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MANUAL

ASEAN GOOD SHRIMP FARM MANAGEMENT PRACTICE

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CONTENT

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ASEAN GOOD SHRIMP FARM MANAGEMENT PRACTICE

1. INTRODUCTION

The objective of this manual is to compile information of appropriate techniques and procedures of shrimp culture from different ASEAN countries so that they can be used as guidelines for marine shrimp culture.

Black tiger shrimp, *Penaeus monodon,* are among the economically important species in ASEAN and the world. In 1995, the ASEAN Member Countries produced about 558,000 tons of *Penaeus monodon,* about 78% of the total world production of shrimp.

Since today's shrimp farming practices are based on the intensive culture system, the danger of major losses due to disease also increases. Marine shrimp farming also has an impact on the coastal environment and mangrove ecology. These problems are considered as barriers towards sustainable development of shrimp farming industry in the region.

It is hoped that this manual will partly help solve the problems encountered in shrimp farming and contribute towards better marine shrimp management and a more sustainable farming industry.

1.1 Current Status of Shrimp Farming in Some ASEAN Member Countries

(i) Negara Brunei Darussalam

The culture of tropical shrimps is of particular importance to Brunei Darussalam, which has a natural distribution of spawning ground of *Penaeus monodon*. In 1988, the Aquaculture Section of the Department of Fisheries, Ministry of Industry and Primary Resources set up a small-scale shrimp hatchery at the Muara Fisheries Station, which produces 1.26 million PL5, 0.06 million freshwater prawn fry and 0.06 million sea bass fry annually. It had very limited facilities, i.e. twelve 0.6-ton and six 0.8-ton larval tanks, two 5-ton maturation tanks, a 30 ton seawater reservoir and four 0.8-ton algal tanks. In addition, the hatchery site was situated near the Muara Port where the water was polluted due to shipping and industrial activities and also sewage and household effluents from nearby housing estates. Thus the problems of poor water quality and disease outbreaks were frequent.

In 1993, a more suitable fish and shrimp hatchery site was established along the coast of Meragang to cater for the growing needs of the country's aquaculture industry. The complex is located on four hectares of land facing the South China Sea where seawater quality is consistently good all year round. It is also accessible by land to Muara Port (5 km), the International Airport (25 km.) and the capital, Bandar Seri Begawan (30 km). It has all the available amenities such as electricity and freshwater supply, and radio and telephone communications.

(ii) Malaysia

Marine shrimp culture in Malaysia was practiced in the 1980's on a small scale basis by trapping shrimp fry into a storage pond. The culture development of the tiger prawn (*Penaeus monodon*) grew rapidly towards the end of 1970's and early 1980's with the availability of technical support from the government. The result of continuous culture development and new technological findings have increased production between 2-3.5 tons/hectare/cycle for semi-intensive culture and 5-7 tons for intensive culture.

In 1994, it was estimated that 5,790 metric tons of tiger prawn were produced through brackishwater pond culture activities throughout the country. The production involves 3,284 ponds of 2447.34 hectares and 787 prawn farmers.

(iii) The Philippines

Commercial scale hatcheries for *Penaeus monodon* shrimp in the Philippines began in 1973 with the establishment of such hatcheries in Naawan, Misamis Oriental by the Mindanao State University Institute of Research and Development (MSU-IFRD), and in 1975 by the Aquaculture Department, of the Southeast Asian Fisheries Development Center (SEAFDEC) in Iloilo. In 1984, there were 60 operational hatcheries in the country, 30% were located in Luzon, 56% in the Visayas and 5% in Mindanao. By 1985, there were 48 hatcheries in Western Visayas alone . By 1992, the country had a total of 461 hatcheries, an increase of 768 % over 1984. Of these, 134(29 %) were located in Luzon, mostly in Quezon, Pangasinan, Cavite, Zambales, Batangas and Bicol provinces. The Visayas accounted for 291 hatcheries (63 %), of which 224 were concentrated in Panay, mostly Aklan and Iloilo. Thirty-six hatcheries (8 %) were in Mindanao.

Of the 461 hatcheries, only 298 (65%) are currently operating. The majority of these are operating intermittently or at reduced capacity. It is estimated that small-scale hatcheries are operating at 70-80%, medium-scale hatcheries at 50% and large-scale ones at 30% of total capacity. Forty-five percent of large hatcheries, 30% of medium-scale and 29% of small-scale hatcheries are not operating. The main reasons for the closing down of operations were poor technical capabilities and management, and natural calamities (eruption of Mt. Pinatubo in Luzon and typhoons in the Visayas). Although water filtration and prophylaxis were employed, these hatcheries still encounter disease problems during the course of operations. At worse the disease problems were significant enough to cause abortion and discard of spawning runs 25% of the time in small hatcheries, 24 % in medium, and 33 % in large hatcheries.

(iv) Singapore

Shrimp trapping from brackishwater impoundments was introduced from China in the 1930s. At the peak of operation, there were more than 1000 hectares (ha) of these brackishwater ponds. The species trapped were *Penaeus indicus*, *P. merguiensis*, *P. semisulcatus*, *Metaenaeus ensis*, *M. burkenroadi* and *M. brevicornis*. These areas have since given way to urban and industrial development. In the 1970s, shrimp trapping from the remaining ponds was modified by holding and supplementary feeding of entrapped shrimp to market size and collecting them with a net at the sluice gate at low tide when pond water can be discharged. *P. merguiensis* fry were also purchased from hatcheries and stocked semi-intensively in some of these ponds and fed until market size before harvesting at the sluice gates at low tide. Shrimps were also cultured in cages of floating fish farms that were established during the 1970s, but this was not a significant activity. Presently, production from the few remaining ponds is negligible and shrimp trapping no longer exists.

The approximately 50 ha. of shrimp ponds which remain today are being developed as semi-intensive shrimp and fish farms. These are located on Pulau Ubin, an island to the north of Singapore, in the East Johor Strait. All the shrimp produced is consumed locally.

(v) Thailand

Research on shrimp propagation in Thailand began in 1968. Three government fishery stations were assigned to conduct research on shrimp production. These were Phuket, Songkhla and Rayong. In 1970, the experiments on spawning, larvae development stages and feeding were completed. In 1972, the Government of Thailand established a "Shrimp Culture Project" under the assistance from the Japanese Government. This project concentrated on mass production and distribution of shrimp seeds (PL 22) to Thai farmers.

At the beginning, shrimp hatcheries in Thailand adopted the Japanese system for the mass production of *Penaeus monodon* and *Penaeus merguiensis* seed. However, there were many problems faced such as differences in culture conditions and a lack of a spawner. So, the method of inducing spawning by eyestalk ablation was used, but the results were not satisfactory during the first phase.

In 1977, the small tank hatcheries (Galveston system) became known throughout the world. Since this system is completely different from the Japanese system and the existing facilities (Japanese type) had to be used, the advantages and disadvantages of these two systems were studied. New techniques of Thai shrimp hatcheries were then adopted by combining the advantages of both systems, which gave favorable results.

Since 1968-1975, Thai shrimp hatcheries were operated by the government. The seeds produced were released to the sea. Some were distributed to shrimp farmers in the Government's effort to change the culture practices from extensive culture to semi-intensive or intensive system. Larvae production techniques were transferred to shrimp farmers until 1997. In 1981, the first private shrimp hatchery was set up in Phuket which produced fries for the company concerned. But, at that time, the private shrimp hatchery was expanding too slowly because of the semi-intensive nature of shrimp farming in which using hatchery produced fry did not operate to capacity due to the lack of suitable feed and techniques. At the same time, there was a low demand for shrimp products.

After 1985, Japan, the largest shrimp importer, could no longer keep Taiwanese shrimp in cold storage over a lengthy period of time for year-round consumption due to the sudden change in cold storage operational costs caused by the economic boom. As a temperate country, Taiwan could only raise just one crop a year, which it was able to export to Japan only over a few months of the year. Therefore, Japan urged the tropical countries, like Thailand and the Philippines, to produce *P. monodon* for a continuous supply throughout the year in order to reduce the cost of storage. Japan then increased the buying price of shrimp from tropical countries to US$ 8.00 - 10.0/ kg in order to encourage the expansion of shrimp farming. This brought substantial profits to operators, and it attracted a large number of investors into this new business. In the meantime, the hatchery techniques used were successful and shrimp production from the aquaculture sector in Thailand has increased immensely since 1985.

In 1985, shrimp culture in Taiwan faced problems of lack of broodstock, diseases, water pollution, land use and high investment cost. Some Taiwanese shrimp farmers shifted their production areas to Thailand and the Philippines. There were many private hatcheries and farm cooperatives between the Thai and Taiwanese. Thai hatchery techniques were modified again by combining the advantages of Thai and Taiwanese techniques, which resulted in better production. New techniques were used such as the use of *Skeletonema* sp. instead of *Chaetoceros* sp., microencapsullated feed and drugs for controlling disease

2. SITE SELECTION

Selection for a suitable site is a critical activity and must be carefully determined before establishing of a shrimp farm. There are several factors involved :

2.1 Topography and Climatic Condition

Topographically, the best areas for shrimp culture are those with average natural ground elevations of about 1-3 meters above mean sea level or at least 1 meter above the highest high tide level to allow drainage and harvesting. The cost of pumping increases in highly elevated sites. The sites should have minimum vegetative cover, be near the sea or other natural waterways such as rivers and streams, have easy access to roads, a sparse population and be nearly square or rectangular in shape. An irrigated rice field, swamps, existing fish ponds or land outside the mangrove areas are the most likely sites having these features.

Lowland or mangrove swamps are not ideal sites because of the following reasons:

1. The lowland may be made up of potential acid sulfate soils.
2. Deeper ponds cannot be built and complete drainage is impossible.
3. Construction costs in swamp land are always higher.

Interms of climatic conditions, areas having short and not as pronounced a dry season with moderate rainfall distributed throughout the year are the best suited for shrimp farming. A pronounced long dry season may cause an increase in water temperature and salinity which will promote excessive growth of algae and result in oxygen depletion at night.

2.2 Infrastructure

2.2.1 <u>Accessibility</u>

The farm must have good accessibility either by road or water, and communication systems throughout the year in order to facilitate supervision and transport of materials and products. It is important that the farm be within 3-6 hrs. traveling time from the hatchery to avoid excessively long transportation time of the larvae and should be within 10 hrs. from the processing plant to avoid deterioration of the product.

2.2.2 Electricity

Availability of relatively cheap and reliable power source is a major consideration in site selection. In areas where electricity supply exists, it is practical and beneficial to utilize electric power to run the farm, especially for the intensive culture system. It is advisable to have a back-up electricity generator as a secondary power source.

2.3 Security

Areas free from security risks result in favorable working conditions, productivity and less extra costs.

2.4 Availability of Labor and Other Factors

The availability of labor, equipment and commercial feed and supplies ensure smooth operations and successful crop.

2.5 Water Supply

The site should have an adequate good quality water supply. The most important factors to consider are pH and salinity. The optimum range of pH is 7.5-8.5 and the optimum range of salinity is 15-18 ppt, but the shrimp can survive over a range of 5-32 ppt. Water from polluted areas containing high concentrations of suspended solids and organic wastes such as effluent water from industry, urban areas, agricultural and other farm locales should be avoided. A settling pond or a large reservoir should be used in such areas for sedimentation and treatment.

In saline areas, a source of freshwater is useful for adjusting the salinity in the ponds and for domestic use by farm staff. The freshwater should be good enough for use and adequate throughout the year.

2.6 Soil Conditions

The type of soil is the most critical in site selection, since the shrimp will spend most of their time on the pond bottom during the culture period. Usually, clay or loam-based soil containing more than 90% clay and pH between 6.5-8.5 is preferable. Sites with sandy or silty soil should be avoided due to their porous nature that may lead to erosion, seepage of water and easy infiltration of waste into the soil. Prior to construction of ponds, samples of soil should be taken randomly from 5-10 spots at the surface and at 1 meter deep and sent to a laboratory for the analysis of soil texture and pH. Such data will be useful during pond construction and preparation.

Mangrove or acid sulfate soils are not suitable for shrimp pond culture due to their high organic matter contents and acidic nature that require a high water exchange rate and low stocking density. A pond built on mangrove soil will also encounter the problems of hydrogen sulfide and ammonia accumulation in the pond bottom. It is best to leave aside the mangrove area since it provides protection from erosion and acts as a natural filter and breaking down of organic waste . In the acid sulfate soil areas, the soil will develop high acidity when dried and then flooded which will lead to difficulty in stabilizing the pH of the pond water and in inducing the growth of plankton during the culture period.

3. POND DESIGN AND CONSTRUCTION

A shrimp pond should be designed according to the characteristics of the selected site and the culture system. There is no unique design, but optimum and functional farm layout plan and design should be based on the physical and economic conditions prevailing in the locality.

3.1 Culture system

There are three types of shrimp culture being practiced in ASEAN Member Countries.

(i) Traditional/Extensive Cultures

The ponds have irregular shapes and sizes, mostly 1.5 ha and bigger with a peripheral ditch or canal of 4-10 m. wide and 40-80 cm. deep. The pond bottom may not be properly leveled, but tree stumps are usually removed, although this is not required. Ponds are normally filled with gravity flow water during the high tide period with natural seeds and left for 60-90 days, without additional fry stocking and feeding. Stocking density in this type of culture is 0.5-5.0 pcs/m^2. These ponds are normally partially harvested.

(ii) Semi-Intensive Culture

Ponds of 1-1.5 ha. in size and are constructed with dikes to hold the water 1-1.5 m. deep. Fry are stocked into the pond at 10-15 fry/m^2 and fed with commercial diets and/or fresh diets. The shrimp are harvested at 90-120 days after stocking.

(iii) Intensive Culture

The ponds are usually of 0.5-1 ha. in size and are designed to keep the water at 1.5-2.0 m. deep. A reservoir of at least 30 % of the pond area is usually required. High stocking density of 25-60 fry/m^2 with feeding rate of 4-6 times daily and strong aeration is maintained.

In some ASEAN countries, particularly in Thailand, three types of intensive culture systems are operated, depending on the quality of the water supply.

Open System.

This system requires a high supply of good quality water because it needs a water, exchange of more than 20% of the total pond volume at one time, in order to reduce pond wastes and the density of the plankton. Fry can be stocked up to 60 fry/m^2 and will grow to 25-35 grams within 120 days. The open system has recently become less favorable to farmers since the environmental conditions, especially the quality of water, tends to deteriorate with time.

Re-circulation System.

In order to avoid deterioration of the environmental conditions, several farms have adopted the re-circulation system to minimize contact with poor quality water from outside the farm. However, the farm must devote 40-50 % of the area for the construction of water storage/reservoir, sedimentation pond, treatment pond and drainage canals. To operate the system, cleaned seawater is initially pumped into the pond and kept within the system. During the culture period, the effluent from culture pond is drained into the sedimentation pond, treated with chemicals and pumped into the reservoir for re-supply to culture ponds. The stocking density for this system generally varies between 30-50 fry/m^2 and the culture period is between 110-130 days.

Minimal Water Exchange System .

The majority of the shrimp farms in ASEAN countries are of small scale. These small farms cannot support space for construction of the water treatment pond and reservoir as in the case of the re-circulation system. To reduce contact with the water from outside the farm, the minimal water exchange system or closed pond system is practised in some countries, particularly in Thailand. The system involves filling up the pond with cleaned seawater, treating it with chemicals to eradicate predators and competitors. Then the shrimps are stocked up to 30 fry/m^2 and cultured for a period of less than 100 days to attain the average weight of 10-20 grams. Since the system does not require water exchange, but maintains the water level in the pond by replacing the water loss due to evaporation and seepage with seawater or freshwater, it can be operated anywhere, even in the inland area where seawater is not easily accessible. The disadvantages of this system are that it requires low stocking density and high efficient water and waste management. However, it is suitable for production of small size shrimp because the culture period is limited.

3.2 Farm Design

(i) Water Supply System

A shrimp pond is filled with water mostly by pumping. The pumps should be installed at locations where they can obtain water from the middle of the water column with least sedimentation and pollution. The pumps and inlet canal should be large enough to allow the ponds or the reservoir to be filled within 4-6 hours. A screen should be installed at the inlet canal prior to the pumps to prevent clogging at the inlets.

(ii) Reservoir

A reservoir is important for the control of pond environment and storage of water supply when the water quality is inconsistent or the supply is intermittent. It is recommended that the area of a reservoir within a farm should be about 30% of the total farm area in order to hold a sufficient volume of the water supply. Some farms may use part of the reservoir for sedimentation purpose where biological filter feeding organisms are stocked. The reservoir must have an outlet that can allow total drainage.

(iii) Supply Canals

An intensive shrimp farm should have a water supply canal to convey the water from the reservoir to the ponds by gravity or pumping. The size of the supply canal will depend on the size of the culture pond, the efficiency of the pump and the required water exchange rate.

(iv) Ponds

A well-designed pond will facilitate the management of water exchange, harvesting of the product, waste collection and elimination, and feeding.

(v) Shape

The shapes of pond that are found to be effective for shrimp culture are rectangular, square and circular. A well-designed pond is one that would allow circulation of the water such that wastes will be accumulated at the center of the pond. Some farmers improve the water movement in the square and rectangular ponds by making the corners of the pond rounded through addition of soil.

(vi) Size

Smaller ponds are easier to manage but the construction and operation can be costly. Ponds of 0.5-1.0 ha. are commonly used in intensive culture and 1-2 ha. for semi-intensive culture.

(vii) Dikes

Earthen dikes, with or without lining, are found to be the most economical. Dikes should be designed to impound higher than 1 m. depth of water and must be high enough to prevent flooding during the rainy seasons and the highest high tide. The slope of the dike depends on the nature of the soil. A slope of not less than 1:1.5 is normally used in the sandy soil area to avoid erosion and 1:1 is used for clay soils. One must be aware that shallow slopes will encourage the growth of benthic algae which will impair the quality of the water in the pond. Some dikes in a farm may be wider than the others to provide space for the access road, storage, electricity and aerators.

(viii) Pond Lining

Lining materials are used in pond where the soil contains a high percentage of sand, and organic matter and is acidic in nature. Lining can reduce erosion, water seepage, waste accumulation in the soil and the leaching of ammonia, hydrogen sulfide, acidic compounds, iron and other potentially stressful compounds into the ponds. The lining also allows easy removal of wastes from the feeding areas, reducing the time and costs to clean the ponds between cycles. Several lining materials are currently available, including the compact laterite, compact clay, bitumen impregnated polypropylene textiles (geotextiles), polyvinylchloride (PVC), polyethylene (PE) and high density polyethylene (HDPE). Farmers may line the pond totally or partially, depending on economic/financial consideration. Another factor will be the rate of waste accumulation in an area on the pond bottom. The economic life of liners varies according to the maintenance and the duration of exposure to sunlight. The following Table 1 shows the economic life of some liners.

Table 1 Economic Life of Some Liners.

Liner type	Thickness (mm.)	Economic life (years)
Compact Laterite	^200	3
PVC, Plastic Sheet	0.2-1.0	<5
Geotextile	0.57	>5

Among the liners, laterite soil is less expensive and commonly used in shrimp farms. However, laterite soil liner may allow the penetration of wastes and requires effective cleaning up. Pond liners with PVC plastic sheeting and geotextiles can reduce the cost for aeration and cleaning up due to the easy movement of wastes and uneaten food on the smooth surface. The disadvantages of PVC plastic and geotextile-lined ponds are difficulties in maintaining plankton bloom within the first month of culture, problem of tears and the floating of the liner if the water and gas accumulate underneath them.

(ix) Gates for Inlet and Outlet

Each shrimp pond should have at least one gate for filling and draining water. However, a typical pond of 0.5-1 ha. usually consists of two gates having similar structure for the inlet and outlet gates. The size of the gate is dependent on the size of the pond, but must allow the pond to be filled or drained within 4-6 hours. Gates of 0.5-1.0 m. wide are usually constructed, since gates wider than 1 m. will cause difficulty in screening and will allow strong currents which will cause erosion of the soil. The position of the outlet should be at the lowest point of the pond with a gradual slope of 1:200 from the inlet to allow total drainage of the pond during harvesting.

The conventional gates constructed at the side of the pond should have a double screen, with fine a mesh for the initial period of culture and a coarser one for a later period. Some farmers may place both meshes in a single frame and cut out the finer mesh when the size of the shrimps are larger than the opening of the coarser mesh.

(x) <u>Central Drain</u>

This has been employed in some farms and consists of perforated pipes laid horizontally at the center of the pond and connected to a pipe leading to the outlet. A screen of small mesh size is used to cover the drain for the first 50 days of culture and is removed to allow for easy removal of water when the shrimps are larger than the diameter of the pipe.

This method has the advantages in that it can remove the waste and clean the pond bottom any time throughout the culture period.

(xi) <u>Drainage Canal and Sedimentation Pond</u>

The drainage canal of a shrimp pond should be at least 50 cm. lower than the lowest point of the pond to allow drainage by gravity. The effluent will be drained into a sedimentation pond to settle the particulate wastes before water is pumped into the reservoir or released out of the farm. It is recommended that the sedimentation pond should be approximately 5-10% of the culture area and should be deep enough to prevent mixing and re-suspension of the wastes. Baffles or soft walls made of fine mesh net or plastic sheeting supported by stakes driven into the pond bottom, may be constructed in the sedimentation pond to decrease the velocity of water and increase the retention time which will enhance the settlement of the wastes. The wastes in the sedimentation pond should be removed periodically and discharged into the waste dumping area.

(xii) <u>Waste Dumping Area</u>

A shrimp farm should provide 5-10% of the area for dumping of the wastes. Wastes from the pond must be collected carefully and dumped into this area without discharging to nearby areas, which will contaminate the natural resources.

(xiii) <u>Buildings</u>

Accommodation, storage, shop and guard houses may be built in the farm as required. It is advised that accommodation for workers should be set up at various points around the farm for security purposes and to allow the ponds to be adequately monitored.

4. POND PREPARATION

Before a pond can be stocked for a new crop, the excessive wastes which accumulate in the pond during the previous crop must be removed and the soil and water conditioned. Growing of shrimp in an improperly prepared pond may lead to difficulty in pond management during the culture period which could result in a decrease in production capacity of the pond.

4.1 Pond Cleaning

The cleaning of a pond or removal of the wastes, especially the organic and phosphatic wastes, that have accumulated in the pond bottom, could be, accomplished by drying, liming and ploughing. However, these methods could still leave an adverse effect on the water and soil quality in the pond which could result in a decrease in the production capacity of the pond.

There are two methods for cleaning a pond according to the possibility of the pond to be dried:

(i) Dry Method

This method is used when the pond bottom can be dried completely. The pond is drained and left to dry in the sun for a period of 10-30 days. Then the waste is removed, either manually or mechanically, and transported to the waste dumping area. Removal of waste by machines has an advantage that it can compact the bottom soil. However, this cleaning method by drying may lead to development of acidity, lowering the level of the pond bottom and the diffusion of wastes if the workers are inexperienced.

(ii) Wet Method

In areas where the pond cannot be dried completely, pressure washing can be used to flush out the wastes. This method takes a shorter time and is more efficient than the dry method. Flushing should be continued until the acid and dark anaerobic layer in the soil are removed. This method is suitable in the acid sulfate areas where the oxidation of the soil must be avoided. However, the method requires a sedimentation pond to all settlement of the suspended wastes to avoid contaminating the drainage canal and the natural environment. The remaining pathogens in the ponds can be eliminated during the liming process.

4.2 Liming

Once the pond is cleaned, it is then filled with water and left overnight before flushing out to remove debris and elevate the pH. This process should be repeated until the pH of the water remains above 7, and only then the lime is applied. The types of lime to be used depends on the water pH. It is recommended that agricultural lime ($CaCO_3$) or dolomite [$CaMg(CO_3)_2$] should be used in a pond with water pH near neutral and the hydrated lime [$Ca(OH)_2$] should be used in a pond with water pH below 5. The amount of lime to be used should be carefully calculated to avoid inducing an excessively high water pH which may increase ammonia toxicity and result in the mortality of the shrimps.

The lime requirement of a pond depends on the soil pH. The measurement of the soil pH should be determined either by the wet soil method or by the dry soil method. The recommended amount of lime that should be applied to a pond is shown in Table 2.

During the application, lime should be spread throughout the pond bottom and up to the top of the dike. A large portion of lime should be applied over the feeding areas and to all parts of the pond that have remained wet.

Table 2 . Recommended Lime Application Rate in Pond.

Soil pH	Agriculture Lime (MT/ha)	Hydrated Lime (MT/ha)
0.5-1.0	>6	1-2
5-6	2-3	1.0-1.5
<5	3-5	1.5-2.5

When the pond is properly limed and filled with water, the average water pH should be between 7.5-8.5 with daily fluctuation of less than 0.5. Agricultural lime, dolomite or hydrated lime at 100 kg./ha./day should be added to maintain the required pH.

4.3 Eradication of Predators and Competitors

After liming, the pond should be filled to the maximum depth through a screen with fine mesh (24 per square inch) to prevent the predators and competitors from entering the pond. These animals, including fish, crustaceans and some invertebrates, may compete for food, prey on the shrimp or carry diseases and parasites. They may establish themselves in the pond that is not effectively screened effectively or is left for a long period of time.

Some chemicals should be used to eradicate these animals in the pond before stocking. Fish can be killed by the application of tea seed powder at the rate of 20-30 ppm. After the application of tea seed, the pond should be left for 3 days before the post larvae can be stocked. Tea seed may also be used when the shrimp has reached a weight of more than 2 grams. However, it must be remembered that tea seed is more toxic at high salinity and temperature, but less toxic at high pH. Application of tea seed in the evening may reduce pH and result in plankton die-off.

Snails can be eliminated by the application of quick lime (CaO) at 530 kg./ha. and sun dried for 2-3 days. Then the pond should be thoroughly cleaned, filled with water and the other pests eradicated.

Hypochlorite, either calcium or sodium salt, is currently used at 15-20 % (60 % active ingredient) to eliminate both vertebrates and invertebrates. The pond must be cleaned prior to the application of hypochlorite since hypochlorite may react with the organic matters and produces the toxic organochlorine compounds. Hypochlorite should be applied after the pond is filled to the maximum height and left for 3 days to allow the hatching of planktonic organisms.

It should be remembered that hypochlorite should be used prior to the liming since the effectiveness of hypochlorite will be lowered in high pH conditions.

After the hypochlorite application, the pond should be aerated and the application of lime and fertilizer should be conducted on Day 3 , while the seed can be stocked on Day 7. During the first month, water must not be added to the pond, unless the water quality is poor, to prevent the introduction of competitors and predators.

4.4 Fertilization

The pond must be fertilized with either organic or inorganic fertilizer to stimulate the plankton bloom in order to provide shade to the pond bottom and utilize the nitrogenous and phosphate wastes within the pond. The shade will also prevent the growth of harmful benthic algae. The sun dried chicken manure is the most common organic fertilizer to be used in the amount of 200-300 kg./ha. The manure must be soaked in water for 24 hours before it is spread over the surface of the water.

Inorganic fertilizers, such as urea (46%N) and compound fertilizers like, ammonium phosphate (16:20:0) or those with N:P:K combination of (16:16:16) can be used at 20-30 kg./ha. The fertilizer must be dissolved in water before it is spread over the water surface to avoid precipitation of the fertilizer onto the pond bottom which will enrich the soil and accelerate the growth of benthic algae.

After fertilization, the plankton should bloom within a few days and the color of the water becomes slightly green. The fertilizer, either the organic or inorganic, should be applied daily in the pond at 5-10 % of the initial amount to maintain the plankton bloom. If the plankton has not bloomed within a few days, additional fertilizer must not be applied, but plankton rich water or green water from the reservoir should be added.

4.5 Aeration

A 0.5-1.0 ha. pond would require, four aerators installed at the corners of the pond, approximately 3-5 m. from the bottom of the dike and positioned at an angle that will encourage the maximum water flow within the pond. The type of aerator to be used depends on the depth of the water. One horse-power paddle wheel aerators should be used in ponds of less than 1.2 m. water depth and the 2 horse-power paddle wheel aerators should be used in ponds deeper than 1.2 m.; while the “Venturi/Aire-O_2” should be employed in a pond deeper than 1.5 m. The most popular type of aerator is the long arm paddle wheel aerator which is driven by a 2-10 horsepower electric or diesel motor mounted on the dike. The aerators should be switched-on 24 hours before the fry are stocked to allow enough time to create the current and clean up the feeding area.

5. STOCKING

5.1 Fry selection

Selection of good quality fry for stocking into a pond is the first important step of the shrimp grow-out management. The farmer must ensure that he or she gets healthy fry by purchasing them from reliable hatchery or hatcheries. It may not always be possible to obtain the desired shrimp fry due to limitations in availability and quantity.

The following parameters should be taken into consideration in purchasing shrimp fry for stocking.

(i) Size

Fry of PL15-20, indicated by the appearance of 4-6 spines on the rostrum, are recommended for stocking in a pond. The healthy fry should have the muscle-to-gut ratio in the sixth abdominal segment of about 4:1 or the thickness of the gut should be about the thickness of the muscle. Practically, fry from the first and second spawning of a broodstock with uniform size can be used.

(ii) Morphology

The fry should have normal appearance of trunk, appendages and rostrum. The abdominal muscle must be clear, no discoloration or erosion on any parts of the body, the gut should be full of food, and the muscle should fill the carapace.

(iii) Color

Fry with the presence of pigment cells in the uropods should be used since this indicates the stage of development. Fry that will have high survival and growth rates will be light gray, brown to dark brown and black in colour. Signs of red or pink coloration are normally related to stress.

(iv) Behavior

Healthy fry swim straight, respond rapidly to external stimuli such as a tap on the side of the basin, actively swim against the current when the water is stirred, and cling to the sides rather than aggregate or be swept down into the center of the container when the current has subsided.

(v) External Fouling

Fry should be free from external parasites, bacteria and other fouling organisms. The presence of these organisms indicates unhealthy conditions which will affect growth and survival of the fry. It is recommended that before purchasing, the farmer should visit the hatchery to check the fry once or twice either in the early morning or late afternoon, especially one day prior to stocking.

However, healthy fry with some fouling may be used when the animals are in good condition after treatment.

(vi) Pathogen Free

Fry should be checked for the presence of viral occlusion bodies. Fry with large numbers of occlusions indicate stress conditions and will not so vigorous in the pond.

5.2 Stocking Density

When a farm is ready for operation, the optimum stocking density of fry in a pond should be determined in accordance with the production capacity of the farm and the culture system, which include the soil and water quality, food availability, seasonal variations, target production, and farmer's experience. It is recommended that farmers should start a new crop with a low stocking density to access the production capacity of the pond. If production is successful, then the stocking density could be increased for subsequent crops. Overstocking should be avoided since it may result in management problems and loss of entire production.

The stocking density between 10-20 fry/m.^{2} is usually practiced in a semi-intensive culture. In an intensive culture, a well-managed pond with consistent good water quality can stock up to 25-30 fry/m.^{2} at 1.2 m water depth and up to 40-50 fry/m.^{2} at 1.5 m water depth or deeper. However, it must be emphasized that intensive cultures involve high densities and can only be sustained in well-managed farms under an experienced farmer.

5.3 Technique of Stocking

Proper stocking techniques will prevent unnecessary mortality of fry. The following methods have shown excellent results.

(i) Transportation

Fry are normally transported in plastic bags. The bags are usually filled up to 1/3 with water, oxygenated and then placed inside styrofoam boxes. If the transportation is longer than 6 hours, small bags of ice should be added into the boxes to reduce the water temperature and maintain it at 20-22 ^{o}C. The densities of fry in a bag are 1,000-2,000 fry/Litre for PL15 and 500-1,000 fry/Litre for PL20. The ideal time for transportation is in the early morning or evening to avoid excessively high temperatures during the day, unless a covered vehicle is used.

(ii) Acclimation

To eliminate stress, the fry should be maintained in water of constant salinity for at least 1 week prior to transfer. The adjustment of salinity by about 3 ppt. daily is advisable. Acclimation of fry to the water pH and temperature of the pond must be rendered upon arrival. Two common techniques are used for gradual acclimation of fry to the water conditions in the pond. The first method is accomplished by placing the fry and water from the transported bag into a tank at the side of a pond containing an equal volume of well-aerated pond water. The fry will be kept for 0.5-1 hour before being siphoned into the pond. The second method, the most favorable one, is to float the plastic bag in the pond until it has reached an equilibrium. The bags are opened one by one and pond water is added gradually to an equal volume. After a further 30 minutes of acclimatization, the fry are released directly into the pond by distributing them throughout the area of the pond or into a nursing system. The actual numbers of fry at stocking can be estimated by counting the fry individually in 3-5 bags with a spoon or small net to attain the average number in each bag and multiplied by the total number of bags.

(iii) Nursing of Shrimp Post Larvae

To ensure high survival and adequate feeding of fry during the first 2-3 weeks, some farms may stock the fry in a separate nursing pond or a small impoundment, usually 5-10 % of the total pond area, within the culture pond. The nursing system will help in concentrating the fry in a limited area until they reach PL30-40 and in more accurate monitoring for survival and feeding of the fry. However, it appears that the separate nursing pond system may lead to some unfavorable results in that the size of the fry varies widely, ('broken sizes'), and the fry difficult to harvest and would experience stress during harvest and transport to the culture pond. As a result, a farmer prefers to nurse the fry in an impoundment installed inside the pond, rather than in a separate pond. Recently, some farmers employ a system in which high densities of fry (100-200 fry/$m.^2$) are stocked into a pond for 1-2 months, then approximately half of the juveniles are transferred to another pond by large lift nets. The same acclimation process should be performed during fry and juvenile stocking.

In a very intensive pond (>30 fry/$m.^2$) where the nursing impoundment is not available, a survival pen may be installed to estimate the survival of the fry during the first 2 weeks after stocking to allow accurate feeding management. The survival pen may be a small net pen or hapa of approximately 1 m^2 containing 100 fry or a large net pen of usually 10 m^2 at 100 fry/m^2 stocking density. In the small pen, the fry can be counted accurately while the fry in the large pen may be counted by using a 1 m^2. lift net placed with 10% of the feed. In this method, fry should appear in the lift net at 3-4 days after stocking and the number of shrimp in the net should be counted at 2 hours after feeding once daily. The survival number of shrimp can then be estimated.

If the survival rate during the nursing period is less than 50%, the problems that cause this initial mortality must be identified and rectified and the addition of more fry should be considered. Fry can be added up to 30 days post-stocking without causing a variation in size at harvest. If the survival is less than 30%, the pond should be drained and prepared for a new crop.

Some farmers release fry directly into the pond. In this direct stocking method, the survival number of fry during the first 2 weeks post stocking may not be accurately estimated, since the shrimp will not approach the feeding trays during this period.

6. FEED AND FEEDING

Cost of feed constitute a major part of the production cost and accounts for 50% to 70% of the total variable cost. The use of feeds will improve shrimp production and increase profits. The availability of nutrients from feeds depends on the type and quality of the raw material used, the formulation, the feed processing, feed storage conditions and the feeding management. Therefore, feed and feeding practices for semi-intensive or intensive shrimp farming require a basic understanding of nutrition and feed requirements.

6.1 Nutrient Requirements

Approximately 40 essential nutrients are required by shrimp. These nutrients are provided in various amounts by natural food and supplemental feeds. Although the nutrition principles are similar for all animals, the quality and quantity of nutrient requirements vary from species to species. The recommended levels of nutrients and dietary components for black tiger shrimp are listed in Table 3.

Table 3. Recommended Nutrient Levels for Shrimp Feed (% as fed basis)

Shrimp size (g)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Moisture (%)	Calcium (%)	Phosphorus (%)
0.0-0.5	45	7.5	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5
0.5-3.0	40	6.7	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5
3.0-15.0	38	6.3	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5
15.0-40.0	36	6.0	Max.4	Max.15	Max.12	Max.2.3	Min. 1.5

Source : Lin, 1994.

(i) Protein

Shrimp consume dietary protein to obtain a continuous supply of amino acids for normal growth. About 20 major amino acids make up most of the proteins and 10 are essential including methionine, arginine, threonine, tryptophan, histidine, isoleucine, leucine, lysine, valine and phenylalanine. Thus, essential amino acids must be provided in adequate quantities and qualities (well-balanced) in the diet. On the other hand, the recommended dietary protein levels for shrimp vary from 30 % to 55 % depending on the shrimp size and species. It is believed that postlarval shrimp require a higher protein level than larger shrimp.

(ii) Lipid

The lipid requirement of shrimp depends on their essential fatty acids and phospholipid content. There are four fatty acids which are considered essential for shrimp, namely linoleic (18:2n6), linolenic (18:3n3), eicosapentaenoic (20:5n3) and decosahexaenoic (22:6n3). In general, plant oils are high in 18.2n6 and 18.3n3, while the marine animal oils are high in 20:5n3 and 22:6n3. The phospholipid requirement is 2 % ; however if lecithin is used this level can be reduced to 1 %. The requirement for cholesterol ranges from 0.25 % to 0.4 %. In addition, the recommended lipid level ranges from 6.0 % to 7.5 % and the level should not exceed 10 %.

(iii) Carbohydrates

The utilization and metabolism of carbohydrates by shrimp are limited. Their type and level in the diet have been shown to affect shrimp growth. Starch as the carbohydrate source is utilized better than dextrin or glucose for *Penaeus monodon.*

(iv) Vitamins

Little is known about vitamin requirements in shrimp. In intensive farming, vitamins must be supplied in the diet for normal growth. Commercial shrimp feeds are usually over-fortified with vitamins to overcome shortfalls due to processing loss and feed storage. The minimum requirement for vitamin C, which is easily lost, is about 50-150 ppm for *Penaeus monodon.*

(v) Minerals

Shrimp can absorb or excrete minerals directly from the aquatic environment via gills and body surfaces. The dietary requirement for minerals is largely dependent on the mineral concentration of the environment in which the shrimp are being cultured. Among the other minerals, phosphorus is the most important, and is recommended at 0.9 % as available phosphorus in the diet. Calcium is not considered to be a dietary essential. However, its level in feed needs to be monitored because it is important to maintain calcium to phosphorus ratio of 1:1 to 1:1.5. Calcium should not exceed 2.3 % in the diet.

6.2 Feed Quality

The use of good quality feed will improve shrimp production and profits, and minimize the environmental pollution from shrimp farming. The practical indicators of good quality feed are:

(i) Ideal Feed Conversion Ratio (FCR)

An ideal FCR always results in model growth rate, healthy shrimp and clean pond bottom conditions. Only the superior quality of feed can achieve an FCR of 1.2. According to recent data, an FCR as low as 1.2 has been achieved, but many farmers are still obtaining FCRs of higher than 2.2. Therefore, besides the feeding management, the FCR is also closely related to the quality of feed.

(ii) Ideal Attractant Ability & Pleasant Odor

The model quality shrimp feed must be highly palatable.

(iii) Good Water Stability

Since shrimp are a slow feeder animal, the water stability of suitable feed should be over 2 hours for *Penaeus monodon.*

(iv) Packaging and Optimal Conditions Storage

Feed quality will rapidly deteriorate if feed is not packed well and properly stored. Feed should be stored in a dry, cool and well-ventilated place to maintain consistent moisture and temperature. Feed should not be stored in direct sunlight and should not be kept longer than 3 months from the time of processing. The spoiled or old feed should not be used.

6.3 Feeding Management

A high FCR or high amount of feed required to produce unit weight gain indicates overfeeding, and consequently, a poor FCR is usually associated with poor growth rate, low weight gain, stressed shrimp, mediocre water quality and adverse pond bottom conditions. Therefore, the proper amount of feed is the most critical factor of feeding management. The guidelines for feeding adjustment to be made according to the mean body weight of the shrimp are shown in Table 4. Since many factors are involved in shrimp feed consumption, careful and frequent observation of shrimp is the most reliable approach for determining the optimal feeding amount.

There are many major key factors for successful intensive shrimp culture. Use of good quality feed with better feeding management by low feed conversion ratios and improved farm management are the important goals to farmers, not only for gaining greater profit, but also for minimizing the pollution of shrimp farming area.

Table 4. Recommended Feeding Rate for Shrimp Based on Body Weight

Shrimp Live Body Weight (gram)	Recommended Feeding Rate (% body weight/day)
2 – 3	8.0 - 7.0
3 – 5	7.0 - 5.5
5 – 10	5.5 - 4.5
10 – 15	4.5 - 3.8
15 – 20	3.8 - 3.2
20 – 25	3.2 - 2.9
25 – 30	2.9 - 2.5
30 – 35	2.5 - 2.3
35 – 40	2.3 - 2.1

Source : Lin, 1991.

7. WATER QUALITY MANAGEMENT

Water conditions in the rearing pond deteriorate through the production cycle due to uneaten food, animal's excretion, etc. Generally, shrimp farmers use dissolved oxygen (DO), pH, ammonia, water color and water odor as indicators to judge the water quality of the pond.

These parameters are observed regularly by using either scientific equipment or the farmer's experience in order to control them within the optimum range (Table. 5).

Table 5. Optimum Water Quality Conditions for Cultured Shrimp (*Penaeus monodon* Fabricius) Pond

Parameter	Value
DO	>4 (mg./L)
pH	7.5 - 8.5
Ammonia	<0.1 (mg./L)
Transparency	30 - 45 (cm.)

7.1 Dissolved Oxygen

The amount of oxygen dissolved in the pond water is vital to the shrimp's health. However, in the rearing pond, dissolved oxygen is mainly consumed by pond sediment (50-70 %) and plankton (20-45 %). Only a small portion of dissolved oxygen is consumed by the shrimp (5%).

The level of dissolved oxygen can be controlled in 3 ways. Firstly, by increasing the water surface area by means of placing paddle wheels in the right position. This is not only causes proper water circulation, but also adds oxygen to the pond water. Secondly, by controlling plankton density to an optimum level and thirdly, by minimizing excess organic substances, such as uneaten food.

7.2 pH Adjustment

Shrimp farmers control water pH within the optimum range of 7.5-8.5, and limit diurnal pH fluctuation to less than 0.5 by applying lime. The application of lime is as follows:

1) At the beginning of a crop cycle, when water pH ranges between 7.5-7.8 about 4.8-8.0 kg./ha. of dolomite should be used every 2-3 days.

2) When pH is in the range of 7.5-7.8 and there is less than 0.5 unit difference between the pH in the morning and the pH in the afternoon, 4.8-8.0 kg./ha. of dolomite should be used every 2-3 days.

3) If the pH in the morning is less than 7.5, 4.8 kg./ha. dolomite should be used every day until the morning pH is increased to above 7.5.
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4) If the pH in the morning is higher than 8.0 and the pH in the afternoon is higher than 9.0, 4.8-8.0 kg./ha. of dolomite should be used every day until the day's pH difference is less than 0.5.

5) In the second half of a crop cycle, 8.0 kg./ha. of dolomite should be used every day or at least every 2 days, depending on water color.

6) Every time before exchanging water, 4.8-8.0 kg./ha. of dolomite should be used.

7.3 Water Color Control and Adjustment

The color of pond water mainly results from suspended particles of phytoplankton. Plankton density and species are two management aspects that require attention of shrimp farmers.

In the first 2 months of shrimp culture, an additional fertilizer either organic (10-30 kg./ha.) or inorganic (1-3 kg./ha.) is added to the pond in order to ensure that there are enough nutrients for plankton bloom. After this period, nutrients derived from uneaten food normally are at adequate levels. Too many nutrients in some cases may lead to excessive plankton bloom, followed by plankton crash. In an open shrimp culture system the farmers exchange pond water with natural clean seawater to reduce excess plankton density. But in a closed system, where exchanging water is not needed, shrimp farmers use algaecides such as calcium hypochloride or benzalkonium chloride (BKC) 0.1-1 ppm to reduce plankton density.

In cases where undesirable water color appears like the 'redtide' caused by certain types of plankton such as dinoflagellates, the plankton can be controlled by switching-off the aerators for a period of time and applying BKC (0.1-1 ppm).

7.4 Water Exchange

Mass shrimp mortality in a pond associated with deteriorating environmental conditions has occurred frequently during the last 5 years. Shrimp farmers have tried to solve this problem by changing the culture system to a low water exchange system, including partial water re-circulation, full water re-circulation and a closed system.

Partial water re-circulation shrimp farming system is practiced where a supply of good quality water may only be available for short periods of time. Normally, the farm area is divided into 4 portions: culture area (60-70 %), effluent settlement (10 %), mixing reservoir (5-10%) and inlet reservoir (15-20%).

In the full water re-circulation shrimp farming system, where seawater can be treated and re-circulated, the farm area is divided into the culture area (40-50 %), inlet water treatment (15 %), seawater storage reservoir (20-25 %) and effluent settlement pond (15-20 %).

In the close shrimp culture system or zero-water discharge system, no pond water exchange is needed. However, the aeration in the pond must be adequate for shrimp respiration and oxidation of organic waste. Additional seawater may be required to make up for losses in the system. The technique provides disease-free seawater with no effluent being discharged. Shrimp may grow slowly and furnish lower production than those of an open or water circulation system.

8. WATER DRAINAGE AND TREATMENT

8.1 Water Quality, Effluent Criteria and Regulations

In an intensive shrimp farming system, a large uneaten portion of feed tends to accumulate at the bottom of the pond. If this is discharged into the natural water body it may cause a negative impact on the environmental, such as eutrophication. Sludge accumulation in the pond bottom also causes severe problems if it is discharged directly into a public canal. In some areas, problems also occur from the discharge of saltwater into freshwater resources. In view of this, some ASEAN Member Countries have established regulations governing shrimp farm operations. These rules and regulations may include:

(i) Prohibition of shrimp farming in mangrove areas.

(ii) Shrimp farmers must be registered with a government agency in charge of aquaculture development such as the Department of Fisheries.

(iii) Water released from the shrimp pond area must be of a specified quality. For example, it must not contain a BOD of above a specified maximum limit such as < 10 mg/litre .

(iv) Shrimp farms over a certain hectarage ($\geq$ 8 ha) must be equipped with a waste water treatment pond or sedimentation pond of not less than a certain portion (10%) of the total pond area.

(v) Sediment from a shrimp farm must not be released into public areas.

(vi) Salt water must not be drained into public freshwater resources or other farming areas.

8.2 Technology for Effluent Treatment

Shrimp farm effluents contain 2 major by-products, namely nutrient -loads and suspended solids that contribute to the degradation of a natural water body and coastal environment. Shrimp farmers normally use physical, chemical and biological techniques to improve the quality of the discharged water. Suspended solids, which usually contain high level of organic carbon, are removed by passing an effluent through the settling pond/canal.

Chlorine, either in powder or aqurous form, is used as a disinfectant to treat discharge water from a shrimp pond in order to minimize the risk of disease outbreak. The concentration used for this purpose is 25-30 ppm.. About 98% of chlorine usually used in shrimp ponds are hypochlorite compounds such as NaOCl, $Ca(OCl)_2$, etc.

Biological treatment, including integrated shrimp farming where shrimp are cultured with seaweed, mollusks, fish, artemia and sea cucumber, have been studied and practiced in Thailand. Seaweeds are used as a primary producer that can biologically remove soluble nutrients, such as nitrogen and phosphorus. *Gracilaria* spp., is the most suitable seaweed to integrate with shrimp culture due to its ability to thrive in a wide range of pond conditions. Mollusks, such as oysters, mussels, scallops, cockles and clams, have already been used in commercial scale shrimp farms to remove algae and other suspended solids from the water. Three herbivorous fish species, namely milkfish (*Chanos chanos*), mullet (*Mugil* spp.) and tilapia (*Oreocromis* spp.) have been stocked in shrimp ponds and/or reservoirs to reduce plankton density.

9. DISEASE, PREVENTION AND TREATMENT

Treatment cannot be carried out effectively when shrimp diseases occur in a pond. The best way to get rid of diseases is by practising good farm management or prevention. In this regard, information on various kinds of diseases and their prevention procedures are useful.

9.1 Parasitic Infestation

(i) Fusarium Disease, Black Gill Disease

Etiological agent : *Fusarium* spp.

Clinical signs:

Brownish to blackish discoloration on the gills of juvenile shrimp.

Diagnosis Procedures :

Microscopic examination ofwet mount of the gills of the shrimp shows the fungus showing the conidial spores. Histological examination demonstrates the characteristic lesions with hyphae and diagnostic condinia.

Treatment :

No treatment is available for fungal infestation without harming the shrimp.

Prevention and Control:

No information on prevention and control. However, good management of the pond bottom and prevention of the entry of wild crustaceans into the pond , which may carry pathogen, can be effective control practices.

` (ii) Surface Fouling Diseases

Etiological Agent:

Many species of bacteria, algae and protozoa such as filamentous bacteria, *Leucouthrix* sp., *Flavobacterium* sp. and *Zoothamnium* sp.

Clinical Signs:

Infected shrimps show black/ brown gills or appendage discoloration or fuzzy/cottony appearance due to a heavy colony of the organisms. In some cases, the severely affected shrimp die during the molting period.

Diagnosis Procedure:

Wet mount preparations of biopsied gills, manidibular palp and appendage examination by bright field, phase contrast microscopy or routine H&E stained paraffin sections.

Treatment:

Chlorine and formalin are often used to treat those commensal organisms if shrimp display heavy infection. Changing water is the most preferable management which stimulates molting of the shrimp in order to reduce the infestation.

Prevention and Control :

Prevention and control of the occurrence of surface fouling are usually done through maintenance of good sanitary conditions at the pond bottom and the overall pond area. Organic matters and suspended solids in the pond should be reduced to prevent the attachment of those fouling organisms. This is achieved by changing the water or applying lime.

9.2. Bacterial Infection

(i) Luminous Vibriosis

Etological Agent : *Vibrio harveyi, Vibrio vulnificus*

Clinical Signs:

High mortality rate in young juvenile shrimp (one month syndrome). Moribund shrimp hypoxic often come to the pond surface and edges of pond. Vertical swimming behavior immediately before onset of acute mortality. Presence of luminescent shrimp in ponds

Diagnostic Procedure:

- Presumptive Diagnosis
  Observation of occurance of typical clinical signs- (Presence of large number of rod-shaped bacteria in the hemolymph (wet mounts).

- Histological Diagnosis
  Observation of occurances of multifocal melanized and/or non-melanized hemocytic nodules with septic centers are the

principal diagnositic feature of systemic vibriosis. These lesions are most common in the lymphoid organ, heart gills and hepatopancrease (proximal tubules).

- Isolation, identification and antibiotic sensitivity of the organism.

Treatment:

Disinfection of intake water (i.e. Formalin 100-200 ppm) Anti-microbial preparation application through feeds

- Oxolinic acid 0.6 ppm.
- Sarafloxacin 5mg./kg. of feeds for 5 days

Prevention and Control:

Proper pond and water management. Utilization of reservoir for intake water.

(ii) Vibriosis

Etological Agent :

Vibrio vulnificus, V. parahemolyticus,V. alginolyticus, Vibrio sp.

Clinical Signs:

High mortality rates, particularly in young juvenile shrimp. Moribund shrimp with corkscrew swimming behavior appear at edge of pond. Reddish discoloration of juvenile shrimp

External Fouling:

Black spots, chronic soft shelling

Diagnostic Procedure:

- Presumptive diagnosis

Observation of occurances of typical gross clinical signs. Presence of large number of rod-shaped bacteria in the hemolymph (wet mounts)

- Histological Examination :

Observation of occurances of different disease manifestation as follows:

a) Localized vibriosis (wounds, shell disease) well circumscribed by hemocytes forming capsules or plugs and melanized. Bacteria visible within and/or adjacent to such lesions.

b) Systemic vibriosis multifocal melanized and/or non-melanized hemocytic nodules with septic centers seen in lymphoid organ, heart, gills, hemocoel and connective tissues.

c) Septic Hepatopancreatitis Syndrome (SHPS) generalized atrophy of the hepatopancreas with generalized to multifocal necrosis and hemocytic inflammation of the HP, the proximal tubules. Isolation, identification and antibiotic sensitivity of the organism.

Treatment:

Disinfection of intake water i.e.formalin100-200 ppm.
Anti-microbial preparation application through feeds

- Oxolinic acid 0.6 ppm.
- Sarafloxacin 5 mg./kg. of feed days

Prevention and Control :

Proper pond and water management and utilization of reservoir for intake water.

9.3 Virus infection

(i) Monodon Baculovirus Disease

Etiological Agent

MBV-type or PmSNPV is a type A occluded baculovirus, 75+4 by 324+33 mm. in diameter and length. It contains ds DNA.

Clinical Signs:

Normally, a low mortality rate or insignificant losses are achieved from the grow-out pond. However, the severity may be increased if shrimp are reared in high density culture.

Diagnosis Procedure :

The demonstration of single or multiple MBV occlusion bodies in squash preparations of biopsied hepatopancreas, midgut and feces stained with 0.05 % aqueous malachite green. In routine histology, the MBV infection is demonstrated by the presence of prominent, single or multiple, eosinophilic speherical occlusion bodies within the hypertrophied nuclei of hepatopancreatic tubule and midgut epithelial cells stained with H&E stains.

Treatment:

No treatment available for BMV infection

Prevention and Control :

There is little information on prevention and control of the MBV infection in shrimp pond culture. The prevention method for the MBV infection is possibly through avoidance by screening the Pls before stocking shrimp in the pond.

(ii) Hepatopancreatic Parvo-like Virus (HPV) Disease

Etiological Agent:

HPV is caused by a small parvo-like virus, 22-24 nm in diameter.

Clinical Signs:

No specific gross signs for HPV infection are reported, but severe infections may include a whitish and atrophied hepatopancrease, poor growth rate, anorexia and reduced preening activity. Losses may be occur due to the increased occurance of surface and gill fouling organisms and secondary infections by the opportunistic *Vibrio* spp.

Diagnosis Procedure:

Diagnosis of HPV is based on the histological demonstration or the Giemso-stained HP impression smear of prominent basophilic intranuclear inclusion bodies mostly within the distal portions of hepatopancreatic tubules in E- or F-type epithelial cells.

Treatment:

No treatment available for HPV infection.

Prevention and Control:

No information is available on the prevention and control procedures for HPV infection. However, screening the Pls before stocking shrimp by routine histology or the Giemsa-impression smear method is recommended.

(iii) Yellow-head Disease (YHD)

Etiological Agent:

Yellow-headed virus (YHV) is a ssRNA, rod shaped, enveloped virus 40-50 nm by 150-200 nm with two rounded ends.

Clinical Signs:

The affected shrimp shows a marked reduction in food consumption. Following this, a few moribund shrimp will appear swimming slowly near the surface of the pond dike and remain motionless. The animals have pale bodies, a swollen cephalothorax with a light yellow to yellowish hepatopancreas and gills. A high mortality rate may reach 100% of affected populations within 3-5 days from the onset of disease.

Diagnosis Procedure:

Diagnosis procedure is based on histological demonstration of massive necrosis in the tissue originating from octoderm and mesoderm and/or observation of prominent nuclear pyknosis and karyuorrhexis and spherical, basophilic cytoplasmic inclusion in a fresh hemocyte smear stained with Wright-Giemsa staining.

Treatment:

No treatment is available for YHV infection

Prevention and Control:

The reliable method to prevent the occurrence of YHD is possibly through avoidance, such as careful selection of postlarvae, reduction or elimination of horizontal transmission including carriers, disinfection of contaminated ponds or equipment with 30 ppm; and chlorine, providing shrimp with good water quality and proper nutrition.

(iv) Red Disease with White Patches or White Spot Disease

Etiological Agent:

The disease is caused by the dsDNA virus, Systemic Ectodermal and Mesodernal Baculovirus (SEMBV), 120 by 275+22 nm in diameter and length. It is a non-occluded, rod-shaped to elliptical culovirus surrounded by a trilaminar envelope.

Clinical Signs:

Clinically affected shrimp were first seen to swim to the water surface and congregate at the pond dikes. Typical clinical signs include white spots or patches, 1-2 mm in diameter, on the inside of the shell and carapace, accompanied by reddish discoloration of the body. SEMBV is able to cause acute epizootics of 5-10 days duration with mortality rate from 40% to 100%.

Diagnosis Procedure:

The diagnosis procedure of SEMBV infection is based on the appearance of the intranuclear hypertrophy in stained histological sections and the presence of virus particles in the nucleus of the infected cells observed under the electron microscope. Rapid Davidson's fixation method of SEMBV infection in gills and subcuticular body shell epithelium. PCR technique is recently used to detect SEMBV in shrimp larval and other stages, including broodstock and subclinical virus carriers.

Treatment:

No treatment is available for SAMBA infection.

Prevention and Control:

Prevention practices through avoidance are strongly recommended for the farmers, involving the combinations of efficient pond management, use of proper feed, selection of good quality of PL, reduction of possible carriers, avoidance of introduction of contaminated water into the pond, and disinfection of all equipment and utensils.

10. HARVESTING AND HANDLING

Successful harvesting can be achieved if the shrimp can be harvested in good condition within a short period of time. The harvesting technique should not damage or excessively contaminate the shrimp with waste. Rapid harvesting will reduce the risk of bacterial contamination and the shrimp will still be fresh when reaching the processor.

10.1 Method of Harvesting

Two methods of harvesting are generally practiced on farms. These are either by draining the pond and catching the shrimp in a bag net or by netting the shrimp within the pond.

For the first method of harvesting, ponds and outlets should be appropriately designed and be able to completely drain the pond within 4-6 hours. A bag net should be able to be fixed to the outlet to collect the shrimp that are carried by the out flouring water. The best time for harvesting is early in the morning and it should be completed before mid-morning. In ponds that can only be drained at low tide, the harvest should be conducted whenever possible. The shrimp should be regularly removed from the harvesting bag in small quantities to prevent damage.

When netting the shrimp within the pond, either a small electric net or a large seine net can be used. The water level of the pond should be reduced to 0.5-0.75 m deep and workers will need to go inside the pond for netting. This method is less advantageous the pond bottom will be disturbed, thus causing contamination of the shrimp. It is also slower and may take a long time to complete.

With either method, it is necessary to hand-pick the remaining shrimp in the pond, after the pond is drained. The harvested shrimp can be quickly killed by giving them a temperature shock (dip in iced water) to prevent damage and to improve storage.

10.2 Timing of Harvesting and Selling

The timing of harvesting depends on the condition of the shrimp in the pond and also the market price. Under normal circumstances, the shrimp will be sampled by a cast net from different areas of the pond to determine their average body weight and general condition. The proportion of soft shell shrimp should not be more than 5% at the time of harvest. This proportion could be obtained by scheduling the harvest halfway between two moultings. The time of moulting is indicated by the presence of exuviae in the pond. For example if the average body weight of the shrimp is 30 g, then the harvest should be planned for 7-8 days after the exuviae are observed, as the next moulting cycle can be observed after 14-16 days.

Harvested shrimp should be iced and transported to cold storage or processing plants in less than 10 hours. If the shrimp have been treated for unhealthy conditions with antibiotics, the recommended withdrawal period should be followed.

10.3 Quality Control

Before harvesting and/or exporting, shrimp should be examined for their health, hygienic quality and safety for consumers. Unhealthy shrimps, which are easily recognized through their appearance, will not be acceptable to consumers and market value could be reduced. Unhealthy shrimp should be treated before harvesting or removed during harvesting and processing if the proportion of unhealthy shrimp in the stock is low.

Human pathogenic organisms could contaminate the shrimp during harvesting, storage and processing. Therefore, samples of shrimp should be sent to a reliable laboratory to conduct necessary test to certify the hygienic quality of the products, before exporting or sending them to market. The harvested shrimp should also be checked for antibiotics and heavy metal residues before export.

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