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Biosecurity in fisheries and aquaculture in the Indian context

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Introduction

Aquaculture is one of the fastest growing industries with an annual growth rate of more than 11% for the past 10 years, producing about 16% of the world supply of animal protein, primarily for human consumption. Driven by population growth, rising demand for seafood and a levelling of production from capture fisheries, the practice of farming aquatic animals has expanded rapidly to become a major global industry. By an estimated production of 47.8 million tonnes in 2005, global aquaculture production in comparison has overtaken the global production of meat from bovine, ovine, porcine and poultry; where the production over the last few decades has not been increased to meet the population growth. In the Indian context, the impressive growth of the sector has raised it to the status of an industry. The strength of Indian aquaculture lies in (a) large water bodies suitable for aquaculture, (b) tropical Climate, (c) species diversity and (d) availability of cheap labour. While the weakness include (a) unregulated development, (b) disease problems and (c) lack of scientific approaches and policies

Shrimp and Carp farming has been the face of Aquaculture in India. By 1993, diseases, especially those of viral etiology have emerged as the major constraint to the sustainability and growth of shrimp aquaculture. Till date, more than 15 viruses have been identified to cause diseases in shrimp and no treatment option is available for their control. The increasing concerns about food safety and the potential negative impacts on the environment makes the control of diseases through chemotherapy/antibiotics a least preferred one. Hence, prevention is the only available option for containing viral disease outbreaks.

Aquaculture has become integral to the economies of many countries especially the developing ones. It provides employment and been a major driver of socio-economic development in poor rural and coastal communities, at the same time relieving pressure on the sustainability of the natural harvest from our rivers, lakes and oceans. Aquatic animals have been displaced from their natural environment, cultured in high density, exposed to environmental stress, provided artificial or unnatural feeds, and a prolific global trade has developed in both live aquatic animals and their products. As aquaculture production expands, diversifies, and becomes more intensive, the risks and effects associated with pathogen introduction, transfer, disease outbreaks, and pathogen spread are bound to be enhanced. Mortality due to diseases or decreased growth rates and/or decreased feed efficiency due to infections are major factors responsible for economic losses in aquaculture. Recent examples of major losses suffered by aquatic animals from disease outbreaks include the carp mortalities in Java, infectious salmon anaemia outbreaks in Norway, United Kingdom and North America, whitespot syndrome virus and Taura syndrome virus epidemics in prawn aquaculture, the spread of epizootic ulcerative syndrome (EUS) in Asia and Akoya disease in Japanese pearl oysters. Preventing a disease introduction is more cost-effective and easier than control and elimination of an introduced pathogen at a later stage. The situation warranted the sector to look for novel strategies to prevent the crop losses caused by diseases and in this context, the development and implementation of biosecure production practices can play an important role in saving this industry. This has already led to the development and implementation of biosecure production practices for fish rearing industry. Hence, Adoption of BIOSECURITY systems, incorporating 'scientific health management' at hatchery and farm, remains the only strategy for controlling the pathogens, especially those of viral etiology.

What is biosecurity?

Biosecurity is a term used in animal farming industry to describe the preventive measures taken against any infectious disease outbreaks. It can be defined as "the protocols, physical systems and health management procedures that protect fish rearing systems from infectious diseases" or "a set of standard scientific measures adopted to exclude pathogens (prevent the establishment and spread of pathogens) from the host and the rearing environment". Though biosecurity does not have a single definition, a working definition for practical purposes could be "The sum of all procedures in place to protect organisms from contracting, carrying or spreading disease". Thus, biosecurity in aquaculture is the protection of finfish or shellfish from infectious agents.

The key elements of biosecurity are a reliable source of stocks, adequate detection and diagnostic methods for excludable diseases, disinfection and pathogen eradication methods, best management practices (BMPs), and practical and acceptable legislation. A biosecurity program is thus comprised of a variety of practices, policies and procedures used on a farm in order to reduce the risk of pathogen entry into the facility; reduce the risk of spreading and reduce conditions that are stressful to the fish, which can enhance susceptibility to disease. The program should be tailored to the needs of the specific site, business needs of the operation, the fish/shellfish species and life stages grown and the disease profile of the surrounding region. Overall, a biosecurity program would include, but not be limited to, practices and procedures involving: 1) surveillance for the presence of disease organisms; 2) vaccination; 3) quarantine and restricted access; 3) appropriate practices of fish husbandry; 4) disinfection; and 5) disease treatment (including eradication).

Biosecurity can mean different things to different stakeholders. Seafood consumers want to have an assurance that the product is safe to eat. Retailers have a responsibility to provide high quality seafood, and processors should follow Hazard Analysis and Critical Control Point (HACCP) guidelines to ensure that their products are safe for human consumption. At the farm site, workers need to know what practices decrease or increase the risk of a disease outbreak occurring. Investors seek to protect their investments from preventable losses. General security precautions need to be established in each facility to help support the activities of both disease prevention and disease control. A manual of standard operating procedures (SOP) should be assembled to provide a set of standard rules for biosecurity measures and disease monitoring. This should include such things as facility design, facility flow for both personnel and stock, rules for limited or restricted access to facility, required visitor log book, disinfection procedures for personnel and equipment, a waste management plan, pest control guidelines, and general husbandry and management procedures.

Thus biosecurity is a team effort, a shared responsibility, and an on-going process to be followed at all times. From the breeder to the hatchery, to grow out operators, biosecurity measures and good aquaculture practices have to be observed to contribute to the success of the industry.

Economic Losses

Water is a continuous medium connecting all parts of planet Earth. In terrestrial situation, the discontinuity of land masses generally facilitate the control of trans-boundary movement of pathogens, while in aquatic system, continuity of water could allow the passage of biota along with the micro and macroflora, with potential pathogenic characteristics and related possibility of disease implications. Huge economic losses from aquatic animal diseases have been documented over the last decade, largely due to the lack of proper biosecurity plans/policies.

Very often, disease problems are the major limiting factors in determining the economic viability in any rearing system including agriculture, animal husbandry and aquaculture. The largest economic losses from aquatic animal diseases have been reported from the shrimp farming regions from both eastern and western hemispheres, though authentic information from many parts of the world is hard to obtain. However the figures given in Table 1, provide an indication of the economic losses. The total collapse of the Shrimp farming Industries in Taiwan in 1987, China in 1992, and India in 1995 was due to infectious viral diseases, causing billions of dollars in lost revenue for the industry. Between 1995 and 1996, disease accounted for 71% of the total losses to trout farming in the U.S., part of a continuing trend of a $ 3.02 billion loss to aquaculture from disease worldwide. It was estimated that loss from diseases accounted for 30% of the operating costs in aquaculture.

Table 1. Estimated losses from aquatic animal diseases. Most losses are from the introduction and spread of crustacean diseases

Area	Year	Estimated losses
Thailand	1983-93	US$ 100 million
China	1993	US$ 400 million
India	1994	US$ 17.6 million
Thailand	1996	US$ 600 million
Ecuador	1999	US$ 280 million
Global	1997	US$ 300 million

Aeromonas salmonicida in Europe in the 19th century, to *Aphanomyces invadans* in Asia and North America in the 21st century, caused disastrous epizootics. Furunculosis caused by *Aeromonas salmonicida* is the oldest of the known fish pandemics, believed to be transferred from US to Europe through rainbow trout (*Oncorhynchus mykiss*). Crayfish Plague caused by the fungus *Aphanomyces astacus* was introduced to Europe from USA. Epizootoic Ulcerative Syndrome (EUS) epidemic caused by *Aphanomyces invadans* has spread to whole Asia, Australia and further. It has caused considerable losses to many wild and farmed species in the Philippines, Indonesia, Thailand, Burma, Bangladesh and India, and even US. All the above three disease conditions have been introduced by fish movements to new ecosystems, where vulnerable host species were present in the wild stocks.

Biosecurity in shrimp farming

By 1993, diseases, especially of viral etiology have emerged as the major constraint to the sustainability and growth of shrimp aquaculture across the world. The past 2 decades witnessed the emergence of more than 15 shrimp viruses and devastating effects caused by them across the world (Table 2). The most important diseases of cultured penaeid shrimp, in terms of economic impact, in Asia, the Indo-Pacific, and the Americas have infectious etiologies. The pattern of spread and trans-boundary movements of many diseases may also pose another important threat. Grossly healthy arthropods tend to carry cryptic viruses (possibly unknown) that can jump to endemic arthropod species and cause massive mortalities. This phenomenon has resulted in 3 major shrimp epizootics that have caused economic losses in the order of several billion US$ since the early 1990's. WSSV which was initially confined to the cultured shrimp has now spread to the marine environment and the brood stock collected from the wild cannot be assumed to be disease free. The threat of many other crustaceans acting as carriers for this pathogen also exists.

Table 2: Viruses of penaeid shrimp (as of July 2001) Adapted from Lightner, 2005.

Acronym	Full name
Parvoviruses (Parvoviridae)	
*IHHNV	Infectious hypodermal and hematopoietic necrosis virus
HPV	Hepatopancreatic parvo virus
*SMV	Spawner-isolated mortality virus
LPV	Lymphoidal parvo-like virus
Baculoviruses and Baculo-like Viruses	
*BP-type	*Baculovirus penaei*-type viruses (PvSNPV type sp.):BP strains from the Gulf of Mexico, Hawaii and Eastern Pacific
*MBV-type	*Penaeus monodon*-type baculoviruses (PmSNPV type sp.): MBV strains from East and SE Asia, Australia, and Indo-Pacific
*BMN-type	Baculoviral midgut agland necrosis type viruses
TCBV	Type C baculovirus of *P. monodon*
PHRV	Hemocyte-infecting non-occluded baculo-like virus
White Spot Syndrome Viruses (Whispoviridae)	
*WSSV	White spot syndrome virus
Iridovirus	
IRIDO	Shrimp iridovirus
RNA Viruses	
Picornavirus (Picornaviridae)	
*TSV	Taura syndrome virus

Reoviruses	
REO-III and IV	Reo like virus types III and IV
LOVV	TOGA-like virus : Lymphoid organ vacuolization virus
RPS	Rhabdovirus: Rhabdovirus of penaeid shrimp
Yellow Head Virus Group	
*YHV/"YBV"	Yellow head virus of *P. monodon*
GAV	Gill associated virus of *P. monodon*
LOV	Lymphoid organ virus of *P. monodon*

*OIE modifiable and listed penaeid shrimp diseases (OIE, 2006)

Among the infectious diseases of cultured shrimp, certain virus-caused diseases stand out as most significant. The pandemics due to the penaeid viruses, WSSV (White spot), TSV (Taura Syndrome) and YHV (Yellow Head), have cost the penaeid shrimp industry billions of dollars in lost crops, jobs, and export revenue (Table 3).

Table 3. Estimated economic losses since the emergence of WSSV, TSV, YHV and IHHNV.

Virus	Year of emergence	Production loss
WSSV	Asia 1992	$ 4-6 billion
WSSV	Americas 1999	$ > 1 billion
TSV	1991-92, Americas & South East Asia	$ 1-2 billion
YHV	1991, South East Asia	$ 0.1-0.5 billion
IHHNV	1981, South East Asia	$ 0.5 1.0 billion

Biosecurity in finfish culture

The international fish disease commission has listed more than 17 diseases of concern among the farmed finfishes (OIE, 2006)

OIE Listed diseases in Fishes

- Epizootic haematopoietic necrosis
- Infectious haematopoietic necrosis
- *Oncorhynchus masou* virus disease
- Spring viraemia of carp
- Viral haemorrhagic septicaemia
- Channel catfish virus disease
- Viral encephalopathy and retinopathy
- Infectious pancreatic necrosis
- Infectious salmon anaemia
- Epizootic ulcerative syndrome
- Bacterial kidney disease (*Renibacterium salmoninarum*)
- Enteric septicaemia of catfish (*Edwardsiella ictaluri*)
- Piscirickettsiosis (*Piscirickettsia salmonis*)

- Gyrodactylosis (*Gyrodactylus salaris*)
- Red sea bream iridoviral disease
- White sturgeon iridoviral disease
- Koi herpesvirus disease

Viral diseases have not been considered to be a significant threat in marine and brackish water finfish culture in India. Other than the Epizootic Ulcerative Syndrome (EUS) and some reports on nodavirus, no other OIE notifiable diseases have been reported from India.

Epizootic Ulcerative Syndrome (EUS) is a pathogenic, invasive, fungal infection caused by the fungus, *Aphanomyces invadans* in Asian freshwater and estuarine fishes. It causes skin ulceration and death in over 30 species of commercially important cultured and wild fishes both in freshwater and estuarine habitats. EUS with its high epizootic potential and mortality rates has already appeared in freshwater systems in many North eastern and some Southern states. In India, losses due to EUS has been estimated at 42.5 million US $ during the period 1992-95. An EUS epizootic on a massive scale can therefore cause devastating losses to the tune of millions for Indian aquaculture.

The recent outbreaks of Koi herpes virus in the neighboring South-East Asian countries is a cause of worry to the country. Koi herpes virus (KHV) is a highly contagious viral disease, capable of causing significant morbidity and mortality in common carp, *Cyprinus carpio*. *C. carpio* is raised as a food fish in many countries and has been selectively bred for the ornamental fish industry, where it is known as Koi. The disease may cause 80–100% mortality in affected populations and affects fish of various ages. Outbreaks of KHV have been confirmed in the United States, Europe and Asia. There is no known treatment for KHV and the virus is believed to remain in the infected fish for life, thus exposed or recovered fish should be considered as potential carriers of the virus. As large numbers of ornamental fishes, especially koi are being imported to India, there is a high risk of KHV entering in the country.

World over, scarcity of water resources suitable for aquaculture purposes and environmental concerns about the wastewater discharges has forced many developed countries to employ “recirculating” technologies - systems that employ an intensive, closed-system approach to fish culture. In such systems, preventing and controlling disease is important because the disease organisms may recycle with the water and, since there is no dilution of the pathogens as in flow-through systems, the resulting rates of infection are greater. In addition, it is extremely difficult to eradicate a disease once a pathogen has become established in a recirculation rearing system.

Biosecurity measures in finfish culture include both physical and biological aspects. The physical aspects start with cleaning and disinfecting measures in hatchery and production facilities. UV treatment of water will control most of the fish viruses. Carefully regulating water temperatures to between 15 °C and 18°C has been shown to be effective at reducing the infectivity of Japanese flounder rhabdovirus (HIRRV)). Dedicated equipment, nets, brushes, etc., are disinfected with ozonated or electrolyzed seawater.

In terms of the biological aspects of disease control, ensure that the broodstock are pathogen-free, and the health of the fry is routinely monitored. Larvae that are cultured in disinfected water should have their normal intestinal flora restored. Immunizing stocks, using commercially available vaccines, is the most effective method for controlling salmonid diseases that cannot be excluded. The “eggs only” policy eliminates the introduction of many pathogens that require a live salmonid fish host. Any eggs that are imported into the area must have originated from certified, specific disease-free sources, to ensure that diseases are not transmitted vertically.

A pilot scale biosecure production system of seabass (*Dicentrarchus labrax*) in France prevented vertical and horizontal transmission of nodavirus disease in broodstock to market size fish and avoided the use of antibiotics and anti-parasitic treatments, at a final production cost that was similar to traditional system. The strategy combined the use of diagnostic tests for early detection and removal of nodavirus carriers to maintain healthy broodstock and control of specific bacterial populations in the recirculating system. Recycling systems greatly reduce the risk of meteorological and ecological events and mastering of the risks associated with rearing the fish is made easy. Thus by implementing biosecurity, the risk of pathological events can be greatly reduced.

Key To Fish Biosecurity

- Control the fish stocks in hatchery level and farmed level
- Identify excludable disease/pathogen of concern
- Vaccination
- Diagnostics for the detection of pathogens of concern
- Adequate environmental control to prevent the introduction of pathogens of concern (specific pathogen free stock)
- Routine management/husbandry practices to ensure pathogen exclusion (sterilization of influent water, pathogen free feed, prevention of pathogen transfer through men, material and vectors)
- Disinfection, treatment and pathogen eradication methods to contain and eradicate disease outbreaks due to pathogens of concern

Biosecurity in mollusc culture

In the Indian scenario, in terms of volume of production, molluscan culture comes nowhere near shrimp/fish farming and comparatively little importance is given for molluscan farming.

In the case of molluscan culture, for controlling the endemic diseases, the health management procedures include assessing and understanding the state of health of individual and populations of cultured shellfish, early diagnosis of abnormal or pathological conditions and preventing and correcting pathological conditions that may arise. Sanitation procedures are aimed at identifying and monitoring culture systems for contamination sources and management procedures to reduce or eliminate contamination. In intensive hatcheries and nurseries, pathogen-free algal stocks undergo surface sanitation in expanded culture and treated water is used with disease-free broodstock. Health assessments are critical at metamorphosis of larval mollusc cultures, and sanitation and health management hold the keys to ensure production of healthy juveniles. Non-endemic infectious diseases are excluded from mollusc culture operations usually through regulations set by authorities. Regulations to restrict the imported shellfish from being released into the culture waters and strict quarantine measures are to be made mandatory.

The following are the OIE listed molluscan diseases (OIE, 2006)

- *Bonamia ostreae*
- *Bonamia exitiosa*

- *Marteilia refringens*
- *Perkinsus marinus*
- *Perkinsus olseni*
- *Xenohaliotis californiensis*
- Abalone viral mortality

Among these pathogens, only *Perkinsus olseni, has been reported from the pearl oyster and edible oyster from India. N*one of the other pathogens/parasites of molluscs have been ever reported from India. But, this does not rule out their presence in Indian waters. Moreover, we do not have a database of molluscan pathogens in Indian waters since very little studies have been done on this aspect. If our country is free from these parasites/pathogens presently, utmost care should be taken to prevent the entry of these pathogens which may turn out to be a major threat in future. Thus the implementation of biosecurity measures holds great importance for the future of molluscan culture in India.

Lessons from Indian Aquaculture

Indian aqua farming is dominated by the culture of carps in freshwater and shrimp in brackish and higher saline waters. Among the carps, along with the common carp *Cyprinus carpio,* many other species of carps are cultured while shrimp farming is synonymous with the farming of *P. monodon.* In India, viral diseases have emerged as the major constraint to the sustainability and growth of shrimp aquaculture. In fishes, except for the occurrence of Epizootic Ulcerative Syndrome (EUS) and some reports on noda virus, no other OIE notifiable diseases have been reported. No comprehensive information is available regarding the status of the viral diseases infecting cultured fin fishes in India.

Presently, unauthorised/clandestine introductions pose a serious threat to the aquatic systems. Besides competing with the native species for food/other requirements, they bring with them a variety of pathogens (sub-clinical infections/carriers) which may pose serious threats to the native populations. Though blocking the introduction of exotic species may seem to be an attractive option in controlling the introduction of new pathogens into the system, in the present global scenario, production and economic aspects compels us from implementing a total ban on introductions. We cannot turn away from introducing new varieties of ornamental fishes and cultivable species with very high growth/production rates for economic reasons. There should be a balanced approach while recommending introductions.

Viral pathogens of primary concern in India

White spot syndrome virus (WSSV)
Monodon baculovirus (MBV)
Yellow head virus complex (YHV-complex)
Infectious hypodermeal and haematopoietic necrosis virus (IHHNV)
Hepatopancreatic parvovirus (HPV)
Taura syndrome virus (TSV)

Among the OIE listed viral pathogens, only WSSV and MBV have wide spread presence in India, and both are now enzootic in the farming systems. Outbreaks of WSSV were first found in

Penaeus japonicus in China in 1992. The disease first spread geographically within the species *P. japonicus*, and only later, in 1993, spread to other species including *Penaeus chinensis*, which is the major cultured species in China. No one knows how the virus spread throughout Asia after that, but the common practice of moving grossly normal broodstock and PL freely amongst countries was probably the most rapid and effective means of spread. Almost certainly WSSV was spread from Thailand to Malaysia and India in this manner.

WSSV is the most virulent virus known to affect cultured shrimps (Fig 1a, 1b). Considered as the largest known animal virus with a genome size of 305 kb and classified into a new family, *Nimaviridae.* Reported from India since late 1993. Till date, no treatment is known to control the White Spot Disease (WSD). Hence, early diagnosis followed by suitable management practices is the only alternative in tackling this viral disease.

Fig. 1a: Tiger shrimp affected with WSSV fro Indian farms. 1b: Ultrastructure of WSSV virus

The global loss caused by WSSV in 2000 is estimated to be 200,000 metric tons, valued at $ 1 billion. While Indian shrimp farming losses due to WSSV is estimated to be 200-300 crores annually, from 1994, with an accumulated loss of about 3000 crores during the last ten years.

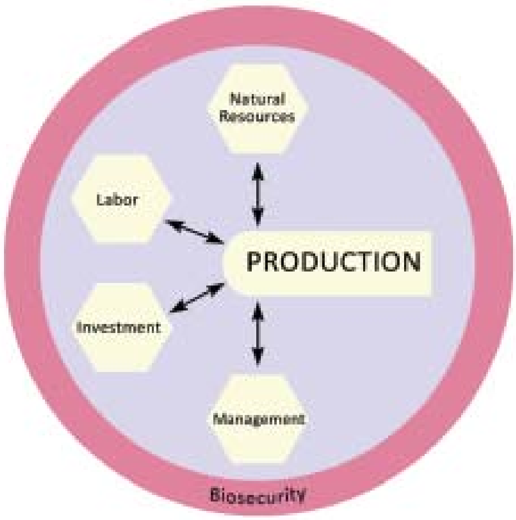

Fig. 2. Relation of production system with other inputs

The viral epizootic such as WSSV results in production losses with a negative impact on different aspects of the production system. Production in any system is closely related to various inputs like natural resources, investment, trade, employment, environment and management costs etc. A common result is that strategies for prevention, control and damage reduction are complementary, and neglect of any of them may lead to unnecessary large social costs (fig.2). Whenever production fails, other than the direct economic losses, these related areas are also affected indirectly. This has resulted in an increased awareness about the shrimp health management concepts including biosecuritiy and hazard analysis and critical control point (HACCP), and their adoption in rearing facilities.

International movement of frozen shrimp products from eastern to western hemisphere for trade and aquaculture has resulted in the transfer of WSSV from Asia to Americas, and TSV from Americas to Asia. Introduction of exotic/dangerous organisms/pathogens through shipping activities (ballast water) also pose a serious risk in this context. Appropriate biosecurity management could have prevented many of the serious losses experienced in aquaculture in recent years.

The main shrimp species cultured in India over the years included *Penaeus monodon* and *Feneropenaeus indicus* until 2003 when *Litopenaeus vannamei* was introduced by some vested farmers. Several farmers have experimented co-culturing of *Macrobrachium rosenbergii* and *P. monodon* in low saline waters. The practice of mixing of species and introduction of exotic species could be one of the reasons for the emergence of new viruses in India. The efforts of Indian shrimp farmers to introduce SPF *L. vannamei* stock and their subsequent experimental introduction to eastern India, in Andhra Pradesh, especially to prevent the specific pathogens such as WSSV and Monodon baculovirus (MBV), and other exotic pathogens brought the focus on the biosecurity facilities in India.

In the wake of the viral pandemics, the shrimp culture industry has sought ways to restore the industry's levels of production to the "previrus" years. Biosecurity risks are increasing every year, as aquaculture develops, new species are cultured and new host-pathogen-environment interactions get tested. Therefore, excluding infectious agents and reducing stress are important in preventing disease outbreaks. The application of biosecurity to shrimp farming is central to those efforts.

The principles of biosecurity is normally considered only for those dangerous pathogens, which are highly virulent, infectious, untreatable, vertically transmitted, have a diverse host range, and threaten the very survival of the industry. From the implementation point, biosecurity can be more easily implemented in small, intensive, and controlled farming systems than in outdoor and large-scale operations. A two-pronged approach is suggested: excluding pathogens from stock (i.e., post larvae and broodstock) through the use of quarantine and specific pathogen-free (SPF) certified stocks and restricting imports of live and frozen shrimp. Excluding vectors and external sources of contamination and preventing internal cross contamination is also important.

Legislations

Several procedures and guidelines developed by different agencies, organisations or nations deal with the components of biosecurity issues and plans. The common objectives include aspects of protecting animal populations, environment, food and the humans itself. Many instruments falling under the terms such as policies, codes, agreements, plans, conventions, regulations and treaties has been made to achieve the objectives of biosecurity. Examples are given in the Table 3.

Table 3. Examples of International or multinational policy instruments containing elements pertinent to aquaculture biosecurity. Dates are years of initial adoption

Lead Organization	Title
World Trade organization (WTO)	Agreement on the application of Sanitary and Phytosanitary Measures (SPS Agreement), 1995Convention on Biological Diversity (CBD), 1992, and its Cartegena Protocol on Biosafety, 2000
Food and Agricultural Organization of the United Nations (FAO)	Organization of the United Nations (FAO)Codex Alimentarius (Codes of Hygienic Practice for the Products of Aquaculture), 1981-1999Code of Conduct for Responsible Fisheries, 1995Code of Conduct for the Import and Release of Exotic Biological Control Agents, 1995International Plant Protection Convention (IPPC), 1997International Council for the Exploration of the Sea (ICES)
International Council for the Explorations of the Sea (ICES)	Code of Practice on Introduction and Transfer of Marine Organisms, 1994
International Maritime Organizations (IMO)	Guidelines for Control and Management of Ships' ballast Water to Minimize the Transfer of Harmful Organisms and Pathogens, 1997
United Nations (UN)	Biological Weapons and Toxins Convention, 1972
International Union for the Conservation of Nature	Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species, 1999

Issues regarding aquatic animal health are usually referred to the *Office International des Epizootices* (OIE) *International Aquatic Animal Health Code* (OIE 2000). Its mission is to inform governments of the occurrence and course of diseases throughout the world and of ways to control these diseases, to co-ordinate studies devoted to the surveillance and control of animal disease, and to harmonize regulations for trade in animals and animal products among its 158 member countries.

The majority of countries possess basic animal health legislation of different levels. In most countries, there is no clear distinction between terrestrial and aquatic animal health legislation. In cases where specific regulations for aquaculture exist, their enforcement is applied mostly as an emergency procedure to deal with a specific problem, and not as the result of an established program for surveillance and monitoring of the health status of cultured organisms. Several countries have specific legislation to regulate the import and export of live aquatic organisms and their products for use in aquaculture, for human consumption, or other purposes. Generally, these laws and regulations are in conformity with the rules of the OIE and WTO-SPS.

Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy provides guidelines for developing a list of pathogens, diagnosing diseases, implementing effective programs for health certification and quarantine measures for aquatic animals, guidance for creating disease zones and monitoring and reporting new diseases. This manual outlines the development of contingency plans and stresses the importance of risk analysis and need for national strategies and policy frameworks.

National legislation and policy

Legislation may play a useful role to enhance responses to aquatic animal health emergencies. Such legislation should address a number of issues, like disease surveillance, control and eradication; contingency plans; new species introductions; domestic movement of live fish and their products; and fish inspection and quarantine. Besides, the challenge is also to design legislation that enables and guides both public and private sectors involved in fish health related activities. It should clearly redefine the duties of various authorities involved in matters of fish health at the national, provincial and district levels and promote effective coordination, power-sharing and communication between all those involved. As providers of information and reports, fish farmers should be enabled to play a role in decision-making processes relating to the implementation of fish health management programmes. Scientists, enforcement officials and fish farmers need to be motivated to carry out relevant emergency preparedness response measures in aquaculture practices.

Legislation with respect to the Indian Fisheries sector

According to the Indian constitution, the states have the power to make laws and regulations with respect to fisheries and hence regulations and control of exotic organisms and diseases have to be enforced by the respective states. At the central level, the Indian Fisheries Act (1897) which is a century-old is still in existence. The legal mechanisms for control of both legally and illegally introduced aquatic organism and enforcement of the quarantine has to be made strict. Provisions should be made for regulating the movement of the native aquatic organisms within India in the wake of disease outbreaks. A draft legislation on “Live aquatic organisms importation Act 2006” has been proposed. Based on the existing international agreements and codes of practices for the trans-boundary movement of aquatic animals, the recommendations made in various consultations on invasiveness, disease diagnostics, risk analysis, emergency preparedness, capacity building etc., and existing legal provisions adopted by different countries, an act becomes inevitable to strictly implement the provisions needed in safeguarding the existing conservation and management of aquatic animal diseases and biodiversity in Indian fisheries.

Normally all introduced/imported organisms (brood stock/egg/larvae) arrive through the ports, and recently through the airports. There should be a mechanism to check and ensure that every consignment entering the country should be absolutely free of any pathogen. Imports should be allowed through selected ports and facilities should be established in collaboration with scientific organizations at these ports to establish their pathogen-free status.

Biosecurity in Indian aquaculture: Future strategies

The term ‘Biosecurity’ appears to be new to the Indian aquaculture industry. While aquaculture has made rapid advances in the past few years in fish and shellfish diagnostics, disease prevention and disease control measures lag significantly behind. Therefore, it is imperative to develop and enforce Ecologically Sustainable Development (ESD) strategies to meet the needs of the present without compromising the ability of the future generations to meet their own needs. A biosecurity program is developed through the scientific analysis of information with the aim of adopting procedures to manage risks to an acceptably low level, through a risk assessment approach. The use of sound epidemiological principles and a logical, structured approach will result in a more accurate outcome. Thus designing an effective biosecurity program requires a thorough understanding of the aquaculture operations, general principles of disease transmission, and knowledge of the fish or shellfish maintained in the facility.

Aquaculture biosecurity policies

Aquaculture biosecurity policies vary from farm-level to the international level, and between areas at each of these levels, but several characteristics are essential if aquaculture biosecurity polices are to be successfully implemented. They include:

- Science-based decision making,
- Economical and socio-political rationales,
- Standardized and uniform methods,
- Relative ease of application,
- Wide recognition,
- Vertical and horizontal integration, application, and agreement,
- Consistent enforcement,
- P7rimary focus on prevention, but with contingencies in place for control and management, or eradication.

Successful implementation of biosecurity at various levels throws up lot of challenges. Implementing strict biosecurity measures at the Hatchery can be the choice, while at the farm level, biosecurity can be very expensive and may not be feasible in open farming systems. Biosecurity measures would be adopted at the farm level only if they are shown to effectively prevent the occurrence of the disease and at a cost the farmer can afford. So, in the present Indian aquaculture scenario, 'Biosecurity' could be a choice and not an option.

*A biosecure system could therefore be based on **specific pathogen-free** (**SPF**) stocks.*

- Wild populations are surveyed to select animals free of the important diagnosable pathogens to establish the initial stock.
- These stock are kept under strict quarantine conditions to maintain the pathogen free status
- Breeding & rearing
- The population is qualified for SPF status, when the progeny is considered free of any diagnosable pathogens
- The quarantine, SPF Nucleus and multiplication centre located in different places.

Strategies used for the pathogen exclusion are:

- Identification of pathogen and their entry routes

- Quarantine and screening of hosts introduced in the system
- Disinfection at defined critical control points
- Restricted access
- Identification of risk factors that favor pathogen establishment and spread

Ideal elements for the setting up of a biosecurity facility are:

- Selection of a site away from potential source of pollution/contamination
- Availability of good quality water
- Water treatment facility to exclude the potential pathogens and other hazards
- Measures to prevent the entry of carriers of infectious agents
- Appropriate back-up for water supply and life support systems
- Operation procedure which allow one-way flow
- Prevention against the escape of animals
- Quarantine facility for screening specific pathogens with novel diagnostic facility
- Routine health monitoring progarmme
- Application of HACCP principles as a risk management tool to check the entry of viral pathogens
- Maintenance of complete records of operation
- Adherence to standards prescribed by international disease commission (OIE)

Recommendations to the Industry

- Restrict movement of sick animals (no “emergency harvest” or “dumping”).
- Implement yield verification programmes to assist in analysis of cost versus benefits of husbandry methods, breeding, vaccine use etc.
- Develop an identity as a united industry for effective interactions with regulatory agencies.
- Include vaccination as part of health management or biosecurity plan for aquaculture.
- Find ways that farmers can use biosecurity procedures to increase their profits.
- Include rapid and early detection tests for pathogen and stress.
- Hire media consultants to survey popular media for aquaculture-related news items and to prepare statements for the press.
- Develop a greater awareness of environmentalist/animal ethics opposition philosophy. Identify agendas of such groups and the consequences that necessarily follow from their position. Uncover basic values and philosophical rationale that underpins them. Enlist professional help to obtain a critique of their position.
- Insist on transparency and stakeholder involvement in your government’s responses to OIE and International trade requirements.

At the shrimp farm level, biosecurity refers to producing healthy finfish/shellfish in a well-controlled environment that excludes the introduction or propagation of unwanted organisms and includes the prevention or escape of organisms back into the natural environment. If past experiences can be taken as an indication, implementing these measures at the national level will be herculean task. It is a well known fact that *L. vannamei* has already been cultured in many regions of the country even before the legal clearance was given. Such unauthorized introductions can raise serious challenges to the very concept of biosecurity in the country. If introductions are not done with sufficient care, the pathogens entering our waters may turn out to be a serious problem for years to come.

An integrated plan for maintaining aquatic animal biosecurity and health, where all levels from border to the farm, including the environment need to be developed. The most important aspect is the management of the disease and pest risks associated with the importation of aquatic animals and animal products. Process of import risk analysis (IRA) and application of Quarantine measures are the scientific approaches to be adopted. The Australian Govt has successfully adopted an AQUAPLAN comprising of different modules viz., International linkages; Quarantine and Surveillance; Monitoring and Reporting; Preparedness and Response; Awareness; Research and Development; Legislation, policies and jurisdiction; and Resources and Funding (AFFA 1999). Such a measure can definitely be taken as a model for India.

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