Improved larval rearing of *Heteropneustes fossilis* with live fish food organism - a method practised in the farmer's field

R. N. Mandal[1*], Kabyashree Bala[2], B. N. Paul[1], A Das[1], S. Adhikari[1], H. Houque[1], A. Hussan[1], S. Sarkar[1], and P. K. Sahoo[3]

1. Regional Research Station, ICAR-CIFA, Rahara, Kolkata 700118, India; 2. Dept. of aquaculture, WBUAFSc, Chak Garia, Kolkata 700094, India; 3. ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Odisha, India.
**Email: rnmandal1964@gmail.com*

Segregated larvae collected from chamber.

Stinging catfish or singhi, *Heteropneustes fossilis*, belongs to the family Heteropneustidae. It has red-brown or brownish-blackish skin with a slender, flattened body. One healthy adult has an average length of 18.0 cm. Male and female brooders weigh 70-80 g and 100-120 g respectively. The head is flattened. Bony plates cover the top and sides. The snout is flat and rounded. The mouth is small, terminal, and transverse, with the upper jaw slightly longer. The eyes are small, lateral, and sit in the anterior part of the head. The nostrils are placed apart. The fish has four pairs of barbels. Maxillary barbels extend to the pectoral fin or pelvic base. Mandibular barbels extend beyond the pectoral fin ends. Nasal barbels reach the middle of the pectoral. The species has accessory air-breathing organs, which enable it to survive in water with low oxygen levels or in shallow water bodies. It also lives in freshwater habitats such as ponds, canals, swamps, marshes, and muddy rivers. It can survive on land for a considerable period because of its accessory air-breathing organ. *H. fossilis* is commonly found in Asian countries, including India, Bangladesh, Pakistan, Nepal, Sri Lanka, Myanmar, Vietnam, and Thailand. In 2017, the IUCN categorised the species as 'least concern' in the IUCN Red List of Threatened Species.

A pair of male and female singhi, Heteropneustes fossilis.

Nutrients profile and medicinal importance

H. fossilis has a rich nutrient profile (amounts per 100 g): calories, 119.50 kcal (27.97 kcal and 91.53 kcal from fat and protein respectively); protein, 16.12 g; total fat, 2.96 g (monounsaturated fat 1.08 g, polyunsaturated fat 0.41 g, omega-3 fatty acid 184.4 mg, omega-6 fatty acid 225 mg, and EPA+DHA 153.90 mg); vitamins (per 100 g): A 49.68 IU, D 197.20 IU, E 0.19 IU, K 1.63 mcg; minerals (per 100 g): Ca 221.37 mg, P 185.68 mg, Na 200.04 mg, K 113.53 mg, Fe 2.32 mg, Mn 0.29 mg, Zinc 1.30 mg, Se 0.31 mg, ash 2.72 g; and moisture, 74.61 g (Paul et al. 2015).

Because of its beneficial nutrient profile, people use it as a medicinal diet to treat different health ailments. Communities also know it through indigenous traditional knowledge for treating many ailments. People consume boiled singhi as a tonic to treat anaemia. They eat singhi cooked with black pepper to relieve pain and promote wound healing. Lactating mothers consume boiled singhi to regain strength after delivery and remove physical weakness.

Larval rearing - a critical stage for survival

Catfish, murrels, and their juveniles, as well as all ornamental fish, prefer to eat live food organisms. Recent progress in developing manufactured diets for fish larvae has yet to provide an alternative for feeding juveniles. Fish larvae are naturally adapted to capture moving prey and are generally visual feeders. In their early stage, they chase organisms that move in the water. Such movement of live food stimulates larval appetite to capture prey.

Live foods are categorised into various groups, including phytoplankton, zooplankton, benthos, nekton, periphyton, and others. Diverse groups of live foods with different sizes are important sources of nutrition, supporting larval survival and growth through easy digestibility and nourishment. In most fish and prawn species, the larval phase is the most critical phase of the life cycle. Live foods contribute immensely to the growth and survival of larvae during their rearing and are considered ‘living capsules of nutrition’.

Why live foods?

Live foods offer the following advantages:

- Early stages of most species feed on live foods.
- Live foods provide suitable diets for various developmental stages of fish species. Farmers can cultivate more finfish and shellfish species as rearing techniques and mass production of live foods advance.
- Live foods include species of microalgae. Farmers use them as food through the ‘green water’ technique for larval rearing, with zooplankton as part of co-feeding.
- Microalgal biomass culture helps maintain water quality in aquaculture. It also supports feeding, digestion, nutrition, nourishment, and overall growth of the larvae. Farmers use zooplankton as live foods either as single items or by way of co-feeding.

Advantages of live foods feeding to larvae

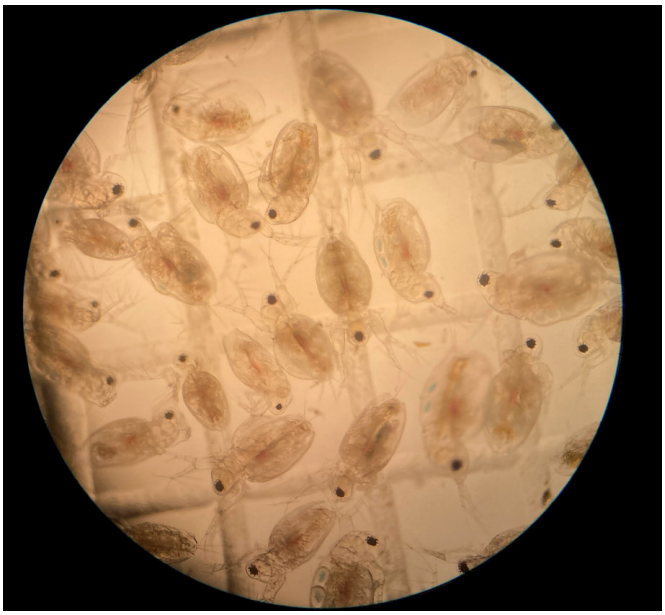
In an ecosystem, organisms at different trophic levels are linked through food webs and feeding patterns. Organisms that feed on others are again fed upon by other organisms at higher trophic levels. Fish larvae prefer to feed on live foods because of advantages from an evolutionary perspective, as follows.

Behavioural adaptation

Naturally, the juvenile phase of fish and prawn species prefer live foods. The larval stages requires compatible nourishment, which promotes early-stage growth. Diverse groups of live foods with the right nutrients support their early growth. The

Adult Moina.

larvae usually have an an undeveloped intestine which may lack the required amount of enzymes to digest artificial feed, at least in the early stages. Instead, they prefer suitable natural food available in the aquatic system. Moreover, at such a stage, larvae may not be used to accepting manufactured feed, which requires training for weaning. Ingredients in manufactured feed may not be suitable for larval nourishment, whereas adults might accept and prefer them.



Moina on Sedgwick Rafter Plankton counting cell.

Life form importance

Live foods have appropriate cell sizes that meet the demands of fish larvae, along with short life cycles. Fish larvae can easily access them through water currents. They can tolerate environmental variation. They have a thin skeleton that is easily digestible.

Nutritional importance

Live foods have adequate nutritional value with high digestibility, which boosts larval growth. They have high water content (>80%) and lower nutrient concentration, which seems suitably palatable.

ICAR-CIFA reaching out to farmers for larval rearing with live fish food organisms

Scientists practise mass culture of live fish food organisms in the outdoor system at ICAR-CIFA. They produce live foods to feed larvae and increase their survival. Larvae of catfish and murrels prefer live foods, and their survival increases after feeding. Farmers who rear catfish larvae, particularly *H. fossilis*, necessarily require the techniques of live food production. The progress of Mr Imran Molla, among others, is remarkable for the production of *Moina* sp., a zooplankton belonging to Cladocera, a suborder of crustaceans.

Senior author and Mr. Imran Mollah with live foods banner.

Hands-on training on culture of *Moina* sp.

Mr Imran Molla is a resident of Uluberia subdivision of Howrah district, West Bengal, India. He was not able to raise the desired number of larvae of *H. fossilis*. He believed that feeding live food to H. fossilis might be the way forward for obtaining desirable larval survival. He came to RRC, ICAR-CIFA, Rahara to learn the techniques of live food rearing, particularly *Moina* sp., which, among other live foods, seems a preferable food for larvae of H. fossilis. He received training in *Moina* rearing with the following steps: (i) identification of *Moina*, (ii) segregation of *Moina* through sieving with plankton nets from pond-collected mixed plankton, (iii) collection of individual *Moina* with the help of a simple microscope, (iv) conditioning of isolated *Moina* in a beaker with underground bore-well water, (v) culture of *Moina* in a small aquarium (length 15 cm × width 12 cm × height 12 cm), (vi) shifting of *Moina* culture into FRP tanks of 1,000 L capacity. Mr Molla then produced *Moina* with different resources and manures: waste bread, mustard oil cake, and meat juice. The combination of carbohydrate, fat, and protein boosts the growth of *Moina*.

Mr Molla's larval rearing of singhi - a success story

Mr Molla has several cemented tanks partitioned into several compartments, each with a respective length, width, and height of 1.2 m × 1.0 m × 1.0 m. He uses each compartment for conditioning five different age groups of singhi larvae: 4-6 days, 7-10 days, 11-18 days, 19-25 days, and 26-35 days. Mr Molla maintains the specified age groups as far as possible and segregates such age groups for better management of larval rearing to reduce cannibalism. Mr Molla observed that cannibalism seems more aggressive in the early age groups of larvae than in older ones. For this reason, he segregates those larvae that are close in age groups, having uniform size.

Population of Moina as segregated in beakers.

Cemented tanks used for Moina rearing.

Mr Molla's effort to culture *Moina* in an outdoor system to feed singhi larvae

Mr Molla has been enthusiastic and confident about the culture of *Moina* in his farm after receiving training. He established 25 tanks, each with 12,000 L capacity, in an open ground near his residential area. Each circular tank is made of a thick polythene sheet supported with a steel-made thick ring so that it will not be squeezed by outer air pressure and will not get ruptured by water pressure within the tank. He covers each tank on the upper side with a green shade nylon net to prevent direct sunlight inside the tank. He unfolds the cover to allow the entry of air when the intensity of the sun is favourable. Mr Molla cultures *Moina* with substances such as waste bread, meat juice, and mustard oil cake in these tanks. A huge number of *Moina* grow in each tank. He maintains two ways of feeding larvae. Firstly, he collects *Moina* from his polythene tanks with plankton nets and segregates them with different mesh sizes of plankton nets. He gives smaller *Moina* to early age groups of larvae, whilst he gives the adult ones to aged larvae, which he segregates and keeps in cemented tanks earmarked for each age group. Secondly, he collects different age groups of larvae and puts them separately into different polyethylene tanks for rearing. The operation of all these activities, as mentioned, is not static but changes as per the situation that arises. Sometimes, he uses 25 tanks exclusively for *Moina* production during the off-season. In peak season, he uses a few tanks for *Moina* production whilst he uses other tanks for raising larvae in huge numbers for farmers as demand increases.

Moina feeding to boost survival of singhi larvae

The mouth aperture of *H. fossilis* larvae is small and terminal. It has a transverse opening and develops within a few hours after hatching. By 72 hours post-hatching, the size of the mouth aperture increases with time. The mouth opens around 12 hours post-hatching. After four days, the larvae are steadily ready for feeding live foods after the disappearance of the yolk sac. On the fourth day, the mouth aperture measures an average of 650 µm, with a wide range of variation observed. The fourth-day mouth aperture of H. fossilis is suitable for feeding juvenile *Moina*, as observed on Mr Molla's farm.

Production of *H. fossilis* larvae through a unique method of feeding

Mr Molla rears singhi larvae for one month and then sells his larvae. He produces an average of 42,000 fry from each circular polyethylene tank. When the weight of an average of 3,000 fry becomes 1.0 kg, it is known as the '3,000 line'

Segregated larvae are placed different containers.

Table 1. Calculation of singhi fry production and earning

Criteria	'3,000 line' (average)	'2,500 line' (average)
Understanding	3,000/kg	2,500/kg
Production	14 kg × 3,000 = 42,000 numbers/tank	12kg× 2,500=30,000/tank
Cost	INR 2.50/individual fry	INR 4.00/individual fry
Earning	INR 2.50 × 42,000 = 105,000	INR 4.00 × 30,000 =120,000
Duration	30 days	40 days
Gross earning from 25 tanks	INR 105,000 × 25 = 2,625,000	INR 120,000 × 25 = 3,000,000
Remark	Most preferable	Less preferable due to risk involvement

as per business procedure for understanding between buyer and seller. Mr Molla produces an average of 14 kg of '3,000 line' (42,000 individuals/14 kg = 3,000/kg) fry from each circular tank. In a '3,000 line' fry, one fry costs around Rs 2.50 (US$0.03), and the cost of 14 kg fry becomes Rs 105,000 (US$1,396), which is earned per tank. He produces one million singhi fry monthly from 25 circular polythene tanks by feeding only *Moina* and earns Rs 2,500,000 (US$33,245) from one breeding season. However, the '3,000 line' may be changed to the '2,500 line' when buyers demand larger-sized fry. In such cases, the cost of a single fry becomes higher, around Rs 4.0 (US$0.05). Then he obtains an average of 12 kg of fry of the '2,500 line' from the single circular tank, and the cost of 12 kg of fry becomes Rs 120,000 (US$1,596), which is earned per tank. However, growing larger fry is always risky because of space constraints, cannibalism, disease, and feeding due to a shortage of live foods. Mr Molla always prefers producing '3,000 line' fry.

Management of larval rearing in tanks

Rearing singhi larvae requires the utmost care. Any negligence in managing larval rearing leads to catastrophe. Mr Molla provides care 24 hours a day, 7 days a week, for rearing singhi larvae. He performs exchange of water, feeding, production of *Moina*, and its application to larval rearing tanks. He also checks cannibalism, growth, and survival in the tanks. Together, all these activities require sincere effort. Mr Molla prefers larval feeding with *Moina*

Mr. Imran Mollah with Scientists and students of ICAR-CIFA.

for the following reasons: (i) water exchange is not always required as compared to manufactured feed, (ii) the application of manufactured feed is not suitable for feeding small larvae, which prefer live foods as an instinctive behaviour, (iii) the application of manufactured feed requires weaning, for which extra effort is needed, (iv) application of manufactured feeds leads to water quality deterioration, which may cause severe larval mortality, (v) application of live foods requires less management care, and maximal survival is achieved. Mr Molla prefers 30 days of rearing to 40 days because when the days increase, the risk of fry mortality may be higher. In larval rearing, increasing days, by and large, invites more risks. However, 30 days of rearing is optimal for larval sale for which buyers are available, except for a few who prefer 40 days of rearing larvae. When the availability of *Moina* is less than required, Mr Molla uses manufactured feed after grinding, followed by sieving. He uses the powder of manufactured feed along with *Moina* for larval rearing as co-feeding.

Conclusion

Larval rearing of singhi with *Moina* feeding is unique and replicable. Mr Molla developed the method for rearing singhi exclusively with *Moina* feeding, which may encourage other farmers to follow. This is cost-effective, environment-friendly, and easy to learn. Moreover, larval rearing with live foods is a natural phenomenon for which management is minimal.

Collected larvae of larger size.

Polythene tanks for rearing H. fossilis seed.

On the contrary, the method of feeding manufactured diet to singhi larvae is costly, time-consuming, and has a poor chance of larval survival. The way by which singhi farming extends requires versatile methods of larval rearing. The advantage of diverse methods of larval feeding is essential because if any method fails, others may compensate to support larval survival; otherwise, farming may suffer.

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