Technological Advancements in Shrimp seed Production with reference to Demand and supply

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Abstract : Shrimp aquaculture has been developed as an industry to cater to the ever increasing export market. Controlled production of the desired species of shrimp seed is vital for the sustained development of shrimp aquaculture industry. The major technologies for shrimp seed production are the Japanese system and the Galveston system. Over the years these systems have undergone a series of modifications to suit the location, species and local requirements. In Kerala two major systems for shrimp seed production are in vogue, one developed by the Central Marine Fisheries Research Institute and the other by the Kerala Fisheries Department. Semiclosed hatchery technology is adopted mainly in these systems so as to take advantage of the prevailing climatic conditions of this area, thereby reducing the production cost. As this technology relies mainly on the prevailing climatic conditions, shrimp seed production can be undertaken for a part of the year only. During monsoon months the hatchery can conveniently switch over to the production of 'Scampi' seed, which has great demand when the production of shrimp seed is not profitable due to unfavourable climatic conditions such as low salinity and temperature, thereby assuring year round operation of the hatchery and increasing the profitability of the unit. The present paper also deals with working details and economics of two types of hatcheries to cater to the needs of two levels of entrepreneurs. A backyard hatchery with a production capacity of 3 million seeds (2.5 million shrimp seed and 0.5 million seed of 'scampi') established with an initial investment of Rs. 3.7 lakhs on infrastructure and an annual operating cost of Rs.1.25 lakhs can yield a net profit of Rs. 0.83 lakhs per year at an average production cost of Rs. 126/1000 seeds. A medium scale hatchery with a production capacity of 15.8 million seeds (15.1 million shrimp seeds and 0.7 million 'scampi' seeds) established at an initial investment of Rs. 44.38 lakhs and operating cost of Rs. 4.81 lakhs can yield a net profit of Rs. 6.08 lakhs per year at an average production cost of Rs. 113/1000 seeds.

Introduction

Shrimp is a highly valuable commodity among the edible crustaceans. Its demand both in the domestic as well as export market has led to over exploitation of this resource throughout the world and during 1988-92 shrimp production of the world had been stagnating at about 2.5 million tonnes per year, of which an average of about 3.7 lakh tonnes (17%) is contributed from the Indian Ocean. The ever increasing demand of this resource has led to the development of shrimp aquaculture as an industry and over 50 countries have undertaken shrimp farming on a commercial scale at present. The farm raised shrimp accounted for 2.1% of the total shrimp production of the world in 1981; increased to 28% during 91-92 and showed a slight decline to 22.5 % during 1993. Among the countries producing shrimp through aquaculture, China ranked first till 1991 with an annual estimated production of 1.45 lakh tonnes. Thailand which ranked third in 1991 with 1.1 lakh tonnes came up as the leading country in 1992 with an estimated production of 1.5 lakh tonnes and continues to maintain that position with 2.2 lakh tonnes produced in 1994. India with an estimated production of 70,000 tonnes in 1994 occupied 4th place.

Due to increased fishing by mechanised units the shrimp production of India has been stagnating around 2.2 lakh tonnes till 1989 and thereafter exceeded the harvestable level of 2.3 lakh tonnes. The shrimp production from aquaculture has been increasing steadily in India from 25,000 tonnes in 1989 to 70,000 tonnes in 1994. This production has been obtained from less than 10% of the presently available water area suitable for shrimp farming. Thus, there exists a huge potential for increasing shrimp production through aquaculture in India.

Hatchery technologies

The hatchery system practised world-wide for the mass production of shrimp larvae fall under two categories - the "community culture" system and the Galveston system. Development and culture of penaeid larvae in different countries have been reviewed in detail by Muthu (1980).

The "community culture" system otherwise known as the fertilized systems is characterised by the use of large tanks for the rearing of larvae, where the larval food; both phytoplankton and zooplankton are cultured together in the same tank along with the larvae (Hudinaga, M. and J. Kittaka, 1967). Depending on the size of the tank, as well as the prevailing weather conditions of the area, the larval rearing tanks are maintained outdoor or indoor under translucent roofing. Although there is no control over the initial stocking density, generally it will be low and is less than 20 nauplii/litre. Even when the larvae are in the nauplius stage, the water is fertilized with nitrate (KNO_3 @ 2ppm) and phosphate ($KHPO_4$, @ 0.2 ppm) for the development of a steady bloom of mixed diatoms on which the protozoeae can feed. The mixed diatom culture is maintained at appropriate concentration by the regular application of fertilizers as per requirement. A good population of zooplankton organisms also develop by the time the larvae metamorphose to first mysis stage. Mysis are also fed with *Artemia* nauplii. In adddition to the live feed present in the tank, advanced postlarvae are also fed with crushed and washed clam meat. Throughout the rearing period the water is vigorously aerated to prevent anaerobic conditions. Exchange of about 1/4 th to 1/3rd water in the tank is initiated daily when clam meat is used as a feed for the postlarvae. Bread yeast @ 2 gm/tonne/day and rotifer *Brachionus* @ 10-25 cells/ml are provided to protozoea and mysis/ advanced postlarvae in the absence of enough quantity of live-feed in the tank in some countries. Although in this system, larvae can be reared in the same tank until they metamorphose to postlarva 20 (seed size), survival is low and ranges from 20-30%.

The Galveston system is more sophisticated and calls for a series of independent processes involving high technical skill (Cook and Murphy, 1966; Salser and Mock, 1974). Spawners are maintained separately in spawning tank and after spawning they are removed and the eggs are allowed to develop and hatch out to nauplii. Healthy nauplii are counted and stocked in cylindroconcial larval rearing tanks of 2-3 tonne capacity, containing filtered sea water. Larvae are fed with selected diatoms and *Brachionus* which are cultured and maintained separately. In the larval rearing tanks the nauplii are stocked at a higher stocking density *i.e.* more than 100 nauplii/litre. Protozoeae are fed with monoculture of diatoms so as to maintain a cell concentration of 10,000-15,000 per ml in the medium; early mysis with *Brachionus* @ 5-10/ml; late mysis and postlarvae with freshly hatched nauplii of *Artemia* @ 5 nos/ml. Microen-capsulated feed of very high nutritional value is also used along with *Artemia* nauplii. As this system ensures proper selection of nauplii, control on stocking rate, water quality maintenance by proper water exchange, control of temperature, prophylactic treatment, proper feeding with sufficient quantity of quality feed, the survival rate is always high and is generally 70-80%. Larvae are reared upto postlarvae 5 in these tanks and afterwards moved to nursery tanks.

Although the basic hatchery technologies can be broadly classified under these two categories, they have been modified in different countries so as to suit different species, geographical and climatic conditions. Thus various combinations and permutations of these two systems are in vogue in different parts of the world. In recent years, uncontrolled growth of shrimp farming, neglecting environment has caused a variety of ecological problems and spread of diseases, leading to an almost complete collapse of the shrimp farming industry in many countries like China, Thiland and Taiwan. The technology recently developed in Tahiti and New Caledonia (Austrand and Vidal, 1995) aims at reducing the risks due to environmental degradation and diseases in hatchery operations. This system is based on the exclusive use of microparticles as a replacement for algae and avoiding the water renewal upto first postlarva. Better hygienic conditions are provided by keeping the different units of the hatchery separately, and providing biological filters to the larval rearing tanks from first mysis onwards. Pathogenic risks have been reduced to minimum by adopting minimum prophylactic treatments and by using encapsulated microparticles and artemia nauplii as feed and allotting sufficient dry-out period in between hatchery runs.

In India, Central Marine Fisheries Research Institute (CMFRI) (Silas *et al.*, 1985; Muthu and Pillai, 1991) and Kerala State Fisheries Department (KSF) (Alikunhi *et al.*, 1980) have pioneered development of technology for seed production of commercially important shrimps. In CMFRI technology, larvae are reared in smaller indoor tanks of 1-3 tonne capacity upto third postlarva under sheds provided with translucent roofing. Postlarvae 3 to 20 are reared in outdoor tanks. Larvae from protozoea to second mysis are fed exclusively on mixed culture of diatoms developed and maintained separately. Third mysis to postlarvae 20 are fed with egg-prawn custard. In the KSF technology larvae are reared in outdoor tanks of 8 to 20 tonne capacity and exclusively fed with squilla meat suspension or with prawn meat suspension. Larvae from nauplii to postlarve 20 are reared in the same tank.

A simplified mini hatchery technology has been developed by CMFRI. This technology is simple and can be operated with the help of semi skilled individuals. A similar hatchery of 1.4 million capacity was established at the Mandapam Regional Centre of CMFRI during 1985. This hatchery is in operation since then and is presently used as a production cum training facility. Operational details and economics of this hatchery are presented.

The hatchery facilities

The mini hatchery is designed to produce 1.4 million seeds of *P. indicus/ P. semisulcatus* in an year in ten hatchery operations. This hatchery is established at Mandapam Camp where unpolluted seawater of 30-35 ppt is readily available throughout the year. Adequate sunlight and a temperature range of 28-34°C is available almost throughout the year. Hatchery is constructed in an area of 250 sq. m. and is provided with the following facilities : (i) A hatchery shed of 90 sq. m. area provided with translucent roofing (Fig. 1), (ii) two sea water storage

Fig.1. Minihatchery of 1.4 million capacity at Mandapam with translucent roofing

pools each with 10 tonne capacity (Fig .2), (iii) one 3 HP motor for sea water pumping, two-nine tonnes rectangular

Fig.2. Seawater storage pools with filter unit

Fig.3. Spawning Tanks

outdoor nursery tanks for rearing postlarvae. The hatchery shed houses the following facilities for the rearing of larvae (i) One compressor of one HP capacity for providing continous aeration, (ii) two 0.5 HP motors for pumping sea water from the storage pools (iii) six cylindroconical spawning tanks of 200 litre capacity (Fig. 3) (iv) four larval rearing tanks of 1.2 tonne capacity each

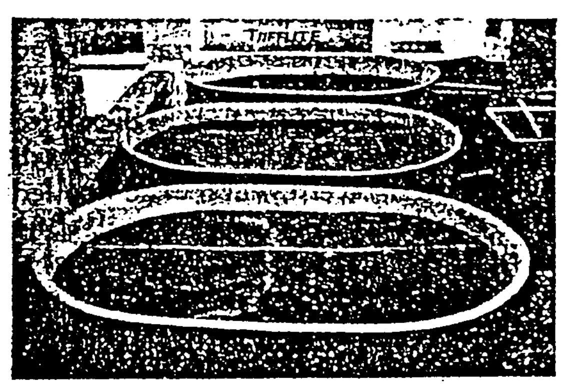

Fig.4. Larval rearing tanks

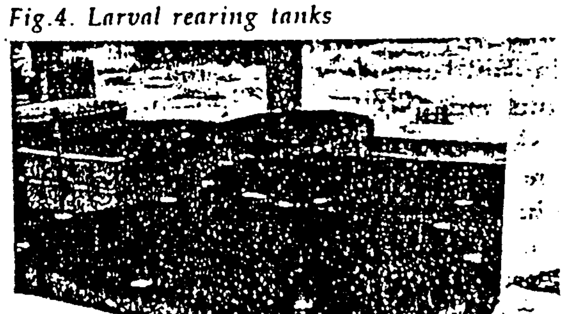

Fig.5. Rematuration tanks

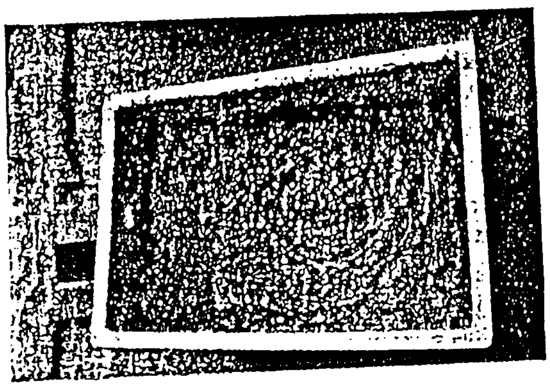

Fig.6. Diatom culture tank

(Fig. 4) (v) 1.2 tonne capacity tanks for rematuration of adult females (Fig. 5) (vi) six rectangular tanks of 300 litres capacity for maintaining mixed diatom culture (Fig. 6) and (vii) facilities to prepare and store particulate feed.

The hatchery operations are as follows:

i. Spawner collection and transport

Spawers for the hatchery operations are collected from the trawl net catches. Healthy, impregnated females with fully mature ovary are selected from the trawl catches and transported to the laboratory in 50 litre bins containing 40 litres sea water. Fully mature ovary is dark green in colour and occupies a major portion of the dorsal side of the animal along its entire length over the alimentary canal and hepatopancreas. Lateral expansion of the ovary in the first abdominal segment can be clearly visible through the exoskeleton.

ii. Spawning, hatching and stocking nauplii in the larval rearing tanks

Impregnated females with fully mature ovary are transferred to the spawning tank of 200 litre capacity containing 150 litres filtered sea water of 30-34 ppt salinity. Spawners are transferred into the spawning tank in the evening at the rate of one per tank. Disodium salt of EDTA is added to the water at the rate of 0.1 g/100 litres of water. The ideal temperature range is 27-32.5°C and pH 8.0-8.2. A mild aeration is provided. Spawning takes place between 8 pm. and 2 am. Females after spawning, are removed from the tank. Continuous aeration is provided and depending on the temperature, hatching takes place within 12-18 hours and by 15 hrs all viable eggs hatch out to nauplii. Healthy nauplii are collected, counted and stocked in larval rearing tanks @ 100/litre between 17.0 and 19.0 hours.

iii. Rearing of larvae upto third/fourth postlarvae

Maintenance of water quality is of prime importance in the larval rearing. Throughout the larval rearing period proper attention is given to aeration, feeding, water exchange and sediment removal. pH of water and larval condition are regulary monitored. After 36 hours of hatching, nauplii will be in the fifth/sixth stage depending on the temperature of the medium. At this stage, 100 litres of mixed algal culture dominated by *Chaetoceros* spp. or *Skeletonema* spp. is added in the larval rearing tank so that food will be readily available when the nauplii metamorphose to first protozoeae. An algal concentration of over 20,000 cells per ml is maintained in the tank throughout the rearing period. From 4th day onwards daily 1/4 to 1/3rd water is replenished. Filter bags of suitable mesh size are used while siphoning out water to prevent escape of larvae. If the algal culture used is dominated by *Chaetoceros* spp. no supplementary feed is required until third mysis stage.

From 2nd protozoea onwards, bottom sediment of the tank are removed daily. Aeration is stopped to allow larvae to surface before removing the sediment. Clear seawater conforming to the following hydrological parameters are conducive for larval rearing. Salinity 30-34 ppt; Temperature 27- 32.5°C; pH 8.0-8.2; Dissolved oxygen 3.0-8.0 ml/litre; light intensity in the hatchery during day time 20,000-1,25,000 lux; Total ammonia <0.1 ppm; Nitrite <0.05 ppm.

From mysis III onwards in addition to diatom, egg-prawn custard is also provided. Larvae are reared in the larval rearing tanks until they metamorphose to PL 2-3. Guide lines for the management of larval rearing tanks are given in Table 1. The volume of water exchange and the amount of feed given should be judiciously varied to meet the exigencies of the situation. When the larvae develop to PL - 3, they are transferred to nursery tanks.

iv. Nursery rearing

Postlarvae 3-4 are reared in the nursery for 12 to 17 days. They are fed mainly with prawn-egg custard. Daily 1/3 rd of water from the nursery tanks are exchanged. Sediments from the bottom of the tanks are daily siphoned out and continuous aeration provided. Postlarvae 15-20 are harvested.

v. Diatom culture

A mixed diatom culture is maintained for feeding the larvae. For initiating the algal culture, fresh unpolluted sea water (30-34 ppt salinity) is filtered through a 50 micron bolting cloth and kept in 300 litre capacity white fibreglass tanks placed under the translucent shed. The sea water in the tanks is fertilized with sodium nitrate @ 12 ppm; potassium orthophosphate @ 6 ppm; sodium silicate @ 6 ppm and EDTA disodium salt @ 6 ppm.

Sodium silicate has to be completely dissolved in fresh water before use. Other chemicals may be dissolved in fresh water or sea water. The chemicals should be mixed thoroughly with the sea water in the algal culture tanks. Continuous aeration is maintained. Under the conditions of adequate light intensity and temperature mentioned

Table 1. Management of larval rearing tanks (one tonne capacity)

Day	Stage	Sea water removed (litres)	Algal culture added (litres)	Egg-prawn custard (g)	Seawater added (litres)	Total vol. of water made upto (litres)
1	N 2	-	-	-	500	500
2	N 5	-	100	-	400	1000
3	PZ 1	-	100	-	400	1000
4	PZ 2	500	100	-	400	1000
5	PZ 3	500	100	-	400	1000
6	M 1	500	150	-	350	1000
7	M 2	500	150	-	350	1000
8	M 3	500	150	40*	350	1000
9	PL 1	600	100	50	450	1000
10	PL 2	500	50	60	450	1000
11	PL 3	500	50	60	450	1000

* *Daily ration of egg custard may be split into 4-6 equal doses and fed at suitable intervals*

above, the diatom cells already present in the seawater will multiply rapidly. As *Chaetoceros* spp. and *Skeletonema* spp. are generally available in coastal waters, a very good bloom of *Chaetoceros* spp. will be developed with in 36-48 hours which is indicated by a golden yellow colour of the medium. At a lower temperature *Skeletonema* spp. will dominate. A diatom culture having 3-4 lakh cells per ml is used for feeding larvae as well as inoculating batch cultures on succeeding days.

vi. Preparation of egg-prawn custard

Mysis 3 and PL 1 to 20 are fed with egg-prawn custard. It is prepared by mixing shrimp meat and hen's egg in the ratio of 5:1 by weight and cooked for 10 minutes in a pressure cooker and then frozen. A solid block of this custard after thawing can be made into suitable particles by passing through proper sieves and fed to the larvae.

A minishrimp hatchery with a capacity to produce 1.4 million postlarvae-20 can be establihsed at a cost of Rs. 3.27 lakhs inclusive of operational expenses of Rs.84,000/-. The production cost of 1000 seeds will workout to Rs.117/- and the details are presented in Table 2.

The above hatchery which is designed as a semiclosed one can be operational year round along Tamil Nadu Coast where adequate sunlight and good seawater are available. But in the south west coast of India, it can be operational for 6-7 months during premonsoon and postmonsoon period. During monsoon period, due to frequent rains and cloudy condition shrimp seed

Table 2. Economics of 1.4 million mini shrimp hatchery

A. Initial investment		
Land		10,000
Shed		75,000
FRP tanks		61,000
Nursery tank		30,000
Seawater storage facility		20,000
Seawater/aeration/freshwater/ electrical connection		8,000
Major equipments		39,000
		2,43,000
B. Operating cost		20,000
C. Fixed cost :		
1. Interest on initial investment @ 18%	43,740	
2. Depreciation	35,350	1,43,090
3. Salary	64,000	
D. Total cost (B+C)		1,63,090
E. No. of seeds produced (in 10 hatchery runs)		14,00,000
F. Annual revenue @ Rs.130/- for 1000 seeds.		1,82,000
G. Profit (F-D)		18,910
H. Cost of production of 1000 seeds		117/-
I. Rate of returns		25.78%
J. Pay back period		4.5 yrs.

Table 3. **Investment details of a 3 million minihatchery for both shrimp and prawn**

A.	Infrastructure facilities Three nos. of 6 tonnes larval rearing tanks (Rs. 45,000/-); Eight nos of spawning as well as diatom culture tanks (Rs. 64,000/-); One seawater storage tank (14.7 tonne) (Rs. 30,000/-); Two nos. of sea water treatment tanks (6 tonne capacity Rs. 30,000/-); Office cum laboratory and Generator rooms (Rs.72,000/-) and to provide covering for tanks (Rs. 21,600/-)	Rs. 2,62,600
B.	Seawater, freshwater, air and electricity facility	Rs. 40,000
C.	Major equipment (Generator, air blower & pump)	Rs. 49,000
D.	Laboratory equipments	Rs, 14,500
E.	Salary of staff	Rs. 1,08,000
F.	Operating cost	Rs. 1,24,250

Table 4. **Economics of a mini hatchery of 3 million capacity**

A.	Initial Investment		Rs. 3,66,100
B.	Annual operating cost		Rs.1,24,250
C.	Annual fixed cost:		
	i) Interest @ 18% for Rs. 366100	= Rs.65,898	
	ii) Depreciation	= Rs. 49,170	
	iii) Salary	= Rs. 108,00	Rs. 2,23,068
D.	Total cost (B+C)		Rs. 3,47,318
E.	Annual production of seeds:	Shrimp - 2.5 million Prawn - 0.5 million	3 million
F.	Annual revenue 2.5 million @ Rs. 72/1000 - Rs. 1,80,000 0.5 million @ Rs. 500/1000 - Rs. 2,50,000		Rs. 4,30,000
G.	Annual net profit		Rs. 82,682
H.	Cost of production of 1000 seed		Rs. 126/-
I.	Profit investment ratio		22.6%
J.	Rate of returns		40.58%
K.	Payback period		2.7 years (3 years)
L.	IRR		45%

production becomes uneconomical. With certain minor modifications the same hatchery can switch over to 'scampi' seed production during monsoon period, thereby increasing the profitability of the unit.

Thus a minihatchery with 3 million capacity integrating shrimp and scampi

Table 5. **Investment (in Rupees) details of a medium scale Hatchery (15.8 million capacity)**

A.	Land cost with compound wall	5,00,000.
B.	1) Larval and nursery rearing tanks with roof	16,52,900
	2) Rematuration facility	3,90,000
	3) Laboratory, office, store room, generator room	2,19,000
	4) Phyto plankton culture facility	4,20,000
	5) Sump, overhead tank and water pumping facility	2,17,000
	6) Effluent treatment unit	50,000
	Total of B	29,48,900
C.	Furniture	25,000
D.	Major equipment	
	1) Blower	1,50,000
	2) Pump sets	66,000
	3) Generator	1,50,000
	Total of D	3,66,000
E.	Aeration, freshwater, seawater and electrical facility	3,00,000
F.	FRP tanks	2,02,000
G.	Lab. equipment	96,950
	Initial Investment	44,38,850

Table 6. **Economics of a medium hatchery of 15.8 million capacity**

A.	Initial Investment		Rs. 44,38,850
B.	Annual operating cost		Rs. 4,81,800
C.	Annual fixed cost :		Rs. 12,99,858
	i) Interest 18% for Rs. 4438850	Rs. 7,989,93	
	ii) Depreciation	Rs. 3,32,865	
	iii) Salary	Rs. 1,68,000	
D.	Total cost (B + C)		Rs. 17,81,658
E.	Annual production of seeds		15.8 million
	P. monodon 2.6 million		
	P. indicus 12.5 million		
	M. rosenbergii 0.7 million		
F.	Annual revenue		Rs. 23,90,000
	P. monodon @ RS 400/1000 nos.	Rs.10,40,000	
	P. indicus @ 80/1000 nos.	Rs.10,00,000	
	M.rosenbergii @ Rs. 500/1000	Rs.3,50,000	
G.	Annual net profit		Rs. 6,08,343
H.	Cost of production of 1000 seeds		Rs. 113/-
I.	Profit investment ratio		13.7%
J.	Rate of returns		31.7%
K.	Payback period		5.4 - 6 yrs
L.	IRR		32%

Table 7. Larval diseases

	Symptoms	*Treatment*
1. Viral diseases		
A. Penaeid Baculoviruses	Affecting hepatopancreas and anterior midgut of postlarvae, infect epithelial cells causing high mortality.	None
B. IHHN. Infectious hypodermal and hematopoietic necrosis.		
2. Bacterial diseases		
a. Bacterial necrosis	Appears as a localisd necrosis or discolouration of any appendage of larval stages.	Prefuran - 1 ppm
b. Vibrio Infection	Affecting haemolymph and midgut. Larvae in acute cases show white turbid liver.	Prefuran - 1 ppm
c. Luminiscent vibriosis	Affecting haemolymph, gut, hepatopancreas of larvae Larvae stop feeding.	Prefuran - 1 ppm
d. Filamentous bacteria	Gills, pleopods of larval stages. Gill filaments get attached to the body, choking the larvae	Prefuran $KMNO_4$ 2.5 - 5 ppm
e. Shell diseases	Affecting exoskeleton, caused by chitinoverous bacteria.	Formalin 10 ppm.
f. Black gill diseases	Affecting gill.	Methalene Blue 8-10 ppm
3. Fungal diseases	Affecting body cavity and appendages of nauplii, protozoea, & mysis; caused by Legenidium leading to heavy mortalities.	Treflan 0.1 ppm
4. Ecto-Commensal infection	Affecting gills, eyes and exoskeleton of larvae caused by *Zoothamnium and Vorticella*.	Formalin 10 ppm
a. Protozoean infection		

seed production can be established with an initial investment of Rs. 3.66 lakhs and operational cost of Rs.1.2 lakh. This hatchery can produce 2.5 million shrimp and 0.5 million scampi seeds. Investment details and economics of the hatchery are presented in Tables 3 & 4.

The same technology can be scaled up and a hatchery of 15.8 million capacity integrating shrimp seed and 'scampi' seed can be established with an initial investment of Rs.44.38 lakhs and operating cost of Rs.4.81 lakhs. Investment details and economics are presented in Tables 5 & 6.

Disease

Disease in a shrimp hatchery is mainly caused by poor hygienic conditions and inadequate water exchange. Commonly encountered diseases in shrimp hatcheries have been dealt in detail by various workers (Bell and Lightner, 1987; Baticadose *et al.*, 1990; Liao, 1992; Lightner, 1993). Most serious diseases affecting the larval stages are caused by fungi (*Legenidium, Fusarium*), bacteria (*Vibrio*), filamentous bacteria (*Leucothrix*) and protozoans (*Zoothamnium, Vorticella*). Antimycotic compounds and antibiotics available for treatment of fungal and bacterial diseases should be used with great care as they themselves are toxic to the larvae at higher doses. The best method of controlling the fungal disease is by disinfecting the spawners which are the potential source of infection. Treating infected larvae is very difficult, often unsuccessful and expensive. The best way is to prevent the disease. Major larval diseases and their control measures are given in Table 7.

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