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A Review On Global Status Of Fresh Water Mussel: Pearl Culture

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Abstract- Pearl is a natural jewel, produced by marine and fresh water mollusks. It is composed of calcium carbonate deposit in response to any foreign particle enter inside the shell. Pearl fascinates from ancient time and now a days Pearl culture is fastest growing industry but in India it still need attention. In India fresh water rivers and ponds are rich in fresh water mussel, which are natural pearl producing bivalves. Cultured Pearl produced by culturing fresh water mussels commercially. Indian fresh water mussel species, *Lamellidens marginalis* is widely used for pearl production in India. This review article summaries the World-wide production of pearls and their culture techniques.

Key words- Pearl, Fresh water mussel, Bivalve, *Lamellidens marginalis*, India

Introduction- Mussels are filter feeding benthonic organisms, widely distributed around the world and perform many important functions in aquatic ecosystems. The importance of mussels in contribution to food security, employment and economy, especially for the poorer segments of the society is well documented by Balian et al., 2008; Strong et al., 2008; Kohler et al., 2012; Ngor et al., 2018. It is also playing an important role in ecosystem services (Ngor et al., 2018; Vaughn, 2018). Though freshwater mussels are not commercially very important as a source of food, these mussels support small-scale fisheries in some parts of India and are potential candidate species for freshwater pearl production (Ramakrishna and Dey, 2007; Thippeswamy et al., 2014). It is also used as a bio-indicator for monitoring the health of aquatic ecosystems because they are extremely sensitive to a wide range of environmental factors including the levels of dissolved oxygen in water (Wayker et al., 2012; Ray et al., 2013; Mundhe et al., 2015; Ramesha and Sophia, 2015). Pearl culture in a freshwater environment is developing sector in India. Pearl culture technology, which probably originated in China, is on the threshold of becoming a major aquaculture industry with an annual receipt of $2(U.S.) billion in Japan and China. Realizing global trade potential of cultured freshwater pearls, other countries Bangladesh like, Korea, Philippines, Thailand, and Vietnam have initiated both research and industrial-scale projects in recent years (Fassler1994). Chinese and Indian major carps are traditionally cultured in Southeast Asian

countries; however, a majority of fish farmers in these countries are presently looking at ways of supplementing traditional aquaculture of food fish with value-added production systems for enhancing monetary returns. Fresh water pearl culture plays significant role in the aquaculture sector and used as fish food because of their high nutritive value. India has more than 50 species of mussels distributed in various freshwater bodies and among them, the genus *Lamellidens* is represented by nine species and two sub-species (Rao, 1989). *Lamellidens marginalis* (Lamarck, 1819), the most commonly available freshwater mussel, is widely distributed in ponds and derelict water bodies in Bihar and substantially contributing as a source of protein and income for local people. Thus, changes in the abundance and biomass of this species can directly or indirectly influence the ecosystem functioning and the livelihood of local people. Unionacean mussels are filter-feeders that have a unique life history, requiring that their larvae (glochidia) parasitize a fish host to complete their life cycle. Embryos mature into glochidia in the gills of the female mussel. Once mature, the female then releases the glochidia into the water, where they must attach and encyst on the gills, fins, or epidermis of a suitable host fish for metamorphosis to the juvenile stage. Once this transformation is complete, juveniles excyst and drop off the fish host to begin their lives on the bottom of a river or lake. Freshwater mussels (Bivalvia, Unionida; hereafter, mussels) are important ecosystem engineers in many of the world's rivers, canals, lakes, and ponds, yet globally they represent one of the most imperilled taxonomic groups (Böhm et al., 2021). Mussels can dominate the benthic biomass of rivers (Newton et al., 2011) and their filtration of water, coupled with the creation of bio deposits, plays a key role in transferring suspended material from the water column to the benthos, thus influencing water clarity, primary and secondary production, biogeochemical cycles, and sedimentation rates (Vaughn, 2018). Their shells provide substrate for epiphytes and refuge for macrozoobenthic taxa (Ilarri et al., 2018). The species of pearl mussels under the genera *Lamellidens* and *Parreysia* are widely distributed in Southeast Asia. Common freshwater mussels, pond mussel *L. marginalis*, paddy field mussel *L. corrianus*, and riverine mussel *P. corrugata* have been identified as important species for pearl culture operations in India (Janakiram 1989). They are widely distributed in the northeast, western, central, and southern states of India (Thomas 1974). Species of *Lamellidens* are described as inhabitants in stagnant to slow flowing habitats such as ponds and reservoirs up to a depth of 0.5-1.0 m, while *P. corrugata* is recorded in lotic habitats (Janakiram and Radhakrishna 1984). Studies on distribution of pearl mussels *L. marginalis* and *L. corrianus* in the state of Orissa have indicated that mussels prefer alluvial soil areas and particularly ponds having soft sediment. *Lamellidens marginalis* (Lamarck), an important pink pearl producing freshwater mussel is increasing demand in pearl producing countries (Ram 1989). Pearl is a natural gem, which is formed by number of molluscan species including freshwater mussels. In nature, a pearl is created by the deposition of a natural secretion called ‘nacre’ over a foreign particle (sand, parasite etc.) that enters the molluscan body accidently. The natural process has been exploited to produce a wide range of natural pearls under captivity across the world, by introducing mantle tissue inside the body of the mussels by various surgical procedures. The finest quality natural pearls have been highly valued as gemstones and objects of beauty for many centuries. Pearl culture technology is a developed sector in countries like China and Japan. China has made tremendous progress in culturing freshwater pearls in triangular mussel *Hyriopsis cumingii* (Yan et al., 2009), through which pink-to-purplish coloured quality pearls are produced. Realizing the potential of the pearl

production, several other countries also have taken up pearl forming. However, the base technology to produce cultured pearls has been standardized (Janakiram, 2003) and more attention is being paid to improve the implantation technique. The Bangladeshi freshwater pearl producing mussel (*Lamellidens marginalis*) is widely distributed throughout the country in majority of the freshwater bodies. Pearl culture technologies involving different implantation methods have been developed with different mussel species (Janakiram, 1989; Janakiram and Tripathi, 1992; Janakiram et al., 1994; Sakpal and Singh, 2000). Barman et al., (2018) reported availability of *L. marginalis L. corrianus, L. jenkensianus* and *L. phenchooganjensis* in natural waters of Bangladesh and their potential for pearl culture. Pearl shine, quality and deposition of nacre layer may depend on culture environment and culture process. The operated mussels can be cultivated in various ways such as releasing it directly in the water body or by hanging it in a bag or by creating a specific area with bamboo fence. Most pearl producing countries like China, Japan, Philippines, etc. follow the net bag hanging method. In this context, fresh water mussels, *Lamellidens marginalis*, collected from natural water bodies were cultured following different methods to find out the suitable culture method of freshwater pearl production in Bangladesh.

Worldwide Dispersal of Fresh water Pearl mussels- Pearls were previously the exclusive possession of the wealthy and powerful and were known for many years as the "Queen of Gems." (Mahnoor and Preeti, 2019). In today's era Freshwater mussel farming for Pearl culture is the world's fastest growing aquaculture sector, with an annual growth rate of about 10%. It is now practiced in many parts of the globe for the production of freshwater pearl mussels and freshwater pearl oysters. China and Japan are the main producers of freshwater and marine pearls, respectively, whereas China is the world's biggest producer of pearls, including both marine and freshwater pearls, with 3540 tonnes produced, accounting for 98% of global pearl production. Bangladesh, Korea, Thailand, and Vietnam, have recently begun both research and industrial-scale programs in response to the worldwide commerce potential of farmed freshwater pearls (Fassler 1994). Fresh water Pearl mussels of the genera *Lamellidens* and *Parreysia* are found across Southeast Asia (Patil et., al. 1976). This sector has expanded as more people become aware of the potential for pearl production in freshwater mussels, particularly in the Republic of China. According to Ward (1985). In North America a native freshwater mussel species, *Potamilus alatus,* has the ability to produce high quality black pearls (Zhu C *et., al.* 2019). Some important collected list of Fresh water Pearl mussel listed below in table-

Country/Place	Species	References
Bangladesh	*Lamellidens marginalis*	MiahMI *et., al* (2000), Hossain MA *et., al* (2004), Niogee SR *et., al* (2019)
	Lamellidens corrianus	Hossain MA *et., al* (2004)
	Lamellidens jenkinsianus	
	Lamellidens phenchooganjensis	
	Parreysia corrugata	
	Parreysia favidens	
	Parreysia daccaensis	Pacatipunan R, *et., al* (1984)
China	*Cristaria plicata*	Dan H, Ruobo G, (2002)
	Hyriopsis cumingii	Bai ZY *et., al* (2008), Lin JY *et., al* (2013)
	Lamprotula tortuosa	Wang G *et., al* (2013)
	Lamprotula leai	Bai Z *et., al* (2014)
	Lamprotula rochechouarti	Bai Z *et., al* (2014)
	Lanceolaria glayana	Wang G *et.,al* (2016)
	Hyriopsis schlegelii	Wu D *et., al* (2019)
Czech Republic	*Margaritifera margaritifera*	Simon OP *et., al* (2015)
Europe	*Margaritifera auricularia*	Prié V *et., al* (2018)
	Margaritifera margaritifera	Sousa R *et., al* (2020)
Finland	*Margaritifera margaritifera*	Oulasvirta P *et., al* (2017)
France	*Margaritifera margaritifera*	Legalle M *et., al* (2008)
Germany	*Margaritifera margaritifera*	Jungbluth JH, (1986-1995)
India	*Lamellidens marginalis*	Janakiram K. (2003)
	Lamellidens corrianus	
	Parreysia corrugata	
Indonesia	*Anodonta woodiana*	Rahayu SY *et., al* (2013)
Ireland	*Margaritifera margaritifera*	Geist J *et., al* (2018)
	Margaritifera durrovensis	
Japan	*Hyriopsis schlegelii*	Shirai A *et., al* (2010)
	Margaritifera laevis	Takeuchi M *et., al* (2015)
	Margaritifera togakushiensis	
	Cristaria plicata	Sano I *et., al* (2017)
	Margaritiana dahurica	Zhu C *et., al* (2019)
Malaysia	*Hyriopsis bialata*	Razak NF *et., al* (2019)
Mexico	*Psoronaias crocodilurum*	Saucedo PE *et., al* (2021)
	Potamilus alata	
Morocco	*Margaritifera marocana*	Sousa R *et., al* (2016)
Nepal	*Lamellidens marginalis*	Husen *et., al* (2018)
North America	*Quadrula sp.*	Graf DL (2000)
Norway	*Margaritifera margaritifera*	Marwaha J *et., al* (2021)

Philippines	*Cristaria plicata*	Battad EM (1984)
Poland	*Margaritifera margaritifera*	Zajac K, Zajac T (2014)
Portugal	*Margaritifera margaritifera*	Sousa R *et., al* (2015)
Russia	*Margaritifera margaritifera*	Popov IY, and Ostrovsky AN (2014)
	Margaritifera dahurica	Bolotov IN *et., al.* (2015)
	Margaritifera middendorfii	
	Margaritifera laevis	
	Cristaria plicata	Klishko OK *et., al* (2016)
Scotland	*Margaritifera margaritifera*	Hastie LC. (2011)
South Korea	*Cristaria plicata*	Patnaik BB *et., al* (2016)
Spain	*Margaritifera auricularia*	Araujo R and Ramos MA (1998)
Sweden	*Margaritifera margaritifera*	Henrikson L *et., al* (2009)
Taiwan	*Anodonta woodiana*	Rahayu SY *et., al* (2013)
Thailand	*Hyriopsis(Limnoscapha) myersiana*	Panha S and Kosavititkul P (1997), Kovitvadhi S *et., al* (2008)
	Hyriopsis desowitzi	Panha S and Kosavititkul P (1997)
	Chamberlainia hainesiana	Panha S and Kosavititkul P (1997)
	Hyriopsis bialatus	Supannapong P *et., al* (2008)
	Cristaria plicata	Chartchumni B *et., al* (2020)
Turkey	*Unio terminalis*	Şereflişan H (2019)
	Potamida litoralis	
	Leguminaia wheatleyi	
	Anodonta pseudodopsis	
USA	*Quadrula ebena*	Simpson CT (1896), Federman D (2012)
	Quadrula undulate	
	Unio sp.	
	Pleurobema oesopus	
	Tritogonia verrucosa	
	Margaritifera margaritifera	

Vietnam	*Sinohyriopsis cumingii*	Van Phuc P *et., al* (2011), Hoang T et., al (2016)
	Cristaria bialata	Van Tu Do LQ, and Bogan AE (2018)
	Sinanodonta elliptica	
	Sinanodonta woodiana	
	Lamprotula leai	

(Table Source- Saurabh, S *et., al* 2021)

Fresh water Pearl mussel, *Lamellidens marginalis*- This species is widely distributed in Indian river and pond system, dispersed in lower and upper Gangetic plains of India and Bangladesh. It Has been reported to be abundant in Sri Lanka, Myanmar and Terian region of Nepal, Sri Lanka, Bangladesh. With in India, reported from the states Of Uttar Pradesh, Bihar, Haryana, Jharkhand, Madhya Pradesh, Rajasthan, Uttaranchal and West Bengal. They play major role in water purification by their filter feeding behaviour. Natural pearl generated in *Lamellidens marginalis* and xenogeneic implantation yields a commercial quality of pearls. Natural pearls are produced when foreign particles such as sand, shell piece or parasite went to the particular region of molluscs and cannot be expelled. As a defence device, the animal secrets a calcium carbonate material known as nacre to coat the foreign body. Nacre is also called mother of pearl. The basic information on the indigenous fresh water pearl culture technology has been detailed by Janaki Ram *et al.,* (1997) Lamellidens marginalis (Lamarck), an important pink pearl producing freshwater mussel is increasing demand in pearl producing countries (Ram 1989). *Lemellidens marginalis* (Lamarck) was also recorded in River Gomti and other water reserviors in and around Lucknow (U.P) India with one more variety of fresh water mussel, *Parreysia favidens* (Benson) by Shukla et., al 2018. *Lamellidens marginalis* is found throughout the year in river Gomti, Lucknow (U.P) and help in producing pearl through their culture (Rawat and Singh 2023). The Shell of *Lamellidens marginalis* consists of two almost equal Lateral valves united by a dorsal ligament. Each valve is an elongate elliptical structure rounded it its anterior margin, but pointed behind. Outer surface is convex, brownish black and light brown borders along ventral margins while inner surface is concave shiny pearly white and smooth, with some bluish tinge. (Shukla et al., 2018).

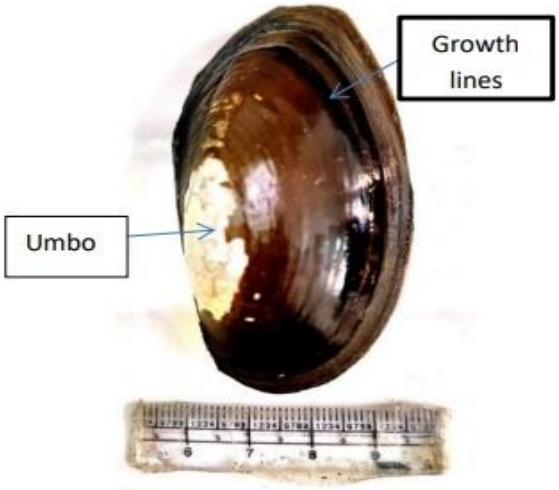

Fig- External view of Shell

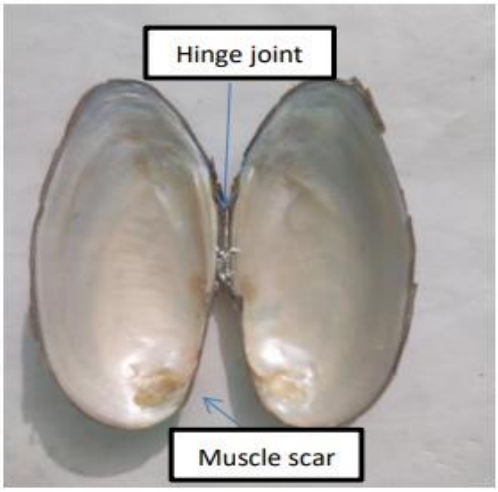

Fig- Internal view of Shell

In Microscopic structure, the shell has three layers, an outer brown, Horny layer, the Periostracum which is protective and is made of a horny organic material Called conchiolin. Below it the middle layer is a thick prismatic layer made of vertical Crystals or prisms of $CaCO_3$ separated by conchiolin. The innermost nacreous layer or the "mother-of-pearl" layer is made of alternate layers of $CaCO_3$ and conchiolin. The hinge Ligament is made of un-calcified conchiolin, it is continuous with the Periostracum. Reserve Calcium carbonate for the two inner layers of the shell is stored in certain cells of the Digestive gland. The nacreous layer is thickest at the Umbo and thinnest at the shell margin, it is used for manufacturing buttons. In formation of the shell the Periostracum is laid down by the outer lobe of the mantle, while the prismatic and nacreous layers are secreted by the entire Outer surface of the mantle, though the nacreous layer is also secreted by the thickened lower Edge of the mantle, and Pearl is formed by secretion of this layer.

Pearl farming and Harvesting- The production of pearls from freshwater mussels is more advantageous than marine pearl culture due to the widespread availability of freshwater pearl mussels in easily accessible habitats, operational simplicity in managing their farms, absence of natural fouling, boring and less predatory organism in freshwater ponds, and overall cost effectiveness of their culture. The technology used to create pearls from freshwater mussels is substantially the same as that used to create pearls from oysters. The freshwater pearl culture farming involves six major steps sequentially given below: 1. Collection of mussels 2. Pre-operative conditioning 3. Surgery 4. Convalescence 5. Culture of implanted mussels 6. Harvesting of pearls.

Collection of mussels- Mussels are manually removed from freshwater bodies and brought to the farm where they are harvested in good health. Mussels typically live in shallow marginal areas, partially hidden in the sand or mud. the habitat that is either stationary or slowly moving, such as ponds, tanks, lakes, rivers, and reservoirs. The Pearl mussel collecting from the natural bed is not always reliable due to their water contamination and erratic production. In order to guarantee a steady supply of pearl mussels, for year-round culture, mussel seed produced in a hatchery is far more dependable. After being produced from such seed, the mussels are chosen for grafting by taking into account their age, weight, sexual maturity level, and general health.

Pre- operative conditioning- Similar to marine mussels, freshwater mussels are also prepared before implantation, however menthol is not employed in this process. The healthy mussels are sent to a lab where they are extensively cleaned for two to three days using old tap water. That is when treated for a further 1-2 days with 7.5 mg/l of limewater, then 1% (v/v) sodium chloride. To thoroughly rid them of any infection, use hypochlorite. In the final, mussels are once more cleaned for another 2–3 days with old tap water to ensure the elimination of chemicals employed in earlier therapies. Finally, the mussels receive a chloramphenicol immersion therapy, (100 mg/l) for a full day. These modified mussels are currently housed in close quarters at a mussel stocking density of 1 mussel/ litre tap water.

Surgery- Fresh water mussels are prepared for grafts, donor mussel mantle tissue can be obtained and prepared in the same manner. The beads or nuclei are often constructed of eggshell powder or other calcareous materials like mollusc shell mixed with appropriate adhesive ingredients. In contrast to oysters, implantations in mussels are performed frequently at the gonad, mantle tissue, and mantle cavity.

Implantation in the Mantle Cavity- After opening the mussel, 4-6 mm-diameter beads are grafted into the mantle cavity area. their two valves and delicately separating them (without harming the adductor muscle). Utilizing surgical instruments, remove the shell's anterior side mantles. Implantation is possible in the mantle spaces on both sides.

Mantle Tissue Implantation- In this technique, recipient mussels are implanted with grafts and nuclei in either a non-nucleated or nucleated fashion. The only component introduced in the non-nucleated form is the mantle piece enters the pocket made at the inside of the ventral region's posterior pallial mantle of the mussel. The nucleated technique uses a tiny (2 mm) nucleus as a graft component is introduced into the pocket (diameter). Care is taken in both procedures to ensure that graft or the nucleus stays inside the pocket. Implants may be placed at either valve's mantle. The pearl output from the non-nucleated implantation technique is tiny.

Gonadal implantation- The labial palps and gills of the mussel are gently propelled upward with a spatula during the gonadal implantation technique. A specially designed knife is then used to make an incision near the edge of the mussel's gonad. The nucleus (2-4mm in diameter) is then put into the gonad after the transplant. It is taken care of ensure that the graft's outer epithelial layer and the intestine's nucleus are in close touch not be cut during the procedure.

Convalescence -The grafted mussels are placed in specially prepared nylon bags (two mussels per bag) right after the procedure, with the ventral side facing up. For post-processing, these bags are hung at a depth of 0.2 meters in ferro-cement or fiberglass-reinforced plastic tanks that contain old tap water for ten days of post-operation treatment. A course of immersion therapy using an antibiotic such Chloramphenicol helps wounds heal more quickly and increases the survival of mussels that have undergone surgery. After three to four days, tanks should be filled with water rich in plankton and algae. Manipulated mussels are checked every day to remove any dead or nucleus-rejecting mussels.

Culture of implanted mussel- The implanted mussels are cultured in the ponds for 12 to 18 months after convalescence. The mussels are stored in nylon bags with two mussels per bag and suspended in the ponds at a depth of one meter from bamboo or PVC pipes. The mussels are raised at a density of around 20,000-30,000/ha. and regular inspection of the mussels like removing any dead ones, and cleaning throughout the cultural period, bags are essential. Plants that are submerged or floating are prohibited to expand as they prevent light from getting through the culture medium. Mussel's main food sources are phytoplankton and zooplanktons. The mussels' gills separate them from other organic materials, which they then consume as food by their filter feeding mechanism.

Harvesting of Pearls- Mussels are brought to the lab for the purpose of harvesting the pearls surgically at the conclusion of the culture phase. Each mussel is opened by severing the adductor muscles, exposing the body such that the gonads and mantle tissue are clearly visible, and pearls are taken out. When using the mantle cavity pearl production process, mussels are sacrificed. Then the obtained pearls are graded, cleaned, and processed for the market purposes.

Conclusion- Culture of pearls, plays socio- economic role in any country. The farming of freshwater pearls has a significant impact on the economy, society, and environment. It is anticipated that pearl-growing technique plays important role in the well-known aspects of India's freshwater aquaculture. Pearls are generally used for decorative and jewellery purposes. They are powdered for pharmaceutical preparations like potions, balms, and salves to treat a wide variety of diseases. Other conditions for which pearls were prescribed for treatments include memory loss, insomnia, asthma, jaundice, liver ailments, heart problems, infertility and also in insect or snake bites. Perfect local methods and an abundance of materials offer India's pearl industry good prospects. Despite the fact that pearl culture is a long-term obligation but good operations can provide enormous profits since pearls are still in high demand on a global scale. India can collaborate with technical specialists, private companies, and increase the effectiveness of pearl production. Over all Pearl culture provide a large-scale industrial sector to the farmers of the India and helps in enhancement of the India's economy.

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