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Review Article

Pinctada margaritifera Farming in Fiji

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ABSTRACT

One of the main challenges faced by pearling researchers in Fiji is lack of documentation on the history and significance of pearl farming in Fiji. Trying to access this information from different sources becomes a confusing task for young researchers. This review will start by introducing factual information on history and significance of pearls from articles of varied sources.

Keywords: Significance; History; Constraints; Pearls; Pearl farming

INTRODUCTION

Pearls have long been considered the "Queen of Gems" and natural pearl necklaces made in combination with matching spheres had unmatched value [1]. In Latin the word pearl means "unique" [2]. It is considered unique among gemstones because it is not sourced by mining of earth but from the sea. It does not require any further processing to increase its magnificent luster. It has been cherished in the past and pearl jewelry is still in fashion.

No one really knows who the first to collect or wear pearls was but the belief is that the ancient fish-eating tribe living on the coast of India was the first to appreciate pearls which were found while opening oysters for food [3]. According to mention of pearls in the ancient books showed their significance. In holy Bible, Genesis the Talmud described the dresses provided by God to Adam and Eve were, "as beautiful as the pearls". The Old Testament mentions pearls in the proverb of Solomon (8:11): *"Wisdom is more precious than corals and pearls and is not even equaled by rubies". In addition, the New Testament references pearls in a story of Jesus: "Again the kingdom of heaven is like a merchant looking for fine pearls. When he found one of great value, he went away and sold everything he had and bought it". The Koran uses pearl as a symbol for exquisite objects: "The trees in paradise bear fruit made of pearls and emerald; and the believer who enters paradise will be crowned with pearls of incomparable beauty".*

The first mention of pearls in Indian history was in the Veda where Lord Krishna offered pearls which were found from the deepest part of the ocean, to his daughter as her wedding gift [1]. Natural pearls were a symbol of wealth and power due to its rarity and extreme cost that it was only reserved for the noble and very rich people [1]. According to the Roman historian Suetonius, the Roman general Vitellius was able to finance its whole military campaign just by selling one of his mother's pearl earrings [1].

Shells also have long history as they were made into jewellery and decorative objects. The oldest finding of this was discovered in 2004 from the Blombos cave in South Africa which was about 75000 years old. Mother-of-pearl inlays from about 4500 BC were found together with the remains of Bismaya in Mesopotamia. Human beings have decorated themselves with shells for thousands of years. In cultures around the world subtle shell shapes were believed to bring good fortune and safe travel [4].

The following review will shed some light on different types of pearls and different pearling industry before moving onto the history and constraints of pearling in Fiji. The review will conclude by briefly discussing the taxonomy, biology and distribution of *Pinctada margaritifera* which is the most common species cultured for round pearls in Fiji.

LITERATURE REVIEW

Types of pearl

Pearls are distinguished by their habitats. Saltwater pearls are formed from oysters that are from saltwater bodies while the freshwater pearls are formed by mussels from freshwater bodies. Both types of pearls can be found naturally or cultured by man. Despite the type, pearls come in variety of size, shape and color [2]. Two more types of pearls eventuate from cultured pearls. In cases where the molluscs reject the implanted nuclei, Keishi pearl forms with the remaining tissue, which was initially implanted together with the nuclei. Keishi pearl does not have nuclei to give it a regular shape and size; such pearls are small with irregular shape. Mabe pearl or half pearl forms when a pearl is grown against the shell of oyster. It is also referred to as blister pearl [4].

Natural pearls

According to FAO in 1991, natural pearls are formed accidently when a foreign particle, such as sand grain, parasite adults or larvae, enters the pearl oyster shell and gets entrenched amongst shell and mantle. A pearl is only formed upon the formation of pearl sac. A layer of epithelium from the mantle or the gill plates forms the pearl sac. Epithelial cells

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than secretes nacre and coats the foreign body forming a pearl which are generally irregular in size and shape. In addition to this theory [5], stated that the natural pearl forms from the pearl sac after the curing of an impurity or wound on the mantle. Mantle tissue then secretes nacre in the pearl sac ultimately forming a pearl.

Cultured pearls

Pearls can be produced due to human intervention [6]. The quality of nacre and the pearl development process in cultured pearls is similar to that of natural pearls. The outer epithelium of the mantle lobe and nucleus (foreign body) are two essential elements in any pearl formation. During pearl culture, the shell bead nucleus together with a piece of mantle epithelium is surgically implanted into the oyster's gonad. The mantle epithelium serves as a source of pearl secreting cells, multiplying rapidly forming a pearl sac around the shell bead nucleus. The surrounding tissue nourishes the cells of pearl sac, which secretes nacre that gets deposited over the nucleus in concentric micro-layers.

Mother-of-pearl (MOP)

According to Landman and Mikkelsen [4], mother-of-pearl is the most commonly used part of bivalve shell. The lustrous nacreous coating on the inside of a shell is referred to as the mother-of-pearl, the same material responsible for rainbow-like color of pearls. After grinding-off the coarse outer layer of the shell, the remaining layer of mother-of pearl is utilized for several decorative items. Thick layers can be carved into cameos or used for making beads. Thin layers can be reduced into veneers for mosaic inlays.

Pearl industry

According to FAO [7], the aquaculture industry has grown drastically. From less than a million tons of production in the early 1950s it has grown to a 59.4 million tons by 2004 with a value of US$70.3 billion. Within the aquaculture sector, the pearl industry has also undergone a considerable economic change [8]. Initially the industry which only relied on wild catch has changed into an industry that largely relies on cultured oysters. This has been the result of developments in market, improved technologies and dissemination of pearl culture technology. Southgate [9], referred to the pearl oyster industry as a growing multibillion dollar sector of the mollusc aquaculture. Pearl farming exists all over Australasia, the Middle East and South America. Traditionally Japan and Australia have been dominant in culturing pearls. However, other countries such as India, Sri Lanka, Thailand, Mexico, Sudan, Philippines, French Polynesia, Cook Islands and China have also grown in pearl production, increasing the competition for quality pearls [10]. Farmed mother-of-pearl shares the same features as the cultured edible oyster [9]. Pearls have a well-established market and are not only non-perishable; shipping cost is also negligible, hence it is considered an ideal product for export by many countries [2].

Seawater cultured pearl industry

The cultured seawater pearl industry comprises three different species. These include Akoya pearl from *Pinctada fucata martensii* oyster, South sea pearls from black-lipped *Pinctada margaritifera* oyster and South sea pearls from white and gold-lipped *Pinctada maxima*. These species are different and have developed independently from each other producing unique pearls from different geographical locations. Akoya pearls are grown in Japan, China, Vietnam and Korea. South sea pearls from black-lipped oysters are farmed in Tahiti and other minor producing areas in the South Pacific while the South sea pearls from white or gold-lipped oysters are farmed in Australia, Indonesia, the Philippines and Myanmar, Subah and Papua New Guinea. The three pearl species are similar in terms of life history and biology, farming methods/systems and techniques. The products are in direct competition with each other and are marketed in a similar way [11].

South sea pearls from black-lipped *Pinctada margaritifera*

Due to availability of *Pinctada margaritifera* all over the Indo-Pacific region, it is cultured in Tahiti, Cook Islands, New Caledonia, Fiji, the Marshall Islands, Indonesia, the Philippines, the Ryukyu Islands, as well as in the Pescadores Islands. Tahiti has been the major producer of black pearls ever since it started. Tahiti dominates the global market, both in terms of weight and value since production is about 93 to 95 percent of all black pearls produced by the south sea black-lipped pearl industry. Apart from Tahiti, the Cook Islands and Fiji are the other very active producers of black pearls. Fiji's Justin Hunter pearl is of high quality although only a small quantity is produced [11].

History of pearling in Fiji

Pearl oyster culture started in Fiji in the 1960s. An emigrant from Japan, Mr. Yasuharu Tokito began trials with mabe pearl on the island of Ovalau. After successful trials he started with round pearls using black-lip. He used techniques he acquired in Japan. Mr. Tokito continued producing black pearls in different sites around Fiji for 50 years. As of late, Mr. Tokito's sons Kenji and Koji operated Tokito Pearls on their own island in Rakiraki [12].

According to Chand & Naidu et al., the Australian Center for International Agricultural Research (ACIAR) in collaboration with Fiji Fisheries identified sites for pearl oyster spat collection in the Savusavu region of Fiji and determined that growth rates of black-lip pearl oyster were best. Based on this, Fiji Fisheries started a demonstration farm in Savusavu where they conducted trials and determined the model for economic feasibility of producing pearl in Savusavu. This was part of the Fiji government's support to private sector investment.

Fiji produces some of the best quality of pearls in the world [2]. According to Hon Ilaitia Tuisese (Minister for Fisheries and Forests) in 2006, Fiji had 14 pearl farmers; 4 were operated by foreigners with local partnership while 10 were owned by indigenous farmers. According to a Fiji Fisheries Department Report in 2008, the 11 operational farms in the Northern and Western divisions had annual revenue of FJ$6 million.

Justin hunter is the leading pearl farmer in Fiji and plays an important role in the development of pearl industry in Fiji. He maintains a strong working relationship with the local community and other pearl famers. The success of Justin Hunter pearls encouraged other operators to start farms in Fiji. Other prominent farms include the Pearls of Paradise in Rakiraki, Valili Pearl farm in Savusavu, Peckham Pearls and Civa Pearls in Taveuni [12] (Figure 1).

Constraints for growth of pearl production in Fiji

A survey by Chand & Naidu et al. identified several factors such as; availability of oyster stock/spat, lack of infrastructure, disease and poor condition of oysters, which were possible constraints to the pearling industry in Fiji [12]. The farmer's priorities were different depending on their farm sizes. Smaller farmers identified availability of infrastructure, training in pearl seeding and husbandry and improving business skills as their utmost priority while larger farmers identified research to improve farming practices and pearl production, product development, and marketing and branding as their priorities. The biggest issues hindering the growth of the pearl farming industry in Fiji was availability of oyster spat and security of tenure of pearl farm sites.

Habitat and distribution of *Pinctada margaritifera*

Pinctada margaritifera naturally inhabits coral reef waters which can be oligotrophy and low in turbidity [13]. It lives attached to hard substrates on the reefs. When compared to other pearl oysters, *P. margaritifera* is most widely distributed across oceans [14]. It is largely distributed across the Pacific Ocean, Indian Ocean, Eastern Mediterranean Sea, East Africa, Madagascar, Red Sea and the Persian Gulf. According to Gervis and Sims [10], *P. margaritifera* is distributed over a wide latitudinal range; from 30.8° north to 28.8° south. Atoll lagoons in French Polynesia and the Cook Islands have the greatest quantity of this oyster species (Figure 2).

Anatomy and Taxonomy

Scientific name: *Pinctada margaritifera* (Linnaeus, 1758);

Kingdom: Animalia

Phylum: Mollusca

Class: Bivalvia

Order: Pterioida

Family: Pteriidae

Genus: *Pinctada*

Species: *margaritifera*

Common name: Blacklip pearl oyster

Fijian name: "Civa" (pronounced; thee-va)

Describer/year: Linnaeus, 1758 (Figure 3).

Physical description of *Pinctada margaritifera*

P. margaritifera shell is greyish green with white or yellowish radial rows of scale on the outside and pearly with pale blue or violet cast on the inside. Inside margins of the shell are black. The shell commonly reaches a maximum size of approximately 200 mm in height. Large and inequilateral shells are heavy and shell valves equal in shape and size. Externally the shells are rough with concentric ridges and rows of wide scales pressed flat against the shell [15].

Reproduction and development

According to Thomas [16], *P. margaritifera* are protandrous hermaphrodites, that is, individuals start as male and later change sex to become female.

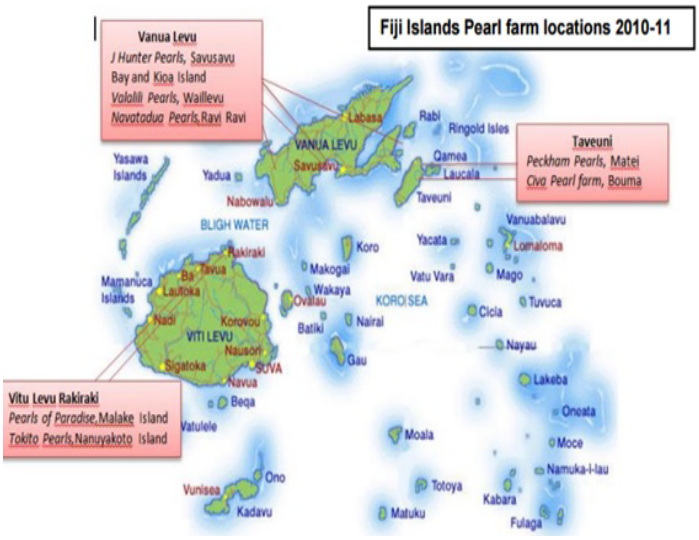

Figure 1: Location of pearl farms in Fiji [11].

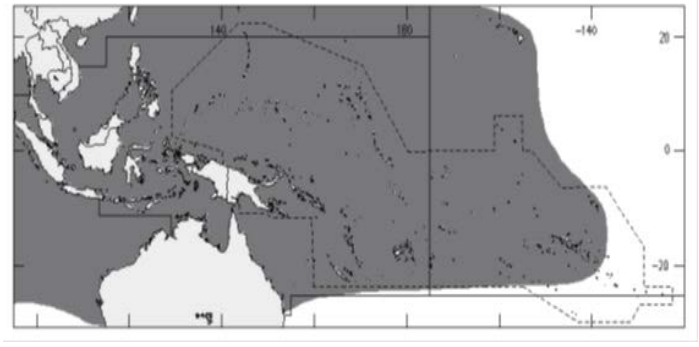

Figure 2: Distribution of *Pinctada margaritifera* in the Indo-Pacific region [1].

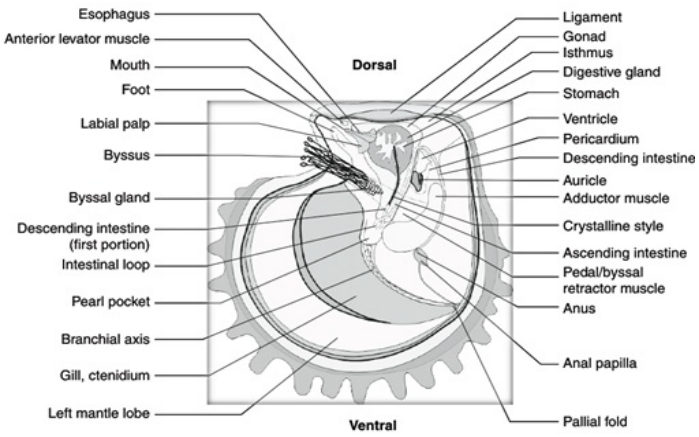

Figure 3: Anatomy of *Pinctada margaritifera* (Source: Fougerouse-Tsing and Herbaut, 1994).

P. margaritifera oysters reach maturity in the first year but their gonad development continues into the second year making them sexually mature at 2 years of age, which is approximately the same time the oyster change its sex [17].

P. margaritifera spawn by releasing gametes into water for external fertilization. Spawning is dependent on factors such as salinity, currents, air exposure, and temperature. Temperature plays one of the major roles in determining spawning times [14]. As seen in Australian Pearl oyster Pinctada albino where highest spawning occurs during the highest temperatures [18]. During a single spawning, females can broadcast 40-50 million eggs while the males will broadcast 10- 100 times more spermatozoa [16]. After fertilization the first larval stage is reached in 24 hours. For this duration, velum aids in swimming and feeding. Vulnerability to predators and changing current is highest during the larval phase [17]. The pelagic larval stage lasts for about 15 to 30 days.

The pelagic larvae then undergo metamorphosis to become spat or juvenile oyster. During metamorphosis it loses swimming capacity and settles to attach to a substrate using byssus [14]. Larvae mostly settle in dark areas or on dark materials [19]. The preferred substrates can be along the flanks of coral pinnacles and on deep coral patches. It can also be debris from coral and mollusk shells [16]. *P. margaritifera* devotes a huge amount of time looking for a compatible substrate and if it is unsuccessful, the oyster uses its foot to migrate to a different location [20]. According to Van Dyke [21], *P. margaritifera* has an average lifespan of 15 years in the wild and they are filter feeders. These oysters primarily feed on plankton but studies have also found mud, inorganic material and other less than ideal items in their gut [20]. *P. margaritifera* as adults are highly vulnerable to predators [20,22]. Their predators include sharks, rays, octopus, starfish, gastropods and mud worms. Within the Red Sea the gastropod Chcoreus virgineus is the most common predator for *P. margaritifera*). In Palau, mud worms were the major cause of mortality for majority of *P. margaritifera*.

Ecosystem roles

P. margaritifera as bivalves consume phytoplankton and contribute to *improving water quality. The "top-down" grazer control role of pearl* oysters decreases suspended particle density allowing more light to reach the benthos. Waste released by bivalves is used as food by phytoplankton. Besides being food for higher-order carnivores, bivalves form beds that in turn form a structured habitat for many epifaunal and infaunal invertebrates [17].

DISCUSSION AND CONCLUSION

History has a vital role in future development of pearling industry. Having looked at the historical significance of pearls together with different types of pearls it is clear that pearling industry in Fiji has developed over the years and has come long way overcoming obstacles. *Pinctada margaritifera* has been one major species utilized for production of round pearls in Fiji. Apart from being a very productive aquaculture species it plays very ecological roles in maintaining environmental sustainability.

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