

Freshwater pearl culture practices and challenges in India

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As the dictum says 'rare objects have more value'. Human-kind tends to value rare objects such as precious metals and gemstones. Pearl is the only gemstone produced by a biological entity and may be considered an organic gemstone. Molluscs, an ancient group of life, can produce pearls as an immunological response to a foreign particle. Studies have reported that the pearl-producing molluscs first appeared 530 million years ago¹. However, not all molluscs can produce nacreous pearls, only the bivalves can. About 10,000 species of bivalve mollusc have been reported across the world², but pearls of commercial quality are commonly produced from a few selected bivalve species. India harbours around 3,270 molluscan species including 1,100 bivalves³ and as many as 625 species of marine bivalves have been reported from India including 88 that are endemic to Indian waters⁴.

In the past, pearls were procured by dissecting mussels collected from nature. This process was cumbersome and it often lead to the extirpation of molluscs from the ecosystem. In 1907, a Japanese scientist Tokichi Nishikawa unravelled the mystery behind the pearl production and proposed the 'Pearl Sac theory'⁵. As per this theory, a pearl is produced by the outer epithelial cells of the mantle tissue (mother of pearl) and can be induced by placing foreign bodies/parasite/a

lesion into the mantle tissues. China pioneered the culture practices of freshwater mussels and produced Buddha image pearls in *Cristaria plicata*⁶.

Mikimoto Kokichi, a Japanese entrepreneur known as the founder of modern cultured pearl, began mass scale pearl production and commercialised the technology. He established the Mikimoto Pearl Company at Ginza, Japan and developed the half round pearl concept and also the mabe pearls. Later, Japan commercialised the culture practice in *Hyriopsis schlegeli* and also standardised the pearl production technique⁶. Since then, the market for pearl has been expanded several fold and now it is a multi-billion dollar sector of the aquaculture industry. In recent years, freshwater pearl culture has accounted for the major portion of the total pearl production. Freshwater pearl culture offers many advantages over its marine counterpart in terms of abundant farming area; absence of fouling, boring and predatory organisms and it is very cost-effective. Several Asian countries such as China, Japan, India, Vietnam, Philippines, Thailand, Bangladesh, South Korea, Malaysia and Myanmar have taken up the culture of freshwater pearl on a large scale and carry out research to meet the global demand for pearls^{7,8,9}.

Around fifty two species of freshwater mussels have been reported from India¹⁰. Among these, those most commonly used species for pearl production are *Lamellidens marginalis*, *Parreysia corrugata* and *Lamellidens corrianus*¹¹. These species are distributed in the northeastern, western, central and southern parts of India. The species *Lamellidens* is reported to inhabit stagnant to slow flowing water bodies such as ponds and reservoirs, whereas lotic habitats are inhabited by *P. corrugata*¹¹. They are filter feeders and feed predominantly on green algae, followed by diatoms, blue green algae and zooplankton¹². *L. marginalis* is the most commonly used mussel for pearl production in India rather than *L. corrianus* and *Parreysia corrugata*¹¹. In 1987, ICAR-CIFA initiated research on the culture and production of freshwater pearls and since then it has been working towards the development of the technology of producing pearls in freshwater environments. Though the breeding protocol for seed production of *L. marginalis* is under progress, the culture practice for pearl production has already been standardised.

Pearl farming

Site selection

The selected site for pearl culture should have a pollution-free water supply and no algal blooms (free of *Microcystis*). Water should be clean with low turbidity as highly turbid water reduces the filtration rate of mussels.

Obtaining pearl mussel stocks

As mussels take 6-10 years to attain implantable size the mussel stocks for culture/implantation procedures are generally collected from natural water bodies like ponds or rivers. Mussels are hand-picked from the pond bottom and are selected on the basis of their size. Healthy mussels that have attained a length and weight of ≥ 8 cm and ≥ 35 g, respectively are selected for implantation in the pearl production process.

Pre-grafting culture

Prior to surgical implantation, the selected mussels are kept crowded for 24-36 hours to ease the relaxation of adductor muscles. The mussels are stocked in FRP/ferro cement tanks in aged tap water at a density of 1 mussel/litre of water. Crowding of the mussels facilitates the smooth opening of the valves for implantation procedure. Pre-operative conditioning is an important pre-requisite to aid surgical implantation due to restricted or no use of narcotising agents in case of *Lamellidens* species, unlike the other pearl forming bivalves. Before starting the surgical procedure, the mussels are kept in an upward facing position for half an hour where the opening part (ventral side) faces upward and the umbo (dorsal side) downwards.

Grafting

The crucial step in the entire pearl production protocol is the implantation of the nuclei or beads into the mussel. The nucleus, made up of acrylic powder or shell powder can be grafted along with the mantle graft (a sliced mantle tissue taken from the edge of the mantle tissue near the pallial line that is obtained from the mussel that acts as donor mussel) that later develops into a pearl sac. Three different methods of implantation are in practice namely, mantle cavity implanta-

tion, mantle tissue implantation and gonadal implantation¹³. The choice of implantation method depends on the type of pearl targeted i.e. designer pearl, round pearl or rice pearl etc.

- **Mantle cavity implantation:** Out of the three methods, this is the simplest method requiring minimum skill and expertise. In this method, the nucleus is implanted into the cavity between the outer mantle layer and the inner surface of the mussel shell. Mantle grafts are not used in the mantle cavity implantation method as the outer mantle layer serves as the source of nacre secretion.
- **Mantle tissue implantation:** In this method, the nucleus along with the mantle graft is implanted into the pockets made on the posterior side, in both the left and right lobes, of the mantle tissue of the recipient mussel.
- **Gonadal implantation:** Here a small incision is made in the gonad of the recipient mussel and then the nucleus together with the mantle graft is inserted into the incision. A live graft of 2 to 3 mm, taken from the pallial mantle ribbon is inserted along with the round nucleus. Care should be taken to utilise the processed graft within 45 minutes to one hour, otherwise graft will be deteriorated and may not be suitable for implantation.

Implantation can be carried out throughout the year except May-June (summer season) so as to prevent graft and mantle rejection as well as to minimise the post-operative mortality rate¹¹. The success rate of pearl production is 60-70% in the mantle cavity and mantle tissue implantation method whereas in gonadal implantations it is 25-30%.

Post grafting inspection

Following the implantation of nuclei, the mussels are subjected to post-implantation care for a period of 7-10 days to minimise post-implantation mortality and to minimise the rejection of implanted nuclei. During this time, the mussels are treated with broad spectrum antibiotics to minimise rejection and for quick healing of the surgical process. They are kept for 24 hours and after a three day interval again subsequently up to nine days and fed with green algae along with vigorous aeration. Antibiotic @ 1-2 ppm is added to the tanks stocked with implanted mussels immediately after the completion of the surgical procedures and after 24 hours of antibiotic exposure, water exchange is carried out.

Post-grafting culture (pearl development)

Following post-operative care, the implanted mussels are shifted to the desired culture system wherein they are kept in hanging condition packed in nylon net bags. The implanted mussels are cultured either in FRP/ferro cement tanks or ponds along with other compatible fish species. The culture period of implanted mussels generally varies from 12 to 18 months depending on the method of the implantation followed. Ambient soil and water quality parameters are conducive to the formation of good quality pearl in captive conditions.

Soil and water quality parameters

The depth of the pond should be 1.5-2.0 m with a clay-soil bottom, slightly alkaline water that is devoid of aquatic macrophytes and algal blooms like *Microcystis* and *Euglena*.

The ponds are employed with bamboo poles as rafts for suspending the implanted pearl mussels. The implanted mussels at a density of 25,000/acre are placed in nylon bags (30 cm x 13 cm; mesh size 1.5 cm) @ 2 mussels per bag and reared. The water quality parameters for freshwater pearl mussel farming should be as indicated below:

Parameter	Range
Transparency of water	40-60 cm
pH of water	7.0- 8.0
Temperature of culture medium	25-30°C
Dissolved oxygen	4-8 ppm
Total hardness	60 ppm
Calcium in water	20-30 ppm
Magnesium in water	5-10 ppm
Total alkalinity	80 ppm
Ammonia	Less than 0.004 ppm

The mussels in pond culture systems are fed with green algae and among them microalgae *Chlorella* is the most preferred food item.

Culture in tanks

Apart from outdoor culture, implanted mussels can also be stocked and maintained in FRP/ferro-cement tanks till the time of pearl harvest in cases where the farmers have reduced or no access to culture ponds. The mussels can be either placed on the bottom of the tank or suspended in nylon net bags similar as that of the pond culture method. Culturing in FRP/ferro-cement tank also allows the ease of monitoring the condition of the mussels and take the necessary steps in alleviating the difficulties, if any. The ease of removal of the dead mussels from tanks is quite an advantage when compared to the same in a pond culture system, which demands a tedious effort.

Management measures in tanks

Regular water exchanges, vigorous and constant aeration along with proper feed supplements are the most important pre-requisites for better survivability and production of pearls in tanks. A sudden decrease or increase in the temperature can sometimes prove to be lethal leading to severe mortality of the stocked animals. In such conditions care must be taken to regulate the temperature as per the favourable ambient of 25-30°C, by immediate water exchange, using thermostat to regulate the temperature, strengthening aeration and thinning the stocks.

Harvest and re-implantation

Harvesting of the pearls is carried out after the designated time period of the culture, based on the implantation method undertaken i.e. 12–18 months. The harvested mussels are sorted based on their quality which is governed by the shape, size, lustre, texture and colour followed by value addition. The mussels after harvest can be reused for implantation only if the mantle tissue method of surgery has been followed. It is necessary that utmost care is taken while obtaining the pearl from the gonads in order to avoid the death of the concerned individuals. In the mantle cavity method of implantation, the mussels have to be sacrificed as the pearl formed attaches to the shell of the animal and requires cutting of the shell to harvest the pearls.



Challenges in pearl farming in India

Despite its economic value, profitability, minimum labour, there has been relatively little mussel farming in India compared to fish and shellfish culture. Underlying reasons include a low number of freshwater pearl farmers in India and the lack of an organised sector for pearl farming in the country, which is one of the pressing concerns behind the situation. Other factors include a lack of proper brood stock management protocols, scattered availability of mussel brood-stock, non-availability of standardised breeding technology, a lack of standardised water quality management protocols as per different agro-climatic zones of India, few research institutes involved in freshwater pearl mussel farming technology, and a poor extension network to disseminate the existing culture technologies and advances. So, pearl farming, though a profitable business, involves huge challenges which need to be addressed for rapid dissemination of this important technology.

Future prospects

In order to meet the financial risk associated with pearl farming the Government of India has been providing subsidies and incentives to pearl farmers. Several schemes are being provided by the fisheries department of various states. ICAR-CIFA, Kausalyaganga, Bhubaneswar has been playing a pivotal role in disseminating the freshwater pearl culture technology to farmers, fisheries stakeholders and entrepreneurs who are willing to carry out freshwater pearl

culture. Every year it conducts a training program wherein the candidates receive hands on training on the different methods of implantation and are also trained on the culture practice technologies viz. the pre and post-operative care, food and feeding of mussels, optimal conditions necessary for pearl mussel culture, and water quality management.

Conclusion

In conclusion, freshwater pearl farming is an emerging sector of the aquaculture commerce in India and laudable progress has been made in developing and standardising the culture techniques. But many obstacles such as the need for proper dissemination of culture technologies among the interested folks, standardised breeding protocol, limited research programmes and so on need to be addressed by the scientific community to boost the contribution of freshwater pearl farming to the national aquaculture produce. Efforts should also be made in producing improved varieties of freshwater pearl producing mussel species and enhancing the quality of pearl produced by the same.

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