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.

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.

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.

- 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.

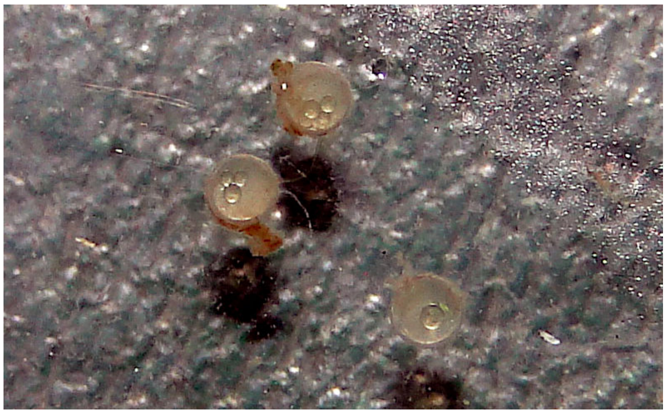

Fig. 8a: Freshly laid fertilised eggs with oil droplets.

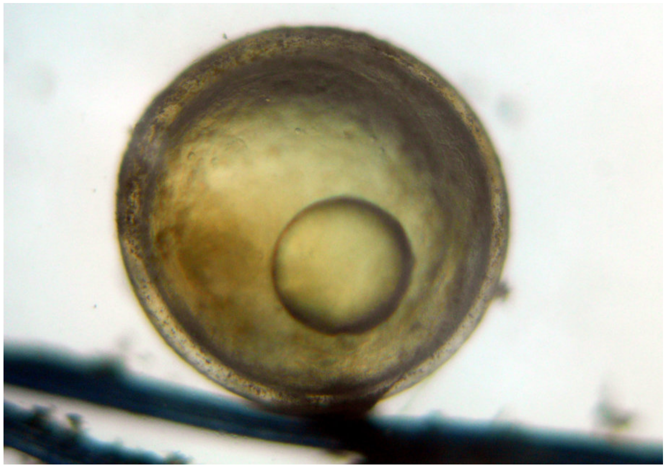

Fig. 8b: A one day old egg.

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

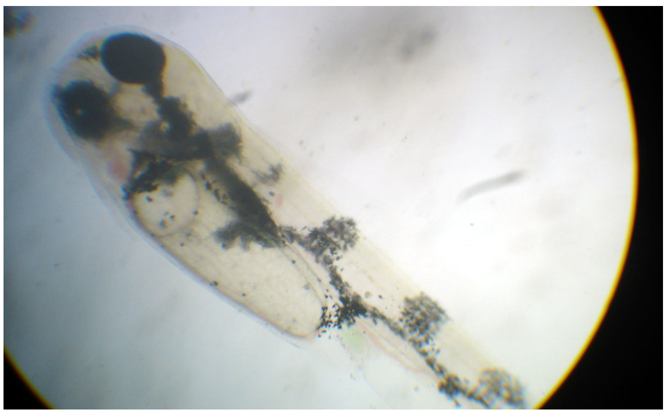

Fig. 9b: One day old larva.

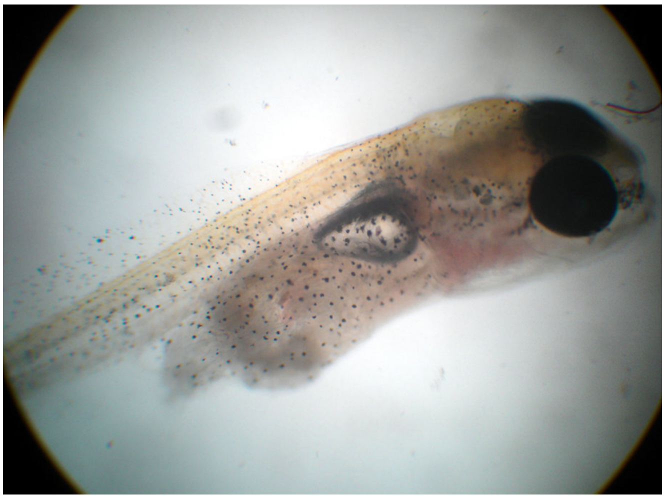
Fig. 9c: A 7 day old larva.


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*.

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Fig. 11b: A haul of fingerlings.


Fig. 12: Management is required to avoid cannibalism.