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PACIFIC ISLAND PEARL OYSTER RESOURCE DEVELOPMENT

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Introduction

The blacklip pearl oyster, *Pinctada margaritifera*, has a wide Indo-Pacific distribution from the Pacific coast of central America to the Red Sea. This species supports cultured black pearl industries in French Polynesia and Cook Islands which generate estimated annual incomes of US\$40 million and \$US4 million, respectively (Sims, 1993). These incomes are very significant amounts in terms of the budget of these small Pacific nations and, understandably, the success of these industries has aroused considerable interest in other Pacific nations.

This project (PN 9131 Pacific Island Pearl Oyster Resource Development) was funded by the Australian Centre for International Agricultural Research (ACIAR) and was formally commenced in July 1993. The major focus of the project was Kiribati although the technology generated from the project is widely applicable to other Pacific nations. James Cook University (JCU) was the commissioned Australian institution for the project and collaborating institutions were the Ministry of Environment and Natural Resource Development (MENRD) in Kiribati, Queensland Department of Primary Industry (QDPI), Australia, ICLARM Coastal Aquaculture Centre (ICLARM-CAC), Solomon Islands and the South Pacific Commission (SPC).

Objectives

The major objectives of the project were :

1. To assess the natural stocks of pearl oysters in Kiribati and Fiji and the rates of spatfall (newly settled juveniles) of blacklip pearl oysters in the atoll lagoons of Kiribati.

2. To develop appropriate low-technology methods for hatchery culture and nursery culture of blacklip pearl oysters, allowing natural stocks to be replenished, the development of sustainable wild population and sufficient spat for culture operations.
3. To improve the yield of gem quality and average quality pearls through better bead insertion and oyster management practices.

Survey work conducted as part of Objective 1 was undertaken in Kiribati by Fisheries Division staff. Survey work in Fiji was undertaken by Fiji Fisheries staff and was coordinated by SPC. Research conducted towards Objective 2 was conducted primarily at JCU. It included collaboration with the ICLARM-CAC where a trial hatchery experiment was conducted in 1994. The methods developed at JCU were implemented in Kiribati towards the end of the project, following the building of a pilot hatchery in Kiribati. Research towards Objective 3 was conducted by QDPI.

Stock assessment and spatfall

Some previous survey data were available for stocks of the blacklip pearl oyster in Abaiang and Butaritari atolls in Kiribati (Preston et al, 1992). Initial surveys conducted as part of the ACIAR project were focused on areas where suitable pearl oyster habitat was known to exist and where anecdotal evidence suggested that pearl oysters may be present. Three atolls, Abaiang, Abemama and Onotoa were surveyed in the first year of the project and a further two atolls, Maiana and Butaritari were surveyed in the second year of the project. All five atolls are in the Gilbert Island group of Kiribati. Very few live pearl oysters were found in Abaiang, Abemama and Onotoa and none were found in Maiana and Butaritari. Clearly, at best, *P. margaritifera* is present in low densities in the lagoons of these atolls. These findings confirm those of previous survey work in the Gilbert island group which reported low densities of *P. margaritifera* (Preston et al., 1992).

Surveys of a number of reefs in Fiji were undertaken in 1995. The surveys showed that *P. margaritifera* populations are low in the areas surveyed; however, moderate numbers of the winged pearl oyster *Pteria penguin* were observed suggesting that there may be some potential for half pearl (mabe) production based on spat collection.

The initial objective also included assessment of pearl oysters spat fall in the lagoons of Kiribati. However, for a number of reasons including the low number of adults found in the stock survey, delay in obtaining spat collector materials and increasing emphasis towards hatchery production in Kiribati, studies on spatfall were not undertaken.

Hatchery and nursery research

Reliable methods were developed for sexing and spawning *P. margaritifera* broodstock. Spawning was reliably induced by holding broodstock overnight at 21-22°C followed by rapid temperature increase to 30-32°C. Initial emphasis was placed on the development of a flow-through culture system for *P. margaritifera* larvae. This system has been used successfully for rearing giant clam larvae (Braley, 1992). In these systems, culture water is exchanged on a flow-through basis where effluent water passes from the tank through a mesh sieve which prevents exit of larvae. Thus, water can be exchanged without removing the larvae from the tank or from the culture water. In conventional static culture systems, water exchange requires removal of the larvae from the culture tank every 1-2 days by sieving. As such, flow through culture requires significantly reduced labour input. Flow-through culture is also likely to result in better water quality (by more frequent water exchange) and reduced handling stress for the larvae. Details of the flow-through system developed during the project are given in a previous report (Southgate, 1995).

A significant proportion of the research was directed at assessing the suitability of flow-through larval culture in comparison with the traditional static culture method. Flow-through culture was shown to be a feasible means of rearing *P. margaritifera* larvae.

Larval growth and survival did not differ significantly between flow-through and static culture methods although water quality (ammonia and nitrite content) was significantly better in the flow-through tanks than in the static tanks. However, use of the flow-through larval culture technique significantly reduces the labour required for larval culture.

The best larval rearing experiment at the JCU Orpheus Island Research Station (OIRS) produced 25,000 5 week old spat of 3-5 mm hinge length. At 3.5 month of age the largest spat had dorso-ventral shell heights of 25-28 mm. However, approximately 63% of the spat at this age fell between a 5 mm and 10 mm square mesh during grading and had a mean shell height of 11.2 mm and a mean hinge length of 11.7 mm. Once graded, spat were transferred to the ocean for nursery culture in suspended plastic trays and pearl nets at different densities for 4 months. Pearl oysters in the trays were held at densities of 10, 50 and 100 per tray while those in pearl nets were held at 20, 50, 100, 150, and 200 individuals per net. Pearl oyster survival in the trays varied from 76-88% and from 68-75% in pearl nets. Pearl oyster growth was affected by density. For example, dorso-ventral height, hinge length and wet weight were 39.2 mm 34.5 mm and 6.8 g, respectively, for oysters held at 20 per pearl net and 29.8 mm, 26.2 mm and 3.2 g, respectively, for those held at a density of 200 per pearl net. An experiment is now under way to assess growth rates and survival of larger *P. margaritifera* juveniles held in plastic trays, pearl nets, panel nets, panel net inserts and by ear-hanging.

Micro-algae are the traditional food source for bivalve larvae reared in hatcheries. Micro-algae were used as the food source for the initial larvae rearing experiments to assess the flow-through system independent of nutritional factors. However, the culture of micro-algae is a major constraint to hatchery development in small island nations. Micro-algae culture is expensive and requires specialised facilities and trained personnel. Part of the research focus within Objective 2 was to assess artificial diets as an alternative to cultured micro-algae. A number of 'convenience' feeds (dried algae, yeast products, algal pastes, commercial microcapsules and experimental microcapsules manufactured at JCU) were assessed for *P. margaritifera* larvae in small scale culture trials. While some yeast-based diets ('Lansy', Artemia Systems, Belgium) and commercially available microcapsules ('Booster', Frippak Feeds, UK) were of little nutritional value for *P. margaritifera* larvae, other commercial products such as dried micro-algae (*Tetraselmis suecica* marketed as 'Algae 161', Celsys, UK) and the Torula yeast based diet ('L-10, Microfeast, USA) were shown to be of high nutritional value to *P. margaritifera* larvae and will allow, at least significant partial replacement of live micro-algae without affecting growth and survival of larvae. More research is necessary in this area to develop appropriate feeding strategies using these 'artificial' diets.

Construction of a pilot-scale hatchery was begun on Fisheries Division property at Tenaia on Tarawa, Kiribati in early 1995. The majority of the equipment was dispatched from Australia and the hatchery was completed in July 1995 at a cost of approximately AU\$60,000. Two batches of hatchery reared spat have been produced in Kiribati. The first larval rearing attempt (October, 1995) resulted in 6-10,000 5 weeks old spat and a second spawning in February, 1996 resulted in 2-6,000 spat which were transferred to the lagoon of Abaiang for subsequent nursery culture. Unfortunately, both batches of spat showed poor survival probably as a result of inappropriate husbandry practices. Major mortality was thought to result from fouling of the containers housing the spat (plastic bins lined with 1 mm plastic mesh) and from infrequent inspection. Subsequent research at JCU has developed more suitable methods for culture of pearl oyster spat after transfer from hatchery tanks which will hopefully alleviate these problems. A major focus for future research will be the development of more appropriate nursery culture techniques.

Pearl quality research

Experiments with half pearls were conducted to evaluate several adhesives, the use of relaxants, the use of plastic half-sphere moulds with either smooth or rough surfaces and the effect of position, number and size of the moulds within each shell valve. Experiments with round pearls were conducted to evaluate several relaxants, several antiseptics, methods of improving wound healing, method of site preparation for pearls sac formation. Attempts were also made to culture mantle cells. Experiments to assist the speed of wound healing included the use of fine nylon thread sutures and the use of several types of adhesive.

For half pearl production, a cyanoacrylate adhesive ('super glue') proved to be ideal. However, no satisfactory outcome was obtained for the other factors evaluated because of poor environmental conditions (water quality, nutrition and cold) for the oysters in the sea. Only cyanoacrylate adhesives showed promise for wound healing in round pearl culture. Cyanoacrylate appeared to speed-up the healing process which occurred within a few days. However, the adhesive caused some reaction where it contacted the oyster tissue. The adhesive used was also inflexible so that it tended to separate from the tissues when they contracted. A more flexible adhesive used in thinner strips is under evaluation.

Of the several relaxants evaluated, propylene phenoxetol used at 2-3 ml/l appeared to be satisfactory. It resulted in rapidly induced relaxation (less than 15 minutes), full relaxation for 10 minutes, rapid recovery (less than 30 minutes), 100% recovery and 100% survival after 7 days. It was simple to use and is non-toxic to the human operator if adequate precautions are taken. It has been used on a pearl farm with satisfactory results. Of several antiseptics evaluated, a 1/50 dilution of 10% Betadine (Povidone Iodine) caused no acute or chronic toxicity and reduced bacterial contamination. However, very few bacteria were found on the mantle and gonad surfaces of normal pearl oysters.

Attempts were made to prepare a pearl sac in the mantle of pearl oysters. One approach was to produce an infolding under the mantle which was unsuccessful. Another approach was to thicken the mantle using chemical and physical agents (eg. heat, cold etc). This was also unsuccessful. Current attempts aim to restrict the flow of haemolymph from the mantle, while at the same time injecting sterile seawater into the mantle to thicken it in preparation for the later formation of a pearl sac. Limited attempts were made to culture the nacre producing cells of the mantle using tissue culture techniques. All attempts were unsuccessful.

Training

A number of project participants received training during the course of the project. Staff from the Kiribati MNRD Fisheries Division and Fiji Fisheries Division received valuable practical experience in the methodology of marine surveys and scientific diving.

Before taking up this position as an Australian Volunteer Abroad (AVA) with the project in Kiribati, Mr Jamie Whitford undertook 3 weeks training on pearl oyster culture methods at JCU and 1 weeks training in spat collection methods at the ICLARM-CAC in the Solomon Islands. Two Fisheries Officers from Kiribati, Mr Tuake Teema and Ms. Tiare Tabee, visited JCU for a 6-week training period in February and March 1995. Mr Maruia Kamatie (Project Leader for Kiribati) also visited JCU for one week during this period. Training included aspects of the anatomy and biology of *P. margaritifera*, maintenance of a longline and broodstock pearl oysters, maintenance and culture of micro-algae stocks, spawning induction and larval rearing and use of hatchery and nursery equipment. A manual for culturing micro-algae was produced for the training courses and other hatchery users. Mr Ben Sagata from the Makogai Island mariculture facility in Fiji received training on pearl oyster biology, spawning induction and larval rearing from JCU staff during a 1 month visit to the ICLARM-CAC. Mr ÊBeero Tioti (Hatchery Manager, Kiribati) and other Fisheries staff in Kiribati received on-site hatchery and nursery training from JCU staff in Kiribati.

Summary

Surveys of the atolls of the Gilbert Island group of Kiribati have shown that *P. margaritifera* exist in very low numbers in the lagoons. Clearly, for pearl culture to reach a point where commercial production is feasible in Kiribati, production of hatchery reared juveniles is necessary. With this in mind, a pilot hatchery was built at Tanaea in Kiribati and two batches of spat have been produced showing the feasibility of hatchery production in Kiribati and other Pacific nations. More suitable simplified methods have been now developed at JCU for nursery culture of *P. margaritifera*. These techniques will hopefully alleviate the initial nursery problems encountered in Kiribati.

Future Research

The project was recently (April, 1996) reviewed and continuation of the project into a second phase has been recommended. A second phase is likely to begin in the first half of 1997 following an interim phase of the project to maintain continuity of research. A second phase of the project is likely to focus on: 1) continued development of hatchery and grow-out technology for use in the atolls of Kiribati and other Pacific nations; and 2) the development of pearl farming systems. The inclusion of Fiji into a second phase of the project was also recommended by the project review. Research efforts in Fiji are likely to focus on spat collection and further stock survey work.

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