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Growth and Survival of the Surf Clam, *Katylesia hiantina*, Spats as Functions of Density, Substrate and Salinity

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ABSTRACT

Different experiments were carried out to assess the growth and survival of the surf clam, *Katylesia hiantina*, spats as functions of three stocking densities, presence of substrate, and different salinity levels under laboratory conditions. Experiments on stocking rate manipulation for a culture period of 20 days at ambient seawater resulted in no significant differences in shell length (1.19-2.56mm) and survival rates (68.1-73.5%, ANOVA, $p>0.05$) of spats. Results of the experiment imply that higher spat densities can be used in commercial scale culture for higher economic returns. Spats reared for 20 days with sand substrate showed higher measurements (SL = 40.5 mm and wet weight = 46.3g) than spats reared without substrate (SL = 31.6 mm and wet weight = 31.3g). Higher survival (89.54%) was also obtained in spats reared with substrate than those reared without substrate (67.54%, t-test $p<0.05$). Spats of most bottom-dwelling species such as *K. hiantina* can attain better growth in the presence of sandy substratum. The faster growth and higher survival rate of spats reared in the sand substrate indicate that a much shortened hatchery culture period is attainable. Low mortalities in the nursery translate to an increased spat production of the surf clam. Spats grown in different salinity levels for 30 days resulted in significantly smaller shell length (2.29 mm) and lower survival rate (85.3%) than those grown in higher salinity of 24 ppt and 34 ppt (ANOVA $p<0.05$). Spats reared at 24 ppt were significantly heavier at 15.72 g than spats grown at 34 ppt (12.2 g) and 14 ppt (1.95 g). Spats of *K. hiantina*, therefore, can survive over a wide range of salinity change although better growth can be obtained at ambient salinity range of 24-34 ppt.

Keywords: Commercial bivalves, stocking rate, culture period and spat production.

INTRODUCTION

Bivalves, particularly clams, mussels and oysters, abundantly found in the intertidal areas of Panguil Bay and Iligan Bay are commonly exploited for various economic purposes. Many fishermen depend heavily on gathering these commercially important bivalves as a consequence of a government ban on destructive fishing gears such as giant filter net (*sanggab*), motorized scissor net (*sudsud*), trawl, and dynamite fishing. Coastal residents recall the great abundance of bivalve resources of Panguil Bay in the 1980s but have observed declining bivalve catches in recent years which they attribute to increasing effort and overharvesting. Others believe that pesticide effluents from prawn farms around the bay caused the massive mortalities of the bivalve resources.

Bivalve catch from natural stock of Panguil Bay had fluctuated over the last two decades. From 292 tons in 1991 annual bivalve production increased to 2,314t in 1995-96 (MSUN, 1996), but declined to 720.64t in 2005 (MSUNFSTDI, 2006). Bivalves comprised 66% of the total fisheries production of Panguil Bay in 1995-96 but this declined to only 35% in 2005. Diminishing resources of commercial bivalves in the bay threaten the livelihood and food security of marginal fishers, thus, efforts to replenish depleted stocks through aquaculture of commercially important bivalves are imperative. Along this objective, a study on the hatchery culture of one commercially important bivalve species, *Katylesia hiantina,* locally known as *punaw* was initiated in order to replenish its dwindling stocks in the bay.

Spats of the surf clam, *K. hiantina,* have been successfully produced at the MSU-Naawan bivalve hatchery since 2004. Like other hatchery cultured bivalves, surf clam spats need to undergo nursery culture before they are transferred to or seeded in grow-out areas in order to avoid high mortalities (Christophersen, 2005). Attaining optimum growth and survival of spats during hatchery and nursery production is critical in the production of a steady supply of spats. Bivalve growth and survival are influenced by a variety of environmental factors that include salinity, temperature, and substrate (Senechal *et al*., 2008). Considering that the surf clam is a bottom-dwelling species, substrate is an important factor to take into account in its cultivation.

Salinity is another environmental factor that affects the growth performance, survival, and distribution of bivalves in their natural environment (Hummel 1980, Fuersich, 1993 cited in Taylor *et al*., 2004). Adult *K. hiantina,* which inhabit the intertidal areas, are continuously subjected to salinity fluctuations; hatchery-reared spats of *K. hiantina*, once transplanted are, thus, not exempt from the effects of salinity fluctuations.

Several studies on the growth and survival of temperate bivalves as influenced by salinity have been reported for majority of commercially important species, such as mussels, oysters, and scallops (Castagna and Chanley, 1973; Mercaldo and Rhodes, 1982; Nell and Gibbs, 1986; Singnoret-Brailovsky *et al*., 1996 all cited in Taylor *et al*. 2004; His *et al*., 1989 cited in Okumus *et al*., 2002). No study, however, has been reported for the tropical species *K. hiantina.*

MATERIALS AND METHODS

Investigations on the effects of stocking rates, different substrates, and different salinity levels on the growth and survival of hatchery-reared *K. hiantina* spats under laboratory conditions were conducted in three separate experiments using sand- filtered seawater.

Stocking rates

Three stocking rates were tested: 2000 spats.15L^{-1} (Treatment 1), 4000 spats.15L^{-1} (Treatment 2) and 8000 spats.15L^{-1} (Treatment 3) with three replicates arranged in a Complete Randomized Design. The initial shell length (SL = 0.54mm) of the spats was measured using a vernier caliper. The spats were reared for 20 days in 20-L capacity basins (area = 1245 cm^2) at ambient salinity (34 ppt) and water temperature (28°C). The spats were fed daily with a combination of *Tetraselmis* sp. and *Skeletonema costatum* after water management. To calculate the food ration, the wet weight of the spats in each treatment was measured weekly, then the daily feed ration was computed using the following formula for bivalve spats, as recommended by Utting and Spencer (1991):

$$V = (S \times 0.4) / (7 \times W \times C)$$

where: V = volume of algal culture to feed;

S = total live weight (mg) of spats at the start of the week;

W = dry weight (mg) per one million algal cells (0.032 mg for *S. costatum*; 0.317 mg for *Tetraselmis* sp.);

C = cell concentration (million cells per ml) of algal culture.

Growth was measured, in terms of SL (mm) and weight (g), by subtracting the initial from the final measurement. Survival percentages were Arcsine-transformed (Gomez and Gomez, 1984) and were analyzed using Analysis of Variance (SPSS ver. 16).

Substrate Experiment

Spats (mean initial SL = 1.58mm) were stocked in 30-L capacity pails (area = 707 cm^2) and reared for 20 days. Each pail was stocked with 2000 spats.15L^{-1} in ambient salinity (34 ppt) and ambient temperature (28-30°C). Treatment 1 utilized sand substrate (1 cm thick) composed of fine sand (97.09%) and very fine sand (2.65%), while Treatment 2 was without substrate. The spats were fed daily with two microalgal species, *S. costatum* and *Tetraselmis* sp., following the recommended rations for bivalve spats (Utting and Spencer, 1991). Growth increment in terms of shell length and weight was determined in each treatment and data were analyzed using Analysis of Variance.

Salinity experiment

For this experiment three treatments, each with three replicates, were prepared using gently aerated, filtered seawater in 30 L cap plastic pails. The salinity of the two treatments was reduced to 14±1 ppt (Treatment 1) and 24±1 ppt (Treatment 2), by adding freshwater to ambient seawater, 34±1 ppt (Treatment 3). These treatments represented general categories of low, intermediate, and high salinity.

One hundred spats were stocked per 15 L seawater in each plastic pail. Initial and final SL measurements and wet weight of the spats were taken. The spats were fed daily on a mixed algal diet composed of *S. costatum* and *Tetraselmis* sp., following the recommended rations for bivalve spats (Utting and Spencer, 1991).

The mean and standard deviations (± SD) were computed for all variables and one-way analysis of variance (ANOVA) was used to test for significant differences among the salinity levels. When significant effect was found, the means were compared with a Tukey's HSD *post hoc* test at 5% level of significance.

RESULTS

After 20 days of culture, *K. hiantina* spats reared at stocking rate of 2000 spats.15L^{-1} registered the largest mean SL increment of 2.56mm followed by spats at stocking rate of 4000 spats.15L^{-1} at a mean SL increment of 2.03mm. Spats reared at stocking rate of 8000 spats.15L^{-1} obtained a mean SL increment of only 1.19mm (Fig. 1). One-way ANOVA showed that SL increments in all stocking densities were not significantly different from each other. Spats reared at stocking rate of 2000 spats.15L^{-1} had the highest mean survival (73.5%) followed by spats reared at 8000 spats.15L^{-1} (68.3%). Low survival at 68.1% was obtained at stocking rate of 4000 spats.15L^{-1} (Fig. 2). Results of the ANOVA showed that differences in survival in all stocking densities were not significantly different from each other at a = 0.05.

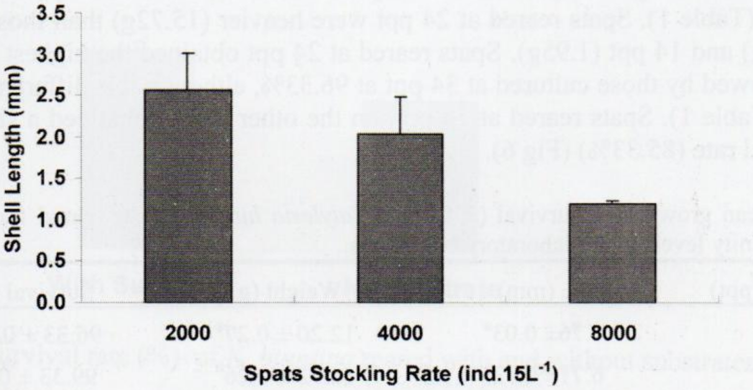

Figure 1. Shell length increment (mm) of *K.hiantina* in three stocking rates.

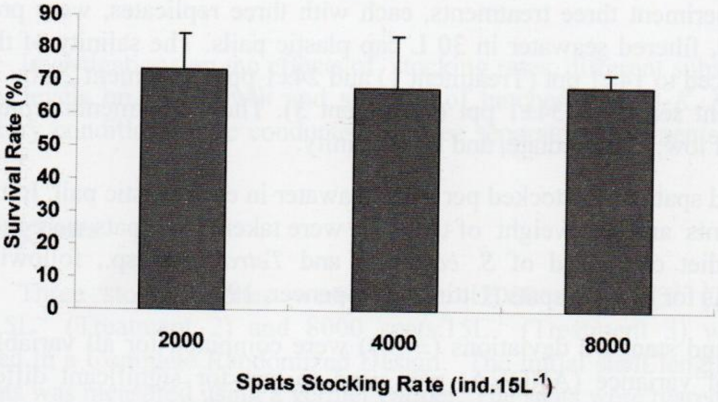

Figure 2. Survival rate (%) of *K. hiantina* in three stocking rates.

The spats reared with sand substrates showed higher shell length (40.5mm) and weight (46.33g) increments and survival rate (89.73%) as compared to those reared without substrates (Figs. 3, 4 and 5). Results of t-test showed that linear growth (SL), weight increase, and survival in both treatments were significantly different from each other ($P<0.05$).

K. hiantina spats grown in different salinity levels for 30 days yielded bigger sizes at 34 ppt (mean SL = 6.76mm) and 24 ppt (SL = 6.71mm) than those reared at 14 ppt (SL = 2.29mm). No significant difference between shell measurements was observed at 34 and 24 ppt; on the other hand, SL values obtained at 14 ppt were significantly different from the two treatments.

Mean wet weight of spats after 30 days of culture at three salinity levels differed significantly (Table 1). Spats reared at 24 ppt were heavier (15.72g) than those reared at 34 ppt (12.2g) and 14 ppt (1.95g). Spats reared at 24 ppt obtained the highest survival at 99.33%, followed by those cultured at 34 ppt at 96.33%, although this difference was not significant (Table 1). Spats reared at 14 ppt, on the other hand, obtained a significantly lower survival rate (85.33%) (Fig 6).

Table 1. Mean growth and survival (± SD) of *Katylesia hiantina* spats reared for 30 days at different salinity levels under laboratory conditions.

Salinity (ppt)	SL (mm)	Weight (g)	Survival (%)
34	6.76± 0.03^{a}	12.20 ± 0.27^{a}	96.33 ± 0.06^{ab}
24	6.71± 0.12^{a}	15.72 ± 0.26^{b}	99.33 ± 0.02^{a}
14	2.29± 0.34^{b}	1.95 ± 0.56^{c}	85.33 ± 0.26^{b}

(note) Means with different superscript are significantly different (Tukeys HSD, $p<0.05$)

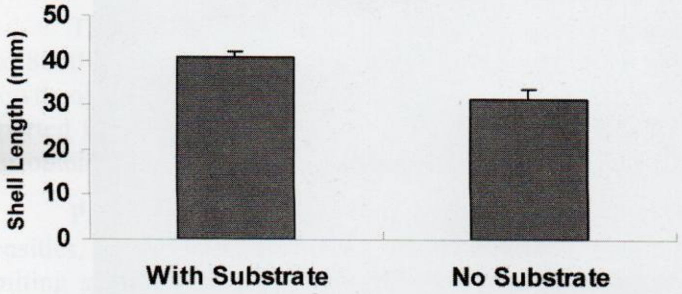

Figure 3. Shell Length increment (mm) of *K. hiantina* reared with and without substrates.

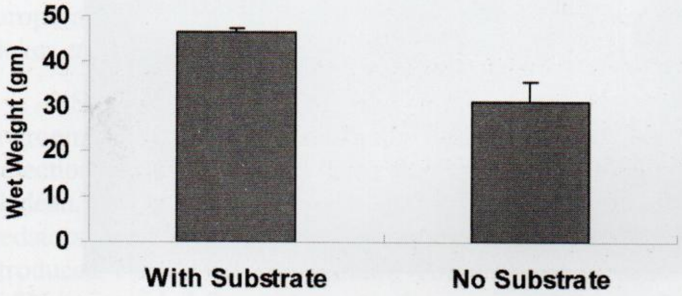

Figure 4. Wet weight increment (gm) of *K. hiantina* reared with and without substrates.

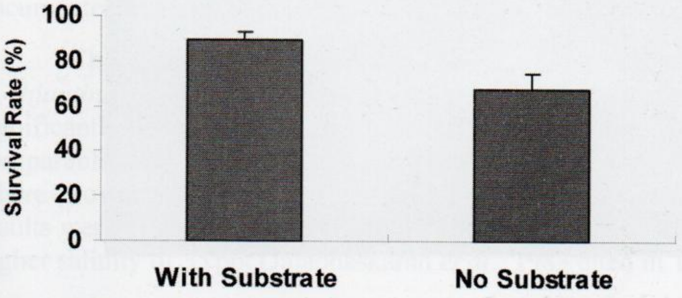

Figure 5. Survival rate (%) of *K. hiantina* reared with and without substrates.

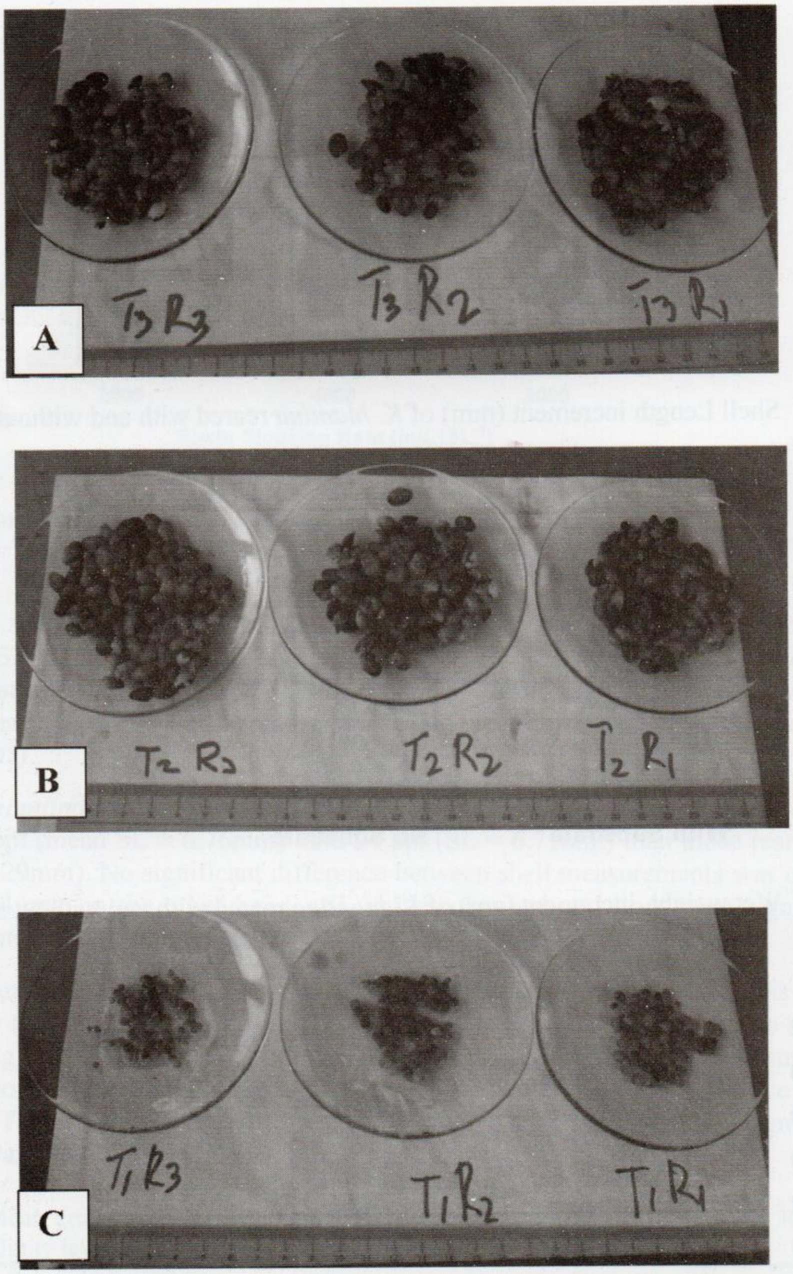

Figure 6. *K. hiantina* spats reared for 30 days in different salinity levels: A) 34 ppt, B) 24 ppt and C) 14 ppt. T_1R_3 stands for Treatment 1 and Replicate 3.

DISCUSSION

The growth in shell length obtained at stocking densities of 4000 spats.15L^{-1} and 8000 spats.15L^{-1} were slightly lower than, but not significantly different from, the growth obtained at 2000 spats.15L^{-1}. These findings are comparable with the results reported for the scallops *Pecten maximus* and *Nodipecten nodosus* where higher growth was obtained at low stocking densities (Maguire and Burnell, 2001; Rupp *et al.*, 2003).

Parsons and Dadswell (1992 as cited in Rupp *et al.*, 2003) reported that at higher densities, intraspecific competition for food reduces food availability per individual, thus, limiting growth. The same authors stated that higher stocking densities would lead to frequent contact among individuals which may induce irritation, retraction of the mantle, or valve closure resulting in reduced feeding rates. Frequent contact among individuals may also cause breakage of shell margins which eventually slows down clam growth (Parsons and Dadswell, 1992 as cited in Rupp *et al.*, 2003). Due to economic considerations, however, higher densities can be recommended for commercial production in order to increase cost-effectiveness. In practice, bivalve hatcheries in Europe and in USA dispose spats for grow-out culture based on the size of the shell (Baker *et al.*, 2005).

Spats of *K. hiantina,* like most bottom-dwelling species, grow better in an environment with sandy substrate. In the natural environment, substrate provides protection for bivalve spats against predators resulting in better growth and survival (Nadeau, 2006). Although predation was not considered a parameter in the present study, predators such as benthic copepods, nematodes, and polychaetes were inadvertently introduced via the culture medium. The presence of sand substrate in the culture tank probably provided the spats protection against these predators resulting in higher shell length increment and survival. Moreover, the substrate in the culture tank possibly reduced competition for space by providing opportunity for burial of spats at different depths, thus, promoting better growth (Peterson and Andre, 1980; Laing and Spencer, 1997). The same authors also reported that although competition for space has not been documented to result in mortality, it has resulted in reduced growth.

The different salinity levels tested had affected both the growth and survival of *K. hiantina* spats. Reducing the salinity from ambient, 34ppt level to 14ppt had significantly lowered the growth and survival of the spats. These observations are comparable with the findings reported for the silver-lip pearl oyster, *Pinctada maxima*, where growth of spats was significantly higher at 30ppt (Taylor *et al.*, 2004). Similar results were also reported for *P. funcata* in which greater growth values were obtained at higher salinity of 35 ppt (Jajabhaskaran *et al.*, 1983 cited in Taylor *et al.*, 2004).

Reduced salinity of the rearing medium may have affected the metabolic or feeding rates of *K. hiantina* spats resulting in lower growth and survival. Rodstrom and Jonssson (2000 cited in Baker *et al.*, 2005) reported that oyster spats subjected to low salinity levels for more than two weeks did not immediately attain normal feeding levels upon return to higher salinities, and mortalities continued to be high. Widdows (1985) also reported that mussels exposed to a sudden decrease in salinity from 30ppt to 15ppt exhibited decreased physiological responses including clearance rate, oxygen consumption, and scope for growth (SFG) or physiological energetics. The mussels closed their valves and a decline in their haemolymph osmolality was observed after 24 to 48 hours' exposure to low salinities. Hatchery-reared *K. hiantina* spats used in the present study demonstrated similar decreased physiological responses when subjected to low salinity levels from the ambient (34 ppt) level.

CONCLUSION

The faster growth in shell length of *K. hiantina* spats in low densities implies the potential of shortened culture period in hatchery, although higher stocking rates can be recommended on commercial scale for cost efficiency. The faster growth of spats reared with substrate also indicates a much shortened hatchery culture period, hence, reduced production costs. The higher survival rate of the spats reared with substrate would translate to low mortalities in the nursery and an increased spat production.

Furthermore, the present results indicate that spats of *K. hiantina* can survive over a wide range of salinity variation. Better growth, however, can be obtained at ambient salinity of 34ppt and at slightly lower salinity of 24ppt; spats were significantly larger than those cultured at much reduced salinity of 14ppt. This finding has an important implication in the selection of suitable transplantation sites for *K. hiantina* spats.

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