Growth Performance and Initial Heritability Estimates for Growth Traits in Juvenile Sea Urchin *Tripneustes gratilla*

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Date submitted: April 7, 2006; Date accepted: August 10, 2006

ABSTRACT

Genetic improvement of performance traits of maricultured species is becoming an important concern. Improvement of performance traits is important for two reasons: it enhances the growth and survival of the animals and it translates to economic gains to the fish farmer. In the sea urchin, *Tripneustes gratilla*, growth performance of the different families and heritabilities for wet weight, test diameter and test height were estimated from 1,020 offspring from a mating of each of the 15 males with 1 or 2 females. Measurements were done monthly starting at the grow-out stage or four months after hatching. There were significant family differences for the performance traits in sea urchin reared in tanks at the BML hatchery as revealed by ANOVA. Estimates of heritabilities based on the sire component of variance were low for wet weight (0.027), test diameter (0.033) and zero for test height. Heritabilities estimated from the dam component of variance were low for wet weight (0.063), moderate for test diameter (0.286) and test height (0.227). The results indicate that test diameter and wet weight have lowly heritable traits, which means that mass or individual selection may not be the best method for improving the traits for sea urchin populations in Bolinao. Other methods such as family and combined family selection should be explored.

Key words: genetic improvement; heritability; sea urchin; *Tripneustes gratilla*; growth trait; mariculture, selective breeding

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INTRODUCTION

Sea urchin fishery in the Philippines has been a major yet underdeveloped source of income for coastal fishers. Since the 1970s, the value of the sea urchins' roe or gonads as a delicacy has been realized in the country. Sea urchins have been collected for local consumption as well as the export market. Unfortunately, constant exploitation due to the increasing demand of both local and export markets brought about the collapse of the sea urchin population in Bolinao, Pangasinan (Northwestern Luzon), during the early 1990s. This in turn resulted in the loss of a major livelihood for some fishers, who were dependent on the said fishery.

The collapse of this fishery brought about the development of sea urchin culture to enhance the recovery of natural populations (Juinio-Meñez et al. 1998). Since its development, aquaculture of sea urchins has been continuously done in the outdoor hatchery of the Bolinao Marine Laboratory (BML) of the U.P. Marine Science Institute. The maricultured sea urchins are used to restock wild populations. However, gonads of these cultured sea urchins are not at par with international quality standards and cannot usually compete with that of other countries for the international market. Clear, bright yellow or orange roe that are firm, 4-5 cm long and free of leaking fluids are the ones preferred fresh and brings out the highest prices (Price and Tom 1995). On the other hand, locally produced roe in Bolinao are usually off-color, with leaking fluids, easily broken and are used for making secondary products such as roe paste only. Nonetheless, traditional aquaculture practices may be further improved to be able to meet the increasing demand for high quality sea urchin gonads.

Application of genetic improvement in aquaculture has gained popularity in the recent years, and estimates of heritability and genetic correlations for many aquatic species have been reported. Studies with Atlantic salmon (Jonasson 1993), Coho salmon (Withler and Beacham 1994), pink salmon (Smoker et al. 1994), rainbow trout (Fishback et al. 2002), and common carp (Vandeputte et al. 2004) revealed moderate to high heritabilities for length and weight. Values of heritability for shell length and weight of mollusks such as European oyster *Ostrea edulis* (Toro 1990), Mercenaria mercenaria (Hilbish et al. 1993), and red abalone *Haliotis rufescens* (Jonasson et al. 1999) were also reported.

However, there are very few published information about heritabilities and genetic correlations for growth traits of sea urchins. The study by Liu et al. (2005) revealed point estimates for heritabilities based on the sire components of variance were moderate to high for body weight (0.21-0.49), test diameter (0.21-0.47), and test height (0.22-0.37), while genetic correlations were found to be significant for body weight with test diameter (0.30~0.65) and test height (0.22~0.37), and test diameter with test height. The results obtained by Liu's group imply that it is possible to improve certain sea urchin populations through selective breeding.

If the local sea urchins can be improved and enhanced genetically to produce the necessary quality for the export market, the value of sea urchin gonads will definitely increase. Genetic principles can be applied to improve both the productivity and product quality, particularly the growth rate and gonad quality of sea urchins, which may help increase the profitability for the fishers and may help the industry produce high quality sea urchins.

Our study aims (1) to document existing cultured sea urchin strain in Bolinao for evaluation of their culture performance, and (2) to estimate genetic parameters (heritability, genetic and phenotypic variances) for growth traits in sea urchins.

MATERIALS AND METHODS

Experimental material

Broodstock of the sea urchin *Tripneustes gratilla* was composed of cultured and wild breeders collected on the reef flat of Lucero, Bolinao, Pangasinan. Culture of *T. gratilla* is continuously done at the Bolinao Marine Laboratory using the reproduction method developed by Juinio-Meñez et al. (1998). This method was followed for our experiment.

Spawning and fertilization

Growth traits (wet weight, test diameter, test height) of each parent were recorded before spawning. Wet weight (weight of sea urchin after letting individuals stand out of water for at least 5 minutes) was measured by using a digital weighing scale (O Haus Model HS 200), while test diameter and height was measured with a vernier caliper.

Sea urchins were spawned artificially by injecting 2 ml of 0.5 M KCl into the gonads through the peristomial cavity. Eggs of each of two females were fertilized with the sperm of a single male (~1000:1 sperm to egg ratio). A total of 30 full-sib (sibling group that has a common mother and father) and 15 half-sib (sibling group that has only one common parent, either a mother or a father) families were generated from a mating of each of the 15 males with one or two females. For this study, a family refers to a full-sib group of closely related individuals that share common genes from a common mother and father.

Rearing

Each family was kept in a jar equipped with motorized stirrers rotating at 30-36 rpm. Larvae were fed daily with *Isochrysis galbana* during the first week and *Chaetoceros calcitrans* two weeks after hatching (~40,000 cells/ml). Larvae were induced to metamorphose into juveniles approximately 40 days post hatching by transferring each family from jars to plastic bins with benthic diatom. When juveniles reached 4 months post hatching, 60 individuals per family were randomly chosen and growth traits of each sea urchin were measured. Out of the 30 families generated, only 17 families had the minimum number of individuals needed for the experiment proper. These 17 families were then transferred to hatchery tanks (each family kept in separate compartments; in triplicates, 20 individuals per replicate) and were then fed with the same amount of *Sargassum* sp. per compartment (~750g *Sargassum* per compartment). Another monitoring of each sea urchin's test diameter, test height, and wet weight was done on the fifth month.

Statistical and genetic analysis

The statistical model used in this experiment is:

$$Y_{ij} = \mu + s_i + d_{ij} + e_{ijk}$$

where Y_{ij} is the test diameter, test height or wet weight of the *k*th progeny or offspring of the *j*th dam (female parent) mated to the *i*th sire (male parent), and e_{ijk} are uncontrolled environmental and genetic deviations attributable to the individuals. The Generalized Linear Models (GLM) Procedure in the SAS System was used to determine significant growth differences among families of sea urchins, while the Variance Component (VARCOMP) Procedure of SAS was used to determine between sire variance component (σ^2_s), dam variance component (σ^2_d), and environmental variance component (σ^2_e). Sire heritability was estimated as $h^2_s=4\sigma^2_s/(\sigma^2_s + \sigma^2_d + \sigma^2_e)$, while dam heritability was estimated as $h^2_d=4\sigma^2_d/(\sigma^2_s + \sigma^2_d + \sigma^2_e)$ (Becker 1984; Bowman 1974; Falconer 1989). Standard errors of heritability were estimated as in Becker (1984).

RESULTS AND DISCUSSION

Means, standard deviations and coefficient of variations of the growth traits for each family is presented in Table 1. There were significant family differences for each trait as revealed by ANOVA (Figure 1). Family number 8 consistently attained the highest measures for the three growth traits, while performance of succeeding families varied for each trait.

Estimates of heritabilities (Table 2) based on the sire component of variance were zero for test height and low for wet weight and test diameter. Heritabilities estimated from the dam component of variance were low for wet weight and moderate for test diameter and test height. As expected, heritabilities estimated from the dam component of variance were slightly larger than the heritabilities estimated from the sire component. This indicates that the dam genetic variance component is confounded with common environmental effects, maternal effects or non-additive genetic effects in the growth traits being measured. However, it is

Family		Test Diameter (mm)			Test Height (mm)			Wet Weight (g)		
	n	Mean	St.Dev.	Coeff.Var	Mean	St.Dev.	Coeff.Var	Mean	St.Dev.	Coeff.Var
1	60	44.6	3.6	8.0	25.3	2.2	8.6	41.1	8.6	20.8
2	60	44.4	2.6	5.9	24.6	1.7	6.9	39.8	5.6	14.0
3	60	45.7	3.2	6.9	25.5	2.5	9.7	43.1	7.0	16.2
4	60	47.2	4.4	9.2	25.2	2.6	10.3	47.5	12.7	26.7
5	60	47.2	3.8	8.1	24.6	1.7	6.9	45.1	8.2	18.2
6	60	45.2	3.4	7.4	25.2	3.3	13.1	41.5	8.3	20.1
7	60	44.9	3.4	7.5	24.9	2.4	9.7	42.4	8.7	20.6
8	60	49.2	4.4	9.0	27.7	2.8	9.9	51.4	12.2	23.7
9	60	46.1	4.3	9.3	25.5	1.7	6.5	44.3	7.3	16.5
10	60	47.7	3.4	7.1	26.1	2.1	8.1	47.6	9.6	20.3
11	60	48.5	5.9	12.1	25.6	3.5	13.9	47.9	14.7	30.8
12	60	46.4	4.6	10.0	26.8	2.5	9.2	45.3	10.9	24.1
13	60	46.8	3.1	6.5	26.0	3.4	13.1	44.8	8.0	17.9
14	60	46.9	4.0	8.6	25.4	2.3	8.9	44.4	10.3	23.1
15	60	47.3	3.1	6.6	25.4	2.2	8.8	44.3	7.6	17.1
16	60	45.4	5.1	11.3	25.8	3.1	11.9	42.2	11.3	26.9
17	60	47.2	4.3	9.1	24.6	2.7	10.8	47.4	11.7	24.7

Table 1
Summary statistics of growth traits of each family for the first monitoring period, n is the total number of individuals measured for each family

possible that the high estimate from dam component can be attributed to maternal effects as Xiaolin and co-workers (2004) noted that in the juvenile phase, development is affected by the quality of yolk reserves, where yolk reserves pertain to maternal effect.

Heritability is a ratio rather than an absolute figure, and changes in any of the sources of variation such as sire and dam genetic variance, and environmental variance, will change the heritability value. Thus, heritabilities for the traits being considered are specific to particular populations, in this case, to the *T. gratilla* populations in Bolinao. The estimates for some of the traits from this study were lower than those of Liu et al. (2003). To estimate genetic parameters and to initiate genetic improvement for a particular population of species usually require a minimum of 50 full-sib families per generation, but due to financial constraint and die-offs, this study was able to produce only 17 families. This may also explain the high standard error values (Table 2) for heritability estimates for the three growth traits.

This is the first study in the Philippines to estimate genetic parameters in the sea urchin, *T. gratilla*. The results indicate that test diameter and wet weight have lowly heritable traits, which means that mass or individual selection may not be the best method for improving those traits for the sea urchin populations in Bolinao. Individual selection means that individuals are retained as future broodstock based solely on their individual performance. Other methods such as family or combined family selections (Falconer 1989) should be explored. For these two approaches, selection is based wholly or in part on the average performance of entire families. The initial results from this study indicate that there is sufficient genetic variation for growth traits of the sea urchin populations studied in Bolinao that could respond to genetic improvement.

Future work

This study is still ongoing and the data presented in this paper were just preliminary results for the initial monitoring period. Final monitoring of the growth traits would be done 8 (eight) months after hatching, when the sea urchins are in their harvest stage and might also be sexually mature. Computations for heritability estimates would be performed on all the measured traits. Correlation analysis would also be performed to determine the relationship of the growth traits with the gonadosomatic index (GSI). Moreover, families would be ranked based on their growth trait performance. The parents for the next generation of sea urchin offspring would be selected from the top ranking families.

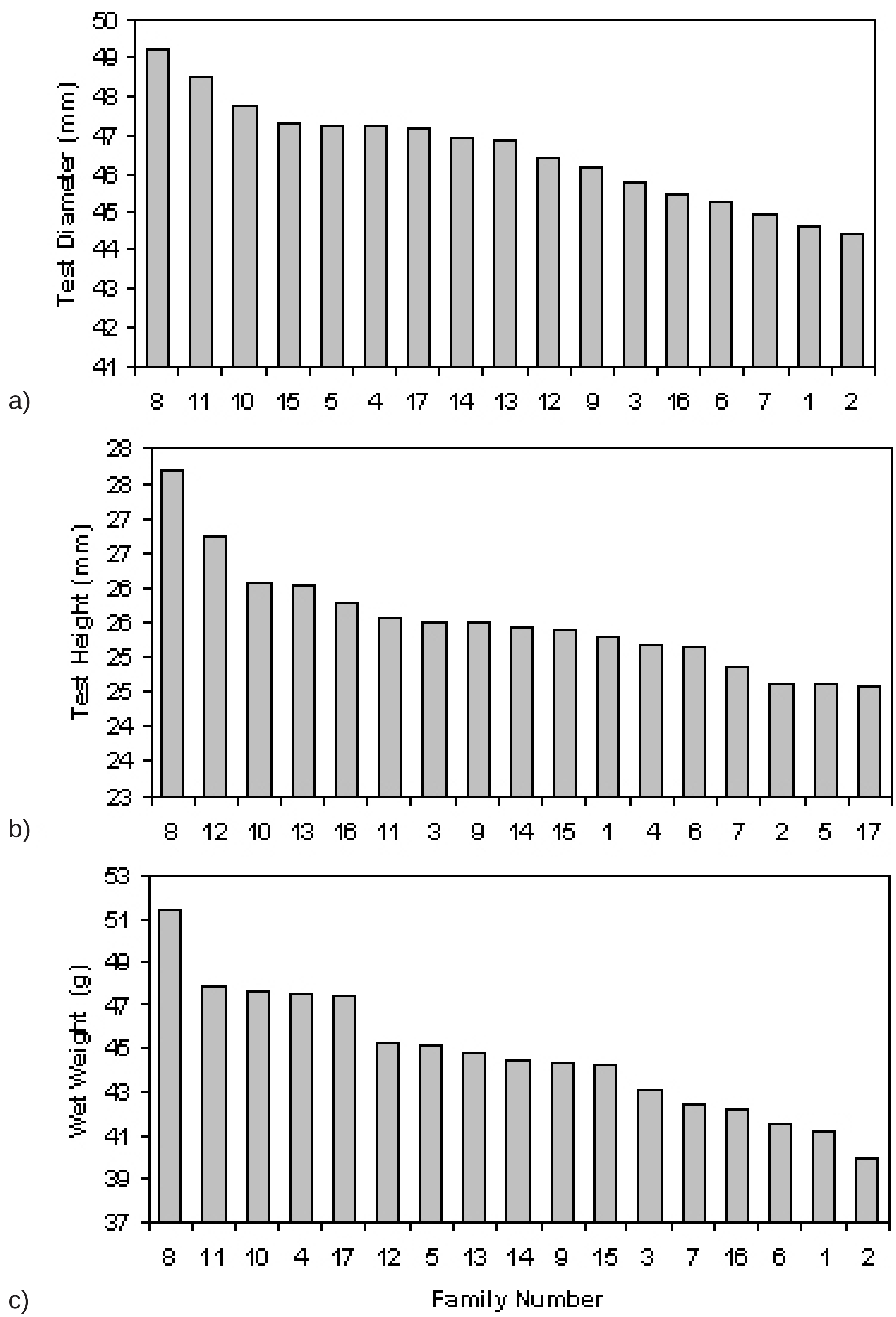

Figure 1. Test diameter, mm (a), test height, mm (b) and wet weight, g (c) means of each sea urchin family for the first monitoring period. Each family number represents one full-sib family. Families are arranged from highest to lowest in terms of their performance in each growth trait.

Growth Trait	h^2_s	S.E. (h^2_s)	h^2_d	S.E. (h^2_d)
Test diameter	0.033	0.26	0.286	0.43
Test height	0	0.13	0.227	0.23
Wet Weight	0.027	0.06	0.063	0.07

Table 2
Initial heritability estimates of growth traits for the first monitoring period

ACKNOWLEDGMENTS

The authors would like to thank the Office of the Vice Chancellor for Research and Development (OVCRD) of the University of the Philippines Diliman for project funding, and the Resource Management II of the SAGIP Lingayen Gulf Project for their kind support.

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