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SHOULD SLOW GROWING PEARL OYSTER (*PINCTADA MARGARITIFERA*) SPAT ("RUNTS") BE DISCARDED?

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ABSTRACT In this laboratory, hatchery-produced *Pinctada margaritifera* juveniles are routinely graded at 3.5 mo of age, when spat of <5 mm ("runts") are generally discarded. This article reports on an experiment to assess the relative growth rates of three size classes (<5, 5–10, and >10 mm) of hatchery-produced blacklip pearl oyster (*P. margaritifera*) spat from the same cohort. The three size classes were classified as runts, normal growers, and fast growers, and had mean (±SE; $n = 30$) dorso-ventral shell heights (DVHs) of 4.5 ± 0.1, 8.6 ± 0.3, and 12.8 ± 0.2 mm, respectively, at the start of the 4-mo experiment. The mean DVH at completion of the study for each initial size class (<5, 5–10, and >10 mm) was 24.6 ± 0.4, 32.3 ± 0.4, and 35.6 ± 0.4 mm, respectively. All differed significantly from each other ($P < 0.001$). The mean incremental increases in DVH for each size class (<5, 5–10, and >10 mm) over the 4-mo period was greatest in oysters from the 5–10-mm size class (mean DVH 23.3 ± 0.4 mm) and lowest in oysters from the <5-mm size class (mean DVH 20.0 ± 0.5 mm). Incremental increases in DVH were significantly different between oysters from the <5-mm size class and those from the larger size classes. The mean (±SE) percentage increase in DVH was greatest in oysters from the <5-mm size class (448 ± 17%) and lowest in oysters from the >10-mm size class (178 ± 7%). A number of oysters in the <5-mm size class grew very rapidly during the experiment and reached the same DVH as oysters in the larger size classes. This study shows that, given appropriate conditions, runts are capable of similar growth rates as larger spat. It may therefore be inappropriate to discard pearl oysters, which are classed as runts (<5 mm) at grading (3.5 mo). Furthermore, it is suggested that grading be delayed until 5 to 6 mo when a greater proportion of oysters are likely to be in the larger size classes.

KEY WORDS: pearl oyster, *Pinctada margaritifera*, spat, runts, growth

INTRODUCTION

The growth of cultured bivalve molluscs is highly variable during hatchery and nursery culture, and variation in growth can occur among individuals of the same age reared under identical conditions (Newkirk 1981). Small differences in the size of spat can become large differences in juvenile size (Mason et al. 1998), and the greater the time required by slow growers to reach commercial size increases costs and reduces profitability (Askew 1978). Pearl oysters need to reach a minimum shell size before being used for pearl production. This size is generally reached at approximately 2 y of age. As such, maximizing growth rate and minimizing growth variation are important factors in pearl oyster cultivation.

A large variation in growth rate is evident for pearl oysters reared under identical conditions. For example, 43-day-old blacklip pearl oyster (*Pinctada margaritifera*) spat have been reported to range in size from 1 to 5 mm in dorso-ventral shell height (DVH) (Pit & Southgate 2000), and from <2 to 23 mm DVH at 3.5 mo of age (Southgate & Beer 1997). To minimize the size variation in pearl oyster spat, Rose (1990) recommended continual grading to separate fast growers from slow growers. Slow-growing pearl oyster spat are often discarded. In this laboratory, hatchery-produced *P. margaritifera* are routinely graded at 3.5 mo of age, when spat <5 mm ("runts") are generally discarded. "Runting" may result from unfavorable culture conditions, and, if this is the case, runts may be capable of good growth rates if provided with appropriate culture conditions. Given the high cost of hatchery production and the high value of pearl oyster spat, it is in the interest of pearl oyster farmers to maximize the number of spat from a given cohort that are eventually used for pearl production. The aim of this study was to determine whether slow-growing *P. margaritifera* spat remained as runts or whether they are capable of similar growth rates as normal spat when provided with appropriate conditions.

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MATERIALS AND METHODS

This study was conducted at the Orpheus Island Research Station of James Cook University, north Queensland, Australia (180°35′146°29′E), and larvae and spat were cultured according to the methods described by Southgate and Beer (1997) and Pit and Southgate (2000). At 43 days of age, when spat had a mean (±SE) DVH of 2.8 ± 0.1 mm (range 1–5 mm), they were transferred from the hatchery to the ocean where they were held in suspended mesh trays at a depth of 6 m (Southgate & Beer 1997).

Spat were graded at 3.5 mo of age into three different size classes, <5, 5 to 10, and >10 mm, which, for the purpose of this study, were classified as runts, normal growers, and fast growers, respectively. The mean DVH ($n = 30$) of *P. margaritifera* in the <5-, 5-to-10- and >10-mm size classes were 4.5 ± 0.1, 8.6 ± 0.3, and 12.8 ± 0.2 mm, respectively, and these differed significantly from each other ($F_{2,87} = 285.42$; $P < 0.001$). Thirty *P. margaritifera* spat from each size class were individually fixed to the bottoms of each of three replicate plastic mesh trays (60 × 35 × 10 cm) using a waterproof cyanoacrylate adhesive (Loctite 454 gel, Loctite Australia, Caringbah, New South Wales, Australia). This minimizes oyster aggregation (Friedman 1999, Pit 1998), which can significantly affect growth (Friedman & Southgate 1999). To minimize the disturbance to spat and to maximize growth rates, oysters were not measured during the 4-mo study; however, trays were cleaned *in situ* every month to remove external fouling organisms (Pit & Southgate in press). Cleaning involved the manual scrubbing of the outside surfaces of the trays. Trays were not cleaned internally, but were moved gently up and down in the water column to remove any silt and mud that had accumulated inside the trays. Oysters from each tray were measured for DVH at the end of the study.

Data were analyzed using a one-way analysis of variance to determine whether *P. margaritifera* from different size classes differed in size (DVH) at the completion of the study. Assumptions of homogeneity and normality were met (Zar 1984). The rates of growth among the three size classes were also assessed using nonparametric analyses to determine whether differences existed. Significant differences were identified using the Tukey's test and the Dunnett's T3 for the parametric and nonparametric tests, respectively (Zar 1984).

RESULTS

On completion of the study, the mean (±SE) DVH for each initial size classes (<5, 5–10, and >10 mm) were 24.6 ± 0.4, 32.3 ± 0.4, and 35.6 ± 0.4 mm, respectively. All differed significantly from each other ($F_{2, 87}$ = 167.67; $P < 0.001$) (Fig. 1). The mean incremental growth in DVH (n = 30) for each size class (<5, 5–10, and >10 mm) over the 4-mo period was greatest in oysters from the 5-10-mm size class (23.3 ± 0.4 mm) and was lowest in oysters from the <5-mm size class (20.0 ± 0.5 mm). Incremental shell growth was significantly greater in the two larger size classes ($F_{2, 87}$ = 15.99; $P < 0.001$) (Fig. 2). Weekly growth rates averaged 1.25, 1.42, and 1.48 mm, respectively, for the <5-, 5-10-, and >10-mm size classes. However, the mean percentage increases in DVH for each size class (<5, 5–10, and >10 mm) over the 4-mo period was greatest in oysters from the <5-mm size class (448 ± 17%) and lowest in oysters from the >10-mm size class (178 ± 7%), while oysters in the 5-10-mm size class increased by 308 ± 12%. A number of oysters in the <5-mm size class grew very rapidly and achieved DVH measurements within the ranges of those shown by oysters in the two larger size classes.

DISCUSSION

P. margaritifera used in this study were hatchery-reared animals of the same age that were cultured under identical conditions. However, when oysters were transferred from the hatchery to the nursery at 6 wk of age, their DVH ranged from 1 to 5 mm (mean 2.8 ± 0.1 mm). It is unclear whether such size variation resulted from environmental factors, genetic factors, or a combination of both. Factors that have previously been suggested to cause such size variation in bivalves include fluctuations in water quality and food quality (environmental), as well as egg and larval quality (genetic) (Gallager & Mann 1986, Rose 1990, Mason et al. 1998, Devakie & Ali 2000, Nicolas & Robert 2001).

Size variation was also evident during early nursery culture prior to grading when oysters ranged in size from 2 to 23 mm. Again, it is unclear whether size variation at grading reflected a continuation of the size variability observed in the hatchery, or

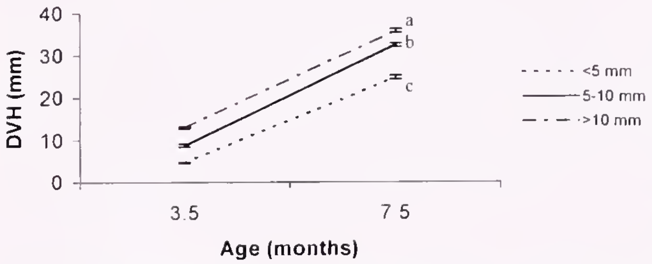

Figure 1. Changes in mean (±SE; n = 30) DVH of *P. margaritifera* juveniles in different size classes (<5, 5–10, and >10 mm) cultured for 4 mo at Orpheus Island. Means with the same superscript are not significantly different (P > 0.05).

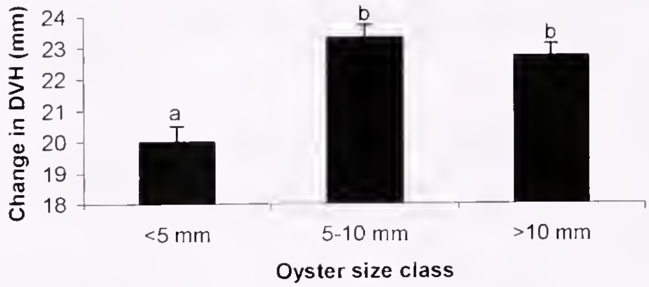

Figure 2. Mean (±SE) change in DVH of *P. margaritifera* juveniles in different size classes (<5, 5–10, and >10 mm) cultured for 4 months at Orpheus Island. Means with the same superscript are not significantly different (P > 0.05).

whether subsequent environmental factors were also involved. The negative impacts of poor growing conditions on pearl oyster growth rates during nursery culture are well documented. For example, pearl oysters aggregate to form clumps in culture units (Southgate & Beer 1997, Friedman & Southgate 1999). This results in a greater size range of individuals within a cohort and a higher proportion of smaller oysters when compared with oysters grown in conditions that prevent clumping (Friedman & Southgate 1999, Southgate & Beer 2000). The smaller oysters in the former group are thought to be those that are bound into clumps of oysters, and, as a result, have impaired access to good water flow and food availability (Friedman & Southgate 1999).

The growth rates of *P. margaritifera* spat recorded in this study were clearly influenced by initial size class, suggesting that genetic factors were more influential on initial spat size than were environmental factors. In a similar study with Pacific oysters, Collet et al. (1999) demonstrated a positive relationship between larval and postmetamorphic growth, indicating a genetic rather than environmental basis for slower growth in postmetamorphic bivalves. In contrast, Mason et al. (1998) reported that growth variation in Sydney rock oyster spat was not affected by initial size class and suggested that initial differences in size resulted from "temporary environmental stunting" rather than from genetic factors. Similar findings have been reported for edible oysters (Newkirk 1981, Newkirk & Haley 1982)

Hatchery production of pearl oysters is expensive, and it is clearly in the interest of pearl oyster farmers to maximize the number of spat from a given cohort that can be used for pearl production. However, the use of smaller spat, which take a longer time to reach a size suitable for pearl production, becomes an economic issue. Pearl farmers must consider the benefits of maximizing the number of usable oysters from a cohort of spat, against the increased time required for slower growers to reach pearl production size. Prior research at the culture site used in this study reported growth rates for *P. margaritifera* during nursery culture ranging from 3.66 mm mo^{-1} (in trays) to 4.86 mm mo^{-1} (in pocket nets) (Southgate & Beer 2000). Assuming similar subsequent growth rates for the three size classes of oysters used in this study, it is possible to estimate the time required for each size class to reach a pearl production size of 110 mm DVH. On this basis, oysters in the 5-10- and >10-mm size classes would reach 110 mm at 19 to 24 mo and 19 to 23 mo of age, respectively. However, oysters in the <5-mm size class would require 21 to 27 mo to reach this size (110 mm DVH). The costs involved in culturing oysters from the smaller size class for this additional time, however, may outweigh the costs of increasing oyster numbers by additional hatchery production or the purchase of juveniles. In a similar study with *Crassostrea virginica*, O'Beirn and Luckenbach (2000) noted that the use of runts for the oyster industry would be feasible, given good growing conditions, but that it may not warrant the investment of extra time and resources.

When provided with good growing conditions, oysters in the <5-mm size class grew at a significantly slower rate than those in larger size classes. Nevertheless, certain individuals from the <5-mm size class did attain sizes within the overall size ranges of oysters in the larger size classes. This suggests that some runts may not always remain runts and indicates that such individuals are likely to have been affected by environmental stunting. Clearly, at first grading (3.5 mo of age), it is not possible to identify those *P. margaritifera* individuals in the <5-mm size class that are capable of growth rates allowing them to catch up to larger individuals within a cohort. Culling runt oysters at this stage would result in the loss of oysters that could subsequently be used for pearl production. A second grading at approximately 5 to 6 mo of age, however, would allow such individuals to be identified. This would maximize the number of oysters used for pearl production from a given cohort of juveniles. A similar outcome might also be achieved through more appropriate spat collector design. Spat are generally transferred from the hatchery to the field on spat collectors and remain on them until grading (Southgate & Beer 1997). Spat collectors that provide more uniform environmental conditions are likely to result in a more uniform size range of spat at grading.

Hatchery production of *P. margaritifera* in many developing Pacific nations is often constrained by limited resources (Southgate & Beer 1997) and cannot be conducted on a routine basis. In these cases, it is preferable to use as many oysters as possible from each cohort of hatchery-produced spat. The results of this study indicate that modifications to the current protocols may allow increases in the number of *P. margaritifera* from a given cohort that can be used for pearl production.

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