Small indigenous fish species: A source of nutritional security through rural aquaculture development

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Locally available SIS in market of North Eastern states of India

Small indigenous fish species (SIS) are a diverse group of native, small-sized freshwater fish that inhabit various natural and man-made aquatic ecosystems such as rivers, beels, canals, ditches, rice paddies, ponds and floodplains. These fish have historically been a staple in the diets of rural populations due to their widespread availability and nutritional richness. SIS are unique in that they are often consumed whole, including bones, head and internal organs, which significantly enhance their nutritional value. This whole-fish consumption provides an exceptional source of essential micronutrients like calcium, iron, zinc, iodine and vitamin A, as well as high-quality protein and beneficial fatty acids. These species play a vital role in ensuring food and nutrition security for underprivileged communities, particularly in regions where diets are heavily carbohydrate based and lack diversity. Importantly, SIS contribute not just to daily nutrition but also to long-term health by addressing public health concerns like vitamin A deficiency, anaemia (iron deficiency) and poor bone health (calcium deficiency).

Additionally, SIS are abundant during specific seasons, especially the monsoon, and thrive with minimal human intervention. These species are often self-recruiting, meaning they naturally replenish in various aquatic systems without the need for hatcheries or intensive aquaculture management. From an ecological and economic standpoint, SIS are crucial to sustainable livelihoods. They are naturally resilient, breed prolifically and adapt well to both stagnant (lentic) and flowing (lotic) water bodies. Early aquaculture practices mistakenly viewed these species as pests or “trash fish”, removing them to prioritise large commercial species. However, modern research and aquaculture practices have highlighted the benefits of integrating SIS into polyculture systems, as they not only boost overall productivity but also maintain ecological balance. Moreover, their low market demand and ease of access, often harvested as bycatch, make them especially important for food-insecure households that cannot afford other protein-rich foods.

Recently, WorldFish is implementing a GIZ-supported project called “Taking Nutrition-Sensitive Carp-SIS Polyculture Technology to Scale” in the states of Odisha and Assam, India. Techniques have been successfully developed for farming SIS in polyculture with carps, and in rice fields, but a lack of readily available SIS seed produced by hatcheries is the key technical bottleneck inhibiting the scaling up of nutrition-sensitive aquaculture (Rajts et al., 2022).

Wild collection of small indigenous fish species.

Despite their significance, SIS remain under-researched, particularly regarding their captive seed production, farming and conservation. Due to their high nutritional value and social relevance, SIS hold immense potential for tackling malnutrition and strengthening rural economies through the development of SIS aquaculture.

Small indigenous fish species

Small indigenous fish species are defined as fish that reach a maximum size of about 25-30 cm at the mature or adult stage of their life cycle. They inhabit natural water bodies such as rivers and tributaries, floodplains, ponds, lakes, beels, streams, lowland areas, wetlands and paddy fields.

In India, 2,319 species of finfish have been recorded, comprising 838 freshwater species, 113 brackish-water species and 1,368 marine species. Of the 765 native freshwater species documented, about 450 may be categorised as SIS, and among these, 104 species (23%) are considered highly important. Of these 104 species, approximately 62 are recognised as food fish and 42 as ornamental fish.

Many SIS are cultivable and can be introduced as candidate species in freshwater aquaculture systems. Examples include *Amblypharyngodon mola*, *Notopterus notopterus*, *Puntius sarana*, *Labeo bata*, *Cirrhinus reba*, *Salmostoma bacaila*, *Nandus nandu*s, *Anabas testudineus*, *Esomus danricus*, *Glossogobius giuris*, *Devario devario* and *Chanda nama*. Other potential species for aquaculture diversification include small carps (*Labeo* spp.), small murrels (*Channa spp*.), air-breathing catfish (*Heteropneustes fossilis*) and non-air-breathing catfish (*Mystus* spp., *Horabagrus brachysoma*, *Notopterus notopterus*, *Ompok pabda*), for which seed production and farming need to be popularised and expanded.

The greatest diversity of SIS has been recorded from the North-Eastern region, followed by the Western Ghats and Central India. Rural populations in many parts of India depend heavily on indigenous fish species for nutritional and livelihood security. Small indigenous fish species are an important source of essential macro- and micronutrients, and can play a significant role in eliminating malnutrition and micronutrient deficiencies in rural communities (FAO, 2003).

Nutritional value of small indigenous species of fish

SIS are widely recognised not just for their abundance in freshwater ecosystems, but more importantly for their superior nutritional profile, especially in contexts where malnutrition and hidden hunger (micronutrient deficiency) are prevalent. These small fish are typically consumed whole, a practice that significantly enhances their nutritional benefit compared with filleted or larger fish, where nutrient-dense parts such as the head, bones and organs are often discarded.

One of the most striking features of SIS is their concentration of essential micronutrients. Species such as *Amblypharyngodon mola*, *Esomus danricus*, *Osteobrama cotio* and *Corica soborna* are especially rich in vitamin A, which is crucial for maintaining vision, immunity and cellular growth. Studies indicate that the vitamin A content in some SIS is so high that a small portion can fulfil a substantial part of the recommended nutrient intake (RNI) for children and adults. In fact, 1 kg of SIS may contain as much vitamin A and minerals as 50 kg of larger fish, such as Indian major carps (IMCs) (Roos et al., 2007).

In addition to vitamin A, SIS are excellent sources of iron, zinc, iodine, calcium and vitamin B12, all commonly deficient in cereal-based diets prevalent in low-income households. Iron from SIS, particularly from their blood-rich organs, contributes to reducing anaemia; zinc supports growth and immune function; calcium from the bones aids bone development and maintenance; and vitamin B12, found in the flesh and organs, is essential for neurological health.

These nutrients are especially important in vulnerable groups such as pregnant women, children and the elderly (Suo et al., 2021). SIS also provide high-quality animal protein and essential fatty acids such as omega-3 (EPA and DHA), which are key to brain development and cardiovascular health. Unlike plant-based sources, the protein in fish is more bioavailable - easily digested and absorbed by the human body. The fat content in SIS, though lower than in marine fish, includes important polyunsaturated fats that help reduce inflammation and support heart health (Thilsted et al., 1997).

Their nutrient profile is particularly beneficial in addressing the “double burden of malnutrition”, where communities face both undernutrition and micronutrient deficiency. For food-insecure households that may struggle to afford meat, dairy or diverse vegetables, SIS are an essential, low-cost dietary component to meet daily nutrient needs (Banna et al., 2022). Furthermore, SIS are seasonally abundant, especially during the monsoon and floodplain expansion, making them a natural solution for seasonal dietary gaps. Integrating them into regular diets can markedly improve nutrient intake without major lifestyle or culinary changes, especially in regions where they are already part of traditional food systems.

However, the nutritional richness of SIS is not yet fully utilised due to limited data, underdeveloped processing methods and low commercial value. There is an urgent need for more nutrient-composition studies, standardised processing and strategies for better year-round availability. Enhancing awareness and accessibility of SIS through nutrition-sensitive policies could play a transformative role in public health nutrition.

Captive breeding potential of SIS

Captive breeding refers to the controlled reproduction of animals, including fish, within specially managed environments rather than in their natural habitats. This practice has become an essential tool for conserving vulnerable or underutilised species, promoting sustainable aquaculture and ensuring long-term food and nutrition security. In the context of freshwater fish, especially small indigenous species, captive breeding holds significant promise. These small-sized, nutrient-dense fish are crucial in the diets of low-income communities. However, many SIS face threats from habitat loss, overfishing, pollution and being mistakenly treated as “trash fish” in intensive aquaculture systems.

Captive breeding presents an opportunity to protect and propagate these native species, while also supporting year-round availability and easing pressure on wild populations. The goal is not just to conserve these species, but also to culture and promote them actively, much like larger commercial fish (e.g. catla, rohu, pangas). This involves developing dedicated breeding programmes, maintaining genetic diversity to avoid inbreeding and mimicking natural environmental conditions such as appropriate water quality, space, temperature and feeding patterns.

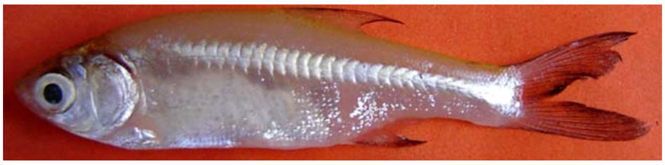
Harvest of farmed small Indigenous fish species.

By creating a controlled breeding environment, SIS populations can be stabilised and farming practices promoted. This approach also allows researchers and fishery experts to study growth rates, reproductive behaviours and micronutrient retention under captive conditions, data that can further improve farming and processing techniques. Moreover, captive breeding of SIS can play a critical role in sustainable aquaculture, as these species are often prolific breeders, require minimal inputs and coexist well with other fish in polyculture systems. This means farmers can rear SIS alongside larger fish to increase overall pond productivity while also diversifying the nutritional offerings from aquaculture.

From a conservation standpoint, such programmes can also safeguard endangered or declining SIS by maintaining broodstock in hatcheries and potentially reintroducing them into the wild when needed. Furthermore, increasing the captive-bred supply of SIS could reduce reliance on wild harvests and help curb destructive fishing practices, while opening doors to value-added products for domestic and export markets.

Mola (*Amblypharyngodon mola*)

A. mola, commonly referred to as moa, mourala, mowka, moya or mola carplet, is a small freshwater fish valued for its high nutritional content, particularly essential fatty acids (EFAs), minerals and vitamin A. This species reaches sexual maturity as early as three months of age and exhibits fractional spawning behaviour. The eggs of *A. mola* are slightly adhesive, meaning that the presence of a suitable substrate can significantly enhance both spawning success and hatching rates. Length at first maturity ranges from 3.57-9.94 cm in females and 3.69-8.88 cm in males. Under

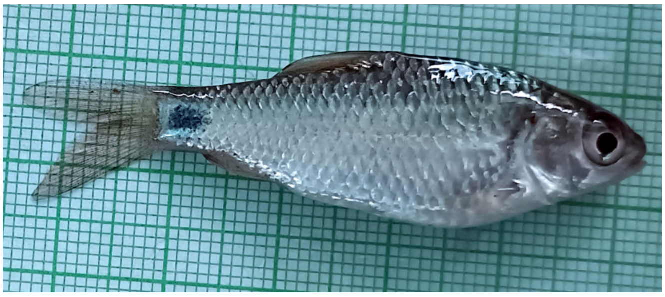


Mola (Amblypharyngodon mola).

optimal conditions, such as a temperature of 27 °C, larval development typically takes about 72 h (Rajts, Belton & Thilsted, 2022).

Puti (*Puntius sophore*)

P. sophore, commonly known as katcha-karawa, phabounga, bhadi punti, jat punti, jatputi, puti or sarputi, is mainly herbivorous. It reaches sexual maturity at a length of about 5 cm, with males showing reddish colouration during the breeding season. It is naturally a pre-monsoon to monsoon spawner, breeding from March to July, though this may vary by region due to environmental conditions. Fecundity ranges from 1,560 to 6,942 eggs, with mature egg diameter around 0.7 mm (Das, 2013).



Puti (*Puntius sophore*).

Climbing perch (*Anabas testudineus*)

A. testudineus, commonly known as koi, kai or kawai. Fecundity ranges from 300-400 eggs per g body weight of the female. The fertilised eggs are incubated in stagnant water in plastic tubs or fibre-reinforced plastic (FRP) tanks. Incubation time is 12-15 h at 26-28 °C water temperature. The newly hatched larvae measure 1.6-1.8 mm in length and rest in an upside-down position. A 2:1 male-to-female ratio was maintained during breeding. Spawning occurred in nylon hapas equipped with *Hydrilla verticillata* as a substrate for egg collection. For induced breeding, females received intramuscular injections of synthetic gonadotropin-releasing hormone (sGnRH). This hormone effectively reduced the latency period, increased egg output and improved fertilisation and hatching success (Sarkar et al., 2005).

Climbing perch (Anabas testudiens).

Peacock eel (*Macrognathus aral*)

Also known as the spiny eel, *M. aral* belongs to the family Mastacembelidae and is distributed across Asia and Africa. In Asia, the genus *Macrognathus* comprises 25 species, while *Mastacembelus* includes 17 species.

Fecundity and ova characteristics

M. aral is considered a low-fecundity species, with total fecundity ranging from 1,000 to 5,000 eggs. A recent study (2023) reported an average fecundity of 1,250 eggs. The ripe ova are dark green in colour, with an average diameter of 0.74 mm.

Hormone-induced breeding

Attempts to breed wild *M. aral* using commercial hormone injections showed that the fish responded after a 20-25 h latency period. The spawned eggs were green in colour and required a suitable substrate for attachment. This method shows potential for controlled breeding in aquaculture settings (Aquaculture Spectrum, Peacock eel, 2024).

Climbing perch (*Anabas testudiens*).

Dhela (*Osteobrama cotio*)

Osteobrama cotio (Hamilton, 1822), also called dhela hafo (Assamese), gila khani or keti (Froese & Pauly, 2021), is a small indigenous species found across Pakistan, India, Nepal and Bangladesh. Adults typically reach a maximum length of about 15 cm. Nutritionally, dhela is rich in calcium, selenium and vitamin A, making it beneficial for human health.

The breeding season begins with the onset of the monsoon in May, peaks in June and July, and concludes before September. Fecundity ranges from 512 to 6,849 eggs, depending on the size of the fish. The gonadosomatic index (GSI) reaches a maximum of 15.31 in June, indicating peak gonadal development, and declines to 3.79 by September, signalling the end of the breeding season.

In aquaculture trials, dhela demonstrated an 83.56% survival rate and nearly tripled its initial weight over four months. Despite this growth, the fish did not reproduce in ponds, likely due to late stocking and unsuitable pond conditions. Consequently, dhela's biomass at harvest represented a

Dhela (Osteobrama cotio).

modest 4.87% of the total, suggesting limited competition with other species such as carps in polyculture systems (Kunda et al., 2014).

Pabda (*Ompok bimaculatus*)

This fish, commonly known as the Indian butter catfish or pabda, is a non-air-breathing freshwater catfish native to South and Southeast Asia. The species faces challenges in captivity, as it does not typically spawn under controlled conditions, complicating conservation and aquaculture development. Fish attain first maturity at one year; males and females become mature from April to July. The breeding season extends from early June to late July.

In many fish species, males and females exhibit distinct external characteristics, aiding identification. Males often possess prominent pectoral-fin serrations, which are absent in females. Generally, males are smaller, more slender and more translucent with less pigmentation than females. The genital papilla in males is typically elongated and pointed or conical. In contrast, females tend to be larger, with a soft, rounded, bulging abdomen. Their genital papilla is fleshy, round and large, with a reddish vent.

Fecundity ranges from 2,000 to 30,000 eggs per female, with the number of mature ova per g of ovary varying between 950 and 1,090. Ripe brooders weighing approximately 40 g or more are optimal for induced breeding. Induced breeding can be achieved by administering synthetic hormones such as Ovatide, Gonadoprim, Ovasis or Wova-FH at doses of 1.5-2.0 mL/kg body weight for females and 0.5-1.0 mL/kg for males. The hormone is injected intramuscularly at the base of the pectoral fin, or between the base of the dorsal fin and the lateral line. After hormone administration, brooders are transferred to a breeding hapa or pool. Females are stripped for spawning by gently applying pressure to the abdomen 8-12 h post-injection, and eggs are collected in a dry enamel or plastic tray. Males are sacrificed to remove testes, which are then macerated in normal saline to prepare a sperm suspension. The sperm suspension is spread over the collected eggs and mixed gently using a bird feather to facilitate fertilisation. A small amount of distilled water can be added to activate the sperm.

The fertilised eggs are thoroughly washed with freshwater, cleaned and transferred to a specially designed hatchery or a simple flow-through system for incubation. Egg incubation is typically carried out using a flow-through system comprising plastic tubs or circular FRP tanks equipped with individual water inlets and outlets. The fertilised eggs are evenly distributed across the containers, and a gentle water current is maintained to facilitate hatching. Optimal hatching occurs at a water temperature of 27-30°C, with hatching completed within 22-24 h post-fertilisation.

The newly hatched larvae are transparent, cylindrical and lack a mouth, pectoral fins and body pigments. The yolk sac is pale greenish in colour and is fully absorbed within three days. For improved embryonic development and hatching success, soft water with low alkalinity is recommended. The mouth of the larvae begins to open by the second day, and a small amount of live feed is provided from that day onwards. During the rearing period, cannibalism is observed from the second day onwards, wherein healthy larvae prey upon weaker ones. Therefore, thinning the density of stocked spawn and subsequent segregation based on size is essential; this is done using nets of different mesh sizes. Fish larvae are fed ad libitum with a heterogeneous mixture of live zooplankton alone up to the 7th day (NFDB, 2018).

Brackish-water catfish, *Mystus gulio*

Mystus gulio, commonly known as whisker catfish, is a high-valued brackish-water catfish. In this species, males and females can be readily distinguished: males have a distinct muscular papilla with a pinkish tip, whereas females have a round genital vent. *M. gulio* typically spawns during the monsoon season, with peak breeding varying by region, often in July or between September and October. Fecundity ranges from about 5,950 to 141,210 eggs in individuals measuring 14.5-23.0 cm. The highest reproductive activity occurs in July,

Pabda (*Ompok bimaculatus*).

marked by peak gonadosomatic index (GSI) values and fully mature ovaries. GSI rises from March, peaks in July and then gradually declines through December.

For induced breeding of *M. gulio*, several hormones have been used successfully. Ovaprim is commonly administered at a dose of 2.5 mL/kg body weight for females and 1.0 mL/kg for males, though some studies report effective spawning with a single dose of 1.0 mL/kg for both sexes. Carp pituitary extract has also been used, with females receiving two doses of 15 mg/kg body weight at a 6 h interval, and males receiving the same dose at the time of the second female injection (Kumar et al., 2019).

Brackishwater catfish, Mystus gulio.

Gangetic mystus, *Mystus cavasius*

Mystus cavasius, commonly known as the Gangetic mystus, is a freshwater catfish belonging to the family Bagridae. It has an elongated, laterally compressed body and a distinctly conical head, with a narrow occipital process. A distinguishing feature is a dark spot located just before the origin of the first dorsal spine, typically highlighted by a contrasting white or pale patch along the ventral edge of the mark. The dorsal, adipose and caudal fins are usually pigmented with melanophores, giving them a shaded appearance.

Despite its ecological significance, the population of *M. cavasius* has been declining in recent years. Contributing factors include excessive capture for food and the ornamental fish trade, as well as degradation and loss of freshwater habitats. Conservation measures and habitat protection are crucial to prevent further reductions and to ensure the long-term survival of this species within its native range (Chakrabarty & Ng, 2005).

The captive breeding of SIS is a forward-thinking approach to conservation and aquaculture production that will support the food security of rural communities. It reflects a shift towards recognising the potential of small fish not only as food but as a sustainable, regenerative resource that merits protection, propagation and promotion, alongside commercially dominant species.

Gangetic Mystus, Mystus cavasius.

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