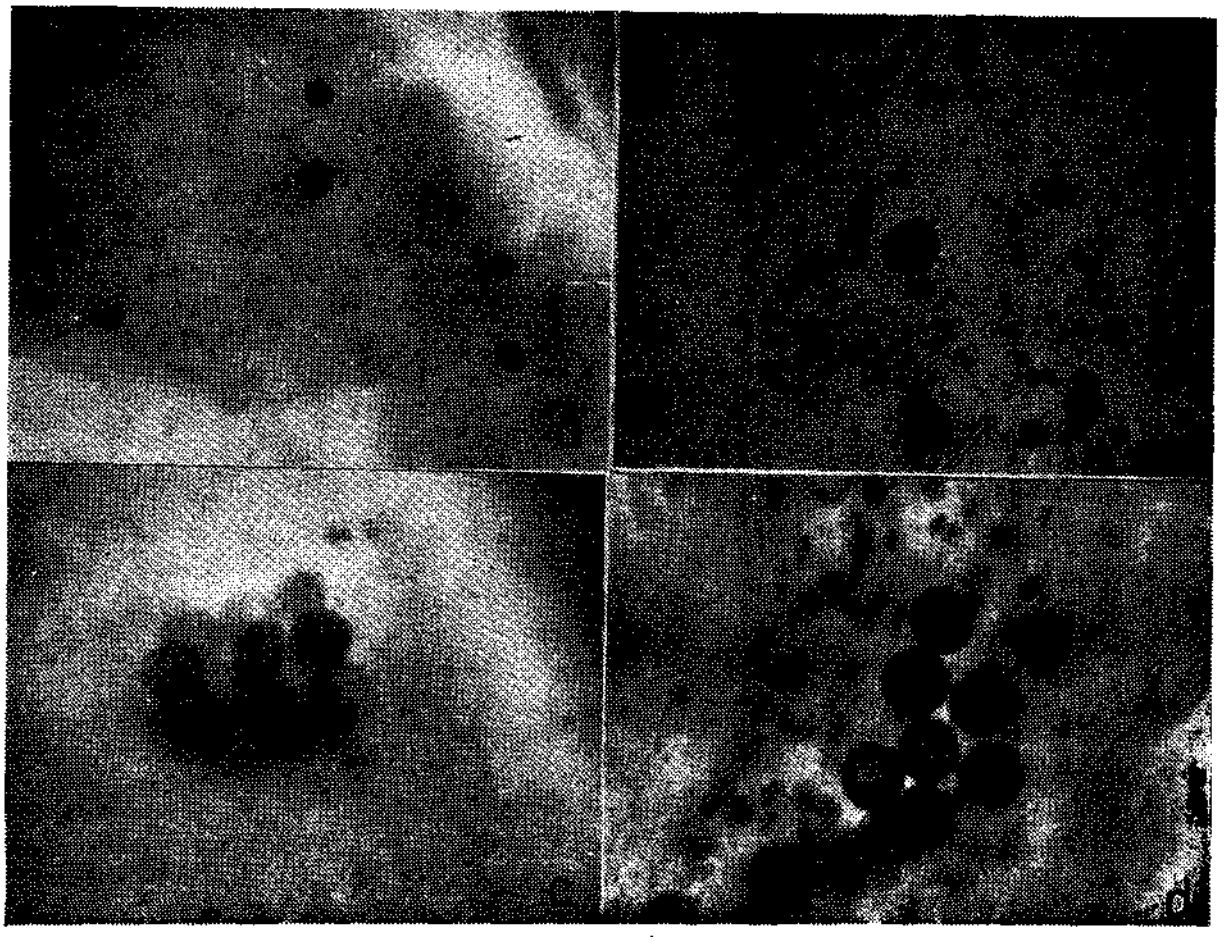

Fig. 1 (a d b). ***Perkinsus marinus*** **in oystsr mantle tissue after seven days of incubation in fluid thioalycollate medium, (C a DJ Cluster of cells in some samples of oyster mantle tissue.**

c & d). The percentage of infection and weighted incidence along with the surface temperature during July 1984 to June 1985 are given in Fig 2. The percentage of infection varied from 10 to 60%, low during February and high in May 1985.

Weighted incidences of 0.05 during February 1985, of 0.10 during November 1984 to January 1985, of 0.15 during March and April 1985 were noted. In the months of August, October 1984 and June 1985 the weighted

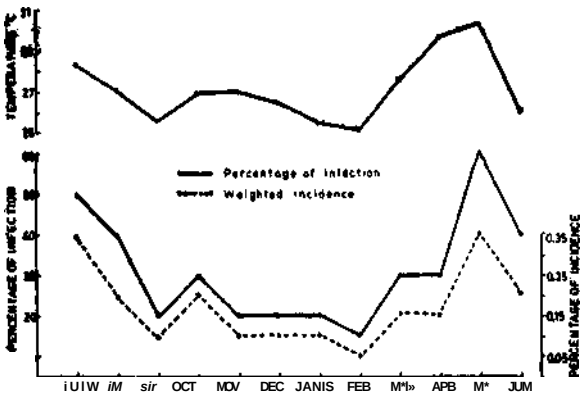

Fig. 2. The monthly percentage Infection and weighted incidence of P. *marinus* Infection In the oyiters, Also monthly temperature shown.

incidence was 0.2. High weighted incidence of 0.35 was observed in July 1984 and May 1985. The range of weighted incidence from 0,05 to 0.35 indicates only very light level of infection.

Temperature and salinity are the important factors in epizootiology of "Dermo disease" (Ray 1954b;. Andrews (1965) stated that *P. marinus* proliferates readily only at temperatures above 25°c. During colder periods, the infection and associated mortalities become reduced because of reduced metabolism of the pathogens rather than elimination of the organism. Low salinity retarded development. Excessively high salinities may also be unfavourable for "Dermo" (Ray 1954b; Ray and Chandler 1955). In the present study, high percentage of infection (60%) and weighted incidence at 0.35 were observed when the temperature was 30.3°c. Percentage of infection was 10-20% and weighted incidence 0.05 to 0.10 during December 1984 to February 1985 when the temperature ranged from 25.1°c-26.5°c ^Fig 2). This indicates broad agreement with the earlier findings of Ray {1954b) on the effect of temperature on *P. marinus*

DISCUSSION

Much attention has been directed towards large-scale oyster mortalities and account of diseases by pathogenic organisms. *P. marinus* is one of the etiological agents for large-scale oyster mortalities. The invasion seems to take place through the gut epithelium and possibly through the mantle. The epithelium is destroyed, the parasite lyses the basement membrane and is distributed by blood to all parts of the body. Mortality results more by acute infections which lyses tissues and clog organ system especially blood sinuses (Mackin 1951).

Ray (1954a) found that the pathogen was transmitted by "proximity method". Hoese (1964) was able to find *P. marinus* in digestive tracts and faeces of fish, oyster drills and crabs that had fed on dying and dead infected oysters, speculating that transmission might be aided by the scavengers. But the mode of transmission is still not firmly established.

Besides being the casuative agent for mass mortalities "Dermo ' inhibits the normal gonad development (Ray et al 1953) and retards the oyster growth (Menzel and Hopkins 1955). Ray et al (1953) found loss of 12-15% meat weight in moderately infected oysters and in heavily infected cases the meat weight reduction was upco 33%.

The occurrence of *P. marinus* was also detected in some of the pearl oysters thus indicating its possible destructive role on the pearl oyster population in the "paars" for the periodical mass mortality of oysters.

Though at present no mortality could be decisively attributed to *P. marinus* in oyster beds, in India, the incidence of the protozoan needs to be regularly monitored considering the epizootological factors.

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44 OYSTER RESOURCES OF KARWAR

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ABSTRACT

Studies on the distribution and abundance of edible oysters from Chendia to Mejali along the Karwar coast in 1984 have shown that the resources conDprising of *Saccostrea cucullata* and *Crassostrea madrasensis,* predominantly the former, were present in sheltered regions namely the Chendia creek and Kailnadi estuary, but ware absent in the intertidal zone along the coast. The distribution of these species in the Kaiinadi estuary was isolated in patches from Sadashivgad upstream to Hotegali while it was scattered in the entire Chendia creek area. The exploitation of oyster in both the places was poor during the period of study.

INTRODUCTION

Oyster IS one of the important edible moilu-scs at and around Karwar in Karnataka. Earlier works on oyster resources and fishing in this region by Patil (1592), Alagarswami and Narasimham (1973) and Nair et al (1984) are based on surveys particularly of the Kaiinadi. Information hitherto published on the distribut-ion and abundance of edible oysters of this area is meagre.

MATERIAL AND IMiETHODS

The Karwar coast extending from Chendia to Majali (Fig 1) was surveyed for the occurrence and abundance of edible oysters. The areas surveyed included Kaiinadi, Chendia creek and the intertidal zone along the coast. Oyster samples were collected with a square quadrat frame (20 cm x 20 cm or 0.5 m x 0.5 *m),* grab or a dredge. The number of oysters in a unit area was recorded from which the number/m^ and the number/oyster bed were calculated. Oysters which could be removed from the substratum without any damage, were used for further analysis. Shell length, total weight, shell weight, meat weight, sex and stage of gonadal maturity were recorded. The temperature, salinity and the dissolved oxygen content of water samples collected from near the bottom close to the oyster beds were measured.

RESULTS

The study conducted along the Karwar coast extending from Chendia to Majali showed that oysters were available in the Kaiinadi estuary and the Chendia creek and were very rare in the intertidal region along the coast.

The distribution of oysters in the Kaiinadi estuary showed concentration of oyster populat-"ons as small beds at five different locations, 1. to 5 (Fig. 1). Of the five oyster beds, the first one, along the northern bank from Sadashi-

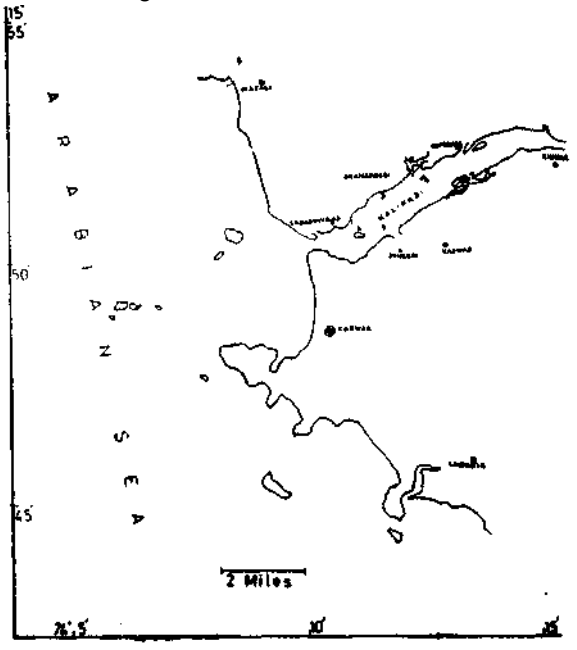

Fig. 1. Map of the Kalinadi estuary

yggd to Kanasgeri covering an area of about 2OO sq. m, had only one species, namely, *Saccostera cucullata* attached to rocks from the high water mark to a depth of 0.5 m.

"^^^ second bed, whose extent in area was about 5,000 sq. m, was found midstream about 100 m away from the first one along the northern bank between Sadashivgad and Kanasgeri. It was composed of a mixed population of *Saccostrea cucullata* and *Crassostrea madrasensis* attached to shells and shell fragments.

The third one approximalely 15 sq. m in area was located east of Kanasgeri on the northern bank in an area with mangrove vegetation. Interestingly, the mangrove roots which get exposed during low tide formed the substratum for S. *cucullata.*

S. cucullata was also found on patches of intertidal rocks around a small island in the middle of the estuary west of Hotegali and the area of this bed was about 1 5 sq.m.

The last of the oyster beds comprising of a mixed population of S. *cucullata* and C. *madrasensis* was found about 50m from the southern bank between Sunkeri and Kadwad. This was located at a depth of just less than 1 m during low tide. Shells and shell fragments provided the substratum and the extent of this bed was about 1250 sq. m.

On the other hand in the Chendia creek, the distribution of *S. cucullata* and C. *madrasensis* was scattered throughout the intertidal and submerged areas where depth did not exceed 1m during low tide. Shells and rocks formed the substratum and the area was about 20,000 sq.m.

The abundance of each species along with the biological characteristics of oysters and hydrographic parameters are given in Table 1.

TABLE 1. *Biological charactaristics of oysters, abundance and hydrological parameters in Kalinadi Estuary and Chendia creels*

Stations	Kalinadi					Chendia
	1	2	3	4	5	creek
S. *cuculatta*						
Mean shell height (mm)	29.6	34.0	33.3	29.8	33.7	27.8
Mean total weight (g)	5.7	9.1	9.0	6.9	9 4	5.2
% shell weight	81.1	80.9	77.9	76.64	81.12	75.53
% Flesh weight	16.4	9.8	10.0	12.9	12.4	13.3
Sex ratio (M.F)	1:1.2	1:1	1:1	1:0.7	1:1.3	1:09
Stage of maturity		Maturing				Maturing
Number per m^	75	12	150	75	16	20
Estimated number of oyster per bed	15,000	60,000	2,250	1,125	20,000	400,000
Estimated quantity of oysters (kg)	85	547	20	8	189	2,092
C. *madrasensis*						
Mean shell height (mm)	—	72.5	—	—	32	39
Mean total weight (g)	—	106.5	—	—	5.5	13.25
% shell weight	—	84.0	—	—	81.8	75 5
% Flesh weight	—	12.4	—	—	9.9	9.4
Sex ratio (M:F)	—	1:1	—	—	0.1	1:1
Stage of maturity	—	Maturing	—	—	Maturing	Maturing
Number per m^	—	0.7	—	—	0.4	0.5
Estimated number of oysters per bed	—	3,333	—	—	500	10,667
Estimated quantity of oysters (kg)	—	362	—	—	3	141
Temperature (°C)	31	31	—	—	31	30
Salinity (7„J	31.6	31.8	—	—	30.9	31.2
Dissolved oxygen (ml/1)	3.87	4.40	—	—	4.58	4 26

DISCUSSION

Study of the oyster resources of the Karwar coast between Chendia and Majali has shown that though their concentration in the intertidal region along the seashore was very sparse, S, *cucullata* and C. *madrasensis* occurred in abundance in the Kalinadi estuary and the Chtndia creek.

In the Kalinadi estuary, of the five locations where concentrations of edible oysters were encountered, *C. madrasensis* was found only in two, 2 and 5 (Fig 1), both remaining submerged throughout the year. Though rocks, shells and shell fragments served as substrata in most of the sites, materials of biogenic origin, that is, roots of the mangrove vegetation exclusively formed the substratum for one settlement in the nothern bank east of Kanasgeri. It is significant to note that the concentration of oysters was higher on the organic substratum than on rocks or shells. It is likely that oysters show greater preference to the live and growing roots placed perpendicular to the plank of movement of the water during the rising and ebbing tides than other types of dead substrata at the bottom or on the banks of the estuary.

The distribution and density of oyster populations appear to be dependent on the availability of suitable substrata, preferably stable ones. The absence of oyster settlements beyond Hotegali during the present study may be due to many factors, one of them being the absence of suitable substratum eventhough Nair et al (1984) reported the occurrence of oysters upto Kinnar situated further upstream from Hotegali.

It may be noted that in the Kalinadi estuary the oyster settlements at sites marked 1, 3 and 4 (Figl) which get exposed and submerged with the alternating tides were more dense than those remaining submerged during both low and high water. Oyster were collected from Kalinadi estuary occasionally and sold in Karavan. There was no regular exploitation.

On the other hand the distribution of oysters in the Chendia creek was scattered along the bottom throughout the intertidal and submerged areas. It may be mentioned here that unlike the Kalinadi estuary, the Chendia creek has no source of freshwater except during the south-west monsoon season and consequently the distribution of substrata consisting of shells, and rocks within the creek vary little. Moreover the movement of the water to and from the creek is mostly due to the tidal incursions from the sea.

Hence the difference in the pattern of distribution of both the substrata and oysters between the Chendia creek and Kalinadi estuary may be attributed to the more stable conditions prevailing in the former than the latter.

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