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AQUACULTURE ASIA

Aquaculture in Arunachal Pradesh

Transforming waste to wealth

Breeding peacock eel

Penga for diversification

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

Transforming aquaculture through unfashionable means

There is consensus that the aquaculture industry needs to transform if it is to meet future demand for food and protein from our growing global population. It needs to produce more, and it needs to do it more efficiently, consuming less resources and with a lower environmental footprint per unit production.

What is less clear, is how to transform it. As the sense of urgency mounts, all sorts of complex and increasingly baroque ideas are being offered. As you may suspect, I have a suggestion on this matter that is simple, straightforward, proven and cost effective. The only problem is, it's dead boring, and quite out of fashion in development circles.

How can we improve farm efficiency and productivity? Training and capacity building! Consider: Most people involved in the aquaculture industry today – nearly all of them - have learnt their skills on the job. Few have had the opportunity to attend a formal training course of any kind.

Aquaculture training is still relatively uncommon and hard to come by, especially if you are already working on a farm or lack the means to pay. Whilst learning on the job is a great way to develop practical skills, it tends to leave gaps in knowledge that would be otherwise filled by a well-rounded training programme.

Having observed the full range of development projects for over 20 years, I can easily say that the greatest return on investment without exception has been education and training. People carry that knowledge with them for the rest of their lives, whether it be in the form of improved farming practices or as an official in the service of their country.

There is an all-too-common view that capacity building is no longer necessary, and I cannot disagree with it more strongly. Better education and training are foundational to the transformation of aquaculture, particularly in small-scale farms, but also in small to medium-sized enterprises. Consider the impact that knowledge of feed management, nutritional principles, water quality and health management have on the productivity of a farm: Do reduced feed wastage, better nutrition, lower disease incidence, and minimising the chance of crop failure count as improved productivity? Does improved profitability increase farm resilience?

It is understandable that donor organisations are under pressure to shift their focus to other serious issues. But it is essential to recognise that training and capacity building remain core requirements for the sustainable growth and development of aquaculture, and among the most cost-effective and long-lasting of investments.

Furthermore, leveraging digital platforms and e-learning tools can enhance accessibility and reach, allowing individuals from diverse backgrounds to benefit from training programs. This approach can also address the constraints of physical infrastructure and limited training facilities in remote areas.

The aquaculture industry plays an important role in meeting global food demand and supporting livelihoods. To realise its full potential, training and capacity building must be reinstated as core needs within the sector. By investing in training, stakeholders can foster sustainable practices, embrace innovation, enhance market access, build resilience, and ensure the industry's long-term viability. If your organisation has dropped support for training programmes, you're doing it wrong.

Simon Wilkinson

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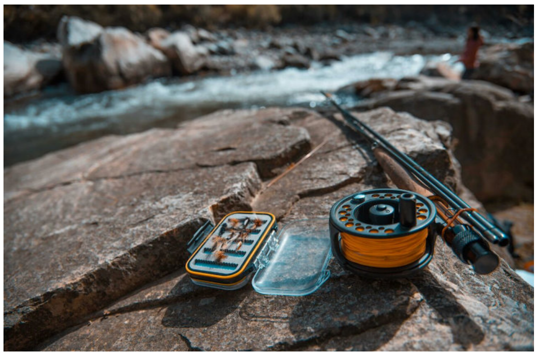

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Aquaculture and fisheries perspectives in Arunachal Pradesh

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Integrated fish farming system in Lower Subansiri District.

Fish is an essential source of protein for the people of Arunachal Pradesh. This hill state is inhabited by a population of 1.38 million people, the majority of whom relish fish. In terms of fish biodiversity, the varying altitudinal regimes ranging from 100-4,000 m play a dominant role in the distribution of species. The foothill regions to an elevation of 300 m are hot and humid and are suitable for culture of warm freshwater fish species viz., Indian major carps, catfishes, feather backs, eels, mahseers and the exotic carps. The sub-tropical mid altitude zone, up to 1,200 m, provides a suitable climate for a mixture of cold and warm water species. The high-altitude alpine zone, above 1,200 m, features cold, fast flowing streams and lakes, which are a suitable habitat for exotic rainbow and brown trout along with indigenous snow trout *Garra* spp., *Noemacheilus* spp., *Glyptothorax* spp., *Psilorhynchus* spp., and occasionally *Barilius* spp.

Arunachal Pradesh has freshwater resources in the form of around 11,000 km of rivers, 226 ha of small reservoirs, 2,300 ha of tanks and ponds, 3,300 hectares of wetlands and derelict water bodies and 56,000 ha of other forms of aquatic resources[1,2] that are home to 259 species of fish.[3] Inland fish production from the state has increased to 5,284 metric tonnes during 2022-23, with the advent of new technologies in the region followed adoption of scientific fish farming practices by farming communities. Furthermore, 20 million fry and 11 million fingerlings were produced during 2022-23 from government and private fish hatcheries. There are around 24,000 fishers in the state is with an average of 961 per district engaged in inland fishery activities. However, the region needs to catch up the rest of the country in developing its water resources to meet the gap between the production and demand. The per capita availability of fish in the state was 3.65 kg/year against the WHO recommended level[1] of 12kg/year during 2020-21. This article reflects on aquaculture and fisheries perspectives in Arunachal Pradesh, based on survey and research activities undertaken by the author over the last two decades.

Aquaculture systems

Aquaculture in Arunachal Pradesh is mainly based on carp, and mostly practiced in the warmer foothill regions where six recommended species namely *Labeo catla*, *L. rohita*, *Cirrhinus mrigala*, *Hypophthalmichthys molitrix*,

Harvesting of Chinese carps in mid elevation fish ponds.

Ctenopharyngodon idella and *Cyprinus carpio* are cultivated under polyculture. Fish are cultivated using extensive methods in earthen ponds and tanks of size varying from 100 m^2 to 1.2 ha. Small to medium sized earthen ponds are mostly prevalent due to the hilly terrain. Cattle manure, pig dung, and poultry waste are applied at the rate of 5-10 tonnes/ha to enhance the plankton growth in the water. Periodically lime @ 400-600 kg/ha/year is applied to neutralise the acidic water (pH 5.0-6.0) typical of the region. The stocking of ponds is done at the rate of 1-2 fishes/m^2. Feeding is done with rice bran and mustard oil cake in the ratio of 1:1 or 2:1. Maize flour, cooked and fermented rice, puffed rice, millet flours etc are also applied in ponds on traditional lines. In recent times, pellet feeds with 20-25% protein composition are fed to the fishes resulting into growth of 0.9-1.0 kg/fish/year.

However, Indian major carps do not grow well in the cooler (< 22°C) high altitudinal ponds and tanks. Therefore, Chinese carps, namely silver carp, bighead carp *Hypophthalmichthys nobilis*, grass carp and common carp are taken as the candidate species for culture in pond fisheries at high altitudes. It has been possible to achieve a production of 0.4-0.6 kg/m^2 under low temperature conditions based on a stocking density range of 3-4 fishes/m^2 with recommended supplementary diet. Monoculture of common carp in ponds and tanks at mid to high altitudes is also prevalent due to its wide thermal adaptability from 5-30°C, robust nature, better food conversion ratio, high fecundity and easy accessibility of seeds.

Integrated fish farming is another successful system adopted by the farmers of Arunachal Pradesh resulting in a 3-4 fold increase in farm production as well as income through multi-cropping. Over the years several components have been integrated with fish farming to evaluate their compatibility. Some of the important integration models are fish-poultry, fish-duck, fish-pig, fish-paddy and fish-horticulture. Large White Yorkshire, Middle White Yorkshire, Berkshire, Hempshire, Land-race, Large Black, and Duroc are some of the exotic breeds of pig commercially cultivated in the region. Kamrupa, Vanaraja, Kadaknath are a few poultry breeds whereas Khaki Campbell, Indian Runner, Charra Chambelli are duck breeds in use. Fish production levels up to 0.6-0.8 kg/m^2 can be achieved without provision of supplementary feeding to fish under this type of integration. The fish integrated with live-stock and poultry helps in recycling of farm-based resources

Common carp raised in rice-fish farming systems in Ziro Valley.

and substantial reduction of risk factors through diversification of food commodities. The farm products are easily marketed as most of the populace are non-vegetarians.

The culture of common carp with local rice cultivars viz. eamo, ampu, mipya, pyapu, pyaping and eylang in terraces of the Apatani Plateau at 1,500 m altitude of Lower Subansiri District has become popular in the recent times. Apart from the common carp, species such as grass carp, silver carp, *Puntius* spp. catfishes, murrels and *Labeo* species are also occasionally stocked in the plots. The dykes of rice-fish plots are used for raising vegetables such as cucumber, radish, brinjal, tomato, pumpkin, chilies, beans and crops such as finger millets, buckwheat, barley and maize to gain additional income. Similar integrated farming practices could be possibly adopted by the farmers in other districts as a self-supporting system. The integrated rice-fish farming in the state produces 150-200 kg fish/ha/3 months and rice production accounting to 10 tonnes/ha/season[4].

The low temperature regime in uplands of Arunachal Pradesh offers tremendous scope for exotic trout farming in raceways. Rainbow trout *Oncorhynchus mykiss* is the most suitable candidate species for upland fisheries due to the favourable water temperature ranging from below freezing point to as high as 20°C. Three trout farms cum hatcheries have been established in Arunachal Pradesh viz., Nuranang stream at 3,660 m altitude and Chuje trout farm at 3,030 m in Tawang District, and Shergaon in West Kameng District, located at an altitude of about 1,954 m. All these hatcheries are producing from 50,000 to 100,000 eyed ova. Menchukha is another potential area in the Shi Yomi District of Arunachal Pradesh for rainbow trout farming. Concerted efforts have been made by the state Fisheries Department, research institutes and entrepreneurs in developing this place as a hub for trout, inviting tourists across the globe. At present, the trout production is at a low stake and the fish produced in the raceways is seldom sold in markets and are consumed in local households.

Ornamental fish keeping has become an important commercial component of aquaculture for many, generating income for unemployed youth and farmers in the country. The concept of entrepreneurship development has led more and more people to enter this lucrative business. The Eastern Himalayan region has been identified as one of the 18 mega biodiversity hotspot regions of the world[5] with 259 species of fishes including loaches, barbs, minnows, catfishes, and murrels. The region has the advantage of having a mild climate, abundant natural waters and export facilities for expansion of the ornamental fish trade to overseas markets. However, little information is available on the ornamental fisheries in the state and the aquarium shops are dependent on exotic varieties such as koi, goldfish, angels, platy, molly, oscar, arowana and so on imported from other states.

Commercial culture of catfish and air-breathing fish has not yet been taken up in the state although such fishes are abundant in natural water bodies. These fishes have a better market price with high consumer preference. The

Fish ponds in Arunachal Pradesh.

Trout farm at Shergaon, Arunachal Pradesh.

most commonly preferred catfishes in the region are *Clarias magur* and *Heteropneustes fossilis*, which can be of great potential for commercial cultivation in the foothills of the district considering the availability of huge resources in the form of ponds, swamps and derelict water bodies. Freshwater eels, pangasius, red-bellied pacu, murrel, tilapia and koi are other potential fish varieties of high consumer preference and candidates for local aquaculture. The recent advances in bio-floc technology and re-circulating aquaculture systems can further enhance the fish production in the hill locked region.

Inland capture fisheries

The inland fisheries in Arunachal Pradesh provide ample opportunities for fish-based ecotourism perspectives, where travellers can experience pristine destinations relatively untouched by human intervention. The undulating terrains, river valleys, upland lakes and green lush vegetation provides opportunities for leisure, knowledge sharing on the environment, ethnicity and in turn sustaining the well-being of the local people with viable income-generating options. Sport fishing or angling, fish watching, river rafting, trekking, and hiking, bird watching, river side camping, local fish cuisine etc are some of the most sought-after adventure tourism activities in the hills and present booming international business opportunities.

Fish groups such as mahseer; the goonch and brown trout are the flagship species of considerable economic, recreational and conservation interest in the state. Mahseer, large bodied potamodromous freshwater fish belong to three

Young rainbow trout for raceway culture.

genera *Tor*, *Neolissochilus* and *Naziritor*. Mahseer are recognised as the 'state fish' in seven states of India due to their superlative sporting quality. Golden mahseer (*Tor putitora*) and chocolate mahseer (*Neolissochilus hexagonolepis*) are the dominant species in the northeastern part of India. This group of mahseer are mostly concentrated in the rivers Kameng, Subansiri, Siang, Dibang, Lohit, and Pare, all flowing through the vast wilderness and finally terminating in the mighty Brahmaputra River. Anglers among these sparsely inhabited areas travel along the river valleys as adventure enthusiasts amongst the picturesque mountains of Arunachal Pradesh, with crystal clear pre and post monsoon waters coursing through them and home to the big fighting fishes. Fish watching platforms on natural and manmade lakes have gained much attention due to their multiple positive benefits to human health. Keeping fish in lakes, tanks and ponds also facilitates in-situ conservation of endangered fish. Concerted efforts are being made for their captive rearing and maturation, breeding and seed production by artificial processes. Trials have been made at Iduli in Lower Dibang valley for the commercial seed production of mahseer. A similar effort is being made to establish another mahseer hatchery along the banks of river Subansiri River along the dam site of a 2,000 MW hydropower plant. The seed will usually be used for ranching in the river systems or for aquaculture purposes in the hill regions.

The goonch or the giant devil catfish *Bagarius bagarius* and *B. yarelli* are fish of high sports value and sought by anglers worldwide. These fish are occasionally encountered in the river Dibang and Siang of Arunachal Pradesh. The species is categorised as vulnerable on the IUCN Red List due to over exploitation of wild populations.

The brown trout (*Salmo trutta fario* Linnaeus, 1758) is regarded as the best coldwater sporting fish in the country. The Yargyap Chu River, flowing through the township of Menchukha at 1,829 m in West Siang District, is home for exotic brown trout. A sizable catch of brown trout weighing up to 12 kg has been reported from this water. The adaptation of the imported trout fishes during 1990s in these cold water provides an excellent opportunity for game fishing in this mesmerising northeastern part of the country. It is also interesting to know and report herewith that the skin of the brown trout is also utilised in preparing dhoor, a musical instrument used during the rituals of the Buddhist communities. The instrument is a goblet shaped hand drum comprised of a light wood coated with fish skin at the either side.

Apart from the fish groups mentioned above, the other game fishes encountered are the cyprinids *Raiamas bola*, *Labeo dyocheilus, L. pangusia*, *Bangana dero*, *Opsarius* spp., Schizothoracines and a few catfishes. These groups of fish are occasional catches in search of the major game fishes.

Snow trout is an important group of fishes from taxonomic, evolutionary and zoogeographical view point as their distribution is mainly restricted to mountain regions of Asia. The important Schizothoracine fishes occurring in Indian uplands embrace seventeen species belonging to eight genera[6]. *Schizothorax richadsonii* and *S. plagiostomus* and *S. progastus* are the indigenous snow trout found in abundance in the region. Unlike carps, these species have a very slow growth rate in capacity (30-40 g/year) and thus are not recommended for culture in ponds and tanks. Snow trout are also important from a recreational point of view as these fishes are caught

A tilapia from the culture tanks in Papumpare District.

A species of mahseer raised in aquaculture system at Siang District.

A catch of snow trout in Dirang Valley.

Seeh Lak: A recently developed water body situated 110 kms from the state capital Itanagar.

by a selective gear noose on line method developed indigenously by the local fishers of Dirang region in West Kameng District[7]. Success has been achieved in captive maturation and breeding of this fish group in the country which enhances its chances of propagation in natural upland water bodies for recreation and food to the mountain dwellers.

Conclusion

There lies a huge potential in generating fish-based revenues in terms of aquaculture and capture fisheries by tapping unutilised or underutilised aquatic resources of the hills of Arunachal Pradesh. Emphasis must be given in identifying and preparing a digital database on water bodies and developing repositories in fish and fisheries of the region. Measures should emphasise the development of breeding protocols of the indigenous and endemic fish species for aquaculture system diversification, human resource development for technology transfer and adoption, framing suitable policies on fish conservation and retaining inhabitable environments for fish and people dependant on them. Responsible fishing and supplementary stock enhancement may generate revenues through fish-based ecotourism in the sector. Further intensifying research in feed development, genetic improvement, and water budgeting can lead to success in developing strategies sustainable for fish production and productivity and in securing fish as a protein rich food to the mountain dwellers in this eastern most part of the country.

A haul of brown trout from Menchukha Valley.

The giant devil catfish (goonch).

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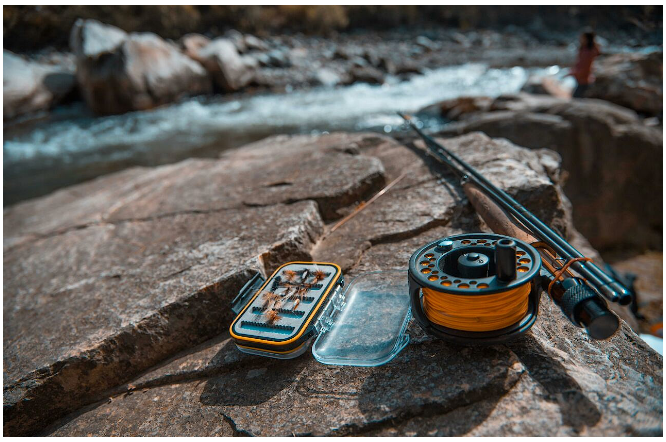

Avid anglers in search of brown trout in coldwater resources.

Present status of medium saline ‘bheri’ fishery and integrated mangrove-aquaculture in West Bengal, India: A short study: Part 2

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Growing mangrove plants in mangrove park at Canning Town.

Brackishwater polyculture in South 24 Parganas

In August 2022, the author met Sri Kaushik Sardar, a progressive brackishwater fish farmer at Krishnachandrapur Village, Gram Panchayat and P.O. Karanjali, PS and Block Kulpi, South 24 Parganas. His farm area (a ‘fishery’ in local dialect) is a single 2.1 ha, elongated water body 1.2-1.4 m deep, taken on lease (@ INR 83,000/year). The farming practice is modified-extensive type brackishwater polyculture, practiced commercially but not recognised under the term ‘bheri fishery’ or ‘bheri farming’. He cultures *Labeo catla*, *L. rohita*, *Lates calcarifer* (only in very small amount), *Mystus gulio*, *Metapenaeus brevicornis*, *Macrobrachium rosenbergii*, *Liza tade*, *L. macrolepis*, *Penaeus monodon*, and *P. vannamei* – all at the same time. Water from the Bhagirathi (Hooghly) River is taken in via a nearby canal and sluice gate. He uses the sluice to take a great quantity of tidal water into his plot, when felt necessary.

He believes that if production of shrimp goes down unexpectedly due to disease (though rare), market sized healthy fish production will compensate for the loss. Details of seeds stocked are as follows:

- Riverine *P. monodon* 8-10 mm, INR 0.60/piece.
- *P. vannamei* 3-4 mm, brought from hatchery in Madhya Pradesh, INR 0.20/piece.
- Riverine *M. rosenbergii* 48 mm, INR 5/piece.
- Riverine *L. calcarifer* 75-100 mm, INR 10-12/piece.

A view of a medium-saline bheri at Minakhan.

- Riverine *L. parsia* 24 mm, *L. catla* and *L. rohita* 100-150 g each, INR 140/kg.
- Wild entry of *M. brevicornis* 4-5 g in good amount.
- *L. tade* 48 mm, INR 5/piece.

Well-maintained mangrove park at Canning Town.

There is no auto-stocking except for *M. brevicornis*. Hence this is a modified-extensive polyculture system. A proper stocking density is not maintained for shrimp species and commercial aquaculture products are not used. Home-made formulated feed is used in the form of dough balls comprising a mixture of mustard oil cake, maize dust and rice bran/ wheat flour. The *P. monodon* reach 15-20 g after 70-75 days of culture, *P. vannamei* reach 20 g on day 90 of culture. After 180 days, *L. macrolepis* and *L. tade* grow to 50-75 g and 300-350 g respectively, and *M. gulio* 50-75 g. After one year, his *M. rosenbergii* attain 100-150 g body weight.

Sri Saiful Piyada and Sri Shyamapada Mondal, fish farmers at Rangafola-Aripara Village, Gram Panchayat and P.O. Belpukur, PS and Block Kulpi informed the author that conduct brackishwater fish farming with emphasis on *M. rosenbergii*, *P. monodon* and *P. vannamei* (PL-20 stage stocked), all simultaneously in an old 880 m^2 pond (150-180 cm deep) taken on lease, and in an adjacent beel of just under 2.4 ha in proximity to the Hooghly River. Water is drawn into the pond and beel at high tide via a canal. Indian major carps and *Tilapia nilotica* are also stocked. Optimum stocking density is not maintained, but culture systems are sparsely populated with a low biomass of fish and shrimp at stocking.

In August 2022, the author went to view medium-saline brackishwater 'bheri' aquaculture at Shyamaprosadpally Village, Canning Bridge Road, Canning town. Here, a total

A small chamber connected to main bheri.

area of a single bheri or 'Jalkar' is about 5.28 ha with 0.9-1.1 m water depth, having influence of tidal water from the Matla River on both sides of road bridge connecting Canning town and Basanti. A farm technician informed that from January-February onwards, hatchery-produced *P. monodon* seeds of 12 mm are stocked @ 7,000 / 0.132 ha bought @ INR 500-600/1,000 pieces. Local riverine seeds also stocked, which cost INR 500-700/1,000 pieces. Those are first reared in a 2,640 m^2 nursery chamber within the vast bheri for a month, and thereafter released into the main plot. Harvest of *P. monodon* begins from the end of March at 30-35 g size, with seed released once per month. Feeds are not used. The shrimp grow only on natural food produced by and over submerged aquatic weeds ('jhanjhee' in local dialect) and submerged aquatic grass. Tidal water from the Matla River, around 100 m away, is exchanged at fortnightly intervals, more frequently if needed.

L. tade seed of around 72 mm are stocked here in a small quantity @INR 6-7/piece; *L. parsia* seed of around 24 mm enter along with tidal water from December onwards. *L. tade* is harvested at 400-500 g, and *L. parsia* in the next November at 30-40 g body weight. Lime and inorganic fertilisers are not applied during the culture period. During November-December, the entire plot is dewatered, the bottom soil dried and raked; inorganic fertilisers, lime and mustard oil cake are applied to the water body before seed stocking. Final harvest of *P. monodo*n is done in August. *T. nilotica* adults are released once in the bheri plot in January, with young self-recruiting. The water is kept 'rolling' (in the words of technician) in this very large bheri, with exchange done frequently, thus natural food and nutrients are supplemented via intake from time to time, and good water quality is maintained inside. Sources of hydrogen sulphide, ammonia, nitrite, methane are removed when bheri is allowed to dry.

Integrated mangrove-aquaculture

The MS Swaminathan Research Foundation (MSSRF) held the International Conference on Sustainable Development in Hill and Coastal Ecosystems in Chennai, 7-9 August 2022. Dr S. Velvizhi, Scientist and Head of the MSSRF Fish for All Research and Training Centre in Tamil Nadu, discussed integrated aquaculture in mangrove areas with sea bass *L. calcarifer* and mud crab *Scylla* sp. At Minakhan Block, integrated mangrove-aquaculture (IMA) has been implemented by the Nature, Environment and Wildlife Society (NEWS), a well-known NGO in Kolkata. The Project 'Sustainable Aquaculture in Mangrove Ecosystems' is a multi-stakeholder partnership to strengthen transformative processes in shrimp trade as a basis for the protection of mangrove ecosystems in South Asia. The project receives cooperation from the Global Nature Fund.

Mangrove ecosystems provide food and livelihood to Sundarbans' dwellers in the two coastal districts of West Bengal. Mangroves protect people and land from frequent environmental hazards like cyclonic storms, violent winds, waves and soil erosion. Polyculture of shrimp and mullet using modified-extensive methods can be taken up in IMA systems and can become a fruitful alternative livelihood for women in the Sundarbans region of West Bengal. IMA practices aim to support the restoration of mangrove ecosystems in this region. By culturing economically important species of shrimp, mud crabs, mullet and other fish in an integrated way along with mangrove plants, IMA can support the livelihoods of farming families, and the well-developed root system of mangrove trees will facilitate protection of coastal lands and embankments of IMA plots from erosion.

IMA is a modified-extensive brackishwater fish and shrimp polyculture system, involves no application of commercial products, antibiotics or chemical compounds, and a minimum

Integrated mangrove-aquaculture plot of Sri A. Mondal at Minakhan Village.

and judicious use of inorganic fertilisers, feeds, mustard oil cake, lime, and seed. Like bheri fisheries, IMA starts after desiltation of plots and embankment strengthening on all sides. Shrimp feed @ INR 90/kg and that of mullets @ INR 45/kg may be used. In every 0.132 ha IMA water body, *L. parsia* seed are stocked @ 3/m^3 (24-36 mm, INR 4/piece); *L. tade* seed @ 2/m^3 (48-72 mm, INR 12/piece) and *P. monodon* @ 5/m^3 (PL-20, INR 1/piece). *L. parsia* will grow up to 40 g, and *P. monodon* 30 g at the end of five months of culture. Wholesale rates of mullets and *P. monodon* at Canning town and Malancha fish markets are INR 300/kg and INR 650/kg respectively.

Sri A. Mondal is one of the two beneficiaries (members) in an IMA adopted by the project implementing authorities at Minakhan Gram Panchayat (GP) of Minakhan Block. It is at Minakhan Village. Prior to this, more local brackishwater fish, shrimp and prawn farmers were adopted as beneficiaries at Chaital GP of this Block. All of them have been practicing brackishwater polyculture in bheris for the 15-20 years. The project implementing authorities provide the major share of inputs, namely *P. monodon* (22-24 mm) and mullet seed, feed, and lime. They also analyse and monitor soil and water quality parameters in IMA water bodies. Member farmers contribute a portion of the total input requirements. Sri Mondal's own IMA plot is 1.04 ha with 0.9 m water depth. A blue nylon net and bamboo fencing at 2 m height has been constructed around the plot to prevent the entry of cattle and goats that may eat planted mangrove saplings. Bidyadhari water is let in through inlet as and when felt necessary; water exchange done once or twice a month during the culture period.

In June 2022, under the initiative of the project, tropical mangrove saplings of *Rhizophora apiculata* ('gorjon' in Bengali), *Heritiera fomes* ('sundori'), *Sonneratia apetala* '(keora'), *Nypa fruiticans* ('golpata'), and *Xylocarpus granatum* ('dhudhul'), 15-60 cm in height have been planted on all sides near the banks on the slopes of IMA water bodies and on embankments at Sri Mondal's plot. He explained that at the time when leaves shed from grown-up mangrove plants in the near future, it will fall over water body where fish and shrimp are under culture, decompose and contribute detritus to increase fertility by providing more nutrients. This will promote fish and shrimp growth. Water in IMA plots remain in good and purified condition. Leaves of the plants are thick and don't pollute the water. The mangroves assist in protecting the environment and maintaining environmental balance. Mangrove trees absorb carbon emissions in greater amounts than other trees. They strengthen the embankment and keep the soil intact. In this project, Sri Mondal has learned the importance and procedure of analysis of essential water parameters of brackishwater aquaculture plots.

Integrated mangrove-aquaculture plot of Sri Shankar Baz at Joygram Village.

In the Sundarbans region, each mangrove sapling normally costs INR 50. Four- to ten-month-old saplings of familiar mangrove trees 30-60 cm in height can be used for planting in IMA plots. A full-grown *S. apetala* tree may attain 20 m in height, *H. fomes* 10-25 m, *Avicennia* sp. 2-10 m.

IMA plot of Sri Shankar Baz

Like Sri Mondal, Sri Shankar Baz is an elderly brackishwater fish farmer, second of the two IMA farmers adopted by project implementing authorities at Joygram Village, Minakhan GP. His bheri is around 1.05 ha, 90-150 cm deep, and has been developed into an IMA system. While giving an account of his plot and species cultured, Sri Baz informed that he procures:

- Hatchery-produced *P. monodon* seeds of 20-22 mm from Chennai/Vishakhapatnam, @ INR 600-700/1000 pieces, stocked at an interval of 20-22 days @ 1,000 pieces / 0.132 ha. His *P. monodon* are sold @ INR 500-800/kg at 30-45 g, harvested at 75–90-day intervals.

- Riverine *M. rosenbergii* seed of 30-50 mm @ 1000 pieces / 0.132 ha in two lots two times in a season (i.e., total 16,000). Seed cost INR 1 per piece and are sold at a marketable size of 50-100 g at the end of culture duration @ INR 400-700/kg.

- Wild-collected crab seed of *S. olivacea* are released in the plot at 20-30 g size, obtaining a good growth rate.

- Low amounts of *M. brevicornis* and *M. monoceros* enter the plot along with tidal ingress and sold @ INR 300-350/kg at 5-10 g size.

- Riverine paddy-grain sized *L. parsia* seeds are stocked @ 200 pieces / 0.132 ha during March end, bought @ INR 2,000/kg. At the end of the year, it achieves 30-50 g, caught in December-January when the plot is completely dewatered.

- *T. mossambicus* adults are stocked at 75-100 g and self-recruit 3-4 times/year, growing to marketable size of 50-100 g, sold locally @ INR 120-150/kg.

- Riverine *L. tade* seeds of 72 mm, bought @ INR 7-10/piece and stocked @ 50 pieces / 0.132 ha during March-April are harvested in January at 400-500 g size, with a market price of INR 150-200/kg.

- Major carp fingerlings are stocked @ 20kg / 0.132 ha during June-July at 100-200 g, bought @ INR 100-120/kg; those weigh 1,000-1,200 g at harvest, sold @ INR 140-150/kg.

- A small amount of *M. gulio* seeds are autostocked via entry with tidal water, grow to 50-70 g, and sold locally @ INR 400-700/kg, along with *Scatophagus argus* and *Glossogobius giuris* that enter the plot.

The water body is made ready for new culture at the beginning of February, on the 30th day of harvest of one crop. The bottom soil is dried, ploughed, and organic manure applied. A mixture of wheat flour byproduct, powdered broken rice and groundnut oil cake is used as feed for *M. rosenbergii* @2-5 kg/day. Cow dung is applied in small amounts once a month. Mangrove saplings are planted on four sides of the IMA plot, and strong erect nylon net fencing is set around from 30 cm deep inside ground. Fish within the will not be able to escape if floodwater enter during super-cyclones and natural calamities. Sri Baz mentioned that many farmers in this region will have to depend upon production and sale of fish to keep up their commercial brackishwater polyculture system, as production of *P. monodon* is not up to expectations.

He explained that brackishwater aquaculture in West Bengal may be semi-intensive to intensive *P. monodon* or *P. vannemei* monoculture in 1,000-1,200 m^2 brackishwater ponds (as mainly done in brackishwater blocks of Purba Medinipur), small- to medium-scale brackishwater fish and shrimp culture or shrimp monoculture in brackishwater blocks of North and South 24 Parganas districts in 0.132-0.264 ha ponds with daily use of home-made feed. The third system is brackishwater bheri/gheri polyculture with *P. indicus*, *P. monodon*, *L. parsia*, *L. tade*, and *M. rosenbergii*. In conditions there are losses in shrimp production, the fish harvest will protect the farmer.

The project provided financial support for earth excavation, fencing and IMA preparation works, as well as procurement of shrimp and *M. rosenbergii* seeds, and mangrove saplings. Saplings of 3-4 mangrove species, about 45 cm tall, were planted in June 2022 keeping a space of 1.2-1.5 m laterally. Those will grow to about 2.5 m in next two years.

One permanent labourer stays at Sri Baz's IMA plot all the time, entrusted with overall management and care. At the end of one year, more labourers will be engaged for the purpose of excavating sediment from the dewatered plot, until the entire area is deepened. Project personnel test of IMA plot soil and water parameters, provide prophylactic medicines, and organise a monthly meeting with 25-30 member IMA farmers in both Minakhan and Chaital GPs in Minakhan Block. Organic manures are applied to achieve good mangrove growth on embankments. Limestone powder is applied over the bottom in February during pre-stocking management, eliminating emission of harmful gases. Lime also increases an IMA plots capacity to be more productive, enhances the decomposition rate of organic matter, destroys pathogenic organisms, and increases the amount of utilisable nitrogen, Sri Baz stated.

Night shelter under construction for watchman.

Information on bheri fishery from published articles

Some information could be gathered after a perusal of some publications on bheri fisheries. Before seed stocking, quicklime CaO should be applied @ 200-300 kg / 0.132 ha in saline bheri(s) for culture of *P. monodon*[1]. In brackishwater ponds, exchanging water too frequently during tidal action may reduce the concentration of nitrogen, phosphorus and other nutrients required for photosynthesis, and thus primary productivity is hampered. Water exchange is needed to remove ammonia and excessive natural food particles. It should be done only when required[2]. In brackishwater polyculture ponds, finfish production gives a certain percentage of return even during the disease outbreak in shrimp. Polyculture of *P. monodon* with *L. parsia* and *L. tade* has emerged to be an effective alternative to brackishwater shrimp monoculture system in ponds. A combination of these three species is most popular among traditional brackishwater fish farmers of North 24 Parganas. Naturally occurring fry of mullets can be procured from fish seed markets at Ghatakpukur, Canning, Sonakhali, Kakdwip, Namkhana, Frasergunj in South 24 Parganas. Maintaining a species ratio of 21:3:1 *P. monodon* (above PL-20) : *L. parsia* (4-6 cm) : *L. tade* (8-10 cm) seed are stocked @ 25,000/ha. In five months with supplementary feed and proper management, *P. monodon* reach 65 g, *L. parsia* 100-110 g, *L. tade* 500 g[3].

During the 1960s and later on at Minakhan and other places in the two districts, adequate numbers of naturally occurring seeds of *L. parsia*, *L. tade*, *L. calcarifer*, *Eleutheronema tetradactylum*, *Setipinna phasa*, *Pseudapocryptes lanceolatus*, *M. monoceros*, *P. monodon*, and *P. indicus* entered into medium- to large-sized bheri(s) along with tidal water of Bidyadhari, Raimangal, Matla and other rivers. Dissolved nutrients and food matter were in high concentration in river water. Shrimp achieved good growth within 2-3 months. Brackishwater 'bheri' farmers got fiss and shrimp production @ 50-200 kg/ha in 8-10 months with very little investment.

In low-saline areas having 1-10 ppt salinity, small-sized plots are dried in November and limestone powder applied. Small earthen nursery enclosures are created at the side and *P. monodon* seeds brought from outside are stocked 50,000-60,000 / 0.132 ha. Salinity levels of water of this enclosure must be the same as that in which seeds have been transported to avoid shock. After 15-20 days, larger-sized seeds enter into main plot after a 1.0-1.5 m cut is made in the nursery embankment, creating a narrow water channel. Submerged aquatic weeds *Najas* sp., *Ceratophylum* sp. are allowed to grow in the main bheri plot before shrimp seed is released. Leaves of palm and date palm trees are placed over bottom soil, upon which periphyton is produced and also living organisms such as algae, which are used by growing


Small chamber connected to main bheri with embankment cut.

shrimp as a natural food source. Fresh tidal water is allowed to enter frequently on every spring tide, favouring the growth of *P. monodon* and facilitating moulting. Production is around 700-800 kg fish (including major carps) and 70-80 kg shrimp and *M. rosenbergii* per year per hectare.

In areas of higher salinity (10-30ppt) in these two districts, stocking of major carp fingerlings is avoided, and only that of *L. parsia*, *L. tade*, *P. lanceolatus*, *S. phasa*, *P. monodon*, *M. monoceros* and their rearing is made in medium-sized brackishwater bodies or 'nona gheri'. Along with tidal water enters the seed of predatory and piscivorous fish such as *L. calcarifer*, *Terapon jarbua*, *E. tetradactylum*, *G. giuris* and others, which are unwanted and thus water is let in carefully. Otherwise, farmers will get a very low shrimp production. Fish and shrimp seed are procured and stocked from outside; mullets @ 1,000-1,500 pieces / 0.132 ha and *P. monodon* 1,500 pieces / 0.1320 ha. Harmful gases are avoided by avoiding build-up of organic matter in the bottom soil. Frequent water exchange is essential. Supplementary feed is provided to growing fish and shrimp @ 2-5% of body weight daily in feeding trays. Brackishwater fish production from such system is around 450-650 kg/year per hectare, *P. monodon* 80-90kg/year per hectare. A medium-sized brackishwater body of 7-10 hectare in area gives good production as it is easy to manage and protect.

A greater part of Sundarbans region in West Bengal is subjected to tidal fluctuation throughout the year. Estuarine region of the Sundarbans in North and South 24 Parganas districts was known as the 'goldmine' of naturally-producing early stages of *P. monodon*, mullets and other economically-important shrimps and brackishwater fishes. But this natural repository has markedly declined over time. According to the late Dr K. R. Naskar, Bidyadhari water is contaminated with organic sewage and enriched with a considerable amount of nutrients from the domestic wastewater of Kolkata city carried via sewage pumping stations of Kolkata Municipal Corporation on the eastern border of Kolkata. Bidyadhari water enriches bheri soils with nitrogen and organic carbon, promoting the production of natural food sources for stocked animals[2]. But presently the situation is different. Raw domestic sewage now enters the Bidyadhari in much greater quantities, carrying pollutants of inorganic origin. The brackishwater fish farmers at Minakhan, having a strong traditional knowledge base, no longer consider it suitable and proper to be let into bheris for fish and shrimp farming. Fish farmers and possessors of medium-saline bheris at Minakhan are trying their level best to keep up brackishwater finfish production for local consumption as well as raising *P. monodon* for export.

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V-shaped bamboo grating at a bheri as observed from behind.

Indigenous basket for keeping harvested animals.

Split-bamboo box for catching and keeping harvested shrimp and fish.

Small chamber main bheri and one of the canals of Bhagirathi.

Transforming waste to wealth: An onsite demonstration of transforming fish waste into fish fertiliser to tribal communities of Jharkhand

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Waste management is one of the serious issues modern civilisation is grappling with, further fuelled by population explosion in emerging economies like India asserting tremendous pressure on the production side to meet ballooning demand. On 15 November 2022, the United Nations celebrated “8 Billion Day”. In 2023 India toppled China as the world’s most populous country with 1.42 billion people (Sundaram, 2023). The United Nations projects that by the end of this century world population will cross the 10 billion mark. Hence, with such a projected scenario, the demand for food and other goods and services will inevitably rise. The producers have always been in the race to meet demand and with help of new technologies have been able to increase production over a period of time. However, in this process waste production has also increased which is now a major issue humanity faces today, especially in urban areas.

In recent times to tackle waste management novel concepts like “reduce-reuse-recycle” and the “circular economy” have been floated and brought into application to some extent. In agriculture and allied sciences, fisheries in particular, waste management has been least attended. Tropical climate, high perishability and a deficient cold chain and storage infrastructure are key factors contributing to fish spoilage, apart from waste generated during harvesting and processing stages.

In marine capture fisheries with the prevalent use of non-selective gears, a large portion of bycatch is discarded in the open sea which could be otherwise used as fishmeal for feed production. Likewise in the inland sector waste generated from fish is discarded in open areas causing pollution and risk health hazards.

Demonstrating fish fertiliser preparation.

To address these issues and bring the discarded portions of fish into use some innovative techniques have been developed such as using fish scales for cosmetics, air bladder for fish maws, use of fish collagen to make suture materials for medicine, aquaculture feeds, silage, fertilisers, fish-mince, and fishmeal. Processing the waste into fertiliser is one of the best options because it requires limited equipment, and machinery and utilises the bulk of the fish waste, is cost-effective and requires less space. This inexpensive technique of converting fish waste into fish fertiliser in the inland sector is least reported and in the state of Jharkhand not yet reported. Therefore, the College of Fisheries Sciences, Gumla, undertook an initiative to introduce fish fertiliser to resource-scarce tribal communities through demonstrations for preparing fertilisers from fish waste, which can be used for kitchen gardens or in backyard ponds, targeting the tribal communities of Jharkhand. Converting fish wastes into fertilisers services the twin objective of adding value to fish waste and reducing the environmental pollution caused by discarding waste into open areas.

Importance of fish waste management

Consumption of fish is increasing continuously worldwide, and seafood is gaining in popularity for both delicacy and health benefits. However, large amounts of fish waste are also being generated in the process of bringing fish from the deck to the plate. Waste disposal and by-product management in the food processing industry pose problems in the areas of environmental protection and sustainability (Russ and Pittroff, 2004). Organic wastes have been found to contain compounds capable of promoting plant growth (Day and Katterman, 1992) and seafood processing wastewater does not contain known toxic or carcinogenic materials, unlike other types of municipal and industrial effluents (Afonso and Bórquez, 2002).

During the processing of fish, usually only the fish fillets are retained while the bulk of other material is discarded. These large quantities of fish waste, if not utilised or disposed of properly, can have large harmful effects on local environments. For that reason, there is a need to find an ecologically acceptable means for reutilising fish waste. Traditionally both whole fish and remains from processing were used to make fertiliser. According to Faid et al., (1997), conventional methods for the utilisation of fish waste include ensilation and the production of high-protein meals used in animal feeds. Liao et al., (1997), suggested composting as a viable solution to the problem of fish waste disposal. Yeasts and/or lactic acid bacteria were used to ferment fish wastes and remove odours (Faid et al., 1994). Acid hydrolysis of fish wastes has been studied to produce low-cost nutrients for the production of lactic acid (Gao et al., 2006), and low-cost protein sources have been produced by ensiling hydrolysed fish viscera to obtain a suitable medium for lactic acid bacteria (Vazquez et al., 2008). A new low-cost fermentation technique using *Aspergillus awamori* that could also apply to fish wastes was reported by Yamamoto et al. (2004) and Yano et al. (2008) described a fermentation technique that improves the quality of fish meal from fish wastes rich in lipids. Some studies have recently examined the re-utilisation of biodegraded fisheries-waste products as a liquid fertiliser (Kim and Lee, 2009; Kim et al., 2010; Dao and Kim, 2011). Therefore, fermented fish wastes could be used as a valuable resource for supplementing nutrients in agriculture.

Fish fertiliser packaged in discarded bottles.

Types of fish fertilisers

Fish fertilisers can be prepared by several different methods based on the use and type of technology utilised for their production. A number of common fish fertilisers include fish meal, fish emulsion, dried fish, soluble and enzymatically digested fish liquids. Fish meal is heated and de-oiled to make the dry meal generally much lower than other types of cold-temperature processed fish fertilisers. Microorganisms and plants do not rapidly utilise this type of fish, although it still provides a beneficial effect but takes longer to do so. Fish emulsion is mainly used for its rapid high organic nitrogen and available soluble phosphorus and potassium benefits as a foliar feed. Fish emulsion is also used as a drench for root feeding. Most fish emulsions have an N-P-K value of 4-1-1 with some having an N value of 5 or 6. Fish meal is mainly a great soil conditioner and great bacterial food to help feed the soil microorganisms. Most commercially made fish emulsions come from trash products of the menhaden fish. This group of fish includes herrings, sardines, and anchovy fishes. The commercially produced fish emulsion also contains 5% sulfuric acid as a preservative, but also it supplies sulphur to the plant and soil. Most commercially produced fish products do not contain fish oil which supplies beneficial soil fungi, or fish bone which provides needed calcium. Fish emulsion contains 9-10% nitrogen available to the soil. Other types of fish fertilisers utilise low-temperature enzyme digesting technology which does not denature the fish, thus making the end product a much more microbial-friendly fertiliser with nearly instant fertility for the crops where it is applied.

Preparation of fish fertiliser

Whole fish, trash fish, or fish discards like heads, guts, intestines and various other parts can be used as raw material. Whole fish will yield a better product. Add the raw material into a blender to mash it up into little pieces. The finer the fish bits, the more effective the fermentation. Add three parts of water to ferment one part of the material. Always prefer non-chlorinated water as it kills microbes. Blend the mixture again. Add *Lactobacillus* to the blended mixture. Add sugar as one third of the amount of fish added. Any cheap glucose source could be used as it provides energy to the microbes. Blend the mixture again. Pour the mixture into a container with a loose cover on it. There is no need to seal the container as it may explode due to the release of CO_2 by fermentation. The process takes three weeks to over a month to finish. During fermentation, there is a nasty smell, but once completed, there will be almost no odour. Finally, the prepared fish fertiliser can be used. The benefits of homemade fish emulsion are many. For one, it is cheap to make in large quantities. There are nutrients in homemade varieties that are not available in commercially-produced products.

Explaining the advantages of fish fertiliser.

How to apply fish fertiliser on agricultural land?

Liquid fish fertiliser can be applied by different methods to any type of cropping. Liquid fertiliser is usually applied via irrigation water through sprinklers, micro sprinklers, foggers, spitters, drip emitters, drip tape, furrow, flood systems, and overhead sprayers. Among these methods, liquid fish fertiliser results will show the best results when the foliar method is applied via a sprayer application. This method is excellent method for providing rapid sources of fertiliser to crop systems. Liquid fish fertiliser is rapidly absorbed and utilised by plants when applied following these techniques.

Advantages of fish fertilisers

Fish fertilisers are considered excellent sources of nutrients for soils and plants as fish contain most of the nutrients necessary for them. Fish fertilisers contain significant quantities of nitrogen as protein (an important source of balanced nitrogen) as well as a healthy balance of all 18 nutrients known to be significant for crop growth. Fish also contains more than 60 other trace minerals which have positive effects on soil biology and crop health. The nutrients in fish are a quick and direct stimulant to the plant's roots and leaves. Applying fish fertilisers can rapidly improve crop fertility in almost all situations. Additionally, fish provides both immediate fertilisation response as well a longer-lasting fertility effect for later in the growth of the crop. The balanced, moderate levels of nutrients in fish products provide a broad spectrum of fertility without the problems associated with the excess application of any one nutrient. Fish fertilisers provide balanced, moderate amounts of nitrogen and all the other essential nutrients, plus many more trace minerals not found in chemical fertilisers. This balance helps to provide full spectrum fertility without an excess of nitrogen and reduces problems with pests and diseases while supplying a fertility boost, and increasing plant growth and vigour. A significant additional benefit of fish as a fertiliser is the dramatic stimulation to the soil's beneficial microorganisms such as bacteria and fungi which consume, digest and release abundant nutrients in the fish when it is applied to the soil. Fish products can make a significant contribution to the overall fertility of the soil and crop while at the same time stimulating the biological activity in the soil, thus improving the quality of the soil for many years to come.

Faculty of College of Fisheries Science, Gumla group photo with tribal women after completion of onsite demonstration of the preparation of fish fertiliser.

Fish fertiliser preparation demonstration to tribal communities of Jharkhand

Jharkhand has as 32 recognised tribal communities mostly dwelling in rural areas. In general, 76 per cent, (2011 census) of the population of Jharkhand still resides in rural areas. Jharkhand is one of the richest states in terms of natural resources, unfortunately, its population are amongst the poorest communities in the country. The tribal communities are resource poor and hardly able to live decent livelihoods due to various constraints that stymie their progress, including a lack of access to knowledge and information that could improve their circumstances. Different institutions and organisations including public, private and NGOs are involved in facilitating these communities' access to modern knowledge and information intended to bring positive changes in their livelihoods. One such effort was carried out by the College of Fisheries, Gumla, providing onsite demonstration to tribal communities on converting fish waste into fish fertilisers which can be used in their kitchen gardens and plants to enhance crop yield. The onsite demonstrations that were positively received by the tribal communities as the technology was easy to adopt without any cost burden. The whole process, types and advantages of fish fertilisers were communicated in vernacular language which helped them receive the technology without any communication constraints.

Conclusion

The demonstration was well received by the tribal communities and since it doesn't require any investment. After hearing the advantages of fish fertilisers, the tribal communities showed interest in adopting this technique. From this demonstration, it was realised that resource-poor communities are open to adopting new technology which has prospects of bringing positive changes in their livelihoods. Like fish fertilisers, there are many available technologies which are inexpensive and have shown significant impact on the production process that could be introduced to these resource-deficient tribal communities to improve their livelihood and socio-economic conditions.

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Innovative fish sale improved livelihoods at Jurala dam in Telangana, India

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Fishing in Jurala dam.

Serving fresh and delicious fish dishes to tourists is an enterprising activity of fisher families dwelling in the vicinity of Priyadarshini Jurala Project (PJP), Mahabubnagar District, Telangana State, India.

About 200 families of Nandimalla Village used to depend on agriculture for a living. These families lost their livelihoods when their land was submerged by construction of the Jurala Project reservoir in 1995. Members of these families now living nearby the dam have adapted to challenging circumstances to become innovative fishing industry entrepreneurs.

An innovative practice

Priyadarshini Jurala Irrigation project was constructed across the Krishna River, situated in Mahabubnagar District of Telangana State, India, and now its limits come under the newly formed districts of Jogulamba Gadwal and Wanaparthy. The submerged Nandimalla Village land is within the limits of Wanaparthy District. The dwellers of this village understood the local demand for fresh fish and fish cuisine, and the entrepreneurs among them initiated the practice of serving the same to tourists. The villagers catch fish from the reservoir and keep them live in metal-framed cages placed in shallow waters of the reservoir until they are sold out. Over 400 people are directly or indirectly self-employed through these practices.

Marketing live fish

Nandimalla Village is somewhat unusual from other fish markets in that local fishers sell their catch live. Fish are captured with the help of suitable variety of nets and stocked in cages placed in shallow waters of the reservoir. It is quite interesting to observe that they not only design but construct the cages locally by welding metal bars together. A small window like opening is left to drop and to collect the fish. Finally, the cage is covered on all sides by thick nylon nets to prevent the escape of fish. The total cost of each cage comes to about of ₹2,000 (US$25). Each cage can store about 100 kg of fish and can be used for 8-10 years. The cages permit live fish to be kept for at least for 3-5 days until sold. Tourists/visitors and the people of surrounding villages prefer buying live fish, as there is no spoilage and deterioration of flesh, compared to dead products typically sold in other markets of the area.

A view of Jurala dam.

Most tilapia sold live

Tilapia is exotic to India but is hardy and tolerant of adverse aquatic conditions. When compared to carps and other edible varieties of fishes, the availability of tilapia is relatively good in most inland waters. In aquaculture practices tilapia is often considered as a weed species. But some innovators such as the Nandimalla fishers are benefiting by capturing and storing live tilapia for use in fresh fish dishes for the tourist trade. Tilapia are easy to dress and prepare boneless fillets from. Fish can be trenched with knife directly from the surface and fried. It is cheap to source and because of its small size, more fish can be stored in a given area.

Locally designed cages for live fish storage.

Observation of fish condition in cages at dam shore.

Cooking fish cuisine

Every day some of the tourists visiting the reservoir buy fish to take home for cooking. A good number of the people visit the places where the local fishers cook fresh fish on demand. This practice of the local fishers has attracted people not only from all over the district but also from Hyderabad and other towns and is generating good income for the local fishers.

Consumers congregating to buy fish.

Uplifted livelihoods

Earlier one fisher on average used to capture 10-15 kg fish per day and was selling it @ ₹40 (US$0.50) per kg to a middleman who carries the same to urban markets for sale. In this practice the fisher was getting an income of ₹400 to ₹600 (US$5 to $7.50) only. But now the same fisher with the help of his family members is selling the live fish at the cost of ₹100 per kg and getting ₹1,000 to ₹1,500 income (US$12.50 to $18.75). Use of cages permits a continuous source of live fish to be maintained to attract consumers regularly.

Early success of the new practice of live fish sales and value-added fish products attracted the other residents of Nandimalla Village towards this business. This new trend encouraged local small-scale merchants to sell the items needed for cooking. It can be concluded that, live fish sale and value addition of fish food may pave the way for new entrepreneurs to start similar practices in other places where fishers still receive little money for their effort.

Wild-caught tilapia.

Tilapia cutlets.

Tilapia cutlets fried with spices.

Tilapia curry.

Tents at dam site for preparation of fish dishes.

Pengba, *Osteobrama belangeri* – a candidate species for diversification in aquaculture

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Adult Osteobrama belangeri, locally known as pengba in Manipur, Northeast India.

With the emphasis on diversification of major carp polyculture systems in India, attempts have been made to incorporate other potential candidate species into the system. Diversification also offers the opportunity to contribute to conservation. *Osteobrama belangeri*, locally known as pengba, a highly esteemed minor carp which is listed as “near threatened” by IUCN has a high market demand due to its better taste and meat quality. Therefore, this species is considered one of the most suitable candidate fish species for aquaculture. Considering its suitability and compatibility with the major carps, it can be incorporated into the carp polyculture system thus enhancing the yield as well as utilising the wetlands of Manipur for a profitable venture. However, the species is faced with constraints such as non-availability of a suitable, nutritionally well-balanced feed for culture, and its susceptibility to bacterial infections at higher densities. This article summarises the culture aspects and technologies adopted as well as the prospects for pengba as a potential species for the diversification of polyculture, extra income, and livelihoods.

Pengba – a brief introduction

The State fish of Manipur, penga is a highly esteemed minor carp endemic to Manipur in Northeast India. Its natural distribution is restricted to Yunnan Province of China, Myanmar, and the eastern parts of Manipur. During the early monsoon season, *O. belangeri* has been reported to migrate from Myanmar’s Chindwin River to the upstream areas of Imphal River and its tributaries in Manipur for breeding in the floodplains[1]. Wild populations of this species have declined significantly, resulting in its being listed among the 91 endangered fish species of India.[2] According to IUCN Red List status, it is categorised as ‘extinct in the wild’[3]. In a survey conducted by the Loktak Development Authority, Manipur, it was found in Loktak lake[4] and hence, it was reclassified as ‘near threatened’[5]. Due to the construction of the Ithai barrage on the Imphal river for the supply of water to the Loktak Hydro-Electric Project[6], a decline in the fishery of Loktak has been observed, owing to obstruction of breeding migration. Another possible reason was the introduction of the exotic common carp into the lake. Pengba has a great demand in the state of Manipur due to its value in the social and cultural life of the Manipuri people. The price of the fish ranges from ₹ 400-800 (US$5-10) per kg in the market of Manipur depending on the season. 93% of fish farmers had an annual income up to ₹ 50,000 (US$625) exclusively from Pengba fish farming[7]. Due to the conservation status of this endemic species and its contribution to farmer income, its culture practices need to be popularised.

Food and feeding habits

Pengba has an omnivorous feeding habit and consumes algae, small insects, aquatic plants, zooplankton, and diatoms.[8] According to Behera et al.[9], this species is suitable for pond culture because it is mainly herbivorous and thus, can be included in composite fish culture in place of grass carp. Based on the study made by Basudha and Viswanath[10], the fish showed herbi-omnivorous feeding habits where it feeds on a variety of food items with aquatic macro-vegetation being the predominant food item. However, the juveniles prefer zooplankton and other animal matter such as insects and worms. With the increase in the size of the fish, a higher preference is given to plant food items (leaves, stems, and roots) with aquatic plants constituting a major portion i.e., 40-60% of the gut content. It is also observed that the fish prefer *Wolffia* sp., a plant of duckweed family Lemnaceae, commonly called watermeal. Pronounced feeding activity was found during October to April whereas the feeding activity was low during the monsoon seasons (June to August).

Advanced pengba fingerling.

Breeding biology

Pengba is a seasonal and riverine spawner and it normally spawns during the monsoon season (June-July).[11,12] Sexual maturity is attained in 2+ years[13] when it reaches a size of 200-250 g. Males mature earlier than females and peak breeding season has been found to be of short duration ie., the first week of July to the second week of August in the mid-hill condition. However, reproduction occurs in higher temperature conditions, with less precipitation, and a long duration of sunshine. Mature fish showed distinct sexual dimorphism as in males, the body is more elongated with no bulging of the abdomen. Alike major carps, pengba also exhibited secondary sexual characteristics during the breeding season such as in males, the roughness of the pectoral fins whereas fully mature females exhibit bulging of the abdomen. In accordance with Angel et al.[14], female fish are comparatively larger in the fully mature stage than their male counterparts. The relative fecundity has been recorded to be approximately 330,000 eggs kg^{-1} of body weight of a female brooder thus indicating that the fish is a prolific breeder. It breeds in riverine conditions during the southwest monsoon season however, it is not able to breed in confined waters without hormone injection[15]. Several trials have been made on induced breeding by ICAR,[13,15,16,17,18] and subsequently, ICAR-CIFA has succeeded in commercialising its captive breeding technology.

Wolffia sp., a free-floating aquatic plant preferred by pengba.

Culture aspects

Pengba has a high potential in composite culture practices depending on its compatibility as well as the types of feeding habits of the fishes. Its fingerlings are being reared along with the Indian major carps in ponds and the survival rate in these fingerling rearing systems ranges from 60-70%. Hence, the production of table-size fish is not sufficient to fulfil market demand. High survival (94.5%), as well as growth rates (784.8 kg ha^{-1}), have been reported in three months of culture with supplementary feeding[19]. Varying levels of *Azolla* in the feed preparation for the species have been tried and a promising survival and growth rate have been achieved. [10, 20, 21] Annual production of 14-15 tons ha^{-1} can be achieved by adopting the scientific carp culture procedure. Grow-out culture of pengba is mainly confined to earthen ponds and 92.9% of the fish farmers followed extensive or traditional pengba farming practices[7]. The general practice of pengba culture in Manipur is similar to a standard carp culture practice, which includes the general pond preparation such as control of predatory and weed fishes; stocking of fingerlings at a combined density of 4,000-10,000 ha^{-1}, pond manuring and fertilisation with organic manure like cattle dung or poultry droppings and inorganic fertilisers; feeding with a supplementary feed prepared from a mixture of rice bran and mustard oil cake, fish health monitoring and water management. The grow-out period is normally one year, during which it can attain a weight of 200-500 g, however, it can grow further up to 800 g in 8-10 months depending on the management level. In certain cases, the farmers carry out partial harvesting of market size groups (>200g) at intervals. Another common practice followed in Manipur is stocking of large-sized pengba fingerlings (12-15 cm) in combination with 2-3 major carp species @4,000-10,000 ha^{-1} density for single stocking and harvesting and at 10,000- 15,000 ha^{-1} density for single stocking and multiple harvesting.

Pengba culture technology

Pen

Despite the vast fisheries resources of Manipur in the form of beels, derelict waters, reservoirs, tanks/ponds, and rivers/canals, the present fish production from these resources is far below their potential. The present productivity of wetlands stands at 75 kg ha^{-1} year^{-1} against the potential productivity of 1,000 kg ha^{-1} year^{-1} [2]. Most of the wetlands are being encroached on for agriculture and allied activities, hence, with improvement measures such as habitat restoration and fish stock enhancement following scientific methods, the productivity of such wetlands can be enhanced. Rational stocking of such wetlands with suitable fingerlings (>10 cm) in adequate numbers (3,000-3,600 ha^{-1}) will help to boost fish production as well as livelihood support[22]. However, major constraints such as the non-availability of fingerlings of the desired size, high costs, and mortality associated with long-distance transportation stress arise. Hence, to increase fish production, pen aquaculture can be a suitable technological option, especially for fingerling production to be subsequently released into wetlands.

A study has been conducted by Yengkokpam et al.[23] to assess the feasibility of culturing pengba along with Indian major carps and exotic carps in net pen enclosures in the Takmu pat, a part of Loktak Lake in Manipur, under the administrative control of the Department of Fisheries, Manipur with a water area of 500 ha in Bishnupur District. A square-shaped pen of approximately 0.1 ha area (31.62 m × 31.62 m) of nylon net (25 mm mesh size) was used. The pens were stocked @ 5 fingerlings m^{-2} maintaining a species ratio of 40% surface feeders (catla and silver): 20% column feeder (rohu): 30% bottom feeders (mrigal and common carp): 10% macrophyte feeders comprising of grass carp and pengba

Pond for semi-intensive polyculture of pengba and Indian major carps.

following the observations of Basudha and Vishwanath[24] so that all the ecological niches were occupied and ensured submerged aquatic macrophytes properly controlled. The results were that pengba attained the highest SGR and weight gain % attributed to the natural lake environment as well as the presence of submerged macrophytes. In pond aquaculture systems, pengba has poor growth and survival compared to Indian major carps[9]. Considering the economic performance, the BCR was estimated to be 1.37 depicting pengba as a potential species for carp polyculture in net pen enclosures, and one of the profitable culture options.

Monoculture and polyculture (species and feed fed)

Pengba farming can be done either in monoculture or polyculture as one of the components with the major carps. Better taste as well as a higher growth rate in ponds of the plain area[25] coupled with its good appearance to attract consumers makes it one of the potential candidates for introduction into the culture system. Ponds in the plain area are mainly utilised to culture the Indian major carps, which have a higher growth rate as compared to pengba. Hence, this species can be established in the plains by culturing along with the major carps rather than substituting any of the component species of the group. Pengba production in a short duration culture in five different locations of Imphal valley for seven months at an inclusion level of 10-15% of the total number of fish seeds stocked as demonstrated by Basudha et al.[26] reported a good growth rate (0.3-0.8 g day^{-1}) with a survival rate of 80-85% and a total production of 400-800 kg ha^{-1} in seven months. A series of experiments on the compatibility of pengba with catla and rohu as well as finding the ideal incorporation level with the three species of Indian major carps were conducted by Das et al.[3] in CIFA. In study I, pengba was stocked either with catla or rohu at a combined stocking density of 6,500 fingerlings ha^{-1}. Improved growth in catla and rohu was observed and indicated a lesser competition from pengba. Further, higher growth was observed in pengba in combination with catla thus revealing better compatibility in comparison with rohu. In study II, pengba was included at 20% with major carps (catla, rohu and mrigal) in grow-out ponds at stocking density of 6,500 fingerlings ha^{-1} and reared for 11 months, good growth and survival rate was obtained with a doubling in the biomass yield. In both the studies, the fishes were fed with a mixture of rice bran and groundnut oil cake (1:1) at approximately 5% of the biomass during the initial two months then weaning to extruded floating pellet feed (28% protein) at approximately 3 and 2% of the biomass in the subsequent months.

Future prospects – potential culture and researchable issues

Pengba forms an important component of carp culture serving as an extra source of income, hence seed production of pengba in captive conditions can be achieved on a commercial scale through induced breeding using pituitary gland extract, Ovaprim, Ovatide, and Wova-FH. Also, the consumer market for pengba is expanding gradually and research on standardising the culture technology is underway in R&D insti-

Experimental pengba culture tanks.

tutes of northeastern India and elsewhere[27]. An experimental setup of pengba culture at the College of fisheries, Central Agricultural University, Lembucherra is shown below.

One of the major issues of concern is the non-availability of a suitable, nutritionally well-balanced feed for culture as the detailed nutritional requirement of the species is not fully understood yet[27]. Another constraint faced is that pengba is susceptible to ulcers and columnaris diseases when it is stocked at higher densities as compared to carps thus, causing mass mortalities and thereby lowering production. Epizootic ulcerative syndrome caused by *Aphanomyces* and *Aeromonas* infections are commonly occurring diseases in pengba[8]. In addition, pengba is more susceptible to handling stress thereby complicating the seed transportation process[27].

Conclusion

Species diversification can be accomplished by exploiting new culture species and in this regard, the local species can be a good candidate. Diversification of species offers dual benefits in aquaculture viz., biological and economic. From the biological point of view, a wide variety of species availability allows the fish farmers to practice crop rotation (fish) thus allowing the pond to recover from unfavourable changes resulting from the culture of single species. Economically, more species favour more choices for consumer demand and thus help in the expansion of the market. Diversification brought many advantages such as less dependence on the wild stocks as well as the development of scientific techniques that help to optimise the yield i.e., polyculture using the native species like pengba thereby enabling the high yield with low inputs. Further research on modification of production technology as well as the development of breeding and culture technologies of other indigenous fish species are encouraged to sustain the aquaculture production along with improving the livelihoods of the people in the region.

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First report on successful captive breeding of peacock eel, *Macrognathus aral*

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Ornamental fish are economically important for employment generation and livelihood development in many developing countries. India's share of the international trade is estimated to be around Rs. 158 lakhs (US$ 197 million) which is only a small part of the world trade. Indigenous wild-caught ornamental fishes contribute the most towards India's exported of ornamental fishes. North-eastern states and West Bengal have a rich freshwater fish biodiversity resource with a high ornamental value. Among these, freshwater peacock eels have enormous opportunities, not only in the domestic ornamental fish market but globally, also. Peacock eels are now widely preferred by aquarists and presently they are exported. As peacock eel species are hardy and compatible with other ornamental species, their importance is growing by the day. However, they are not yet fully incorporated in inland culture systems; the main reasons behind this are lack of information on the captive induced breeding, inadequate availability of natural fry and absence of commercial hatchery production.

The peacock eel *Macrognathus aral* belongs to the family Mastacembelidae. This is both a potential food fish as well as an indigenous ornamental fish.

The peacock eel, Macrognathus aral.

M. aral is classed as "Low Risk near threatened" (LRnt-category) in the CAMP report. The species is distributed in the Eastern Ghat region of India and has found a place in the IUCN Red List. The presence of 2-7 ocelli at the base of the dorsal fin and a long stripe on the dorsal part of the body can easily distinguish this species from others. *M. aral* mainly inhabits shallow waters in plains, floodplain wetlands, canals, paddy fields, beels, ponds and slow-moving rivers with vegetation in India, Pakistan, Sri Lanka, Bangladesh, Nepal, and Myanmar. The fish mainly prefers to feed on zooplankton, fish and insect eggs and larvae, crustaceans, annelids, molluscs, and algae. Although detailed study on the sex ratio, gonadosomatic index, ova diameter and fecundity of *M. aral* have already been conducted there is no report on the captive breeding of *M. aral*. The eels are unique choice for the hobbyist and a valuable species for entrepreneurs to export, but they are also in demand as food fish across the country and hence are a candidate for aquaculture. The captive breeding of these freshwater eels is the only way to protect the wild stock and fulfill demand. Hence, the present study aimed to develop captive breeding techniques for of *M. aral*.

Cast net and trap (overleaf) for collection of peacock eel.

Collection of wild *M. aral* for captive rearing

The eels for captive breeding trials were collected from North and South 24 Parganas, Nadia and Bankura districts of West Bengal. Fish were mainly found in weed-choked wetlands, swamps, lakes and ponds with water depth of less than 1.5 m and a muddy bottom. The fishes were generally collected using bamboo traps in swampy areas, cast nets as well as hook and line in wetlands. The water parameters in natural habitats ranged between 24-32°C, pH 6.8-7.48, alkalinity 136-185 PPM and dissolved oxygen 4.9-7.0 mg/l. A total of 600 live specimens were collected and acclimatised for captive breeding.

Maintenance

Tanks were provided with aquatic weeds and bamboo or PVC pipes for hides. The base was filled in with mud or sand to simulate natural conditions. The morphometric and meristic characteristics of *M. aral* was studied to identify the species. The food and feeding behaviour of the fishes were studied and they found to be omnivorous in nature, preferring live feed.

Peacock eels are very capricious in choosing food, so their daily diet needs to be varied and adapted to the preferences of individuals. Often there are situations when this fish will eat any food with pleasure, and the next day completely refuses the same. Therefore, to maintain the fish in captivity, they were fed with invertebrates, earthworms, crustaceans, mosquito larvae and small fish. Their preferred food was tubifex.

Reproductive biology

The reproductive biology was studied during the month from April to September, and it was observed that 48% fishes were maturing stage (stage II), 36% mature (stage III) and 12% ripe

stage (stage IV). Out of total fish collected, the male: female ratio was found to be 3:1. The average weight of the gonads of males and females were 0.17 g and 1.94 g respectively. The ripe ova were dark green in colour with average ova diameter of 0.74 mm and fecundity of 1,250 eggs.

In captive conditions they preferred to stay inside any artificial hideout or amongst aquatic plant roots or the mud bottom. The preferred water temperature varied between 18-28°C. The suitable water quality parameters are mentioned below.

Suitable water quality parameters.

Parameter	Range
pH	7.5-8.33
Alkalinity	136-185 ppm
Total dissolved solids	1,012 mg/l
Dissolved oxygen	9.77 mg/l

Sexual dimorphism.

Male	Female
Stripe on the body is darker in males than females. Dorsal side is brownish in colour.	Females are quite larger than males. The belly of mature females is fully oranges. Dorsal side is greenish in colour.

A spawning pair.

Breeding

The maturation of peacock eel occurs at the age of three years, but they reproduce very poorly in captivity. To keep peacock eels comfortable in captivity, we tried to simulate its natural habitat to keep the fish healthy, strong, and attractive. Simulating flooding conditions encountered during the rainy season in their natural habitat was believed to stimulate breeding behaviour.

Natural breeding in captivity: Breeding trials of peacock eels were conducted in glass aquaria of 60 x 45 cm. Small bamboo logs and aquatic plants such as water hyacinth were provided as substrate for spawning of the adhesive eggs. A mild flow of water was maintained in the aquarium with the help of an electrical filter and aerator. The length and weight/ size of females and males were 12.8-15.2 cm and 10-15 g and 12.4-13.8 cm and 10-12 g, respectively. Female to male ratio was 2:4 for breeding.

Induced breeding: The synthetic hormone (SGnRH + Domperidone), commercially known as Spawn Pro was administrated in different dosages (0.03-0.05 mg/kg body weight). The doses were calculated based on the body weight of the brooders and were administrated near the base of the dorsal and pectoral fin at 45° with the body. Nylon threads and aquatic plants were provided as substrate for spawning. The size of females and males were 13.5-15.8 cm and 8.4-10.2 g and 10.7-12.5 cm and 6.5-7.6 g, respectively. Different ratios of females to males was taken for induced breeding, described below.

Breeding performance

Male and female brooders were released at the sex ratio 1:1, 1:2 and 1:3 in separate glass aquaria. Courtship behaviour started after sunset; it was monitored without disturbing the breeding pairs. Spawning response varied from 10-12 hours. A total of 50-65 fertilised eggs of diameter 2.0-2.5 mm were collected from one pair of fish after 14 hours. The fishes proved to be batch spawners. After ovulation the adhesive eggs were observed microscopically.

Embryonic development

The developmental stages of *M. aral* embryo were categorized into different stages viz. zygote, cleavage, blastula, gastrula, segmentation, hatching and larval stages.

- **Zygote stage:** The fertilised eggs were adhesive, dark greenish brown in colour and the diameter was recorded as 0.74 + 0.05 mm. Cytoplasmic movements started after fertilisation.

- **Cleavage stage:** Blastomeres were formed after the first cleavage, after 30-40 min of fertilisation. Simultaneously, the blastomeres completed 64 cell divisional stages within 2-3 hours. As divided at an interval of 20-30 min after the first cleavage.

- **Blastula stage:** Blastula stage was initiated while 128 numbers of cells were formed. Rearrangement of cells was observed during this stage.

- **Gastrula stage:** Three germ layers and the embryonic axis were formed due to initiation of substantial cell movements with convergence, involution, and extension. Gastrula period remained for 5 to10 hours.

Hatching was observed after 48-56 hours of spawning. Fertilisation rate was 40-45% and hatching rate was <50% in semi-natural breeding. 7-10 hatchlings were collected from a pair. The yolk sac was absorbed after 84-96 hours. The maximum mortality of the larvae was found after the fourth day of hatching. Larvae were fed with infusoria and egg yolk.

Larval development was successful for one month. Although the number of survivors was very low the survivors were healthy.

Hiding behaviour of the peacock eel.

Larval length and weight by age.

Age (days)	Length
1	5 – 7 mm
3	8 – 9 mm
5	8 – 10 mm
7	9 – 12 mm
10	1.4 – 1.6 cm
15	2.7 – 3.2 cm
30	4.5 – 5.7 cm
60	7.2 – 8 cm

Conclusion

The maturation and captive breeding technique of *M. aral* has been accomplished successfully by maintaining the favourable environmental conditions along with different other important factors viz. condition of broodstock, sex ratio, set up of the aquarium tanks, and temperature. As the fish is a nocturnal feeder and has unpredictable food preferences, it is very important to develop proper feeding strategies to grow the fish. Scrupulous monitoring and care is also required in the post spawning period, which is very critical phase as it determine the reproductive success. This study gives an overview of the reproductive dynamics, feeding and environmental preferences of *M. aral* in captive conditions. The present study also revealed that the fish responded well with the synthetic fish breeding hormone Spawn Pro and a 2:3 female and male ratio. But the fertilisation rate did not reach above 50% and the hatching rate also varied between 40-60%. Natural breeding is a better option for *M. aral* if the cative rearing is done successfully.

Eggs attached to aquatic plants and bamboo logs.

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Webinar on Fish Welfare: What we need to know?

FAI and NACA convened a webinar on fish welfare issues on 8 March from 9:30-11:30 am Bangkok time (GMT+7), via Zoom. The webinar addressed the relationship between welfare, health, quality and profit in aquaculture production.

The programme featured:

- Animal welfare applied to aquaculture.
  Murilo Quintiliano, FAI Farms, Director of Aquaculture Strategy
- Preliminary tilapia welfare assessment results in Thailand.
  Win Surachetpong, Kasetsart University
- A practical framework for assessments on aquaculture productions.
  Ralf Onken, FAI Farms, Chief Technology Officer
- Communicating welfare to the aquaculture industry.
  FAI Farms, Project Manager – Thailand

- A joint panel discussion on fish welfare issues.

We would like to invite you to view video recordings of the presentations, which are available for viewing on Vimeo, with subtitles in five languages (English, Chinese, Thai, Portuguese and Spanish):

https://vimeo.com/channels/naca2023/page:1

Artemia side event at the FAO Sub-Committee on Aquaculture

A side event on the *Potential of brine shrimp Artemia production for aquaculture transformation* will be held at the upcoming FAO Sub-Committee on Aquaculture meeting at Hermosillo, Mexico, 16-19 May.

The objective of the event is to follow up on the SDG-aligned Artemia aquaculture workshop, which was held in conjunction with the Global Conference on Aquaculture Millennium +20 in Shanghai, China (September 2021) and the COFI SCA 11 conclusions regarding Artemia: Recommendations for further action, as proposed by the International Artemia Aquaculture Consortium (IAAC).

The newly established IAAC, hosted by NACA, aims to explore needs and opportunities for new international initiatives to guarantee a more sustainable provision of Artemia cysts.

The programme will include:

- A brief history of Artemia use in aquaculture since the Kyoto FAO Copnference in 1976 – need and opportunities for new action.
  Patrick Sorgeloos, IAAC Facilitator and Advisor.
- Presentation of the International Artemia Aquaculture Consortium.
  Eduardo Leano, NACA.
- Recommendations as formulated by the IAAC membership.
  Yeong Yik Sung, IAAC Chair.
- Pond production of Artemia.
  Nguyen Van Hoa and Meezanur Rahman.
- Artemia resources and use in China.
  Liying Sui.
- Production interests for Africa.
  Betty Nyonje, Kenya.
- Sustainable harvesting of inland salt lakes.
  Thomas Bosteels, Great Salt Lake Brine Shrimp Cooperative.
- Potential for improved use of Artemia in fish and shrimp hatcheries.
  Philippe Léger and David Garriquez.
- Use of Artemia biomass as human food.
  Shahina Syeda.

NACA looks forward to the outcomes of the event. If possible, recordings of the presentations will be made available on NACA's YouTube channel.

Handbook for Artemia pond culture in Bangladesh

Muhammad Meezanur Rahman, Nguyen Van Hoa and Patrick Sorgeloos

Brine shrimp *Artemia* nauplii constitute the most widely used live-food item for the larviculture of crustaceans and fish. The advantages of *Artemia* nauplii compared to inert diets are its small size (450 µm), movement stimulating feeding responses, high digestibility, high nutritional content in terms of protein and highly unsaturated fatty acids. Annually, about 3,500 MT of *Artemia* cysts are marketed worldwide. The unique property of *Artemia* is its ability to to form dormant embryos or 'cysts'. The cysts are available year-round in large quantities along the shorelines of hypersaline lakes, coastal lagoons and solar salt works scattered over the four continents. At present, Bangladesh imports 40-50 metric tons dry *Artemia* cysts annually worth an approximate value of USD 4 million. Some countries such as Thailand and Vietnam have successfully adopted technologies for *Artemia* production in solar salt farms.

The aim of this manual is to provide technological guidelines to extension agents, researchers, and salt farmers on *Artemia* production in salt farms in Cox's Bazar. The manual was prepared through review recent of activities in *Artemia* production, the 1996 FAO Manual on the production and use of live food for aquaculture, the 2019 book " Principle of *Artemia* culture in solar salt works", relevant books and published research papers.

The manual covers:

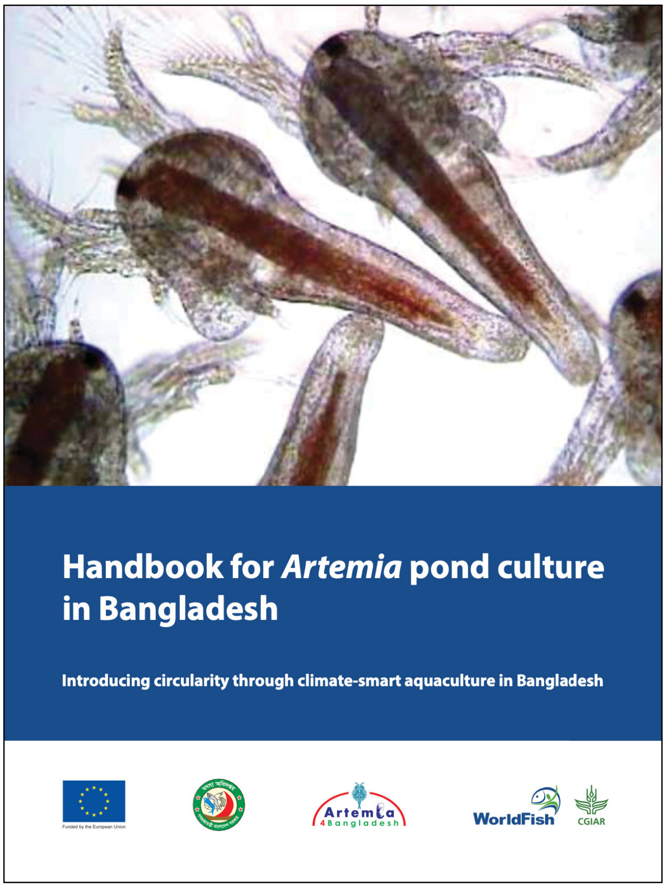
- Biology and ecology of *Artemia*.
- Cyst biology and physiology during the hatching process.
- Factors to consider in proper site selection.
- Different models of *Artemia* culture.
- Steps in proper pond construction.
- Procedure in shortening the duration of *Artemia* pond preparation through application of concentrated sea water or crude salt.
- Standard method of *Artemia* cyst incubation and stocking.
- *Artemia* pond maintenance and management.
- Suitable algae production for feeding *Artemia*.
- Preparation of processed feed and supplementary feeding.
- Diseases and health management.
- *Artemia* cyst and biomass harvesting, processing and preservation.

Earlier studies described limited knowledge, improper pond management, and climatic conditions as bottlenecks in *Artemia* production in salt farms. Recent improvement in *Artemia* production include deepening ponds to more than 50 cm water depth, a stocking density of 100 nauplii per litre, stimulating the growth of suitable algae species (diatoms, green algae), optimum supplementary feeding of green water with fermented agricultural waste products (molasses, monosodium glutamate by-products), use of formulated shrimp feed, improvement of routine pond management such as raking of pond bottom, and health management through application of bioflocs.

Download the manual from:

https://artemia.info/enclosure/?id=63

Development of this manual was funded by the European Union. It is published by the Artemia4Bangladesh Project (WorldFish). Redistributed with permission.



NACA YouTube channel: @aquacultureasia

NACA now has a custom YouTube handle to make it easier to visit our channel, "@aquacultureasia". Thanks to our subscribers for signing up and making this possible! You can find us anytime by visiting:

https://youtube.com/@aquacultureasia

Check out the playlists on our channels to access presentations organised by workshop. We already have many great educational materials available for free access!

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the Third 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 third quarter of 2022, and the original and updated reports can be accessed at the QAAD page (https://enaca.org/?id=8). The following diseases were reported:

Finfish Diseases

- **Infection with *Aphanomyces invadans* (EUS):** Australia in wild male adult mullet (*Mugil cephalus*); Bangladesh in rohu (*Labeo rohita*), catla (*L. catla*) and mrigal (*Cirrhinus mrigala*); and Chinese Taipei in largemouth bass (*Micropterus salmoides*) and ayu (*Plecoglossus altivelis*).

- **Infection with red seabream iridovirus (RSIV):** Chinese Taipei in Asian seabass (*Lates calcarifer*), hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*) and jade perch (*Scortum barcoo*); and India in freshwater angelfish (*Pterophyllum scalare*) and Ram cichlid (*Mikrogeophagus remirezi*).

- **Viral encephalopathy and retinopathy (VER):** Australia in captive juvenile Queensland grouper (*Epinephelus lanceolatus*); and Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*).

- **Infection with Tilapia lake virus (TILV):** India in tilapia (*Oreochromis niloticus*); and, the Philippines in tilapia fingerlings (*Oreochromis* spp.).

- **Enteric septicaemia of catfish:** Vietnam in pangas catfish (*Pangasius microneme* and *P. hypophthalmus*).

Molluscan Diseases

- **Infection with *Perkinsus olseni*:** India in wild mussel (*Mytella strigata*).

Crustacean Diseases

- **Infection with white spot syndrome virus (WSSV):** Australia in broodstock black tiger shrimp (*Penaeus monodon*); Bangladesh in *P. monodon* and mudcrab (*Scylla serrata*); Chinese Taipei in whiteleg shrimp (*P. vannamei*); India in *P. vannamei*; the Philippines in postlarvae and grow-out of *P. monodon* and *P. vannamei*; and Vietnam in *P. monodon* and *P. vannamei*.

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

- **Acute hepatopancreatic necrosis disease (AHPND):** Bangladesh in *P. monodon*; the Philippines in *P. vannamei*; and Vietnam in *P. monodon* and *P. vannamei*.

- **Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP):** India in *P. vannamei*; and the Philippines in *P. vannamei*, *P. monodon* and freshwater prawn (*Macrobrachium rosenbergii*).

Amphibian Diseases

- **Infection with *Batrachochytrium dendrobatidis*:** Australia in various species of frogs including *Crinia signifera*, *Limnodymastes peronii*, *Lim. tasmaniensis*, *Litoria caerulea*, *Lit. fallax*, *Lit. lesueuri*, *Lit. nasuta*, *Lit. nudidigitus*, *Lit. peronii*, *Lit. phyllochroa*, *Lit. verreauxii*, *Lit. wilcoxii*, *Lit. raniformis* and *Mixophyes iteratus*.

Other Diseases

- Bangladesh reported Infection with *Streptococcus agalactiae* in Tilapia (*O. niloticus*), and Infection with *Aeromonas* spp. in climbing perch (*Anabas testudineus*), shing catfish (Heteropneustes fossilis), gulsha (*Mystus cavasius*) and pabda (*Ompok pabda*). Hong Kong SAR reported Infectious spleen and kidney necrosis virus (ISKNV) in speckled blue grouper (*E. cyanopodus*) and hybrid Sabah giant grouper (*E. fuscoguttatus* x *E. lanceolatus*)

E.M. Leaño, Senior Programme Officer
Health and Biosecurity

13th Asia-Pacific Marine Biotechnology Conference 2-6 October 2023, Australia

The 13th APMBC and 5th ANZMBS conference are combining to engage marine biotechnologists, industry, investors, and policy makers in current marine biotechnology research, and industry development in the Asia-Pacific region. The conference will be held from 2-6 October 2023 in Adelaide, Australia.

This is the first time the APMBC will be held in the Australia/New Zealand region. The combination of Australian and New Zealand marine territories makes it the second largest in the world and the largest in the Asia-Pacific region, with a rich biodiversity.

This provides a great opportunity to participate in the growth and future development of the marine biotechnology industry in the region and globally.

A key objective of the joint Conference is to encourage academic-industry partnerships across the region.

A key feature of the conference program will be the balance of academic and industry participants.

The program also offers industry, investment and policy forums to align industry needs and government priorities with productive collaborations and research and development essential for achieving industry's full potential.

Abstract submissions and early bird registrations are now open!

Program development information is available at the APMBD conference website https://apmbc2023.com/

Or download the prospectus at:

https://enaca.org/enclosure/?id=1266

Professor Wei Zhang
Conference Chair and Convenor

Global Seafood Trade Fair 28-30 June Guangzhou, China

In June, China will open its doors to the world through the Global Seafood Fair.

With over 50,000 visitors and a strong buyer presence, the fair is an excellent opportunity for businesses to showcase their products.

The event will feature over 1,000 exhibitors and more than 10,000 products for buyers to choose from.

Attendees can also participate in several industry-focused events, including the Global Shrimp Industry Development Summit Forum, the Overseas Seafood Products Digital Trade Forum, the Tilapia Industry Chain Summit, and the China Aquatic Prepared Dishes Development Summit.

In addition to aquatic products, the fair will also showcase aquaculture technology and equipment, feed, medicine, oceangoing fishing tools and equipment, processing and packaging equipment, cold chain storage and transportation, and trade services.

China is the largest producer and consumer of fish products globally.

The fair is a world-class event, jointly built by Liangzhilong and China Food Trade Fair, and an essential platform for seafood enterprises to expand their customer base.

The Canton Fair Complex (Area D) in Guangzhou, China, will be the venue for the fair.

The fair is being organized by Wuhan Shihedao Network Technology Co., Ltd. and hosted by the China Aquatic Products Processing and Marketing Alliance and the China Aquatic Production Chamber of Commerce.

For further details, please refer to the information sheet linked below.

https://enaca.org/enclosure/?id=1265

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