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Brackishwater Aquaculture Practices in Coastal West Bengal

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Brackishwater aquaculture in West Bengal is an age-old traditional system confined mainly to *'bheries'* sustaining production of 500–750 kg ha^{-1} $year^{-1}$. Commercial scale tiger shrimp (*Penaeus monodon*) farming started during 1988–1989 and semi-intensive farming demonstrated production levels reaching 4–6 t ha^{-1}. Area under semi-intensive shrimp farming increased substantially during 1990–1994 with remarkable growth rate till 1995 as the boom period and the bust came in during 1995-96 with the outbreak of viral disease. Later with the advent of bio-secured closed culture technology using better management practices, shrimp farming again started to regain its lost glory during early years of the present century.

As tiger shrimp farming was regressed by viral diseases since 1995, the Coastal Aquaculture Authority of India (CAA) permitted introduction of *Penaeus vannamei* (Pacific white leg shrimp) in India during 2009 with prescribed guidelines. Before introduction, risk analysis was carried out by ICAR-Central Institute of Brackishwater Aquaculture (CIBA) and National Bureau for Fish Genetic Resources (NBFGR) after pilot scale initiation in 2003. Since introduction, *L. vannamei* farming showed rapid growth and a shift towards *L. vannamei* from *P. monodon* was observed (Plate 1). Accidental releases of non-native species into natural waters are common and can represent impacts in the environment and biodiversity, and a serious risk of transmission of pathogens.

Plate 1. Harvested *L. vannamei*

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Feeling the importance of domestication of potential native shrimp species in addition to tiger shrimp, Indian white shrimp (*Penaeus indicus*) has been domesticated by ICAR-CIBA and its experimental farming showed encouraging results with production of 3-5 tons ha^{-1}. In spite of having huge potential for mud crab farming in the state, still there is no organized farming to support the export trade, mainly due to inconsistent availability of seeds. Technology for seed production, culture and fattening of green mud crab *Scyllla serreta* has been developed by CIBA. After the inception of crab hatchery by the Rajiv Gandhi Centre for Aquaculture (RGCA) in Tamil Nadu, some progressive farmers have started crab grow-out farming in the state using hatchery produced seeds.

High value fishes like Asian seabass (*Lates calcarifer*), grey mullet (*Mugil cephalus*), Tade mullet (*Liza tade*), Parsia (*Liza parsia*), Nona tangra (*Mystus gulio*), Milkfish (*Chanos chanos*), Pearl spot (*Etroplus suratensis*) and Cobia (*Rachycentron canadam*) are available for farming. Successful technology has been developed for the seed production of Asian seabass, Milkfish, Pearl spot, Cobia and Nona tangra under controlled conditions and farming by ICAR-CIBA. Controlled breeding of grey mullet (*Mugil cephalus*) and grouper (*Epinephalus tauvina*) has also been successful. All those fishes have shown promises for commercial aquaculture in inland saline soil / water areas with production ranging from 0.5 to 4 tons ha^{-1} $year^{-1}$.

Shrimp farming practices

Most common shrimp farming practices followed in West Bengal are traditional (Plate 2), extensive, semi-intensive, and intensive. These four categories are divided, according to their stocking densities (shrimp m^{-2}), and the extent of management over grow-out parameters, *i.e.* level of inputs (Table 1).

Table 1. *Farming practices based on level of management, stocking density and production*

Component	Traditional	Extensive	Semi-intensive	Intensive
Pond size (ha)	0.1-50.0	1.0-10.0	0.2-2.0	0.1-1.0
Stocking	Natural	Natural + Artificial	Artificial	Artificial
Stocking density (seed m^{-2})	Unregulated	2-6	6-20	20-50
Seed source	Wild	Wild +Hatchery	Hatchery +Wild	Hatchery
Annual production (t $ha^{-1}yr^{-1}$)	< 0.6	0.6-1.5	2.0-6.0	7.0-15.0
Feed source	Natural	Natural	Natural +Formulated	Formulated
Fertilisers	No	Yes	Yes	Yes
Water exchange	Tidal	Tidal + pumping	Pumping	Pumping
Aeration	No	No	Yes	Yes
Diversity of crops	Polyculture	Monoculture, polyculture rarely	Monoculture	Monoculture
Disease problems	Rare	Rare	Moderate to frequent	Frequent
Employment (persons ha^{-1})	1-2	2-3	3-4	4-5

Plate 2. Traditional brackishwater aquaculture "*bheries*"

Traditional culture practices dependent completely on the natural tidal entry of seed and food through water exchange. Furthermore, traditional systems are often characterized by polyculture with fish or by rotation with rice as in the *bheris* of West Bengal. In this method, low lying areas near the banks of saline water rivers and creeks are encircled by peripheral dyke and tidal water is allowed to enter in the impoundment along with natural seeds of various species of shrimps, crabs and fishes. Water is retained with periodical exchanges during lunar cycles and the animals are allowed to grow. After 3 – 4 months, harvesting is done partially during lunar cycles. Productivity in this system ranges between 500 – 750 kg ha^{-1} of which about 30 percent is constituted by prawns/ shrimps and 70 per cent by mullets

Extensive shrimp aquaculture is primarily used in areas with limited infrastructure. Producers rely on the tides to provide most of the food for the shrimp and as a means of water exchange. Feed for shrimp is naturally occurring, in some cases fertilizers or manure is added to promote algal growth. Low stocking densities result in modest yields. Land and labour are the principal inputs, which keeps operational cost at a minimum. This system involves construction of peripheral canals/ ponds of size ranging from 1 – 5 ha. Shrimp seed at the rate of 15,000 – 20,000 ha^{-1} are stocked. Water management is done by tidal effect. The average yield is 1,500 – 1,700 kg ha^{-1}, including fin fishes. In most of the cases the stock is left at the mercy of nature and the predators. Supplementary feeding is not generally practiced as the entire production system is dependent on utilization of natural productivities. However some farmers use oilcakes and rice bran to increase production.

Semi-intensive and intensive farming involves stocking densities beyond those that the natural environment can sustain without additional inputs. Consequently these systems depend on a reliable shrimp post larvae (PL) supply, and a greater management intervention in the pond's operation compared to extensive ponds. Following are the steps involved in semi-intensive and intensive shrimp farming:

Site selection

The site is selected only after thorough analysis of information on topography, ecosystem, meteorological and socioeconomic conditions and economic viability. Coastal sites with gentle slopes towards the sea are selected requiring less financial inputs. Clay-loam or silty-clay loam is preferred. Site should be easily accessible with availability of basic needs (Plate 3).

Plate 3. Scientific shrimp farming

Farm design and construction

Proper designing and construction of farms are essential for efficient management and for promoting environmental protection. The height of peripheral dyke is built in accordance with highest flood level. Height of the pond dyke should be at least 2 m with slope of 1:1 for clayey soil and 3:1 for sandy soil. Rectangular or square ponds are appropriate. A reservoir pond is required to act as settlement pond. Effluent treatment pond (ETP) becomes an essential part of a semi-intensive farm.

Pond preparation

Good pond preparation is the key to reduce disease risks and improving shrimp production. Presence of black soil in pond bottom is checked in wet condition. Black soil is removed either using mud pumps in wet condition or manual labor after drying. Optimum soil pH is 6.5-7.5. Lower soil pH is corrected by applying lime. Soon after pH correction, ponds are filled with water of optimum quality up to a depth of 130-150 cm after screening through 60-80 mesh net. Water is retained for 3 days with aeration for 1-3 hours daily. Aerators should be positioned properly to achieve maximum water circulation. Every 500 kg production beyond 2000 kg ha^{-1} requires minimum 1 KW aeration power. Pond is disinfected by applying bleaching powder @ 60 ppm (20 ppm chlorine) during late evening. After 5 days, dolomite @ 100-200 kg ha^{-1} and organic juice @ 200 litre ha^{-1} on the following day is applied to stimulate the plankton bloom. This schedule is repeated three times at a gap of 3 days. Organic juice is prepared by mixing 60 kg paddy flour, 20 kg molasses and 3 kg yeast in 200 L freshwater ha^{-1} and incubated for 48 hours in air tight condition. When the color of the water is green, fluctuation between morning (6:00 AM) and late afternoon (3:00 PM) pH is below 0.5 and other parameters in optimum range, the pond is ready for stocking.

Biosecurity measures

Biosecurity measures are of immense importance in shrimp farming to protect the stock from diseases. Farm should be protected with bird fencing and crab fencing. Proper hand and foot wash in potassium permanganate solution is mandatory before entering the farm. Every pond should have separate utilities. Depth more than 120 cm reduces stress and risks of diseases. Farming in closed ponds *i.e.* '0 exchange' restricts entry of pathogen and carriers of diseases. All utilities are washed in chlorinated water before first use. Proper understanding about biosecurity is most important.

Stocking

Selection of good quality PL for stocking is an important step. Good quality seeds are of uniform size, light gray or brown in colour and with good activity. Batches which test negative for MBV and WSSV are stocked. Stocking is done during early morning or late night after proper acclimatization. Recommended stocking density is up to 25 numbers m^{-2} for *P. monodon* and up to 60 numbers m^{-2} for *P. vannamei* and *P. indicus*.

Feeding management

Feed accounts for about 60% of total operational expenditure. Both over feeding and under feeding may result crop loss. Feed should contain appropriate nutrients for the particular species and of appropriate crumble or pellet size as per size of shrimp. Feed should be stored in dry and aerated place. Daily ration is divided into meals and applied as per table 2 and 3.

Daily ration is calculated as per table 3 and 4. Blind feeding is practiced up to 50 days and feed requirement afterwards is calculated based on estimated biomass through sampling and using the formula:

$$\text{Daily ration (Kg)} = \frac{\text{Mean body weight (g) x Stocking No. x Assumed survival x \% of biomass}}{1000}$$

$$\text{Quantity of feed in each tray (g)} = \frac{1600 \times \text{\% lift net x Quantity of meal (g)}}{\text{Area of pond}}$$

Six check trays or lift nets (80×80×10 cm) ha^{-1} are placed on the pond floor just beyond the dyke slopes. Quantity of feed in check trays can be calculated from '% lift net' provided in table 4 and 5 for respective species. Check trays are monitored after 2 hours of feed application. If some feed is left in trays after 2 hours, feed is reduced by 10-20%, when feed is fully consumed within 2 hours; increment of 10-20% in the next meal is done.

Table 2. *Distribution of daily ration in meals in Tiger shrimp and Indian white shrimp farming*

Period	Percentage of daily ration in meals				
	6 AM	11 AM	2 PM	6 PM	10 PM
1st month	40	-	-	60	-
2nd month	40	-	-	30	30
3rd month	20	20	-	30	30
4th and 5th months	15	15	10	25	35

Table 3. *Distribution of daily ration in meals for P. vannamei farming*

Period	Percentage of daily ration in meals				
	6 AM	9 AM	12 PM	3 PM	6 PM
1st month	40	-	-	60	-
2nd month	40	-	-	30	30
3rd month	20	20	-	30	30
4th and 5th months	15	15	10	25	35

Table 4. *Feeding schedule for Tiger shrimp and Indian white shrimp*

	For first 50 days			50 days onwards		
Age in days	Feed increment day^{-1}	Feed day^{-1} 1lakh PL 15^{-1}	Crumble/ pellet size	Mean body weight (g)	% of biomass	Lift net (%)
1	-	2.0	Fine crumble	5-10	5.5-4.7	*2.4-2.8*
2-10	400	2.4-6.0	Fine & coarse crumble	10-15	4.7-4.0	*2.8-3.0*
11-20	500	6.5-11.0	Fine & coarse crumble	15-20	4.0-3.6	*3.0-3.3*
21-30	600	11.6-17.0	Course crumble	20-25	3.6-3.0	*3.3-3.6*
31-50	500	17.5-27.0	Coarse crumble & pellet	25-35	3.0-2.3	*3.6-4.1*

Table 5. *Feeding schedule of Penaeus vannamei farming*

	For first 50 days			50 days onwards		
Age in days	Feed increment day^{-1}	Feed day^{-1} 1lakh PL 15^{-1}	Crumble/ pellet size	Mean body weight (g)	% of biomass	Lift net (%)
1	-	2.0	Fine crumble	5-10	5.5-4.5	*2.4-2.8*
2-10	400	2.4-5.6	Fine crumble	10-15	4.5-4.0	*2.8-3.0*
11-20	500	5.6-10.1	Fine & coarse crumble	15-20	4.0-3.5	*3.0-3.3*
20-30	600	10.1-15.5	Course crumble	20-25	3.0-2.5	*3.3-3.6*
31-50	700	15.5-28.8	Coarse crumble & pellet	25-30	2.5-2.0	*3.6-4.0*

Water quality management

Maintaining optimum water quality (Table 6) is very important to reduce disease risks and to achieve better shrimp production. Liming is most important in water and soil quality management. Water pH should range at 7.5-8.5 with diurnal fluctuation less than 0.5. Dissolved oxygen (D.O) should not be allowed to drop below 4 ppm at any time. Aeration is done before each feeding. Organic juice is applied fortnightly to maintain C: N ratio in the pond. Commercially available probiotics are also used.

Mineral supplementation is required for *P vannamei* at low salinity and in areas with mineral

Table 6. *Normal, optimum and critical ranges of water quality parameters in shrimp farming*

Physico-chemical parameters	Shrimp farm pond water		
	Normal	Optimum	Critical
Temperature (p C)	18-32	28-32	< 14
pH	7.0-9.0	7.5-8.5	< 6 (Daily fluctuation more than 0.5)
Salinity (ppt)	10-35	15-25	< 5 and > 40 (Daily fluctuation < 5)
Transparency (cm)	25-40	30-40	< 20 and > 60
Dissolved oxygen (ppm)	3.0-9.0	4.0-7.0	< 4
Total ammonia nitrogen (ppm)	< 4	< 3.7	-
Free ammonia (ppm)	< 0.1	< 0.1	>0.1
Nitrite-N (ppm)	0.25	< 0.25	>1.5
Nitrite-N (ppm)	-	0.2-0.5	-
Dissolved-P (ppm)	0.008-0.20	0.10-0.20	-
Hydrogen sulphide (ppm)	< 0.003	Nil	>0.003

Table 7. *Mineral concentration in seawater and factors for 1 ppt salinity*

Particulars	Sodium	Potassium	Magnesium	Calcium	Chloride	Sulphate
Sea water (35 ppt)	10500	380	1350	400	19000	2700
Factor	304.5	10.7	39.1	11.6	551	7.40

deficiency in soil. Mineral concentrations at a particular salinity should be equivalent to that of sea water diluted to that salinity. Mineral concentrations of seawater and factors for I ppt salinity are presented in table 7

Mineral requirement is calculated by using the following formula:

$$\text{Mineral salt requirement (g m}^{-3}) \quad \frac{\text{Concentration of mineral in water (mg L}^{-1})}{\text{Percentage of the mineral in salt}} \cdot \text{x } 0.1$$

Fish farming practices

In recent years, successful farming demonstrations of finfishes have paved the way for commercial farming expansion in brackishwater sector in West Bengal. Asian seabass, grey mullet and pearlspot are presently under farming in the state. Milkfish farming has been initiated recently with remarkable success. Asian seabass (*Lates calcarifer*) can tolerate wide range of salinities. Cannibalism being one of the most serious problems, farming is done in two phases *viz.* nursery and grow-out. Nursery pond size ranges from 500 to 2000 m^2 with water depth of 50-80 cm. A well-prepared pond is important as predators and competitors can endanger the stocked fry. Fry ranging from 1to 2.5 cm are stocked @ 20-50 individuals m^{-2}. Fry are fed with chopped and grounded (4-6 mm^3) trash fish @ 100 -10 % of fish biomass subdivided into two equal meals during 0900 and 1700 hours. The nursing period lasts about 30-45 days until fingerling stage (5-10 cm). Hapa nursery (Plate 4) rearing in pond is also practiced where 200-300 fry are stocked in series of hapas and fed with finely chopped trash fish in same way as in ponds.

Plate 4. Hapa nursery of seabass

Fishes are graded in different size groups at 5-7 days intervals and restocked in thoroughly cleaned and sundried hapas. Better survival is achieved in hapa nursery rearing compared to pond. The grow-

out phase lasts about 8-12 months. There are two culture systems employed in pond grow-out of seabass:

i) The supplementary feeding system is followed in places with adequate supply of fresh trash fish at low cost. Fingerlings are stocked @ 1000-2000 ha^{-1}. Chopped trash fish is fed twice daily in the morning at 0800 hours and afternoon at 1700 hours @ 10-5% of fish biomass. A very recent development on improving the dietary intake of seabass is the introduction of moist feed. A production of 2-3 tons ha^{-1} can be achieved in 8-12 months.

ii) Forage fish feeding system shows great promise. Abundant natural food is produced and selected tilapia brood stocks are released in the pond at the rate of 5,000-10,000 per hectare. Sex ratio of male to female is 1:3. The tilapia is reared in pond for 1 to 2 months or until tilapia fry appear in sufficient number. Seabass juveniles (8-10 cm in size) from nursery are stocked at the rate of 10000-20000 ha^{-1}. Fertilization is continued to maintain tilapia seed production. Seabass production of 2-3 tons ha^{-1} and tilapia production of 1-2 tons ha^{-1} is achieved in 8-12 months.

Full-scale commercial production of grey mullet (*Mugil cephalus*) is a new area of aquaculture diversification in India. This is done in two phases *viz.* nursery rearing and growout culture. After acclimatization, fry are stocked in well prepared earthen nurseries at high densities (up to 25 m^{-2}), where they depend mainly on natural food. Rice or wheat bran is sometimes used as an additional source of food. Fry are kept in the nursery ponds for 4–6 months (from January-February till June-July) until they are about 10 - 20 g BW. The fingerlings are then caught, either by draining the nursery ponds into catch ponds or by netting.

Grey mullet are usually grown in monoculture or polyculture ponds. Prior to stocking, ponds are prepared by drying, ploughing and manuring with 2.5–5.0 tonnes ha^{-1} of cow dung. Ponds are then filled to a depth of 25–30 cm and kept at that level for 7–10 days to build up a suitable level of natural feed. The water level is then increased to 1.5–1.75 m and fingerlings are stocked @ 1-2 m^{-2}. Extruded feed is supplied to semi-intensive ponds @ 5-1% of fish biomass. The growing season is normally about 7–8 months. A production of 2.3-3.7 tons ha^{-1} can be achieved. When polycultured, they are usually stocked with tilapia, milk fish, pearl spot in brackishwater and with common carp and silver carp in freshwater. In this case, feeding and fertilization programmes are usually targeting the other cultured species and the mullet feed on the natural feed, detritus and feed leftovers. Acclimatized to the appropriate salinity, and stocked as 10–15 g individuals at 6000–7000 ha^{-1}, a harvest of 4.3–5.6 tonnes ha^{-1} $crop^{-1}$ can be obtained.

Pearl spot fish is cultured in the state of Kerala in traditional manner in the *Pokkali* fields. Farming of this species is practiced in West Bengal in a small scale. These fishes are highly adapted to captive farming due to its ability to feed on a variety of natural foods. Pearlspots can spawn many times during a prolonged breeding season. Environment simulation, rather than hormonal manipulation is employed for inducing captive breeding of pearlspots, Captive breeding is carried out in ponds providing artificial substrates and breeding pits. Appropriate water levels and a moderate water flow induces breeding. Around 400–2000 eggs are laid per brood and over 90% survival is generally obtained. Nursery rearing is done in small earthen ponds. Ponds are sun dried and limed before letting in water. Water is taken through fine mesh filters to avoid entry of any predators. Organic fertilizer is applied @ 500 – 1000 kg ha^{-1} to boost up plankton bloom. After achievement of sufficient plankton bloom fry of 1 – 1.5 cm size are stocked @ 5 – 10 numbers m^{-2}. Fishes are fed with mixture of rice bran and mustard oil cake (3:1) in fine powder form @ 20 – 5% of biomass. After two months, fishes attain a length of 5 – 10 cm depending on availability of natural food in the nursery ponds. Most of them are harvested to be sold as ornamental fish. Grow out monoculture is done in similar way with 2 – 5 numbers m^{-2} and feeding at a rate of 5 – 2% of biomass for 6 - 8 months. Fishes attain an average body weight of about 100 g in this practice.

Way forward

Exports will remain the mainstay of the sector for years to come. Institutional agencies focused towards this end must seek to examine the scope for diversification of markets, communicate to exporters and processors the niche markets that exist for exclusive markets for value added fish and shrimp. It is the versatility and capability of the seafood industry to adapt that will enable them to survive such onslaughts on their territory. Domestic markets for fish and fish products not only provide an entirely new opportunity for growth but also can act as a buffer in case of gluts in the international

markets. Mud crab farming is one of the avocations started in the brackishwater sector recently to enhance the production of mud crabs as well as to uplift the socio-economic condition of coastal rural population. In the brackish water sector there were issues of waste generation, conversion of agricultural land, salinization, degradation of soil and the environment due to the extensive use of drugs and chemicals and destruction of mangroves. Efforts towards adoption of improved farming technologies like recirculatory aquaculture system (RAS), improved polyculture, integrated multi trophic aquaculture (IMTA) may make brackishwater aquaculture more environmentally acceptable.