

Present status of medium-saline 'bheri' fishery and integrated mangrove aquaculture in West Bengal, India: A short study: Part I

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V-shaped bamboo grating constructed in water channel near entry of bheri.

Bheri fishery: Concept and resource

Since the late 1960s, brackishwater rural aquaculture in West Bengal grew and improved at a fast rate, from an extensive method of farming to a modified-extensive method. The indigenous *bheri* fishery, known as *nona gheri* or *chingrir bheri* in Bengali dialect, is a well-known fishery system throughout all coastal states of India. In West Bengal, 95% of the fishery is confined to North and South 24 Parganas, two out of three coastal districts of the state.

The bheri fishery isn't a capital-intensive practice. Extended tracts of wetlands and fisheries systems with low earthen embankments occur beyond the eastern edge of Kolkata city on both sides of Kolkata-Basanti State Highway.

Tidal water is retained inside large low-lying embanked areas. These are mainly suitable for simultaneous farming of brackishwater finfish and tiger shrimp *Penaeus monodon*

throughout most of the year. Freshwater species such as the Indian major carps and the giant freshwater prawn *Macrobrachium rosenbergii* also grown.

This region falls within the jurisdiction of Minakhan Block in North 24 Parganas, a leading district for brackishwater bheri fisheries, making Minakhan a prominent area for brackishwater finfish and shrimp polyculture in West Bengal. Except for export-oriented *P. monodon*, other fishes and prawns raised in bheri are supplied to fish markets in Kolkata city and suburban towns. Reclamation of saline swamps in the Indian Sundarbans to form productive impoundments and bheri fisheries has been in vogue in these areas since the mid-1960s.

Minakhan Block in the upper Sundarbans is a region dominated by brackishwater fisheries, with 52% of the geographical area occupied by bheri fisheries¹. The activity has flourished in villages such as Joygram, Kalitala, Malancha, Chaital, Balihati-Bagirhulo, Minakhan, Uchildaha,

Bachhra, Majherpara, Ghusighata, Bamanpukur, Kushangra, Simuldaha, Dhuturdaha, Tentulberia, and Shibpur. Presently it is a perennial brackishwater fishery and paddy farming is not practiced simultaneously nor synchronously.

Minakhan Block has the second most brackishwater bheri fisheries in North 24 Parganas district, after Haroa Block. The area used for extensive brackishwater finfish and shrimp polyculture was 4,047 ha in 1980-'81 but increased to 6,294 ha in 2007-'08 and 8,310 ha in 2018. In this district, the total bheri area increased from 15,249 ha in 1980-'81 to 33,850 ha in 2007-'08 and 50,570 ha in 2018¹. According to a 1993 publication, Minakhan had 3,234 ha out of 28,396 ha in thirteen bheri-fishery blocks of North 24 Parganas². In 1986, the Minakhan medium-saline brackishwater bheri fishery occupied 1,982 ha out of a total of 23,887 ha in North 24 Parganas, and 32,939 ha in North and South 24 Parganas combined³.

Another publication reports that 33,918 ha of extensive brackishwater bheri fishery existed in West Bengal for *P. monodon* and brackishwater finfish (mullet) farming⁴. These productive, extensive, and perennial medium-saline water bodies have no proper shape, particularly the medium and larger ones. Traditional shrimp culture in medium-saline bheri is unlikely to pose any adverse environmental effect when effluent is discharged into open coastal ecosystems⁵. It is an environmentally and society friendly activity that provides employment for the local people. Many poor people are employed by bheri lease holders for overall management of brackishwater polyculture practice in such large areas.

Characteristics

Bheri fisheries in the villages have developed on both a small-scale (0.4-1.6 ha for individual farmers) and large-scale (2.6-13.2 ha plot taken on lease by groups of 2-9 of farmers). They are dependent on water from the nearby Bidyadhari, a brackishwater tidal river of the Sundarbans. The main sources of water for bheri fisheries in the two districts are brackish rivers and estuaries, namely the Saptamukhi, Thakuran, Matla, Gosaba, Muriganga, Harinbhanga, Kulti-Bidyadhari, Ichhamati, Raimangal, and Hooghly, with their tributaries. Groundwater is not used to fill bheris. The success of bheri farming depends on the entry of good quality tidal water.

Water replenishment is conducted periodically, first in January-February after pre-stocking management, via feeder canals at the time of high spring tide, mainly during the full moon and new moon. Locally this is termed *gon*, continuing four days before and after each full and new moon. Water is released during low (neap) tide; a closely woven bamboo screen with a dense nylon net is kept at the sluice mouth so that fish and shrimp cannot escape.

A unique feature inside bheri plots is the presence of water channels on the way into the main bheri entrance after the sluice box (gate), which are excavated to allow water exchange. Typically, closely placed split-bamboo screens or gratings are fixed and arranged vertically erect in a 'V' or 'W' shape in front of the sluice to prevent the escape of fish under culture. The sluice is rectangular in shape and operated mechanically.



W-shaped bamboo grating in another bheri at Canning town.



Aatols (traps used for harvesting) stored on embankment.

To harvest marketable fish and shrimp, cage traps made of split bamboo sticks (locally termed *bitti*, *atol* or *ghurni*, are fixed in the gaps at the apex of the bamboo screen fixed erected across inlet channels near the sluice gate. The open ends of cage traps face the bheri plot. When tidal water enters the bheri during the spring tide, shrimp and mullet move against the current towards the sluice box and get caught in the traps. Fish farmers operating the bheris have considerable experience in conventional brackishwater polyculture. They are familiar with the scientific version and standardised packages of practices of more profitable brackishwater finfish and shrimp farming, both mono- and polyculture.

Since inception of the bheri fishery method, naturally occurring fish and prawn seed have been recruited via entry with tidal water. But since the recent past, bheri farmers have planned for selective stocking of quality prawn, shrimp, and finfish seeds in most of the areas in addition to the stock received through tidal ingress, purchased from market and/or fish seed traders in North and South 24 Parganas. Seeds are no longer abundant in the Bidyadhari at Minakhan Block.

Bheri soils hold a portion of the dissolved nutrients from tidal water on their surface layer, facilitating the development of benthic algae upon which fish, shrimp and prawns feed. The soils are a source of phosphorus, aiding in finfish and shrimp production, detritus rich in decaying organic matter, important salts, and settled matter. Aquatic grass grown on the bank decays and adds nutrients to the water and soil when water



A narrow canal of serving water from the Bidyadhari to bheris.



Sluice gate or water gate with wooden shutter in a bheri.

levels increase and they remain submerged for long periods. Fish and shrimp feed on natural foods and materials present in the bheri, i.e. they are dependent on natural productivity. During the intake of tidal water, nutrients and natural foods are carried into the bheri plots. The size of small bheris varies from 2-15 ha, whereas the larger bheris may reach 267 ha, although the average is around 15-34 ha. There were 458 bheris in the medium-salinity zone of North 24 Parganas (including Minakhan), covering an area of 15,613 ha. At Minakhan, the water salinity of bheris does not generally rise above 20 ppt during summer⁶. Bheris at Minakhan have 15-16 mmhos/cm salinity until July when good growth of brackishwater fish and *P. monodon* occurs. Monsoon salinity here is 4-6 mmhos/cm (a salt concentration of 1g/litre is about 1.5 millimhos/cm salinity)⁷.

Small brackishwater bheri fishery

Recently, the author spoke on-site with a few progressive bheri farmers at Minakhan Block and the facts and figures they provided are presented here verbatim. On 20 August, the author visited Sri Habibur Rahaman's bheri at Malancha Village, North 24 Parganas. He oxygenates hatchery-produced *P. monodon* seed of 20-24 mm size for an additional 1-2 hours after opening the oxygenated packet. Bidyadhari water is taken in during high tide via a 3-4 m wide narrow canal. He leases his fish and shrimp polyculture plot and was trained in this activity by his father-in-law who started in 1998. The water temperature in the packet in which



Bheri fishery of Sri H. Rahaman at Minakhan.



Fry of *Planizila tade* 72mm.



Fry of *Planizila parsia* 24mm.



Fry of *Planizila macrolepis* 45 mm.

P. monodon seed were brought should be acclimatised with that and that of bheri water before stocking. According to him, two oxygenated packets contained in one carton hold 8,000-8,500 seed, for which he pays INR 4,200 (around US\$50), bought from M. Star Aquatech Hatchery, Chennai. He stocks 1,000 seed in every 0.132 ha water body but first acclimatises them in a 3 m x 3 m hapa enclosure for 4-5 days. His bheri plot is 1.02 ha in area and is surrounded by larger ones. In addition to *P. monodon*, he stocks and rears seed of three

mullet species *Planizila tade* (bought @ INR 10/piece, 7.5 cm); *P. parsia* (INR 1,500/kg, 15-24 mm); *P. macrolepis* (INR 600/kg, 4.8 cm); and giant freshwater prawn *M. rosenbergii* (INR 1/piece, 2.5 cm). Like others, he is not dependent upon a single economically important brackishwater aquaculture species. He procures seeds from producers and traders at Dhamakhali village in Sandeshkhali-II Block, North 24 Parganas. He has constructed shallow depressions and trenches in two border areas of his bheri within and along embankments with a 75 cm water depth in the main bheri and 150 cm in trenches.

In it, he stocks a total of 1.5 kg *P. parsia* seeds, 8 kg of *P. macrolepis*, 600 pieces of *P. tade*, 8,000 pieces of juvenile *M. rosenbergii*, a small amount of *Tilapia nilotica* - all just once - and one carton of *P. monodon* seeds every month (8-10 packets every season). Shrimp achieve 25-30 g weight in three months of culture. In 7-8 months, *P. parsia* and *P. macrolepis* achieve 15-20 g and 30-50 g respectively. To get a good price in the retail market, the two mullet species are cultured for 10 months in such a bheri and grow faster in even larger water bodies. *M. rosenbergii* achieves 60-100 g in 8 months and *P. tade* 300 g in 8-10 months (but reaches up to 500 g in same period in larger plots). Compared to semi-intensive scientific *P. vannamei* or *P. monodon* monoculture as in the coastal blocks of Purba Medinipur District, money invested in 1.056-1.32 ha of such a brackishwater modified-extensive polyculture system here is equivalent to that made in a 0.132 ha shrimp monoculture pond at Purba Medinipur, Sri Rahaman stated.

He applies 3 kg of groundnut oilcake on the first day, 3 kg of commercially available shrimp mash feed (INR 50/kg) on the second day, and 3 kg of poultry mash feed (INR 42/kg) on the third day for his growing fish and shrimp, continuing this practice almost every day. He applies zeolite to eliminate ammonia and harmful gases from the bottom soil, and lime when felt necessary. Normally the bheri provides enough nutrients to support fish and shrimp under culture. His *P. monodon* is sold at INR 700/kg (25 g) and INR 750/kg (30 g) at Malancha wholesale fish market. Others like the mullet *P. parsia* 15-30 g sold @ INR 350/kg in district fish markets, *P. tade* 300 g @ INR 240-300/kg. In a season, if harvested from bheri in advance and ahead of others and supplied to markets, fish farmers get a good price for their harvested fish and *P. monodon*. The latter meant for export are de-headed and packed in ice and sent to different private companies. He experienced that *T. nilotica* shouldn't be stocked in the presence of *P. monodon* seeds as the latter is devoured by the former.

Another small bheri fishery at Minakhan

On 3 September the author visited another bheri, 0.858 ha and some 80-100 cm deep, located 500 m from the previous one. The farmer operating this water body experienced that *P. monodon* seeds stocked during January to April attain good growth. His harvest begins from mid-April when the shrimp reach 25 g. Under good soil condition, his *P. monodon* grows up to 32-35 g. *P. parsia* seeds in his plot exhibit stunted growth due to a lack of natural food sources, with only 7.0-7.5 cm length attained. He stocks *P. monodon* seeds at 25-28-day intervals @ 1,000-1,500 / 0.132 ha. He



A small bheri at Minakhan 0.660-0.726 ha.

avoids drawing in Bidyadhari water frequently during high tide as, according to him, the load of chemical compounds, pollutants and raw domestic city sewage has increased in Bidyadhari steadily with the progress of time. Deterioration of the river water quality due to contamination with effluent from tannery factories is a big concern for almost all bheri farmers at Minakhan Block. It threatens the success and survival of the bheri polyculture system and significantly decreases *P. monodon* production, which is slow in present times, with mortality of stocked seeds observed in considerable numbers.

Sales of fish will help to meet the lease amount already paid by him to the landowner, but overall, his profit margin is decreasing. The lease amount is INR 12,000-14,000 per 0.132 ha bheri area per twelve months at Minakhan, with the lease agreement made for three consecutive years. He bought riverine *P. parsia* seeds from Dhamakhali, some 4,000-5,000 pieces weighing a total of 1 kg. The price was INR 1,000/kg. For larger sized seeds, it is INR 1,500/kg. Many of the small-scale bheri farmers here are medium grade to poor in economic condition. Until the very recent past, wheat flour was given to him for household members as a monthly ration from the Government of West Bengal free of charge, which he used in his bheri to feed growing mullets. But supply



Bags of sundried and hygienic poultry manure for feeding.



Broken rice for feeding fishes after boiling.

of wheat from ration shops has stopped. Now he uses broken rice of medium- to low-grade, containing little husk @ INR 20/kg. After boiling, it increases in volume, turns soft and is then fed to growing *P. monodon*, *M. rosenbergii* and mullet at bottom of water body after mixing with small amount of trash shrimp meal. Hatchery-produced *P. monodon* seeds are used mostly for stocking because availability and supply of local riverine seeds is inadequate. Sometimes he uses commercial shrimp feed in a low amount, that costs INR 40-42/kg. Some farmers prefer to use dried chicken manure in water body as feed for finfishes @ INR 50-60 for a 50 kg sack including transportation cost. According to him, at Minakhan, hatchery seed of *P. monodon* brought from south India cost INR 100 more (INR 600-700/1,000 pieces) for every 1,000 pieces in comparison to that of riverine seeds of North and South 24 Parganas districts.

He experienced Asian seabass *L. calcarifer* to be unsuitable component for brackishwater polyculture in bheri. He also observed that riverine *P. monodon* have much less disease incidence and that hatchery-produced seeds seem more prone to viral infections. Many farmers, including him, have not observed natural occurrence of *M. brevicornis* and *M. monoceros* seed in the Bidyadhari River since the recent past, due to impact of pollution. Shrimp seed enter into the Bidyadhari at Minakhan along with high tide water which it receives from Bay of Bengal, but those do not survive as the river receives Kolkata city sewage discharge conveyed by storm weather flow channels and wastewater released from factories that have their outfall in the Bidyadhari at its other end via the Kulti river. He stocks Indian major carp fingerlings during June-July. During December-January, the water level in the Bidyadhari and other rivers is lowest, and it is easy to dewater bheri plots. He keeps few dry branches of babul, tamarind and bamboo trees fixed in bottom soil which are useful as growing *P. monodon* and giant prawn take shelter here and clinging onto it if the condition of bottom soil becomes improper and unhygienic.

After harvesting fish in December-January, he uses cow dung, mustard oil cake, diammonium phosphate, and single super phosphate during bheri preparation in January for the next crop. Many farmers have individual 15-30 cm diameter pipelines to take in Bidyadhari to their plots from a common feeder canal. These are mostly kept closed, during which the water level in canal rises. Earlier his *P. parsia* grew to 20-50 g in about ten months in good water and soil conditions.



A view of the large bheri at Canning Shyama Prosadpally.

Large single 13.2 ha brackishwater bheri

Since 1991, Sri Achintya Mondal has been practicing modified extensive brackishwater polyculture in a bheri at Minakhan. A total of ten elderly progressive fish farmers in this village, including him, educated but unemployed in the beginning in 1996, collaborated to take a large 13.2 ha bheri on lease. Good faith has existed among all of them over the preceding two and a half decades. Both natural riverine *P. monodon* seeds of the Sundarbans region and those produced in hatcheries of Andhra Pradesh/Tamil Nadu are cultured here. Initially, the 12-24 mm sized *P. monodon* are stocked in a small embanked 200-340 m² earthen chamber inside the bheri, 0.9 m deep @ 1,000 pieces / 0.132 ha in December-January and reared for 5-6 days. These are automatically transferred to 2.26-3.3 ha plots as second chambers, all within the 13.2 ha water body. *P. monodon* attains 5.1-6.4 cm over the next 20-25 days. Finally, these are released in 9.9 ha main plot. In next 90-110 days, these grow up to 33-40 g (25-30 pieces in one kg). A total of 100,000 *P. monodon* are required to be raised in the 13.2 ha bheri. If soil and water conditions are not ideal (less productive), then *P. monodon* attains 16-18 g weight in this period (60 pieces / kg), Sri Mondal stated. Rotational farming is practiced here, newly brought seeds will be stocked again in the first chamber after 24-25 days, continued until early August every year. For transferring growing seeds to larger plots and grow-out, netting and harvesting of young is not done; instead, the embankment is cut at one point (*paar katiye deowa* in Bengali vernacular or 'cutting the bundh') and smaller chambers connected to the larger ones. As Sri Mondal mentioned, no use of commercial chemicals or fertilisers is done in this farming system. It is a contrast to the semi-intensive or intensive *P. monodon* and *P. vannamei* projects of Purba Medinipur District, which are highly capital- and cost-intensive. Normally, natural food sources are present in bottom soil here, and a good environment favours good shrimp growth and production.

Before transferring *P. monodon* in the 9.9 ha area, the water is let out, and the bottom soil with only a little water remaining exposed to sunshine, ploughed, treated with mohua oil cake, lime and inorganic fertilisers. When small weeds like *Sesbania* sp. are grown over bheri soil and chopped and mixed with soil, it results in good production of algae (as food)



Author (left) with farmer Sri A. Mondal.



Small chamber connected to bigger chamber in a bheri.



Small earthen chamber for *P. monodon* seed rearing.

over the bottom later. In the off-season (November-December and December-January), Sri Mondal and others observe the conditions of embankments on all sides that should withstand tidal waters, the V/W shaped split bamboo screen is mended, sluice box and other components repaired, and inside channel desilted. At 15-30 cm water depth, mustard oil cake and cow dung are applied to increase productivity and thereby the natural food production of the water body. After 9-12 days, water from the Bidyadhari is allowed to enter up to 1.0-1.2 m height from the feeder canal. Harvesting begins from the 90th day of first stocking. On every spring tide, comprising a continuous 4–5-day period, adult *P. monodon* move against the water current towards the sluice gate and are collected in traps at the mouth of the inlet when river water is allowed to enter from the canal. But this conventional system of harvesting marketable *P. monodon* is not followed by Sri Mondal as presently the Bidyadhari water quality is not good, so intake is minimised as much as possible. Instead, cage traps aatol made of split bamboo sticks are employed over the bottom at the periphery of the plot on spring tide days. According to Sri Mondal, a single bheri in North 24 Parganas may be up to 80 ha in extent.

Moulting carried out on neap tide days favours growth of shrimp. Unhealthy *P. monodon* and stunted individuals cannot moult properly. It is a continuous stocking, growing and harvesting practice for the main crop *P. monodon* in this 13.2 ha bheri. A fine-meshed nylon net or sieve is put at the water

gate so that young predatory fishes aren't able to enter along with the tidal water. Chambers smaller in size than main bheri plot typically have thin cut embankments. During January-April, *P. parsia* seed are stocked in main 9.9 ha plot, bought from seed traders @ INR 2,000/kg, 12-18 mm, 1,500-2,000 pieces weighing a total of around 1 kg. Slightly larger 36-48 mm seed also stocked, 200-250 pieces / kg, costing INR 500/kg. A total of 10 kg of *P. parsia* seed are stocked in the 9.9 ha area, harvested in September-October, when reaching 20-25 pieces per kilogramme. Riverine *P. parsia* fry 24-36 mm grow to 100-150 mm after eight months. *M. rosenbergii* and *P. parsia* have been included in this bheri fishery since 2015. *T. nilotica* and *Mystus gulio* are also reared simultaneously with *P. monodon*. Salinity in the bheri is reduced with onset of the monsoon season. *Gibelion catla* 400-500 g stocked in July-August, are harvested in December-January of the following year at 1.6-2 kg size. The presence of macroalgae and scattered thick masses of submerged green aquatic weeds with soft stems and small leaves, viz. *Najas graminea* and *Ceratophyllum demersum* are important in such extended brackishwater polyculture plots near the periphery and in the shallow regions, Sri Mondal stated. They prevent dissolved oxygen scarcity in water, absorb dirt and pollutants from the water body through their roots and stems, and provide food and shelter for the growing fish and shrimp. These are allowed to grow in the low water column before stocking fish and shrimp seed.



V-shaped bamboo grating in inlet of Sri A. Mondal's bheri.



Small chamber connected to main bheri via cut embankment.

Brackishwater fish are harvested during September to November using ber jaal (zero mesh seine net). *L. calcarifer* seed are first obtained from natural sources during March-April. Previously they would enter plots during spring tides but are now stocked from outside only in small quantity after purchase from seed traders of North and South 24 Parganas @ INR 10/piece. To gain and arrive at 1 kg body weight, it will devour 6-10 kg of other fishes available in the culture system. It is harvested during November-December and attains 500 g – 2 kg, sold @ INR 400-450/kg. *P. tade* seed of 24-48 mm at stocking grow to 225-250 mm during the same period. Some reach even 330-360 mm. A total 5,000-6,000 seed of this species stocked in 9.9 ha, 36-40 mm, bought @ INR 8-10/piece; harvested in December at 300-500 g body weight, sold @ INR 130-140/kg. The fry are first stocked in a small chamber and reared for about 3-4 weeks. *L. calcarifer* and mullet seed are not very abundant presently in the rivers of these districts, so depending on natural / self-stocking is not viable.

T. nilotica naturally breed 4-5 times in a year in these plots, and self-recruit; the presence of submerged aquatic weeds favours its growth.

M. rosenbergii seed are stocked in May-June, 12-14 mm, total 50,000-60,000 pieces in the 9.9 ha bheri in a season, at a cost of INR 700-900/1,000 pieces. It grows to 70-100 g, is harvested in December by dewatering when the plot is allowed to dry, and preparations are taken for the next crop. It is sold @ INR 500-550/kg.

At the end of September, market sized *P. monodon* are almost entirely harvested and sold, mainly done during the gon of full moon, marking the end of its culture cycle while it is time for the fish to grow. March-April to the end of August is the peak culture and production season of *P. monodon*, Sri Mondal stated. Tapioca-pearl-like white spots are observed on the cephalothorax to a low extent in some adult *P. monodon*, without any mortality. *M. gulio* and *T. nilotica* are kept separately in a 0.132-0.264 ha chamber at one end of plot, which are released after entry of new water in January-February and submerged aquatic weeds are grown to a proper size. A mixture of mustard oil cake, rice bran or rice dust and maize dust is used as feed in the form of small dough balls in each of three consecutive days during the neap tide at fortnightly intervals. Sri Mondal is the main technical person among the ten members, responsible for proper management, maintenance, and daily attention of this 13.2 ha bheri, good fish and shrimp production and harvest. An aggregated mass of rooted and unrooted soft submerged weeds naturally grows in clear water in absence of fish and shrimp; they are not produced in conditions when the bheri water turns semi-turbid or turbid. Phytobenthos and a periphyton-mat-type natural food called lablab grows over the body of the weeds. Food matter is also produced on the bottom soil when these weeds die and decompose. In bheris with a desirable quantity of submerged weeds, market-sized *P. monodon* take on a bluish hue on their body and are more attractive in the wholesale market; their presence is conducive for a good harvest.

Harvested fishes and shrimp are disposed and sold to merchants and dealers in wholesale markets at Malancha town, 1.5-2 km from this bheri. He gets INR 320-820/kg for *P. monodon* (according to size gradation). Chaitalhat, Minakhan and Sorberia are also nearby wholesale markets for *P. monodon* and brackishwater fish. There are well-developed



Growth of *Najas graminea* - useful for growing shrimp.

local *P. monodon* and fish marketing centres for both medium-saline and high-saline zones bheris and readily available transport facilities, he stated. Growing *P. vannamei* under culture in brackishwater farming areas consumes a lot of commercial feed, so it is not included in this bheri. Sri Mondal applies mustard oil cake and raw cow dung during water body preparation before stocking of seed. Agricultural lime (to condition the soil prior to stocking) and inorganic fertilisers are also used once in low amounts. After raising the water depth to 1 m and above and stocking the fish and shrimp seed, use of commercial fertilisers, chemical compounds and commercial formulated feeds is completely avoided. It is not a traditional grow-out brackishwater polyculture system. Rather, it is a natural semi-scientific and improved farming system, which is definitely a profitable venture. No entry of naturally seeds occurs with tidal water intake from the Bidyadhari into bheris at Minakhan.

The water supply from the Bidyadhari is becoming unreliable and brackishwater fish farmers at Minakhan Block will experience a huge setback in days to come, Sri Mondal stated. He fears that chemical pollutants in the Bidyadhari may contaminate bheris if water is frequently exchanged. Naturally occurring and riverine *P. monodon* seeds are collected at places such as Tengrarchar in Kulpi Block, Sonakhali and Jharkhali in Basanti Block, Herobhanga in Canning-I Block, Tambuldaha and Amjhara in Canning-II Block, Harwood point and Jumainaskarhat in Kakkdip Block, some areas in Patharpratima Blocks, all in South 24 Parganas and at Dhamakhali, Najat, Malancha, Hasnabad in North 24 Parganas. *Plotosus canius*, *Brachyobius* sp. and others are predators of young *P. monodon* and must not be allowed to enter the bheri. Stocking of *T. nilotica* is non-compatible with shrimp, although it controls excessive growth of algae, he stated. Feed mixtures prepared out of ingredients such as rice husks, rice bran, rice dust, broken rice dust, wheat flour by-products, pulverised shrimp head waste, low-cost shrimp meal, and wheat flour may be used. *P. monodon* seeds are obtained in maximum quantity during March to July in the Matla River and lower Bidyadhari, and during February in the Hooghly River. *P. parsia* are at their maximum during January-March and *P. tade* during March-May in the Hooghly River.

Sri Mondal learnt from experts that 25,000 (4 cm) *P. monodon* and 15,000 *P. parsia* should be stocked in every 1 ha bheri area. Application of limestone powder @ 15-20 kg/0.132 ha is effective before seed stocking. *G. catla* and *Cirrhinus*



Harvested market-sized *P. monodon*.

mrigala grow in such brackishwater bheri during June-July to December in reduced salinity conditions. Sri Mondal further stated that if the bheri soil is ploughed after drying and weeds mixed with it, a good production of algae will develop over the bottom soil bed once the bheri is filled to 25-30 cm over the next fifteen days. Thereafter *P. monodon* seeds should be stocked. Typical rectangular-shaped split bamboo box (*haapar* in local dialect) are used to catch marketable-sized shrimps from bheri.

Opinion of another two bheri farmers at Minakhan

P. monodon farming in bheri at Minakhan is not as profitable as it was in the mid-2000s and earlier. On 3 September, the author visited another two bheri farmers at Minakhan who stated that riverine *P. monodon* seeds had good growth in these bheri until the early 2000s. But since 2004-2005, farmers are dependent on hatchery-produced seed. In previous years, sufficient wild shrimp seeds came in with the tidal water and grew very well, so stocking hatchery seed was not necessary. Now even if seed is stocked from outside, whether collected from rivers or hatchery-produced, they commonly display significant mortality. They also noted that brackishwater normally cause a speedy erosion of bheri embankments and riverbanks in comparison to freshwater.

At Minakhan, in one *gon*, i.e., continuous four-day period before and after the full and new moon, they reported that 150-160 kg marketable *P. monodon* could be harvested from a 2.64 ha bheri (supposedly) in previous years. But now the typical harvest is 20-50 kg from the same area. A good number of bheri lease holders are not able to pay the full rent to landowners due to unexpectedly low amount of shrimp production and profit. But until 2009-2010, bheri farmers at Minakhan earned a good and highly satisfactory profit from *P. monodon* farming in these plots. Young of few species of estuarine finfishes *Acanthopagrus latus*, *Gudusia chapra*, *Scatophagus argus* and others, that come up along high tide in Bidyadhari are not able to grow, and seed is killed due to the deteriorating condition of river water. Those that enter from Hooghly-Matla estuary do not survive in good numbers when they encounter untreated domestic sewage and contaminated mixed water from Kulti and Bidyadhari rivers (and also other pollutants) outside the Kulti-Ghusighata lockgate when the gate is opened. This has been happening since 2007-2008. The Kolkata sewage effluent gets mixed up with tidal water. Domestic sewage is also received from the Kestopur and Bhangore canals.

Until 2005, each of these bheri were a single stretch of 13.2-66 ha brackishwater area. But steadily, many of these were divided into small individual plots of 0.2640-1.056 ha

each and were leased out to brackishwater fish farmers. Now brick kilns have been established in some places that were previously occupied by bheris.

At Kati centre at Minakhan beside main roadway, 18 mm *P. monodon* seeds brought from hatcheries of south India are stocked in 24-32 m² earthen chambers having high embankments, water depth 0.6 m @ 15,000 / chamber. During January to mid-June, some youths earn a living by rearing tiger shrimp seed here for 4-7 days until they grow a little bigger (24-36 mm), with blackish body colour, and are sold to farmers. Seed are bought @ INR 0.50/piece and sold @ INR 0.60/piece. Salinity in bheri plots is reduced with the onset of the monsoon season, so the Kati centre operated till the end of June as there was no new stocking of *P. monodon* from mid-July. But such *P. monodon* seed production centres are not getting much profit nowadays.

Conditions in 2022 have not been for good *P. monodon* production due to poor quality river water, coupled with continuing hot weather, high water temperature with reduced dissolved oxygen content in bheri plots. Adult *P. monodon* produced from hatchery-produced seeds from Nellore, Visakhapatnam, and Chennai are harvested on and from the 75th day of stocking, and those produced from riverine seeds from the 90th day. Some farmers stock brackishwater finfish and *M. rosenbergii* seeds during early to mid-June, and that of major carps in July-August. The harmful effect of sewage water released from Ghushighata lockgate and entering the Bidyadhari continues far downstream to Dhamakhali Village. To save the bheris and to get a satisfactory production overall, Indian major carp seed are stocked, which grow during June-July to December. Naturally occurring young mullets can survive only scarcely in the Bidyadhari, slowing the growth of *P. parsia* and *P. macrolepis* in some bheris due to the aforementioned water quality issues. Farmers expressed concern that diesel pumps are often used to intake Bidyadhari and other river water into bheris during high tide by means of mechanical pumping, and diesel is now very high-priced.

Part II of this article will be published in the April-June issue of the magazine. It explores brackishwater polyculture in South 24 Parganas and integrated mangrove aquaculture.

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