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# Post-operative care of implanted pearl oysters *Pinctada fucata* in low salinity seawater improves the quality of pearls

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# ABSTRACT

Current techniques for culturing the Akoya pearl oyster *Pinctada fucata* result in low yields of blemish-free, round pearls (high-quality pearls). We compared the effects of five factors on the proportion of high-quality pearls produced during culture using a generalized linear model (GLM). Two factors were physiological, shell-closing strength (SCS) and the whole wet weight of host pearl oysters, and three factors were procedural, post-operative care method, technician, and nucleus diameter. Our results suggest that post-operative care methods have the most significant effect on increasing the proportion of high-quality pearls. The proportion of high-quality pearls was five-fold higher in the group held in low salinity seawater than in the conventional treatment group. We propose a new post-operative care method in which oysters are immersed in low salinity seawater to increase the production of high-quality pearls.

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# 1. Introduction

Current methods for culturing pearls result in low yields of highquality pearls (Norton et al., 2000; Kripa et al., 2007). The minimum requirement for a high-quality pearl is that it be round and have no blemishes (Matlins, 1996; Wada, 1999; Akamatsu, 2003; Kripa et al., 2007). The commercial value of pearls is decreased by the presence of deformities and blemishes (Matlins, 1996; Norton et al., 2000; Akamatsu, 2003; Kripa et al., 2007; Ogimura et al., 2012). Deformed pearls have projections or humps. Although blemishes do not affect the shape, they are visible as bluish black or dark brown spots. Minimizing or preventing such deformities and blemishes is one of the most important technical issues currently facing the industry.

Pearl culture consists of four steps (Wada, 1999; chapter 8 by Taylor and Strack, Southgate and Lucas, 2008): 1) pre-operative conditioning, 2) nucleus implantation (hereafter, implantation), 3) post-operative care, and 4) culturing and harvest. A number of studies have evaluated methods for implantation and post-operative care and have resulted in improvements in pearl quality (Norton et al., 2000; Ruiz-Rubio et al., 2006; Atsumi et al., 2011). During implantation, nuclei and mantle grafts are embedded into the gonad of host oysters (Cochennec-Laureau et al., 2010). Proper post-operative care minimizes extrusion

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0044-8486/\$ - see front matter © 2013 Elsevier B.V. All rights reserved. http://dx.doi.org/10.1016/j.aquaculture.2013.12.022 of the nuclei soon after implantation and reduces the occurrence of abnormal pearls (Uemoto, 1962; Wada, 1999; Akamatsu, 2003). During post-operative care, the host oysters are placed into small mesh nets that are suspended in the sea in areas that do not experience strong currents or rapid changes in salinity and temperature and held for 1 to 2 weeks after implantation.

The quality of pearls is influenced by at least five factors: postoperative care method (Uemoto, 1962; Hayashi, 2008; Atsumi et al., 2011), the competency of the technician performing the implantation (Nava et al., 2000; Atsumi et al., 2011), the shell-closing strength (hereafter, SCS) of the host oyster (Aoki et al., 2010a), the whole wet weight of the host oyster, and the nucleus diameter (Hasuo, 1961; Funakoshi et al., 1991).

We recently developed a new post-operative care method that increased the proportion of blemish-free, round pearls (hereafter, highquality pearls). Immersion in low salinity (25 psu) seawater just after implantation (hereafter, the low salinity treatment) resulted in a significantly higher proportion of high-quality pearls than from oysters that were immersed in the sea (hereafter, the conventional treatment) during the post-operative care period (Hayashi, 2008; Atsumi et al., 2011). SCS is the maximum load value needed to open the shell of the pearl oyster to 10 mm with a shell opener. This index is useful as an indicator of an individual oyster's health and physiological condition (Okamoto et al., 2006a; Okamoto et al., 2006b; Aoki et al., 2010b). The unit of SCS is kilogram-force (kgf), where 1 kgf is approximately equal to 9.8 N (SI unit). Aoki et al. (2010a) noted that the proportion of high-





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quality pearls produced by host oysters with an SCS of 2.0–4.9 kgf was higher than for oysters with an SCS of 1.0–1.9 kgf and 5.0–6.9 kgf. The technician typically decides on the diameter of nucleus to be implanted based on the whole wet weight of host oysters. Some studies suggest that implantation of a larger nuclei is associated with a decrease in the production of high-quality pearls (Hasuo, 1961; Funakoshi et al., 1991). Despite the importance of this issue to the industry, to our knowledge no one has evaluated the combined effects of these factors on the production of high-quality pearls.

Our objective was to determine which of the five factors exert the most significant effect on the production of high-quality pearls. We compared the effects of the factors on the proportion of high-quality pearls using a generalized linear model (GLM). We defined "high-quality pearls" as round nacreous pearls that have no blemishes or just one blemish smaller than 0.5% of the pearl surface (Inoue et al., 2011; Atsumi et al., 2011).

## 2. Material and methods

#### 2.1. Pre-operative conditioning

Pre-operative condition

We conducted two experiments to evaluate the effects of five factors (SCS, whole wet weight, post-operative care method, implantation technician, and nucleus diameter) on the proportion of high-quality pearls produced in culture. The first experiment was carried out from April to August in 2009. The second experiment was carried out from May to September in 2009. We obtained 2-year-old Japanese oysters from the Mie Prefectural Farming Center (Shima, Mie, Japan). The

experimental procedure used during the pre-operative conditioning, implantation, and post-operative care is outlined in Fig. 1.The preoperative conditioning in each experiment consisted of the following four steps. 1) Physiological conditioning in the sea: the host oysters were deliberately crowded into a plastic conditioning box with a lid ( $L \times W \times H$ : 355 × 420 × 155, 35 plastic conditioning boxes, 70 oysters/box, chapter 8 by Taylor and Strack, Southgate and Lucas, 2008). The host oysters were suspended from a raft in Ago Bay for 10-13 days during the first experiment and 11 days in the second experiment. 2) Physiological conditioning in a tank: the host oysters were moved from the sea to a tank containing 9000 L seawater at 25 °C and 33 psu (hereafter, tank 1) for 4 days in the first experiment and 5 days in the second experiment. 3) Spawning induction: the host oysters were moved from tank 1 to a tank containing 9000 L ozonated seawater (Aishinsanki, OA-1) at 25 °C and 33 psu (hereafter, ozonated tank) for 7 h in both experiments. The host oysters were moved from the plastic conditioning boxes to round pearl nets (35 round pearl nets, 70 oysters/net) while immersed in the ozonated tank. The host oysters were immersed in tank 1 for 3 days after spawning. 4) Measurement and identification: the SCS and whole wet weight of each host oyster (N = 2022 in the first experiment, N = 1599 in the second experiment) were measured, and each individual was numbered with a marker for identification. The SCS was measured following the method described by Aoki et al. (2010b). The device used for the measurement of SCS consists of a portable load meter and a shell opener. To close the shell, the host oysters were soaked in tap water for 10 min before SCS measurement. Subsequently, the shell opener was inserted into the shell of the closed oyster, and the maximum load value to open the



Fig. 1. Outline of experimental procedure from the pre-operative conditioning to the post-operative care in this study. Numbers of oysters implanted were indicated as well as how all groups were split up in each experiment.

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