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Women transforming rural aquaculture

Aquarium fish culture in West Bengal

Spiny eel production

Chocolate mahseer

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

PSA: The world has changed

This issue's editorial is not really about aquaculture, but it is about something that will certainly impact aquaculture, and nearly every aspect of our lives: Artificial Intelligence. I want to encourage everyone to go take a look at it, because you need to.

My job heavily revolves around digital technology – multimedia, websites, programming languages, software libraries, servers and virtual environments. But perhaps you would be surprised to learn that I generally resist new technologies. Why? There are just too many cool new things to keep up with and most of them turn out to be fads. After a year or two they get replaced by some newer and cooler tech, and the time you invested in learning them is wasted. So, I try to avoid new technologies until it's clear who the survivors are.

There has been hype about "artificial intelligence" in products for decades, but most of it was (and remains) exaggerated claims from marketing departments trying to upsell old school procedural software models. Somewhere around 2010 advances in neural networks, computer vision and *actual* machine learning began to become mainstream, perhaps most famously exemplified and expedited by the development of autonomous self-driving cars.

Last year the hype on AI "large language models" (LLMs) gained critical mass. LLMs are a type of AI model designed to understand and generate human-like language. This means: You can talk to them. And they can talk back.

Yes, I was sceptical. Actually, I didn't believe a word of it. With reluctance, I recently created a free account on the ChatGPT AI website (https://chat.openai.com) and started playing around to see what all the hype was about, expecting to be moving on within five minutes. What I found blew my mind.

It is shockingly good. I urge you to try it out for yourself. Forget 'Googling it'. Ask ChatGPT a direct question and it will compose a direct answer for you. The models are trained on language patterns and associations using vast quantities of documents from many different sources. Consequently, a vast quantity of human knowledge is encoded into the model. It's like having a team of research assistants at your disposal.

Open source LLMs are also available now that include some cut down models that can run on limited computer hardware. I have one running on a Raspberry Pi, a small credit card sized computer devised as an educational device. It's slow, but it works. The transformation of this tiny computer into something that is approaching an oracle is incredible. It's almost like it's haunted.

Aside from LLMs, similarly stunning models are being publicly tested for generating images, and specialist models are being tested that operate in specific scientific domains including bioinformatics and genomics, drug discovery, materials science, chemistry, environmental science and many more.

Now they aren't perfect. They do make mistakes. The answers you get seem to represent the consensus view of the data the model was trained on. So if you ask questions about controversial or sensitive topics don't expect anything but mainstream answers. But if you want to know more about the world around you, they're and incredible tool. I can't wait to see what the aquaculture industry is going to do with it.

Simon Wilkinson

AQUACULTURE ASIA

Neolissochilus hexagonolepis (chocolate mahseer): A flagship species for diversification of hill aquaculture in Northeast India

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Mahseers are exceptional game and food fishes found in India, Pakistan, Bangladesh, Afghanistan, Sri Lanka, and Myanmar. They serve as cultural icons with diverse economic, recreational, and conservation value in the rivers of eleven Asian nations. The Mahseer Declaration, held in Kuala Lumpur in 2006, recognised many new species that transcend natural geographical boundaries. Taxonomically, mahseers are classified as carps with large scales, fleshy lips, continuous angles at the mouth with an interrupted fold or groove across the lower jaw, two pairs of large barbells, and lateral-line scales ranging from 22 to 28. The head length is equal to or greater than the depth of the body.

India hosts seven species of mahseer, including *Tor putitora* (golden mahseer/Himalayan mahseer), *T. tor* (tor mahseer), *T. mosal* (copper mahseer), *T. progeneius* (jungha mahseer), *T. khudree* (Deccan mahseer), *Neolissochilus hexagonolepis* (chocolate mahseer), and *T. mussullah* (humpback mahseer). Of these, *T. putitora* and *N. hexagonolepis* are regarded as 'flagship species' in India. While extensive research exists on the former, studies on the latter species are limited and fragmentary.

Neolissochilus hexagonolepis (Mc Clelland), commonly known as chocolate or copper mahseer, holds significant importance as a prominent fish species in Northeast (NE) India. It thrives in nearly all the major rivers and hill-streams of Meghalaya, Assam, Arunachal Pradesh, Sikkim, Manipur, Nagaland, Mizoram, and Tripura – the eight states that comprise North Eastern India. Additionally, this fish species is also present in the Cauvery River, which meanders through the states of Karnataka and Tamil Nadu in South India. Beyond India's borders, the geographical range of *N. hexagonolepis* encompasses Bangladesh, China, Nepal, Myanmar, Thailand, Malaya, Sumatra, and Vietnam.

Distinguished for its remarkable size and robust strength, this fish stands out as a true game fish. It attains an impressive maximum length of 6 feet and can weigh up to 28 kg. Notably, its adaptability to captive environments presents substantial potential for aquaculture, while its exquisite taste contributes to its elevated market value. Revered as a flagship species and an emblem of water ecosystems within NE India, it commands a price ranging from Rs. 400 to 500 per kilogram. The delectable meat of *N. hexagonolepis* is in high demand for its scrumptious flavor and relatively bone-free texture, often surpassing the preference for Indian major carps and Chinese carps. Beyond its culinary appeal, it serves as a bountiful source of high-quality lipids and proteins, making it a valuable asset in diversifying protein sources and promoting a holistic, healthful diet[8].

Neolissochilus hexagonolepis (chocolate mahseer).

Mahseer recipe in the diet of the Khasi tribe, Meghalaya.

Furthermore, this species plays a pivotal role within the unique 'Johra' fishery, an integral practice in terraced ponds nestled amidst the picturesque Darjeeling and Kalimpong hills. This practice not only sustains local communities but also upholds cherished fishing traditions.

Chocolate mahseer also plays a distinct role as a potential ornamental fish during its early life stage, often classified as non-classified within this context. In the beautiful state of Meghalaya, it is known by the local name 'kha saw'. Here, innovative fish farmers engage in the cultivation of the fish within their ponds, utilising them as a resource for generating income through fishing competitions and subsequent sales within the market. However, this endeavor presents challenges, as procuring the fish seeds from local streams, rivers, lakes, etc., involves considerable effort and dedication.

Until recent years, the rivers, lakes, and reservoirs of the region were teeming with the chocolate mahseer. However, its population has suffered a sharp decline due to a combination of factors. The rampant capturing of both adult brooders and juvenile fish, coupled with habitat degradation, pollution, the construction of barrages obstructing migratory routes, acid mine drainage, the introduction of non-native species (primarily *Cyprinus carpio*), and the absence of strategies to replenish stocks through hatchery-produced seeds and ranching have all contributed to this alarming trend[7]. Consequently, the species has earned a "near-threatened" status according to the International Union for Conservation of Nature (IUCN).

This fish's value extends beyond its ecological importance; it holds significance for food security, nutrition, recreational sport fishing, and ecotourism. Acknowledging this, three states within NE India, namely Meghalaya, Nagaland, and Sikkim, have designated *N. hexagonolepis* as their official "State fish." This proactive measure aims to raise public awareness and galvanise conservation efforts. Among these states, Meghalaya stands out with its robust commitment to preserving aquatic biodiversity. Boasting 79 fish sanctuaries that provide a haven for various fish species, including the chocolate mahseer, the state has taken a proactive stance through its Meghalaya State Aquaculture Mission (MSAM), 2012-17, which has been actively engaged in conservation activities since 2012[1].

Taxonomy of *Neolissochilus hexagonolepis*

The taxonomy of mahseer fish has been a subject of confusion due to the varying morphological traits they exhibit. Challenges arise from incomplete morphometric information in original descriptions, scarcity of original holotypes of mahseer species, and disagreements over the recognition of specific morphological characteristics. This has led to a somewhat disorderly taxonomy, with certain mahseer species being described multiple times.

Traditionally, the differentiation of the two mahseer genera has been based on the presence of the labial groove, which is discontinuous in *Neolissochilus* and continuous in *Tor*, as well as the disparity in the number of gill rakers on the first arm of the gill arch (8-9 in *Neolissochilus* and 11-13 in *Tor*). Identifying chocolate mahseer in their early life stages has proven challenging. However, regular field observations have facilitated the development of key indicators for identifying *N. hexagonolepis*. For instance, young fish measuring 2-5 cm exhibit a distinctive black blotch at the base of their caudal fin, contrasting with their silvery body color. This attribute differentiates *N. hexagonolepis* from other genera like *Barilius*, *Danio*, *Garra*, and *Puntius*, which often coexist within the same habitat.

A mature chocolate mahseer boasts an elongated, slightly flattened body profile that is not excessively deep. The dorsal and ventral profiles demonstrate nearly symmetrical arches; the head is relatively compact and terminates in a blunt rounded shape. Rows of sturdy horny tubercles are evident on the snout's sides, positioned in front and beneath the eyes. The lips are robust and encircle the mouth's angle, although the labial groove is significantly interrupted in the center. The lower jaw is coated with a sharp horny covering. A pair of barbells exists on the maxillary, with the maxillary pair longer than the rostral pair. The fish exhibits captivating coloration,

Chocolate mahseer is the state fish of Meghalaya.

featuring olive-green hues on its upper regions and silvery-white tones below, with a prominent dark yellowish-green lateral band positioned above the lateral line. The sides of the head are adorned with golden accents. In larger individuals, the back, head, fin bases, and scales assume a blackish-grey tint, while opercular plates, fins, and scales are tipped with yellow.

Sexual dimorphism and growth pattern

Sexual dimorphism is evident in *N. hexagonolepis*, as males demonstrate a faster growth rate compared to females. Despite this, females ultimately attain a larger size than their male counterparts. Within the same age cohort, a noticeable disparity in size exists between females and males; the sex ratio stands at approximately 1 female to 1.26 males.

The ICAR Research Complex for NEH Region, Meghalaya conducted a comprehensive study on the length-weight relationship and condition factor of this fish species in the Umngot River, a vital breeding and spawning ground in Northeast India[2]. Over the course of January to December 2022, a collection of 467 specimens was obtained from various sections of the river, utilising gill nets and cast nets. These specimens exhibited a size range of 26 to 162 mm in length and a weight range of 0.23 to 155.0 g.

Examination of fish population parameters unveiled that the growth pattern of *N. hexagonolepis* within the river environment follows a trend that is either negative allometric or almost isometric. Specifically, the growth coefficient 'b' was calculated as 2.88 during the pre-monsoon season, 2.74 during the monsoon season, and 2.46 during the post-monsoon season. These calculations were accompanied by high regression coefficients (r^2), ranging between 0.95 and 0.98. Furthermore, the condition factor (Fulton's condition factor) exhibited variations, with a value of 0.95 (ranging from 0.49 to 1.8) during the pre-monsoon period, 0.87 (ranging from 0.5 to 1.3) during the monsoon period, and 0.80 (ranging from 0.24 to 1.25) during the post-monsoon period.

Captivating colouration in chocolate mahseer.

Breeding

In their natural habitat, *N. hexagonolepis* engages in spawning activities in distinct batches throughout specific time periods. These reproductive events typically occur during January-February, May-June, and July-September. Males generally achieve their first maturity milestone at around 9 months of age, while females reach this stage slightly later, at around 11 months of age. Female fish achieve their first maturity at a minimal length of 17.8 cm and a weight of 70 g. In comparison, males reach maturity at an average length of 17.3 cm and a weight of 50 g. In ripe females, the gonado-somatic index (GSI) measures 16.2, offering an indicator of the reproductive activity in relation to the overall body weight. Additionally, the average fecundity factor, which quantifies the number of eggs produced by a female, is reported to be 3,000 to 3,500 per kg body weight.

During the spawning season, distinguishing between mature male and female *N. hexagonolepis* is achievable through distinct visual cues. A mature male can be identified by the release of milt upon gentle pressure applied to the belly area. In contrast, mature females exhibit a fully distended and soft abdomen, along with a slightly swollen pinkish vent and anal fin.

For controlled breeding purposes, the broodstock of males (weighing 50-100 g) and females (weighing 200-300 g) can be cultivated in concrete tanks at a temperature range of 18-22°C. The recommended stocking density is 2-3 individuals per square meter, with meticulous attention to water quality ensured through effective filtration systems. Clear, pristine water conditions, coupled with a balanced diet containing 35-40% protein, contribute to optimal health. Regular health assessments are integral to this process. When well-managed conditions are maintained, the species can naturally undergo multiple spawning events in captivity without the need for synthetic hormones. In cases where natural spawning doesn’t occur, a single dose of hormones such as Ovafish or Gonopro FH can be administered intramuscularly. The recommended dosages are 0.2-0.3 ml/kg body weight for males and 0.6 ml/kg body weight for females, while maintaining a ratio of 1 female to 2 males[5].

The timing of stripping operations is typically synchronised with the female’s signs of ovulation, which typically manifest about 10-15 hours after hormone injection. During this process, the female’s eggs are gently extracted through repeated stripping, often performed in a dry tray. This is followed by a similar procedure for males to obtain milt, which is subsequently mixed with the eggs using a feather for approximately 1-2 minutes. Gradual addition of water facilitates fertilisation, and the mixture is rinsed several times with clean water. The resultant fertilised eggs are demersal, displaying a white coloration and possessing a diameter of 2-2.5 mm. After fertilisation, the eggs of *N. hexagonolepis* can be successfully incubated in perforated hatching trays, which are placed in elongated tubs with a continuous flow of oxygen-rich water during the entire incubation phase. While multiple breeding cycles are achievable in captivity using the stripping technique, the most responsive period tends to be August. The species produces non-adhesive eggs, though they exhibit a mild stickiness prior to water hardening. Fertilisation rates generally range between 80 to 85%. The incubation duration varies, spanning from 80 to 95 hours, and hatching success rates range from 75 to 80%. Larvae complete yolk-sac absorption around 6-7 days after hatching, provided optimal water quality is maintained. To progress from spawning to rearing, newly hatched fry can be cultivated in glass aquaria, where they exhibit an average survival rate of 80-85% within 15-20 days of rearing. During this timeframe, the fry achieve an average length of 2 to 2.5 cm and a weight of 0.2 to 0.25 g. Subsequent to this phase, the fry can be transferred to cement cisterns at a density of 1 individual per litre. On average, a survival rate of 80-90% can be attained after 2-3 months of rearing. Throughout this period, the fish undergo a growth spurt, with an average length of 4-5 cm and a weight of 1-2 g being achieved.

Culture aspects

The growth performance of *N. hexagonolepis* was studied in earthen ponds and a polyhouse setting, each spanning 200m^2, at the fish farm complex of ICAR NEH in Meghalaya over a 6-month period. Fish seeds were collected from the Umngot River and stocked at a rate of one fish per litre in each setting. They were fed a locally prepared diet consisting

Umngot River, a potential breeding and spawning ground for chocolate mahseer.

of rice polish, dry fish, mustard oil cake, and a vitamin-mineral mixture, with a protein content of 36.2%. The feeding rate was 5% of their body weight during the initial two months, followed by 4% in the subsequent two months, and then 3% in the final two months.

The average water temperature was 18.8°C (ranging from 8.6 to 23.2°C) in pond conditions, while it was 21.2°C (ranging from 13.2 to 28.8°C) in polyhouse conditions. The average dissolved oxygen content was 7.85 ± 0.85 ppm in the pond and 7.75 ± 1.55 ppm in the polyhouse. The average pH was 7.8 ± 0.2 in the pond and 7.5 ± 0.3 in the polyhouse. The average total dissolved solids were 86 ± 22 ppm in the pond and 82.5 ± 29.5 ppm in the polyhouse. The average total alkalinity was 58.62 ± 4.8 ppm in the pond and 62.63 ± 5.6 ppm in the polyhouse. The average ammonia content was 0.65 ± 0.25 ppm in the pond and 0.50 ± 0.35 ppm in the polyhouse.

At the beginning, the fish had an average weight of 2.03 ± 0.32 g. By the end of the culture period, in pond conditions, the fish reached an average weight of 44.1 ± 5.7 g, while in the polyhouse conditions, they achieved an average weight of 42.1 ± 4.5 g. The specific growth rates were 1.71 ± 0.15% per day in the pond and 1.69 ± 0.13% per day in the polyhouse. Survival rates were 91% in the pond and slightly higher at 92.5% in the polyhouse. The total fish biomass yield was 8,015.3 g in the pond and 7,790.4 g in the polyhouse.

Based on these findings, it can be concluded that pond environments typically provide a wider range of natural food sources, including microorganisms, zooplankton, and phytoplankton, contributing to enhanced growth rates. On the other hand, the slightly lower growth rate in the polyhouse condition can be attributed to the more controlled and potentially restricted environment. While polyhouses offer advantages such as protection from external predators and weather fluctuations, they may provide a more limited range of food sources, which could potentially affect growth rates. The higher survival rates in the polyhouse can be attributed to the controlled environment that minimises external stressors and predation risks, ensuring a stable habitat for the fish throughout the culture period.

The proximate composition of fish under two rearing settings was also studied. The moisture content averaged 75.66% in the pond and slightly higher at 76.08% in the polyhouse, reflecting potential water-related environmental differences. Crude protein content stood at 16.25% in the pond and slightly elevated at 16.52% in the polyhouse, indicative of varied dietary sources. Crude lipid content was 5.83% in the pond and marginally lower at 5.62% in the polyhouse, suggesting possible diet-driven distinctions. Ash content averaged 1.12% in the pond and slightly higher at 1.15% in the polyhouse, potentially related to environmental mineral availability. These variations underscore the impact of rearing

Fish samples collected from the Umngot river for population parameter studies.

environment and diet on chocolate mahseer's nutritional composition, crucial for effective aquaculture management tailored to specific conditions and growth objectives.

Food and feeding habits

The fish is a column-to-bottom dweller and occasionally rises near the water's surface to nibble on flowing food items. Zooplankton is the dominant food in their fry stage, while phytoplankton is most dominant in their fingerling/ juvenile phase. A study in Meghalaya indicated that, in nature, vegetable matter, algae, and insects form the basic food items of the fish, and there is a rise and fall in the feeding intensity of the fish during the breeding season, with the feeding intensity increasing after the spawning season[3].

The fish is found to be a voracious feeder not only in riverine water but also in pond conditions[4]. In captivity, the larvae can be maintained on a planktonic diet for a period of one month. Subsequently, they can be raised with a mixture of rice bran and mustard oil cake (1:1) with daily feeding at 10% of the total fish biomass (the amount may be split into 2-3 times). The protein requirement for the fish varies from 35 to 40%. Fish meal can be incorporated into their diets at a 15% level. While slaughterhouse wastes and soybean meal can be supplemented in their diets, research evidence is required on this aspect.

For pond culture, the fish can be offered a diet containing mustard oilcake, wheat bran, wheat middlings, rice polish, and rice bran. For seed raising, diets can be formulated using soybean meal, silkworm pupae, rice/wheat starch, casein, gelatin, and cod liver oil fortified with vitamins and minerals at appropriate levels, containing about 40 to 45% crude protein. A study conducted at the fish farm complex of ICAR Research Complex for NEH Region in Meghalaya indicated that a feed containing rice bran, mustard oilcake, silkworm pupae, fish meal, and a local herb (*Gynura crepidoides*) delivers satisfactory growth in chocolate mahseer.

A diet prepared using deoiled silkworm pupae (50%), rice bran (22%), mustard oilcake (10%), tapioca flour (17%), and a vitamin-mineral mixture (1%) and has a proximate composition of moisture: 6.14%, crude protein: 40.04%, crude lipid: 5.69%, NFE (nitrogen-free extract): 14.6%, crude fibre: 10.43%, and ash: 14.60% is also effective for rearing chocolate mahseer. The incorporation of 17-alpha methyl-testosterone at 7.5 mg/kg in a formulated diet has a positive effect on the growth and survival of mahseer.

Water quality requirement

Effective chocolate mahseer farming necessitates precise control of water quality parameters due to their significant impact on fish health, growth, and overall aquaculture

Tail rot.

Red spots.

success. The optimal temperature range of 18-22°C is essential as it influences metabolic rates and enzymatic activity, affecting growth and physiological functions. Additionally, a study in Meghalaya on temperature quotient (Q_{10}) and standard metabolic rate has revealed a preferred range of 23-27°C, with the growth optimum at 25°C[6]. This preference is tied to the fish's thermal tolerance zone (41.68°C^2) and high active respiration rates (0.5-0.54), underlining the importance of maintaining appropriate thermal conditions.

Maintaining a pH range of 7.5-8.5 is crucial as it impacts nutrient availability, metabolic processes, and fish behavior. Dissolved oxygen levels exceeding 5 mg/L are essential to prevent hypoxia and maintain optimal respiration rates. Controlling ammonia and nitrite concentrations is vital due to their potential toxicity, particularly on fish gills and overall health. Adequate water hardness of 50-150 mg/L ensures proper osmoregulation and overall well-being.

Clear water with minimal turbidity supports feeding and breeding behaviors by enhancing visual cues and light penetration. Adequate water flow prevents stagnant conditions, aiding nutrient dispersion and waste removal. The incorporation of natural habitat elements, such as substrate and vegetation, simulates the fish's ecological preferences, promoting natural behaviors and well-being.

Disease

The information pertaining to disease and health management of *N. hexagonolepis* is limited and fragmented. There is a dearth of data on microbial and nutritional diseases affecting the fish. Occasionally, instances of fungal infections, predominantly *Saprolegnia* infections, have been observed in mahseer housed in confinements like ponds or tanks with restricted water exchange. Another occasional observation includes body darkening and skeletal deformities due to

Fish with no scales remaining on the body.

nutritional deficiencies. Notably, reports exist of corneal hypertrophy, a condition marked by corneal damage and shrunken eyes during advanced infection stages.

In our recent study in Meghalaya, a number of illnesses were recorded in fish, including tail rot, red spot, cotton wool disease, and a condition where fish with no scales remained on the body were seen. The understanding of stress and its management in chocolate mahseer is still lacking. Stress, whether triggered by environmental or physical factors, significantly impairs breeding performance. Stress in brood fish can lead to non-spawning or partial spawning in hatcheries, impacting overall reproductive competence.

Given the limited insights into disease, health, and stress management in the fish, dedicated research is essential to formulate effective strategies for maintaining their well-being and optimising aquaculture practices.

Socio-economic and technical aspects

Chocolate mahseer fisheries hold a significant yet seasonal livelihood opportunity for numerous fisher communities in NE India, particularly in the hills. This species is harvested using simple methods such as long lines, pole and line fishing in natural water bodies, and drag nets in ponds. The accessibility of this fishery, requiring minimal capital, equipment, and skill, makes it accessible to individuals of various backgrounds. The fish commands a premium price, approximately Rs 400-500/kg in Meghalaya, indicating its economic viability. Its delectable taste and consumer preference contribute to its demand.

Processing is usually minimal, as the fish is favored fresh. In Meghalaya and other hill states, fishermen obtain licenses for seasonal mahseer capture. However, due to its endangered status, efforts are shifting towards stock enhancement and aquaculture to counter declining catches. Although chocolate mahseer aquaculture is sporadic, there’s potential for co-culture with Indian major carps. Several state governments have established farms and hatcheries, recognising the species’ economic potential.

As focus intensifies on conservation and sustainable practices, chocolate mahseer farming offers income generation and employment prospects for local hill communities. It represents a balance between species recovery, economic benefits, and community livelihoods.

Points to ponder and way forward

Several factors can drive the growth of chocolate mahseer farming in hilly regions. One key aspect is ensuring a consistent supply of high-quality seeds to farmers, which can be achieved through well-functioning hatcheries and seed production facilities. Developing cost-effective feeds with optimal Feed Conversion Ratios (FCR) is crucial, as it directly impacts production costs and profitability. Efficient marketing channels and accessible transportation facilities are essential to connect farmers with markets effectively. Guaranteeing the availability of clean and suitable water sources is vital for maintaining the health and growth of the fish. Implementing disease management strategies and addressing predation risks contribute to sustained farming success.

Given the species’ slow growth rate, genetic improvement through selective breeding or biotechnological tools holds promise for enhancing growth potential. Environmental manipulation and the formulation of appropriate supplementary feeds offer avenues for growth enhancement. These measures can collectively create opportunities for increased fish production and income for hillside farmers. By addressing these multifaceted aspects, chocolate mahseer farming can become a sustainable and profitable venture, benefiting both the farmers and the conservation of this endangered species.

References

1. Dash, P. R.S. Tandel, D. Baruah and D. Sarma. 2020. Mahseer sanctuaries of Meghalaya: A conservation and recreational perspective, Aquaculture Asia 24 (1): 3-7.
2. Debnath, C., Sanjay Kumar Das, Prasanta Mahanta and Pynhun J. Ryntathiang.2022. Assessment of *Neolissochilus hexagonolepis* (chocolate mahseer) for growth and condition from Umngot River, Meghalaya. In the Book of Abstracts of “International Conference on “Responsible Aquaculture and Sustainable fisheries Interact (RASHI) held at Tripura from 13-16, December, 2022, p. 102.
3. Jyrwa, L.B and Bhuyan, R.N. 2016. Study on the food and feeding habits of the chocolate mahseer (*Neolissochilus hexagonolepis*) from Meghalaya, India. Indian J. Sci. Res.7 (1): 23-26.
4. Laskar, B.A., B.C. Tyagi and D.N. Das. 2009. Growth performance of chocolate mahseer - *Neolissocheilus hexagonolepis* (McClelland) in pond system in Arunachal Pradesh. Indian Journal of Fisheries 56: 55-59.
5. Mahapatra B. K.; Vinod K. 2011. Reproductive biology and artificial propagation of chocolate mahseer *Neolissocheilus hexagonolepis* (McClelland) in Meghalaya, India. Indian J. Fish., 58(2): 35-40.
6. Majhi S. K., Das, S.K. and Rajkhowa, D. 2013. Effects of elevated water temperature on tolerance and stress in Chocolate mahseer *Neolissochilus hexagonolepis*: implications for habitat restoration and conservation. Current Science 105(3): 379-383.
7. Rupak Nath, Deepjyoti Baruah, Partha Das and Debajit Sarma. 2016. Present Status, Threats and Conservation Measures of Mahseer Resources in the Central Rivers of Meghalaya. SKUAST Journal of Research 18(1): 32-40.
8. Sarma, D., Akhtar, M.S., Das, P., Das, P., Shahi, N., Ciji, A., Mahanta, P.C., Yengkokpam, S. and Debnath, D., 2013. Nutritional quality in terms of amino acid and fatty acid of five coldwater fish species: implications to human health. National Academy Science Letters, 36(4), pp.385-391.

Aquarium fish culture in open village ponds in South 24 Parganas, West Bengal

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The successful breeding and propagation, rearing, and sale of various aquarium fish species is carried out on a commercial scale, primarily in Howrah and South 24 Parganas districts of West Bengal. These locations serve as major hubs for aquarium fish production in the region. In selected areas of these districts, over 600 families engage in traditional ornamental fishery[1].

Aquarium fish culture, also known as ornamental pisciculture, presents a promising opportunity for income generation, especially in suburban and rural areas, offering a potential solution to unemployment. Certain villages in Falta and Bishnupur-II Blocks (focused on freshwater) in South 24 Parganas are designated as 'Ornamental Fishery Villages'. In these villages, economically important aquarium fishes are raised by families on a cluster basis. This is either done in a series of rectangular cement concrete cisterns (with capacities ranging from 1,000 to 3,000 litres) constructed on vacant land within home premises under sheds, or in hapas (rectangular net cages constructed from fine-meshed nylon nets and twine) for large-scale production. Hapas are secured to nylon ropes and bamboo poles and placed in shallow backyard ponds that are aged and naturally rich in planktonic population. It's worth noting that hapa-based aquarium fish culture is not observed in Howrah but is predominant in South 24 Parganas.

In the urban area of Howrah Municipality in the Howrah district, a few ornamental fish farmers, who also act as wholesale fish sellers to shopkeepers and hobbyists, rear aquarium fishes in tanks ranging from 120 to 240 square meters. These tanks have concrete sides and bottoms. Most farmers in this area typically use 6 to 36 medium- to large-sized cement concrete cisterns, each with a higher water-holding capacity.

A notable recent development in West Bengal involves two experienced aquarium fish farmers from the distant Canning-I and Patharpratima Blocks, situated near the Sundarbans

Bird fencing over Sri Sau's pond.

region in South 24 Parganas. These farmers, namely Sri Bikash Sau and Sri Swapan Parua, have introduced a new practice in the state. They engage in the scientific holding and rearing of aquarium fishes in open earthen and common village ponds. These ponds, being both perennial and rainfed, make use of natural food and the entire water body and large surface area for cultivation.

Sri Bikash Sau's aquarium fish culture unit

In the village of Tengrakhali-Kayalpara within the Dighirpar Gram Panchayat under Canning-I Block, Mr. Bikash Sau, aged 48, has achieved success in commercial-scale aquarium fish farming since 2018. His operation takes place in an open rainfed freshwater pond covering an area of 1,320 square meters, with a water depth ranging from 1.0 to 1.4 meters. This initiative, known as 'Coloured Fishes in Pond,' gained recognition from the Block Administration, TV News Channels, and fellow fish farmers in December 2021. The village is located 55 km away from Kolkata city, while Mr. Sau's residence is near Howrah Maidan, in the heart of Howrah city, District Howrah. He has leased the pond for this purpose.

A milky carp produced at Sri Sau's pond.

Sub-adult koi carp from Sri Sau's pond.

Mr. Sau has played a guiding role for two other aquarium fish growers in the Taldi GP area of the same block on this innovative practice. He secured financial support from a fishery-related scheme in the ATMA Project under the Department of Agriculture, Government of West Bengal.

Various aquarium fishes with good commercial value, such as milky carp, koi carp, red-capped goldfish, discus, and two varieties of angelfish, have exhibited satisfactory growth (reaching a marketable size of 5.0-7.5 cm) within fifty days from the stocking of seed. Typically, they are harvested within the next 30-45 days for sale. Additionally, red-eye tetras are also reared in the pond. Importantly, Mr. Sau adheres to an organic approach, refraining from the use of chemical compounds, commercial aqua-products, medicines, or antibiotics in his pond for rearing aquarium fishes.

Pond fencing and growth of fishes

To prevent the entry of the non-venomous but highly piscivorous water snake *Xenochrophis piscator* (measuring 0.45-0.75 meters), the pond is enclosed on all four sides up to a height of 0.45 meters from the level of the slope or embankment. This fencing is constructed using high-quality used monofilament net, specifically designed for catching climbing perch *Anabas testudineus* in natural water bodies and priced at INR 400 per kilogram with a 1 cm mesh.

The stocking of the pond involves introducing 75,000-90,000 high-quality aquarium fish seeds (3 days old) twice a year, initially in February-March. Throughout the cultivation period, a composted mixture of raw cow dung and molasses is added to the pond monthly. Additionally, a feed mixture for major carps and aquarium fishes, consisting of wheat flour by-product, soybean oil cake, groundnut oil cake (GNOC), and mustard oil cake, is provided in a controlled semi-decomposed state.

To protect the fishes from predatory herons, cranes, and kingfishers, a previously-used durable monofilament gill net in good condition is recycled.

Sample netting of growing aquarium fishes in Sri Sau's pond.

This net, originally intended for catching *Hilsa ilisha* in rivers and estuaries and priced at INR 140-150 per kilogram with a 3.8-5.0 cm mesh, is stretched overhead throughout the water area and slope of the pond.

The koi carp and milky carp, stocked at 12-20 mm (1-2 weeks old), reach a size of 8-10 cm within the next 75-120 days. Harvesting begins on the 90th day and continues until the 180th day. These fishes are transported for sale to wholesalers in oxygenated packets at a price ranging from INR 20-40 for fish measuring 10-15 cm. The demand for these fishes is significant at Kashipur (Sanpur) CTI, Dasnagar in Howrah, a well-known aquarium fish wholesale market.

Seed of goldfish, angelfish, and colour widow tetras are purchased at sizes of 5-7 mm (3-4 days old) for stocking. Angelfish are harvested and sold when they reach 3.8-5.0 cm in size, while colour widow tetras, stocked in limited quantity, are sold when they are 45 days old or older. Koi carp and milky carp of larger size fetch a price of INR 90-100 per piece.

In this pond, colour widow tetras achieve a size of 2.5-3.8 cm in 90-100 days, and angels, with a roundish body, reach a length (diameter) of 3.5-5.0 cm in 3-5 months. Lime is applied to the pond during the pre-stocking pond management phase. The farmer plans to lease two additional ponds nearby soon to transfer and restock the early stages of aquarium fishes from the current pond, ensuring low density for better growth.

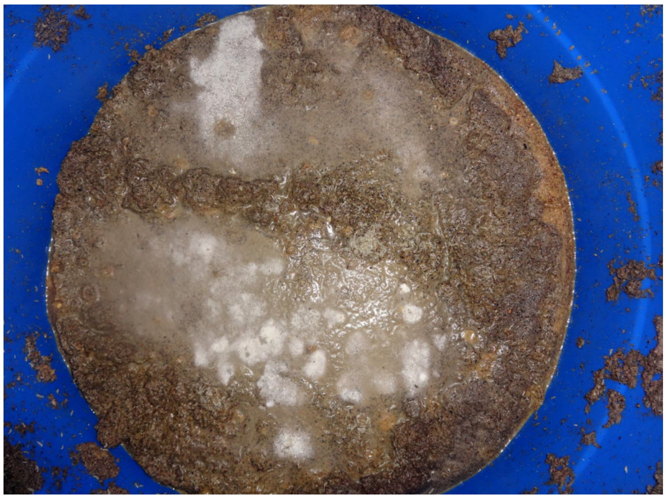
Major carps in aquarium fish pond

According to Mr. Sau, there is no harm or growth retardation observed in aquarium fishes when fingerlings of catla *Catla catla*, rohu *Labeo rohita*, and silver carp *Hypophthalmichthys molitrix* are stocked in smaller numbers alongside. For the past two years, starting in December, Mr. Sau has been introducing 40-45 rohu fingerlings (50-100 g), 30 catla fingerlings (200-250 g), and 20 silver carp fingerlings (7.5-10 cm) with koi and milky carp into the same pond with an area of 1,320 square meters. This practice aids in controlling excessive phytoplankton growth.

Within 4-5 and 6-7 months, catla grows to weights of up to 1.5 kg and 2 kg, respectively, in the aquarium fish pond. Marketable-sized major carps are harvested within the 4-5 month period (during April-May of the following year) and sold, providing an additional income source for Mr. Sau from the aquarium fish pond. Fingerlings of catla stocked at 10 cm attain a weight of 250 g in just 45 days in this pond.

Feeding practices

The aquarium fishes at Sri Sau's farm are fed a combination of commercially available fish feed from a reputable company (priced at INR 60-70 per kg) and a semi-decomposed, farm-made feed mixture. During the first 7-8 days of stocking, no feed is given to koi carp, milky carp, and goldfish, provided they are all 6-8 mm in size. From the 9th to the 30th day, only pulverised groundnut oil cake (GNOC) is given daily. From the 31st to the 50th day, a semi-decomposed mixture of GNOC and mustard oil cake is provided. Starting from the 51st day until the 75th day, a fermented feed mixture is given, consisting of 10 kg mustard oil cake, 10 kg machine-made dust from a rice mill, 5 kg wheat flour by-product, 5 kg GNOC,



Fermented-type fish feed prepared by Sri Sau.

2 kg soybean dust, and 25-30 g yeast. This mixture, partially decomposed with the addition of 40 litres of water, is applied to the 1,320 m^2 pond on the 7th-8th day.

From the 76th-80th day onwards, the application of the feed mixture continues for growing fishes, excluding GNOC. To enhance the zooplankton population in the pond, a composted mixture, including 70-80 kg cow dung, 3 kg single super phosphate, 5 kg mustard oil cake, 700 g urea, and 500 g limestone powder, is applied every 45 days. Occasionally, 'Success Booster' is included in this mixture. According to Mr. Sau, on the 90th day and beyond, 70-80% of aquarium fishes survive and reach a marketable size out of the initially stocked 75,000-90,000 seeds.

As of October 2023, Sri Sau is primarily cultivating koi carp and milky carp, with a limited presence of colour tetras and goldfish in the pond. Monthly drag netting is conducted, leading to the harvest of larger-sized fishes approximately 5-7 times per year. The frequency of harvesting is adjusted based on market demand and price patterns to optimise sales and meet consumer preferences.

Sri Parua's aquarium fish farm

At Biswanathpur village of Ramganga Gram Panchayat under Patharpratima Block, Sri Swapan Parua, aged 64, is engaged in commercial aquarium fish breeding and culture in open ponds with a slightly brackish nature. Starting in 2006 with goldfish culture, he has expanded to include varieties like ryukin, oranda, red-capped goldfish, black goldfish, and black oranda. Presently, he is also rearing imported-quality guppies, milky carp (in fewer numbers), and colour widow tetras. Having received training on aquarium fish culture from the Directorate of Fisheries, Government of West Bengal in both 2012 and 2023, Sri Parua sells aquarium fishes to businessmen at Kashipur (CTI), Dasnagar, Howrah on a weekly or fortnightly basis.

Rearing colour widow tetras, guppies, and goldfish

Sri Parua maintains four ponds, each 720 m^2 in area with 60-90 cm water depth, for his aquarium fishes. Bird fencing is carefully installed around and overhead of each pond. For goldfish, he procures good quality seeds that are 7-8 days old (priced at INR 0.20-0.30 per seed) three times a year

An aquarium fish pond of Swapan Parua.

(15,000-30,000 each time from CTI Dasnagar wholesale market, Howrah). For five varieties of colour widow tetras, he acquires rice grain-sized seeds at INR 1.00-1.25 per piece. Goldfish and colour tetras are reared separately as they have different feeding preferences. Goldfish accept floating pelleted feed (commercially available, 0.5-1.0 mm), while colour tetras are given sinking pellets.

In two ponds dedicated solely to colour widow tetras, Sri Parua stocks 120,000 seeds each time (4,500-5,000 / 64m^2 area), and in 45-60 days, they reach a marketable size of 3 cm, selling at INR 6-7 per piece. The colour widow tetras is fed with commercially available feed priced at INR 60 per kilogram. The feeding process takes place in suspended squarish tray-like structures, commonly used in commercial brackish water shrimp farming in ponds. These structures are positioned at a depth of 45 cm from the water surface. The colour widow tetras exhibits a tendency to consume a lesser amount of feed. During the initial 21 days after hatching, the fish only reach the size of a rice grain, indicating a slow growth rate.

In addition to his own farming practices, Sri Sau has extended his expertise to train one of his relatives in goldfish culture. This relative is now independently practicing goldfish culture in three larger ponds, each with an area of 1,320 m². During each culture cycle, the farmer stocks 300,000 goldfish seeds in these ponds, showcasing a significant scale of goldfish cultivation.

For guppies, Sri Parua acquires brooder females at INR 10 per piece. Within a week, females produce young that are reared until adults and marketable stage (25-38 mm) in four months. They fetch a price of INR 2.50-4.00 per piece. Sri Parua maintains a stock of one-month-old 7,000-8,000 export-quality guppies, all at market size. According to him, sufficient phytoplankton growth in ponds is essential for proper body colour development in aquarium fishes. To achieve this, he employs a mixture of 10 kg of mustard oil cake, 6 kg of molasses, and 500 g of baker's yeast. This mixture is applied once or twice throughout the entire culture period. Additionally, liming is carried out at a rate of 1.5-2.0 kg per 64 m² of the sun-dried pond before stocking. After dewatering, ponds treated with commercial aqua-products and new stocking done on 10-12th day.

Similar to Sri Sau, Sri Parua employs a high-quality monofilament net with a 1.0 cm mesh on all four sides of his ponds, extending up to a height of 45 cm from the slope/embankment level. This netting serves as a protective measure against water snakes and frogs. Sri Parua sources water from a nearby large perennial pond, which can be pumped into the aquarium fish ponds as needed. These ponds have the flexibility of being totally drained and refilled as required.

On a weekly or bi-weekly basis, Sri Parua sells 3,500-4,000 marketable-sized colour widow tetras, goldfish varieties, and guppies to aquarium fish businessmen from his farm. Additionally, another batch of 7,000-8,000 aquarium fishes is harvested and sold during the same time frame from his relative's three ponds. In July 2023, Sri Parua further expanded his operations by constructing eight rectangular cement cisterns, specifically for rearing and maintaining guppies. This development was made possible through financial support from the Department of Fisheries, Government of West Bengal, as part of a developmental scheme. Over time, Sri Parua has honed the process of colour widow tetra rearing in open ponds, showcasing a continuous improvement in his aquaculture practices.

To maintain hygienic bottom soil conditions, Sri Sau and Sri Parua take measures such as liming, using a mixture of mustard oil cake, molasses, and bakery yeast, and applying composted mixtures containing cow dung, single super phosphate, mustard oil cake, urea, and limestone powder. Both farmers use monofilament nets with 1.0 cm mesh on all four sides of the ponds, extending up to a height of 45 cm from the level of the slope/embankment, to deter water snakes and frogs.

Author with Sri Swapan Parua.

Water from a nearby perennial pond is pumped into the aquarium fish ponds as needed, allowing for drainage and refilling. Harvesting is done every month, and bigger-sized fishes are collected 5-7 times a year based on market demand and price patterns. Sri Parua sells 3,500-4,000

Colour widow tetras collected after sample netting.

marketable-sized aquarium fishes every week or two, along with another lot of 7,000-8,000 fishes harvested from his relative's three ponds.

End Note

Sri Sau has observed that the growth of aquarium fishes in open pond conditions surpasses that in hapas and rectangular cement cisterns. The presence of natural light (sunlight), hygienic bottom soil conditions, and an abundance of planktonic food contribute to faster growth and bright body colouration of marketable-sized fishes in pond conditions. However, Sri Sau believes that aquarium fishes reared and produced in cement cisterns exhibit enhanced strength, hardiness, permanently bright body colouration, and greater longevity. As a result, they are preferred for purchase and placement in common rectangular glass tanks (50-120 litres) in homes and other locations compared to pond-grown fishes.

Sri Sau emphasises the importance of recognising the differences between the living conditions in an aquarium and an earthen village pond. Therefore, marketable-sized aquarium fishes harvested from open culture ponds should not be directly placed in common glass aquariums. Instead, to prevent fish mortality in the aquarium environment, harvested fishes should be maintained in rectangular cement cisterns for around two weeks with proper oxygenation and feeding before being sold to hobbyists and shopkeepers.

Both Sri Sau and Sri Parua maintain hygienic conditions of pond bottom soil with no foul smell, toxic gases, silt, black topsoil, or organic matter. Open culture ponds typically do not experience dissolved oxygen scarcity, so long as excessive phytoplankton blooms are avoided, eliminating the need for pond aerating devices, unlike in cement cisterns. Additionally, they highlight that unlike cultivable food fishes, particularly major carps, poachers would face challenges in selling aquarium fishes after catching them from ponds, either in live or dead states.

Production of juveniles and sub-adult spotted scat and pearl spot in open brackishwater ponds in South 24 Parganas as brackishwater ornamental fishes is reported[2].Although Canning-I and Patharpratima Blocks are not recognised as major centers for freshwater aquarium fish production in West Bengal, skilled farmers like Sri Bikash Sau and Sri Swapan Parua serve as inspirations for small and medium-scale farmers and aqua-entrepreneurs in nearby areas. Their success highlights the increasing potential and expansion of the aquarium fish business. The system of open pond production for aquarium fishes in villages is uncommon in the state, and these pioneers have introduced and demonstrated a new approach to this unique form of aquaculture.

Feeding tray for colour widow tetras.

Colour tetras sampled from Sri Parua's pond.

Growing goldfish from Sri Parua's pond.

References

1. Biswas, S.N. and Lepcha, R.F. 2004. The state of art of ornamental fishery in West Bengal. Proc. Nat. Sem. Prospects of ornamental fish breeding and culture in eastern and north-eastern India, ICAR-CIFE Kolkata Centre publication: 65-78.
2. Ghosh, S. 2018. Rearing of *Scatophagus argus* and *Etroplus suratensis* in coastal West Bengal, India. Aquaculture Asia, Vol. 22 (3): 1-6.

Women nurtured transformative aquaculture in rural Bengal

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Women engaged in ornamental fish rearing.

In traditional agriculture, women have long been involved from sowing seeds to harvesting crops. However, rural aquaculture has historically been male dominated. Changes in rural environments, with men migrating to cities for better opportunities, have led spirited rural women, mostly housewives, to step up. Despite the challenges, they've acquired vocational skills through training in aquaculture, supported by farmer agencies.

Fortunately, Krishi Vigyan Kendras (KVKs) and local R&D institutions like ICAR have collaborated with these women. They've provided hands-on training in ecological aquaculture, focusing on resources like *Azolla*, lotus, ipomoea, lily, and makhana. Seasonal leafy vegetable farming on pond dykes, sometimes integrated with duck farming, has also been introduced to make them self-reliant. This collaborative effort empowers women to engage in agro-ecological farming, utilising local inputs like green manure and neem-based phytoremediation products. They've tapped into the traditional knowledge of elderly farmer-scientists in the villages.

This cooperative approach has allowed them to systematise production processes at a reasonably low cost, overcoming various challenges and reviving local production. Their commitment and capability are evident in their contributions to family earnings without neglecting routine household activi-

Hatchery net preparation by rural women.

ties. Organisations like the National Fisheries Development Board (NFDB), State Directorate of Fisheries, and NGOs have stepped in to support fish seed production, providing benefits like doorstep input availability, fry to fingerling stage rearing, and farm-made pelleted fish feed preparations. This includes using local agro-based residues such as oil seed cakes, rice polish, and corn dust. They've also embraced farm tools and implemented management to assess water and soil indices to maintaining ambient water quality in culture ponds.

Women team leaders, dedicated to serving fellow rural women, form self-help groups with the cooperation of local panchayats. They have access to unconventional water resources like canals, swampy ponds, village ditches, and wetlands, which were previously unutilised. Equipped with training, sincerity, and exposure to successful farms and hatcheries, these women have developed expertise in various aspects of aquaculture including breeding, pond preparation, feed formulation and storage. They use mobile communication tools, such as Android handsets, to stay connected and continue strengthening the fish production system.

Their strengths shine through their passion and commitment, as reflected in their continuous engagement with local fisheries and aquaculture institutions, Krishi Vigyan Kendras, and various aquaculture-related capacity-building centers. This harnessing of potential is a step towards realising the vision of an 'Atmanirbhar Bharat' and bringing positive changes to the quality of life in rural areas, including Gangasagar block in Sundarbans, coastal villages of Tamluk in Purba Medinipur, and Kaliaganj block in Uttar Dinajpur district in the north Bengal region.

Significant role of women in diverse domains of aquaculture

The significant roles played by women in diverse domains of aquaculture are strikingly noticeable. The proverb, 'The belly rules our mind,' has been a universal truth for centuries. In ancient times, when wild resources were the primary source of food, providing a regular supply of 'biological fuel' to empty bellies was crucial for sustaining life. As humanity evolved into the modern era with a new definition of food, exploration of various food sources became paramount.

Agriculture, primarily involving the rearing and growing of staple crops and vegetables in green fields, was a conventional approach confined to terrestrial farming. However, with technological advancements and a rapidly increasing population, the concept of scientific rearing of crops under water, specifically aquatic life, gained prominence. This innovative idea presented a lucrative opportunity for middle-class individuals, offering employment and income prospects.

Rural women clearing off the unwanted plant cover for healthy fish culture.

The agricultural system, whether on land or water, heavily relies on human intervention, playing a pivotal role in numerous aspects. Unfortunately, socio-economic backgrounds and cultural orthodoxy have contributed to a significant rise in male participation in agriculture, often overlooking women categorised under the "Below Poverty Level" (BPL). Recent shifts in this scenario, driven partly by male migration from rural areas to enhance their standard of living, have led to a noteworthy increase in women's participation in aquaculture.

This paradigm shift owes its success to the active engagement of women in various aspects of aquaculture, including fish rearing, hatchery management, ornamental fish nurturing, and fish processing. Despite limited educational qualifications, as evidenced by degrees from colleges or universities, women have strengthened their roles through intensive scientific and technical hands-on training. This positive development is evident in the aquaculture landscape in India, showcasing the resilience and capability of women in this field.

Role of women in fish culture

Women play a crucial role in fish culture, an integral aspect of aquaculture. The process begins with the release of fish into ponds or designated culture sites, followed by the meticulous scientific care of the fish, culminating in the harvest of matured fish for household consumption or national and international marketing.

In rural settings, the predominant focus is often on either consuming the fish within households or selling it in the local market. The activity of releasing fish into ponds holds paramount importance and significantly influences the overall success of aquaculture. In many areas, women have taken on the responsibility of this critical task, challenging traditional social structures and cultural norms.

During the harvest, women continue to contribute by assisting their male counterparts, enhancing the efficiency of fish harvesting to its maximum potential. Additionally, there are situations where fish need to be harvested by dragging them with fine nets, and then the collected fish are concentrated in net bags. In these cases, women actively participate in these activities, exemplified by recent images captured in urban settings. This shift in gender roles within aquaculture highlights the evolving dynamics and contributions of women in various aspects of the industry.

Role of women in hatchery management

Women play a crucial role in hatchery management as aquaculture embraces modernisation and applied research in the life sciences. Traditional ponds, which have been the age-old sites for fish culture, are gradually giving way to a new concept—culturing fish in more confined areas to produce healthier fish seed under controlled conditions, mimicking natural ecosystems.

Hatcheries have emerged to address the challenge of obtaining robust and healthy fish seed, a key factor in the success of aquaculture. Hapa hatcheries, known for their easy installation and management, have seen increased involvement of women, particularly in the preparation of nets resembling inverted mosquito nets.

The aquaculture industry in India heavily relies on carp farming, with carp seed being a critical component for rural farmers sustaining their livelihoods. Chinese carp hatcheries have become significant players in addressing the timely and adequate supply of carp seed. A vital element in these hatcheries is the spawning chamber, featuring a double-walled structure where eggs hatch, and fingerlings are collected in the inner chamber, protected by a fine mesh. In the preparation of these nets, women from various communities have stepped forward, showcasing their efficiency in contributing to the success of aquaculture.

Role of women in nutrition

Women play a vital role in fish nutrition and feeding, contributing significantly to the effective growth and survival of fish. The discussion highlights the importance of factors such as biological tuning, particle characteristics, color, and odor in fish feed. Women take the lead in feed formulation, and for procurement of natural fish feed items like such as phytoplankton and zooplankton.

Extensive training, encompassing theoretical knowledge and hands-on experience, has positioned women as experts in various aspects of aquaculture, including choosing feed ingredients, mixing them with additives, and shaping them into noodles using hand pelletisers. Beyond feeding, women actively engage in other critical aspects of aquaculture, such as providing proper nutrients for soil activity, releasing natural feed for fishes, checking the efficiency of aqua instruments, and conducting periodic water quality assessments to prevent deterioration using tools such as pH meters, salinometers and the Winkler method.

Women also contribute significantly to the preparation of biofertilisers or home-based fertilisers, strategically placing them in ponds either directly or by assisting their male counterparts. In addressing the high cost of fish feed, women play a crucial role in the home-based preparation of feeds, adapting simple steps with minimal economic and labor costs. *Azolla*, a small floating aquatic fern of the taxonomic family 'Salvinaceae,' holds significance as a common and valuable feed ingredient for fish feeds due to its high nutritional content.

Cultivating *Azolla* involves utilising small ponds or traditional unutilised ponds, clearing undesired weeds, and using ditches or pits excavated in backyards. Women actively engage in managing these organic feed ingredients, conducting daily routine monitoring of the cultured mass, and making nutrient medium additions when needed. Their contribution is enhanced through participation in vocational skills training programs conducted widely in their native areas.

Feed check-tray management by rural women.

Role of women in fish processing technology

In the domain of fish processing technology (FPT), women play a crucial role, particularly in the post-harvest section. They are actively involved in preserving harvested fishes by allowing them to dry under the sun. This simple yet effective technique is a common practice among many rural women in coastal areas of India, such as Digha Mandarmani beach areas. Harvested fishes are often laid out over horizontally placed bamboo poles in lines for sun drying. The provided picture associated with this aspect in the article helps provide a clear idea. Additionally, in the ornamental sector, including ornamental fish rearing, cage culture of fishes, and the management of feeding trays, women actively contribute to a considerable extent.

Looking towards the long-term sustainability and future expansion of aquaculture, there is a need to focus on developing farming systems that enhance overall efficiency in natural resource use and rely on primary renewable resources. This approach holds both economic and ecological viability, establishing the genuine 'magical effects' of women's participation in aquaculture. It is crucial to utilise available water bodies under all panchayets/talukas for the production of edible aquatic organic food sources. Introducing social aquaculture, akin to social forestry, with a local women participatory approach wherever possible, utilising small indigenous fish species, can serve a dual purpose. This includes the conservation of species, some of which are becoming endangered, and the production of an inexpensive yet high-quality edible animal product for better human health.

Breeding and seed production technology of striped spiny eel *Macrognathus pancalus* to benefit fish farmers

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Fig. 1: Broodstock selected for breeding.

The striped spiny eel, *Macrognathus pancalus*, is a bottom-dwelling fish belonging to the family Mastacembelidae under the order Mastacembeliformes. Indigenous to India, Pakistan, Sri Lanka, Bangladesh, Myanmar, and Nepal (Pathak et al. 2012), this species inhabits rivers, canals, beels, karanjali, tanks, ponds, paddy fields, and wetlands. Often residing in bottom mud, it seeks shelter in aquatic plants, especially the roots of water hyacinth, when moving in open water.

Known for its fine flesh, soft meat texture, fewer bones, good taste, and high nutritional value, *M. pancalus* holds economic importance as a freshwater food fish. Additionally, it is considered one of the significant high-priced small indigenous freshwater fish species (SIFFS) and has ornamental value as an indigenous aquarium fish in India. The live cost of this species can exceed Rs. 800/- per kg in the northern, eastern, and north-eastern parts of India. The high price is attributed to poor market supply despite substantial demand.

However, the population of *M. pancalus* has experienced a drastic decline in diverse habitats in recent years due to various anthropogenic factors. These include ecological changes, widespread use of pesticides and insecticides in agricultural fields, reckless exploitation, habitat destruction, and wetland encroachment (Rahman et al. 2009). As a result, the species has been listed as “near to threatened” in India and holds a “Least concern” status in the IUCN Red List (Vishwanath et al. 2010).

Despite its economic and ecological significance, *M. pancalus* has not been introduced to aquaculture practices, likely due to a lack of sufficient knowledge regarding its breeding and culture techniques. To address this gap, captive breeding and seed rearing techniques have been explored under controlled conditions at the Regional Research Centre, Rahara, ICAR-CIFA. The aim is to provide technological support to fish farmers, enabling them to culture the species and contribute to its conservation. The details of these breeding and seed rearing techniques are expected to empower farmers with the necessary knowledge for successful cultivation and conservation efforts.

Fig. 2: A fully ripe female broodstock.

Fig. 3: A fully ripe male broodstock.

Broodstock management

M. pancalus, commonly known as the striped spiny eel, exhibits natural breeding behavior in confined and slow-flowing waters. To establish a protocol for broodstock management and facilitate captive breeding, the following procedures were undertaken:

Broodstock selection

Fully ripe adult male and female eels were identified based on morphological differences. Females were distinguished by a slightly bulging abdomen (Fig. 2), while males exhibited a slender abdomen (Fig. 3). Broodstock, measuring 124 ± 4.27 mm in length and weighing 7.4 ± 1.02 g, were collected from a paddy field in August.

Stocking and tank conditions

Broodstock were stocked in rectangular cemented cisterns at a ratio of 3 females to 2 males. The cistern dimensions were 7.5 m in length, 1.2 m in width, and 0.5 m in water depth (Fig. 4), providing an area of 9 m^2 and 4.5 m^3 water capacity. To simulate a natural habitat, a 7.5 cm layer of a sand and pond mud mixture (1:1) was placed at the cistern’s bottom (Fig. 5). One-fifth of the cistern area (1.8 m^2) was allocated for the attachment of fresh water hyacinth and to serve as shelter for the eels.

Water conditions, plankton inoculation and plant cover

The cistern was filled with bore well water. Plankton, collected from a farm pond, was introduced into the cistern to establish a natural food source for the broodstock. Daily feeding included mixed zooplankton from the farm pond and boiled, finely chopped chicken viscera, provided at 5% of the total body weight, once daily at 10-11 am.

Before introducing water hyacinth into the cistern, thorough cleaning of roots, stems, and leaves was conducted with freshwater. Rotten stems and roots were removed to ensure the health of the water hyacinth.

Water management

Water replenishment was done at a rate of 10% every alternate day until the first breeding was observed. Water quality parameters, including pH (7.6), alkalinity (46 mg/L), hardness (120 mg/L), dissolved oxygen (8 mg/L), and temperature (27-29 °C), were recorded during the experimental period.

This comprehensive approach to broodstock management and habitat simulation aimed to create favorable conditions for natural breeding and subsequent captive breeding of *M. pancalus*. The inclusion of natural food sources, proper habitat structures, and regular monitoring of water parameters contributed to the success of the breeding program.

Breeding

The artificial simulation of the natural environment, such as the provision of a soil bed, water hyacinth, water exchange, and supplementation of natural food along with artificial feed in the cemented cistern, created a favorable environment for natural breeding. The water hyacinth in the breeding tanks was examined daily to observe if eggs were attached to the rootlets (Fig. 6). Females typically released eggs at night, especially during rainy or cloudy weather.

Fig. 4: A series of cemented breeding tanks with water hyacinth for M. pancalus breeding.

The fish exhibited natural breeding behaviour 11 times in the cistern over a one-month period, ranging from August 11th to September 10th, with intervals of 2-9 days between breeding events. Consecutive breeding occurred typically for 2-4 days at a time. The specific breeding dates were August 11-14, August 21-24, August 24-29, and September 9-10. The results suggested that not all females bred simultaneously, and individual females released eggs intermittently. However, further confirmation is necessary to ascertain whether the same fish participated in multiple breeding events.

Post-breeding – an ecological association between animal and plant

The adhesive eggs, characterised by their distinct stalk, stuck to the root hairs of water hyacinth (Fig. 7). Typically, the eggs were laid on the inner branches of the upper part of the roots of water hyacinth, positioned approximately 5-7.5 cm below the water surface. The observation of eggs required manual exposure of the inner branches of the roots. Each water hyacinth plant hosted a variable number of eggs, ranging from 3 to 23, with an average of 8.79 ± 1.13 eggs per plant.

The fertilised eggs exhibited a spherical to oval shape, were transparent, demersal, adhesive, and displayed a yellowish-brown coloration, with a mean diameter of 1.51 ± 0.005 mm (Fig. 8a). Notably, the egg yolk was extensive, covering nearly the entire area of the egg (Fig. 8b).

Hatching and spawn production

Management of eggs

The branches of the roots bearing the adhered eggs were carefully removed and placed in glass aquaria measuring 90 cm x 1.5 cm, with a water depth of 100 mm, to facilitate the hatching of eggs. The collection of eggs proved to be a meticulous task, necessitating careful segregation from the roots of water hyacinth. This process was essential to ensure a significant number of eggs for survival under controlled conditions. Hatching occurred within 48-60 hours after fertilisation, a timeframe that varied depending on the prevailing temperature conditions.

Features of hatchlings

The hatchlings, in the form of yolk sac larvae, were characterised by their transparent bodies adorned with black stripes (Fig. 9a). The prominent yolk sac remained attached to the abdomen. A longitudinal black band ran dorsally from head to tail, giving rise to alternating black stripes that extended laterally towards the ventral side of the body. These hatchlings were housed in cement cisterns and FRP tanks, with twigs of *Hydrilla* plants provided in the aquaria for shelter.

Immediately after hatching, the yolk sac larvae rested laterally on the container's bottom. They sought shelter among the leaves and stems of *Hydrilla* or the roots of water hyacinth. When these aquatic plants were removed, the larvae were found in corners, at the bottom, or attached to the walls of trays, glass aquaria, cement cisterns, and FRP tanks. The length of the one-day-old yolk sac larvae measured 3.96 ± 0.02 mm (Fig. 9b).

When associated with the leaves, stem of *Hydrilla*, and roots of water hyacinth, the larvae were difficult to see due to their camouflage, likely providing protection against predators in the environment. Typically, yolk sac larvae do not swim and may appear motionless, resembling a state of rest. However, external water flow prompts rapid movement within seconds, followed by a return to rest by attaching themselves to the bottom, container walls, or plant parts. This behavior contrasts with the continuous and vigorous body movement observed in the yolk-sac larvae of some common catfish species (*Ompok* sp., *Pangasius* sp., and *Clarias* sp.).

The absorption of the yolk sac occurred within 2 days after hatching. As the yolk sac was absorbed, black stripes began disappearing from the tail region, completely vanishing from the body after 1.5-2 days. Nevertheless, black pigments (melanophores) remained scattered throughout the body for 7-9 days after hatching (Fig. 9c). The color of the hatchling's body transformed from transparent to pale yellow after the disappearance of black stripes. At this stage, around 4-5 days old, the larvae started feeding on exogenous natural food (mixed zooplankton and chopped tubifex worm) and were referred to as spawn. The movement of the spawn was faster than that of the yolk sac larvae.

Fig. 5: Preparation of bottom with 1:1 soil and sand.

Fig. 6: Monitoring of water hyacinth roots to observe if eggs adhere with them.

Fig. 7: A view of eggs adhered with roots of water hyacinth.

Larval rearing

Traits of early spawn

The newly hatched larvae were initially reared in glass aquaria using rainwater collected during heavy showers. Following the absorption of the yolk sac, the larvae exhibited a cannibalistic nature. The cannibalism tendency became more pronounced in 2-day-old spawn. Out of the initially stocked 1277 spawn (black-banded yolk sac larvae) in a glass aquarium, only 543 fry (yellow-colored) were alive within 9 days (Fig. 10), resulting in a 42.52% survival rate.

Plankton and chopped tubifex were provided once a day. Despite the cannibalistic behavior observed, the surviving fry continued to grow, eventually developing into healthy fingerlings (Fig. 11a and b). The stronger larvae often preyed upon the smaller and weaker ones, occasionally consuming the entire individual (Fig. 12).

Precautions to prevent cannibalism

To improve spawn survival and reduce cannibalism, several measures were implemented:

- Initially, the water level in the containers was kept at 100-120 mm and gradually increased to 200-250 mm after the second week to minimise stress on the larvae.
- Regular water exchanges were conducted, replacing 80% of the water with rainwater up to 15 days after hatching.
- Aquatic weeds such as branches of the *Hydrilla* plant and small pieces of plastic hollow pipes were introduced as hiding spots to provide shelter for the larvae.
- The stocking density was reduced to 200/m^2.
- Larval food, including mixed zooplankton and tubifex worms, was provided in sufficient quantity to discourage cannibalism.

- Initially, chopped tubifex and plankton were fed daily ad libitum, and after the second week, the feeding frequency increased to twice daily at 5% of their body weight.

These practices resulted in an improved fry survival rate of 88% within a month. During the first month, the spawn grew to an average size of 15.6 ± 0.22 mm and 0.2 ± 0.0003 g. In the following month, the average growth was recorded as 55 mm and 0.6 g. Water quality parameters during larval rearing were maintained at 25-28°C temperature, 7.2-7.8 pH, 60-80 mg/L alkalinity, and 80-120 mg/L hardness.

Feeding fingerlings in captivity

In an experiment conducted using glass battery jars, it was observed that fingerlings of *M. pancalus*, ranging in size from 38.9 ± 0.87 mm/0.2 ± 0.02 g to 34-43 mm/0.11-0.3 g, demonstrated a remarkable feeding capacity. These fingerlings were capable of consuming 0.55 g tubifex worms per day per individual, equivalent to 275% of their body weight.

Another experiment conducted in glass aquaria over a period of 30 days, incorporating continuous aeration, provided valuable insights into the species' growth patterns. The fingerlings, initially sized at 15.6 ± 0.22 mm/0.02 ± 0.003 g, exhibited a statistically significant ($P < 0.05$) increase in growth (61.193 ± 0.79 mm/0.897 ± 0.04 g) when fed a combination of plankton and tubifex. This growth surpassed that of fingerlings fed exclusively with either plankton (50 ± 0.57 mm/0.403 ± 0.016 g) or tubifex (54.07 ± 0.85 mm/0.56 ± 0.04 g). Furthermore, the fingerlings showed enhanced growth in the presence of continuous aeration compared to the condition without aeration in the rearing system. These findings underscore the importance of dietary composition and environmental factors, such as aeration, in optimising the growth of *M. pancalus* fingerlings during the critical early stages of development.

Conclusion

The natural breeding and seed production technique developed by ICAR-CIFA for *M. pancalus* is easily adaptable for farmers. Successful implementation requires farmers to exercise caution in handling the vulnerable juvenile *M. pancalus*. For breeding, adult males and females are sourced from the wild before the onset of the monsoon. They are then maintained in cement cisterns, providing artificial conditions that simulate their natural habitats to enhance the maturity of the broodstock for breeding.

After successful breeding, careful measures are essential to prevent cannibalism and ensure optimal larval survival. During this critical phase, several straightforward steps can be taken to synergistically enhance survival and growth, producing healthy stockable fry. These include:

- Utilising live foods such as planktons and chopped tubifex to supply essential nutrition.

- Providing effective hiding spots for larvae using small plastic hollow pipes and branches of *Hydrilla* plants.

- Preferring rainwater over bore well water for larval survival.

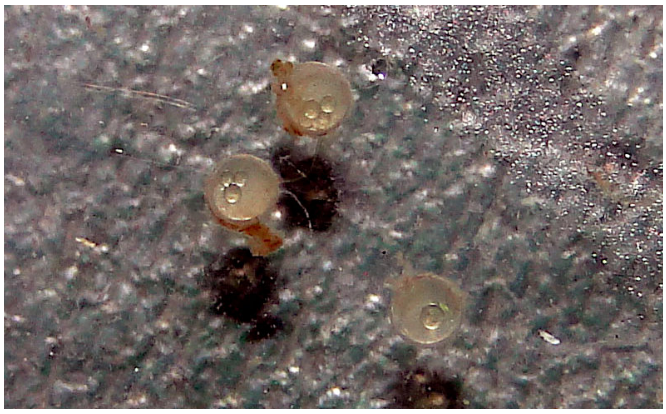


Fig. 8a: Freshly laid fertilised eggs with oil droplets.

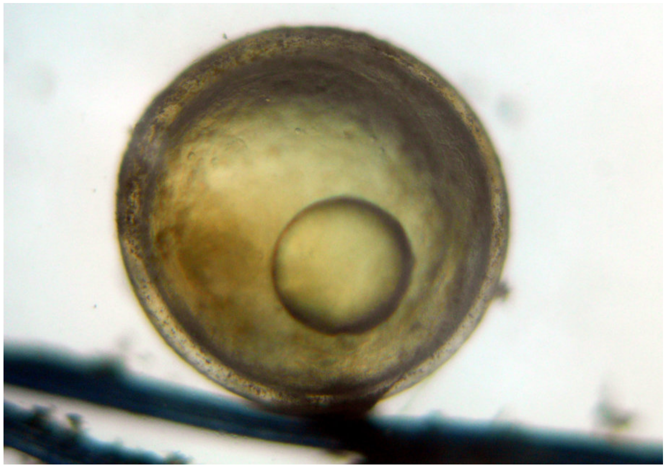


Fig. 8b: A one day old egg.

Fig. 9a: A haul of newly hatched larvae.

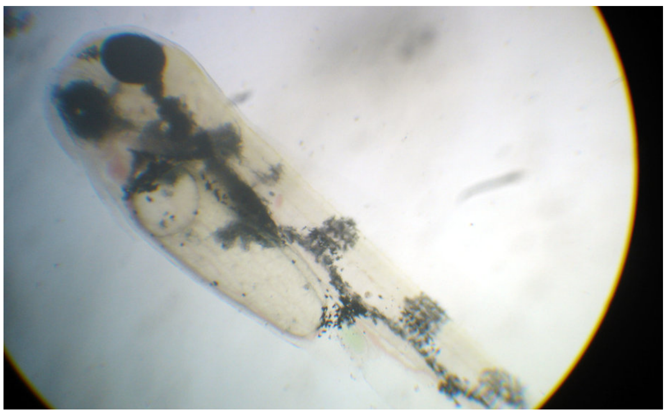


Fig. 9b: One day old larva.

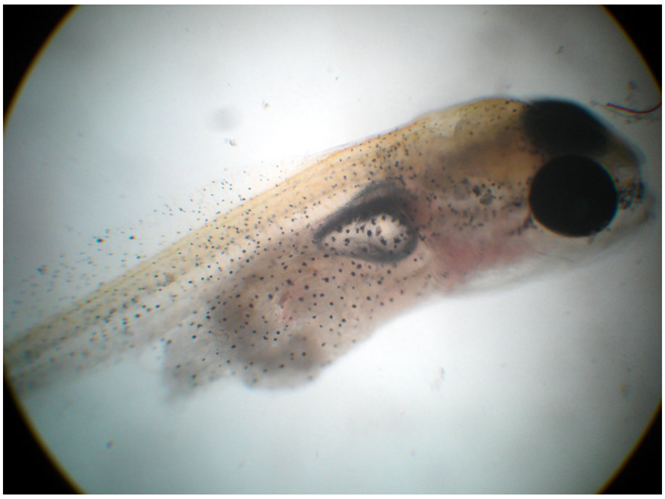


Fig. 9c: A 7 day old larva.

Fig. 10: A view of moving, scattered fry.

Fig. 11a: D.N. Chattopadhyay displaying fingerlings.

- Implementing continuous aeration coupled with regular water exchange to maintain water quality, particularly during the initial 30 days of larval rearing.

The adoption of these farming practices not only holds the potential to safeguard the species from the risk of future extinction but also introduces a nutritious option for fish consumers at affordable prices. This underscores the importance of sustainable aquaculture practices for the conservation and utilisation of valuable aquatic resources like *M. pancalus*.

Acknowledgement

The authors express their gratitude to the Director of ICAR-CIFA for facilitating and supporting the research. Special acknowledgment is extended to Ms. S. Mitra, Mr. A.K. Jha, and Mr. G. Paul for their valuable help and assistance during the conduct of this research.

References

1. Pathak B.C., Ali R., Serajuddin M. 2012. Comparative analysis of reproductive traits in barred spiny eel, *Macrognathus pancalus* (Hamilton1822) from lotic and lentic ecosystems of Gangetic basin, India.
2. Rahman M.M., Miah M.I., Taher M.A., Hassan M.M. 2009. Embryonic and larval development of guchibaim, *Mastacembelus pancalus* (Hamilton). Journal of Bangladesh Agricultural University 7(1):193-204.
3. Viswanath W. 2010. *Macrognathus pancalus*. In: IUCN 2011.IUCN Red list of threatened species. Version 2011.2.www.iucnredlist.org

Fig. 11b: A haul of fingerlings.

Fig. 12: Management is required to avoid cannibalism.

Grow-out culture of the loach *Lepidocephalichthys thermalis* in modified tanks

P. Velmurugan., J. Stephen Sampath Kumar and Somu Sundar Lingam

Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam

The ever-increasing global population necessitates access to clean water, land, and nutritious food. India, with 4% of the world's freshwater resources, finds itself in a critical situation as it is categorised as a water-stressed country. The aquaculture industry plays a significant role in meeting the nutritional demands of the expanding global population. Projections indicate that by 2050, this industry will provide nutritious food to support nine million people. However, the majority of water resources are directed towards the agricultural sector, resulting in a shared water resource scenario with aquaculture. This shared usage limits the availability of water for aquaculture.

In light of this situation, the aquaculture industry must double its production through sustainable expansion, all while minimising water and land usage to mitigate the impact on these resources. Apart from intensification, diversifying the cultivation of native species proves beneficial in efficiently utilising water resources, thereby enhancing water security. Fish species like *L. thermalis* (Indian spiny loach) hold both market value and medicinal significance in the local market. Notably, this species can survive for several hours out of water and endure adverse environmental conditions.

Considering these factors, a preliminary grow-out study was conducted at the field level to promote the future cultivation of this species. The study took place in indigenously designed poly-lined iron frame tanks.

Biology of the fish

L. thermalis is commonly known as the Indian spiny loach, common spiny loach or Ayirai meen. It is a cypriniform fish of the family Cobitidae that occurs in freshwater environments such as ponds, rivers, streams and canals in India and Sri Lanka. *L. thermalis* is an omnivorous bottom feeder.

Fabrication methods for poly-lined iron frame tanks

Tank material

Various dimensions of rust-resistant iron material were utilised to fabricate a rectangular tank for loach fish culture. The selection of iron material was specifically based on its ability to provide sufficient strength to contain the volume of water required for the tank. The tank components include an iron-meshed frame and a low-density polyethylene sheet.

Tank construction

The design for construction involved creating a rectangular tank with dimensions of 2 m^2 (1 m width x 2 m length). A 3 mm thickness of iron material was employed to construct the box frame, including corner legs. The total height of the four corner legs was 50 cm, with the box frame fixed 15 cm above the bottom. The mesh size of the iron frame was 3 cm. A low-density polyethylene sheet (200 microns) measuring 3.75 m^2 (1.5 m x 2.5 m) was laid over the iron mesh frame (Figures 1-8).

2.3 Location: The tank is portable and can be moved to any required location. However, it is essential to place it on an even surface. For optimal water quality maintenance during the grow-out phase, these tanks can be positioned indoors. It is advisable to avoid waterlogged areas to prevent rusting of the tank frames. Ensure proper fixing of the poly sheet to eliminate contact between water and the iron frame box. The tank has a capacity of 700 liters of water with 5-6 kg of riverine sand.

Grow-out culture

Pre-stocking management

Before filling the water, a thin layer of sand (up to 5 cm) should be spread over the tank bottom. The sand must be washed thoroughly, at least three times, and sun-dried. Following this, water should be filled up to a height of 25-30 cm, creating a minimum culture water volume of 400 liters. The freeboard area should be 10-20 cm. Fish can be stocked three days after water filling. Floating weeds should cover at least 20% of the water surface, and a few stones can be added as substrate to mimic the natural environment.

Stocking of fish

Typically, indigenous farmers practice a one-year grow-out period for this fish, depending on water availability. Stocking density is a crucial factor influencing growth, survival, and production. Although no stocking density study is reported for this species, based on our preliminary studies, this species can be stocked at a rate of 800 individuals/m^2 (average length: 3.5 cm, weight: 0.24 g). A total of 1,600 individuals/2 m^2 were stocked.

Food and feeding

Loach's natural feeding habitat is detritus, and they exhibit nocturnal feeding behavior. They feed on algae, detritus, insect larvae, and copepods using their specialised filter-feeding mechanism. A supplementary feed mixture of GNOC and cottonseed oil cake (60:40) can be provided at an ad-libitum level throughout the culture period. Other sinking feeds can also be used, as the species is highly adaptable to various feeding situations. During feeding, the species comes to the surface, takes feed, and returns to the bottom immediately. At the end of the 90-day culture period, the study calculated an FCR value of 1.2.

Water quality management

Water quality is crucial for fish production. A minimum water level of 20 cm was maintained for culture. To prevent surface water from heating, the tank should be placed indoors or in a shaded area to avoid direct sunlight exposure. Floating weeds (*Azolla* and *Lemna*) can be provided, covering up to 20% of the surface area, to prevent temperature fluctuations in surface water. Floating aquatic plants and sand substrate are used to maintain a constant water temperature. During the culture period, optimal levels of dissolved oxygen (4-5 mg/L), temperature (28°C), and pH (7-7.5) were recorded.

Harvest and yield

In nature, loaches hide in the sand substrate, making harvesting possible only by completely draining the tank water. While draining, the sand substrate is collected to harvest the hiding fish, and then the sand particles are placed back in the tank. In the 90-day grow-out culture, the total harvest was 1,005 g (average length: 4.9 cm, weight: 0.67 g), contributing to a net yield of 621 g using 400 liters of water. The study found that with increasing culture duration and altering feed composition and feeding rate, a net production level of 1 kg can be easily achieved in 400 liters of water while maintaining favorable water conditions. The fish can be sold in live condition at the local market at a good price, earning a profit of Rs. 1,300 from a single tank. Increasing the number of tanks, using vertical platforms in a smaller area, may further boost the profit of this fish culture.

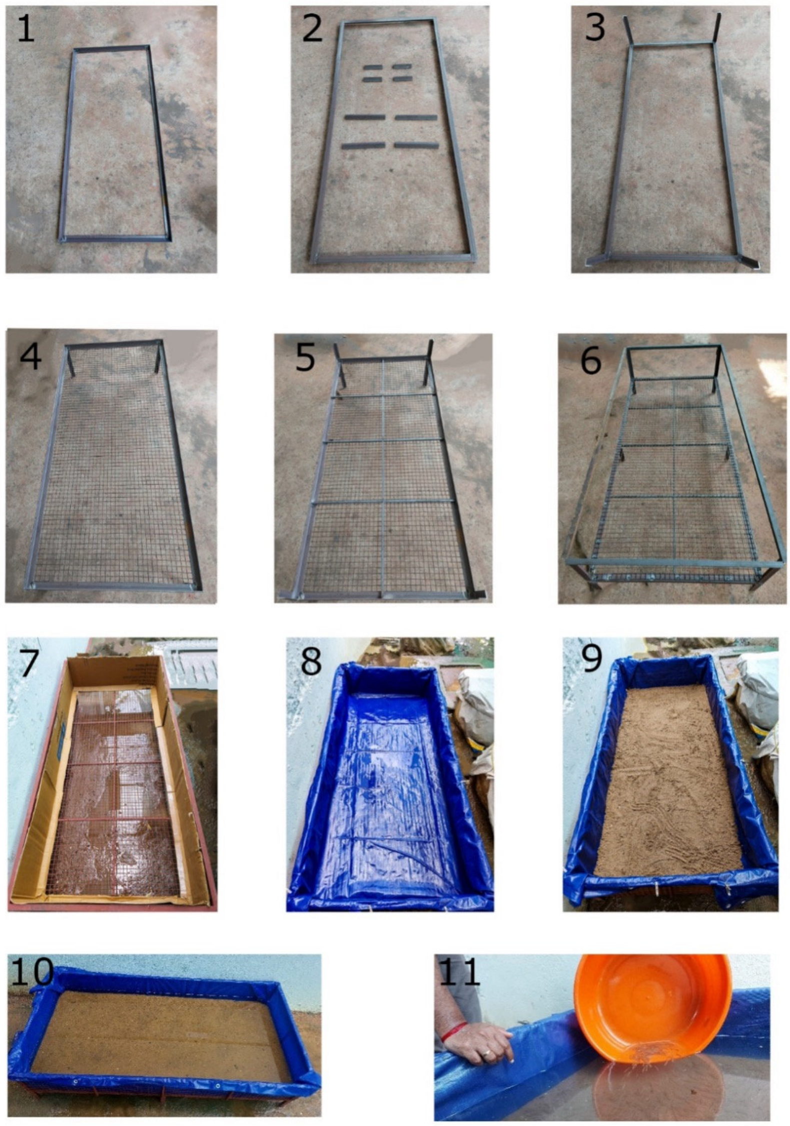
Conclusion

The rapidly growing aquaculture industry faces numerous challenges that are likely to impact future fish production. Simultaneously, the industry must provide solutions, employing upcoming technologies, to meet the demands of the growing population. These challenges include the need to address nutritional requirements, double farmer income, efficiently utilise water resources, and conserve and diversify aquatic species.

The Indian spiny loach, or true loach, emerges as a promising candidate for future aquaculture given its various advantages. It requires less water and land, involves lower investment with higher profitability and increased production, demands minimal cultural management, aligns with regional and local market preferences, boasts a high nutritional profile, lacks strong spines, has a shorter culture duration, and is highly suitable for vertical farming. Consequently, this single species addresses the pressing challenges faced by the aquaculture industry.

This foundational study serves as a stepping stone for farmers in our country to initiate pilot farming of this species. Moreover, it paves the way for the adoption of diverse culture practices for this fish. Additionally, the developed modified tank-based rearing system for loach proves highly beneficial for loach culture in hilly regions and is particularly suitable for areas with limitations in land and water resources.

Fig A: 1-3: Base structure fabrication; 4-6 tank bottom and side covered with iron square mesh size (3 cm); 7: tank side covered with duplex carton; 8: tank covered with polyethylene sheet; 9: substrate provided; 10: water filled; 11: stocking of loach.



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Second High-Level Meeting on Aquaculture Transformation in Asia and the Pacific Region

Left to right: Michael Phillips (Moderator), Tom Prins (Aqua-Spark), Amorn Luengnaruemitchai (Manit Farms), Chris Aurand (Thai Union), Zhu Jian (Freshwater Fisheries Research Center), Rakesh Kumar (Deputy Commissioner, Fisheries, India), Kitiya Vongkamjan (UniFAHS).

Aquaculture development in the region faces many challenges, including resource scarcity and resource use conflicts, environmental pressure, climate change, demographic changes in farming communities and shifting trends driven by globalisation.

Innovations and investment are required to transform aquaculture into more efficient, inclusive, resilient, and sustainable aquatic food systems. This approach is aligned with the FAO's Blue Transformation Roadmap, which provides a vision for the sustainable intensification and expansion of aquaculture to contribute to future global food supply needs.

In November 2022 FAO and NACA convened the First High Level Meeting on Aquaculture Transformation in Asian and the Pacific Region (HLM). The meeting provided a forum for government policy makers, business leaders, development banks and investors to identify strategies and mechanisms to stimulate innovation and investment for aquaculture transformation by 2030. As a background to discussions FAO and NACA developed a white paper entitled Aquaculture transformation: Innovations and investment for sustainable intensification and expansion of aquaculture in Asia and the Pacific region.

A second High Level Meeting on Aquaculture Transformation: A Call for Collective Action was held in Bangkok from 8-9 November 2023 to further facilitate regional collaboration towards the Blue Transformation vision. The purpose of the meeting was to review progress made after the First HLM and discuss specific actions and mechanisms needed to enhance regional cooperation and progress transformation at scale by 2030.

Opening remarks were given by Dr Xinhua Yuan, Deputy Director Fisheries and Aquaculture Division, FAO; Dr Jie Huang, Director General, NACA; and Dr Taworn Thunjai, Deputy Director General, Department of Fisheries (DoF), Thailand. A keynote presentation on aquaculture transformation through innovation and investment in Thailand was given by Dr Montakan Tamtin, Director of the Kung Krabaen Bay Royal Development Study Center, Coastal Aquaculture and Development Division, DoF Thailand. Dr Tipparat Pongthanapanish, FAO RAP, gave a presentation on the white paper and progress made after the First High Level Meeting on Aquaculture Transformation, which was held in 2022.

To set the scene, the meeting began with a panel discussion on "Innovation and investment for aquaculture transformation: What's going on in the region and the way forward?" Panelists were Rakesh Kumar, Deputy Commissioner for Fisheries, DoF India; Zhu Jian, Chief of the R&D Division, Freshwater Fisheries Research Center, China; Amorn Luengnaruemitchai, Chairman of the Thai Tilapia Farmers Association and Managing Director of Manit Farms, Thailand; Chris Aurand, Innvation Leader, SPACE_F, Thailand, and Tom Prins, Head of Deal Flow, Aqua-Spark, the Netherlands. It was moderated by Michael Phillips, FUTUREFISH.

The meeting discussed and reviewed a draft Action Guide for Aquaculture Transformation for Asia and the Pacific Region, developed through two expert consultation workshops, involving virtual and in-person dialogue on 9–10 May and 11–12 July 2023. The action guide provides guidance to both public and private sector actors on progressing aquaculture transformation against the priority areas for innovation and investment identified by the white paper. It also guides the development of mechanisms to support implementation and monitor progress. The action guide is in press and will be published on the FAO / NACA websites in due course.

A key proposal discussed in plenary at the meeting was the development of an Asia-Pacific Aquaculture Innovation and Investment Hub, as a regional mechanism providing policy advice, monitoring, resource mobilisation, partnership and capacity building functions as a regional platform driving aquaculture transformation. The discussion focussed on the organisation, structure, mandate and functions of the hub, resource mobilisation strategies and proposed activities and workplan from 2024 to 2026.

The aquaculture innovation hub concept is still at an early stage of development. Further details will be published on the NACA website in due course.

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the Second Quarter of 2023

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

With the implementation of the new aquatic animal disease reporting in the Asia Pacific region from January 2021, and in lieu of the published QAAD Reports (last issue published was 4th quarter of 2020), NACA is publishing reported aquatic animal diseases submitted by countries in the Asia-Pacific region. This report covers the second quarter of 2023 and the original and updated reports can be accessed from the QAAD page at https://enaca.org/?id=8.

The following diseases were reported:

Finfish diseases

- Infection with *Aphanomyces invadans* (EUS): Bangladesh in catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*); and, India in climbing perch (*Anabas testudineus*) and snakehead (*Channa marulius*).
- Infection with epizootic haematopoietic necrosis virus: Australia in adult redfin perch (*Perca fluviatilis*)
- Infection with red seabream iridovirus (RSIV): Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*); and, India (ISKNV) in oscar (*Astronotus ocellatus*) and black tetra (*Gymnocorymbus ternetzi*)
- Infection with Tilapia lake virus (TiLV): India in tilapia (*Oreochromis niloticus*), and Philippines in tilapia fry (*Oreochromis* sp.).
- Grouper iridoviral disease (GIV): Chinese Taipei in seabass (*Lates calcarifer*)
- Viral encephalopathy and retinopathy (VER): Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*), seabass (*L. calcarifer*) and giant grouper (*E. lanceolatus*).

Molluscan diseases

- Infection with *Perkinsus olseni*: India in farmed mussel (*Perna viridis*), and wild samples of charru mussel (*Mytella strigata*) and black clam (*Villorita cyprinoides*).

Crustacean diseases

- Infection with white spot syndrome virus (WSSV): Australia in farmed black tiger shrimp (*Penaeus monodon*); Bangladesh in black tiger shrimp (*P. monodon*); Chinese Taipei in whiteleg shrimp (*P. vannamei*); India in *P. monodon* and *P. vannamei*; and, the Philippines in *P. vannamei* (PL, juveniles, grow-out culture, and adult), *P. monodon* (PL, grow-out culture, broodstock), freshwater prawn broodstock (*Macrobrachioum rosenbergii*), and crab (adult).

- Infection with infectious hypodermal and haematopoietic necrosis virus (IHHNV): India in *P. monodon*; the Philippines in *P. vannamei* (PL and grow out culture) and *P. monodon* (grow-out culture); and, Thailand (marine shrimp, species not specified).

- Acute hepatopancreatic necrosis disease (AHPND): Bangladesh in *P. monodon*; Chinese Taipei in *P. vannamei*; the Philippines in *P. vannamei* (grow-out culture and adult) and *P. monodon* (eggs, PL, juveniles) and *P. indicus* (grow out culture); and Thailand (marine shrimps, species not specified).

- Infection with Infectious myonecrosis virus (IMNV): India in *P. vannamei*.

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

- Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP): India in *P. vannamei*; the Philippines in *P. vannamei* (PL and grow out culture) and *P. monodon* (PL); and, Thailand (marine shrimps, species not specified).

Amphibian diseases

- Infection with Ranavirus species: Chinese Taipei in bullfrog (*Lithobates catesbeianus*).

- Infection with *Batrachochytrium dendrobatidis*: Australia in unknown species of frog.

Other diseases

- Bangladesh reported Infection with *Streptococcus agalactiae* in Tilapia (*O. niloticus*), and Infection with *Aeromonas* spp. in shing catfish (*Heteropneustes fossilis*), gulsha (*Mystus cavasius*) and pangas catfish (*Pangasianodon hypophthalmus*).

Expert Workshop on Aquaculture Effluent Management

Participants in the workshop.

In 2023, FAO and NACA initiated a consultation process on aquaculture effluent management in Asia and the Pacific in collaboration with NACA member governments. Experts across the region gathered information to assess the state of governance, advancements in technology and innovation in aquaculture effluent management.

The Asia-Pacific region has been leading the world in aquaculture production for decades, producing 91.6 % of globally farmed aquatic animals and algae in 2020. Aquaculture is contributing to multiple Sustainable Development Goals including ending hunger, improving health and nutrition, responding to climate change, wealth creation and poverty reduction, gender equality, and decent work. The region will likely continue to play the leading role in global aquaculture development in the future to provide sufficient and nutritious aquatic foods for the growing population.

Notwithstanding the past achievements, the future requires that aquaculture in the region grows continuously under a broad range of challenges ranging from competition and conflict use of resources to environmental pressure, and climate change. Sustainable intensification is the primary approach to transform aquaculture in the region towards more efficient, inclusive, resilient, and sustainable aquatic food systems. The environmental resilience of aquaculture systems, much determined by the effluent reduction, reuse, and recycling, is one of the fundamental pillars supporting sustainability in the intensification.

Simon Funge-Smith (FAO) and Yuan Derun (NACA).

Aquaculture effluent management represents the major technical and engineering challenge to ensure resource efficiency and environmental integrity of farming systems. Innovations and technology for aquaculture waste management have been fast advancing in recent years in the region. These include the development of new farming systems, reconfiguration, and improvement of the integration of farming components, improved feed, and feeding technology to increase feed utilisation efficiency, and novel engineering, mechanical and biological designs for effluent treatment. In addition, policies and regulations developed at the national level for aquaculture effluent management have gradually evolved into more efficient and effective institutional mechanisms for better governance of the sector.

However, there are disparities in technological development and governance among nations in the region regarding aquaculture effluent management. There is a need to facilitate collaboration, information exchange, and experience sharing to accelerate technology extension and scaleup of innovations for aquaculture effluent management.

The consultative process culminated in an expert workshop, convened from 14 to 15 November, funded by FAO, to share views and national experiences on aquaculture effluent management. The workshop was attended by 31 people from 12 countries including Bangladesh, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Nepal, Philippines, Sri Lanka, Thailand, and Vietnam, with representatives from the Thailand Department of Fisheries and Asian Institute of Technology.

The workshop forms part of a broader process to promote good practices and build technical and governance capacity for aquaculture effluent management. It will contribute to the larger goal of transforming aquaculture in the region towards more efficient, inclusive, resilient, and sustainable aquatic food systems. The specific objectives of the workshop were to:

- Review and examine existing national policies, regulations, and institutional setups for aquaculture effluent management and governance.
- Showcase technological advances and innovations in aquaculture effluent management and governance.
- Identify country-specific challenges and issues in governance on aquaculture effluent management and governance.
- Identify national and regional needs for technical assistance and capacity building on aquaculture effluent management and governance.
- Recommend future policy directions, priority areas for governance, technology development, innovation, and capacity building in aquaculture effluent management in the region.

Videos

Video recordings of the technical presentations from the workshop are in preparation and will be published on this page / made available through YouTube in due course.

Larvi 2024: First announcement and call for papers

The 8th fish and shellfish larviculture symposium (larvi ‘24) will be held in Ghent University, Belgium, from 9-12 September 2024. Submissions are open until 12 February.

Closing the life cycle of aquaculture species of economic importance is critical for the ultimate success of aquaculture. Predictable & cost-effective availability of high-quality fry, fingerlings, postlarvae, seed, spores, etc. remain the key for a successful aquaculture venture. Knowledge generated at many different levels can further increase the success of the sector. Much progress is being made in knowledge-based insights on e.g. the genetic make-up of the broodstock, steering the ontogeny, the importance of first feeding, steering host microbial interactions and its immunological consequences, automation, etc. Research in these fields are increasingly supported and stimulated by a variety of novel and sophisticated techniques such as omics’ and artificial intelligence tools. They generate an unprecedented and often fascinating insight into biological processes. Although they generally also raise new research questions, they stand for a major leap forwards as compared to the empirical approach of a relatively recent past.

Capitalising on the previous “larvi” symposia (in ’91, ’95, ’01, ’05, ’09, ’13, ‘17), the Aquaculture R&D Consortium of Ghent University, the Norwegian University of Science and Technology and SINTEF Ocean have joined again in the organizing committee for “larvi’24” and are inviting the academic as well as the private sector to attend the 8th Fish and Shellfish Larviculture Symposium. Bringing together European and non-European stakeholders, once again the latest progress in academic research and in the production sector will be reviewed, problems identified and avenues for future collaboration explored.

For further information and pre-registration, please see the full first announcement.

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NACA is a network composed of 20 member governments in the Asia-Pacific Region.

Tuskfish CMS 2.0.7 released

Tuskfish CMS is a fast and lightweight open source software project used to build the NACA website. Version 2.0.7 introduces a couple useful features:

- Automatic expiry of content via cron job script. Expired content is marked offline and the cache is rebuilt to update pagination links.
- Back end toggling of content on/offline now uses a htmx call to avoid page reload.

Third party libraries have been updated and a few minor bug fixes implemented.

Tuskfish is available for free download from:

https://github.com/crushdepth/tuskfish2/releases