

Case study on freshwater pearl cultivation at tribal district Chhindwara, Madhya Pradesh, India

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Abstract

When we think about pearl cultivation in the world, China ranks first. The cultivation of pearl includes; Natural pearls, Seawater cultured pearls, and Freshwater cultured pearls. There are two types of varieties of cultured pearls; freshwater and saltwater. Freshwater pearls are grown primarily in man-made lakes reservoirs and ponds. Saltwater pearls are grown in bays, inlets, and sea in many places around the world. Indian pearl-producing mussels, more than 40 varieties, are found in Asia in various places like ponds, rivers, and lakes however there are 3 main categories of pearl-producing mussels in India and the country. We have cultured the designer pearls at our Krishi Vigyan Kendra located at 22.0574° N, 78.9382° E Chhindwara (M.P.) and found prominent conditions with *Lemlidens Corrianus* for fresh-water designer pearl production.

Keywords Pearl cultivation, Harvesting, Freshwater and Seawater cultured pearls

Introduction

The pearl is known as the queen of jewels. From ancient times pearl is a symbol of material wealth throughout human history. Many ancient civilizations had their myths and legends about pearls and showed great appreciation for them (Zhang and Fang 2003; Strack 2006). When pearls are not cultured, they were collected manually from different water bodies that hold the pearl. Historical sources of pearls collected in this way included the Gulf of Mannar, between India and Sri Lanka, the Bay of Bengal, the Egyptian coast (Red Sea) and the Persian Gulf (Saudi Arabian coast) (Matlins 2001; Strack 2008) where the economy was particularly dependent on pearl fishing before the twentieth century (Carter 2005). The situation changed at the present condition in the early 1900s when natural pearl harvesting became popular and many countries had a long history of pearl harvesting. But in the present condition, the world's market for designer pearl is becoming increasingly popular.

Pearl producing Indian mussels

When we consider Indian pearl-producing mussels there are more than 52 varieties that are found in India in various places

like ponds, rivers, and lakes. Freshwater pearl mussels can be cultured in freshwater ponds, rivers, or lakes. Over 98% of freshwater pearls are produced in China (FAO 2016), with the remainder produced in Japan, Australia, America, Vietnam, and other countries (Yang et al. 2003). But there are 3 main categories of pearl-producing mussels in India and they are as follows.



Fig.1 *Lemlidens marginalis*

Lemlidens marginalis

It is among the most preferred freshwater bivalve species used as food by some ethnic groups in Nepal, India, and Bangladesh.

They are used for freshwater pearl farming in various states of India because of the good nacre formation inside the mussel. This breed is found in both lentic (stagnant) and lotic (moving) Water bodies like ponds, rivers, lakes, and dams. But it mostly prefers moving water. Many bird species like an open billed stork, painted stork feed on these mussels. The size of these mussels varies between 7-10 cm. This variety is highly used for pearl farming in Bangladesh.

Lemliden corrianus

It is a freshwater bivalve found in sand, silt, and mud substrate of large lowland rivers. This species prefers lotic water bodies with a very rich macro zoo benthic community. This is the most commonly used mussel across India for the pearl farming business because this species is commonly found everywhere in India in abundance. They prefer lentic (stagnant) water bodies like ponds, lakes, and dams where the water is mostly stagnant as their preferred habitat. The nacre formation in this mussel is as good as *Lemliden marginalis*.



Fig. 2. *Lemliden corrianus*

Parreysia corrugata

It's another freshwater bivalve mussel that is capable of producing pearls. It shows a nomadic movement as it keeps moving from one place to another place on regular basis. So, this is known as movable mussel also. The outer shell color of this is mostly green in color and the surface of this mussel is quite smooth. Nacre formation in this mussel is quite similar to *Lemliden marginalis* and *Lemliden corrianus*.



Fig. 3. *Parreysia corrugata*

Technically all kinds of freshwater mussels are capable of producing pearls but due to the bad quality of nacre, the

quality of pearls formed in other bivalve mussels are of inferior quality and have no financial value. So, these 3 varieties mentioned above are considered most suitable for pearl production.

Various phases of pearl farming production

Pond construction and culturing

This is the first and one of the most important phases of freshwater pearl cultivation as the construction should be done with the right dynamics. We have constructed a natural pond sized 10x60x3.3 meter at Krishi Vigyan Kendra, Chhindawara (M.P.)



Fig. 4 Cultured pond

Minimum pond size to start pearl culture can be as small as 100 ft (L) × 80 ft (B) × 12 ft (D) for 10,000 mussels. Firstly dig a pond then fill it with water till 10 ft. Take a cement tank of size 4 ft (W) × 4 ft (L) fill it with water and add 10kg dry cow dung then leave it in the tank for 24 hours. After 24 hours, take out the water and filter it with a filter cloth (cotton) then mix that water with 5kg seaweed and then put that filtered mix in the pond filled with 10 ft of water then leave the pond for 10-15 days. When the water turns green, it is an indication that the pond is ready to use for mussel deployment. This process is applicable for once and for natural pond only.

Feed preparation for mussels

Natural pond

Preparing food or feed for mussels is of most importance as it plays a key role in the growth of mussels and subsequently nacre formation. Take a 4ft (w) × 4 ft (L) circular cemented tank filled with water, add 10 kgs of cow dung. Algae and other phytoplankton will start developing in the circular tank after a week or 10 days. This process will repeat every 15 days with 5kg dry cow dung. Once the water turns greens then the water will be deployed in the pond. There is another process to prepare food, that is • Take a circular cemented tank of 4 ft(w) × 4 ft(L) fill it with water then add 5 kgs of cow dung. Let it ferment for 7-10 days till the time water turns green. Once the water turns green filter the mix with a filter cloth and deploys the water in the pond. • Take 2.5 kgs of seaweed and dilute it in 25 liters of water then put that mix equally in the pond. This process should be repeated in every week along with 5 kgs of cow dung process.

Cemented circular tank or ferrous tank

Artificial pond

Such kinds of ponds require special care. Once the pond liner is set in the pond fill it with water till 10 ft. Take a circular tank (4 ft w × 4 ft D) fill it with water then add 10 kgs of dry cow dung. Let it ferment for 24 hours. Once the mix is fermented for 24 hours filter the water with a filter cloth. Put the filtered water in all four corners and the middle of the pond. Then take 2.5 kgs of seaweed and mix it with 25 liters of water and apply it to the filled pond.



Fig. 5 Feeding tank

Checking and controlling water quality

Due to various fluids released by mussels and various natural chemical reactions sometimes harmful chemicals are formed in the pond which can lead to an increased mortality rate in mussels. Various types of chemical compounds that can form in a pond can be ammonia, nitrogen, nitrite, and nitrate.

Table 1: Checking and controlling water quality parameters

Content	Standard	Precaution
pH level	6.5– 8.5 ppm	To increase use of limestone to decrease the use of vinegar
Ammonia.	>50ppm	Decrease 20% of water and fresh 20% water. Keep repeating the process till its zero or Micro life S2 solution
Nitrate	0	Decrease 20% water and fresh 20% water. Keep repeating the process till its zero
Nitrite	0	Decrease 20% water and fresh 20% water. Keep repeating the process till its zero.
Temperature of water	28-32 ^o C	N.A
Chlorine.	Campden tablet	1 Tablet is sufficient to treat 20 gallons of water
Oxygen	Above 4 ppm	Check D.O everyday

Pre-operative care

A day before operating the mussels for surgery keep the mussels out from the main pond and put them in a half-filled water tray in an upside-down position without feed according to 1litre/Mussel so that the muscles of the mussel become relaxed and surgery can effectively take place. Once the muscles of the mussel are relaxed the chances of injuries in internal organs are less.

Post-operative care

Before starting the surgery fill a tray with normal water and add a pinch of chloramphenicol tablet in water and mix it well. Once the surgery of the mussels is over the mussel are kept in the antibiotic water for 1 day, then on the next day transfer the mussels in the net and deploy them in the pond. There are still some technical difficulties associated with growing beaded pearls within the visceral mass of freshwater mussels because of their physiological structure (Xie et al., 2015). Survival rate and nucleus retention rate of implanted oysters are strongly correlated with factors such as size and age of oysters, size of nucleus, and grafting method (Yukihira and Klumpp 2006; Kripa et al., 2007; Liang et al. 2015).

Various types of surgeries

Mantle cavity

In this type of surgery firstly the mussel is opened with the help of an opener. Then either the half-round or designer nucleus is implanted beneath the tissues of the mussel by lifting the tissue on both sides of the mussel. Which means a mussel is nucleated on both sides. Then the tissue is put back in its original place without harming the mussel. In this process, the nucleus is implanted between the mantle Cavity and mantle tissue. Then after 10-12 months, the desired shape of a pearl is harvested, and the process gets completed.

Mantle tissue

Firstly take 2 mussels then consider one mussel as a donor mussel who donates its tissue and the second one as a recipient mussel who receives the tissue from the donor mussel. Make small grafts of 2mm size from the tissue which is taken from the donor mussel. This is done by preparing a mantle ribbon (a complete strip of tissue in the shape of a ribbon), in this process the donor mussel gets sacrificed. Then the implantation takes place, in which very small pockets are created in the tissue of the mussel, this implantation can be of 2 types' i.e. nucleated one and non-nucleated one. Which means it's up to your choice to use the nucleus or not to use the nucleus. Once the tissue is taken out from the donor mussel then the tissue should never remain dry, so to take care of dryness, a liquid medicine

called 'EOSINE' is constantly put on the tissue so that it doesn't get dry and always remains wet.

Gonadal

This type of surgery also needs to do the grafting. First, cut the edge of the gonad of the mussel. Then put a graft inside the cut, then put the nucleus and then again put the graft. Then the mussel is closed slowly. While cutting the gonad, precaution should be taken that cuts are made with precision so that the intestine of the mussel doesn't get hurt. Only around the nucleus is implanted in this surgery therefore only round pearls are produced via this process. It takes approximately around 18-24 months to form a round pearl.

Deploying mussels in tank and ponds

Before deploying mussels in the main pond, a netting with small pockets is made. After the preparation of nets, the mussels are fitted in the net. Then the nets which are holding the mussels are deployed in the pond in such a way that the net remains 1ft above the ground level so that the pearls can be adjusted in the later stages throughout the year according to the weather conditions. Keep a check of 7 days for the dead mussels so that dead mussels can be interchanged with the newly implanted mussels. Secondly, keep a regular check on the feed of the mussels every 30 days. 15 liters of feed is required for a 10ft × 15ft size pond.

Maintenance of pond and tanks

Everything has a depreciating impact in the same way the pond and tanks used for the pearl farming business need care and maintenance on regular basis. There are certain situations norms which need to be followed on a strict basis like never allow the inflow of sewage or polluted water, washing clothes and taking bath in ponds, it can lead to some kind of chemical reaction which can be harmful to the health of mussels.

Harvesting of pearls

In winter or when the water temperature is relatively low, the nacre secretion rate slows, resulting in a more detailed, smooth, and lustrous pearl surface. Thus colder conditions are the best time to harvest pearls (Wang et al., 1993). Akoya and South Sea pearls are grown within the gonad tissue of host oysters (Taylor and Strack 2008). Depending upon the type of nucleus, the pearls can be harvested. If the designer nucleus is implanted then the pearls can be harvested after 8-12 months depending upon the nacre formation on the nucleus. If the round or half-round nuclei are implanted, then it can take 18-24 months. In round pearl harvesting the mussels can be reused after the care of two months and when the mussels live the entire span of life there are chances to produce the pinnacle quality of pearls. In the case of designer pearls, the mussels are sacrificed. However, raw pearls may have to be processed to

improve their quality to meet the standards of gem-quality merchandise, and pearl enhancement is routinely used for Akoya pearls and freshwater pearls (Strack 2006). While fine-quality cultured pearls (marine and freshwater) are selected to make jewelry, small non-beaded cultured pearls, which have little value, maybe processed into drugs and cosmetics (Yang et al. 2016).

Mussels life cycle

Freshwater mussels have an unusual life cycle. They can live from about 10 to 40 years. Females' brood eggs in modified sections of the gills, called marsupia, where they develop into bivalve larvae, called glochidia, bearing a pair of hooks, on the apex of each shell valve. Most species brood in spring and summer. Mussels need a fish host to complete the reproductive cycle. The method of host infection greatly varies from species to species. Some species release small structure containing glochidia called conglutinates which float freely in water and gets attached to the gills of the host fish subsequently. Once the glochidia are released from the female, they get attach to the gills or fins of the appropriate host fish to complete the development process. Metamorphosis takes place within weeks depending on the species and temperature. The glochidia transform into the microscopic juvenile and then drops off. Then it's taken almost 2 years for a mussel to be used as a pearl farming mussel.

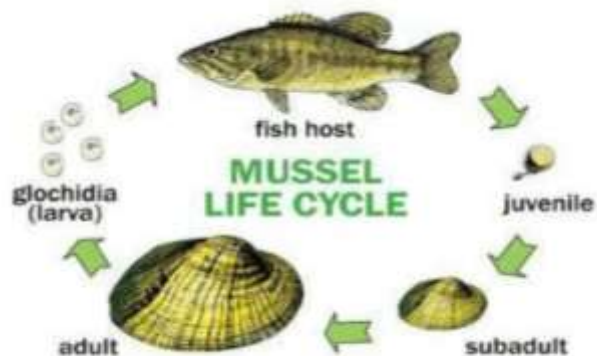


Fig. 6 Mussel life cycle

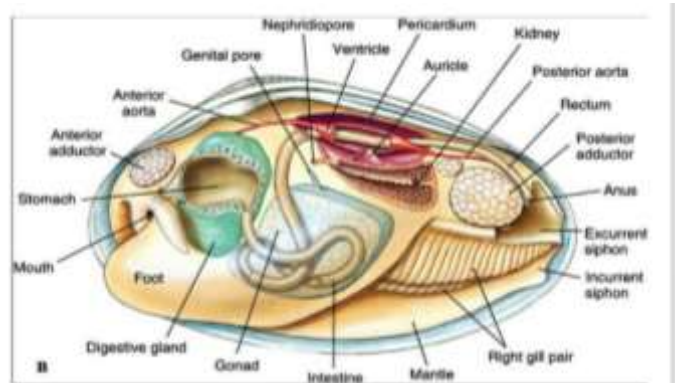


Fig. 7 Structure of mussel

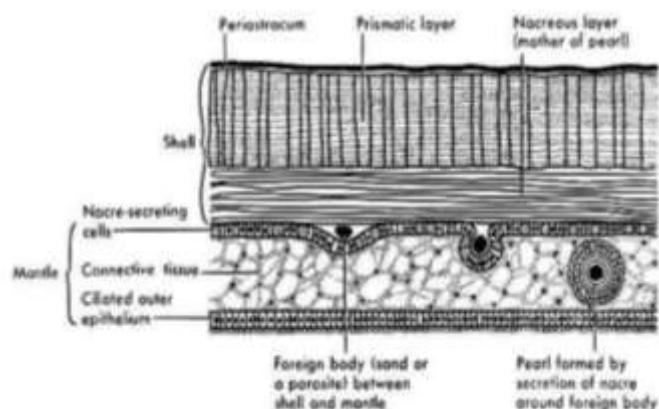


Fig. 8 Shell and mantle of mussel

The mussels are made up of three layers 1) Periostracum 2) Prismatic 3) Nacreous. The outer Periostracum is an organic and non-clarified thin layer of conch Islington, the middle layer mainly consists of calcite, and the inner layer is composed of crystalline aragonite calcium carbonate.

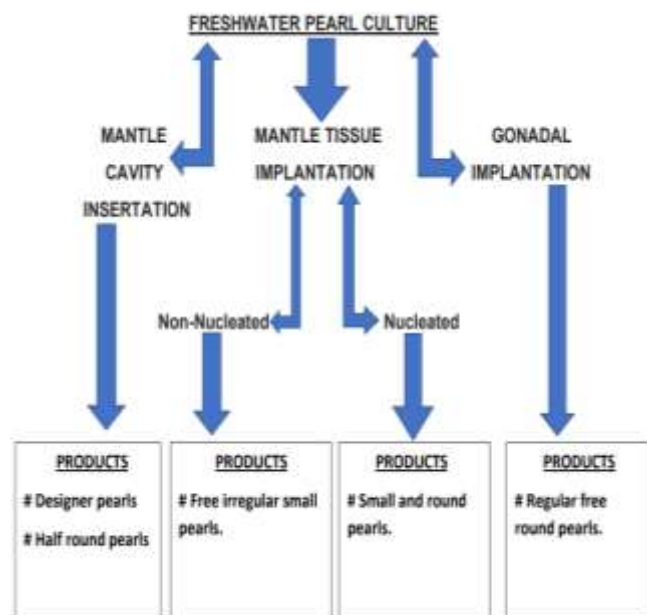


Fig. 9 Freshwater pearl culture structure

Some important aspects of freshwater pearl culture

We observe that pearl farming is a very challenging and labor-intensive activity. In general, post-operative survival of nucleated oysters is less than 70% and, of these, 30–40% is likely to reject the implanted nucleus, 20% will produce salable pearls, but only 5% will produce top-quality gemstones (Fassler 1992; Norton et al. 1996).

1. India is the world’s biggest importer of pearls across the globe.

2. Every year India purchases more than 5000 crores of pearls from China and Japan because we are not able to produce it in India.

3. Technically or scientifically mussels are known as filter feeders which means that a single mussel can filter up to 40 liters of water in a day.

4. Market and demand for designer pearls is huge in India but till now it’s like a blank sheet as there is no big name or brand to date, so early movers in this sector of pearls will have first mover’s advantage.

5. Freshwater pearl culture is the only sector, which can reap up to 200% returns on investment.

6. The dead mussels can be crushed in powdered form and sold as limestone to the real state sector.

Conclusion

The results of the proper business plan with a good marketing strategy establish or generate substantial revenue to support running costs and provide a share of the dividend. It is more effective to work in favor of the set objectives to achieve the desired goal by sharpening skills and adapt the market cost-effectively and practically. Pearl production can be established as a small scale based pearl farms but is providing to become a significant means for income generation among the communities. Furthermore, the pearl industry provides an opportunity for the involvement of women and provides the raw materials for local handicrafts manufacture, which may include lower grade pearls or pearl shells. As the business grows, additional pearl cultivators are on the horizon, the existing farms will enjoy the first-mover advantage in the local market. Pearl culture can be possible with a minimum budget to exclude the business plan; pearl farming should be carried out efficiently and cost-effectively targeting both tourists and the domestic market. The budget of both small and medium-size pearl culture farm, it can be possible that by scaling up to the medium size farm, a farmer can earn or make higher returns. Essentially, the returns double, but the costs increased only slightly since many of the costs are similar for small and medium-size farms. Start-up costs are slightly higher in the medium-size farm, but this increase in scale modest, the start-up costs are recovered by the first harvest. That’s why it is advisable to establish a larger farm when possible.

Authors’ contributions

All authors have contributed significantly to the conception and design of the study, the interpretation of data, and the drafting and revision of the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

The authors hereby declare no conflict of interest.

Consent for publication

The authors declare that the work has consent for publication.

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