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The effect of different culture methods on the quality of round pearls produced by the black-lip pearl oyster *Pinctada margaritifera* (Linnaeus, 1758)

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ABSTRACT

A range of culture units and husbandry methods may be used for pearl oysters and the two most commonly used for *Pinctada margaritifera* are panel nets and chaplets. In this study, six hundred *P. margaritifera* were grafted for the first time and cultured using panel nets or chaplets at three commercial farm sites to determine if these different culture methods influences resulting pearl quality. The pearls produced were compared in terms of size, shape, lustre, colour, surface perfection and overall quality. The highest proportion of pearls produced in all treatments was in the 10–11 mm size category (37–54%) but culture method did not significantly ($p = 0.211$) influence the size of pearls produced. Oysters held on chaplets produced more pearls with concentric surface grooves or 'circles' (47–60%) compared to oysters in held panel nets (43–45%) at all three culture sites. Oysters held in panel nets produced higher proportions of pearls in the more desirable 'round' and 'semi-round' shape categories (6% and 25%, respectively) than oysters held on chaplets (5% and 15%, respectively) at all three culture sites, and culture method had a significant impact ($p = 0.031$) on pearl shape overall. Higher proportions of pearls in the 'very high' and 'high' lustre categories (8% and 40%, respectively) were produced by oysters held in panel nets compared to those on chaplets (3% and 16%, respectively) at each of the three culture sites. However, the overall impact of culture methods on pearl lustre was not significant ($p = 0.100$). At all three culture sites, higher proportions of pearls assigned to grades 'A' (6%) and 'B' (46%) were produced by oysters in panel nets compared to those held on chaplets where 3% and 29% of pearls were assigned to grade 'A' and grade 'B', respectively. Oysters held on chaplets produced higher proportions of grade 'C' (49%) and grade 'D' (19%) pearls than those in panel nets (39% and 9%, respectively) at all three culture sites. The grades of pearls were significantly influenced ($p = 0.035$) by culture method. This study clearly demonstrated the benefits of pearl production using panel nets compared to the traditional chaplet-based system used by the majority of pearl farmers in Fiji and throughout the Pacific. Pearls production using panel nets will provide better returns with higher profit margins for pearl farmers but requires greater outlay for infrastructure and labour that may be beyond the scope of most pearl farmers in Fiji and the Pacific. A detailed cost–benefit analysis of the two husbandry options would be beneficial to pearl farmers.

Statement of relevance: This paper presents novel new information showing that grafted *P. margaritifera* cultured using panel nets produced pearls with fewer 'circles' and of higher quality and value than oysters cultured using chaplets. The potential benefits to pearl farmers of pearl production using panel nets compared to the more traditional chaplet-based system are clear and the results of this study support improved pearl quality and income for pearl farmers in the Pacific.

1. Introduction

Cultured pearl production is initiated when a piece of mantle tissue (saibo) from a donor pearl oyster and a round inorganic nucleus are inserted into the gonad of a host pearl oyster (Gervis and Sims, 1992; Taylor and Strack, 2008). This process is commonly called 'seeding' or 'grafting'. Subsequent proliferation of the donor mantle tissue forms a 'pearl-sac' around the nucleus (Kishore and Southgate, 2014) and continued deposition of nacre from secretory cells in the pearl-sac onto the nucleus eventually forms a cultured pearl over a period of about two years (Dix, 1972; Scoones, 1996; Taylor and Strack, 2008; Cochennec-Laureau et al., 2010).

A range of culture units and husbandry methods may be used to hold pearl oysters during culture (Gervis and Sims, 1992; Southgate and Beer, 2000; Southgate, 2008). These vary from enclosed units such as

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plastic mesh trays, mesh cages, and various types of nets (Gervis and Sims, 1992; Southgate and Beer, 1997; Southgate and Beer, 2000) to 'ear-hanging' which does not involve a culture unit per se. In Australia and south-east Asian countries, pearl oysters are predominantly cultured using panel nets that are made from strong steel or galvanized frames covered by mesh that is sewn to form pockets to hold the oysters. Pocket size and mesh size are increased with increasing oyster size. In French Polynesia and the western Pacific however, 'ear-hanging' is the major culture method used for juvenile and adult *P. margaritifera* (Ellis and Haws, 1999; Haws and Ellis, 2000; Haws, 2002; Southgate, 2008). Ear-hanging involves drilling a small hole close to the hinge in the antero–dorsal region of the oyster shell through which a monofilament line is inserted to tie the oyster to a single rope, which is itself suspended from a long line or raft (Gervis and Sims, 1992; Haws, 2002; Southgate, 2008). Multiple oysters are attached to each rope forming a 'chaplet'. Culture of pearl oysters using chaplets minimizes costs and labour needed for pearl production, but increases the susceptibility of oysters to predation and the impacts of wave agitation.

Many studies have considered the influence of various culture units on the growth rates and survival of pearl oysters (Southgate, 2008) and much of this research has focused on the black-lip pearl oyster *P. margaritifera* (Coeroli et al., 1984; Southgate and Beer, 1997; Friedman and Southgate, 1999; Southgate and Beer, 2000). However, we are unaware of any prior study into the effects of culture method on the quality of resulting round pearls. Lack of research in this area is surprising given that only around 5% of the total harvest of cultured pearls from *P. margaritifera* are of the highest quality and these generate approximately 95% of farm profits (Haws, 2002). On this basis, only a small increase in the proportion of the highest quality pearls could result in substantial economic benefits to pearl farmers.

The major characteristic affecting the quality of pearls produced by *P. margaritifera* is the presence of 'circles' or concentric depressions or grooves on their surfaces (Ito, 2009). There is anecdotal suggestion that oysters cultured on chaplets produce a higher proportion of pearls with circles than those held in nets. Kishore et al. (2014) recently showed that 'ear-hung' *P. margaritifera* produced greater numbers of byssus that were thicker and had greater tensile strength than those produced by oysters held in panel nets. They speculated that these factors may negatively impact the development or function of the pearl-sac which, in turn, may affect resulting pearl quality (Kishore et al., 2014). If this is the case, then a greater understanding of the influence of culture method on pearl quality would greatly assist the cultured pearl industry to optimize husbandry practises for cultured pearl oysters. This study therefore assessed the quality of pearls produced by *P. margaritifera* held in panel nets and on chaplets during the pearl development period.

2. Material and methods

This study was conducted at three commercial pearl culture sites owned by J. Hunter Pearls (JHP) of the Fiji Islands. The three sites, Nawi (16°46′12.14″S, 179°19′15.48″E), Raviravi (16°47′19.44″S, 179°18′10.55″E) and Cousteau (16°47′18.83″S, 179°18′12.65″E) are located in Savusavu Bay on the island of Vanua Levu.

The oysters considered for this experiment were among those collected as wild juveniles (spat) obtained from spat collectors deployed at various sites within Savusavu Bay. Once removed from spat collectors, oysters were cultured using standard commercial methods until they reached a size suitable for pearl grafting. A total of 600 oysters with mean (±SE) antero-posterior measurement (APM) of 100.78 ± 0.21 mm and dorso-ventral measurement (DVM) of 112.41 ± 0.43 mm were randomly selected from the available pool of oysters for grafting. The oysters had not previously been used for pearl production. Oysters were cleaned before being grafted by one of the three professional and experienced *P. margaritifera* grafting technicians. The grafting procedure generally followed that described by Taylor and Strack (2008). Briefly, it included careful selection of healthy donor oysters, excision of mantle tissue from each shell valve, stripping the pallial mantle from the excised mantle portion and cutting it into small square pieces to obtain saibo. A 2.7 *bu.* nucleus (ca. 8.2 mm diameter) together with a single piece of saibo was then grafted into the gonad of each recipient oyster. The maximum time between saibo preparation and its use for pearl grafting was less than 25 min. Grafted oysters were placed into lantern nets and transferred to one of the three culture sites where they were held at a depth of 7 m. Two-hundred grafted oysters were held at each site for three weeks but they were not turned during this convalescent period. Oysters were then transferred to either eight-pocket panel nets (40 × 40 mm mesh pore) or chaplets. One hundred grafted oysters were held using each culture method at each of the culture sites (i.e. a total of 600 oysters were used in the experiment). Grafted oysters were maintained according the normal commercial husbandry procedures at J. Hunter Pearls, which included inspection and cleaning every two months for a period of 18 months before the pearls were harvested and graded.

2.1. Pearl grading

The five main characteristics used to determine pearl quality are shape, size, lustre, colour and surface perfection (Matlins, 2002; Strack, 2006; Taylor and Strack, 2008). These characteristics are used cumulatively to determine a pearl's overall grade and value. Pearls are normally graded using an AAA-A or A-D (Tahitian Grading) system (Matlins, 2002; Strack, 2006), where quality decreases from AAA to A or from A to D (Matlins, 2002). However, this is a subjective exercise and the extent to which individual characteristics contribute to a pearl's overall grade may be perceived differently by different pearl graders. Pearls produced in this study were graded using an A–D grading system by an experienced, professional grader of *P. margaritifera* pearls at J. Hunter Pearls.

2.1.1. Pearl shape

Pearls harvested from *P. margaritifera* in this study were classified into one of five shape categories; round, semi-round, circles, baroque and keshi, described in Table 1. The proportions of pearls in each of these categories produced by oysters cultured in panel nets or on chaplets were then compared. Shape was reflected in the overall grade assigned to a pearl as outlined in Table 2.

2.1.2. Pearl size

Pearl size was determined as the maximum diameter at the widest point of each pearl (Taylor and Strack, 2008) and was measured to the nearest 0.05 mm using a micrometre. Pearls (excluding 'keshi' pearls) were then classed into six size categories; 8–9 mm, 9–10 mm, 10–11 mm, 11–12 mm, 12–13 mm and 13–14 mm. The proportions of

Table 1
The different categories of pearl shape used to grade pearls produced by *Pinctada margaritifera* (Modified from Strack, 2006; Taylor and Strack, 2008).

Shape	Description
Round (R)	Pearl completely spherical with virtually no variation present on the surface.
Semi Round (SR)	Pearl not completely spherical but appears spherical when viewed from a particular angle. Slightly flattened or elongated shape is only visible when observed very closely. These pearls appear nearly round to the naked eye and were grouped with round pearls in this study.
Circles (C)	Pearls have symmetrical lines or 'grooves' on their surface. Pearls of all above shapes but with grooves were classed in this category.
Baroque (B)	Pearls are asymmetrical and appear distinctly irregular.
Keshi	Non-nucleated pearls with unique shapes produced following nucleus rejection.