Culture of hilsa, *Tenualosa ilisha* in freshwater ponds: Progress and prospects in farming practice

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A table-sized hilsa.

Hilsa shad, *Tenualosa ilisha* (order Clupiformes, subfamily Alosinae) is an anadromous marine fish of high economic value, and the most preferred food fish to people of Bay of Bengal region, particularly West Bengal, India and Bangladesh. Not only because it has a unique taste, but also because it has an aesthetic appeal to consumers and has socio-cultural importance. Hilsa is a rich source of protein (18-23%), essential amino acids, vitamins and minerals essential to human health (Hossain et al., 2014). Hilsa is also a good source of n-3 polyunsaturated fatty acids (PUFAs), particularly eicosapentaenoic acid and docosahexaenoic acid. The n-3 PUFAs play a vital role in the development and function of the nervous system (brain), photoreception (vision) and the reproductive performance (Sidhu, 2003). They reduce the risk of cardiovascular ailments, coronary heart disease, inflammation, hypertension, hypertriglyceridemic effect, allergies, arthritis, autoimmune disorders and cancers (Sidhu, 2003; Von Sckacky, 2003; Mnari et al., 2007).

Migration of hilsa between river and sea

Hilsa have a complex and migratory life cycle. During breeding season adults migrate from the sea to the freshwater reaches of rivers via their estuaries. On the Indian subcontinent, hilsa migrates from the Bay of Bengal to the Hooghly River in India and to the Padma River in Bangladesh twice a year during September-October and February-April. Hilsa breed in the river and then return to the sea. Their ferti-

lised eggs hatch and grow to fingerling and juvenile stage in freshwater, before the fish begin to move towards the estuary and the sea.

Initiative for domestication of hilsa

Alarmingly, the population of hilsa has been declining very fast due to over exploitation and indiscriminate catch from inland open water systems. Besides, the breeding and nursery grounds in the river are highly disturbed and thereby, breeding and the different life stages are stressed, resulting in lower recruitment over successive generations. In this context, the strategic plan for their conservation is to culture them in captivity, for it needs to be domesticated in pond - a challenge be prioritised. ICAR-CIFA has initiated a program of hilsa domestication and overcome some of the critical limitations for achieving the task through initiatives including onboard breeding, transport of fertilised eggs, rearing fertilised eggs in hatching pools, rearing of larvae, fry and fingerlings through co-feeding, weaning the fish at early stage with supplementary feeds and pond management for hilsa. Until now, the onboard breeding, transport and culture techniques of hilsa are limited to the extent by which farmers are able to culture them in ponds. The success of hilsa culture in the farmer's pond is achieved through scientific intervention of ICAR-CIFA in support with the carp culture experiences of the farmers.

Hilsa research towards farming practice

Different technologies of hilsa culture were tested on a trial-and-error basis and then established by ICAR-CIFA in its Regional Research Centre at Kalyani Field Station, Rahara. But it was felt necessary to validate the techniques on farm. In search of a suitable fish farmer, the person who was immediately identified was none other than Mr Shyama Charan Chatterjee, Magra, Hooghly District, West Bengal. Mr Chatterjee is a progressive fish farmer as well as a known fish seed producer in the country, with vast experience in carp breeding and culture. He was selected to initiate and propagate hilsa culture under the technical guidance of ICAR-CIFA as he possessed a well-established breeding pool, Chinese hatcheries and several ponds used for nursery, rearing, stocking and broodstock holding in his 14-hectare property, which were deemed suitable for hilsa farming. More and above, he bears a keen interest and is enthusiastic enough to venture such

Packing polythene bags with fertilised eggs into carton for transport.

Observing incubated eggs.

Below: Scientists of RRC, Rahara, observing hilsa fry.

a new initiative. Hilsa culture was initiated in his freshwater ponds with the usual activities: Pond selection, analyses of water quality, and preliminary guidelines including netting, application of live foods, feeding and sampling. Initially, during December 2016, a minimal quantity of hilsa seed were supplied from Kalyani Field Station of RRC, Rahara, ICAR-CIFA and stocked in his pond as a trial to observe the survival of the fry. Subsequently, during April, June and July 2017, fry, fingerlings and yearlings of hilsa were supplied further and stocked to his other two ponds of 0.1 ha each.

Nurturing the farmer's team

To strengthen the knowledge, skill and attitude in hilsa farming, the farmer and his field staff were provided with on-farm guidance on different aspects of artificial breeding and culture technologies of hilsa through frequent visits by the scientists of RRC, Rahara of ICAR-CIFA.

Activities included:

- Onboard artificial breeding of hilsa.
- Transportation of fertilised eggs (refer article in previous issue).
- Egg incubation and spawn production in cement carp hatchery.
- Spawn collection and stocking in nursery ponds.
- *Chlorella* and rotifer culture.
- Handling techniques of hilsa egg, spawn, fry, fingerlings, table-sized fish and broodstock.
- Weaning procedure for hilsa fry.

Above, below: Releasing spawn into nursery ponds.

- Pond management, including feeding schedule.
- Juvenile rearing in pond, including spawn to fry, fry to fingerlings, fingerlings to table size fish production and development of broodstock.

To develop hilsa culture practice in Mr Chatterjee's ponds, he was provided the immediate needs of some critical culture-inputs such as fertilised eggs, fry, fingerlings and supplementary feed. The ultimate long-term aim was to establish hilsa husbandry including raising of hilsa broodstock

Provision of aeration to hilsa fry in the nursery pond.

in freshwater ponds so that domesticated breeding of pond raised hilsa could be conducted to overcome the constraints on dependency of wild caught hilsa broodstock.

Onboard breeding and spawn production in the farmer's hatchery

During March 2018, consecutive onboard breeding trials of hilsa were conducted in the Hooghly River at Godakhali, South 24 Parganas, West Bengal, India. The live broodstock were directly collected on the motor boat from traditional fishermen as soon as they caught them from the river with nylon monofilament nets from their conventional fishing boats. Immediately after collection, females were stripped of eggs, followed by stripping of the males for milt in a steel tray, using the dry stripping method. Collected eggs were intermingled with milt by means of a soft feather, resulting in an average of 95% fertilisation over different trials. After water hardening for an hour, fertilised eggs were packed with oxygen filled polyethylene bags and transported by four wheeler motor vehicle to the Kalyani Field station of RRC, ICAR-CIFA, Rahara 120 km away, and to the Chatterjee Brothers farm, Magra some 133 km distant from the breeding spot. Fertilised eggs were then incubated in the modified FRP hatchery at the Kalayni Centre and in the cement carp hatcheries of Chatterjee's farm. Continuous surveillance was undertaken to study the possibility of hatching and producing larvae in the carp hatchery. By the technical guidance and continuous monitoring of the scientists of ICAR-CIFA, the farmer's hatchery successfully produced around 350,000 four-day old larvae, ready to stock in the nursery pond for fry production. This is the first recorded production of hilsa spawn in a cement carp hatchery in a farmer's ponds. The spawn was stocked in two rectangular cemented cisterns (modified Bangla bundh) and in two nursery ponds.

With the encouraging result, the next breeding trials were conducted in a similar way in February, March and April 2019 and the fertilised eggs were transported to RRC, ICAR-CIFA, Rahara and farmer's ponds at Magra in a similar way as before. In both places, fertilised eggs were incubated in cement carp hatcheries. The purpose was to obtain the mass scale spawn production of hilsa in hatcheries in different locations with different water quality. A great success was achieved and an estimated total number of 1.05 million hilsa spawn were produced in the farmer's hatcheries.

Larval rearing in farmer's ponds

Pond preparation

Fifteen days before the breeding operation was undertaken in the farmer ponds (0.1- 0.2 ha) were dried and cleaned with removal of fishes, and kept empty under sunlight for 7-10 days. When the fertilised eggs hatched, the ponds were filled with bore water up to 1.0 m depth. No fertilisers were applied to the ponds. The surface water of the ponds above 1.0m height was entirely covered with nylon monofilament net to prevent the entry of predatory birds – a serious threat to juveniles.

Hilsa fingerlings.

Counting hilsa fingerlings before release into the pond.

Fingerlings packed into polythene bags for transfer to another pond.

Releasing fingerlings into the pond.

Feeding larvae

Larval rearing of hilsa requires the utmost care and monitoring. The mouth of the larvae seems open on the 4th day, when they require exogenous natural foods. At this critical stage, the larvae were transferred from the hatching pool and stocked into the nursery pond. The larvae first feed on *Chlorella* (green water) as a starter food due to their small mouth gape. With increasing size, they feed on other phytoplankton, and rotifers, followed by large zooplankton. Therefore, the initial food supplied to them was *Chlorella*, even in the hatching pool. In the nursery pond, *Chlorella* water was supplied every day until they attained 50-60 mm fry stage, within 40-60 days.

Production of *Chlorella* to increase the amount of green water

The mass production of *Chlorella* was conducted in outdoor large cement hatching pools where direct sunlight was available. After thorough cleaning with bleaching powder and washing with bore-well water, the hatching pools were filled with freshwater. Ammonium sulphate, urea and single super phosphate @ 0.1g/L, 0.01g/L and 0.01g/L, respectively were added and mixed thoroughly. *Chlorella* inoculum, which is maintained in the RRC laboratory, Rahara, was added and the inoculated water was stirred twice daily. Normally within 4-6 days, *Chlorella* inoculated water turns green as the organisms multiply.

Co-feeding: An essential technique for larval rearing

After 2-3 days of larval stocking, co-feeding was initiated with application of rotifers (*Brachionus* sp.) along with *Chlorella*. In co-feeding, hilsa larvae feed on both *Chlorella* and *Brachionus* sp. while *Brachionus* feed on only *Chlorella* for its growth and survival. Therefore, the supply of *Chlorella* serves two purposes: (i) used as food for both hilsa larvae and *Brachionus* which grow profusely within 2-3 days, and (ii) increase of dissolved oxygen levels through photosynthesis.

Netting hilsa for sampling.

A 500 g mature hilsa.

For the production of *Brachionus*, two procedures are adopted; one procedure is to put *Brachionus* inoculum in the *Chlorella* culture water and another one is to produce *Brachionus* naturally in the pond fertilised with biogas slurry as used as an organic fertiliser. Then rotifer-rich water was sieved through 194 µm bolting cloth that allowed rotifers to pass through while large zooplankton such as *Cylops*, *Diaptomus*, *Moina*, and *Daphnia* are left behind. Generally, after 12-15 days growth, larvae were able to ingest large zooplankton along with *Chlorella* and *Brachionus*. When the fry started moving along the side of the ponds, they were provided with finely powdered supplementary feed following three 'F's –fixed time, fixed type of feed, and fixed place for weaning. This principle of feeding that the farmer needs to learn is to be maintained meticulously during the weaning phase to sustain hilsa larvae within the first 10-15 days – a critical phase of larval survival. When the weaned fry start feeding on the supplementary diet spontaneously, it may be considered as the first step of domestication of hilsa.

Production of fingerlings

After 40-60 days of larval rearing in nursery ponds, fry (50-60 mm) were collected by soft net and stocked into another prepared pond to raise fingerlings. A colossal number of mixed zooplankton was grown in the channel water body separately and also in the rearing pond. The mixed zooplankton was collected daily along with powdered supplementary feed @ 5-10% of the individual body weight of larvae. The fry survived and grew to fingerlings, reaching 100-125 mm and 10-20g within 2-3 months.

Grow-out culture

Production of table-sized fish

Initially ponds (0.4 - 0.6 ha) were partially dewatered keeping 15-30 cm water depth, followed by application of mahua oil cake @ 2,500 kg/ha/meter water depth to kill predatory and weed fish. Then lime was applied after 10 days, followed by pond netting at 2-3 days intervals. Heavy sinkers were used during netting to disturb the bottom soil to remove any foul and obnoxious gas, release nutrients from soil to the water and stimulate production of plankton. Usually, ponds seemed ready for stocking fish after 30 days post application of mahua oil cake. The fingerlings, ranging 100-125 mm/10-20g), were stocked in such ponds for production of table size hilsa. A sinking scrambled supplementary feed @ 5-10% of the body weight was provided to fingerlings. Biogas slurry was applied in the pond to increase the plankton density for use as food by the growing fingerlings. A few rohu, mrigal and grass carp were also released in the pond to reduce the infestation of algae and some other weeds. The carps appeared to

maintain the pond condition in a congenial state for hilsa. The fish survived and grew to table-sized fish of 80-100 g during 5-6 months of culture.

Broodstock raising

For raising hilsa broodstock, a similar size of pond (0.4 - 0.6 ha) was prepared in a similar way as the grow-out pond. A numbers of hilsa of greater than 100 g were stocked for further growing to adults. They were regularly fed with zooplankton cultured in separate ponds, and also with supplementary feed @ 3% of their body weight. Biogas slurry was also applied to the pond to increase the plankton population. Dissolved oxygen was maintained above 6ppm by operating pond aerators and 5 HP water pumps as an alternate day. Water exchange was done at 30-45 day intervals. Netting was conducted at regular intervals to measure fish growth. The males became mature with freely oozing milt at the end of two years of age, while the females showed protruding eggs through the vent at the maturity considered as 5th stage after two years and nine months of age.

Conclusion

Until now, hilsa production in India has exclusively depended on wild caught fish, with natural populations in a declining trend. In spite of conservation measures, captive rearing and breeding are needed to enable domestication and farmed production of this species. Since hilsa is highly sensitive to stress, it is necessary to culture it in different environmental and agro climatic zones to test its ecological and environmental tolerances. ICAR-CIFA has paved the way for its culture in captivity and under on-farm conditions. However, breeding of pond grown hilsa remains a challenge that needs to be worked out with scientific approaches, particularly through the development of broodstock feed, monitoring environmental conditions and hormonal manipulation. The farmers who have expertise in breeding and culture of other fin fish species may take on this venture, particularly onboard breeding, seed rearing and grow out culture, through availing the opportunity for adoption of technological advancement that ICAR-CIFA has established through rigorous experimental exercises. Hopefully, the farmer's participation in this field combined with a scientific approach can generate momentum in the domestication as well as the sustainable production of farmed hilsa in India and abroad in the near future.

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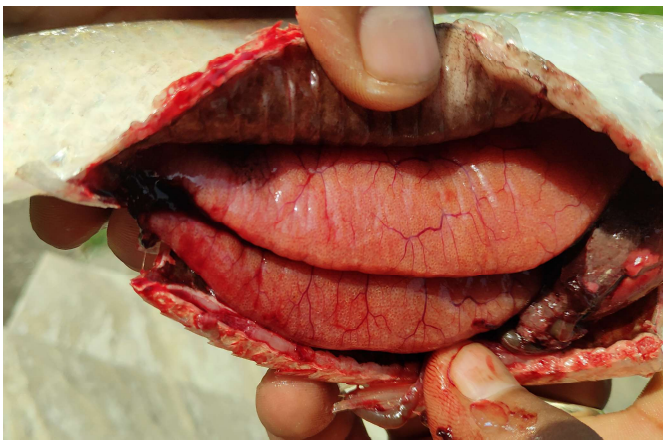
A pond grown female hilsa with eggs in ready condition.

Above, below: Ovary of pond grown female hilsa examined for maturity.



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