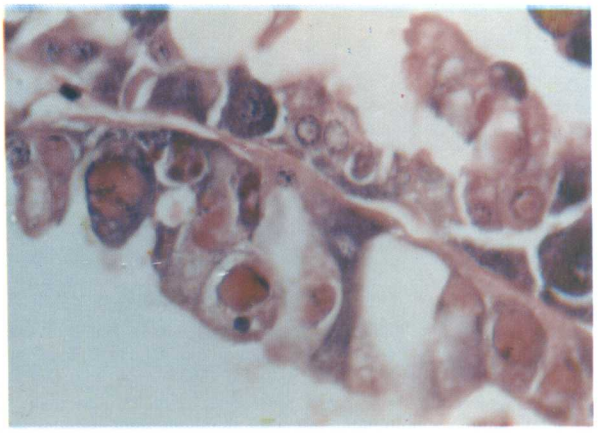
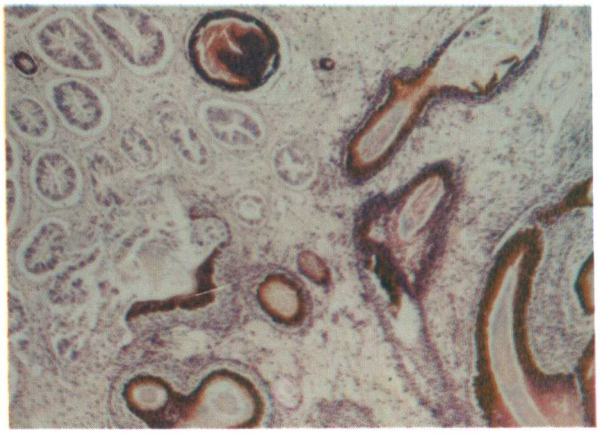
SHRIMP DISEASES, THEIR PREVENTION AND CONTROL





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नं.१४१, मार्शल्स रोड, एगमोर, मद्रास – ६०० ००८.

CENTRAL INSTITUTE OF BRACKISHWATER AQUACULURE
(Indian Council of Agricultural Research)
141, MARSHALL'S ROAD, EGMORE, MADRAS - 600 008

SHRIMP DISEASES, THEIR PREVENTION AND CONTROL

S. V. ALAVANDI, K. K. VIJAYAN AND K.V. RAJENDRAN

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Restricted Circulation

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Cover photos:

Top Left	:	Tiger prawn, *Penaeus monodon*
Top Right	:	Monodon baculoviral occlusion bodies within the nuclei of hepatopancreatocytes
Bottom Left	:	Hepatopancreatic necrosis in tiger prawn, *Penaeus monodon*
Bottom Right	:	*Zoothamnium.* sp., a peritrichous ciliate

Printed at: Prints & Proofs, Madras-8

PREFACE

During the early phase of shrimp culture in India, when we had only the traditional and extensive systems, there had not been many reports on shrimp diseases and mortality except for the soft-shell syndrome which is caused largely by environmental stress. With the expansion and intensification of shrimp farming during the last five years, instances of large-scale mortalities have been reported from several areas. The severest of these so far is the one from the shrimp farms along Kandaleru creek, Nellore district, Andhra Pradesh that occurred during July - August, 1994. The problem is likely to spread over a larger area, if the shrimp farmers continue to overdo things. The basic need to avoid or minimise problems is to provide a knowledge base to the farmers on what are the conditions under which a disease manifests itself and spreads widely as an epizootic and what are the methods to be followed to prevent the occurrence of diseases, as also what options are available to control the diseases once they occur. Information should also be made available on the types of diseases that commonly occur in shrimp farms and their symptoms to enable the farmers to take appropriate steps to protect the stock.

*Since 1990, the Central Institute of Brackishwater Aquaculture has carried out investigations covering a large range of shrimp diseases including bacterial, fungal, parasitic and viral diseases both in the hatcheries and in the farms. A number of major disease problems of commercial farms have been investigated comprehensively, including the pond environment. The experience gained has enabled us to prepare the present publication entitled "***Shrimp diseases, their prevention and control***" which perhaps is the first such publication in the country. While describing the diseases in some detail, emphasis is laid on proper management of water quality and inputs such as quality of seed, stocking rate and feeding. Drugs and chemicals that can be used as a last resort and their impact on the environment are also outlined. Indeed, their role in disease control of aquatic animals is not well understood.*

It is hoped that the shrimp farmers and hatchery operators will find the information useful and adopt such measures as suggested for prevention of diseases rather than trying to control them after they occur. I appreciate the efforts of scientists Shri S. V. Alavandi, Dr. K. K. Vijayan and Dr. K. V. Rajendran for the preparation and Shri K. N. Krishnamurthy, Principal Scientist, for editing this important publication.

Madras - 8
2.1.1995

K. ALAGARSWAMI
DIRECTOR

CONTENTS

1. INTRODUCTION

Shrimp aquaculture has become one of the fastest developing industries in recent times. More than 80,000 ha have been brought under shrimp culture in the coastal areas of India. While the traditional type of shrimp farms are being improved, new extensive and semi-intensive farms are being established at a rapid pace. Most of these new farms stock shrimps at high densities and use compounded pelleted feed in order to achieve higher production rates. These modern methods impose stress on the shrimps, making them susceptible to diseases. The most important predisposing factors leading to disease outbreaks in shrimp culture are:

i) adverse environment (poor soil and water quality)
ii) high stocking density with limited water exchange facilities
iii) nutritional deficiency / poor nourishment
iv) accumulation of unutilised feed followed by its putrefaction by the native heterotrophic microorganisms
v) inadequate aeration
vi) suboptimal or heavy algal blooms in the pond
vii) physical injury and
viii) presence of virulent pathogen in high counts

These and many other less known stress factors lead to outbreak of diseases, sometimes of epizootic proportions in shrimp farms and hatcheries causing heavy mortalities.

The diseases may be caused by various etiologic agents such as viruses, bacteria, fungi, parasites, algal toxins, nutritional deficiency or adverse environment. Many of the microbial agents of shrimp diseases form part of the natural microflora of marine and brackishwater ecosystems. These microbes are facultatively pathogenic and cause disease when the shrimps are under stress. The shrimp feed stored under unhygienic conditions may harbour myco-toxins and sometimes pathogenic microbes, and these get introduced to the ponds. The farm personnel may unknowingly transmit shrimp pathogens from affected to the unaffected ponds when same nets and implements are used without periodic disinfection.

Intensive research is being conducted at the Central Institute of Brackishwater Aquaculture, Madras, on various aspects of diseases of shrimps occurring in the hatcheries and grow-out ponds. The diseases enlisted in this bulletin are those on which the Institute has conducted detailed investigations. In order to overcome the disease problems in the hatcheries and grow-out ponds, **emphasis is laid more on the disease prevention aspects rather than resorting to drugs, considering the disadvantages associated with their usage.**

2. DISEASES IN HATCHERIES

2.1. Necrosis of appendages

Signs and symptoms:

The disease often results after physical damage to the appendages. The affected larvae show browning of exoskeleton and tips of appendages, making them appear eroded and opaque.

Cause:

The epibiotic bacteria such as *Vibrio* spp., *Pseudomonas* spp., *Aeromonas* spp., and *Flavobacterium* spp.

Diagnosis:

Based on gross signs and symptoms and confirmed by isolation and identification of pathogenic bacteria by standard microbiological methods.

Prevention:

Stock at optimal densities. Maintain good water quality.

Control:

Improve water quality by increased water exchange with good quality water.

2.2. Vibriosis

Signs and symptoms:

The affected shrimp larvae show necrosis of appendages, expanded chromatophores, empty gut, absence of faecal strands and poor feeding. Cumulative mortalities may be very high reaching up to 80% within few days.

Cause:

Bacteria such as *Vibrio alginolyticus, V. parahaemolyticus,* and *V. anguillarum.*

Diagnosis:

Microscopic demonstration of motile bacteria in the body cavity of moribund shrimp larvae, and confirmed by isolation and identification of pathogenic bacteria by standard microbiological methods.

Prevention:

Maintain good water quality and reduce organic load in the water by increased water exchange.

Control:

10-15 ppm Ethylene diamine tetra acetic acid (EDTA) to the rearing water.

2.3. Luminescent bacterial disease

Signs and symptoms:

The infected larvae appear luminescent in darkness and suffer heavy mortality.

Cause:

Luminescent bacteria such as *Vibrio harveyi.*

Diagnosis:

Based on gross signs and symptoms and microscopically demonstrating swarming bacteria within the haemocoel of moribund shrimp larvae. The luminescent bacteria can be isolated on Zobell's marine agar or a selective medium for luminous bacteria and identified based on their morphological and biochemical characteristics.

Prevention:

Use chlorinated (calcium hypochlorite 200 ppm for 1 hour) and ultraviolet irradiated water. Clean bottom debris in rearing tanks daily.

Control:

Exchange water upto 80% daily with sand filtered /UV sterilized seawater.

2.4. Filamentous bacterial disease

Signs and symptoms:

The affected shrimp larvae show fouling of gills, setae, appendages and body surface. Moulting is impaired and the larval shrimp may die due to hypoxia.

Cause:

Filamentous bacteria such as *Leucothrix mucor.*

Diagnosis:

Based on gross signs and symptoms and by microscopically demonstrating filamentous bacterial fouling of body surface and appendages of shrimp larvae.

Prevention:

Maintain good water quality with optimal physico-chemical conditions.

Control:

0.25 - 1 ppm copper sulphate bath treatment for 4-6 hours.

2.5. Larval mycosis

Signs and symptoms:

Affected shrimp larvae appear opaque. The protozoeal and mysis stages are highly susceptible. Within 1-2 days, whole stock of shrimp larvae may suffer mortality.

Cause:

Oomycetous fungi such as *Lagenidium* spp., *Sirolpidium* spp., and *Haliphthoros* spp.

Diagnosis:

Microscopic demonstration of presence of extensively branched non-septate, fungal hyphae within the body cavity of the shrimp larvae (Plate 6. A).

Prevention:

Clean tank bottom periodically. Disinfect the tanks and other equipment in the hatchery from time to time. Treat spawners with 5 ppm treflan bath for 1 hour.

Control:

Treflan (Trifluralin) 0.1-0.2 ppm bath for 1 day.

3. DISEASES IN GROW-OUT PONDS

3.1. Monodon-type baculovirus (MBV) disease

Signs and symptoms:

Shrimps lethargic with surface and gill fouling. The virus affects all life stages. Disease severe in postlarvae and senescent adults. High cumulative mortalities.

Cause :

Type A baculovirus.

Diagnosis :

Tentatively diagnosed by microscopic demonstration of single or multiple spherical intra-nuclear occlusion bodies in fresh squash preparations of hepatopancreas under phase contrast microscope or by staining with 0.1% malachite green (darkly stained intranuclear occlusion bodies). Confirmed by demonstration of characteristic single or multiple oval eosinophilic intranuclear occlusions with associated histopathology by hematoxylene and eosine (H & E) staining (Plate 1. A).

Prevention:

Use MBV-free stock for culture purpose. MBV infections are well tolerated by *P. monodon* until the environmental conditions are not hostile. Hence, it is essential to maintain good water quality by increased water exchange in order to minimise risks of secondary bacterial infections cumulatively leading to mortality.

Control:

Not known. Destroy affected shrimp by burning or burying them after mixing with lime away from the culture facility.

3.2. Necrosis of appendages

Signs and symptoms:

The tips of walking legs, swimmerets and uropods undergo necrosis and become brownish black (Plate 1. B). The setae, antennae and appendages may be broken and melanized.

Cause:

The epibiotic bacteria such as *Vibrio* spp., *Pseudomonas* spp., *Aeromonas* spp. and *Flavobacterium* spp.

Diagnosis:

Based on gross signs and symptoms.

Prevention:

Maintain good water quality. Stock at optimum density. Avoid unnecessary handling of the shrimps, which may lead to injuries and necrosis.

Control:

Induce moulting by applying 5 - 10 ppm teaseed cake.

3.3. Brown spot disease (Shell disease or Rust disease)

Signs and symptoms:

The affected animals show presence of brown to black eroded areas on the body surface and appendages(Plate 2. A).

Cause:

Bacteria such as *Vibrio* spp., *Aeromonas* spp., and *Flavobacterium* spp., with chitinolytic activity.

Diagnosis:

Based on gross signs and symptoms and confirmed by isolation and identification of bacteria from the site of infection by standard microbiological methods.

Prevention:

Reduce organic load in water by increased water exchange. Avoid unnecessary handling and overcrowding to minimise chances of injury and infection.

Control:

Induce moulting by applying 5 - 10 ppm teaseed cake. Improve water quality by increasing water exchange. If there is no improvement, shrimps may be fed with antibiotic (after ascertaining *in-vitro* sensitivity of the pathogen) fortified feeds (e.g., 1.5g oxytetracycline /kg of feed) at 2- 10% of the biomass for 10-14 days.

3.4 Bacterial septicaemia (Vibrio disease)

Signs and symptoms:

This is one of the severe systemic diseases caused by bacteria. The affected shrimps are lethargic and show abnormal swimming behaviour. The pereopods and pleopods may appear reddish due to expansion of chromatophores and the shrimps may show slight flexure of the abdominal musculature. In severely affected shrimp, the gill covers appear flared up (Plate 3. A) and eroded. In more severe cases, extensively melanised black blisters can be seen on the carapace /abdomen (Plate 2. B).

Cause:

Bacteria such as *Vibrio alginolyticus*, *V. anguillarum*, or *V. parahaemolyticus*.

Diagnosis:

Based on gross signs and symptoms and confirmed by isolation of pathogen from haemolymph by standard microbiological methods and histopathology (Plate 3. B & Plate 7. B).

Prevention:

Maintain good water quality and reduce the organic load by increased water exchange.

Control:

Increase water exchange with good quality seawater. Feed shrimps with antibiotic fortified feeds (only after ascertaining *in-vitro* sensitivity of the pathogen), e.g., feeds containing oxytetracycline @ 1.5g /kg, fed at 2-10% of body weight for 10-14 days along with proper water and pond management. Sufficient withdrawal period (about 25 - 30 days) should be allowed for the antibiotic to become inactive or harmless.

3.5. Protozoan fouling

Signs and Symptoms :

Affected shrimps are restless and their locomotion and respiratory functions are hampered. In heavily infected jnvenile and adult shrimps, one can observe fuzzy mat-like appearance due to ciliate fouling (Plate 4. A).

Cause:

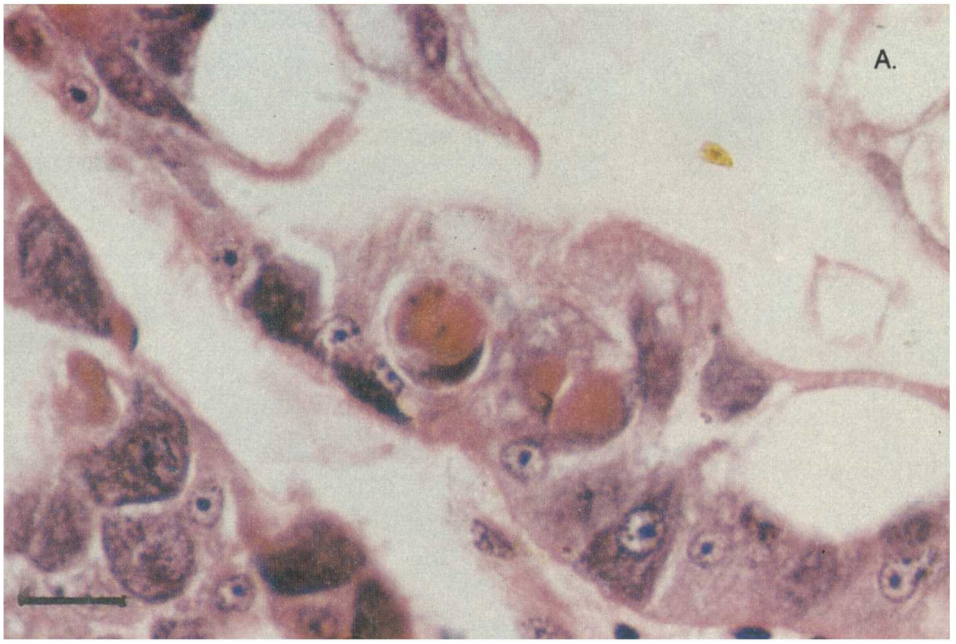
The protozoans such as *Vorticella, Zoothamnium, Epistylis, Acineta* and *Ephelota.*

Diagnosis:

Based on gross signs and symptoms and microscopic demonstration of ciliates (Plate 6.B).

Prevention:

Maintain good water quality. Reduce organic load and silt in water by increased water exchange with good quality water.



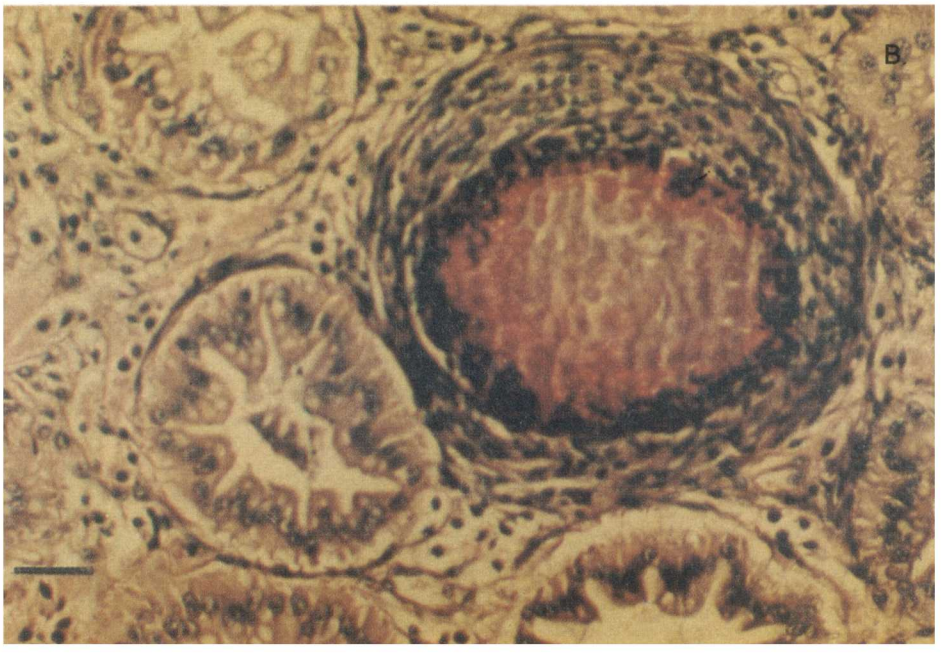
A. MBV occlusions in the hepatopancreatic tubule epithelial cells (H & E stain). Scale: 10 μm.

B. Necrosis of appendages in the tiger prawn, *Penaeus monodon.*

A. Shell disease in *Penaeus monodon* .

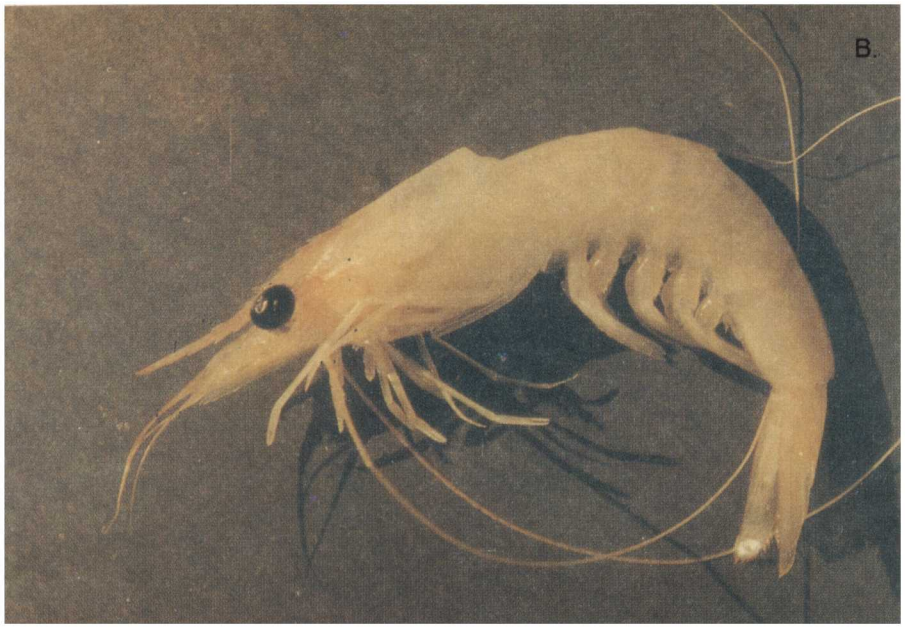
B. Vibriosis of the tiger prawn, *Penaeus monodon.* Melanised blister on the branchiostegite.

A. Vibriosis of the tiger prawn, *Penaeus monodon.* Flaring up of gill covers.



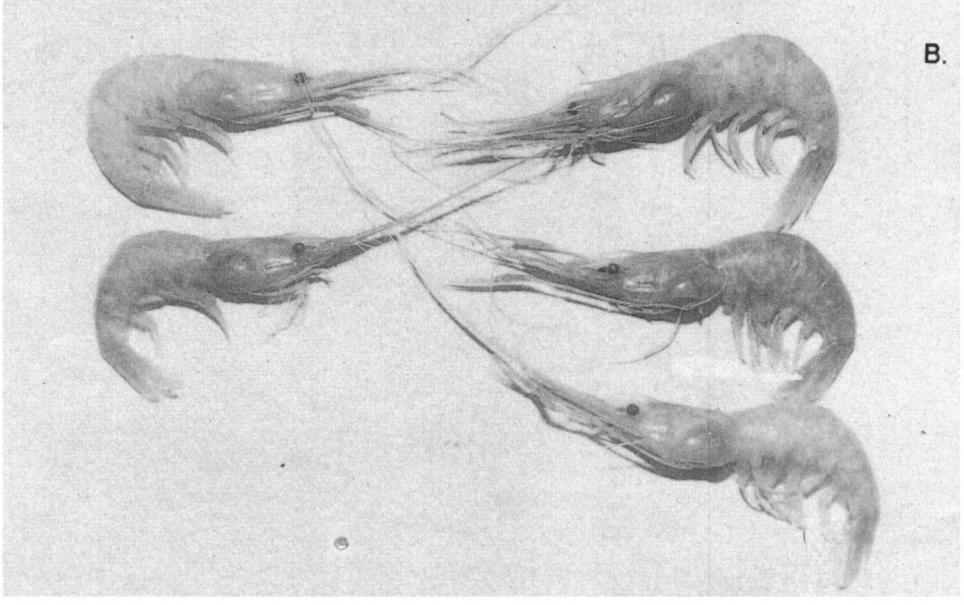
B. Vibriosis of the tiger prawn, *Penaeus monodon.* Haemocytic nodule in the hepatopancreas due to bacterial septicaemia. Scale: 20 μm.

A. Protozoan fouling of tiger prawn, *Penaeus monodon*.

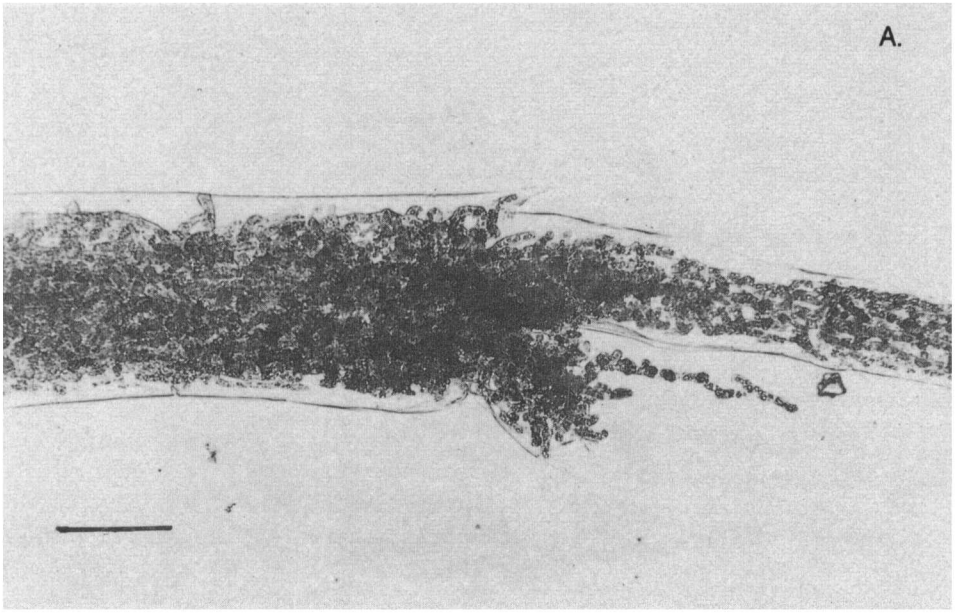


B. Cotton shrimp disease in the white prawn, *Penaeus indicus* .

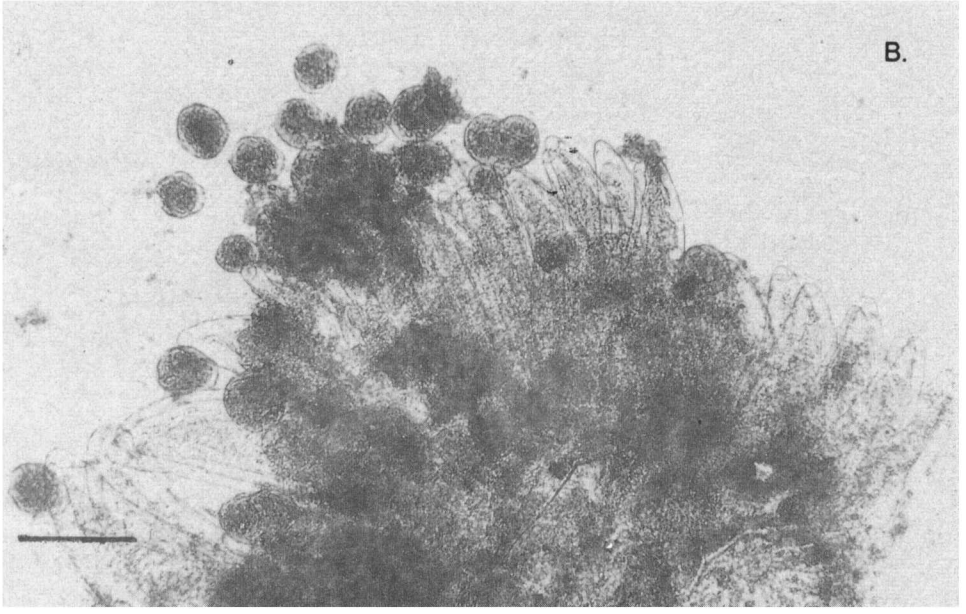
A. Black gill disease in the tiger prawn, *Penaeus monodon* .



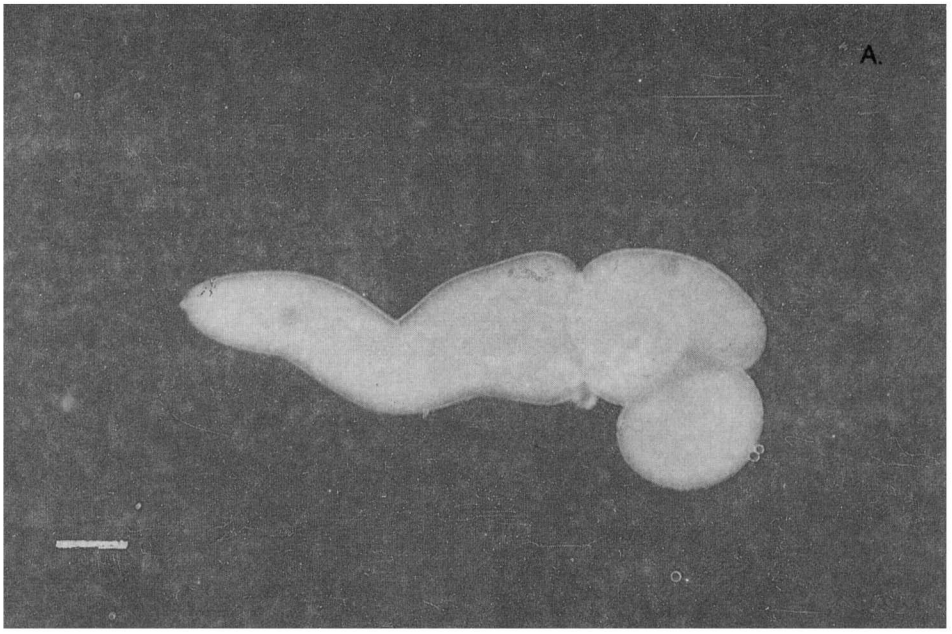
B. Bopyrid parasitic infection in *Palaemon* sp.



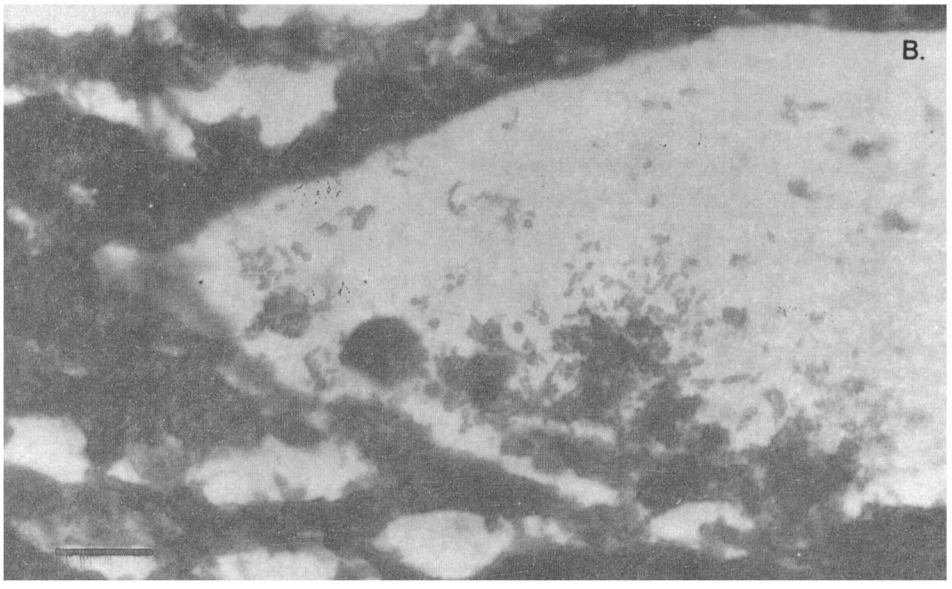
A. Larval mycosis of the tiger prawn, *Penaeus monodon.*
Scale: 50 μm.



B. *Zoothamnium* sp. infestation on the gills of the tiger prawn, *Penaeus monodon*. Scale: 50 μm.



A. Gregarine parasite, *Cephalolobus* sp. from the gut of *Penaeus indicus.* Scale: 20 μm.



B. Histological section of hepatopancreas showing bacteria. (Gram's Stain) Scale: 10 μm.

Control:

15 to 25 ppm formalin (single treatment) for ponds or dip treatment of affected individuals in 50 -100 ppm formalin for 30 min. Maintain good aeration during treatment.

3.6. Cotton shrimp disease

Signs and symptoms:

Muscle of affected shrimps appears cooked (Plate 4. B) In severely affected shrimps, the exoskeleton appears bluish black, and white tumour-like swellings may be found on gills and subcuticle.

Cause:

Microsporidia such as *Agmosoma, Ameson* and *Pleistophora.*

Diagnosis:

Based on gross signs and symptoms and microscopic demonstration of developmental stages of microsporidia in the affected tissues.

Prevention:

Affected animals should be destroyed and buried with lime away from the farms. After harvesting, the pond bottom should be thoroughly dried to kill the spores of the microsporidia.

Control:

Not known.

3.7. Bopyrid parasitic infestation

Signs and symtpoms:

These parasites can be found lodged in the branchial cavity, which is clearly evident on inspection of the animals (Plate 5. B). Affected shrimps suffer from impaired respiration.

Cause:

Bopyrid parasite, *Epipenaeon* spp.

Diagnosis:

Based on gross signs and symptoms and identification of the parasite by gill biopsy.

Prevention:

Not known.

Control:

Affected shrimps may be separated and given formalin (150-250 ppm for 1 hour bath) treatment.

3.8. Enterozoic cephaline gregarine infection

Signs and symptoms:

Affected shrimps are anorexic, lethargic and weak. Low levels of mortalities.

Cause:

Cephaline gregarines (protozoan) such as *Cephalolobus* sp.

Diagnosis:

Microscopic demonstration of developmental stages of the parasite in the digestive system (Plate 7. A).

Prevention:

Avoid wild seeds.

Control:

Not known.

3.9. Chronic soft shell syndrome

Signs and symptoms:

Shell of the affected shrimps is persistently soft, loose and papery for several weeks. In acutely affected shrimp, lesions/blisters may develop and the body becomes very soft. The shrimps become weak and susceptible to cannibalism. It is very common in traditional, extensive, seasonal as well as perennial ponds. Severely affected *P. indicus* show undulating gut in the first three abdominal segments.

Cause:

This disease is found to occur during adverse environmental conditions like sudden increase or decrease of temperature and salinity of water, high soil pH, highly reducing conditions in soil, low organic matter content in soil, low phosphate content and pesticide pollution in water, nutritional deficiency and insufficient water exchange.

Diagnosis:

Based on gross signs and symptoms.

Prevention:

Feed adequately with balanced diets. Maintain good water quality by increased water exchange.

Control:

Restore good water quality by increased water exchange. Feed shrimps adequately with feeds such as fresh clam meat @ 14% of body weight for 2 - 4 weeks daily or formulated feeds fortified with calcium and phosphorus.

3.10. Black gill disease

Signs and symptoms:

The affected shrimps show brown to black spots on the gills. In acute cases gills may completely become brown or black with atrophy and necrosis (Plate 5. A).

Cause:

A number of causes have been assigned to this disease. Presence of excessive levels of toxic substances like nitrite, ammonia, acids, crude oils, potassium permanganate, copper, cadmium, ozone , etc. in the culture water may lead to black gill disease. Presence of 2-3 ppm nitrite leads to black gill condition resulting in low levels of mortalities. High organic matter content and highly reducing conditions in soil also cause black gills. Infection with infectious hypodermal and haematopoietic necrosis (IHHN) virus, bacteria (*Vibrio, Cytophaga, Flexibacter)* and fungi *(Fusarium* and *Haliphthoros)* also leads to black gill syndrome in shrimps.

Diagnosis:

Based on the signs and symptoms and histopathology. Black gill condition due to microbial etiology may be confirmed by standard microbiological metnods.

Maintain good water quality. Avoid overfeeding.

Control:

Treatment of black gill disease depends upon the cause of the disease. When the disease is due to pollution of pond water with toxic substances, the water quality must be improved by sufficient water exchange and aeration. If the disease is due to microbial infection, antibiotic treatment may be given (Please refer bacterial septicaemia) after knowing the *in-vitro* sensitivity of the pathogen.

3.11. Red disease

Signs and symptoms :

The disease starts as yellowish discolouration of the body, subsequently, the appendages turn red and finally the whole shrimp becomes red. In the cephalothorax region, excessive fluid with foul odour may be found.

Cause:

Definite causative agent of this disease is not known. Presence of aflatoxins in feeds, prolonged high pH and low salinity of water may lead to red diesase.

Diagnosis:

Based on gross signs and symptoms and confirmed by demonstration of massive necrosis of hepatopancreas in histological sections.

Prevention:

Use fresh and properly stored feeds. Reduce organic matter content in water by increased water exchange. Do not use high doses of lime during pond preparation since it increases pH of water during culture.

Control:

Not known. Avoid using old and rancid feeds.

3.12. Cramped tail disease

Signs and symptoms :

Affected shrimps have very rigid flexed abdomen. These shrimps lie on their sides at the bottom of the pond and are susceptible to cannibalism.

Cause:

Exact cause for this disease is not known. The disease may be due to adverse environmental conditions.

Diagnosis:

Based on gross signs and symptoms.

Prevention:

Avoid handling shrimps during hot humid climate.

Control:

Not known.

4. METHODS OF DISEASE PREVENTION

The saying that prevention is better than cure holds true in aquaculture also. Application of chemical or antibiotic treatment when the shrimps are affected with disease may not help as they are already under stress due to the disease. Another practical difficulty with the use of drugs is that it is difficult to treat only the affected stock, and healthy shrimps are also exposed to the drug. Hence, adequate preventive measures must be taken in order to avoid proliferation of pathogenic microorganisms, thereby keeping the stock healthy.

4.1. Disease prevention in hatcheries

(i) Location of the hatchery: The hatchery should be located in a place where good quality water is ensured for maintenance of broodstock, spawning, larval rearing, phytoplankton culture and all other hatchery activities.

(ii) Water treatment: Disinfect the seawater with calcium hypochlorite (20-30 ppm) or sodium hypochlorite (150ppm) for 1-2 days ensuring thorough mixing to eliminate pathogenic microorganisms. Remove excess chlorine from the seawater by neutralising with sodium thiosulphate. Filter the seawater (e.g. pressure sand filter) and preferably sterilize by UV treatment.

(iii) Cleanliness of hatchery facilities: The tanks used for broodstock, spawning, larval rearing, etc. should be kept thoroughly clean by scrubbing, disinfecting and thorough rinsing.

(iv) Treatment of broodstock: The brood shrimps should be treated with 2ml/100 l formalin (20 ppm) and oxytetracycline (10 ppm) for 30 minutes before stocking in broodstock tanks to reduce the population of epibiotic microflora.

(v) Care at the time of spawning: Remove the scum formed after spawning.

(vi) Stocking of nauplii: Stock only healthy nauplii at an optimal stocking density. The nauplii may be disinfected by dip treatment in 20-30ml formalin/100 l (200 - 300 ppm) or 0.1 ppm iodophore.

(vii) Care during larval rearing: Remove the unused feed, sediments, debris, algal growth and wastes accumulated at the bottom or sides of the tanks routinely by siphoning and scrubbing as these wastes encourage bacterial proliferation.

(viii) Feeding: Feed the larvae with optimal amounts of good quality balanced feed as the defence mechanism of the larvae depends upon their nutritional status.

(ix) Use of chemicals and antibiotics: The antibiotics should be used carefully at right doses, only after ascertaining *in-vitro* sensitivity of the pathogens. Low dose of antibiotics leads to development of antibiotic resistant mutants of bacteria and higher doses may be toxic to the shrimp larvae.

(x) Monitoring of larval health and water quality: Examine the larvae every morning before changing water for any visual abnormality, and microscopically for fouling protozoa, filamentous bacteria, fungal infections, and presence of swarming bacteria within the haemocoel. Wet mount preparations of hepatopancreas should be examined from time to time for viral infections. Observe rearing water and shrimp larvae in dark for bioluminescence. This helps in understanding the status of health of the shrimp larvae and thereby take appropriate remedial measures as needed. Monitor the water quality to maintain important parameters at optimal levels (Temp. 27-30°C, Salinity 27-31 ppt, DO > 5 ppm, pH 7.8-8.5; Ammonia-N: < 0.5 ppm, Nitrite-N: < 0.02 ppm).

(xi) Since treatment of viral diseases of shrimps is not known, disease outbreaks due to viral infection may be avoided by quarantine measures and destroying carriers and contaminated animals. Once viral infection is detected in a hatchery, all activities should be stopped and all the contaminated facilities should be thoroughly disinfected before restarting hatchery activities.

4.2. Disease prevention in grow-out ponds

(i) Location of the shrimp farms : The shrimp farms should be located in areas free from industrial, agricultural or domestic pollution.

(ii) Pond preparation: Before stocking, the ponds should be thoroughly drained, sun dried, black layer of soil formed during the previous crops be removed and the pond tilled. Lime should be applied at the rate of 200 - 600 kg/ha depending on the pH of the soil.

(iii) Stocking: Stock only healthy postlarvae after achieving optimum algal bloom in the ponds. Maintain optimum density of shrimp larvae.

(iv) Water management: Always maintain good water quality in the pond. Visual examination of pond water reveals health of the shrimps to a great extent. Light green colouration of the pond water is known to be ideal. Very clear water and high turbidity are known to be stressful for the shrimps. Presence of bubbles or foam on the surface of water is also undesirable. Monitor routinely the pond environment for optimum colour(light green), transparency(30 - 40 cm), DO (4 - 6 ppm), pH (7.5 - 8.5), NH_3(unionized ammonia: < 0.1 ppm) and H_2S (< 0.03 ppm) content in the pond water. Upon considerable fluctuations in these parameters, water exchange becomes necessary. The incoming water must be ensured for optimum quality especially with respect to pH, salinity and turbidity.

(vi) Feeding: The shrimps should be fed with balanced diets at optimum quantities. Care should be taken to avoid accumulation of unutilized feed, otherwise it may lead to spoilage of the pond bottom. Do not use old, rancid and mouldy feeds.

(vii) Health check up : A routine examination should be carried out on the status of health of the shrimps. Examine shrimps routinely for their swimming behaviour. Infected shrimps often show poor escape reflex. Frequent microscopic examination of gills, hepatopancreas and haemolymph for microbial infections or any disease symptoms should be done to ensure the health of the shrimps. Diseased and infected shrimp should be destroyed by burning or burying with lime into the soil away from the shrimp farms, in order to avoid spreading of infection.

5. DISEASE CONTROL

The disease control programmes in aquaculture must include examination of diseases and mortalities in a holistic manner and consider various factors such as stocking densities, environment (turbidity, temperature, pH, salinity, dissolved oxygen, H_2S, NH_3, NO_2, etc. of water and redox potential of soil), rate of water exchange, presence of bottom dwelling algae, the type of feed and its rate of consumption by the shrimps, phytoplankton bloom, physiological status of shrimps, etc.. These factors considered together go a long way in management of disease problems. Most of the disease control methods are based on preventive measures. They are :

(1) Good husbandry practices
(2) Use of adequate balanced diets
(3) Quarantine measures
(4) Use of genetically resistant stock for culture purpose
(5) Use of prophylactic vaccines and
(6) Use of Drugs

Disease prevention by adopting good husbandry practices and by providing balanced diets has been adequately mentioned in the earlier section (under methods of disease prevention).

5.1. Quarantine measures

The seed and brood shrimps may sometimes harbour pathogenic microbes particularly viruses without showing external clinical manifestations. Transport of such seed and broodstock to other geographic regions for culture purposes may lead to disease outbreaks. Hence, it is important to screen the seed and broodstock for pathogenic microorganisms before they are transported to different geographic regions for aquaculture purposes.

5.2. Use of genetically resistant stock for culture purpose

Susceptibility of shrimps to various infectious agents appears to be species specific and is probably genetically aquired trait, e.g. the yellow head disease has been reported to be specific to *Penaeus monodon*. Hence, in the shrimp farming areas endemic to yellow head disease culture of other penaeid species such as *Penaeus indicus* which is known to be resistant to this disease may be helpful in the prevention of yellow head disease. Similar possibilities may be explored to prevent other such epizootics.

5.3. Use of prophylactic vaccines

Prophylactic vaccines may be used for controlling specific diseases. Certain commercial vaccine preparations against vibriosis of shrimps are available for use. Various factors, such as methods of administration of vaccines, disposal of spent vaccine suspensions that may create environmental problems have to be considered carefully.

5.4. Use of drugs

In spite of best management practices adopted in the hatcheries and grow-out ponds, disease outbreaks may occur, and we may have to use drugs for controlling these diseases. Although some drugs have been advocated (Table 1) for treatment of diseases, **drugs should be employed only as a last option,** since the art of disease control in aquaculture is in the early phase of development. Various aspects of using drugs for disease control such as their dosages, intervals of drug administration, duration of exposure of shrimps to drugs, their effect on the shrimps, their efficacy in controlling the disease, withdrawal period from the tissues, their impact on the environment, etc. are yet to be clearly understood. The disease control measures using drugs would be useful only if they are applied during the early phase of the disease. Hence, right diagnosis of diseases at an early stage is a very important aspect that will aid in taking measures to control the disease.

Table 1. Drugs useful in aquaculture

	Drug	Purpose	Therapeutic dose and duration	Mode of application	Precautions
1.	Formalin	Ectoparasitic infections	(i) 150-250 ppm for 1 h (ii) 20 ppm for 12 h (iii) 50-100 ppm for 4 h in ponds	Bath	Formalin has deoxygenating effects. Use aeration during treatent. Shrimps with gill infections should be treated carefully since it affects availability of oxygen.
2.	Potassium permanganate	Ectoparasitic infections	(i) 1-5 ppm for 1 h repeat if needed after 2-3days (ii) 1000 ppm for 10-40 sec. (iii) 2 ppm in ponds	Bath Dip	In muddy waters not effective.
3.	Copper sulphate	Ectoparasitic infections	0.1 ppm		High doses toxic to shrimps. After treatment, excess CuSO4 can be removed from water by using 3 g/l activated carbon, followed by increased water exchange.
4.	Benzal-konium chloride	Disinfectant, external bacterial infections (shell disease, necrosis of appendages, black gills) symptomatic treatment	(i) 10 ppm for 5-10 min. (ii) 5 ppm for 30 min. (iii) 2 ppm for 1 h (iv) 0.1-0.5 ppm as prophylactic	Bath Bath Bath	Lower dose preferred.
5.	Iodine compounds	Disinfection of eggs and broodstock	3 ml/l for 10 min.	Bath	May be toxic to unfertilized ova. Rinse thoroughly after treatment.
6.	Ethylene diamine tetra acetic acid (EDTA)	Vibriosis	5-10 ppm for 12 h Repeat if needed after 2-3 days		
7.	Oxytetra-cycline	Bacterial diseases including systemic infections (vibriosis, septicaemia)	5-10 ppm *via* feeds (1.5g antibiotic/kg feed, fed at 2-10% biomass) for 10-14 days		Use only during initial stages of disease at right dose only after ascertaining the antibiotic sensitivity *in-vitro*. Allow 35-40 days withdrawal period.

5.4.1. Criteria for selection of drug for disease control

i) Sensitivity of the pathogen to the drug /antibiotic *in-vitro* must be known
ii) The antibiotic /chemical should reach the pathogen and kill the pathogen only without adversely affecting shrimps
iii) The treatment should not aggravate the disease
iv) The antibiotic /chemical should not adversely affect the user and the natural flora and fauna
v) The drug should rapidly be broken down to avoid problems due to tissue residues
vi) The metabolites of the drug should be harmless to the animals and the consumer
vii) The drug should be stable at normal storage conditions

5.4.2. Methods of application of drugs

i) Oral route:

The chemotherapeutant may be incorporated in the feed at right dose and fed to the shrimps. Acceptability (palatability and absorption) of medicated feeds needs to be clearly understood, otherwise, the drug may diffuse into the water body and create problems. Drug therapy by this method should start preferably during the initial stages of the disease, since the shrimps in the advanced stages of disease often feed poorly.

ii) Dip treatment:

The shrimps are held in containers with strong solution of the chemotherapeutant for short durations e.g., 15-60 sec. This method may be useful when small portion of the stock is affected with non-systemic infections such as fouling, shell disease, necrosis of appendages, etc.

iii) Bath treatment:

This method is applicable only when a small portion of the stock are affected with disease. The shrimps are given bath treatment in containers for 30-60 min. in a suspension containing the drug.

iv) One-time application:

Low concentration of the chemical is applied to the culture tanks/ponds for indefinite periods. However, this method poses pollution problems. Care should be taken to apply uniform concentration of the therapeutant and to ensure thorough mixing of the pond water. Certain chemicals are known to alter the environment, e.g. formalin applied to the ponds reduces oxygen availability which has to be supplemented by aeration.

v) Injection:

This method is practicable only for small number of large and valuable stock such as brood shrimps sufferring from systemic bacterial diseases.

vi) Topical application:

This method is also applicable only for small number of valuable brood shrimps, suffering from non-systemic diseases such as shell disease. When the shrimps refuse to accept medicated

feeds through oral route, bath treatment or dip treatment or application to the rearing water may be required. After treatment, adequate time should be allowed for the drugs to withdraw from the tissues which varies with the drug and species of shrimp.

5.4.3. Disadvantages of use of drugs in aquaculture

Drugs used for disease control may release large quantities of active substances and their metabolites into the aquatic ecosystem and pollute the habitat affecting flora and fauna. Due to release of such active substances, self recovery of the aquatic habitat may become difficult and the drug or its metabolites may get accumulated in the aquatic fauna. These chemicals may even adversely affect beneficial microflora, particularly those involved in the mineral cycles. Antibiotics used in suboptimal levels, especially for prophylactic purposes may lead to emergence of antibiotic resistant mutants of the pathogens and the same antibiotic may not find use in the subsequent disease control operations. When the shrimps harbouring drugs or their metabolites are consumed, natural gut microflora of the consumers may be disturbed.

6. CONCLUSION

Disease problems arising in aquaculture can be mainly attributed to environmental deterioration, since the shrimp pathogens are basically facultatively pathogenic in nature. The metabolic waste products of shrimps and products of microbial activity on the highly nutritious shrimp feed such as ammonia, nitrite, hydrogen sulfide, etc. may accumulate in the culture ecosystem when water management becomes inadequate. Hence, stocking density of shrimps and feeding rates must always be maintained at optimum levels. A great deal of research needs to be carried out on the use of chemicals and antibiotics either for prophylactic or therapeutic purposes in aquaculture. Chemicals and antibiotics must be used with utmost restraint only with expert opinion. Hence, adequate scientific measures including careful pond preparation, water quality and pond bottom management must be adopted to prevent outbreak of diseases. Periodic disinfection of equipment used in shrimp farms and hatcheries helps a great deal in containing spread of diseases. The hatchery and farm personnel must always be vigilant on the status of health of shrimps and promptly take action to prevent outbreak of any epizootics. Successful disease-free aquaculture operation can be achieved by scientific planning and proper management of farming environment.

7. ACKNOWLEDGEMENTS

The authors thank Dr. K. Alagarswami, Director, Central Institute of Brackishwater Aquaculture, Madras, for encouragement and critical evaluation of the work and this report, Shri K. N. Krishnamurthy, Principal Scientist and Head, Crustacean Culture Division, for critically reviewing the manuscript and to Shri M. Kathirvel, and Dr. K. Gopinathan, Senior Scientists, for photographs and to all the colleagues who helped in bringing out this publication.

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