Promotion and protection of small fish species through farming: An initiative in Tripura

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ICAR-CIFA scientists provide training to fish farmers.

Small fish species are a valuable source of minerals and vitamins, particularly for rural communities. They are often referred to by different terms: SIS (small indigenous species), SIFS (small indigenous fish species), and SIFFS (small Indigenous freshwater fish species). Small fish are defined as species that reach a maximum length of 25 cm at maturity. Unlike larger fish, they are consumed whole, including the head, bones, eyes, and viscera, with no wastage.

India has recorded 104 small freshwater fish species, including 62 food fish and 42 ornamental species (Felts et al., 1996; Sarkar and Lakra, 2010). Despite their high nutritional value, these fish are often labelled as weed fish, trash fish, or poor man's fish. In many cases, they have been removed to make way for carp farming and treated as incidental catch (Chattopadhyay and Mandal, 2023).

Food value of small fish species: Nutritional excellence for human health

Small fish are an easily digestible source of protein, rich in minerals and vitamins. They provide both micronutrients and macronutrients. Micronutrients include iron, calcium, zinc, iodine, phosphorus, selenium, fluorine, and cobalt. These elements are highly bioavailable, meaning they are easily absorbed by the human body. The protein content of small fish ranges from 14–22% of fresh weight. They are more affordable than other sources of animal protein, and their production cost is low, making them accessible to farmers (Chattopadhyay and Mandal, 2023).

Fish oil, which makes up 0.5–7% of fresh weight, helps reduce the risk of cardiovascular disease. It contains omega-3 polyunsaturated fatty acids (PUFAs), including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Although the human body requires only small amounts of micronutrients, they are essential for preventing malnutrition. Small fish are a unique dietary source of these nutrients. They are rich in vitamins A, B, C, D, E, and K. For example, *Amblypharyngodon mola* contains 2,680 µg of vitamin A—fifty times more than other fish species. Eating Mola supports vision, eye health, cell growth, immune function, reproduction, and foetal development.

The vitamins and minerals in 1 kg of small fish are roughly equal to those found in 50 kg of larger fish, such as Indian major carp (Mohanty et al., 2011; Mohanty et al., 2013). The calcium in small fish is as bioavailable as that in milk (Thilsted, 2010). Pregnant women who eat small fish once a week have a 3.6 times lower risk of delivering low birth weight (LBW) or premature babies.

Sustainable Development Goals

The United Nations has set several criteria for the Sustainable Development Goals (SDGs). In many developing countries, small-scale fisheries and aquaculture remain the primary source of fish for rural communities. This sector plays a crucial role in food and nutritional security, particularly through the contribution of small indigenous fish species.

Small fish offer many benefits. They have high nutritional value, are compatible with carp culture, thrive on low trophic levels, and can self-recruit. They also have strong market demand and remain affordable. Farming small fish species can contribute to achieving several United Nations SDGs.

Recognising the importance of small fish as a rich source of protein, vitamins, and minerals, ICAR-CIFA has launched an initiative to promote and protect them through farming. This approach supports food security, rural livelihoods, and biodiversity conservation.

Promotion of small fish species: A step towards farming

Small fish populations are rapidly declining due to habitat loss, dewatering, fragmentation of water bodies, wetland encroachment, and urbanisation. The filling of small water bodies, use of insecticides, pesticides, hazardous agricultural chemicals, industrial and domestic pollution, siltation, and the introduction of exotic species further threaten their survival. To prevent further decline, a strategic plan has been developed, focusing on breeding, feeding, and rearing.

Breeding of small fish species: An established technique

Breeding is the reproductive process between male and female fish to produce offspring. In controlled breeding, suitable male and female brooders are selected for reproduction. Many small fish species reproduce naturally through self-recruitment. However, when natural breeding is disrupted, alternative methods are needed.

Indian major carps, which cannot breed in stagnant water, are induced to spawn using hormonal treatments. This method has revolutionised fish breeding. Several small fish species face difficulties in reproducing, so specific breeding techniques have been developed (Table 1; figures overleaf).

The breeding process involves the following steps:

- Collecting the desired small fish species in sufficient numbers.
- Selecting healthy males and females through careful observation.
- Keeping broodstock under controlled conditions.
- Monitoring their health at regular intervals.
- Choosing the right breeding time, typically the rainy season.
- Encouraging natural breeding by simulating ecological and environmental conditions.
- Using artificial breeding methods if natural breeding fails.
- Selecting suitable broodstock.
- Measuring fresh weight of brooders.
- Determining appropriate hormonal doses for males and females.
- Administering hormonal treatments.
- Releasing males and females into controlled breeding pools.
- Using aquatic plants as breeding substrates to support egg attachment in both natural and artificial breeding.
- Rearing hatchlings.

Feeding – a challenge for small fish larvae

Feeding newly hatched larvae is a challenge, even for larger fish species, as their small mouth gape makes it difficult to accept formulated feed. Instead, they rely on plankton. Similarly, small fish larvae must be fed plankton to match their natural feeding behaviour.

To meet this need, live food organisms, which serve as natural feed for fish larvae, are cultured. Selected phytoplankton and zooplankton are grown in fibre-reinforced plastic tanks using a combination of outdoor methods, different manures, fertilisers, and environmental manipulation. The following live foods have been established for mass production:

- *Graesiella emersonii* (phytoplankton and single-cell protein).
- *Brachionus calyciflorus* (rotifer).
- *Cyclops* (copepods).

Anabas testudineus.

Macrognathus aral.

Amblypharyngodon mola.

Gudusia chapra.

Clarias magur.

Heteropneustes fossilis.

Macrognathus pancalus.

Mystus cavasius.

Mystus vittatus.

Ompok bimaculatus.

- *Moina* (cladocerans).

Live food cultures provide several advantages:

- Larvae can be fed either a single live food species or a combination of multiple live foods sequentially.
- Co-feeding of inert diets alongside live food is possible for selective fish larvae.
- Natural feeding behaviour is supported, minimising feeding stress.

Feeding small fish larvae with live food ensures they receive appropriate nutrition based on their natural feeding preferences. This method has been tested successfully in several small fish species.

Rearing: Environmental simulation for sustainable husbandry

Rearing small fish species in monoculture or mixed culture systems is still being developed. Monoculture is often not economical due to the slow growth and small size of many indigenous fish species. Before introducing a mixed culture, it is necessary to study species interactions, including:

- Habitat preferences.
- Space-sharing behaviour.
- Cannibalism.
- Competition for food.
- Feeding preferences and overlaps.

Mixed culture is generally preferred as it optimises space usage and increases yield per unit area compared to monoculture. The Regional Research Centre, ICAR-CIFA, Rahara, has already conducted trials on selected small fish species. Profitable small fish farming is achievable when mixed culture is managed efficiently to ensure production exceeds farming costs.

Puntius sophore.

Soil and water quality must be continuously monitored, including water depth and temperature, to adapt to climate variations. Feeding with live food helps maintain ecological balance. Additionally, selected aquatic plants should be introduced to simulate a natural environment that supports the survival and growth of small fish species.

Training farmers in Tripura on small fish breeding and feeding

Tripura is part of India's northeastern region, covering 10,491 km². It is almost surrounded by the deltaic basin of Bangladesh. Tripura has a warm and humid tropical climate with five distinct seasons: spring, summer, monsoon, autumn, and winter. Summer begins in mid-March and peaks in April–May, followed by pre-monsoon rains. Temperatures range from 10°C to 35°C, with high humidity throughout the year. Annual rainfall varies from 1,920 to 2,855 mm.

Tripura has a population of 3,673,917 (Census 2011), and fish is a major source of protein. In 2019–20, per capita fish consumption in the state was 29.29 kg, the highest in India. Water resources include ponds, tanks, lakes, reservoirs, canals, wetlands, and rivers, covering 37,382 ha. Of this,

29,503 ha is used for culture fisheries, while 7,879 ha falls under capture fisheries. The state produced 82,000 metric tonnes of fish in 2020–21.

Key training components for small fish culture

Tripura was selected for small fish culture due to its abundant fishery resources and skilled human resources familiar with aquaculture. A total of 25 fish farmers were chosen from different parts of the state. They had prior experience in carp breeding, rearing, and culture. The training, titled “Production of live fish food organisms and culture of small indigenous fish species with emphasis on mola *Amblypharyngodon mola*, chapila *Gudusia chapra*, punti *Puntius* spp., pankal, *Macrognathus* spp. and tangra, *Mystus* spp."

Breeding and rearing

The training began with a discussion on the importance of breeding small fish species to generate interest. Farmers were already familiar with these species as culinary delicacies and became enthusiastic after learning about their medicinal and nutritional benefits.

Scientists conducted hands-on training, using audiovisual aids where necessary, especially for small fish rearing. Farmers were trained in broodstock selection, identification of males and females, and species-specific hormone dosage for breeding.

Live fish food production and feeding small fish

Farmers received hands-on training on producing live fish food in outdoor systems, focusing on mass culture of phytoplankton and zooplankton. Different mesh-sized plankton nets were used to separate zooplankton through a sieving method. The Sedgewick-Rafter plankton counting cell was used to measure plankton density.

For phytoplankton production, selected fertilisers were used in a 10:1:1 ratio, including:

- Ammonium sulphate.
- Urea.
- Single super phosphate.

Farmers were trained in feeding individual live food organisms to small fish and using co-feeding techniques. Feeding live food aligns with the natural behaviour of small fish, improving their survival rate and growth.

Soil and water quality management

The environment plays a crucial role in small fish rearing. Water quality management was a key discussion point. Farmers learned how to monitor and maintain water quality to ensure a healthy environment, which directly affects fish health.

For small water bodies, the following materials were recommended to enhance water productivity through phytoplankton growth:

- Lime.
- Cattle dung.
- Mustard oilcake.
- Groundnut oilcake.

Farmers were also trained in monitoring ammonia levels and controlling them to maintain fish populations. Good-quality water was emphasised as a factor that can support natural breeding.

Table 1: Important SIFS with their farming potential in Tripura

Species	Family	Local name	Farming strategy
Amblypharyngodon mola	Cyprinidae	Mola	Introduction of adult fish; self-recruitment; polyculture
Anabas testudineus	Anabantidae	Koi	Semi-artificial breeding; monoculture, polyculture
Clarias magur*	Clariidae	Magur	Natural, semi-artificial, and artificial breeding; monoculture, polyculture
Gudusia chapra	Clupeidae	Chapila	Environmental management; introduction of adult fish; self-recruitment; polyculture
Heteropneustes fossilis	Heteroneustidae	Singhi	Natural, semi-artificial, and artificial breeding; monoculture, polyculture
Macrognathus aral	Mastacembelidae	Tara baim	Introduction of adult fish; self-recruitment; semi-artificial breeding; environmental management
Macrognathus pancalus	Mastacembelidae	Pankal baim	Introduction of adult fish; self-recruitment; semi-artificial breeding; environmental management
Mystus cavasius	Bagridae	Sadatengra	Semi-artificial breeding; polyculture
Mystus vittatus	Bagridae	Lal tengra	Semi-artificial breeding; self-recruitment; polyculture
Ompok bimaculatus**	Siluridae	Pabda	Semi-artificial and artificial breeding; environmental management; polyculture
Puntius sophore	Cyprinidae	Jatpunti	Environmental management; introduction of adult fish; self-recruitment; polyculture

*IUCN status: *Endangered, **Near Threatened, Others: Least Concerned.*

R.N. Mandal demonstrating segregation of plankton.

Farming of small fish – a pathway to livelihood generation and gender equity

In Tripura, backyard water bodies provide an ideal setting for small fish farming. Small water bodies (<0.1 ha) are suitable for the mixed culture of small fish species, allowing different species to occupy their respective ecological niches. Studies indicate that small fish farming either enhances overall production or does not negatively impact major cultured species.

The culture of *Amblypharyngodon mola*, *Puntius sophore*, *Osteobrama cotio cotio*, and *Gudusia chapra* alongside carps has shown a synergistic effect, leading to increased profitability. Wahab et al. (2002) reported that introducing *P. sophore* did not affect the productivity of rohu and catla, but the productivity of mrigal increased by 50%, while common carp production decreased by 20%. Additionally, *P. sophore* had no impact when stocked with either common carp or mrigal. Further studies by Roos et al. (2007a, 2007b) showed that co-culturing *A. mola* with carps improved overall fish production.

However, integrating catfish species with carp at the larval stage requires further investigation, as catfish exhibit cannibalistic behaviour that could significantly impact carp populations. Small fish farming provides opportunities for greater women's participation, promoting gender equity. Once farmers are trained in breeding and culturing small fish species, they become more efficient in managing their rearing. Success in small fish farming depends on breeding, feeding, and maintaining a suitable environment, which ICAR-CIFA has taken the initiative to promote.

Conclusion

The establishment of small fish farming offers several benefits:

- Farming in backyard water bodies is feasible.
- More women can participate in fish farming.
- Employment opportunities increase.
- Rural households gain a steady source of protein.
- Small fish consumption provides essential minerals and vitamins, benefiting human health, especially pregnant and breastfeeding mothers.
- Selling small fish generates income, supporting the rural economy.

Arabinda Das delivers the lectures on breeding and rearing of small fishes.

- Biodiversity conservation of small fish species is ensured.
- Natural farming methods can help mitigate climate change.

Further research and development in small fish farming are essential, particularly in rural areas. Widespread participation from rural communities can ensure sustainable growth in this sector. Mass awareness programs are crucial for the protection and promotion of small fish farming.

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