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AQUACULTURE ASIA

Hilsa pond aquaculture practices

Promoting entrepreneurship in tribal women of Jharkhand

Bheri fisheries

Yellow tail catfish breeding

Aquaculture Asia

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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NACA

An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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AQUACULTURE ASIA

Fish welfare on the agenda

On 8 March FAI and NACA will convene a free webinar entitled “Fish welfare: What we need to know?” via Zoom. The speakers will address the relationship between animal welfare, health, quality and profit in aquaculture production.

Farmers well understand well that good husbandry is central to achieving a good crop, but historically the aquaculture industry has not often used ‘welfare’ as a term of art. This has occasionally led to conflicts with, and criticism from, external actors that favour this term.

The aquaculture industry has instead favoured terms such as ‘better management practices’, ‘good aquaculture practices’, and similar. If you scrutinise such practices, you will find it difficult to find any that cannot be linked to animal welfare in some way. Due to the sensitivity of aquatic animals to their environment, and the need to carefully manage water quality, stocking density, nutrition, and health issues, among others, animal welfare is a central concern in any successful aquaculture operation.

The link between stress and disease in aquaculture is beyond all doubt, as it is in all livestock industries. Nobody needs to be convinced that animals subject to inappropriate environmental conditions, bad water quality, overcrowding, or deficient food will grow poorly, or that they will be subject to significantly higher incidence of disease. In aquaculture, this extends to the real possibility of sudden mass mortality events and complete crop failure. Farmers have a strong incentive to look after the welfare of their stock. The consequences of crop failure, particularly for small-scale farmers, are dire.

If there is an area that is lacking, it is post-harvest handling and humane slaughter. There is clearly room for improvement here, particularly with smaller animals and invertebrates that may not receive the same level of attention as, say, large fish. But still, there are economic reasons for industry to improve its practices. While fish are not as well studied, pre-slaughter stress is known to affect meat quality and shelf life in other livestock industries. Poor handling during harvest certainly can lead to injuries that may affect the appearance of animals, which may affect their market price, and seriously, in the case of high value species. For low-cost products sold into local markets, such considerations may not be adequately addressed at present, and infrastructure may also be a constraint, but moves are afoot to address that.

So, let’s talk about it. I would like to invite you to attend the webinar on 8 March. Participation is free, but registration is required. To attend, please visit the link below where you will find the programme details and a link to the registration form. The webinar will kick off at 9:30am Bangkok time (GMT +7). See you there!

https://enaca.org/?id=1260

Simon Wilkinson

AQUACULTURE ASIA

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Augmenting entrepreneurial attitude among tribal women of Jharkhand through a skill development programme in fish value added products

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Tribal women participating in hands-on training in preparation of fish value-added products.

India as a nation has come a long way from a literacy level of just 14 per cent (Shah, 2013) and a life expectancy of 32 years at the time of independence (Ahuja, 2022), to around 70% literacy and 70 years of life expectancy. As a diverse country with a heterogenous society, it is to be expected that development has not taken place evenly. Due to the effects of social hierarchies and structures, some communities need special attention and focus to make them active participants in the development of our country.

Today, tribal people comprise 8.6 percent of the Indian population (Kumar et al., 2020) and are one of the most disadvantaged sections of society. Many tribal groups in different parts of the country depend on natural resources for their livelihoods, which are slowly been eroded due to due to mining and stringent environmental laws. There is a serious effort from both the states and central government to assist these communities and enable them to improve their livelihoods and standard of living through various initiatives such as Stand Up India, the Tribal Sub Plan and different scholarship schemes for tribes.

Poverty among plenty

Jharkhand is one of the richest states of India in terms of natural resources, but the majority of its population is still poor, a perfect example of poverty amongst plenty.

Jharkhand's population is around 26.67 percent tribal (Ekka, 2020), in fact state's inception bifurcating from its mother state Bihar was a movement led by tribal groups. It is just two decades since Jharkand came into existence; but is has improved significantly in terms of development although there is a long way to go. In this mission to further develop the state and improve the livelihoods of the people, everyone, be they from the state government, NGOs, civil societies, educational institutions, or the private sector, have a crucial role to play in progressing Jharkhand and its tribal communities on the path of development.

Fisheries were first recognised as an important activity for livelihoods and food security by Sir Nicolas in the 1870s to combat drought and food shortage. Ever since, governments have passed legislation and regulations gradually improving the conservation and development of fisheries resources in the country. In recent times, fisheries have also been recog-

College of Fisheries Science, Gumla.

nised as an important source of livelihoods by both central and state governments. However, many of the schemes that have been introduced are skewed more towards production and less towards value addition. We still lack infrastructure in processing, and we are still exporting semi-processed fisheries products in international markets, which has limited our export earnings through fisheries, although they have improved significantly.

ICAR-Central Institute of Fisheries Technology, Kochi

The ICAR-Central Institute of Fisheries Technology was established in 1957 as the only national centre where research in the areas relating to fishing and fish processing is undertaken. Its headquarters are located in Kochi and its subcentres are located in Veraval, Vishakhapatnam and Mumbai.

College of Fisheries Science, Gumla

The College of Fisheries Science, Gumla was founded in 2017 under the auspices of Birsa Agricultural University. It's first batch of BFSc graduates was out performed the expectation at the national level exam for JRF and 17 students were able to qualify and took admission to other national and state universities.

Training Programme at the College of Fisheries Science, Gumla

The college, despite being young, started undertaking extension activities. Recently it secured a project worth Rs. 1 million for the training of tribal fish farmers under the Tribal Sub Plan from ICAR-CIFT.

With the financial support from ICAR-CIFT the college, under the able leadership of its Associate Dean, began training fish farmers in preparation of value-added products, which was the first of its kind in the state. Although the Directorate of Fisheries, Jharkhand, also provides numerous training programmes to fish farmers, many of the training modules are oriented towards production rather than processing and marketing. Seeing this gap, the College of Fisheries Science started providing training programmes to meet the need, aiming to improve post-harvest activities from the grass roots level to the top, with a view to financially empowering local communities.

To empower women from economically and socially marginalised tribal communities the College of Fisheries Science was granted a project from ICAR-CIFT under the Tribal Sub Plan. Within a short period, the college was able to undertake seven training programmes for tribal women from different districts in value addition to fisheries products.

The training programme was mainly oriented toward instilling skills among the tribal women that would unlock their micro-entrepreneurship capabilities so that they can launch their own business in fish value added products. The women were given hands-on training in the complete process of preparation of value added fish products from dressing and filleting of fish onwards. The different value-added products produced included fish pickles, fish cutlets, fish fingers and fish momo. The women were also encouraged to translate the skill acquired during the training into a livelihood option that would transform them into financially independent, empowered and productive participants in the rural economy. In addition, the trainees were also allowed to sell the products that they prepared during the three days training programme, which has also given them exposure and experience in marketing.

Training programmes such as this provide women from marginalised communities hope and strength to break with tradition and help them to become financially independent.

Tribal women awarded certificates after successful completion of the training programme in the presence of District Magistrate Gumla, DFO, Gumla and Former Director of Fisheries, Jharkhand.

Conclusion

Tribal communities, and in particular tribal women, are one of the most disadvantaged and vulnerable sections of society in many places around the world. These communities are historically dependent on natural resources for food and livelihoods, and due to climate change, developmental activities and conservation policies, have been gradually losing access to these means. Governments have made many attempts to bring these communities into the mainstream through various schemes and initiatives, to improve their livelihoods and economic status. The training programme at the College of Fisheries, Gumla, with financial assistance from ICAR-CIFT under the Tribal Sub Plan, is a step in this direction to augment the entrepreneurial skills among the tribal women of Jharkhand. As we know women make up 50 per cent of our population and if we can provide additional opportunities for them to contribute to our economy this will greatly improve the holistic development of our nation at large. The College of Fisheries Science, Gumla shares this vision is committed to serving the state of Jharkhand and nation at large.

Acknowledgement

The authors would like to acknowledge ICAR-CIFT for providing financial assistance under the Tribal Sub Plan that has made this training initiative of the College of Fisheries Science, Gumla possible. The authors would also like to acknowledge the Vice Chancellor, Birsa Agricultural University, Ranchi, Jharkhand for constant support and encouragement through the training programmes that have been conducted under this initiative.

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Culture of hilsa, *Tenualosa ilisha* in freshwater ponds: Progress and prospects in farming practice

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A table-sized hilsa.

Hilsa shad, *Tenualosa ilisha* (order Clupiformes, subfamily Alosinae) is an anadromous marine fish of high economic value, and the most preferred food fish to people of Bay of Bengal region, particularly West Bengal, India and Bangladesh. Not only because it has a unique taste, but also because it has an aesthetic appeal to consumers and has socio-cultural importance. Hilsa is a rich source of protein (18-23%), essential amino acids, vitamins and minerals essential to human health (Hossain et al., 2014). Hilsa is also a good source of n-3 polyunsaturated fatty acids (PUFAs), particularly eicosapentaenoic acid and docosahexaenoic acid. The n-3 PUFAs play a vital role in the development and function of the nervous system (brain), photoreception (vision) and the reproductive performance (Sidhu, 2003). They reduce the risk of cardiovascular ailments, coronary heart disease, inflammation, hypertension, hypertriglyceridemic effect, allergies, arthritis, autoimmune disorders and cancers (Sidhu, 2003; Von Sckacky, 2003; Mnari et al., 2007).

Migration of hilsa between river and sea

Hilsa have a complex and migratory life cycle. During breeding season adults migrate from the sea to the freshwater reaches of rivers via their estuaries. On the Indian subcontinent, hilsa migrates from the Bay of Bengal to the Hooghly River in India and to the Padma River in Bangladesh twice a year during September-October and February-April. Hilsa breed in the river and then return to the sea. Their fertilised eggs hatch and grow to fingerling and juvenile stage in freshwater, before the fish begin to move towards the estuary and the sea.

Initiative for domestication of hilsa

Alarmingly, the population of hilsa has been declining very fast due to over exploitation and indiscriminate catch from inland open water systems. Besides, the breeding and nursery grounds in the river are highly disturbed and thereby, breeding and the different life stages are stressed, resulting in lower recruitment over successive generations. In this context, the strategic plan for their conservation is to culture them in captivity, for it needs to be domesticated in pond - a challenge be prioritised. ICAR-CIFA has initiated a program of hilsa domestication and overcome some of the critical limitations for achieving the task through initiatives including onboard breeding, transport of fertilised eggs, rearing fertilised eggs in hatching pools, rearing of larvae, fry and fingerlings through co-feeding, weaning the fish at early stage with supplementary feeds and pond management for hilsa. Until now, the onboard breeding, transport and culture techniques of hilsa are limited to the extent by which farmers are able to culture them in ponds. The success of hilsa culture in the farmer's pond is achieved through scientific intervention of ICAR-CIFA in support with the carp culture experiences of the farmers.

Hilsa research towards farming practice

Different technologies of hilsa culture were tested on a trial-and-error basis and then established by ICAR-CIFA in its Regional Research Centre at Kalyani Field Station, Rahara. But it was felt necessary to validate the techniques on farm. In search of a suitable fish farmer, the person who was immediately identified was none other than Mr Shyama Charan Chatterjee, Magra, Hooghly District, West Bengal. Mr Chatterjee is a progressive fish farmer as well as a known fish seed producer in the country, with vast experience in carp breeding and culture. He was selected to initiate and propagate hilsa culture under the technical guidance of ICAR-CIFA as he possessed a well-established breeding pool, Chinese hatcheries and several ponds used for nursery, rearing, stocking and broodstock holding in his 14-hectare property, which were deemed suitable for hilsa farming. More and above, he bears a keen interest and is enthusiastic enough to venture such

Packing polythene bags with fertilised eggs into carton for transport.

Observing incubated eggs.

Below: Scientists of RRC, Rahara, observing hilsa fry.

a new initiative. Hilsa culture was initiated in his freshwater ponds with the usual activities: Pond selection, analyses of water quality, and preliminary guidelines including netting, application of live foods, feeding and sampling. Initially, during December 2016, a minimal quantity of hilsa seed were supplied from Kalyani Field Station of RRC, Rahara, ICAR-CIFA and stocked in his pond as a trial to observe the survival of the fry. Subsequently, during April, June and July 2017, fry, fingerlings and yearlings of hilsa were supplied further and stocked to his other two ponds of 0.1 ha each.

Above, below: Releasing spawn into nursery ponds.

Nurturing the farmer's team

To strengthen the knowledge, skill and attitude in hilsa farming, the farmer and his field staff were provided with on-farm guidance on different aspects of artificial breeding and culture technologies of hilsa through frequent visits by the scientists of RRC, Rahara of ICAR-CIFA.

Activities included:

- Onboard artificial breeding of hilsa.
- Transportation of fertilised eggs (refer article in previous issue).
- Egg incubation and spawn production in cement carp hatchery.
- Spawn collection and stocking in nursery ponds.
- *Chlorella* and rotifer culture.
- Handling techniques of hilsa egg, spawn, fry, fingerlings, table-sized fish and broodstock.
- Weaning procedure for hilsa fry.
- Pond management, including feeding schedule.
- Juvenile rearing in pond, including spawn to fry, fry to fingerlings, fingerlings to table size fish production and development of broodstock.

To develop hilsa culture practice in Mr Chatterjee's ponds, he was provided the immediate needs of some critical culture-inputs such as fertilised eggs, fry, fingerlings and supplementary feed. The ultimate long-term aim was to establish hilsa husbandry including raising of hilsa broodstock

Provision of aeration to hilsa fry in the nursery pond.

in freshwater ponds so that domesticated breeding of pond raised hilsa could be conducted to overcome the constraints on dependency of wild caught hilsa broodstock.

Onboard breeding and spawn production in the farmer's hatchery

During March 2018, consecutive onboard breeding trials of hilsa were conducted in the Hooghly River at Godakhali, South 24 Parganas, West Bengal, India. The live broodstock were directly collected on the motor boat from traditional fishermen as soon as they caught them from the river with nylon monofilament nets from their conventional fishing boats. Immediately after collection, females were stripped of eggs, followed by stripping of the males for milt in a steel tray, using the dry stripping method. Collected eggs were intermingled with milt by means of a soft feather, resulting in an average of 95% fertilisation over different trials. After water hardening for an hour, fertilised eggs were packed with oxygen filled polyethylene bags and transported by four wheeler motor vehicle to the Kalyani Field station of RRC, ICAR-CIFA, Rahara 120 km away, and to the Chatterjee Brothers farm, Magra some 133 km distant from the breeding spot. Fertilised eggs were then incubated in the modified FRP hatchery at the Kalayni Centre and in the cement carp hatcheries of Chatterjee's farm. Continuous surveillance was undertaken to study the possibility of hatching and producing larvae in the carp hatchery. By the technical guidance and continuous monitoring of the scientists of ICAR-CIFA, the farmer's hatchery successfully produced around 350,000 four-day old larvae, ready to stock in the nursery pond for fry production. This is the first recorded production of hilsa spawn in a cement carp hatchery in a farmer's ponds. The spawn was stocked in two rectangular cemented cisterns (modified Bangla bundh) and in two nursery ponds.

With the encouraging result, the next breeding trials were conducted in a similar way in February, March and April 2019 and the fertilised eggs were transported to RRC, ICAR-CIFA, Rahara and farmer's ponds at Magra in a similar way as before. In both places, fertilised eggs were incubated in cement carp hatcheries. The purpose was to obtain the mass scale spawn production of hilsa in hatcheries in different locations with different water quality. A great success was achieved and an estimated total number of 1.05 million hilsa spawn were produced in the farmer's hatcheries.

Larval rearing in farmer's ponds

Pond preparation

Fifteen days before the breeding operation was undertaken in the farmer ponds (0.1- 0.2 ha) were dried and cleaned with removal of fishes, and kept empty under sunlight for 7-10 days. When the fertilised eggs hatched, the ponds were filled with bore water up to 1.0 m depth. No fertilisers were applied to the ponds. The surface water of the ponds above 1.0m height was entirely covered with nylon monofilament net to prevent the entry of predatory birds – a serious threat to juveniles.

Hilsa fingerlings.

Counting hilsa fingerlings before release into the pond.

Fingerlings packed into polythene bags for transfer to another pond.

Releasing fingerlings into the pond.

Feeding larvae

Larval rearing of hilsa requires the utmost care and monitoring. The mouth of the larvae seems open on the 4th day, when they require exogenous natural foods. At this critical stage, the larvae were transferred from the hatching pool and stocked into the nursery pond. The larvae first feed on *Chlorella* (green water) as a starter food due to their small mouth gape. With increasing size, they feed on other phytoplankton, and rotifers, followed by large zooplankton. Therefore, the initial food supplied to them was *Chlorella*, even in the hatching pool. In the nursery pond, *Chlorella* water was supplied every day until they attained 50-60 mm fry stage, within 40-60 days.

Production of *Chlorella* to increase the amount of green water

The mass production of *Chlorella* was conducted in outdoor large cement hatching pools where direct sunlight was available. After thorough cleaning with bleaching powder and washing with bore-well water, the hatching pools were filled with freshwater. Ammonium sulphate, urea and single super phosphate @ 0.1g/L, 0.01g/L and 0.01g/L, respectively were added and mixed thoroughly. *Chlorella* inoculum, which is maintained in the RRC laboratory, Rahara, was added and the inoculated water was stirred twice daily. Normally within 4-6 days, *Chlorella* inoculated water turns green as the organisms multiply.

Co-feeding: An essential technique for larval rearing

After 2-3 days of larval stocking, co-feeding was initiated with application of rotifers (*Brachionus* sp.) along with *Chlorella*. In co-feeding, hilsa larvae feed on both *Chlorella* and *Brachionus* sp. while *Brachionus* feed on only *Chlorella* for its growth and survival. Therefore, the supply of *Chlorella* serves two purposes: (i) used as food for both hilsa larvae and *Brachionus* which grow profusely within 2-3 days, and (ii) increase of dissolved oxygen levels through photosynthesis.

Netting hilsa for sampling.

A 500 g mature hilsa.

For the production of *Brachionus*, two procedures are adopted; one procedure is to put *Brachionus* inoculum in the *Chlorella* culture water and another one is to produce *Brachionus* naturally in the pond fertilised with biogas slurry as used as an organic fertiliser. Then rotifer-rich water was sieved through 194 µm bolting cloth that allowed rotifers to pass through while large zooplankton such as *Cylops*, *Diaptomus*, *Moina*, and *Daphnia* are left behind. Generally, after 12-15 days growth, larvae were able to ingest large zooplankton along with *Chlorella* and *Brachionus*. When the fry started moving along the side of the ponds, they were provided with finely powdered supplementary feed following three 'F's –fixed time, fixed type of feed, and fixed place for weaning. This principle of feeding that the farmer needs to learn is to be maintained meticulously during the weaning phase to sustain hilsa larvae within the first 10-15 days – a critical phase of larval survival. When the weaned fry start feeding on the supplementary diet spontaneously, it may be considered as the first step of domestication of hilsa.

Production of fingerlings

After 40-60 days of larval rearing in nursery ponds, fry (50-60 mm) were collected by soft net and stocked into another prepared pond to raise fingerlings. A colossal number of mixed zooplankton was grown in the channel water body separately and also in the rearing pond. The mixed zooplankton was collected daily along with powdered supplementary feed @ 5-10% of the individual body weight of larvae. The fry survived and grew to fingerlings, reaching 100-125 mm and 10-20g within 2-3 months.

Grow-out culture

Production of table-sized fish

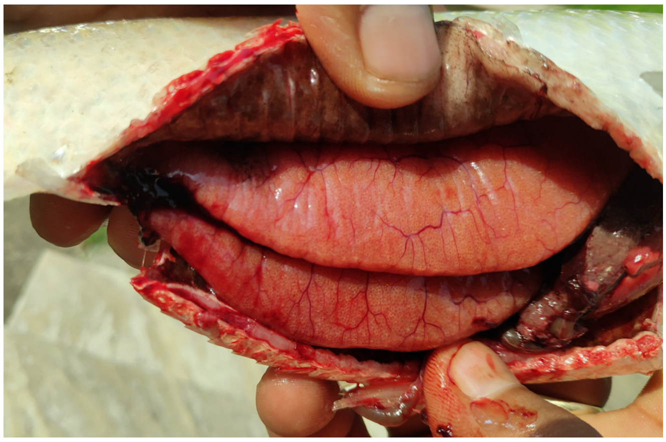
Initially ponds (0.4 - 0.6 ha) were partially dewatered keeping 15-30 cm water depth, followed by application of mahua oil cake @ 2,500 kg/ha/meter water depth to kill predatory and weed fish. Then lime was applied after 10 days, followed by pond netting at 2-3 days intervals. Heavy sinkers were used during netting to disturb the bottom soil to remove any foul and obnoxious gas, release nutrients from soil to the water and stimulate production of plankton. Usually, ponds seemed ready for stocking fish after 30 days post application of mahua oil cake. The fingerlings, ranging 100-125 mm/10-20g), were stocked in such ponds for production of table size hilsa. A sinking scrambled supplementary feed @ 5-10% of the body weight was provided to fingerlings. Biogas slurry was applied in the pond to increase the plankton density for use as food by the growing fingerlings. A few rohu, mrigal and grass carp were also released in the pond to reduce the infestation of algae and some other weeds. The carps appeared to maintain the pond condition in a congenial state for hilsa. The fish survived and grew to table-sized fish of 80-100 g during 5-6 months of culture.

Broodstock raising

For raising hilsa broodstock, a similar size of pond (0.4 - 0.6 ha) was prepared in a similar way as the grow-out pond. A numbers of hilsa of greater than 100 g were stocked for further growing to adults. They were regularly fed with zooplankton cultured in separate ponds, and also with supplementary feed @ 3% of their body weight. Biogas slurry was also applied to the pond to increase the plankton population. Dissolved oxygen was maintained above 6ppm by operating pond aerators and 5 HP water pumps as an alternate day. Water exchange was done at 30-45 day intervals. Netting was conducted at regular intervals to measure fish growth. The males became mature with freely oozing milt at the end of two years of age, while the females showed protruding eggs through the vent at the maturity considered as 5th stage after two years and nine months of age.

A pond grown female hilsa with eggs in ready condition.

Above, below: Ovary of pond grown female hilsa examined for maturity.



Conclusion

Until now, hilsa production in India has exclusively depended on wild caught fish, with natural populations in a declining trend. In spite of conservation measures, captive rearing and breeding are needed to enable domestication and farmed production of this species. Since hilsa is highly sensitive to stress, it is necessary to culture it in different environmental and agro climatic zones to test its ecological and environmental tolerances. ICAR-CIFA has paved the way for its culture in captivity and under on-farm conditions. However, breeding of pond grown hilsa remains a challenge that needs to be worked out with scientific approaches, particularly through the development of broodstock feed, monitoring environmental conditions and hormonal manipulation. The farmers who have expertise in breeding and culture of other fin fish species may take on this venture, particularly onboard breeding, seed rearing and grow out culture, through availing the opportunity for adoption of technological advancement that ICAR-CIFA has established through rigorous experimental exercises. Hopefully, the farmer's participation in this field combined with a scientific approach can generate momentum in the domestication as well as the sustainable production of farmed hilsa in India and abroad in the near future.

Acknowledgment

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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 fisheries[1]. 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 2018[1]. According to a 1993 publication, Minakhan had 3,234 ha out of 28,396 ha in thirteen bheri-fishery blocks of North 24 Parganas[2]. 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 combined[3].

Another publication reports that 33,918 ha of extensive brackishwater bheri fishery existed in West Bengal for *P. monodon* and brackishwater finfish (mullet) farming[4]. 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 ecosystems[5]. 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.

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

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 levels increase and they remain submerged for long periods. Fish and shrimp feed on natural foods and materials present in the bheri, ie. 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 summer[6]. 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

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

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.

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 m^2 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)

A view of the large bheri at Canning Shyama Prosadpally.

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 *Ceratophylum 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 Kakdwip Block, some areas in Patharpratima Blocks, all in South 24 Parganas and at Dhamakhali, Najat, Malancha, Hasnabad in North 24 Parganas. *Plotosus canius*, *Brachygobius* 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* and15,000 *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 m^2 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 Ghusighata 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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Information for farmers on yellow tail catfish, *Pangasius pangasius*, for easier captive production

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Haul of P. pangasius for broodstock selection.

Production from wild capture fisheries, both inland and marine, are reducing with the time. But people's demand for fish is increasing day by day as they become more aware of the health benefits of fish consumption. Increasing demand for fish has encouraged researchers to give more thought to captive production of favoured fish species for consumers in different regions of the globe, to help meet requirements.

The ICAR-Central Institute of Freshwater Aquaculture, a leading research institute, has worked extensively on many carp, catfish and air-breathing fishes to develop technology for farmers under the programme of species diversification for aquaculture, and to promote adoption of new practices through training and demonstration.

The yellow tail catfish, *Pangasius pangasius*, a large Indian catfish, is one of the species that has been studied. Yellow tail catfish is found in different river systems of the Indian sub-continent. The initial work on captive breeding of *P. pangasius* was carried out by researchers from our institute during the early 90's. The present article will provide updated information on the captive production of *P. pangasius*, which will be of use for farmers and entrepreneurs in increasing culture of this fish.

About yellow tail catfish

P. pangasius (Hamilton, 1822) is distributed through the river systems of the Indian sub-continent. Many other species of this genus also occur in Asian countries. It prefers to stay in deep areas of the river and moves in groups. It migrates in search of food and searches for suitable breeding grounds during monsoon months. It matures during the third year of its life and is a monsoon breeder. It is a highly fecund fish with from 160,000-180,000 eggs reported in a one kilogramme female. While the adults are omnivorous, the larvae subsist on plankton, but shift their habit to feed on both plant and animal matter as they grow. Molluscs are eaten during the juvenile stage onwards, and for this reason it is recommended as a bio-control species for molluscs in pond culture systems. Feeding intensity is high during post winter to the pre-breeding season. It is reported to reach 1.2-1.5 metres in length.

Captive production

Yellow tail catfish breed during the monsoon months. The fish begin to aggregate for spawning after one or two showers during the wet season, when muddy water flows into the river. They migrate to shallow areas from the main river stretch or tributaries to lay eggs. Seed of this catfish are often encountered in these areas after the river floods. People catch the seed along with other species after flood for grow out.

Broodstock development

Transporting the larger fish from the river is problematic and mortality often occurs even when using oxygenation. Hence collection of juveniles in large numbers during pre-winter is a bit easier with a lower mortality rate. Juveniles of 70-80 g collected from river are reared in earthen ponds for 2-3 years to obtain broodstock. Yellow tail catfish readily accept compound feed of floating or sinking nature during captive rearing. It is better to give floating feed to observe their degree of consumption, which will enable the ration size to be adjusted appropriately. Usually 28-30% protein bearing feed at 3-4% of body weight is sufficient to maintain the fish. This ration is usually reduced to 2% or less during the winter months when the water temperature remains >20°C. Overfeeding not only leads to increased cost of production, but also impacts the water quality due to decay of uneaten feed, which may cause blooms in the pond. This fish is sensitive to low oxygen levels. Settling of excess feed in the pond may create ammonia and hydrogen sulphide gas. Hence it is necessary to replenish the water after netting through the pond, which reduces the bloom density and ammonia content of the water. The fish usually grows to around 500 g by the end of the first year, rearing from 80 g, and subsequently they grow to 1-1.5 kg during the next two years, after which are ready for breeding operations.

Induced breeding

As it is a monsoon breeder, around July-August the broodstock will become gravid showing sexual dimorphism. The females have a bulging abdomen due to developed ovary and males show free oozing with a little pressure on the vent region. There is no sexual differentiation between male and female fish based on genital papilla as occurs in *Clarias batrachus*. The maturity of eggs can be verified by catheter during broodstock selection. The broodstock are transported to the hatchery in canvas stretcher bags with water from the rearing pond to reduce stress. Both sexes are kept separately in holding tanks. The females are injected with a synthetic hormone such as Ovatide, Wova-FH, or Gonopro @ 1 ml/kg body weight in a single dose. Repeated injections does not improve stripping success. The males do not need any hormonal injection during peak breeding season. However, the above hormones may be administered to males @ 0.5ml/kg body weight towards the end of the breeding season to

Use of a catheter to verify egg maturity.

Stripping milt from a male fish to fertilise eggs.

obtain a higher quantity of milt. We have observed that spent males can can be re-used for breeding if at least two weeks is allowed to pass. The successful ovulation and stripping of eggs from female fish is conducted 13-14 hours after hormone injection. Stripped eggs are fertilised with the milt before incubation in hatching devices. The eggs are slightly milky in colour and range in size from 1.09-1.28 mm.

Hatchery for egg incubation

The eggs become very sticky after contact with water during the fertilisation process. Hence many farmers use a special type of soil collected from the forest to reduce the stickiness. Washing of fertilised eggs with the prepared solution of tannic acid @ 1 g/l of water will also reduce the stickiness of the eggs and allow them to separate from each other. The eggs can be incubated in circular or glass jar hatcheries as they move independently in the water current like carp eggs. The eggs are demersal, but they rotate or float in water if current increases. There is no certain hatchery design to incubate the eggs, but operators typically use glass jar or circular hatcheries after destocking them, which allow them to rotate with the flow of water. This system ensures good water quality due to frequent renewal. Some farmers also incubate fertilised eggs in the hatchery before they become sticky and the flow of water rotates them in the water column, but they may still stick on the wall or bottom. Usually, farmers do not collect the hatchlings from the circular hatchery until yolk sac

Jar hatchery bearing coconut thread as a substrate for eggs.

absorption has occurred, after which they are collected and released into plankton rich pond or tanks. In the case of glass jar hatcheries, the hatchlings flow out continuously and are collected in a plankton hapa fixed on the holding tank, which allows them to subsequently be released in indoor rearing tanks until yolk sac absorption. Afterwards, they are released either in a plankton rich system or reared in indoor tanks for growing to fry or fingerlings. The eggs hatch after 22-24 hours of incubation, when the hatchlings are 3.0-4.5 mm in size. The larvae are transparent in appearance and show feeble swimming movement after hatching.

Larval rearing

The yolk sac of the larvae serves as a food supply until the third day of life during indoor rearing. Live feed such as mixed zooplankton or artemia nauplii are well accepted. The larvae fed with artemia show better growth and survival. We have also observed that more mortality is found in zooplankton fed tanks. It may be that the larger plankton can damage the larvae. Hence it is always advisable to sieve it frequently to get smallest possible plankton during feeding. The 8–10-day old larvae can also be fed tubifex in chopped form, after proper cleaning. The larval rearing tank is usually aerated. The larvae will aggregate in certain areas of the tanks as they do not have much free-swimming capability during their first days of life. They are seen to rotate even in medium aeration, which may be stressful for the tiny larvae leading to mortality. Hence a very slow air flow may be given to avoid the stress.

The mouth of larvae initially remains open after hatching. There is a possibility of injury due to teeth in the lip region of larvae damaging others in the crowded areas, leading to high mortality. Jaw movement or closure of mouth is seen in

Cement tanks for raising fingerlings.

7–8-day old larvae, which results in reduced early mortality. Some farmers are also of the opinion that heavy aeration does not allow the larvae to aggregate in hatchery conditions, which reduces mortality as the larvae remain separated. While rearing the larvae in indoor systems, the bottom of the tank should be cleaned periodically to remove dead larvae, unutilised live feed, and faecal matter, which may degrade water quality, and water renewed with light aeration provided to keep conditions good. After 11-12 days the larvae may be provided with compound feed in the form of dough. Our institute has developed a larval feed “Starter Pangas”, which is a dust feed. This feed is moistened little and formed into balls which are placed in the tank. The larvae grow 20 to 30 mg during their first 2-3 weeks of rearing, after which they are shifted to ponds or larger cement tanks for fingerling production. A lot of *P. hypopthalmus* seed is produced in a few provinces of India. The farmers release yolk sac absorbed larvae in the prepared nursery for fry/fingerling production. The motivation for this activity might be due to the availability of plenty of live feed in the rearing environment for the larvae and their dispersal over a larger area may reduce interactions and losses as observed in indoor rearing. The farmers also provide dust feed after 7-8 days of release to avoid a feed shortage in the pond. Some farmers have also adopted a similar pattern for *P. pangasius* seed rearing.

Fry to fingerling rearing

Usually cement tanks and ponds are in use for limited and mass production of seed, respectively. Fry of 15-20 days age produced from indoor larval rearing are shifted to cement tanks for on growing to fingerling stage. A density of 100-150/m^2 may be ideal for good growth during this period. The fry and fingerlings swim continuously. Fry readily accept compound feed as they are weaned during the late part of indoor rearing. This acclimatisation to formulated feed ensures higher survival later on. It is advisable to provide crumbled feed considering the mouth gape of fry, which may be increased as the seed grow. The feed must be spread in the tank to avoid competition and encourage even growth. It is also better to provide sinking crumbled feed to fry just after their release to cement tanks, but this feed type may be changed to small floating feed after 3-4 weeks of rearing. However, the seed accept both sinking and floating feed during their rearing in this system. They are fed at liberty until they reach early fingerling stage. They may feed voraciously, but the ration size should be reduced on the next day, if fed more on the previous day. Experimental results on fingerling feeding of this species indicates that the ideal feed consumption is less than 3% of body weight. Providing more is not beneficial. This is a valuable management tip that can reduce feed wastage and reduce the cost of production.

A lot of unused feed and faecal matter is expected in the rearing environment, which degrades water quality. The seed are very sensitive to low oxygen levels, which can be reflected by surfacing behaviour during early morning in tank conditions. Hence it is essential to renew the water to reduce stress.

Algal blooms may occur in tanks due to rich nutrient supply from unused feed and sunlight penetration in shallow rearing tanks. If these occur, they should be netted out at regular intervals to avoid adverse changes in water quality and to give scope for the free movement of seed.

Haul of P. pangasius fingerlings.

Application of floating feed.

Farmers are not satisfied with low production in tank systems. Hence many farmers opt for stocking of yolk sac absorbed larvae in prepared nurseries for late fry or early fingerling production. As discussed earlier, the larvae subsist on natural feed followed by dust feed and crumbled feed at their necessity. The farmers start selling them at the age of thirty days, and continue until sixty days. The seed purchased by farmers are directly stocked in grow out ponds. Many farmers also rear the fry to late fingerlings before stocking them to grow out ponds. Seed grow to 3-4 g after 4-5 weeks and >50-60 g after 20-24 weeks, which are then stocked for grow out.

Grow out culture

The grow out culture of this catfish is feed based. Small water bodies are not suitable as this species is a long-distance swimmer. Water bodies should also be perennial since the culture period can be lengthy. Early fingerlings of 4-5 g or juveniles up to 100 g are stocked for pond culture. Small seed are more prone to predation by water birds and take more time to reach harvestable size. These problems are not seen if juveniles are stocked. Slow growth during the winter season is also observed. Hence the culture period may be enhanced to give adequate scope for growth of the fish, which is best when the water temperature persists around 28-32°C. It is always beneficial to provide floating feed to get an estimation of their daily consumption and to allow the fish to be observed as to their health status. Yellow tail catfish are voracious feeders and become very active when feed

Harvest of P. pangasius

is added to the pond. It is advisable to spread the feed over a larger area to give scope for uniform feeding by the fish. Although the feeding is vigorous, farmers should exercise discipline and maintain the ration at a maximum 3% of their body weight to avoid wastage. The provision of feed may be reduced during winter months as consumption falls with lower water temperature. There is also a tendency for this fish to vomit after a few hours of feeding if it has consumed an excessive amount. Over feeding may lead the pond water to turn green because of uneaten feed and faecal matter of the fish fertilising the water body leading to plankton blooms. Water may be renewed in this situation to avoid sudden oxygen depletion associated with a collapsing bloom and to provide a congenial environment for higher growth of fish. This catfish does not perform well in high densities, unlike *P. hypothalamus*. Hence stocking of seed @ 10,000-15,000/ha may be best for harvesting 600g - 1.3kg fish after a one year culture period.

Health management

Light red patches near the snout and fin region and slow feeding may be indications of infection. Water renewal at the beginning of this observation may resolve the problem. However, fish health should be checked 3-4 times a year.

Red patches seen during grow-out indicate onset of disease.

Partial haul to check health.

Captive breeding and larval rearing of *Cirrhinus reba*, a small indigenous fish of aquaculture importance

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Wild collection of Cirrhinus reba.

The technique of induced breeding and seed production has led to a boom in aquaculture production around the world. Aquaculture is one of the fastest growing food production sectors, providing food and livelihood security to millions of people across the globe.

In India, freshwater aquaculture is dominated by Indian major carps (*Labeo rohita*, *Gibelion catla* and *Cirrhinus mrigala*) and exotic carps (*Hypopthalmichthys molitrix*, *Ctenopharyngodon idella* and *Cyprinus carpio*), which together presently contribute about 90-95% of the total freshwater production of the country. However, India is known for its rich diversity of carps in its freshwater ecosystems. The country is blessed with 15-20 varieties of minor and medium carps that have a high potential for freshwater aquaculture. These species can be considered as alternatives to the major carps for diversification in freshwater aquaculture.

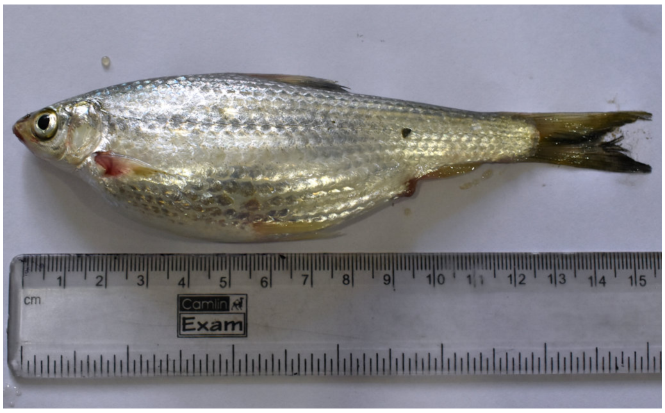
C. reba or 'reba carp' is a commercially important indigenous minor carp species distributed over south Asia. It is highly popular among consumers due to its taste, oily flesh, and nutritional value, being a good source of minerals and protein. It is mostly distributed in rivers and wetlands of India, particularly in the north-eastern states Assam, Meghalaya, Arunachal Pradesh, and Tripura. An herbivorous species, *C. reba* has been identified as a priority species for aquaculture diversification in India and has great scope for incorporation in carp culture and polyculture systems. If juveniles are available in adequate numbers, reba carp can be widely accepted as a cultivable fish because of its high market value and consumer preference, which can also serve its conservation. Apart from its food value, reba carp can also be regarded as an ornamental fish of economic importance. It has a striking appearance due to the presence of hexagonal scales throughout its body with a dark transverse band throughout its entire length. The need for conservation and propagation of indigenous fish species in recent years has resulted in increased interest in the breeding and culture of indigenous reba carp.

Broodstock management

For broodstock development, fingerlings were collected from the wetlands of Morigaon District, Assam, and were brought to the College of Fisheries farm at Assam Agricultural University (AAU), Raha. The fingerlings were reared for one year in the earthen ponds of 0.02 ha. During the one-year rearing period, liming, and manuring were done following the standard guidelines mentioned in the package of practice of AAU. Throughout the culture period, a minimum water depth of 1.0-1.5 metres was maintained with frequent water exchange during the winter season. The fish were fed with farm made formulated feed comprising soyabean meal, mustard oil cake, rice polish and vitamin and mineral mixture, with a crude protein content of 30-32%. The feed mixture containing all the ingredients was sieved through a fine meshed screen and mixed with water to make dough. The feed mixtures (mash or moist feed) are kept in perforated fertiliser bags tied to bamboo poles. Feed was transported on a small raft and distributed in the feeding bags. Fishes browse on the feed through perforations in the bag and within two hours the feed was consumed. About 20-30 bags can be used per hectare of waterbody. The fish attain maturity after one year and males/females weigh around 150-250 g at the peak breeding season of May-June. Males are of a smaller size than females and attain maturity faster. Female broodstock attain a size of 15.5-16 cm and weigh 200-250 g while male broodstock attain a size of 13-14.5 cm weighing 90-120 g. During the breeding season sexual dimorphism can be easily observed. The females exhibit a bulging abdomen with more prominent dark band across the lateral line, which is a unique characteristic of *C. reba* brooders. Since the fish are minor carps, applying slight pressure to the abdomen for check for milt and eggs causes mortality and should be avoided. For the breeding experiment, male and female fish were taken in the ratio of 3:l, unlike that of Indian major carps where a 2:1 male/female ratio is maintained. Prior to breeding male and female broodstock of *C. reba* were kept in a separate breeding hapa at the spawning pool of the AAU model carp hatchery. Induced breeding was carried out during evening hours at an air temperature of 24-25°C. Ovafish, a synthetic inducing agent was administered at the rate of 0.5 ml/kg body weight for females and 0.25 ml/kg body weight for males. Both males and females were released into the spawning pool after injection. After 7-8 hours eggs were released by the females and were collected in the early morning. The spent fish were dipped into potassium permanganate solution ($KMnO_4$) and then released back into the stocking pond. Eggs hatched after 24 hours of incubation at the carp hatchery.

Larval rearing of *Cirrhinus reba*

The water temperature at hatching was of 24°C. A total of 140 broodstock were injected with 35 females and 105 males. The average fecundity was around 55,000 per 200 g of female brooders. The hatchlings were 1.75-2.1 mm in length and a prominent dark band was observed under the stereo zoom microscope. Approximately 0.6 million hatchlings were obtained during the breeding season and were released into a nursery tank of 0.01 ha. All the better management practices of carp farming were followed during stocking of the spawn. To observe the food preference of hatchlings some fishes were put in a glass aquarium. The hatchlings fed on green



Female C. reba broodstock.

Farm raised reba carp broodstock.

Stereozoom microscopic image of C. reba fry.

algae attached to the glass panes of the aquarium and acted as algae cleaners in the aquarium. Their feeding behaviour exhibits the herbivorous feeding habit of *C. reba*.

Culture prospects as alternative carp species

C. reba fetches a better price than the Indian major carps in different parts of the country. It is a highly fecund fish and this may be advantageous for short duration culture in seasonal water bodies. Marketable size is 100-300 g as compared to 700 g-1.5 kg for major carps. It is compatible with Indian major carps in composite fish culture. As the fish is herbivorous in nature it can easily digest plant protein sources. Therefore, different plant based agro-industry by-products, which are rich in protein and abundantly available in India, can be used for low-cost feed formulation for the species, which is easily domesticated in pond environments and readily accepts artificial feed. *C. reba* also have potential in aquarium trade, particularly as juveniles.

The need for diversification of farmed fish species in recent years has resulted in renewed interest in the breeding, propagation and culture of *C. reba*. This has resulted in successful induced breeding of *C. reba* for the first time in Assam, where the fish has high market demand with price ranging from Rs. 400-500 / kg in local markets. To make aquaculture more profitable new species should be introduced into farming systems which could be a successful step towards species diversification.

From a conservation point of view the successful breeding and seed production of *C. reba* achieved by College of Fisheries, Assam Agricultural University, Raha will surely generate availability of fish seed of this species which will overcome the decline in wild population and safeguard the species for the future.

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Above, below: Breeding and larval rearing of Cirrhinus reba.

Better management practices adopted in *Cirrhinus reba* culture	
Pond preparation	Pond drying (sun dry for 10 days). Lime application @ 300 kg/ha of agricultural lime. Manuring @ 6,000 kg/ha of raw cow dung/poultry manure. Inorganic fertiliser: Urea @10 kg/ha and single super phosphate @15 kg/ha applied fortnightly.
Water quality parameters	Dissolved oxygen: 5-6ppm. pH: 7.5-9. Alkalinity: 25-150 ppm. Hardness: 100-130 ppm. Nitrate: 0.2-0.5ppm.
Feeding practice	Feed mixtures were given in feed bag. Each bag contains 2-3 kg of feed. Bags were kept on bamboo poles within 30 cm of water.
Fish health management	Monthly fish sampling was done to check the health and growth. The body surfaces were checked for the presence of parasites. Potassium permanganate treatment was done as a prophylactic measure.

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High-level meeting on aquaculture transformation in the Asia-Pacific region

As a follow on from the September FAO/NACA workshop on aquaculture transformation (see article in previous issue), FAO and NACA convened a high-level meeting to discuss the issue and the outcome of the previous consultation with policy makers. The meeting was held virtually from 22-23 November and was attended by 79 senior officials from 25 countries and international organisations, with observers from industry and international NGOs.

Specific objectives of the high-level meeting were to:

- Engage senior policy makers and business leaders in the process of defining regional targets, action areas and initiatives for aquaculture transformation in the region by 2030.
- Identify strategies and mechanisms to stimulate innovation and investment.
- Enhance collaboration in the defined action areas.
- Recommend follow up actions and commitments on aquaculture transformation as a regional contribution to the global targets.

The high-level meeting provided a forum for government, private sector and development partners to identify policy, innovation and investment priorities for aquaculture transformation in the region by 2030.

As a background to the meeting FAO and NACA developed a white paper entitled *Aquaculture transformation: innovations and investment for sustainable intensification and expansion of aquaculture in Asia and the Pacific region*, drawing on contributions from stakeholders across the region through the September consultation. The draft was informed by a series of country analyses, a regional synthesis, and an aquaculture investment paper.

The white paper provides guidance on the translation of the global vision and targets for 'blue transformation' into clear and workable strategies for transforming the aquaculture sector of the region. It has considered the FAO Committee on Fisheries Declaration for Sustainable Fisheries and Aquaculture and the Shanghai Declaration, which outline ways to maximise the contribution of aquaculture to the 2030 Agenda and the Sustainable Development Goals.

Blue transformation will not be achieved without innovation in systems, investments and partnerships. It requires commitment from national and local governments, private business and investors, civil society organisations and other stakeholders to work together towards sustainable aquatic food systems. The white paper provides guidance to put these global aspirations into practical action.

An important focus of the discussions at the high-level meeting was on follow up actions for implementing aquaculture transformation, with special emphasis on strengthening regional collaboration to progress aquaculture transformation at the scale needed.

Aquaculture transformation through sustainable intensification and expansion of aquaculture is widely recognised as a priority for the future of sustainable agrifood systems in Asia and the Pacific region. The region is the world's aquaculture leader and its progress in aquaculture transformation has global implications for the blue transformation agenda.

Developing a regional strategy for aquatic organism health: Progressive management pathways

On 28-29 November FAO and NACA collaborated on a virtual workshop to develop a regional strategy for aquatic organism health, using a progressive management pathway for improving aquaculture biosecurity. The workshop was held under the auspices of the project "Responsible use of fisheries and aquaculture resources for sustainable development component 3: Biosecurity and health management". The workshop involved 31 experts from 16 countries, including national focal points, FAO and NACA.

The goals of the workshop were to:

- Present the country responses to a FAO self-assessment survey on biosecurity and health management capacity and performance.
- Present a preliminary analysis of the combined survey returns.
- Provide guidance to country participants on conducting a SWOT analysis.
- Prepare detailed plan for Phase II of the initiative.

The trend in aquaculture during the last few decades is that serious pathogens frequently emerge, spread rapidly, and cause major production losses. There is often a long period, usually years, from the time that a serious mortality event caused by an unknown and emerging pathogen is observed in the field, to its subsequent identification and confirmation, to global awareness, the establishment and implementation of surveillance and reporting/notification systems and cost-effective risk management measures.

Biosecurity measures are less expensive when put in place preventatively and are significantly more costly when implemented in response to disease outbreaks. Biosecurity should be put in place and parallel to any aquaculture development by all producing countries. However, countries are at widely varying stages of aquaculture development, and vary in their technical capacity and resources available to manage aquatic health issues. While some countries in the region have a high proportion of industrialised production, others have many small-scale, resource-poor farmers that are in dire need of technical support.

During the last few years, FAO and partners have developed the "progressive management pathway for improving aquaculture biosecurity" concept (PMP/AB), an extension of the "progressive control pathways" used for controlling major livestock and zoonotic diseases. As the name suggests, these progressive pathways enable risk management approaches to be tailored to suit the technical capacity and resources of stakeholders at different levels, or with different roles, while maintaining a coordinated national approach. The approach also focuses on progressively building management capacity through combined bottom-up/top-down approaches with strong stakeholder engagement.

The PMP/AB is a pathway aimed at enhancing aquaculture biosecurity capacity at the regional, national, local-sector and enterprise levels by building on existing frameworks, capacity and tools using risk-based approaches and public-private sector partnerships. Whereas most progressive control pathways focus on the control of a single disease or disease complex, the PMP/AB focuses on building a generalised resilience to aquaculture biosecurity vulnerabilities, e.g. threats to sustainable aquaculture due to pathogens and the associated diseases that result from poor management practices, legal and uncontrolled trade, and lack of capacity in public and private institutions.

The PMP/AB addresses the lack of effective national plans by focusing on mid- to long-term national aquaculture biosecurity strategy development processes and by promoting a co-management approach to actively engage stakeholders. Specifically, the PMP/AB enhances awareness and adoption of appropriate biosecurity governance at the producer and sector levels, which can lead to reduction in the incidence and impact of targeted priority diseases and thus promotes greater recognition of the important role of biosecurity. The PMP/AB provides a solid platform for public-private sector partnership, as PMP/AB's strategic and implementation plans should be jointly developed by industry stakeholders and governance authorities. This encourages buy-in and best-fit for each country, whilst providing a template that delivers a degree of consistency between participating countries or regions.

The preparation conducted during this workshop will feed into a physical meeting to finalise a regional biosecurity strategy. Further details will be announced on the NACA website and in this newsletter in due course.

Job opportunity - fish health management and husbandry researcher (three years)

The Norwegian Veterinary Institute has a vacant three-year position as a researcher in the expanding area of sustainable aquaculture development internationally, with a desired start-up as soon as possible. This is an exciting opportunity for competent candidates with interest and experience from working internationally with farmed aquatic animal health management and husbandry. The right candidate will be joining our team of experts in epidemiology, biosecurity, diagnostics and applied health management.

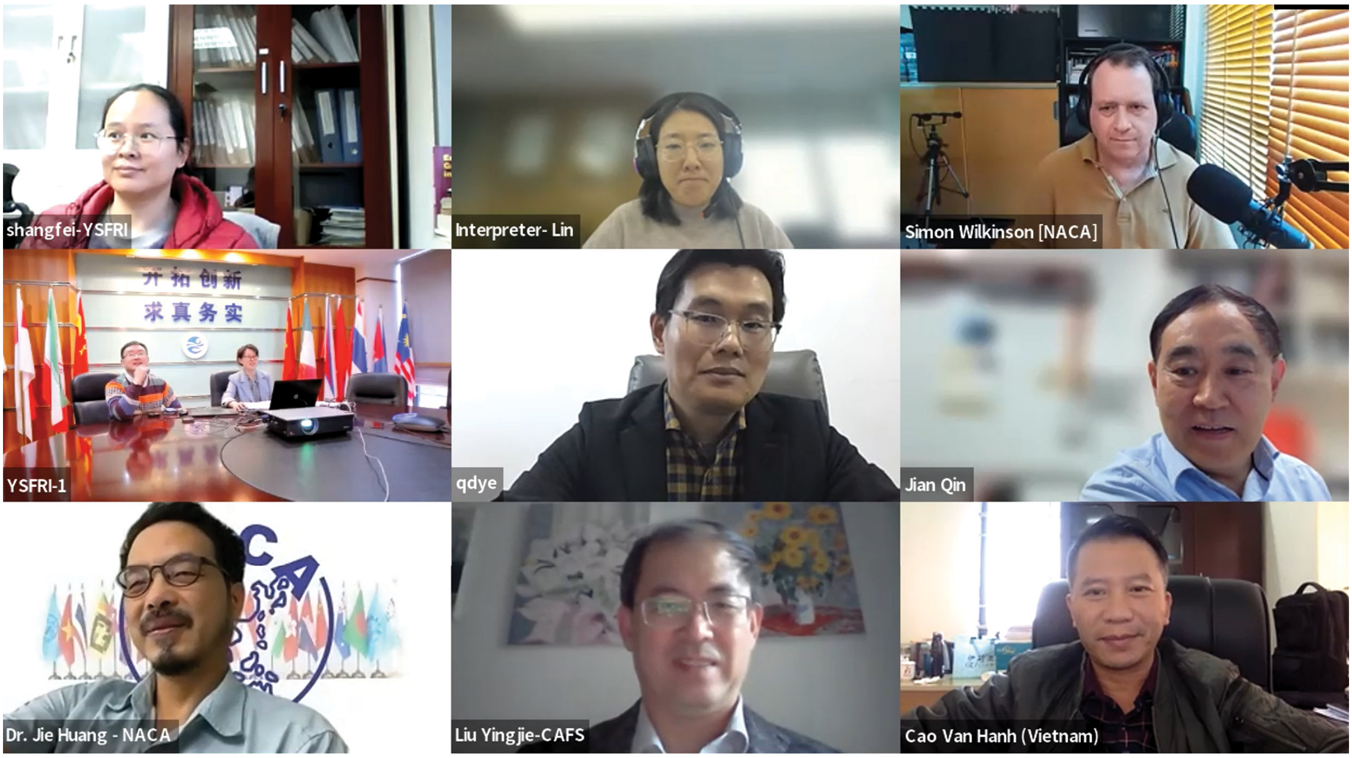
Our projects are presently located in African, Latin American and Asian countries, funded mainly by the Norwegian Agency for Development Cooperation (NORAD). We collaborate with other national/international scientific institutions and international organisations such as Food Agriculture Organisation (FAO) and World Organisation of Animal Health (WOAH). The working language in the group is English. The working place is our main office at Ås, 30 km south of Oslo.

The Norwegian Veterinary Institute is committed to diversity, and we therefore encourage anyone who is qualified to apply for the position, regardless of age, gender, and functional ability, gaps in CV, nationality or ethnic background.

Applications close **16 January 2023**. For more information, please visit the website below:

https://10600.webcruiter.no/Main/Recruit/Public/4592292269

2022 China-ASEAN International Forum on Sustainable Development of Fisheries and Aquaculture Under the Blue Transformation Strategy



Ocean University of China (OUC), in collaboration with universities, research institutes, organisations, and associations, convened the 2022 China-ASEAN International Forum on "Sustainable Development of Fisheries and Aquaculture Under the Blue Transformation Strategy" from 20 to 22 November 2022. The forum was held in a hybrid format with participation in-person in Qingdao, China and also online via Zoom, with participants hailing from 15 countries.

The forum will host discussions about the implementation of the "Blue Transformation" strategy, further expansion of the space for fisheries and aquaculture, and ways of improving the production capacity of aquatic products, with the purpose of facilitating the achievement of the UN Sustainable Development Goals. The strategy was discussed in the context of international talent cultivation and training, innovation in science and technology, and industrial synergy.

The forum aimed to promote the high-quality development of fisheries, accelerate industrial transformation and improvement, and enable the production of more aquatic products with better quality. China and ASEAN together shoulder the important task of carrying out this "Blue Transformation".

International talent cultivation and training

Universities and research institutes of China and ASEAN spoke on the demand for international talent, talent training programs and achievements in fisheries and aquaculture under the "Blue Transformation" strategy, with a view to promote the development of higher education and vocational education in fisheries to meet the growing needs of international competition and cooperation in fisheries and aquaculture.

Science and technology innovation

To meet the demand of the "Blue Transformation" strategy, hot topics and new measures for scientific and technological innovation were discussed from perspectives such as the protection, development and utilisation of fishery resources, aquaculture, the processing and safety of aquatic products, and fishery management.

Industrial synergy

Discussions will be centred around markets and information, processing and trade, derogation and waste, policies and support in the fisheries and aquaculture industry, as well as measures and experiences of enterprises and institutions to respond to the change, cooperation or potential cooperation with ASEAN.

The forum was organised by the Research Center for Shandong-ASEAN Exchanges and Cooperation; Key Laboratory of Mariculture, Ministry of Education, China; Engineering Research Center of Mariculture, Ministry of Education, China; China Fisheries Alliance in Emerging Agriculture; Sino-Thai Academic Center on Marine and Fishery Sciences; UMT-OUC Joint Academic Centre for Marine Studies; Seaweed Center for International Science and Technology Cooperation.

It was co-organised by Xiamen University; Dalian Ocean University; Guangdong Ocean University; Jimei University; Hainan Tropical Ocean University; Institute of Oceanology, Chinese Academy of Sciences; Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science; South China Sea Fisheries Research Institute, Chinese Academy of Fishery Science; Fourth Institute of Oceanography, Ministry of Natural Resources; China Aquatic Products Processing and Marketing Association; Society of Aquaculture Ecology of Chinese Society for Oceanology and Limnology; NACA and the ASEAN Fisheries Education Network.

A new progressive management pathway for improving seaweed biosecurity

A new paper in Nature Communications by Cottier Cook et al. describes the need for a new progressive management pathway to improve seaweed biosecurity.

The seaweed aquaculture industry has rapidly expanded to 35 million tonnes per annum, a production that represents 51% of global coastal aquaculture by volume. The industry is globally connected supplying a variety of products including foods, ingredients for cosmetics, pharmaceuticals, and food additives. Recently, seaweed aquaculture has been recognised for its potential to capture atmospheric carbon.

Rising seawater temperatures and coastal eutrophication have led to an increase in infectious diseases and pest outbreaks. However, research to identify seaweed pests and diseases is at an early stage. Control is difficult, given the open nature of seaweed farming systems, but there is evidence that relatively simple control measures can significantly reduce the incidence of disease.

The paper, which is co-authored in part by NACA staff, describes a process for developing and implementing locally-adapted progressive management pathways to address seaweed disease and pest issues. It is an open access publication, distributed under the Creative Commons Attribution 4.0 International License. The paper may be downloaded for free from:

https://www.nature.com/articles/s41467-022-34783-8

Indian delegates visit Thailand for training and industry exposure

NACA welcomed five delegates from India on an aquaculture training and exposure visit from 31 October to 4 November. The delegates were:

- Mrs Nallamani Chandra, Executive Director (Technical), National Fisheries Development Board.
- Mr Ramakrishna Rao Guttula, Fisheries Research and Investigation Officer, Department of Fisheries, Animal Husbandry and Dairying.
- Mr Ajith Stalin Justin Christopher Laisal, Senior Executive (Technical), National Fisheries Development Board.
- Mrs Janjarapu Deepa Suman, Executive (Technical), National Fisheries Development Board.
- Ms Kanchi Bhargavi, Executive (Technical), National Fisheries Development Board.

The visit began with a discussion at the NACA Secretariat on Thai mariculture, the recently established International Artemia Aquaculture Consortium, and better management practices concerning hatchery production and use of live feeds.

The delegates left Bangkok the next day to visit seabass cage and pond culture and a shrimp nursery in the Chachengsao area and Bangprakong River. The following day they travelled to the Rayong Coastal Aquaculture Center and visited local farm sites before overnighting in Chantaburi. On the final day they visited the Kung Krabae Bay Royal Development Study Center and mangrove walk; and a freshwater fish farm to observe intensive carp and pangasius culture.

NACA would like to thank the Thai Department of Fisheries for their generous assistance and sharing of experience with the delegation.

PhD scholarships: Shanghai Ocean University PhD Programme 2023

Shanghai Ocean University (SOU) is offering full scholarship PhD programmes in a wide range of marine sciences 2023. Disciplines include: Aquaculture, biology, fisheries science, fisheries resources, marine science, food science and engineering, fishery economics and management, and marine engineering and information.

Scholarships

The scholarships are open to non-Chinese citizens under 30 years old who have a masters degree with a good academic record and outstanding research potential. The scholarships cover tuition, accommodation, medical insurance and include a stipend.

Applications

Applications are due **1 February 2023**. For details of the programmes, eligibility criteria, required documentation and application procedures, please download the prospectus linked below. If you have any questions, please email admissions@shou.edu.cn.

Postgraduate opportunities

Postdoc positions are available for excellent graduates and full-time faculty positions are available for excellent international postdocs.

Download the prospectus

https://enaca.org/?id=1240

Reported aquatic animal diseases in the Asia-Pacific region during the second quarter of 2022

With the implementation of the new aquatic animal disease reporting in the Asia Pacific region from January 2021, and in lieu of the published QAAD Reports (last issue published was 4th quarter of 2020), NACA is publishing reported aquatic animal diseases submitted by countries in the Asia-Pacific region. This report covers the second quarter of 2022 and the original and updated reports can be accessed at the QAAD page at:

https://enaca.org/?id=8

The following diseases were reported:

Finfish diseases

- Infection with *Aphanomyces invadans* (EUS): Australia in wild adult mullet (*Mugil cephalus*), bony bream (*Nematalosa erebi*) and yellowfin bream (*Acanthophagrus australis*) and Chinese Taipei in largemouth bass (*Micropterus salmoides*).

- Infection with red seabream iridovirus (RSIV): Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*); and India in freshwater angelfish (*Pterophyllum scalare*) and Ram cichlid (*Mikroge-ophagus remirezi*).

- Viral encephalopathy and retinopathy (VER): Australia in wildstock garfish (*Belone belone*) and kahawari (*Arripis trutta*); Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*).

- Carp edema virus (CEV): India in koi carp (*Cyprinus carpio*).

- Infection with tilapia lake virus (TILV): India in tilapia (*Oreochromis* spp.), and Philippines in tilapia (*Oreo-chromis* spp.).

Molluscan diseases

- Infection with *Perkinsus olseni*: Australia in wild abalone; and India in saltwater clam (*Paphia malabarica*).

Crustacean diseases

- Infection with white spot syndrome virus (WSSV): India in whiteleg shrimp (*P. vannamei*); Philippines in black tiger shrimp (*P. monodon*), *P. vannamei*, mudcrab (*Scylla serrata*), and Philippine freshwater prawn (*Macrobrachium daqueti*); and Thailand (shrimp species not specified).

- Infection with yellowhead virus genotype 1 (YHV-1): Thailand (shrimp species not specified).

- Infection with infectious hypodermal and haematopoietic necrosis virus (IHHNV): Philippines in *P. vannamei* and *P. monodon*.

- Acute hepatopancreatic necrosis disease (AHPND): Chinese Taipei in *P. vannamei*; Philippines in *P. vannamei* and *P. monodon*; and Thailand (shrimp species not specified).

- Hepatopancreatic microsporidi-osis caused by *Enterocytozoon hepatopenaei* (EHP): Chinese Taipei in *P. vannamei*; India in *P. vannamei*; Philippines in *P. vannamei* and *P. monodon*; and Thailand (shrimp species not specified).

- Infection with decapod iridescent virus 1 (DIV1): Chinese Taipei in *P. vannamei*.

Amphibian diseases

- Infection with *Batrachochytrium dendrobatidis*: Australia in yellow-spotted tree frog (*Litoria castanea*), Australian green tree frog (*Litoria caerulea*) and striped marsh frog (*Lymnodynastes peronii*).

Other diseases

- Singapore reported Infection with *Lates calcarifer* birnavirus in Asian seabass (*L. calcarifer*).

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NACA is a network composed of 19 member governments in the Asia-Pacific Region.