CIBA Special Publication No.- 67

NFDB

NFDB Sponsored Training

BMP in shrimp farming with special reference to West Bengal

17 - 21 September, 2013

काकद्वीप शोध केन्द्र
केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
Kakdwip Research Centre
Central Institute of Brackishwater Aquaculture
(Indian Council of Agricultural Research)
Kakdwip, South 24 Parganas, W.B. - 743 347

भाकृअनुप
ICAR

Ciba

CIBA Special Publication No. 67

NFDB Sponsored Training Manual

on

BMP in shrimp farming with Special reference to West Bengal

September, 2013

Compiled and edited by

Dr Ashutosh D. Deo
Dr P.S.Shyne Anand
Dr P.Ravichandran

काकद्वीप शोध केन्द्र
केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
Kakdwip Research Centre
Central Institute of Brackishwater Aquaculture (ICAR)
Kakdwip, South 24 Parganas, West Bengal- 743347

Concept and Facilitation

Dr. A.G. Ponniah

Director, CIBA, Chennai

Dr. C. Gopal
Head of the Division, Crustacean Culture Division

Dr P.Ravichandran

OIC, Project Monitoring and Evaluation

Dr. Ashutosh D. Deo, *Senior Scientist, KRC of CIBA*

Course Convener

Dr. P.S. Shyne Anand, *Scientist, KRC of CIBA*

Course Coordinator

CIBA Special Publication No. 67
September, 2013

केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
Central Institute of Brackishwater Aquaculture

डॉ. ए. जी. पोन्नयाह
Dr. A.G. Ponniah
निर्देशक/Director

Foreword

Indian shrimp farming industry has transformed from a traditional shrimp trapping system to a high investment semi-intensive system due to ever increasing consumer demand, high foreign exchange and stagnation in the wild catch. The country possesses huge brackishwater resources of over 1.2 million hectare (ha) suitable for shrimp farming; however, the total area brought under cultivation was approximately 16%. The state of West Bengal is blessed with rich resources for aquaculture in India. It has cosmic potential for commercial farming of shrimps. Currently, around 0.59 lakh ha are under culture in West Bengal against the potential area of 2.10lakh ha. This indicates the slow growth of the brackishwater sector in West Bengal. The major bottleneck in the augmenting shrimp production is lack of knowledge on the scientific management of shrimp farm which results in environmental issues, disease outbreak and loss of standing crop.

Better management practices (BMP) in shrimp aquaculture signifies methods for responsible farming of shrimp that address environmental, social and production issues. Implementation of better management practices can improve the quantity, safety and quality of products taking into consideration animal health, food safety, environmental and socio-economical sustainability. Present NFDB sponsored training program on "BMP in shrimp farming with special reference to West Bengal" 17-21 Sept,2013 at Kakdwip Research Centre(KRC) is planned to sensitize the government officials, scientists and academicians about the benefits of implementing BMP so the growth of shrimp aquaculture can take place in a sustainable manner. I think this training is an appropriate endeavor to fulfill the required trained manpower in sustainable shrimp farming.

I express my best wishes to the convener for the successful conduct of training program. I also express my gratitude to the NFDB for sponsoring this training and funding this manual. I am sure this manual would enable the participants to enhance their knowledge and competence in the field of BMP in shrimp farming.

16/9/13

(A.G.PONNIAH)

नं. ७५, संथोम हाई रोड़, राजा अण्णामलैपुरम, चेन्नई - ६०० ०२८, भारत
No.75, Santhome High Road, Raja Annamalaipuram, Chennai - 600 028. INDIA
Phone : 91-44-2461 7523 Fax : 91-44-2461 0311 E-mail : director@ciba.res.in Website : www.ciba.res.in

काकद्वीप शोध केन्द्र
केन्द्रीय खारा जलजीव पालन अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
काकद्वीप, २४ परगणा (साउथ), पश्चिमबंगाल - ७४३३४७
Kakdwip Research Centre
Central Institute of Brackishwater Aquaculture
(Indian Council of Agricultural Research)
Kakdwip, 24 Pgs. (S), W.B. – 743347
☎: 03210 – 255072, Fax:- 03210-257030, E-mail: krc@ciba.res.in / krckakdwip@yahoo.co.in

PREFACE

In the last few decades shrimp aquaculture has witnesses a rapid growth. The expansion was driven by high profitability in shrimp farming that has attracted a wide range of investors starting from an individual farmer to business houses. One among nine maritime states in India the state of West Bengal is endowed with vast and varied fisheries resources and considered as sleeping giant. The brackish water potential resources are at the tune of 2.10 lakh ha which is distributed in three districts viz. Purba Mednipur, South and North 24 Pargana. The total aquaculture production of shrimp *P.monodon* in West Bengal from 0.59 lakh ha culture area was almost 46000 tons in 2011-12. This outlines the possibility of enhancing production from shrimp farming.

In recent past it has been experienced that the outbreaks of various viral diseases in shrimp farming along with several environmental and social issues demand scientific management of shrimp farm. In this direction Better Management Practices (BMP) is one method which can ensure efficiency and productivity by reducing the risk of shrimp health problems. Available information from India as well as other foreign country suggests that following BMP is helpful in reducing the impact of farming on environment, improves farmed shrimp product quality ,brings social acceptability and finally sustainability.

The Present NFDB sponsored training program on "BMP in shrimp farming with special reference to West Bengal" 17-21 Sept,2013 at Kakdwip Research Centre(KRC) is planned to create awareness about the benefits of BMP among the government officials, scientists and academicians so that the message could percolate down to shrimp farmers.

I am extremely thankful to Dr. A.G. Ponniah, Director, CIBA for his keen interest and valuable guidance in conduct of this training program. I express our sincere gratitude to Dr P.Ravichandran OIC PME and former HOD Crustacean Culture Division (CCD) and Dr C Gopal HOD CCD for necessary support and pragmatic suggestions.

I express my sincerest gratitude to NFDB for generously funding this training program and the manual. I acknowledge the help and cooperation received from guest faculty and colleagues in conducting this training program.

I hope this special publication would serve as study material in providing valuable information to the participants and other readers who are in quest for knowledge on sustainable shrimp farming.

Ashutosh D Deo
(Convener)

Date: 16.09.2013
Place: Kakdwip

NFDB sponsored Training Manual on
"BMPs in shrimp farming with special reference to West Bengal"
17-21 September, 2013

Contents

1

Present issues and future strategies of shrimp farming in West Bengal

Ashutosh D. Deo, P. Ravichandran*, Shyne Anand P.S. and C. Gopal*

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

**Central Institute of Brackishwater Aquaculture, Chennai*

1. Introduction

The state of west Bengal is one of nine maritime states in India has vast potential for fisheries development. The state has coastal length of 158 km which gives rise to a total of 2.10 lakh ha of potential brackishwater resources spread over three districts viz. Purba Mednipur (70,000ha), North 24 Pargana (50,000ha) and South 24 Pargana (90,000ha). As per the latest information only 0.59 lakh ha area has been brought under culture which is only 27.61% of the total area. The traditional age old 'Bhery'farming is practiced in almost 0.32 lakh ha. This is an indication of the slow development of brackishwater aquaculture in the state. The total production of black tiger shrimp *Peneaus monodon* was 45998 tons in 2011-12 that provides second place after Andhra Pradesh in the country. Since the state of West Bengal has recognized brackishwater aquaculture as a carrier of rural development and employment generation it is important to understand the strength and weakness responsible for slow development of the sector. In the present document some of the important issues which are affecting the development of shrimp aquaculture and future strategies to give boost to the sector described briefly.

Table: 1 Fisheries resources and aquaculture area of West Bengal

Sl. No.	Type of resources	Total potential resources (lakh ha.)	Under culture (lakh ha.)	% of resource area under culture
1.	Pond / Tanks	3.12	2.87	91.98
2.	Beel / Boar	0.41	0.21	51.21
3.	Reservoir	0.27	0.13	46.96
4.	River	1.90	-	-
5.	Canal	0.83	-	-
6.	Sewage fed fishery	0.04	0.04	100.00
7.	Brackish water fishery	2.10	0.59	27.61

Development of brackishwater aquaculture in West Bengal is centred on Shrimp farming. The dominant species under culture is *P.monodon* however in recent years farmers are also taking up *Litopenaeus vannamei* farming due its high growth, low cost of production and increasing demand in market.

2. Present issues in shrimp farming in West Bengal:

2.1. Non - availability of quality shrimp seed:

The first and foremost problem faced by the farmers in West Bengal is non-availability of quality seed for stocking at appropriate time. At present no shrimp hatchery is functional in west Bengal. Therefore farmers are compelled to get substandard seeds from the agents of other shrimp seed producing states. The cost of seeds is also very high due to airlifting. Secondly the shrimp seeds are produced at higher salinity when stocked in the ponds with low water salinity without proper acclimatisation results in stress and poor survival.

2.2. Supply of shrimp feed:

Farmers face serious problems of quality shrimp feed also. Feed which comes from other states cost very high (Rs.75-80/kg) due to long road transportation. Beside this feeds are generally time barred and infected with fungus and insects. Farmers and dealers in want of proper storage facilities and knowledge sometimes could not store feed in proper condition

2.3. Non-availability of proper brackishwater land lease policy:

There is no clear cut land lease policy for brackishwater in the state. This is a bottleneck in the development of potential area under shrimp culture. Several thousand hectares of such area which is unsuitable for agriculture operation but suitable for shrimp culture, mostly under the government is lying ideal and being encroached by the people. So far no sincere attempts have been made to survey the available areas to evaluate their parameters to categorise them for shrimp aquaculture purposes.

2.4. Poor infrastructure facilities:

The infrastructure facilities such as road connecting to the farms, cold storage, ice plants, power supply etc. are not adequate. It is said that the most of the unutilised brackishwater potential resources are in remote mainly in islands where there is no infrastructure.

2.5. Problems of basic inputs:

The supply of basic inputs other than seed and feed *viz* LSP, quick lime, dolomite, zeolite are unorganised. Farmers are often misguided or even cheated by the agents or retailers.

2.6. Environmental and disease problems:

Generally farmers avoid following proper stocking density of PL in their farm. In addition to this there knowledge about the feed management is very poor this results in high rate of feeding. Higher accumulation of nutrients at the pond bottom leads to algal bloom, low DO, hydrogen sulphide production, high ammonia concentration etc. These are pre-disposing factors for the disease. Viral disease (WSSV, IHHNV, Loose Shell Syndrome and Slow Growth Syndrome) bacterial (Vibrio infection) and environment associate disease (black gill disease) are very common. In absence of strict regulation when such water are drained into canal or estuary it causes eutrophication and may facilitate the entry of disease agents in others farm.

2.7. Non-availability of adequate credit facilities:

Non-availability of adequate and timely credit hampers the growth of shrimp aquaculture in the state as the shrimp farming is capital intensive venture.

2.8. Poor extension framework:

Latest technological interventions are not reaching to the farmers due to poor extension network.

2.9. Poor Marketing infrastructure:

Farmers face serious problem of marketing their harvested product. In most cases they land up in the trap of middleman.

2.10. Poor existence of cluster or group farming approach:

Shrimp farmers are mostly take guidance from the agents due to which they are not able to form groups hence they are deprived of benefits.

2.11. Climate change and natural disaster:

Shrimp farmers are facing serious problem of high tidal amplitude, increase in salinity particularly during February month, untimely rainfall, flood and cyclone.

3. Future strategies for the development of shrimp farming in West Bengal:

3.1. A shrimp hatchery which can cater to the need of farmers of west Bengal may be established in the region of high salinity and low siltation zone. Sand head could be an option however technical feasibility should be studied before establishing it. In case it is not going to be worked out government should ensure or facilitate supply of quality shrimp seed to the farmer.

3.2. Private shrimp feed manufacturers should be encouraged to establish shrimp feed manufacturing unit. Since some of the agencies have established feed manufacturing unit for cattle, poultry and fin fish in the state they may extend it for shrimp feed also.

3.3. A simple and appropriate brackishwater land lease policy will be helpful in developing the shrimp farming in the state.

3.4. Development of proper infrastructure like roads, bridges, cold storage and ice plants will definitely boost the shrimp aquaculture in the state.

3.5. Proper coordination between the banks and departments will ensure adequate and timely credit to the farmers. There is a need at district level to create awareness regarding the alternate credit delivery mechanism like SHGs and joint liability groups for facilitating small shrimp farmers who are not in position to offer adequate collateral securities to avail bank credit.

3.6. A popular and effective shrimp farming insurance scheme is needed for augmenting shrimp production in the state.

3.7. Effective extension network is required to make aware farmers about the latest technological intervention .This must be supported by soil and water testing facilities and disease diagnostic laboratory.

3.8. There should be regular refresher course for the officers involved in development of shrimp aquaculture.

3.9. Bhery farmers should be encouraged to adopt organic shrimp farming, the technology radially available with CIBA.

3.10. Farmers should be encouraged to form groups such as SHGs or Farmers Club or shrimp farmer's cooperatives. This will help farmers to come out from the traps of agents and will ensure low coast for input ultimately more returns and social status.

3.11. New overseas market facilities need to be explored. This is more relevant in the latest ethoxyquin issue imposed by Japan. Stress should also be given to develop local hygienic fish market in each ward/sector of the district.

3.12. In shrimp farming the major expenditure goes for site selection / farm design and construction of intake and outlet channels. The state government may explore the possibilities of providing such facility/infrastructure.

3.13. Farmers should be encouraged to culture SPF *L.vannamei* as an another candidate species of shrimp.

3.14. Climate resilient shrimp farming technology should be developed and made available to the farmers.

3.15. A holistic approach and transparent shrimp culture farmer oriented policy by the state government can give encouragement to shrimp aquaculture in the state.

3.16. Emphasis should be given to adopt eco-friendly sustainable shrimp culture technology in the state; this will ensure minimum damage to the environment and higher production year after year.

4. Conclusion:

The state of West Bengal is uniquely placed in the map of the country and is considered to be a sleeping giant in shrimp farming. A proper and effective strategy and coordination between the state fisheries department, Universities and ICAR institutions are the need of hour for the development of shrimp farming in the state. CIBA through its vibrant centre at Kakdwip understands its responsibility and developing region specific shrimp farming technology for small farmers and playing a pivotal role in the development of shrimp aquaculture in the state.

******

2 Better management practices for shrimp seed production

P. Ravichandran and Ashutosh D Deo*

**Central Institute of Brackishwater Aquaculture, Chennai*

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

1. History of the development of shrimp hatchery technology

1.1 Japanese system of larval rearing

Studies on the life history of *Penaeus japonicus* was initiated in 1933 in Japan with the beginning of shrimp farming. Non-availability of larval stages from wild hampered the research. But the observation that the mature females lay the eggs when held in aquaria, led to the experimentation in the artificial rearing of the larval stages. There was not much of a success in the rearing till 1940, because of the lack of suitable live feed for the larvae. The technique of pure culture of *Skeletonema costatum* was developed which led to the first successful rearing of *P. japonicus* (Hudinaga, 1942).

Though various experimentation was done on the water quality requirements, efficiency of different live feeds etc., the mass production of shrimp larvae was not successful till 1964. The successful mass production of *P. japonicus* postlarvae in large outdoor tanks in 1964 was the epoch making event in the history of shrimp hatchery development. This method is popularly known as "community culture" method and the basic principle was to keep the shrimp larvae and their food organisms together in the same tank at an appropriate concentration by proper management of light intensity, aeration and concentration of nutrients. The technology was simple and it involved - filling up of the tank to 80 cm, mature females are introduced to lay their eggs. The water was not changed until the larvae attained the mysis stage. Then fresh sea water was added daily in small amounts. By the time the shrimp attained the postlarval stage, the rearing water would be as deep as 2 m, almost the full depth of the tank. Then 20-40% of water was changed daily, depending on water quality deterioration. The essential points of water management was to avoid excess accumulation of metabolites and the food residues, and to keep relatively stable concentration of diatoms, as noted by the brown colouration. The system required very little technical knowledge for keeping it in operation.

Though this system could produce shrimp seed in large scale, failures in the rearing was very common due to bacterial, fungal and protozoan infections. The total inability to control the quality of the rearing water seemed to be primarily responsible for the onset of diseases. This system was modified in 1972 with the introduction of chemical sterilisation of water using sodium hypochlorite solution, production of *Chaetoceros* independently for feeding zoea and mysis stages and the introduction of formula feed in suspension for the later stages instead of the clam meat suspension which was considered as highly polluting. (Kurata and Shigueno, 1976)

1.2 High density larval rearing (Galveston Method)

The most significant modification of the early system was made in the Galveston Laboratory for the larval rearing of *P. azetecus, P. duorarum and P. setiferus* (Cook and Murphy, 1966; Mock and Murphy, 1970). In this system, instead of inducing a plankton bloom in the larval rearing tank, pure algal cultures were produced separately and then fed at predetermined amounts to the larvae in the larval rearing tanks. The rearing tanks were of 2 t capacity fitted with air-lift pumps. The sea water used for larval rearing was treated throughly to get rid of all suspended matter. For algal production the medium was artificial sea water. The algae were mass cultured independent of the larval rearing, concentrated by centrifuging and stored in frozen conditions. As and when required the algae are thawed out, suspended, diluted and used in the automatic continuous feeding device. Stocking densities for this system may be as high as 100-500 larvae per liter with survival rates ranging from 60-80 percent from nauplii to postlarvae (Mock and Murphy, 1971).

1.3 Small-scale hatchery technology (Low-density Rearing)

Simplified hatchery technologies were developed during early seventies in Southeast Asia, particularly in Thailand, Taiwan, Indonesia, the Philippines and Southern China. They were known as “Backyard hatcheries”. In this system, the hatcheries are located on a small plot of land and run by a family group. The rearing method was non-technical. They utilize small tanks of 2-10 tonnes with the capacity ranging between 2-10 million PL20 per year. They use low densities and untreated water. Most of these hatcheries take up only one phase of the production, like nauplii production or postlarva production. In Thailand, these type of hatcheries are located away from the coast and prepare the required saline water by diluting brine. The major advantage of this system is the low capital and operational cost and the ability to close down or start production as per the market demand. Disadvantage of these systems are the lack of control over the survival rates which range between 0 to 90%

2. Induction of maturity in captivity

Till early 70's, the penaeid hatcheries were dependent on the wild, fully mature spawners for the production of larvae. Though male penaeids have been observed to mature and mate in estuarine phase of their life cycle, females of most of the species do not mature in estuaries or in captivity. Studies on the hormonal control of maturation in decapod crustaceans by Adiyodi and Adiyodi (1970) showed that the removal of Gonad Inhibiting Hormone through eyestalk ablation will lead to maturity in most of the decapod crustaceans. During 1971-1976, various authors have succeeded in maturing different species of penaeid shrimps using eyestalk ablation technique (Idyll, 1971; Caillouet, 1973; Arnestein and Beard, 1975; Alikunhi et al., 1976; Wear and Santiago, 1976) and it has become an established technique for the maturation of penaeid shrimps in captivity.

Though completion of life cycle of various penaeid species has been achieved in captive conditions (CNEXO Aquacutlure team, 1974; Alikunhi et al., 1975, Santiago, 1977, Primavera, 1978), the quality of the eggs produced is generally poor in pond grown broodstock.

3. Status of shrimp hatchery technology in india

In India, rearing of shrimp larvae under controlled conditions started in an experimental scale in Central Marine Fisheries Research Institute in 1976 (Silas and Muthu, 1977). A simplified experimental hatchery system was developed with mixed diatom and mantis shrimp powder as feed for the different larval stages. This system is like the backyard hatchery technology described earlier. During early 80's, a few more experimental and commercial hatcheries were set up in India under public/ Private sector. But the production levels were very low. By 1989-90, Marine Products Exports Development Authority established two large scale shrimp hatcheries in technical collaboration with external experts TASPARC and OSPARC in Andhra Pradesh and Orissa respectively. The success of these two large-scale hatcheries and the offer of subsidy/ assistance from MPEDA had induced the establishment of a number of private hatcheries in the country.

Commercial penaeid shrimp seed production in India is restricted to two species *Penaeus monodon* and *P. indicus* with maximum percentage of hatcheries producing *P. monodon.* As on today about 351 shrimp hatcheries are operational in the country with a total production capacity of 14 billion PL 20/year. State-wise details of shrimp hatcheries are presented in the following Table.

State-wise distribution of shrimp hatcheries

State	No.	Capacity (million)
Gujarat	2	45
Maharashtra	8	345
Karnataka	14	321
Kerala	29	537
Tamil Nadu	81	3078
Andhra Pradesh	191	9335
Orissa	15	475
West Bengal	11	166
Total	351	14302

The hatcheries have varying annual production capacities ranging from 2-200 million PL 20 with an average of about 45 million PL20/hatchery.

Though induced maturation techniques have been standardized, most of the commercial hatcheries in India still depend on the wild spawners for nauplii production, since the fecundity and the quality of the eggs are comparatively better in wild spawners than the induced matured shrimps. In hatcheries, where induced maturation is practiced, the source of broodstock is always from wild. Some of the smaller hatcheries now procure nauplii from larger hatcheries and rear them to postlarva due to the uncertainities associated with availability of wild spawners and broodstock.

4. Sea water intake

There are numerous designs now in use in the various sea water based hatcheries. These designs are dependent on specific site characteristics, topography, geology, climate etc.,

Mostly used system of drawing water is through **intertidal borewells** or through inshore open wells. Low depth intertidal borewells (Fig. 1) are suitable in areas where the wave action is minimal. Inshore open wells (Fig. 2) could be used where the wave action is more in the intertidal zone and there is no freshwater aquifer in the shoreline. Where the water from the inshore wells are low saline due to freshwater table, drawing of water directly from open sea by constructing concrete jetties (Fig. 3) into the sea beyond the breaker zone.

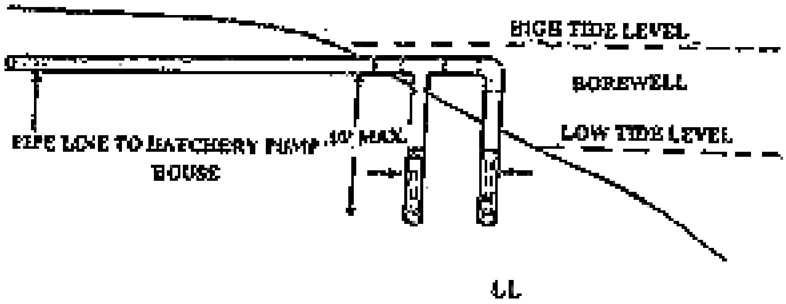
4.1. Water quality

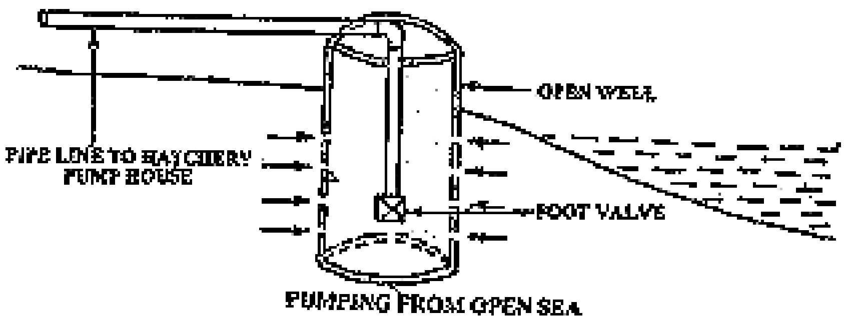
The sea water used inside a hatchery should be free from suspended solids, living organisms and chemical contamination. It is therefore essential to provide facility for water treatment in the hatchery depending on the quality of source water.

Water quality requirements for shrimp hatcheries for some of the parameters are given below

PARAMETERS	TOLERABLE LIMIT	OPTIMAL LEVELS
Temperature (^{o}C)	18 - 36	28 - 32
Salinity (ppt)	26 - 34	30 - 34
PH	7.0 - 9.0	8.0 - 8.4
Dissolved oxygen (ppm)	Above 3	Above 4
Ammonia - N (ppm)	Upto 0.1	Less than 0.01
Nitrite - N (ppm)	upto 0.1	Less than 0.01

Fig. 1. Intertidal borewell





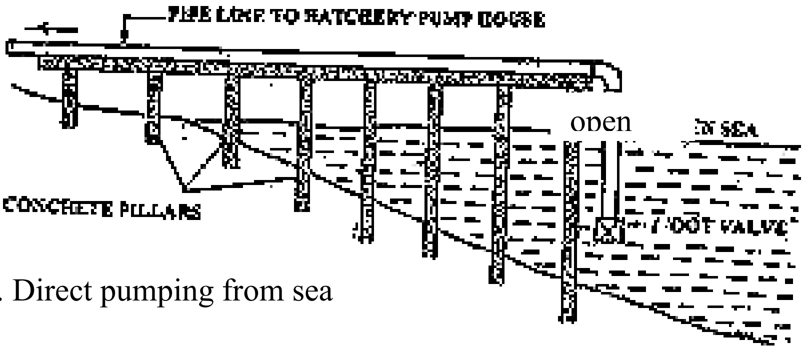


Fig. 3. Direct pumping from sea

4.2 Water treatment

The water treatment facilities in a shrimp hatchery should be able to provide sea water of required quality without suspended particles, biological and chemical contamination.

If the water is drawn from the open shore, it will contain suspended particles which are to be removed as a first step before any other treatment. Large suspended particles are easily removed by allowing the water to stand overnight in settling tank by the process of sedimentation. If the sea water is drawn from intertidal borewells or inshore wells, then the water will be free from suspended particles and no sedimentation will be necessary.

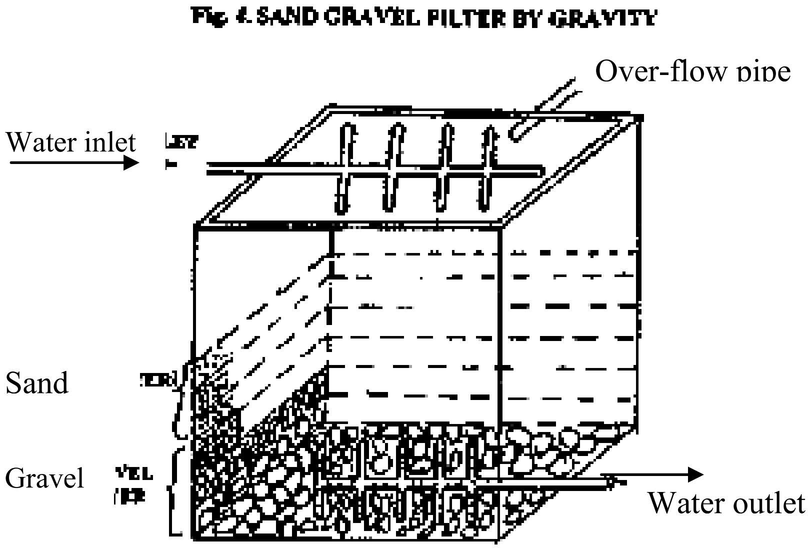
The next step in the treatment of sea water is the removal of unsettled suspended particles and other living organisms. This could done by filtration. The filtration is done through sand-gravel filter which is simple and most practical. Two types of sand- gravel filters are generally used in the hatcheries -

a) Filtration by gravity and

b) Filtration by pressure.

A simple gravity filter consists of a wooden or concrete tank with layers of gravel and sand. The gravel layer consists of larger layer at the bottom with medium and smaller layers above it. Similarly, three grades of sand, (coarse to fine) is used above the gravel layers. A perforated PVC pipe, embedded at the bottom of the gravel layer and extruding out of the tank acts as the outlet (Fig. 4). The water is pumped into the filter at the top. The water flows through the sand and gravel-bed. The coarse suspended particles are trapped in the sand bed and the clean water is collected through the outlet at the bottom.

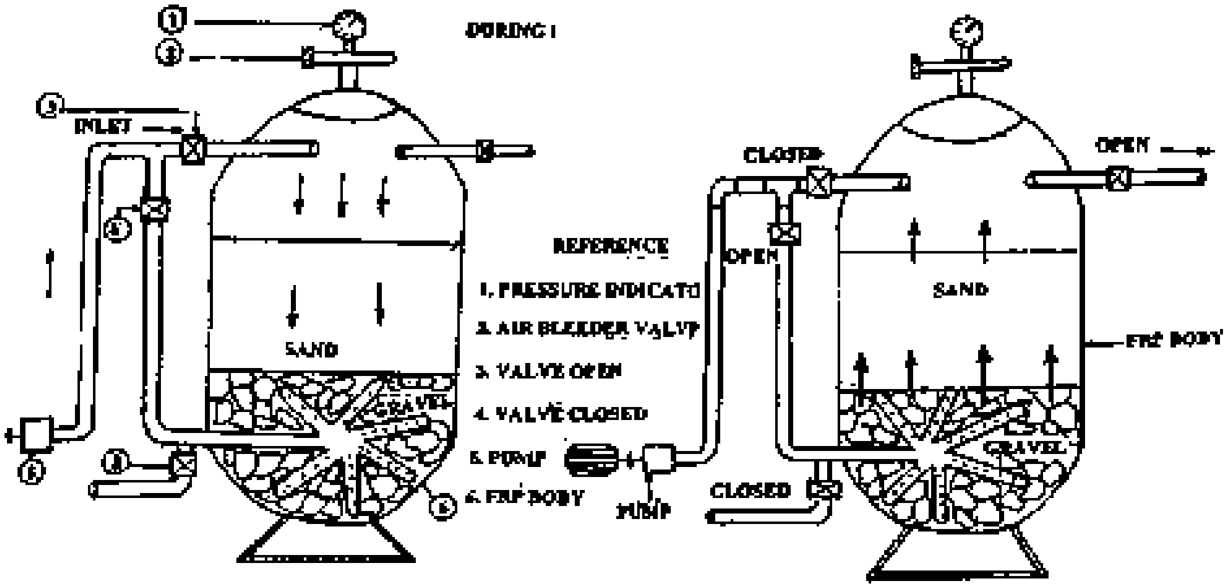
Fig. 4. Sand gravel filter



Pressure/rapid sand filters use the same principle as that of the gravity filters (Fig. 5). The difference is that the water passes through the sand and gravel bed through pressure. The filter housing is made of FRP and is sealed air tight after arranging the sand and gravel in position. The delivery from a pump of required capacity is attached to the inlet of the filter and the filtered water flows out through the outlet at the same velocity as that of the pumped in water. The filtering rate is very high and hence it is called as rapid sand filters.

Pressure sand filter

During filtration During backwash



The operation of the filter results in the accumulation of waste materials in the sand bed. The filtration capacity and rate reduces with such accumulation. Cleaning of the sand bed becomes essential. Allowing the water to flow in the return direction i.e. entering through the gravel and flowing out through sand is adapted and provisions for such backwash is given in all the sand filters.

Sand filtration removes only coarse materials up to 10 micron in size. Further filtration can be done by using fibre based cartridge filter, which will remove suspended particles of up to 1 micron in size. The fibre filter is enclosed in a non-corrosive housing. The water is pumped through the cartridge to the outlet. This could be easily fitted to the water lines.

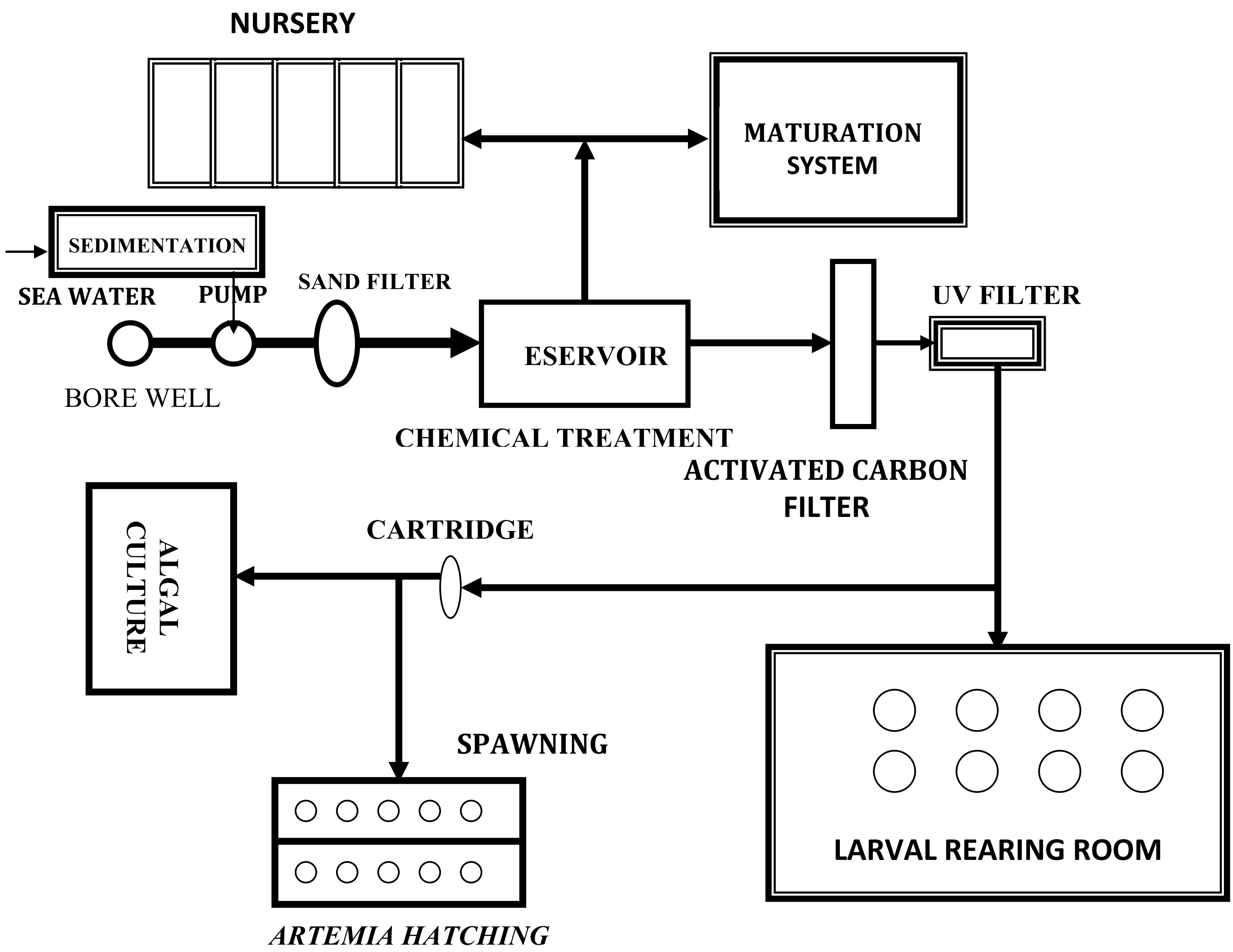
The filtered water might still contain microorganisms like bacteria, which could cause disease to the larvae. Hence, it is desirable to disinfect the water before use. Several chemicals have been commonly used for disinfection viz., chlorine, hypochlorite, ozone, etc., The use of UV sterilisation is also carried out to disinfect the water

Recommended concentration of disinfectants in water depends on the level of bacterial load. The usual range of chlorine dosage is 5-20 ppm of active chlorine. Treatment should last preferably for 24 hours. Before the seawater is used, the excess chlorine should be neutralised using sodium thiosulphate.

Further, application of EDTA, as a metal chelating agent, have to be applied in the water in tanks to avoid contamination from heavy metals in the water.

The flow-diagram for water treatment is presented below.

FLOW-DIAGRAM OF WATER TREATMENT



4.3 ALGAL CULTURE

In hatcheries, shrimp larvae are fed on unicellular diatoms such as *Chaetoceros* and *Skeletonema* or nannoplankters such as *Isochrysis and Tetraselmis* (Fig. 5 to 8). Hence mass culture of these species is a pre-requisite for successful hatchery operation. Algal culture involves two major aspects. They are

a) collection, isolation, purification and axenic culture of the required species and
b) mass culture technique.

The requirements for algal culture is clean uncontaminated seawater, temperature and light controlled laboratory and nutrients. As seen earlier, the water in the hatchery is treated and contaminated and for the pure culture of algae the water is further purified by UV treatment. The pure cultures are maintained in 10 ml (test tube) to 20 liter flasks. Mass culture of these algal species are carried out in outdoor tanks of 1 to 40 t capacity according to the requirement of the hatchery.

For mass culture, 10 – 20% the pure culture is used as the starter culture. In the pure culture the algae are maintained at a cell density of 2-3 million cells/ml and in mass culture within 24 hours they attain 3 – 4 lakh cells/ml. The required volume of algal water is calculated depending on the larval stage and larval tank volume and directly pumped into the larval tanks.

4.4 Artemia Hatching

Artemia nauplii is fed to mysis and postlarval stages of shrimps. Commercially available *Artemia* cysts are used. The cysts are washed thoroughly and disinfected with hypochlorite and then suspended in clean sea water atleast 16-18 hours before the actual time of requirement. Continuous aeration and subdued light is provided. After the naupii are fully hatched, they are separated from the cyst walls using their positive phototactic behaviour and fed to the larvae as per requirement. For this purpose small, black, conical FRP tanks of 40 – 100 l with transparent bottom and draining outlet are used.

4.5 Induced Maturation

The technology for the induced maturation of *P. monodon* has been standardised (Rao et al., 1995) and is being adapted by many hatcheries. The basic requirements and technology involved is summarized below:

Housing	Ventilated roofed shed
Tank size	5-15 t capacity circular or rectangular made of fibre glass or concrete
Light intensity	Reduced, 100 lux (artificial) dim light
Light quality	Blue or green
Photoperiod	12 hours light : 12 hours dark
Water depth	80 - 100 cm

Water quality	
Salinity (ppt)	30-36
pH	8.0-8.5
Dissolved oxygen (ppm)	Saturation by continuous aeration
Stocking rate	4 numbers/m ^{2}
Stocking size	Females - 90 - 180 g ; Males 60 - 90 g
Sex ratio	2 Females : 1 male
Water management	100 % exchange/day using filters; 200 % exchange by flow through system per day.
Feeds Fresh	Clam, mussel, squid & oyster meat @ 15 % of the total biomass/day, polychaete worms @ 6 % of the total weight or Artemia biomass @ 3 % of the total biomass
Artificial (Pellet)	2 % of the total biomass during night
Feeding schedule	Four times in a day
Sampling	The females are to be examined for the development every alternate day using underwater torch lights without handling.

4.6 Spawning

Matured females from wild or from induced maturation are treated with formalin before being placed individually in 500 l FRP tanks for spawning. In the spawning tanks no feeding is done. The room is kept dark without any undue disturbance to the spawners. Continuous aeration is maintained in the tanks. They generally spawn during the night. The eggs are collected in the morning, washed thoroughly and dipped in formalin and placed in the same tank with fresh filtered sea water for hatching.

Washing and disinfection procedure for eggs:

1. Gently collect eggs in a 50-60µ mesh net (a preliminary 300µ net is used to collect and discard any faeces from the spawning tank).
2. Gently rinse in running seawater for 5 minutes
3. Dip in 100 ppm formalin solution for 30 seconds
4. Dip in 50 ppm povidone iodine solution for one minute
5. Gently rinse in running seawater for 5 minutes
6. Stock eggs in hatching tanks.

Hatching

The eggs from each spawning tank are transferred to separate hatching tanks filled with clean seawater with mild aeration. 5-30 ppm EDTA and 0.05-0.1 ppm treflan are also added into the water. The eggs hatch out into nauplii in 12-16 hours after spawning depending on the water temperature. The nauplii from each spawning are estimated by counting four 100 ml random samples and multiplying the number to the total volume of water. The hatched nauplii that come to light are harvested and disinfected before stocking into the larval rearing tanks.

Washing and disinfection procedure for nauplii:

1. Gently collect nauplii in a 100µ mesh net.
2. Gently rinse in running seawater for 5 minutes
3. Dip in 200 ppm formalin solution for 30 second
4. Dip in 50 ppm povidone iodine solution for one minute
5. Gently rinse in running seawater for 5 minutes
6. Stock nauplii in larval rearing tanks.

4.7 Larval Rearing

The major aspects of shrimp larval rearing are water quality monitoring and management, feed management, and health management. At N6 stage, the nauplii are collected from the spawning tank and dipped in formalin before being stocked in the larval rearing tanks @ 50 – 100 nos/l. The larval rearing tanks are generally made of concrete/ FRP and the capacity ranges from 2 – 10 tonnes. The management methods followed are detailed below.

Days	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**15**	**20**	**30**
Larval stages	**Nauplius**			**Protozoea**					**Mysis**				**Postlarva**		
Feeding schedule															
Algae/Diatoms				20 - 50,000 cells/ ml											
Artemia nauplii									3 - 5 no/ml				2-5 no /ml		
Suspension feed/ Pelletised feed														5 - 10 g/t/day in small doses	
Water exchange	No Change Only filling			30% change					50% change					50 - 100% change	

The above mentioned schedule is only a very generalized one. Various hatcheries adapt the schedule according to the conditions of the source water, water treatment methods followed and availability of live feed. Further, some of the hatcheries use additional feed items such as Spirullina powder, Artemia flake diets, commercial micro-encapsulated diets, etc.,

The importance of health management during larval rearing is very seriously felt in India after the outbreak of White Spot Virus disease. Seed being one of the major source of this virus and vertical transmission of the virus has been established, some of the hatcheries have adopted some of these following procedures.

- Screening of wild spawners and broodstock for virus
- Treatment of wild and induced matured spawners with formalin to remove the externally attached pathogens.
- Washing and treatment of eggs with formalin.
- Washing and treatment of nauplii with formalin before stocking in larval rearing tanks.
- Application of broad spectrum antibiotics in the larval rearing tanks
- Additon of broad spectrum antibiotics in the feed for nursery rearing of postlarvae
- Screening of all the feed used in the hatchery for virus/ bacteria
- Screening of PL5 for White spot virus before transfer to nursery tanks.

Shrimp farmers have understood the importance of seed quality and they have started to seed certification before buying from the hatchery. Hence the hatchery operators are more concerned about the health of the larvae reared.

4.8 Nursery Rearing

5 day-old postlarva (PL5) are collected from the larval rearing tanks and stocked in 10-20 tonne concrete, outdoor tanks for further rearing upto PL 20. They were stocked @ 15-25 nos./l and fed with Artemia biomass/ pelleted feed/ suspension feed. Water was exchanged every day by 50-100%.

5. Health monitoring and disease diagnosis

Each larval tank is monitored twice daily to assess health of the larvae and to take corrective measures if any problem is noticed. This is crucial for taking decisions on water exchange, feeding and other management activities. Larval samples are examined for their stage, swimming activity, behaviour, feed intake, muscle gut ratio, excretion, disease or physical deformity.

Samples from broodstock, eggs, nauplii, PL should also be screened for viral diseases like white spot virus and Monodon baculovirus. Periodic examination of the water and larvae are also done to find out luminescence bacterial disease, necrosis etc

6. Recent advances in shrimp seed production

6.1 Probiotics based seed production

Food-safety issues like presence of antibiotic residues in shrimps that are exported has become has become very contentious with stringent standards prescribed by the importing countries. Usage of antibiotics in hatcheries need to be completely stopped. Presently techniques are being evolved to produce seed by using probiotics in the larval rearing phase. The probiotics are used in various stages of the larval cycle mainly through water.

6.2 SPF and SPR broodstock

In the post disease scenario, emphasis has been given to produce pathogen free seed to overcome the huge loss due to WSSV. Specific Pathogen Free (SPF) broodstock are produced by rearing the shrimps in a high bio-secure facility which excludes most of the OIE listed pathogens over a period of 2-3 generations. SPF broodstock are commercially available of *Litopenaeus vannamei and L. stylirostris* from United States. One company from Hawaii is also started marketing SPF, *Penaeus monodon*.

Specific Pathogen Resistant shrimps are produced through selective breeding for disease resistance. A number of countries are attempting this for the different species of shrimps. *L. vannamei and L. stylisrostris* resistant for Yellow Head Virus is commercially available.

6.3 Biosecurity in *P. monodon* seed production

Biosecurity is the measures and methods adopted to secure a disease free environment in all production phases for improved quality. Biosecurity is the ability to prevent losses to disease through effective elimination of pathogens and their carriers. The shrimp aquaculture industry has been experiencing severe setbacks due to the devastating viral diseases which are believed to be transferred between regions through the importation of broodstock, postlarvae and shrimp products. Biosecurity encompasses policy, regulatory, and programme frameworks (including instruments and activities) in response to managing risks associated with diseases. The basic elements of a biosecurity programme in a shrimp hatchery include the physical, chemical and biological methods necessary to protect the hatchery from the consequences of all diseases that represent a high risk.

Biosecurity programme for a shrimp hatchery include the following elements:

- Specific pathogen free (SPF) or high health (HH) shrimp stocks should be used.
- All the incoming stocks should be quarantined in the designated area.
- All incoming stock should be analyzed for diseases.
- All incoming water sources should be treated to eliminate pathogens.
- Equipment and materials should be sterilized and maintained clean.
- Personal hygiene measures including washing of hands and feet and clothing.
- Knowledge of the potential pathogenic diseases and the sources of risk and methods and techniques for their control and /or eradication
- Specific pathogen resistant (SPR) stocks to be used.
- Maintenance of optimum environmental conditions.
- Immune enhancers and probiotics to be used in place of antibiotics.

******

3 Site selection, design and construction of shrimp farm for optimization of production

Ashutosh D. Deo, Shyne Anand P.S., and G Biswas

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

1. Introduction

The brackishwater aquaculture has grown at an average annual rate of 10% since 1984 in the country and has great potential to generate employment and attract foreign exchange. In the state of West Bengal out of 2.1 lakh ha potential area for development of brackishwater aquaculture only 27.6% of the area has so far been brought under culture. Thus there is a vast scope for development of brackishwater aquaculture in the state. However, lack of awareness about the management practices has attributed to the disease outbreak and severe economic losses to the brackishwater aquaculture. Moreover, improper site selection, lack of good layout plan and design and faulty construction of farm result in various environmental issues like salinization of agricultural lands and drinking water, destruction and conversion of ecologically sensitive mangrove areas etc. Therefore, besides technological aspects of the culture, the environmental and socio-economical aspects need to be considered before finalizing the site for brackishwater farms.

2. Site selection

Selection of a suitable site has a critical influence on the success of shrimp aquaculture. A suitable site provides optimum conditions for the growth of species cultured at the targeted production level, given an effective pond design and support facilities. Proper guidelines are to be followed for integrating coastal aquaculture with the local environment and social settings. The following factors are to be considered in order to select a best possible site for brackishwater aquaculture.

2.1 Major factors

2.1.1 Topography and tidal amplitude

Topography refers to changes in the surface elevation .The best area for brackishwater ponds is where the ground is leveled (flat) or there is a slight slope between 0.5-1.0%. The area should be rectangular/square shaped near brackishwater sources like creek, rivers, canals etc. and there may be natural ground elevation of 1–3 m above MSL having minimum vegetation. Preference should be given for gravity flow of water to facilitate easy pond bottom drying and proper water exchange. Average tidal amplitude of 1.5–2.0 m is ideal for brackishwater farms.

2.1.2 Type of soil and its quality

Soil is one of the most important components of a brackishwater aqua farms.The water retention capacity of soil depends on the soil texture. A soil permeability of < 5×10^{-6} m/sec is desirable. Clayey loam soil is ideal for brackishwater farms as it has low permeability and high fertility. Clayey loam contains textural components like sand: 20–50%, silt: 15–30% and clay: 25–40%. Area containing higherpercentage of sandy soil should be avoided as it causes seepage and salinization problems. Artea with acid sulphate soils (pH 2.5–5.0) should be rejected. The desirable soil parameters are as follows:

Sl. No.	Parameter	Optimum range
1.	pH	6.5–7.5
2.	Organic Carbon	1.5–2.5%
3.	Calcium Carbonate	> 5%
4.	Available Nitrogen	50–70 mg/ 100 g soil
5.	Available Phosphorus	4–6 mg/ 100 g soil
6.	Electrical Conductivity	> 4 µmhos/ cm

2.1.3 Water source and its quality

Brackishwater farm requires good quality water in adequate amount throughout the culture period. The water source could be from brackishwater creeks/canal, lagoons or backwaters. The quality of the water available in the site has a strong influence on the success of the shrimp/ fish farm. The water source should be free from any industrial or agricultural pollution.Desired watern quality parameters are as follows:

Sl. No.	Water quality parameters	Ideal range
1.	Temperature (°C)	28–33
2.	pH	7.5–8.5
3.	Salinity(ppt)	15–25
4.	Dissolved oxygen (ppm)	> 5
5.	Transparency (cm)	25–45
6.	Total alkalinity (ppm)	80–200
7.	Nitrite-N (ppm)	< 0.01
8.	Nitrate-N (ppm)	< 0.03
9.	Ammonia-N (ppm)	< 0.01
10.	Mercury (ppm)	< 0.001
11.	Cadmium (ppm)	< 0.01
12.	Chromium, Copper, Zinc (ppm)	< 0.1

2.2 Other miscellaneous factors

The following factors need to be considered before selecting a site:

i) Environmental (Meteorological) factors for climatic conditions, storms, etc.

ii) Accessibility of the site

iii) Socio-economic conditions of the locality

iv) Pollution problems

v) Availability of seed from vicinity

vi) Availability of freshwater and power supply

vii) Transportation and marketing facilities of the farm produce

viii) Social and political factors

ix) Technical guidance

3. Design of brackishwater aquafarms

To make functionally efficient and economically viable fish farm there should be sound design following scientific and engineering aspects. It is also important to have a site specific design. Brackishwater aquafarms are classified into 3 groups as follows:

3.1 Tide-fed farms

Tide-fed farms are best suited for traditional extensive systems. It is suitable at places where mean spring tide ranges in between 1.3–2.0 m. Invariably tide-fed aquafarms require only one water channel, i.e. feeder channel-cum-drainage channel. There should be a main sluice gate to control the flow of water in the farm. Every pond of the farm needs individual sluice for water exchange. This type of farm is expensive on investment but economical in operation.

3.2 Pump-fed farms

Pump-fed farms are best suited for semi-intensive and intensive systems. Pump-fed farms generally have separate water channel and drainage channel. It also requires a storage-cum-sedimentation tank (reservoir) and an efficient pumping unit. It does not require big main sluice gate. This type of farm is economical on investment but expensive in operation.

3.3 Tide-cum-pump fed farms

The places where tidal water is available only during some months, tide-cum-pump fed farms are suitable. It requires main sluice gate and individual pond sluices like in the case of tide-fed farm. In addition pumping unit is required for supplying the water during the shortage of water. The tide-cum-pump fed farm is expensive on whole because of heavy investment and operation.

3.4 Orientation of the farm

The farm should be square in shape to minimize the cost on peripheral dyke. The cost of construction of square shaped pond is cheaper than the rectangular pond.

3.5 Design and construction of dike

3.5.1 Types of dike

There are two types of dike-

i) Peripheral dike: It provides the protective cover to the whole farm against flood, tidal thrust and cyclone. Pond size, high flood level, slope of pond bottom, vehicular load etc. are important factors to be considered while designing the peripheral dyke.

ii) Internal dike (Secondary dike): It is the partition between two ponds. Water depth for culture plays an important role in the design of an internal dike.

3.5.2 Free board

Free board is provided as a safety factor to prevent overtopping of dike. Free board is defined as the vertical distance between crest after settlement and the surface of water level in the pond at its design depth. It is maintained as minimum of 0.6 m for periphery dike and 0.3 m for internal dike.

3.5.3 Side slope

Side slope of pond dike depends mainly on soil texture and prevailing site conditions. Flatter slope provides more stability. Ideal slope is 1.5:1 to 2:1 (H:V). The slope of dyke may range from 1:1 for clayey soil and 3:1 for sandy soil.

3.5.4 Top width

The top width or crest of dike depends on the height of dike and its purpose. It generally varies from 1.5 to 2.5 m. When the dike is used as a roadway, minimum 3.7 m top width is provided.

3.5.5 Dike protection

Dike is constructed by putting earth layers of not more than 30 cm soil with proper compaction and consolidation of each layer. Slopes of dike should be lined with suitable lining materials, like stone pitching, brick tiling, concrete slabs, lime concrete mixtures, polymer based chemicals, etc. to prevent soil erosion.

3.6 Layout and design of ponds

As per Coastal Aquaculture Authority (CAA) guidelines, 60% of total farm area should be water spread, rest 40% for other purposes.

3.6.1 Shape, size and depth of ponds

Square shaped pond for shrimp culture provides better uniform aeration. Pond size may be 0.5–1.0 ha for better management point of view. Pond depth depends mainly on the species to be cultured, topography of the area and the climatic conditions.

3.6.2 Types of pond

Based on the culture operation there are three types of pond-

i) Nursery ponds: 10–15% of total water spread area is kept for nursery ponds with size 0.5 ha for shrimp with 0.8–1.0 m depth.

ii) Stocking/ grow-out ponds: About 60–65% of total productive area is kept for grow-out ponds with 0.5–1.0 ha size. These ponds should have one inlet and one outlet placed diagonally. Corners of the ponds are made round and smooth for better circulation of water and to prevent soil erosion in the corners.

iii) Bio-ponds/ Effluent treatment ponds (ETP): As per CAA guidelines, 10% of the water area is to be converted into ETP when the farm area is > 5 ha and this pond can be used for secondary fish culture.

3.6.3 Berm

A berm is step like structure constructed between dike base and top. It mainly helps in preventing soil erosion from dike. It also helps in easy netting operation.

3.7 Water intake and supply system

Design of water intake and supply canal depends on the daily water requirement. Depending on the soil quality, earthen/ stone pitched/ concrete canal can be designed. PVC pipes (10–12 inch dia) can be used for the water supply system. While designing sluice gate it is essential to consider tidal fluctuation in order to ensure effective control of water flow to fill the ponds within 4–6 hours. Sluice gates are classified in to main sluice gate and secondary gates. Main sluice gates are situated at the periphery dike and secondary gates are in the individual ponds. Wooden shutters are used to regulate the entry and exit of water flow into the ponds. The coarse and fine meshed screens are used in the outlet sluice gate to prevent the entry of unwanted organisms. Separate inlets and outlets should be constructed and must be diagonally placed for proper drainage.

3.8 Drainage systems

3.8.1 Outlets

It is constructed in various forms such as open sluice, monk sluice, pipes made structure etc. Outlet sluice constructed on the dike opposite to inlet point is used for water drainage from pond. It may be rectangular masonry monk type with provisions of nylon screens and wooden plank shutters to drain water completely from pond to drainage canal.

3.8.2 Drainage channel

Drainage channel network is must specially for semi-intensive and intensive shrimp culture farms. The design of drainage channel is more critical in tide affected larger ponds. Earthen or lined drainage canals with a minimum bed width of 0.3 m and bed slope of 1:1500 (V:H) should be 0.3 m below pond bottom level and 0.3 m above the lowest low tide level (LLTL) at the end of canal.

4. Construction of farm

Farm construction requires proper planning, careful supervision and skilled workmanship. The sequence of operations followed in farm construction is mentioned below.

i) Land clearing: There are three types of land clearing methods- manual, mechanical and chemical clearing
ii) Land marking: Dry white powder is used to mark the positions of dikes, channels, ponds etc. to be constructed.
iii) Excavation: Either manually or mechanically
iv) Construction of dikes and sluices
v) Construction of ponds
vi) Construction of water channels and drainage units
vii) Lining of dike slopes: With stone pitching/ brick pitching/ cement concrete lining/ stone slab lining/ polyethylene paper lining/ growing grass, etc.
viii) Office, lab, store room, etc.
ix) Construction of residence, watchman shed etc.

5. CAA guidelines for construction of brackishwater aquafarms

i) Mangroves, agri lands, saltpans, sanctuaries, etc. should not be converted into brackishwater farms.
ii) The farm should be 100 m away from a village with < 500 population, 300 m away from a village with > 500 people and 2 km from towns, heritage areas.
iii) It should be 100 m away from drinking water source.

iv) The farm should not be located across natural drainage canals/ flood drain.

v) Traditional activities like fishing should not be interfered while using creeks, canals, etc.

vi) Space between two adjacent farms: 20 m for small farms, 100–150 m for bigger farms.

vii) Farm should be minimum 50–100 m away from the nearest agri land.

viii) Water spread area of farm should not exceed 60%, rest 40% for other purposes.

ix) Areas with many farms should be avoided.

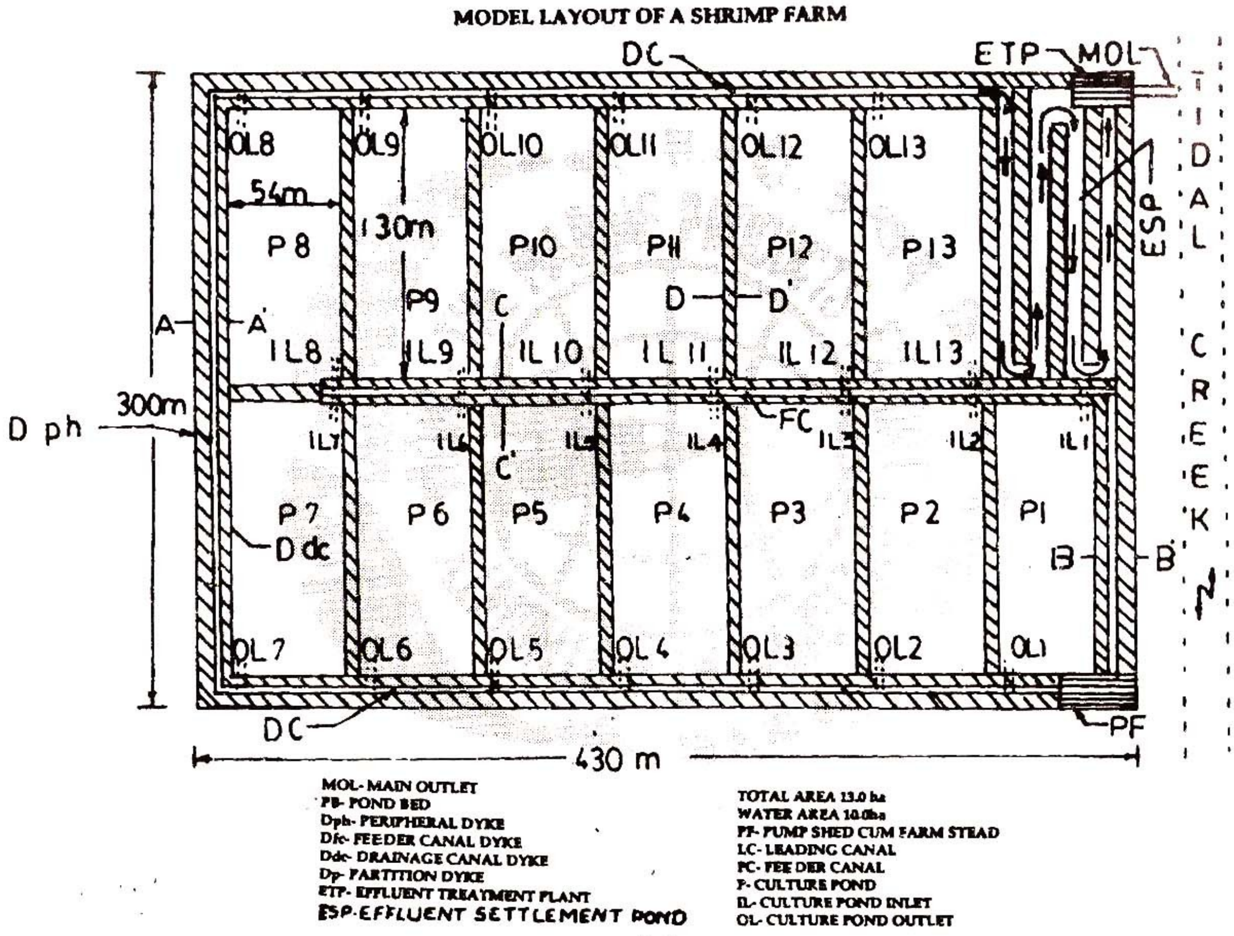


Fig. - Model layout of a shrimp farm (Source: MPDEA)

******

4

Provision for biosecurity in shrimp farm

P.S. Shyne Anand, Sujeet kumar and Ashutosh. D.Deo

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

Introduction

Biosecurity in shrimp aquaculture can be defined as the preventive measures for exclusion of specific pathogens from cultured shrimps in brood stock facilities, hatcheries and shrimp farms. It is a sets of practices that will reduce the probability of a pathogen introduction and its subsequent spread from one farm to another. To make a biosecurity program successful in shrimp farming, the relevant risks should be identified and the appropriate biosecurity measures must be taken in to practice to mitigate those risks.

The basic elements of a biosecurity programme include the physical, chemical and biological methods necessary to protect the farm from the consequences of all diseases that represent a high risk. Responsible shrimp farms must also consider the potential risk of disease introduction into the natural environment, and its effects on neighboring farms and the natural fauna. It is a two pronged approach: excluding pathogens and eliminating pathogens when they are present. Excluding pathogens from stock can be done via quarantine measures and specific pathogen free certified stocks, while eliminating pathogen includes prevent external source of contamination and internal cross contamination.

Biosecurity measures to be taken in shrimp farms

- **Site selection:** Most locations in Asia and India are not viral free and the farmers needs to operate their culture activities amid viral threats. Biosecurity starts with quality of farm design. Examples of biosecurity measures put into place for this purpose may include such basics as site selection when the intent is to locate a new shrimp culture facility in an area where certain diseases are not enzootic. To keep harmony with environment, mangrove deforestation for shrimp pond construction is prohibited.Standard facility farm operating procedures can be adapted to minimize the risks of disease introduction and spread within a facility through such concepts as pretreatment of all source water, and reduced or "zero" water exchange.

- **Pond preparation:** It is one of the first and foremost step which determine the success of a shrimp farm. Best biosecurity measures involves in pond preparation activities are removal of bottom sludge by removal of black soil layer of previous crop, which contain high organic content. Ploughing of soil also can be adopted as it exposes the black soil layer to sunlight and atmospheric oxygen, which oxidize the organic waste. Lime application to correct soil pH also help to disinfectant and reduces pathogenic load in soil. To keep the harmony with environment, mangrove deforestation for shrimp pond construction is prohibited. Use crab fence in all the periphery of the entire shrimp farm, which will prevent entry of land borne carriers – crustaceans crabs, human, domestic and wild animals, etc. Bird scare lines must be provided in each shrimp ponds to ward of air borne carriers such as birds which pickup infected dead or live shrimp and drops in to culture ponds;
- **Water intake:** Intake water must be filtered with fine mesh screen filter bag (<60 micron) to prevent the entry of virus and carriers such as crabs, wild shrimps and to avoid entry of predatory or weed fishs or crustaceans. Pond water must be disinfected with bleaching powder @60 ppm. It reduces the risk of pathogens. Preferably, in a one ha pond area there must be provision for 10-15% area for a water reservoir and treatment pond. Disinfection of water and fertilization for growth of plankton can performed in this reservoir before pumping in to grow out ponds as and when required. All equipment in operation – eg. PWAs, water pumps, siphon equipment, etc need to be disinfected with bleaching powder application before stat of shrimp culture.
- **Seed Selection and Stocking:** Stocking shrimp is perhaps one of the most important component of a biosecurity program. Use seeds produced from domesticated shrimp stocks that are free of specific diseases ("Specific Pathogen Free" or SPF) and or with stocks resistant to specific disease agents (SPR) SPF broodstock from certified Nucleus Breeding Center (NBC). These are biosecurity facilities where there are two or more years of documented disease testing to support their SPF status. Before purchasing, shrimp post larvae should be checked for their general condition such as activity, color, size, etc. If there is any dead and

abnormal colored PL in the stock, the entire batch should be rejected. Before stocking at the pond, PL should be treated with formalin at 100 ppm concentration for 30 minutes in well aerated tanks to remove weak PL. Maintain a balanced or optimum stocking density is also an important component of biosecurity programme.

- **Pond bottom and water quality management:** Disease outbreaks in shrimp growout culture is directly related to pond bottom and water quality. Zero water exchange must be followed through out the culture period to prevent the disease occurrence. Use chemical like KmNo4 dip treatment may be followed to disinfect all equipment– screen net, cast net, trays or accessories while sampling and regular monitoring (surveillance) of shrimp stocks in biosecure culture facilities is a necessary component of a biosecurity plan.
- **Better-Feed management:** Cost of feed accounts for about 40% to 60% of the total production cost. Do not use fresh feed, trash fish, bivalves etc. as it can carry vectors. Feed monitoring should be done with check tray evaluation for optimum feed management. Feeding area can be shifted at least once in 7 to 10 days depending on the bottom condition along feeding area. Reduce feeding during periods of low DO, plankton crash, rain fall, extremes of temperature etc. Slightly under feeding is better than over feeding, which saves money and reduce disease risks and during disease outbreaks. Proper storage of feed is also an important component in the biosecurity plan.
- **Shrimp Health Monitoring:** Shrimps should be sampled once in a week by cast netting and should be checked for their general health conditions like external appearance For example, a pale whitish gut showed gut infection while a normal gut will have a light or golden brown colour. Probiotics, immunostimulants, bioremediating agents can be employed as prophylactic measures in grow out culture. Yeast based organic preparation (60 kg rice flour, 30 kg yeast and 3 kg yeast) application can be applied to improve the overall pond microbial balance. Since there is a serious concern on the use of antibiotics, their use in shrimp farming should be avoided. Avoid unnecessary handling (touching)

Control workers' movement in and across the farm and minimize number of workers in stocking, harvest, sampling etc. It is utmost important to make environmental cleanliness and control Human traffics - guest, workers, technicians and movement across the farms. Educate people on biosecurity.

Better management practices during Disease Outbreak

When viral out-break is suspected you need to quarantine the suspected pond. At the same time implement the following during disease outbreak:

- Stop all traffic – people, trucks, cars, motorcycles passing across the pond and stop sampling activities
- Check any abnormalities in water and soil condition and take immediate action to correct the problem
- To increase the the carrying capacity of the remaining unaffected ponds, increase DO by operating longer or more numbers of aerators.
- Make sure all inlet and discharge gates are secured and no leakages.
- Apply bleaching powder in water and run the paddle wheel aerators. After shrimps are killed, stop the paddle wheel aerators. Do not take paddle wheels out of the pond.
- Leave the pond with water for at least 7 days – until the dead shrimps become red. Remove dead animals and bury them away from the ponds. Bleach pond water for 5 – 7 days before releasing into to the drainage. The pond water should be treated in an effluent treatment system
- Neighboring farmers should be kept well informed about shrimp disease problems, emergency harvesting and the time and date of water discharge.
- To avoid the cross contamination during periods of disease outbreak, surrounding farmers should try to avoid water exchange. Fence off the pond – put signs (do not enter)
- Emergency harvesting, if the mortality rate is increasing rapidly and shrimp are not feeding. It can be carried out preferably using cast netting to avoid discharge of infected water into the main water source.
- Make sure all people and equipment involved in the quarantine process to follow the biosecurity protocol

- **Farm Record Maintenance:** Records are necessary to identify various risks and to rectify these problems at the earliest during the production cycle. Record keeping also helps the farmer to learn from past mistakes, thus reducing risk and costs of production in subsequent crops.
- **Better Practices for harvesting:** Harvesting must be avoided during moulting period and agricultural lime can be applied 3-4 days before harvesting. Try to do harvesting in the early morning or evening. Harvesting should be done with dragnet with minimum delay. After harvesting transport crates with crushed ice at 1:1 ratio for better preservation. Nutrient rich pond effluent must be treated before get discharged in to water source.

Conclusion

Impacts of BMP includes Reduced costs and improved Profits, Reduced risk to small-scale farmers, Increased co-operation and harmony among farmers ,Better organized farmer groups, Reduced disease incidence, Reduced FCR and increased efficiency of resource use.

******

5 Pond preparation and pre stocking management in shrimp farming

Shyne Anand P.S. and Ashutosh.D.Deo

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

Success of any shrimp culture depends to some extent on the better management practices involved in pond preparation and pre-stocking management steps. Pond preparation is one of the most important pre stocking management measures essential for optimum growth of shrimp in grow out farming systems. There are various points to be taken care during the pond preparation for shrimp culture.

1.1. Drying the pound bottom

After each harvesting cycle, the pond bottom is allowed to dry and crack. It helps to oxidize the decomposed organic components, leftover in the pond after the previous culture. Generally pond bottom is allowed to dry for 7-10 days and, it allows soil crack to a depth of 25-50 mm. It helps to reduce the risk of disease outbreaks and improve shrimp production.

1.2. Ploughing or raking:

Ploughing or raking the pond bottom help to exposes the nutrient rich sub soil and fast mineralization and oxidation of the organic compounds and harmful gases. Tiling and ploughing is not generally recommended in acidic soils as it increases the soil pH.

1.3. Top soil removal:

The top black soil and bottom sludge to be removed to prevent development of anaerobic condition during culture period. The sludge must be disposed away from the pond site, so that it does not seep back into ponds. Grow out pond with high stocking density, entire pond top soil is removed where as modified extensive ponds, areas of the pond where there is a high accumulation of organic matter from previous crops, such as feeding zone should be removed.

Top soil removal

Pond bottom after top soil removal

2. Liming:

During pond preparation liming is applied to optimize pH and alkalinity conditions of soil and water. The type and amount of lime to be added depends mainly on the soil and water pH, which should be checked before lime application. The recommended levels of lime application during pond preparation are given in Table 1. The soil and water pH can be measured with a pH meter. Generally agricultural lime or dolomite can be applied if soils of pH >5and Quick lime or hydrated lime can be applied if soil pH below 5. Where disinfectants like bleaching powder (calcium hypochlorite) is used, applies lime only 3-4 days after the application of disinfectant as lime reduce the effectiveness of the disinfectant.

Lime applied on pond bottom

Lime application in pond water

Table 1. Amount of lime (tons/ha) to raise the soil pH to 7.0.

Soil pH	Quantity of lime material (tons/ha)		
	Dolomite	Agricultural	Quick lime
6 to 6.5	5.7 to 2.8	5.5 to 2.8	4.6 to 2.3
5.5 to 6.0	8.5 to 5.7	8.3 to 5.5	6.9 to 4.6
5.0 to 5.5	11.3 to 8.5	11.1 to 8.3	9.2 to 6.9
4.5 to 5.0	14.2 to 11.3	13.9 to 11.1	11.5 to 9.2
4.0 to 4.5	17.0 to 14.2	16.6 to 13.9	13.8 to 11.5

3. Water intake

Stringent measures to be followed to prevent entry and growth of any unwanted and pathogenic agents in culture ponds. It can be achieved via proper filtration of intake water using appropriate mesh screens, disinfection of intake water. Generally bleaching powder @ 600 ppm is recommended for reducing the load of harmful bacteria and virus in the cultured water. Optimum water quality criteria for intake water are given in table 2. Keeping a suitable reservoir also facilitate chemical treatment to reduce disease outbreak and to make water management more effective during production cycle.

Table. 2. Optimum water quality criteria for intake water

Sl. No.	Parameter	Normal Range
1.	Temperature (°C)	25-33
2.	Salinity (ppt)	10-34
3.	pH	7-9
4.	Transparency (cm)	25-50
5.	Dissolved Oxygen (ppm)	4-6
6.	Total Alkalinity (ppm)	50-300
7.	Nitrate- N (ppm)	< 0.03
8.	Nitrite- N (ppm)	< 0.01
9.	Ammonia- N (ppm)	< 0.01
10.	Heavy Metals (ppm)	Nil to 0.0001

4. Fertilization of pond water

The purpose of fertilization is to ensure the growth of primary producers in culture ponds. They initiate natural food web in the aquatic ecosystem and directly or indirectly contribute shrimp growth also. It also helps to maintain desirable level of transparency (25-40 cm) which prevents development of harmful benthic algae. Phytoplankton in culture ponds also help to improve the water quality parameters in grow out ponds.

Fertilizers can be applied depending on the fertility status of the soil. Organic fertilizer like dry cow dung at the rate of 500 - 2000 kg ha^{-1} and inorganic fertilizers like urea and single superphosphate (SSP) at 25 - 100 kg ha-1 can be applied depending on the organic carbon content (1.5-2.5%), available N (50-75 mg/100 g soil) and available P (4-6 mg/100 g soil) content in the pond. Of the original dose, 10% can be applied fortnightly to maintain the desired level of algal bloom. The Secchi disc transparency should be in the range of 25-40 cm. Brownish green colour of pond water indicate that the pond is ready for stocking the seed.

4.1. Application of organic juice

Yeast based organic preparation are recently being used in zero water exchange shrimp culture ponds as a probiotic. It can be prepared using ingredients like 30 kg paddy flour, 30 kg molasses and 4 kg yeast *Saccharomyces cerevisiae*. Allow these ingredients to get ferment in 48 h and can be applied in one ha pond. Organic juice can be applied in biweekly interval to improve the fertility status of water @ 1-2 ppm.

Shrimp pond water

Table3. Commonly used nitrogenous and phosphatic fertilizers in brackishwater shrimp aquaculture

Fertiliser	Availability
Ammonium sulfate $(NH_4)_2 SO4$	20-21 % as NH_3
Ammonium nitrate (NH4NO3)	17-18 % as NH_3 17-18% as NO_3
Urea (NH_2CONH_2)	46 % N
Single super phosphate [Ca $(H_2PO4)_2$	16-18 % P
ammonium phosphate (NH4H2PO4)	48-56 %P

******

6 Role of soil and water parameters in shrimp aquaculture

P. S. Shyne Anand, Ashutosh.D.Deo and G. Biswas

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

Water and soil quality management is one of the most important aspects of shrimp culture. Suitable bottom soil and good quality water are essential components for successful shrimp culture. As pond ecosystem provides suitable environment for the cultured shrimp to grow properly maintenance of optimum culture environment through soil and water quality management limits the risk of stress and diseases of species under culture. It is a well-known fact that the pond soil condition strongly influences water quality parameters. Proper pond management is the key to sustainability in shrimp culture. Proper procedures for pond management will improve environmental conditions, sustainability, and profit.

1. Water quality parameters

Physical, chemical, or biological parameters of water influence the pond environment and affect the growth and survival of aquatic organisms. Optimum requirement of these parameters vary among the cultured species.

1.1 Temperature

Temperature affects the metabolism and biochemical reaction rates of aquatic organisms. The chemical and biological processes of organisms are doubled for every 1°C increase in temperature. Optimum temperature for growth of brackishwater shrimp ranges between 25°C and 32°C. Temperature in pond water can be measured using thermometer. During summer period, especially in the afternoon, in deeper ponds there is a chance of development of thermal stratification due to heating up of surface water. Aerator running can reduce this problem to some extent by creating good water circulation.

1.2 Dissolved oxygen (DO)

Dissolved oxygen is one of the most important critical parameter in shrimp culture. Optimum requirement of oxygen for shrimp culture is 5 ppm and critical limit is 3 ppm. Shrimp farms with high-density culture need artificial aeration using paddle wheel aerators. Oxygen requirement increases in the early morning, cloudy days, moulting periods etc.

1.3 Salinity

Salinity is the total amount of solid material in gram contained in one kg of seawater, when all the carbonate converted to oxide, the bromine and iodine replaced by chlorine and all organic matter completely oxidized. Salinity of brackish water ranges between 0.5 to 30 ppt. Salinity in shrimp culture is measured through salinometer or refractometer. Even though, most of the brackishwater shrimps are euryhaline, optimum salinity for growth of penaeid shrimps are 15-20 ppt. Although, shrimps adapt variation in salinity regime, shrimps are highly sensitive to sudden changes in salinity.

1.4 pH

pH is a measure of hydrogen ion concentration in water and indicates how much the water is acidic or basic. pH exerts considerable influence on toxicity of ammonia and hydrogen sulphide as well as solubility of nutrients. Optimum pH range for culture environment should be 7.5-8.5. Liming and applying gypsum ($CaSO_4$) can be applied to increase and reduce the pH, respectively. In shrimp culture ponds, pH shows diurnal variation with maximum pH in the afternoon and minimum pH in the early morning.

1.5 Turbidity

Turbidity in a shrimp pond can be raised from suspended soil particles and plankton population. In culture systems, turbidity caused by planktonic organisms is a desirable trait, whereas that caused by suspended clay particle is undesirable. Transparency can be measured by Secchi disc. Optimum range of transparency in a culture pond is 25-45 cm. If it is less than 25 cm indicate plankton bloom, hence water treatment is required. If it is more than 45 cm, indicate primary productivity in pond is less and hence fertilization is to be done to increase plankton production.

1.6 Total alkalinity

Alkalinity of water is determined by all the carbonates and bicarbonates of alkaline and alkaline earth metals present in solution. Alkalinity more than 110 mg/l as $CaCO_3$ is found to be productive. Calcium and magnesium are most common basic ions, which are indispensable for shrimp culture. Alkalinity can be increased by lime application.

1.7 Ammonia

Ammonia is the end product of protein metabolism. There are two forms of ammonia, unionized ammonia (NH_3) and ionized ammonia (NH_4^+). Unionized ammonia is more toxic than ionized ammnonia. Uneaten feed, shrimp excreta are the main source of ammonia in water. Shrimps are very sensitive to unionized ammonia (NH_3) and the level must be below 0.05 ppm in pond water. Normally in the case of high DO concentrations, the toxicity of ammonia to shrimp is reduced.

1.8 Other nitrogenous compounds

Nitrite is an intermediate product in the bacterial nitrification of ammonia to nitrate. Under normal conditions, the nitrite concentration of shrimp ponds is negligible if they kept well oxygenated. Nitrite is highly toxic to fish as it oxidises haemoglobin to methemoglobin, which is incapable of transportation of oxygen. Optimum level of nitrate is less than 0.2 ppm. Other nutrients present in pond water are nitrate –N (NO_3-N), phosphate-P (PO_4-P). These nutrients directly involved in improving primary productivity in water however, there excess level can be leads to eutrophication.

2. Soil parameters

Soil is one of the most important factor which determine productivity of a pond. Dynamics of availability of most of the nutrients is determined by the condition prevailing in the bottom soil. Considering this significance, bottom soil is designated as the chemical laboratory of the pond. However, soil quality problems are common in aquaculture ponds.

2.1 Soil texture

Soil texture indicates the relative proportion of soil particles, *viz.*, sand, silt and clay. Texture of the soil affect the fertility of shrimp ponds. Soils with moderately heavy texture such as sandy clay, sandy clay loam, clay loam, silty loam, silty clay are found to be favorable for brackishwater shrimp aquaculture. Shrimp pond soil should not be too sandy to allow water seepage or too clayey to keep all the nutrients adsorbed on to it.

2.2 Soil reaction (pH)

Soil may be acidic, alkaline or neutral. Soil pH is one of the important factors for pond productivity point of view, as it controls most of the chemical reactions in the pond environment. Slightly alkaline soil pH (7 and little above) is considered to be ideal for shrimp production. Low soil pH reduces the availability of key nutrients in the water and lower pond productivity. Liming is one of the best options to increase soil pH.

2.3 Organic carbon content

Organic carbon acts as a source of energy for bacteria and other microbes that release nutrients through various biochemical processes. Pond soils with less than 0.5% organic carbon is considered unproductive while those in the range of 0.5-1.5% and 1.5-2.5% to have medium and high productivity, respectively. Organic carbon content of more than 2.5% may not be suitable for shrimp production, since it may lead to excessive bloom of microbes and oxygen depletion in water. C: N ratio of soil influences mineralization process by microbes. Mineralization is very fast, moderately fast and slow at C: N ratios in the range of less than 10, 10-20 and more than 20, respectively. In general, soil C:N ratios between 10 and 15 are considered favourable for aquaculture.

2.4. General nutrient status

Nitrogen, phosphorus and potassium are the major nutrients present in soil. Soil nutrients play an important role in phytoplankton production. Single most critical nutrient for pond productivity is phosphorus content of soil and water. Pond soils with 60-120 ppm available phosphate (P_2O_5), 250 to 500 ppm available soil nitrogen are considered to have good productivity.

2.5 Hydrogen sulphide

Under anaerobic condition hydrogen sulphide is produced in pond bottom soils and it is highly toxic to shrimp. At concentration of 0.01 ppm of hydrogen sulphide can make shrimp subjected to stress. Frequent exchange of water can prevent building up of hydrogen sulphide. Further, increasing water pH through liming can also reduce the hydrogen sulphide toxicity.

******

7

Feed and feeding management in shrimp farming

T.K.Ghoshal and Debasis De

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

Introduction:

Aquaculture has now been recognized as an important area for fisheries development to meet the food needs of the people, and also to create employment opportunities. In recent years there has been a great emphasis on enhancement of aquaculture yield through approaches such as the use of genetically improved varieties and also complementing the natural food with supplementary diets, which meet all the nutritional requirements of the cultured species of fish and shellfishes. Of late the use of formulated feeds have become unavoidable especially under high stocking densities as observed in practices of intensive and semi-intensive rearing of fish and shrimp. Hence, feed is a major expenditure for shrimp farmers. Good feed management can reduce the overall culture cost, improve farm environment and ensure healthy growth of shrimp stock. Shrimp feed management includes choosing the right feed, using a correct feeding method, calculating the feeding cost and ensuring the cost effectiveness of farm. Poor feed management not only reduces profit to farmers but also leads to serious environmental pollution. Provision of well-balanced feed is important as it not only help to attain genetic potential for growth but also to hasten recovery from diseases and aid in overcoming environmental stress. Thus, proper feed management helps in reducing the cost of culture operations since in farming operations cost of feed accounts to about 55-60% of the total operating costs.

Shrimp farming is one of the most profitable and fastest-growing segments of the aquaculture industry. Shrimp farming is currently practiced in over 50 countries worldwide and the sector has grown at an annual average of over 18.8% since 1970. It is perhaps not surprising therefore that farmed shrimp currently contribute over a quarter of total global shrimp landings and constitutes the single most valuable internationally traded aquaculture commodity worldwide. Shrimp farming has shown phenomenal growth in the last decade in India producing protein rich health food and earning valuable foreign exchange.

As with all animal production systems, the growth and production of farmed shrimp is largely dependent upon the supply and intake of dietary nutrient inputs and feeds. Feed is a major input in shrimp farming. Preparation of nutritionally adequate feed for tiger shrimp (*Penaeus monodon*) involves understanding the dietary requirements of the species, proper selection of feed ingredients, formulation of feeds and appropriate processing technology for producing water stable pellet feeds. Depending upon the type of farming, a wide range of feedstuffs is used for feeding stocked shrimp. While no feed is used in traditional farming systems, supplementary and adequate feeds are used in improved extensive aquaculture.

In general, the feeding methods employed by shrimp farmers consist of the following:-

- **No fertilizer or feed application** is a typical of traditional extensive farming systems, in which shrimp growth and production depends on the consumption of food organisms naturally present in the pond ecosystem and influent water.
- **Fertilizer application** is similar to the method above but applies chemical fertilizers and/or organic manures to simulate and enhance the natural productivity of the pond ecosystem, thus increasing natural food production and availability for the cultured shrimp.
- **Fertilizer and/or supplementary feed application** is usually used in semi-intensive farming systems, in which shrimp growth relies on co-feeding of endogenously supplied local food organisms (whose production is usually enhanced by applying fertilizers) and exogenously supplied supplementary feeds. The later feeds may be simple farm-made moist/dry aquafeeds or industrially formulated commercial aqufeeds.
- **Fertilizer and/or complete feed application** are typical of intensive farming systems, where shrimp growth is almost totally dependent upon the external provision of a nutritionally complete diet for the entire culture period. These feeds generally consist of formulated commercial aquafeed or, to a lesser extent, farm-made aquafeed or fresh items such as trash fish.
  The choice of feeding method largely depends on the intended farming system and shrimp stocking density (and the resulting availability of food per stocked animal), the financial resources and other inputs available to the farmer, and the market value of cultured species. At one end of a spectrum are low cost extensive/semi-intensive farms using fertilization

and supplementary feeding generally with farm made aquafeeds from locally available resources. At the other end, large-scale commercial farming operations use intensive methods with fertilization and feeding, usually using industrially compounded aquafeeds.

The performance and success of a formulated diet for shrimp depends on many factors, the most important being

i) Feed formulation and nutrient content of feed ingredients
ii) Feed manufacturing process and physical characters of the feed
iii) Feed handling and storage
iv) On-farm feed management-feed application methods, feeding regime
v) Aquatic environment and natural food availability

To formulate a practical diet for tiger shrimp, first and foremost point to be considered is the nutrient requirement (Table-1) of the species. Shrimp diet should have adequate energy and protein to meet the requirement for maintenance and growth. In nature, shrimp can meet their requirement from a variety of feed available in the ecosystem. But when shrimps are cultured in confined systems, they should be provided with balanced diet as close to natural feed as possible.

Table 1. Requirement of major nutrients for tiger shrimp

Nutrient	Dietary requirement
Energy (Kcal/Kg)	2800-4300
Protein (%)	35-45
Lipid (%)	5-15
Carbohydrate (%)	20-25
Phospholipid (%)	0.1-2.0
Cholesterol (%)	0.5

Feed Management in culture pond

Feed management means control and use of feed for aquaculture operation in such a manner that utilization of feed is optimum with minimum wastage, negligible impact on environment, achieving best feed conversion ratio (FCR) and maximum growth of shrimp. Proper feed management is essential for successful and profitable shrimp culture. As feed alone costs 50-55% of total culture expenditure, strict supervision on feeding of tiger shrimp is required. Following points should be strictly followed while feeding the shrimp for maintaining good pond hygiene and to reduce wastage of feed and to avoid accumulation in pond bottom.

1) Pond biomass should be assessed regularly and ration should be offered as per biomass of the pond.
2) Time and method of feeding should be proper. Daily ration should be divided and given 3 to 4 times a day (Table 2). The feeding activity and quantity of feed consumed may be checked by keeping feed in check trays (size: 80 cm x 80 cm) @ 4-6 nos./ha in different places in pond. After one month of stocking, consumption of feed should be checked by using check trays. 1% of feed ration is to be kept in check trays and observed after 2 hr. Depending on the quantity of feed consumed in the check tray, the next dose should be increased or decreased. Feed should be broadcasted evenly in a periphery of about six feet from dyke in all sides of the pond.

Table 2. Feeding Schedule for shrimp

Feed type	Shrimp weight (g)	Time of feeding				
		6.00 AM	11.00 AM	6.00 PM	10.00 PM	2.00AM
Starter	Up to 4.0	30 %	-	35%	35 %	-
Grower	4 – 15	25 %	15 %	30 %	30 %	-
Finisher	> 15	25 %	15 %	20 %	25%	15%

Table 3. Recommended shrimp pellet size

Feed type	Size of shrimp (g)	Pellet size
Starter	0-4.0	0.5-1.0 mm crumble
Grower	4.0-15.0	2 - 2.3 mm x 4 - 5 mm
Finisher	>15	2-2.5 mm x 6 - 8 mm

Shrimp appetite will vary due to the environmental conditions i.e., water quality, water temperature, sunny/overcast days and physiological conditions such as disease and moulting. Feed should never be given in excess as uneaten feed pollutes the water. As shrimps are the nocturnal feeder, larger doses may be offered in the evening and during night. Regular observations and experience helps in mastering the management of feeding in a culture farm. Generally during new moon and full moon moulting of shrimp takes place and they become sluggish and reduce the feed intake. So, quantity of feed offered should be reduced at the extent of 30-50 % during that period.

3) Quantity of feed**:** Generally the method of calculating the daily ration is based on the body weight of shrimp (Table 4).

Table 4. General guideline for calculating dose of feed

Days of culture	Expected survival (%)	Expected ABW (g)	% of ABW to be used as feed.	Feed Required (g) per 1000 post larvae/day	Total feed (g) required for the period
1-5	99	0.1	20.0	20	100
6-10	97	0.3	13.0	40	200
11-15	95	0.5	10.0	50	250
16-20	94	0.7	9.5	65	325
21-25	93	1.0	9.0	85	425
26-30	91	1.4	8.5	100	500
31-35	89	1.9	6.5	110	550
36-40	88	2.5	4.5	115	575
41-45	86	3.4	4.3	120	600
46-50	84	4.6	4.0	150	750
51-55	83	5.7	3.8	180	900
56-60	81	6.8	3.7	200	1000
61-65	79	7.9	3.6	225	1125
66-70	78	9.2	3.5	250	1250
71-75	76	10.5	3.4	280	1400
76-80	75	12.8	3.3	320	1600
81-85	73	14.9	3.2	350	1750
86-90	71	17.0	3.1	375	1875
91-95	69	19.2	3.0	425	2125
96-100	67	21.5	2.9	450	2250
101-110	65	24.6	2.8	425	4250
111-120	62	28.4	2.3	400	4000

Total feed required for initial stocking of 1000 PL for culture of 120 days is 28 kg approximately. Success of feed management depends on the farmer's experience and observation on the feeding behaviour and feed intake of shrimp. Following a strict feed management, survivability up to 80 % and average weight of 30 g can be achieved in culture duration of 120 days. Progressive farmers may have small scale feed mill to prepare shrimp feed using locally available feed ingredients for tiger shrimp culture and may get a good economic return. Central Institute of Brackishwater Aquaculture (CIBA), Chennai and its regional centre at Kakdwip extend technical guidance to set up feed mills in West Bengal and other parts of the country for preparation of shrimp feed using ingredients available in the country.

******

8 Farm made feed and its importance for small shrimp farmers

Debasis De and T.K.Ghoshal

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

Introduction

Farm made feed is typically a feed that is produced by farmers or small-scale feed manufacturers using some form of processing on farm or in a small processing plant, resulting in a moist dough or a simple moist or dry pellet. Farm-made aquafeed produced by the farmers is often synonymously termed "home-made aquafeed". Feed cost alone constitutes 60-70% of the total cost of shrimp culture. For successful culture of shrimp nutritionally balanced formulated feed is essential. At present, commercially available shrimp feed are very expensive and small shrimp farmers doing culture in a less intensive manner may not be able to afford the costlier feed. To minimize the cost of culture farmers get option for continuing the shrimp culture with farm made feed prepared from locally available feed ingredients. Often high quality, commercially produced feeds are provided to aquaculture systems with little regard to the economic or nutritional rationale for their use. Such practices may result in feed wastage and the poor economic performance of the production systems. Factors affecting the poor feed utilization and resulting in high feed conversion ratios (FCRs) include the inappropriate selection of feed type (pellet type and formulation), quality and the feeding strategy. Among others, the quality of the feed is influenced by the quality and digestibility of the feed ingredients, the suitability of the formulation in terms of supplying the nutritional requirements of the culture species, the stability of the feed in the water, the storage and handling of the feed, and whether the feed is extruded or pelleted.

Factors to be considered before choosing to make farm made feeds for shrimp

- Type of farming
- Time available for farming activities
- Availability of labour
- Stages of life cycle and nutrient requirement

- Feed ingredients availability and cost
- Nutrient content of available feed stuffs
- Food and feeding cost per unit of production or per unit time.

Nutrients in shrimp feed

Shrimp/fish need energy and essential nutrients for maintenance, movement, normal metabolic functions and growth. They can obtain their energy and nutrients from natural food in ponds, from feed supplied by the farmer or from a combination of both sources. To formulate a practical diet for shrimp and fish, first and foremost point to be considered is the nutrient requirement of the species. Shrimp diet should have adequate energy and protein to meet the requirement for maintenance and growth. In nature, shrimp can meet their requirement from a variety of feed available in the ecosystem. But when shrimps are cultured in confined systems, they should be provided with balanced diet as close to natural feed as possible. The feed requirements of shrimp vary in quantity and quality according to their stage of life cycle. Feed requirements are also affected by environmental variations such as temperature and the amount and type of natural food available. The major components of feeds are water, protein, lipid, carbohydrate, minerals and vitamins.

Table 1. Nutrient requirement of different brackishwater shrimp

Nutrient	***P. monodon***	***P. indicus***
Energy (Kcal/kg)	2800-4300	3500-4000
Protein %	35-45	30-43
Lipid %	5-15	6-10
Carbohydrate %	20-25	25-30
Phospholipid %	0.1-2.0	0.1-2.0
Cholesterol %	0.5	0.5

Mineral requirement: Micro-nutrient such as vitamins and minerals significantly influence the growth and survival of fish and shrimp and these cannot be synthesized by these organisms. About 20 inorganic elements (macro and micro) are required to meet the metabolic and structural functions in the body of animals. The aquatic organisms regulate the mineral needs through dietary source and also through internal regulatory mechanisms in the kidneys and gills. In saline waters calcium (Ca) is abundant, which is absorbed by most aquatic animals. Since the availability of phosphorus (P) through water medium is poor, P should be made available through diet. Usually the preferred Ca:P ratio is 1:1 in feeds of aquatic species. Mono and dicalcium phosphate contain more available P than tricalcium phosphate. Incorporation of P should be very discrete in fish and shellfish feeds, as most of it gets excreted leading to eutrophication. The dietary requirement of P ranges from 1-2% in shrimps. The requirement of magnesium (Mg) in shrimp ranges between 0.04-0.3%. The requirement of zinc (Zn) ranges from 80-120 mg/kg diet for shellfishes. The requirement of iron (Fe) ranges from 60-100 mg/kg diet for shrimps. In shrimps, manganese (Mn) requirement goes up to 40-60 mg/kg which may be due to periodic ecdysis. Trace minerals like copper (Cu), cobalt (Co), selenium (Se), iodine (I) and chromium (Cr) have some role in general upkeep of the organism. Copper is needed by crustaceans because of hemocyanin. Optimum dietary level of Cu ranges from 40-60 ppm and it was also observed that omission of Cu from the diet was not detrimental as, crustaceans are able to meet their demands from seawater.

Table 2. Vitamin requirement of shrimp

Vitamin (mg/kg)	**Shrimp**
Thiamin	120
Riboflavin	40
Pyridoxine	120
Pantothenic acid	100
Niacin	150
Folic acid	5
Vit B_{12}	<0.1
Choline	600
Inositol	2000
Vit C	1000
Vit E	200
Vit A (IU)	5000
Vit D (IU)	1000
Vit K	40

Ingredients used for farm made feed

There are 3 factors to consider in the choice of ingredients:

a) Quality - nutrient composition and presence of any anti-nutrient substances that interfere directly with the absorption of nutrients or contaminants.

b) Quantity – how much is available locally & is the supply regular?

c) Price or cost

Special care should be taken to inspect the materials for wetness, mould growth, insects and parasites. The inspection procedure starts with visual examination of a sample for the colour and texture and smelling for obvious contamination or rancidity.

Table 3. Different ingredients of plant origin with nutritional value

Ingredients	As % dry matter			
	Crude Protein	Crude Lipid	Crude Fibre	Total Ash
Soybean cake	42-48	2-7	6-8	5-7
Ground nut cake	40-43	3-8	6-9	4-8
Cotton seed cake	36-44	4-8	16-22	6-9
Sun flower oil cake	38-47	4-6	14-16	6-7
Wheat flour	9-12	3-4	6-8	4-6
Maize	10-12	4-6	4-8	6-9
Tapioca	1.5-2.5	0.4-0.6	2-6	2-4
Brewer's yeast	40-45	1	2-7	6-9
Spirulina	55-68	6-8	1-3	8-10

Table 4. Different ingredients of animal origin with nutritional value

Ingredients	As % dry matter			
	Crude Protein	Crude Lipid	Crude Fibre	Total ash
Fish meal	52-60	5-12	1-4	22-38
Prawn meal	58-65	4-7	4-7	21-26
Prawn head meal	34-45	4-7	11-18	36-44
Squilla	37-40	4	-	23
Clam meal	40-58	6-12	-	5-9
Cuttle fish	67	5	1	12
Meat meal	44-52	8-11	2-4	24-31
Silk worm pupae meal	48-53	26-30	6-8	7-11

Mineral-vitamin supplement and binder (guar gum, cellulose, hemicellulose, and synthetic binder) are the other essential ingredients generally used for formulation of aquafeed.

Feed Formulation

Before proceeding with formulating a feed, the ingredients are to be selected from available sources. No single ingredient can be expected to provide all the nutrient requirement. Each ingredient in the diet should be included for a specific reason i.e., either to supply a specific nutrient or physical property to the diet. Formulation of a feed by the nutritionist is only the beginning of a process that ends when the feed is finally consumed. Feed formulation is essentially a recipe making process keeping in mind the nutritional requirement of particular species, palatability and growth promoting ability of that feed. These objectives can be achieved by judicious selection of feed ingredients, mixing them in proper proportion and presenting them in a most acceptable form.

The basic technique used in ingredient selection is through "Least cost" or "Best buy" calculations

Least-cost or Best-buy technique

The price of the feedstuffs used in diet formulations must be considered to formulate a cost-efficient diet. Feedstuffs can be compared with one another on the basis of cost per unit of protein, energy, or amino acid. The cost of protein is often the greatest part of the cost of a fish diet. Therefore, substantial savings can be made by using best-buy techniques to determinate least expensive protein supplement.

When several feedstuffs are available to supply a particular nutrient then it is useful to calculate the cost per unit of nutrient from each of the ingredients and compare.

Example: If soybean cake costs Rs.43/kg and contains 45 % protein-

Cost/ kg protein = 43/0.45 = Rs.95.50

Ground nut cake costs Rs. 36/kg and contains 40 % protein

Cost/kg protein = 36/0.40 = Rs.90.00

Thus, although soybean cake contains higher level of protein, the cost per kg protein from ground nut cake is less. Therefore ground nut cake is a better buy.

To compare feedstuffs on the basis of cost per unit of an amino acid, one can calculate the best buy in the same way as before.

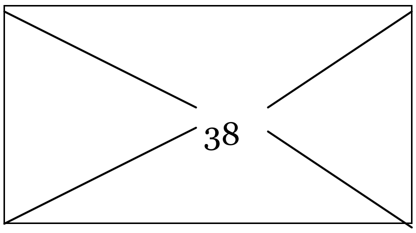
For example, sesame oil cake which has twice as much methionine content as does groundnut cake on a per unit protein basis would be a more attractive buy at comparable prices. These kinds of comparisons are only valid if the nutrient in one feedstuff is as valuable or available to the animals as the same nutrient in another feed. Such comparisons should be made whenever prices charge.

Balancing nutrient levels

In most animal diets, protein is the most expensive portion and is usually the first nutrient that is computed in diet formulation. The energy level of the diet is then adjusted to the desired level by addition of high energy supplements which are less expensive than protein supplements. The square method is an easy way to determine the proper dietary proportions of high and low protein feedstuffs to add to a feed to meet the dietary requirement of the animal to be fed. The protein in the diet can be adjusted by following Pearson's square method. For example to prepare a diet with 38% protein using soybean meal (CP – 45 %), fish meal (CP-55%) and wheat flour (CP-10 %), ingredients are to be divided into two groups- Group A- protein rich ingredients (soybean meal and fish meal) and group B- energy rich ingredient (wheat flour). Mean protein percent has to be calculated from both the groups. A square is constructed first and the names of the feed groups are written on the two left corners along with the mean protein content of each group assuming that under each group ingredients are mixed in equal proportion. The required protein level of feed is written in the middle of the square. Next, the protein level of the feed is subtracted from that of the ingredients and answer is placed ignoring the positive or negative sign.

Group A (CP-50 %) Group A 28

Soybean meal : Fish meal (1:1),
Mean protein=(45+55)/2=50 %



Group B (Wheat flour-CP-10 %) Group B 12

40

Add the figures on the right hand side of the square, i.e., 28+ 12 = 40

Now to make the feed with 38 % protein we should mix

Group A ingredients- 28/40 x 100 = 70 %

So, Soybean meal to be mixed- 70/2= 35 %

Fish meal to be mixed- 70/2 = 35 %

Group B ingredient i.e wheat flour - 12/40 x 100 = 30 %

The square method is helpful to novice feed formulators because it can get them started in diet formulation without the need to resort to trial and error. The square method can also be used to calculate the proportion of feed stuffs to mix together to achieve a desired dietary energy level as well as a crude protein level. The square method cannot be used to simultaneously solve for both crude protein level and ME level.

Types of farm made feed

Farm made feed may be of different types viz. mash feed, semi moist feed and dry pellet depending on the facility available with the farmer and species to be cultured. As shrimp is slow eater, farm made pellet feed needs to be used for shrimp culture.

Farm made pellet feed preparation

For preparation of farm made feed the following methods is to be followed-

STEP 1-Grinding: Use finely ground ingredients of similar particle size. Dissimilar sizes results in an unstable pellet. Individual ingredients should be ground using a hammer mill, or other type of grinder or even a mortar and pestle. A sieve can also be used to remove large particles or foreign material like stones, pieces of metal etc that can damage machinery.

STEP 2-Weighing: Weigh or measure the feed ingredients as per the formula. Take particular care when weighing micro-nutrients (vitamin and mineral premixes) as these are used in very small quantities and are very expensive.

STEP 3-Mixing: Mix all the ground ingredients thoroughly by hand except vitamin and mineral mixture. If large batches are to be prepared, the dry ingredients can be mixed in a horizontal mixer or even in a cement mixer. Poor mixing will result in variation of daily nutrient intake. Good mixing can also improve palatability.

STEP 4. **Mixing of oil:** Add the oil and then mix for at least another five minutes. To ensure oil is well mixed throughout the ingredients, it is useful to warm the oil or make an emulsion with warm water. Mix with dry ingredients slowly.

STEP 5- Addition of water: Add water and mix well to form a mash with a cake-like consistency. Water should be added slowly and small test batches of the mixture extruded through the pellet machine (mincer) to see how easily the mixture passes through the die and how the pellets hold together. As a general rule, the total moisture content of the mash should be in the range of 45 to 55% to produce good pellets. If moist ingredients like trash fish, minced poultry etc are used, less moisture will be needed (e.g. 25-45%). Adjustments must also be made depending on the type of binders, if any, are used.

STEP 6-Steam cooking: Cook the mixture in an idly cooker or in a big container at 100^{o}C temperature for 5-10 minutes. Take out and cool the feed mixture. Steam cooking will gelatinize the starch and also sterilize the feed mixture.

STEP 7-Incorporation of Vitamin-Mineral mixture

Mix vitamins and minerals with small amount (e.g. 10% of total batch) first then blend into larger mixture (to help ensure the vitamins and minerals are evenly distributed within the mixture). Vitamin and mineral mixture may be added with dry ground ingredients before steam cooking, but, in that case heat labile vitamin will be destroyed during cooking.

STEP 8- Pelletisation: Pass the feed mash mixture through a pellet machine (mincer) with a 1, 2, or 3 mm die depending on the size of the fish that is being fed. Cut the pellet (which look like noodles) into similar lengths to the closest pellet diameter (i.e. 2 mm long for 2 mm diameter pellets for fish). Pellets can be cut off with a knife during extrusion or broken into smaller lengths after they have been dried.

STEP 9- Drying: The moist pellets should be dried to a moisture content of 10% or less. Ideally, this should be at low temperature (less than 60 ^{o}C) and with good airflow to dry the pellets as quickly as possible to ensure that heat-sensitive micronutrients such as vitamins are not destroyed. This can be achieved using:

• A fan-forced oven (e.g. set at <60 ^{o}C) for several hours,
• A simple drying cabinet (with hot air supplied by a heater blower),
• A solar dryer or
• Simply by spreading the pellets in the sun.

It is most important to prevent fungal contamination and to avoid an excessive loss of critical nutrients when drying pellets. Fungus can be toxic to fish and to the humans who handle the feed.

Checking quality of feed: Dried pellet feed should be physically examined for visual appearance such as uniformity, color and smell. The pellet should have surface without cracks. Feed may be sampled and analyzed for proximate composition. Water stability of the pellet may also be tested after 24 h of preparation.

Step 10-Storage: When pellets are dry and cool they should be stored in bags or containers that can be sealed against insects, rats or other pests and to keep out moisture. Avoid using plastic bags because feeds can sweat and this encourages growth of mould. Farm made feed should not be stored for long time. Freshly prepared farm made feed should be fed to fish.

Advantage of farm made feed

- Feed formulae may be diverse as per availability and cost of ingredient
- Feed cost can be minimized
- Farmers can prepare the feed at their farm itself and feed their animal a fresh feed.
- Loss of vitamin and mineral during preparation can be minimized.

Drawbacks of farm-made feed

- Poor water stability of feed which may pollute pond water if not consumed by fish immediately after offering.
- Quality of raw material varies hence nutrient composition of feed will vary.
- Digestibility of farm made feed may be inconsistent.
- Large scale aquaculture with farm made feed is not feasible.

The adoption of inappropriate feeding strategies and the inadequate monitoring of feed usage can result in feed wastage that negatively impacts production parameters. Correct delivery of food is important to reduce feed waste. Underfeeding can result in loss of production while overfeeding results in feed wastage and can lead to deterioration in water quality. A serious decline in water quality can result in loss of stock.

******

9 Common shrimp diseases and their management

R. Ananda Raja* and K. P. Jithendran*

**Central Institute of Brackishwater Aquaculture, Chennai*

Introduction

Aquaculture is growing by leaps and bounds with an annual growth rate of 4.5% and the overall contribution of 0.75% to the total GDP in the country. It is one of the world's fastest growing industries in food production. In aquaculture, shrimp plays a pioneer role being the best export commodity. In India, shrimp species such as *Penaeus monodon*, *Fenneropenaeus indicus* and *Litopenaeus vannamei* (since 2009) are majorly cultivated for indigenous and export market. Due to good profit and short duration of culture, many farmers venture in to shrimp aquaculture. The intensive shrimp aquaculture has parallely brought disease problems leading to great economic loss. Generally, diseases are broadly classified in to infectious and non-infectious. Former is caused either by virus, bacteria, fungi, parasites and/or rickettsia while later is due to environmental stresses, genetic factors and nutritional deficiencies. Diseases may be caused by a single or combinations of multifarious factors. This chapter is aimed at highlighting the common shrimp diseases and their management.

I. Viral diseases

i) Monodon baculo virus (MBV) disease

MBV is associated with high mortalities in shrimp hatchery infecting all life stages except eggs and nauplii of *Penaeus monodon*, caused by Type A baculo dsDNA virus first reported in Taiwan during 1983 and in India during 1995. It infects other penaeid species also. But the virus does not infect *Litopenaeus vannamei*, *P. stylirostris* and *P. californiensis*. It is transmitted by ingestion of free virus and occlusion bodies, and by cannibalism. It is also believed to be transmitted vertically from broodstock to offspring, but not yet been proven. It is severe in postlarvae with over 90% cumulative mortalities and senescent in adults. Clinically, sudden onset of mortality in the early life stages reduced feeding and growth rates, and an increase in gill and surface fouling. Severely infected prawns may display a whitish hepatopancreas and midgut since the virus is strictly enteric infecting epithelial cells of the hepatopancreas tubules and the anterior midgut. Persistent infection occurs commonly in penaeid hosts of MBV. Wet mount microscopical examination reveals large, single or multiple, roughly spherical, eosinophilic, polyhedral intranuclear occlusion bodies (OB's) in squash preparations of hepatopancreas and feces when stained with 0.05% aqueous malachite green.

ii) White spot disease (WSD)

It is an acute, infectious disease of shrimp, caused by a large, ovoid, bacilliform, non-occluded enveloped dsDNA virus belonging to the family *Nimaviridae* (Nima: In Latin, means thread) and genus *Whispovirus* consisting of thread-like polar extension. The virus is inactivated in <120 minutes at 50°C and <1 minute at 60°C and is viable for at least 30 days at 30°C in seawater under laboratory conditions and is viable in ponds for at least 3-4 days. The virus is viable and infective up to 19 and 35 days in pond sediment despite sun-drying and in water-logged conditions, respectively. It infects all life stages of decapod crustaceans of marine and brackishwater sources. The virus infects ectodermal and mesodermal tissues, especially the cuticular epithelium and subcuticular connective tissues. Both vertical and horizontal transmission is reported. Clinically, the disease is characterized by lethargy, inappetence, crowded at pond margin, red to pink discoloration of the body, loose cuticle, swelling of branchiostegites, broken antennae, damaged appendages, and the most conspicuous feature of small to large white spots on the inner side of the carapace which spread all over the body in advanced infection. Cumulative mortalities in infected populations may reach 100% within 3 to 7 days of the onset of clinical signs. Histologically, degenerated cells are characterized by hypertrophied nuclei with marginated chromatin and eosinophilic to basophilic intranuclear inclusions.

iii) Infectious hypodermal and haematopoietic necrosis (IHHN)

The disease is caused by ssDNA virus of family *Parvoviridae*. In *L. vannamei* it causes the chronic disease called runt deformity syndrome (RDS) characterized by lower overall crop production, shrimp with increased size variability, and cuticular deformity. Infected shrimps have been observed to rise to the water surface, remain motionless for a few moments then roll over and sink to the bottom. This behavior may be repeated until mortality occurs. In juvenile *P. stylirostris,* more than 90% mortality reported within several weeks of onset of infection. Gross signs of infection include white to buff mottling of the cuticle, opacity of striated muscle and melanized foci within the hypodermis. In the later stages of infection *P. stylirostris* and *P. monodon* may appear bluish in color. Infected *P. vannamei* display deformed rostrums, cuticle and antennal flagella. IHHNV forms Cowdry Type A intranuclear inclusion bodies (IB's) associated with widespread cytopathological changes including hypertrophy of the nucleus and margination of the chromatin in cells of ectodermal (epidermis, gills, fore and hind gut, antennal gland and neurons) and mesodermal origin (hematopoietic tissue, haemocytes, striated muscle, heart, lymphoid organ and connective tissues).

iv) Hepatopancreatic parvovirus (HPV) disease

Hepatopancreatic parvo virus is an ssDNA virus. High levels of HPV infection occurs in early juvenile stages result into slow growth which finally stops to grow at approximately 6 cm in length. Horizontal transmission occurs by cannibalism and vertical transmission by infected broodstock. Microscopically, single prominent basophilic intranuclear inclusion bodies in the hypertrophied hepatopancreatic epithelial cells are seen.

v) Infectious myonecrosis (IMN)

Infectious myonecrosis (IMN) is a recently identified viral disease caused by dsRNA infectious myonecrosis virus (IMNV), a putative totivirus. IMNV particles are icosahedral in shape and 40 nm in diameter. It causes mortalities in juvenile and sub adult pond-reared stocks of *L. vannamei* and the mortality range from 40 to 70%. Outbreaks of the disease seems to be associated with certain types of environment and physical stresses (i.e. extremes in salinity and temperature, collection by cast net, etc.), and possibly with the use of low quality feeds. Experimental infection is observed in tiger shrimp, *P. monodon* and blue shrimp, *P. stylirostris*. IMN affected shrimp presents focal to extensive white necrotic areas in the striated (skeletal) muscle, especially of the distal abdominal segments and tail fan, which can become necrotic and reddened in some affected shrimp. By histopathology, shrimp with acute phase disease presents lesions with coagulative necrosis of skeletal muscle. In shrimp recovering from acute disease or those in the more chronic phase of the disease, the myonecrosis appears to progress from coagulative to liquefactive necrosis accompanied with haemocytic infiltration and fibrosis. Significant lymphoid organ spheroid formation is typically present, and ectopic lymphoid organ spheroids are often found in the hemocoel and loose connective tissues, especially in the heart lumen and adjacent to antennal gland tubules. In some histological preparations, perinuclear pale basophilic to dark basophilic inclusion bodies are evident in muscle cells, connective tissue cells, haemocytes, and in cells that comprise lymphoid organ spheroids.

vi) Yellow head disease (YHD)

Yellow-head disease is first noted by Limsuwan in cultured *P. monodon* adults in central Thailand during 1991. It appears to be widespread in cultured stocks of *P. monodon* in South-East Asia and India. It is caused by ssRNA virus of genus *Okavirus*, family *Roniviridae* of the order *Nidovirales*. Contaminated water, cannibalism of weak or moribund shrimp, animate vector, net and other equipment transmit the disease. Vertical transmission has not been reported. Shrimps with YHD display yellow coloration of the dorsal cephalothorax caused by the underlying yellow hepatopancreas showing through the translucent carapace. Within the ponds, infected animals, usually between 5 and 15 g, begin consuming feed at an abnormally high rate for several days then cease feeding entirely. One day after cessation of feeding, moribund shrimps may be seen swimming slowly near the edges of the pond. By the third day, mass mortality occurs and the entire crop is typically lost. Histologically, moribund shrimps suffering YHD usually have extensive abnormalities in the lymphoid organ. These include foci of necrotic cells which resemble degenerate tubules with occluded lumens and contain cells with hypertrophied nuclei, pyknotic nuclei, large vacuoles and cytoplasmic, basophilic, Feulgen-positive inclusions. Similar inclusions may also be found in the interstitial tissues of the hepatopancreas, connective tissues underlying the midgut, cardiac tissues, haematopoietic tissues, haemocytes and gill tissues.

vii) Monodon slow growth syndrome (MSGS)

MSGS is a condition of *P. monodon* cultivation ponds characterized by abnormally slow growth and coefficients of size variation greater than 35 per cent. It is assumed to be caused by Laem-Singh virus (LSNV). It is a positive-sense ssRNA virus measuring 25 to 30 nm, first identified in Laem Singh Province in Thailand during 2003. The virus is observed in the lymphoid organ, heart and other tissues of the affected shrimps. The major lesion observed is retinopathy. Retinopathy comprises abnormally enlarged haemolymphatic vessels, haemocytic infiltration and rupture of the membrane that separates the fasciculated zone from the overlying row of retinular cells. By transmission electron microscopy (TEM) and *In situ* hybridization (ISH), LSNV is detected in the fasciculated zone and in onion bodies of the organ of Bellonci in the affected shrimp. It suggests that retinopathy associated with LSNV may be linked causally to stunting of *P. monodon* in MSGS.

viii) Taura syndrome (TS) / Red tailed disease

It is caused by a non-enveloped, linear, ssRNA virus called Taura syndrome virus belonging to the family *Dicistroviridae*. TS is widely distributed in the shrimp-farming regions of the Americas and South-East Asia. Both horizontal and vertical transmission is reported. During the preacute/acute phase of infection, shrimps appear pale red while their tail fans become bright red. They are soft shelled, lethargic and anorexic. Those with severe infections die during moult and cumulative mortalities may reach 80-95%. Recovering, chronically infected shrimps generally display multifocal, melanized cuticular lesions and may also have soft cuticles and red body coloration with normal feeding. Microscopically, Feulgen-negative inclusion bodies, which may first appear eosinophilic then change to basophilic, observed in the cytoplasm of cells in areas of necrosis.

ix) Loose shell syndrome (LSS)

LSS has been reported in India from farmed black tiger shrimp *P. monodon* since 1998 and is recognized as a major disease problem next to WSD causing significant economic loss. It is caused by a filterable infectious agent. It causes low-level progressive mortalities unlike the rapid mortalities associated with viral pathogens such as WSSV and YHV. The clinical signs include a flaccid spongy abdomen due to muscular dystrophy, space between the exoskeleton and muscle, and shrunken hepatopancreas with reduced feed conversion efficiency and poor meat quality. Histologically, LSS-affected shrimp shows shrinkage of extensor and flexor muscles with occasional haemocytic infiltration, inflammation of hepatopancreatic tubules with enlargement of intertubular spaces and haemocytic infiltration, and low levels of lipid reserves in the R cells. In advanced stages, many tubules are in highly necrotic condition with a sloughed epithelium, reflecting the dysfunction of the digestive gland.

II. Bacterial diseases

i) Vibriosis

It is a serious problem in shrimp hatcheries, intensively raised farm and pond culture stocks especially before the juvenile stage. Higher salinity, increased ammonia level in the culture environment, low dissolved oxygen, rise in temperature and higher stocking density are found to be predisposing causes for Vibriosis. The identified and reported pathogenic *Vibrio* spp. for shrimp and fish are *Vibrio harveyi, V. alginolyticus, V. parahaemolyticus, V. anguillarum, V. mimicus, V. fluvialis, V. splendidus, V. penaeicida, V. campbellii, V. carchariae, V. cholerae, V. damsela, V. ordalii,* and *V. vulnificus*. Characteristic luminescence is seen in severe *Vibrio* infection. Symptomatically the disease is associated with melanized cuticular lesions of the appendages and melanized nodules in the gills and other organs. Other major clinical signs such as disoriented shrimp swimming weakly, gathering along the edges of the pond, cloudiness of the musculature, red discoloration of the appendages and dorsal flexure at the third abdominal segment with slight rigidity. Fish eating birds gather and feed on the weakened shrimp. Haemolymph from moribund shrimp will fail to clot or will clot very slowly. Histopathological investigation of moribund shrimp reveals the presence of pathogens in different tissues.

ii) Fouling/black gill disease

Microbial colonization on the cuticle surface of penaeid shrimp and other crustaceans is a common occurrence in larvae, juveniles, and adult shrimp. Normally, the density of microorganisms attached to shrimp remains low without causing pathological changes. But, in poor management /culture conditions the increase in population of the fouling organisms can cause impairment of physiological functions of the host. A filamentous bacterium, *Leucothrix mucor* is the predominant bacterial fouling organism affecting shrimp culture. Sometimes *Vibrio* and other rod shaped organism also colonize cuticle surface. *Thiothrix* sp., *Flavobacterium* sp., *Flexibacter* sp., and *Cytophaga* sp. are the other related bacterial genera causing fouling. Usually, heterogenous mixture of filamentous and non-filamentous bacteria, blue green algae and protozoa (*Zoothamnium*) causes fouling and black gill. Disease occurs when there is abundant colonization on the gill lamellae, mouth parts and/or swimming appendages with respective physiological dysfunctions. Affected shrimps show slow growth rate associated with sporadic but persistent mortality.

III. Fungal diseases

i) Larval mycosis

Larval mycosis is the disease of penaeid hatcheries. The fungus *Lagenidium* and *Sirolpidium* are the responsible for larval mycosis. *Lagenidium* infections often occur in nauplial and protozoeal stages while the *Sirolpidium* disease is usually in the late protozoeal to mysis stage. Juvenile or older shrimp are not susceptible to fatal infection by the phycomycetes fungi, presumably because of thicker exoskeleton. Diagnosis of larval mycosis is based on microscopic demonstration of characteristic fungal mycelia that fills the body cavity of dying or dead infected larvae. The fungus can be grown on standard fungal media such as Sabouraud dextrose agar.

IV. Parasitic diseases

i) Protozoan infection

a) Endocommensal / Invasive protozoa

It affects muscle and causes **"milk or cotton shrimp disease"**. Shrimps are infected by ingestion of spores. The affected shrimp show cooked- muscle appearance and the exoskeleton appears bluish black, and white tumor-like swellings may be found on gills and subcuticle. The spores extrude a filament that penetrates the gut wall and deposits an infective unit which enters nucleus of the gut cells where schizonts are developed. The schizonts divide and develop to form spores which are located in muscles and other organs of the shrimp. The infected shrimp is infective to fish species and advice versa but not to the shrimp itself. The major genus under the order, ***Microsporidia*** are *Pleistophora* sp. (>8 spores / envelope), *Thelohania* sp. and *Agmasoma* sp. (8 spores / envelope). Order, ***Haplosporida*** affects the digestive glands of shrimp but the incidence is rare. Order, ***Gregarina*** affects the digestive tracts and other tissues of shrimp. Shrimps are infected by ingestion of spores. The developed sporozoites attach to the gut wall, grows in to trophozoites and form gametocysts. Gametocysts undergo multiple divisions to produce gymnospores which are released outside and be an infective stage for invertebrates such as clams, snails or marine worms. Spores are developed in the intermediate hosts and released in mucous strings which become infective to shrimps. The major genus involved are *Nematopsis* sp., *Cephalobus* sp. and *Paraophioidina* sp. Several protozoa invade the body and feed on tissues of weakened and diseased shrimps are called body invaders. They are *Parauronema* sp., *Leptomonas* sp and *Paranophrys* sp. and amoeba.

b) Ectocommensal protozoa

They are found on the gill and body surface of the shrimp. They are *Zoothamnium* sp., *Epistylis* sp., *Acineta* sp., *Lagenophrys* sp., *Ephelota* sp., and

Apostome ciliates. Special staining technique like silver impregnation staining is used for identification of *Apostome* ciliates. They cause **"protozoan fouling"** and **"Fuzzy mat-like appearance"** due to ciliate fouling. The affected shrimps show restless and difficulty in locomotion and respiration.

ii) Metazoan parasites / Helminthiases

Metazoan parasites in shrimp are categorized as Trematodes, Cestodes, and Nematodes. Immature forms and adult worms are found in the different parts of the body in shrimps.

(a) Trematodes (flukes)

The cercarial forms of the flukes are infective to the shrimps. The cercaria penetrates the shrimp and encysted in the form of metacercarial forms in tissues which are infective to the first intermediate host (fish). The metacercaria develops in to adult and release eggs. Eggs are hatched out and miracidia released which penetrate second invertebrate host, snail and develops in to sporocysts. Cercariae develop inside the sporocysts in second intermediate host and released in to water which become infective stage for shrimp. Eg. *Opecoeloides fimbriatus*, *Microphallidae* sp. and *Echinostomatidae* sp.

(b) Cestodes (tape worms)

Shrimp ingest copepods or other crustaceans with larval form of tape worm which develop in to advanced larval stage in shrimp. The advanced larval stage enters the first intermediate host (sting ray) by ingestion of the infested shrimp and develops in to adult and release eggs. The eggs are eaten by copepods, second intermediate host and develop in to larvae which are infective to shrimps. Eg. *Prochristianella penaei*, *Parachristianella* sp., *Renibulbus* sp., Pear shaped worms, and Cyclophyllidean group.

(c) Nematodes (round worms)

Shrimp ingest copepods or other crustaceans with larvae which develop in to advanced larval stage in shrimp. The advanced larval stage enters the first intermediate host (toad fish) by ingestion of the infested shrimp and develops in to adult and release eggs. The eggs are eaten by copepods, second intermediate host and develop in to larvae which are infective to shrimps. Eg. *Spirocumallanus pereirai*, *Leptolaimus* sp., *Ascaropsis* sp., and *Hysterothylactum reliquens*.

iii) Other infestations

Single cell plant diatoms (on larvae), Over growth of algae of mixed variety, barnacle, leeches, colonial hydriod *Obelia bicuspidata*, insects eggs, Isopods -*Aega* sp. are occasionally observed among wild and poorly farmed shrimp populations. Bopyrid parasitic infestation caused by *Epipenaeon* spp. belonging to family *Bopyridae* which are lodged in the brachial cavity leads to impaired respiration and reproductive failures.

Diagnosis

The correct diagnosis is obviously a critical step in any control program. The available diagnostic methods that may be selected for diagnosis of the shrimp diseases or detection of their etiological agents are based on:

1) Anamnesis, gross and clinical signs.
2) Direct bright-field, phase-contrast or dark-field microscopy with whole stained or unstained tissue wet-mounts, tissue squashes, impression smears, haemolymph smears and wet-mounts of fecal strands as per the requirements.
3) Post mortem findings.
4) Histopathological and histochemistry findings.
5) Isolation and identification of the causative agents.
6) Bioassays of suspected or subclinical carriers using a highly susceptible host as an indicator.
7) Transmission or Scanning Electron Microscopy (TEM or SEM).
8) Antibody-based tests for pathogen detection using polyclonal antibodies (PAbs) or monoclonal antibodies (MAbs).
9) Molecular methods.

Prevention and control

The disease prevention and control strategy is the best practice for successful hatchery and grow out culture practices in shrimp industry. Quarantine measures should strictly be adopted to import broodstock to avoid entry of existing or emerging pathogen. Extensive cannibalistic nature of shrimp warrants removal of the moribund shrimp from the pond to avoid 100% mortality during the outbreak of any infectious diseases. With good management practices and less stress to the animals, there are many reports of successful harvest even in the presence of dreadful disease causing pathogen WSSV. So, some of the salient points to be followed in disease prevention strategy are discussed as follows.

1) Ponds should be dried before starting the culture.
2) Strict biosecurity measures to be adopted.
3) Sieve should be used at water inlet and the water should be bleached before stocking to weed out wild shrimp, fishes and intermediate hosts.
4) Good water quality should be maintained through out the culture.
5) Zero water exchange or minimal water exchange from reservoir ponds.
6) Disease-free stock should be used from good genetic strain of broodstock.
7) Development and use of disease resistant stocks will help in prevention of catastrophic disease out break and loss.
8) Coastal Aquaculture Authority (CAA) guidelines should be followed for optimum shrimp stocking density in grow out culture system.
9) Quarantine measures should strictly be adopted to import broodstock to avoid entry of existing or emerging pathogen.
10) Adequate balanced good nutrition to be made available to avoid problems associated with cannibalism and horizontal spread of diseases.
11) Proper destruction and disposal of infected as well as dead animals to be regularly monitored.
12) Animals should be handled with good care to avoid unwanted stress.
13) Proper chemical prophylaxis and vaccine development is needed for immunological protection.
14) Regulations are required to prevent transfer of pathogens from one host population to another, nationally or internationally.
15) Sanitation and disinfection of hatchery and equipments are to be strictly followed.

Conclusion

Etiological identification plays the key role in disease treatment, prevention and control. Many times it becomes too much complicated to identify the specific etiological factor by virtue of complexity of the aquaculture system. The dictum prevention is better than cure should be the main objective of aquaculture.

For further reading

Alavandi, S.V., Babu, T.D., Abhilash, K.S., Vijayan, K.K., Kalaimani, N. and Santiago, T.C. (2008). Loose shell syndrome of farmed *Penaeus monodon* in India is caused by a filterable agent. *Dis. Aquat. Org.* 81: 163-171.

Ananda Raja, R., Panigrahi, A. and Sujeet Kumar. (2012). Epidemiological investigation of brackishwater culture systems in West Bengal, India, *J. Appl. Aquaculture,* 24 (1): 49-59.

Flegel, T.W. (2006). Detection of major penaeid shrimp viruses in Asia, a historical perspective with emphasis on Thailand. *Aquaculture*, 258: 1-33.

James A. Brock and Brad LeaMaster. (1992). A look at the principal bacterial, fungal and parasitic diseases of farmed shrimp. Proceedings of the Special Session on Shrimp Farming. *World Aquaculture Society*, Baton Rouge, LA USA.

Satheesh Kumar, S., Ananda Bharathi, R., Rajan, J.J.S., Alavandi, S.V., Poornima, M., Balasubramanian, C.P. and Ponniah, A.G. (2013). Viability of white spot syndrome virus (WSSV) in sediment during sun-drying (drainable pond) and under non-drainable pond conditions indicated by infectivity to shrimp. *Aquaculture,* 402-403: 119-126.

******

10 Harvest and post-harvest management of farmed shrimp

Ashutosh D Deo, M.Jayanthi, Shyne Anand P.S. and C.P.Balasubramanium**

Kakdwip Research Centre of CIBA, Kakdwip, West Bengal

**Central Institute of Brackishwater Aquaculture, Chennai*

1. Introduction

Harvest and post-harvest management are the final phases of any shrimp culture operation. Shrimp are most commonly grown in earthen ponds 4 to 5 feet deep that range in size from less than an acre to few hectares. Farmers routinely monitor shrimp size and condition and estimate survival by capturing live shrimp throughout the growing season. As harvest time nears, samples should also be checked for their quality and safety for human consumption. The return from the culture operation depends on the quantity of shrimp harvested and that of marketing on the quality achieved.

2. Harvest procedures:

In the traditional shrimp culture practices harvest is carried out by nets, bamboo-screen traps and complete draining of pond water and subsequent hand picking. In some of the developed country harvesting of shrimp is accomplished by mechanically driven drag nets.

Ponds are generally harvested by draining water and shrimp into a net or catchment basin located outside of the pond dyke. The pond is usually drained through a screened barrier to approximately 30 percent of its operating volume two days before harvest. A more rapid draining or merely fluctuating water levels, can induce molting and cause an unacceptably high percentage of soft-shell shrimp. Final harvesting is usually begun in late afternoon and completed at night or early morning hour when water temperature is cooler and bird predation is minimal. When the water level in the culture pond is two feet deep, drag net can be operated. However efficacy of nets depends on the organism under culture. In the bheries of West Bengal during low tides traps made of bamboo are placed in the bottom of the pond near the sluice gate to catch the cultured shrimp.

Better Management Practices for Harvesting and Post harvesting:

To retain the freshness and quality and without muddy smell in the cultured shrimps, the following criteria are suggested.

Harvest:

1. 5-7 days before harvesting make sure pond bottom is clean without any dirty area. Removal of algae and keeping the bottom of pond free from unwanted materials are to be performed.
2. If heavy bloom is present frequently exchange the pond water to remove algal water.
3. Avoid harvest during molting period (full moon or new moon).Two days before harvest check if there are any newly molted shrimp, if newly molted shrimp are more than 5-10%, delay the harvest by 2-3 days. Do not exchange water or reduce water level 3 to 4 days before harvest
4. Apply LSP (200 kg/ha) 3-4 days before harvest in to the pond and specially in feeding zones.
5. Do not feed the shrimps 6 hours prior to the harvest, in order to keep the stomach empty, this improves the shell life.
6. During the harvesting maximum suspended particles are likely to be released into the open waters. Hence great care should be taken to prevent such a release.
7. Draining of water and harvest should be completed within 6-8 hours, mostly between 6 P.M. and 6 A.M.
8. Harvesting can be done by completely draining the pond either by gravity or through pumping and hand picking or trapping.
9. Use more pumps if necessary to complete the harvesting at a stretch.
10. Harvest and packing of shrimps should not be done during hot days.
11. Usage of bag net in knee-deep water will catch more shrimps than cast net.
12. Wherever, the complete draining is not possible, lead screens may be fixed in deeper areas of the pond, which will guide the shrimps towards the bag net from where shrimps can be collected.
13. The water drained out for harvesting should be pumped into the effluent treatment ponds and kept for a few days for settlement before releasing into the open water.

14. Icing with good quality ice made up of potable water should be done immediately and liberally after harvest.
15. If refrigerated van facility is not available for prolong transportation the shrimps should be beheaded and stored in ice to prevent spoilage.
16. Marketing facilities for small farmers should be provided by forming farmers' co-operative/ associations/SHGs to avoid monopoly of a few processors.

Post-harvest handling:

1. Shrimps harvested by bag net and hand-picking should be separately kept. Hand-picked shrimps should be thoroughly washed and packed separately.
2. Clean water should be used for washing shrimps and ice made up of potable water should be used for packing.
3. The washed shrimps should be immersed in slurry of ice for not less than 15 minutes, which enhances freshness of shrimps and increasing their weight by 5 %.
4. Do not, use any chemicals while, washing the shrimps or chill killing without knowledge of processors .
5. Harvested shrimps can be packed in plastic crates with crushed ice at 1:1 ratio (i.e. 1 kg of shrimps versus 1 kg of ice) for better preservation. Adequate use of ice will ensure fast chilling of shrimps.
6. Before stacking the packed plastic crates one above the other, the cleanliness of the bottom of each crates should be ensured.
7. The packed tubs should reach the processing plants quickly without any delay, which will ensure better quality

Conclusion:

Following BMP increases the efficiency and productivity by reducing the risk of shrimp health problems. It also mitigates the impacts of farming on the environment. At the same time it ensures improved food safety and quality of farmed shrimp ultimately social acceptability and sustainability.

******

11

Group approach for sustainable coastal aquaculture

M.Kumaran* and P. Ravichandran*

**Central Institute of Brackishwater Aquaculture, Chennai*

Introduction

'If we are serious about fostering the external forces to make research organizations client-driven rather than research-driven, investments will have to be made in developing local farmers associations'(Bebbington et al., 1994).

Coastal aquaculture is important farming system in the coastal agro-ecosystem providing livelihood to about one million people directly and indirectly through allied activities. Since time immemorial aquaculture has been practiced as 'trap and rear' of fishes in the tide fed ponds with out any external inputs known as *Bheries* in West Bengal, *Pokkali* fields in Kerala, *Khazan* lands in Goa and Karnataka by the coastal community as a livelihood activity. Commercial export driven monoculture of high value shrimp farming came in to existence during late 80s due to scientific advancements and policy interventions. Today, coastal aquaculture is synonymous with monoculture of shrimp which is being practised in about1.4 lakh ha with an annual production of 1.4 lakh tonnes mostly operated by small scale farmers with a holding of less than 2 ha. However, in Kerala and west Bengal both traditional (in 40,000 ha) and scientific aquaculture systems have been practiced. The small scale farmers were unorganized and most of the farmers did not have access to technological innovations and scientific applications. They contribute around 80% to the total shrimp production, but were poorly served. Small-scale farmers are innovative and productive, but because of poor organization, lack of skills, inadequate information, and knowledge base, they are vulnerable to the numerous risks and hazards that impact their livelihoods, farm productivity, and competitiveness.

Phases of shrimp aquaculture development in India

Indian shrimp culture has passed through three distinct phases. The '*bloom phase-I'* (late eighties to 1995) wherein a sense of competitiveness prevailed among the farmers in a given locality. The farmers maintained 'at most secrecy' in all farm operations to produce more shrimp and make huge profits in just about four months of crop period. The *'falling phase-II'* (1995-2001) witnessed the pervasion of virulent viral diseases, particularly the 'White Spot Syndrome Virus' (WSSV) which brought the shrimp aquaculture to chaos mainly due to greediness for high production, 'self pollution' due to poor farm management, negligence and lack of cooperation among the shrimp farmers. Nevertheless, as a blessing in disguise this disaster made the shrimp farming a self mature and more responsible farming regime despite colossal losses and legal interventions. The 'sustainable phase-III' (Since 2002) facilitated with interventions from research and development institutions educated the farmers to be open to their fellow farmers to the extent that one's success is dependent on his neighbour's success too. Market forces (price, quality, traceability etc) and economics had also strongly influenced them to look for collective actions.

Evolution of group approach in shrimp aquaculture

This attitudinal change of 'neighbour also should be safe' is mainly due to the self-realization that if you want to be successful your neighbour should also be safe and cooperative. This has been the major reason (50%) for farmers joining together for collective management of shrimp farm clusters. Secondly, anti-shrimp farming campaign, legal and other socio-economic threats were also a significant cause for coming together of farmers (25%). Thirdly the intervention by development agencies especially the MPEDA to educate the farmers on group approach by mobilising the farming community for collective action and adoption of better management practices (from seed to shrimp – Phase - IIII) has also come as handy for some areas to become united and form a group/association to have a platform to 'communicate' effectively with other key stake holders (25%). Experiences have amply proved that aqua farmer groups, as an effective institution, ensure responsible and sustainable aquaculture development, empowered farmers through collective decision making, offered opportunities to link with markets and ensured social, environmental and food safety responsibilities, could take care of farm extension service too and guarantee sustainability of the shrimp farming in the long run.

Kinds of shrimp farmer groups exists

Two kinds of aqua farmers groups based on the locale they operate are observed in shrimp aquaculture. They are creek and area based. The creek based associations were also of two types, farmers association established by the farmers themselves i.e self initiated (internal facilitation) and farmers societies mobilised by public extension agency (NaCSA) (external facilitation). The area based associations also self initiated in a neighbourhood to safeguard farmers interest against their potential problem makers (social, legal issues) and to exchange information among them. Area centric associations prevalent along the sea coast where every farm is independent of the other and directly lifted the required saline water from the sea. In case of creek based associations the farms located along the creek on both the sides have to lift water from the creek or from the sub-canal developed collectively and drain the water in a common drain if available. Hence, in a strict sense, group farming concept applicable only to the creek based associations. Among the creek based farmers associations, self initiated associations are the time tested and being in operation for a longer time (5-15 years) while the societies promoted by public funded promotional/extension agency are of hardly one to two years old. Further, in the self initiated farmers association all the farms operating in the cluster are compulsory members of the association and the collective decisions are binding on every body. However, in case of NaCSA facilitated societies only 20-25 nearby farmers are organised into a group and mostly it comprises of small farmers who had one or two hectare of farm. Remaining farms operating in the same cluster are not part of the association and hence they are independent. Cluster aquaculture which depends on a common water source is possible only when all the farms in the creek are involved, however, in the facilitated clusters this approach is missing.

Steps in mobilising and organizing farmer groups

A synthesis of studies published on farmer groups have identified the following are general steps to be followed in mobilising and organizing producer groups.

Step 1. Understanding the village community, structure and composition

Step 2. Understanding the present level of farming, production practices, constraints

Step 3. Identification of key informants and potential leaders in the community

Step 4. Liaison with the identified leaders and seeking cooperation from other agencies

Step 5. Facilitate local farm leaders to call community meetings

Step 6. Identifying core group members to frame guidelines and establish the farmer group

Step 7. Developing an organizational structure for the farmer group

Step 8. Provision of legal status to the group through registration as per law

Step 9. Developing the farmer group management through education and action learning

Step 10. Gearing up for collective action

Step 11. Implementing collectively identified activities at the community

Step 12. Monitoring and evaluating the group progress

The success of the farmer organization can be evaluated by measuring the increase in the members' productivity, the increase in their net income, and the net reduction in the cost of cultivation due to bulk purchases of inputs, collective compilation of practices and access to premium markets. The group core committee should have scheduled meetings to conduct monitoring and periodic evaluations the activities of the group.

Assessment of shrimp farmer group

In the case of shrimp aquaculture compulsory membership, collective farm management, group operation management and interaction with other stakeholders are the criteria on which the farmers groups need to assessed for its effectiveness. Compulsory membership of all the farms operating in the cluster is an absolute critical factor for a group to be successful. It is very essential that the FO should ensure that all the farms using the same water source within its boundary ought to be governed by the FO and all should be its members. Considering the nature of farming system and everyone’s dependence on the same water source compulsory membership is fundamental for a society to satiate the sprit with which it is evolved. An effective farmer group should have full membership and its decisions are binding. The structure and composition of associations and societies differ between them. Mostly the office bearers were nominated by consensus and it is purely honourary. First meeting the GB, most of the members participated. Subsequent meetings are to be organised whenever required during the culture period. In the first meeting prior to beginning of culture operations, the dos and don’t s are to be discussed and written as a minutes and signed by all the farmers. The issues are discussed and finalised collectively by consensus. Once the decision is agreed it is to be complied and no incidences of non-compliance reported. Since most of the farmers belonged to the same or nearby villages in majority of the associations should maintain cordial relations with every body. The farmer groups should help in developing and maintaining infrastructure like road for the villages and fishermen in their neighbour hood. Associations should have negotiation power with hatcheries and buyers for a better seed and price respectively. Public and private developmental institutions should consider the farmer group as the representative of the farming community.

Group cohesiveness and its determinants

Group cohesiveness is the degree to which the members 'own and belong' to the group and it is the determining factor for the group effectiveness. The following are the determinants of group cohesiveness.

- Size of the farmers group/association
- Homogeneity of group members (same village, community etc.)
- Accountability of the group members to the collective decisions
- Key functions of the group/association
- Presence of dynamic and balanced leadership in the group
- Group's capacity to deliver as perceived by the members
- Age of the group
- Sense of 'owning the group' by the members
- Achievement of group's objective and its consistency
- Equality of all members irrespective of farm holdings etc.,
- Functioning of the group as per the norms decided collectively
- Members participation in group decision making
- Compulsory membership–all the farms are absolute members of the group
- Conviction of the members that group action alone ensure success to everybody
- Accessibility of meeting venue every member
- Timings of the group meetings permit majority of the members to attend
- Mutual trust exist among the members
- Members feeling that their group is one of the best in the region (sense of belonging and morale)

Pamini river shrimp cluster - a success story for group approach

The primary advantage of group approach to shrimp farming is that it enables the shrimp cluster to organise the scheduling of farm operations, quality seed procurement, simultaneous stocking, water exchange and harvesting regimes contributing to substantial reduction in the vertical and intra cluster horizontal transmission of the deadly diseases. In this context, the Paminiriver Shrimp Farmers Association in Tiruvarur district of coastal Tamil Nadu (South India), a self initiated dynamic cluster based shrimp farmers' association was studied to assert its role in sustainability of shrimp farming. Popularly known as DCM cluster (land owned by M/s. DCM textile company and later sold to the local villagers), this Paminiyaru (Pamini river) shrimp farmers' association was formed by the farmers themselves in the year 2003, mainly to prevent and manage the disease outbreaks collectively by enforcing better management practices. The cluster started with just five farms (35 ponds) in 2003, has grown to 50 farms (320 ponds) now. One season of shrimp culture (February - July) was practised in this cluster. The association oversaw the farm operations in this cluster beginning from pond preparation, stocking, farm management, harvesting and marketing to prevent the vertical and horizontal transmission of diseases, optimum utilisation of resources and ensure better price for the shrimps produced.

Planning, seed procurement and stocking

The Association has planned shrimp farming through a General Body meeting in which the farming calendar and better management practices including the bio-security measures to be followed were decided as a written document endorsed by all the farmers. The Association monitored the farming operations in the cluster by appointing a technical person who facilitated proper pond preparation, initial water intake, double filtration and chlorination in the ponds. It constituted a seed team for seed procurement from one reputed hatchery and the team monitored the complete seed production process. Seed selection included screening of mother brooders, nauplii, early and later stages of post larvae (PL 5 and PL 15 – 20), the time of purchase in more than one diagnostic laboratories. Seeds were procured collectively or individually from the same hatchery. When seeds were purchased by a group, seed requirement of the individual members was calculated and packed separately. Even in the case of individual purchase, the hatchery was asked to furnish the details of seed taken by every individual farmer.

This measure ensured that there was no variation in the stocking density among the member farms. It was mandatory to submit a copy of the report to the association that seeds have been subjected to the PCR screening. The Association decided that the stocking was done in a period of 20 days and the stocking density was kept less than 6 PL/m^2. Collective seed procurement reduced the seed cost due to the nature of bulk order procurement and the low incidental and transport expenses. Moreover, there was a plan to raise 'seed money' from the common fund raised to supply 'free seed' to farmers for the next culture.

Pond management

It was mandatory that every pond was bird fenced and non-compliance attracted penalty of Rs.2000 per pond (40 USD). It was reported that bird fencing had reduced the disease spread by 30-40%. Every farm had a reservoir wherein the source water was disinfected and used for water exchange. Every farm had a paid consultant who visited the farm once a week to monitor and advice. The following practices in farm management were strictly followed:

1) Feed rationing and scheduling based initially on feed off-take from the check tray up to 60 days and then based on check tray and weekly sampling till harvesting and

2) Soil and water quality management through application of probiotics, adequate aeration and continuous monitoring of animal behaviour.

The association permitted only a few well-known consultants to advise the farmers. The consultants were asked to appraise the association about the farm conditions of their clients. Movement of people were strictly restricted if there were disease incidences in the nearby areas. Consultants alone were permitted to move in the restricted areas after disinfection and as a precautionary measure, feed tray checking was not allowed during that time. Use of antibiotics was banned. However, use of probiotics and sanitizers were encouraged during the culture period.

Collective disease management

In spite of all precautions, if an outbreak of the disease occurred it was immediately informed to the association. The association convened an emergency meeting and decided the course of action. There were two courses of actions, (i) either premature harvest was resorted to or (ii) the pond was bleached. Depending on the DOC (Day of Culture), nature and magnitude of problem, appropriate decision was taken. Disease affected ponds were bleached if the culture was in less than 60 DOC. Bleaching of ponds was continued to certain number of ponds to carry forward the culture in the other ponds to the maximum possible period. During such occasions the association assured the affected farmers' in-writing that they would be compensated. The cost of bleaching was borne by the association. In 2007, when there was a disease attack in this cluster, the association bleached about 20 ponds and a sum of Rs.20 lakh (approx. 50,000 USD) was paid as compensation to 20 ponds @ Rupees one lakh (4000 USD) per pond. Pre-mature or emergency harvesting was also allowed if the disease was other than WSSV. Even in the event of an outbreak of WSSV, if the size of the shrimp was above 15g, with due precautionary measures the ponds were safely harvested using drag nets without letting out the pond water.

Compensation to the affected farmers through facilitated marketing

The association invited quotations from shrimp buyers for negotiating the best price for the shrimp produced in the cluster. However, the price was not binding on the members. Irrespective of the buyer, a stamped agreement (legally enforceable) was signed and given to the association by the farmers and the chosen buyers. This agreement stated that a given amount of the sale price per kg of shrimp sold was to be deducted at the buyer's end and handed over to the association to compensate the affected farmers and for maintaining the common facilities. It was the responsibility of the buyer to ensure this payment to the association. The same procedure was adopted to collect the common fund for the association to take up collective works even in normal culture seasons. This amount was deposited in the bank as a joint account operated by three executive members to ensure its safety and make certain that the agreed compensation was paid to the farmers who lost their crop due to the disease.

Group management of operations

All the farmers in the cluster were members of the association and they owned it. The association had written bylaws but was not a registered body. The association had a President, Secretary and a Treasurer. They were nominated unanimously and these positions were honorary. While the General Body meeting was the first one in which most of the members participated the subsequent meetings were organised only whenever required during the culture period. In the first meeting prior to beginning of culture operations, the do's and don'ts were discussed, recorded as minutes and signed by all the farmers. The issues were discussed, sorted out collectively by consensus and the decisions were fully complied. The association had dynamic leaders to carry forward its activities taking the members together in confidence. The association was socially cohesive and successful since most of the members belonged to the same village and community. Mutual trust and commitment prevailed among the members as is evident from the consent given for crop bleaching on the event of full scale disease outbreaks and compensation agreed upon. The association adjudicated the conflicts if any between the members amicably. It had also kept proper financial records officially audited every year.

Interaction with key stakeholders and social responsibility

The Association was authorised to negotiate with hatcheries and shrimp buyers for quality seed and price respectively. Public institutions and private input traders considered the association as the representative of the farming community. It had closer interactions with the neighbouring farmers and shared information for mutual benefit. Since most of the farmers belonged to the same or nearby villages, cordial relations were maintained with everybody. The associations helped the village in developing and maintaining infrastructures, like roads, school buildings, temple renovation etc., for the benefit of the villages and fishers. Moreover, local villagers and fishers were given employment in shrimp farms. The group maintained close rapport and linkage with government departments and facilitated through the Department of Fisheries for availing farming approval from the Coastal Aquaculture Authority (CAA) which is mandatory for setting up aquaculture farms.

The factors behind the success of this group approach:

Since formation of the Paminiriver Shrimp Farmers Association in 2003 barring 2007, all the crops were successful. The association attributed its triumph to the factors indicated in the box.

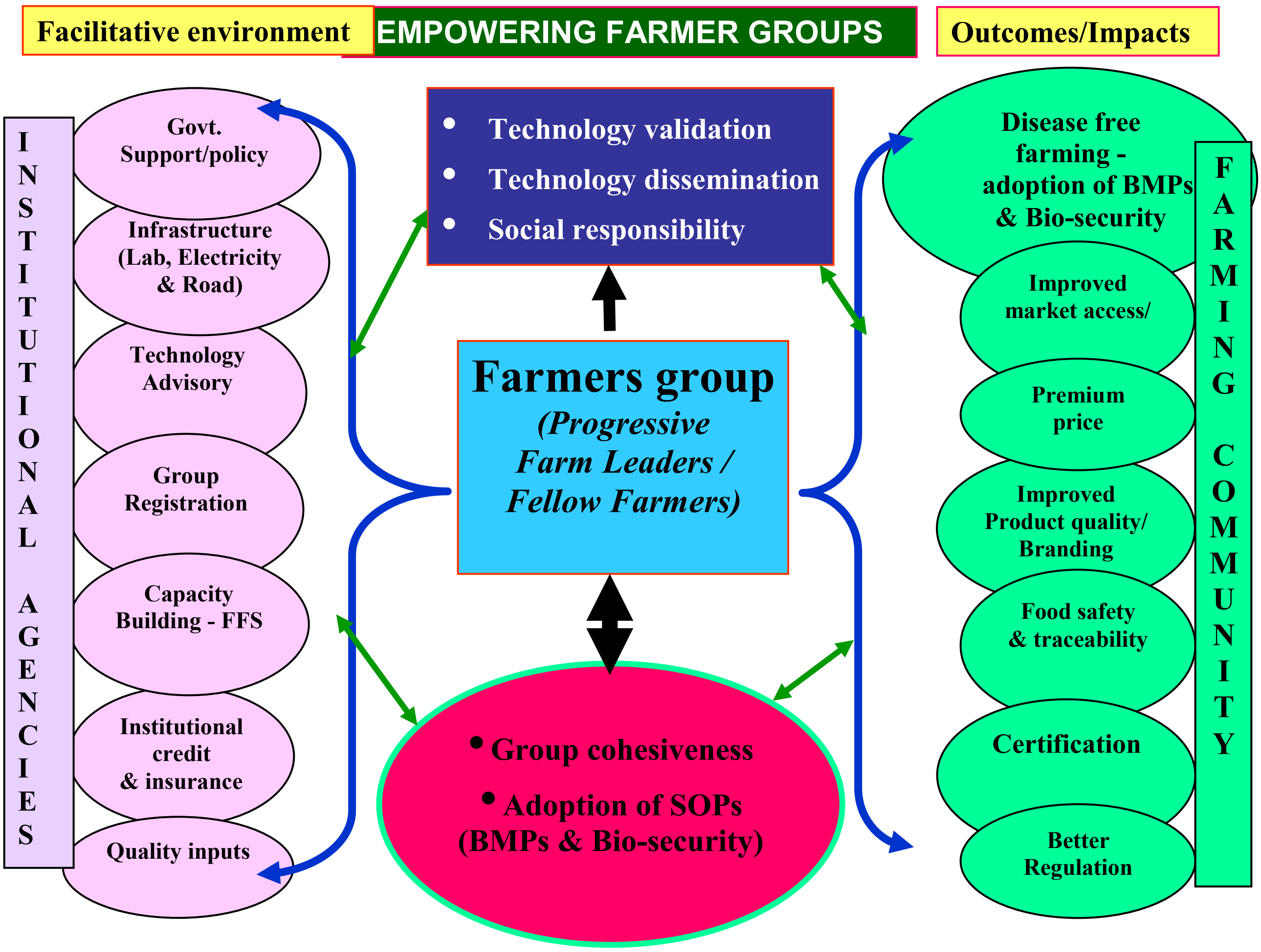
Factors behind the success of this group approach

1. Complete membership of all farms
2. Economic deliverability through continued success
3. Compulsory technical consultancy
4. Community linked social cohesiveness
5. Conviction that group action is indispensable
6. Accountability – payment of compensation and auditing
7. Collective and compulsory compliance of BMPs
8. Dynamic leadership
9. Equality of all irrespective every factor

→ **Sustainability of Group & Shrimp Farming**

Empowering farmer groups for shrimp aquaculture sustainability

Organizing farmer groups which enforces uniform crop calendar, seed production through contract hatchery system and collective compliance of BMPs including bio-security principles is the just approach to ensure sustainability of shrimp aquaculture. Self initiated clusters which had the full membership of the cluster exhibited higher group cohesiveness. The survey and the focus group discussions conducted with farmer leaders have clearly indicated that farmers group should be the '*interface*' to reach the primary produces (Fig). Further, an extension strategy to empower the farmer groups was arrived based on the findings. It is essential that research and extension agencies should engage farmers groups as *'field partner'* for technology demonstrations and know-how transfer. Extension agencies should organize '*farmer field Schools*' at annual basis for science based capacity strengthening of farmers in each cluster. Farmers groups need to be sstrengthened by extending '*institutional credit support*' and evolve a facilitating mechanism like *contract farming* to access premium markets. Facilitate in "*branding*" the quality shrimps produced by farmers groups and facilitate obtaining Geographical Indication (GI) from appropriate agencies, like the "Mahagrapes" by grape farmers of Maharashtra in India. Facilitate the groups in availing '*group certifications*' from the national and international aquaculture certifying agencies to certify the cluster as the producer of safe and quality shrimp. Facilitate the farmer groups to have a '*farm to firm linkage'* to access quality inputs and premium markets so that they could establish necessary supply chain linkages.



Conclusion

Farmers groups are a powerful force for providing farmers with an array of collective services (including technology testing and dissemination), and for enabling collective action in natural resource management and sustainable natural resources management and development. Farmer groups and their voluntary code of conduct are very important for sustainable the shrimp aquaculture. Quality inputs and proper farming practices are essential for successful shrimp farming and the farmer groups need to ensure the supply of quality inputs to its members. Shrimp farming practiced with due consideration to environment and other stakeholders will help in eliminating social and environmental conflicts.

******

12 Regulation of shrimp farming in India

(From CAA guidelines)

Aquaculture Authority (1997-2005)

Background

The Honourable Supreme Court in its orders on the Writ Petition (Civil) No. 561 of 1994 dated 11.12.96 directed that:

"The Central Government shall constitute an authority under Section 3(3) of the Environment (Protection) Act, 1986 and shall confer on the said authority all the powers necessary to protect the ecologically fragile coastal areas, sea shore, water front and other coastal areas and specially to deal with the situation created by the shrimp culture industry in the coastal States, Union Territories. The authority shall be headed by a retired Judge of High Court. Other members preferebly with expertise in the field of aquaculture, population control and environment protection shall be appointed by the Central Government. The Central Government shall confer on the said authority the powers to issue directions under section 5 of the Act for taking measures with respect to the matters referred to in Clauses (v), (vi), (vii), (viii), (ix), (x) and (xi) of sub-section (2) of section 3. The Central Government shall constitute th authority before January 15, 1997"

Constitution of the authority

Following the directions of the Honourable Supreme Court, Government of India issued Gazette notification (No. 76 dt. 6.2.1997) regarding the constitution of the Aquaculture Authority of India. Subsequently, THE AQUACULTURE AUTHORITY BILL, 1997 (Bill No. XVII-C of 1997) was presented in the Parliament and it was passed by the Rajya Sabha on 20th March, 1997.

Members

As per the Notification, the following members of the Authority have been **appointed by the Central Government.**

1) A retired Judge of High Court - Chairman
2) An expert in the field of Aquaculture - Member
3) An expert in the field of pollution control - Member
4) An expert in the field of environmental protection - Member

5)	A representative of the Ministry of Environment & Forests	-	Member
6)	A representative of the Ministry of Agriculture	-	Member
7)	A representative of Ministry of Commerce	-	Member
8)	(To be appointed by the Central Government)	-	Member Secretary

Powers

The Authority shall exercise of powers under section 5 of the Environment (Protection) Act for issuing directions and for taking measures with respect to the matters referred to in Clauses (v), (vi), (vii), (viii), (ix), (x) and (xi) of sub-section (2) of section 3 of the said Act.

Functions

The Authority shall perform the following functions:

1) To ensure that no shrimp culture pond can be constructed or setup within the Coastal Regulation Zone and upto 1000 m of Chilka Lake and Pulicat Lake (including bird sanctuaries namely, Yadurapattu and Nelapattu);
2) To ensure and give approval to the farmers who are operating and traditional and improved traditional systems of aquaculture for adoption of improved technology for increased production;
3) To ensure that the agricultural lands, saltpan lands, mangroves, wetlands, forest lands, land for village common purposes and the land meant for public purposes shall not be used or converted for construction of shrimp culture ponds;
4) The Authority shall implement the "Precautionary principle" and the "Polluter Pays Principle", by adopting the procedure described in the Supreme Court Order dated 11.12.1996 passed in the Writ Petititon (Civil) No. 561 of 1994;
5) The Authority shall also regulate the shrimp culture activities outside the Coastal Regulation Zone areas and beyond 1000 m from the Pulicat Lake and Chilka lake and give the necessary approvals/ authorisation by the 30th April, 1997.
6) The Authority in consultation with the expert bodies like National Environmental Engineering Research Institute, Central Pollution Control Board, respective State Pollution Control Boards shall frame

scheme/ schemes for reversing the damage caused to the ecology and environment by pollution in the coastal States and Union Territories.

7) The Authority shall ensure the payment of compensation to the workmen employed in the shrimp culture industries as per the procedure laid down in the Supreme Court Order dated 11.12.1996 passed in the Writ Petition (Civil) No. 561 of 1994;
8) To comply with the relevant orders issued by the concerned High Courts and Supreme Court from time to time.
9) To deal with any other relevant environment issues pertaining to coastal areas with respect to shrimp culture farming, including those which may be referred to it by the Central Government in the Ministry of Environment and Forests.

Licensing of the shrimp farms were taken up as per the instructions of the Apex Court. State level and District level committees were constituted by the State Governments as per guidelines of Aquaculture Authority for screening the applications for recommendation to the Aquaculture Authority for issue of license.

- The Aquaculture Authority has also brought out "Guidelines on Adopting Improved Technology for Increasing Productivity in Tradition and Improved Traditional Systems of Shrimp Farming" and "Effluent Treatment System"

Coastal Aquaculture Authority (2005 – To Date)

Coastal Aquaculture Authority Act enacted in 2005 and a new Coastal Aquaculture Authority was instituted Gazette Notification No. 1336 dated 22nd December 2005.

Coastal Aquaculture Act, 2005 has inserted a sub-paragraph ((xiv) "*nothing contained in this paragraph shall apply to coastal aquaculture")* in Paragraph 2 of CRZ Notification of 1991, which makes the Coastal Aquaculture a permissible activity in CRZ and "*no coastal aquaculture carried on or undertaken or purporting to have been carried on or undertaken shall be deemed to be in contravention of the said notification and shall be deemed to be and to have always been for all purposes in accordance with law………"*

The constitution of the authority also has been changed as given below to include representatives from coastal states:

a)	Chairperson	: Who is or has been a Judge of High Court
b)	Member	: Expert in the field of coastal aquaculture
c)	Member	: Expert in the field of coastal ecology nominated by DOD of Central Govt.
d)	Member	: Expert in the field of environment protection or pollution control nominated by Ministry of Environment and Forests, GOI
e)	Member	: Representative from Ministry of Agriculture
f)	Member	: Respresentative from Ministry of commerce, GOI
g)	Four members	: Representative of coastal states on rotation basis
h)	Member-secretary	

The act clearly specifies that (a) no coastal aquaculture shall be carried on within two hundred meters from High Tide lines and (b) no coastal aquaculture shall be carried on in creeks, rivers, and backwaters within the CRZ declared for the time being under the Environment (Protection) Act, 1986.

As per the Notifications of CAA Act, applications for registration for farms less than two hectares of water spread area can be directly sent to the CAA by the District Level committee under intimation to State Level Committee. State Level Committee will examine the applications of farms which are more than 2 ha area.

Under this Act coastal area for aquaculture includes the land within a distance of two kilometres from the High Tide Line of seas, rivers, creeks and backwaters. As per the Notification dated 23 January 2006, the delineating boundaries for coastal aquaculture along rivers, creeks and backwaters shall be governed by the distance unto which the tidal effects are experienced and where salinity concentration is not less than 5 ppt. For this purpose the salinity measurements should be during the driest period of the year. (In the case of ecologically fragile areas, such as Chilka Lake and Pulicat Lake the distance would be upto 2 kms from the boundary of the lakes).

In the case of earlier Authority only shrimp farming was regulated. As per CAA Act and Rules, culture of all aquatic organisms within the coastal zone will come under the purview of CAA. Further this regulation is for all the inputs like seed, feed, chemicals etc., CAA is formulating guidelines for the culture of seabass and mud crab. Registration of shrimp hatcheries is also being taken up through MPEDA.

******

13 Shrimp - A major commercial seafood item for export

Ginson Joseph

Assistant Director, MPEDA, R.O, Kolkata-17

Seafood is good sources of proteins, lipids, vitamins and minerals which are vital for growth, development and health. About 85-90 % of seafood protein is easily digestible and contains all essential amino acids. Among the seafood shrimps are highly demanded and healthy choice of food is because of its good source of protein, and low saturated fat. It also contain vitamins A & D, and several dietary minerals such as Ca, Fe etc. which are beneficial to man and animals. Iodine content in prawn is good for the proper functioning of the thyroid gland.

When compared to previous year Indian seafood exports showed a growth of 7.68% in terms of quantity, 13.61 % in Rupee value and 0.1% in US$ in 2012-13 (Table 1). The increase in export figures must be viewed in the light of the weaker economic conditions in European Union, still recovering economy in USA, Moderate growth in China, technical barriers to trade by Japan, continuing antidumping duty and the possibility of Countervailing duty on frozen shrimp by US and continuous devaluation of Indian currency. Prawns are the commercial seafood item having high market value so it has a significant role in the contribution of the export earnings of our country. Export of frozen shrimp during 2011-12 and 2012-13 have shown in table 2. shrimp export showed an increasing trend of 20.88 %, 18.73 % and 3.56 % in terms of quantity, rupee value and US$ value respectively. Frozen shrimps continued to be major export value items accounting for 51.34% of total US$ earnings. It was observed a steep drop in unity value realisation of frozen shrimps at 14.33%. An export earring of Rs. 18856 crore has achieved is mainly due to higher production and export of prawn especially *Litopenaeus vannamei* and *Penaeus monodon*.

Major export markets for Indian seafood are European Union, USA, Japan, China, South East Asian countries etc (Fig. 2). Export of frozen shrimps to South East Asia has showed a growth of 27.87% in volume and in US market has showed a growth of 49.13 % and 20.89 % in terms of volume and US$ earnings respectively. It was observed that a tremendous increase of the export of *L. vannamei* shrimp of 141.34% and 100.09% in terms of quantity and US$ value respectively. For export of Frozen shrimps in Japan market is concern there is decrease of 11.03% and 21.29 % in terms of quantity and value respectively. Decreasing trend of frozen shrimp export to Japan market is mainly due to the technical barrier like ethoxquin issue from Indian seafood.

Increasing aquaculture and production of value added seafood will help to achieve an increase of seafood export from India in future. *L. vannamei* one of the major shrimp for export was introduced in 2009 in India when there was a downturn in shrimp industry due to exclusive of *P. mondon* culture and its associate disease outbreak. The introduction of Vannamei to India through this approved quarantine premise had benefited in augmenting the marine shrimp production through aquaculture of the country from a level of around 88,000 MT worth Rs 1,915 crore in 2008-09 to about 145600 MT worth Rs 3,585 crore in 2010-11 and to about 224500 MT valued at Rs 6,600 crore in 2011-12. *L. vannamei* shrimp production touched 1.47 lakh tonnes in 2012-13 as compared to 80,000 tonnes during the previous year. Since its full fledged introduction, the aquaculture production of Vannami rose from 1730 MT in 2009-10 to about 80717 MT in 2011-12, an annual growth of around 584%, thereby increasing its share in the total cultured shrimp production from 1.6% to around 35.9% in two years. RGCA quarantined more vannamei brooders keeping the sustainability of the industry in prior focus. MPEDA expects seafood exports to grow to $ 4.3 billion during the current financial year with help from increased Vannamei production and better quality control measures.

Table 1. Exports during 2012-13 compared to 2011-12

Export details	**2012-13**	**2011-12**	**Growth**
Quantity Tonnes	928215	862021	7.68
Value Rs. Crore	18856.26	16597.23	13.61
Value US $ Million	3511.67	3508.45	0.1

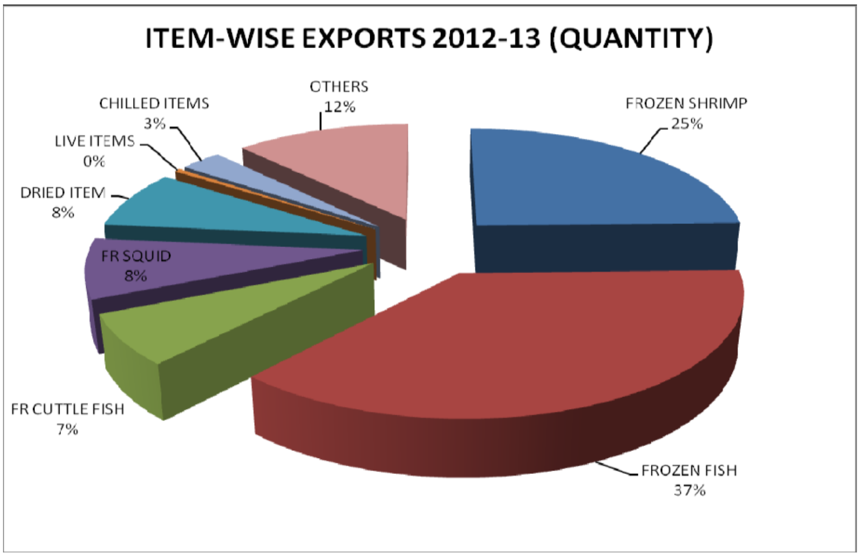
Source: (MPEDA, 2013)

Table 2. Export of frozen shrimp during 2011-12 and 2012-13

(Q=Quantity in tonnes, V = Value in Rupees crores, $=USD million)						
Item		Share%	2012-13	2011-12	Variation	(%)
FR. SHRIMPS	Q V $ US$	24.63 51.48 52.35	228620 9706.36 1803.26 7.89	189125 8175.26 1741.20 9.21	39495 1531.10 62.06 -1.32	20.88 18.73 3.56 -14.33

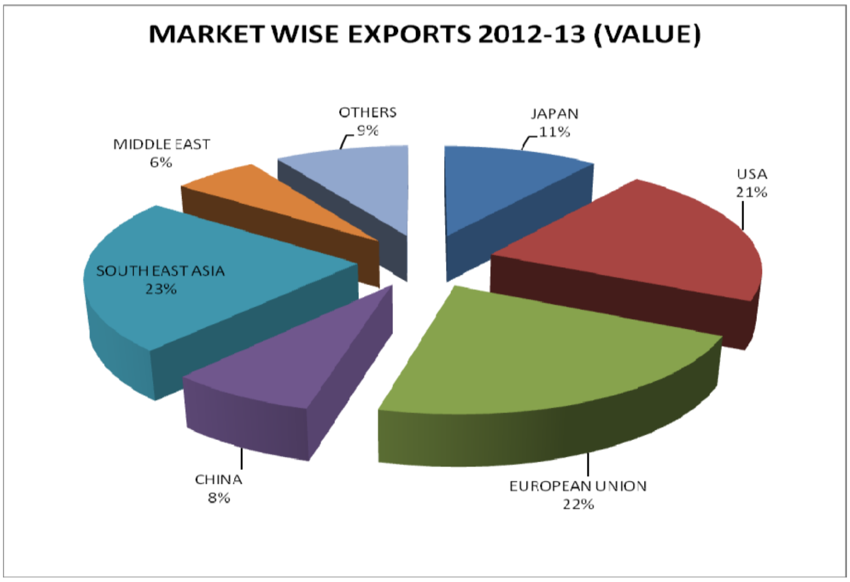
Source: (MPEDA, 2013)

Figure 1. Item-wise export in terms of quantity during 2012-13



Source: (MPEDA, 2013)

Figure 2. Market-wise export in terms of quantity during 2012-13

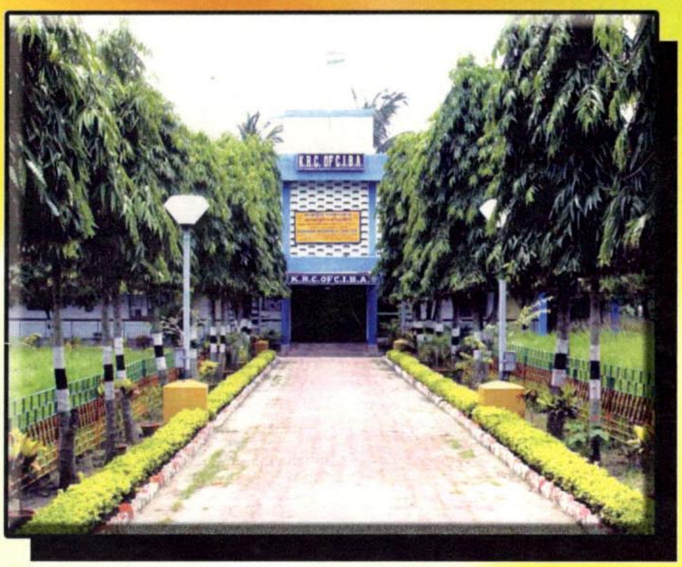


Source: (MPEDA, 2013)

******

****

Central Institute of Brackishwater Aquaculture
(Indian Council of Agricultural Research)
75, Santhome High Road, R. A. Puram, Chennai - 600 028, Tamil Nadu, India
Tel. No.: 91-44 24617523 / 24618817, Fax: 91-44 24610311
E-mail: director@ciba.res.in, Web: www.ciba.res.in



Kakdwip Research Centre
Central Institute of Brackishwater Aquaculture
(Indian Council of Agricultural Research)
Kakdwip, South 24 Parganas, W.B. - 743 347, India
Tel. No.: 91-3210 255072, Fax: 91-3210 257030
E-mail: krc@ciba.res.in / krckakdwip@yahoo.co.in