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Polynesian pearls

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Abstract :

Black-lip pearl oyster culture in French Polynesia is still based on natural spat collection from wild stocks, but new developments in hatchery technology and selective breeding are bringing substantive change to the sector.

In French Polynesia, the black-lip pearl oyster *(Pinctada margaritifera)* is the top aquaculture species.The cultured pearls produced in this Pacific region, are the top export resource and second economic driver after tourism.

In 2014, there were 536 pearl producers across 26 atolls and islands, concentrated in three archipelagos: Tuamotu (79.0%), Gambier (14.5%) and Society (6.5%).

Black-lip pearl oyster aquaculture in French Polynesia is still based on natural spat collection from wild stocks, mainly taken from the atolls of Ahe, Katiu, Takapoto, Takume in the Tuamotu Archipelago, and from the lagoons of the Gambier archipelago. Spat are collected in these lagoons during the reproductive season where they settle onto artificial collectors and are left up to six months for pre-growing. They are then transferred to different pearl farm locations where they are grown in various culture systems.

Production of a cultured pearl requires two animals: One is used for collection of a small piece of mantle tissue (a graft) which is inserted with a round bead of nacre (nucleus) into the gonad of a recipient oyster. Approximately 18 months after implantation a pearl is harvestedand oysters are sometimes re-implanted to produce a second pearl (*surgreffe*).

Quality over quantity

The need to improve pearl quality over quantity remains a major concern for the industry in French Polynesia. One of the potential solutions is the genetic improvement of stocks through selection of both donor and recipient oysters. Indeed, the production of high quality pearls through family genetic selection remains one of the main challenges for future aquaculture development of black-lip pearl oysters.

Selection for traits like growth performance of both donors and recipients for breeding programs offers great potential for increasing cultured pearl size, which is one of the most important pearl quality traits, with the largest pearls being the most valuable.

Hatchery processes for mass production is then an essential tool for such promising developments. Several first-generation donor families have already been bred and reared at experimental scalethrough hatchery-produced spat in conjunction with selective breeding strategies.

Collaboration between private companies, DRMM (Direction des Resources Marines et Minières) and Ifremer (French Research Institute for Exploitation of the Sea) has been initiated to establish multiple selected lineages for quality traits of interest through progeny testing.

Important partnerships

Financial partnerships between private companies in the pearl industry and Ifremer in French Polynesia began with the "RikiGEN" project which was supported by the French Ministry of Overseas Department and Territories between 2012 and 2015. This project was entitled: “Hatchery and genetic improvement of the pearl oyster from the Gambier Archipelago”.

The objectives were to establish the basis for the development of multiple selected pearl oyster lines through broodstock set-up and experimental *in-situ* reproduction. In addition to this project the characterization of the genetic resource specific to the Gambier archipelago has been managed in several ways. This includes several experimental grafts designed to estimate the potential of using first

generation progenies as graft donors while studying their biomineralization gene expression level at a molecular scale.

Today, the RikiGEN project has initiated other collaborations with several private companies located in the Tuamotu archipelago. The goal is to develop hatchery-produced oyster of selected lines for some rare oyster phenotypes.

Some phenotypes can be particularly advantageous because of their local adaptation to their specific environment (e.g. excessive heat observed in Marquesas habitat) which improves not only their survivability, but also their performance. In extreme environments, adaptability (e.g. heat stress resistance in Marquesas) often constitutes a potential for global climate change anticipation.

Four projects will address different non-exploited origins, with pearl oysters originating from Marquesas and Australe archipelagos, where particular phenotypes have been collected (outer and inner shell colouration).

Dominique Devaux, head of the Regahiga Pearl Farm & Hatchery, a partner of the RikiGEN research project, said: “As a pearl producer since 1986, I have always sought to improve the quality of my production. But for a decade I realized that technologies and science could bring me further in the quest for quality. The hatchery constitutes a formidable and essential tool to genetically improve the animal through important quality traits of shell that determine overall cultured pearl quality.”

Key step ahead

As many marine species show a high degree of fecundity characterized by a planktonic larval stage of dispersion, the main objective in hatchery-produced pearl oyster is not only to reach a maximum rate of survival, but to select elite individuals for the pearling industry and discard the weakest.

As an illustration, during the entire production cycle, including the larval rearing stages, the water quality is not filtered through UV sterilisation as a way to apply a selective pressure during the different development stages.

In the frame of this rearing objective, the captive breeding and rearing of this species over its entire life cycle has been developed and adapted to the specificity of *P. margaritifera* through the following key steps:

•Microalgae production- Microalgae production of two tropical species, *Isochrysis galbana* (from the seventh day after fertilization) and *Chaetoceros gracilis* (added after day 7), without use of CO2 enrichment. As a consequence, this methodology need more time for the microalgae production, but is more adapted to local constraints in French Polynesia, where a supply of CO2 was difficult to obtain in isolated island and atolls;

• Broodstock conditioning –This involves the conditioning by microalgae feeding of the breeders for their gonad growth and maturation during one month in land facilities (continuous flow rate), prior to artificial spawning induction. This methodology allows for breeding throughout the year and especially out of the natural spawning season, which normally takes place in November to March in French Polynesia;

• Breeding procedure - Natural spawning following thermal shock is the current process for an improved yield of good D larvae quality production. Nevertheless, gonad scarification procedure using ammonium allows farmers to select genitors on the basis of characters such as inner shell colour, only distinctly observable on sacrificed animals and therefore not possible with thermal shock induced spawning.

A recent study showed that breeding of sires and dams exhibiting the most colourful inner shell phenotypes would be possible with the gonad scarification spawning procedure without affecting overall growth performance;

• **Larval rearing and selection -** Larval rearing is conducted in small tanks (30 L) under continuous flow rate (200 ml min^{-1} water flow and 40 % renewal rate per hour), without need of antibiotic (currently applied during the critical phase of metamorphosis to Embo stage and settlement, which showed massive larval mortalities owing to infections caused by bacterial pathogens).

During the larval rearing (20 days after fertilisation when the pediveliger stage was reached), cleaning of the small tank, selection of the larvae by size (they were sieved on 60 µm and 100 µm mesh at day 8 and day 15) are sequentially applied. This methodology has significantly improved the time of work for larval rearing in comparison to static larval rearing usually made at bigger volume (tanks of several m^3).

• **Transfer into lagoon -** Transfer of two-month-old juveniles, through "scattering procedures," onto commercial spat collectors made from modern synthetic materials provides promising results. This process consists of a two day settlement before transfer of the collector to the lagoon where they are left for on-growing. After one year of rearing, promising results have been observed and the first hatchery-produced and selected oyster generation of the black-lip pearl oyster would be used at pilot scale in farming conditions by end of this year.

Genetic improvement

Although spat can be collected from the wild in French Polynesia, difficulties in collecting it from areas where the resources for black-lip pearl oysters are not abundant, or are of low quality, have led other countries (Fiji islands and Micronesia) to start hatchery-produced spat with static larval methods.

In Japan, Australia and southeast Asia, hatchery programs have also been developed for other pearl oyster species (*Pinctada fucata* and *Pinctada maxima*) to meet the needs of production.

This global genetic improvement program for black-lip pearl oyster started several years ago. Some major results were obtained from these research actions, together with an understanding of the larval rearing of the species, a key step in its domestication.

First generation families (G1) were produced through hatchery technologies at the Ifremer facilities (Tahiti), with artificial crosses of individual and selected wild dams and sires. These G1 families were tested for their potential as graft donors in graft experiments at farm-scale.

For pearl colour, family effects were clearly detected, with some families showing fairly different colour expression (Lustre was shown to be more influenced by the environment than by genotype).

In addition, a classification tree model was built to predict the color and darkness level of harvested pearls. Controlled crosses were also set up according to flesh and shell color phenotypes to investigate inheritance patterns of these characteristics. All these preliminary results have implications for the selective breeding of the black-lip pearl oyster.

In bringing together academic expertise and industry ambition, this transformative project could deliver measurable economic growth in a key Polynesian sector.

The time is not far off when multiple donor and recipient oyster lines producing pearls with specific quality (colour, size...) can be developed for the pearling industry.

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