Article

Reproductive characteristics of a brachyuran crab, *Grapsus tenuicrustatus* (Herbst, 1783) (Decapoda: Grapsidae) found in Talim Bay, Batangas, Philippines

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Abstract
The study determined some reproductive characteristics of a brachyuran crab, *Grapsus tenuicrustatus* (Herbst, 1783), one among the most widespread and diverse groups of invertebrates. Results revealed that there were more males (52.94%) than females (47.06%) collected at the study sites with a sex ratio of 1:1.13. Thirty percent (30%) of the samples were ovigerous females. Ovigerous females have the largest caraface length, CL, (31.25 ± 1.43) compared with the males (22.14 ± 0.726) and non-ovigerous females (26.63 ± 1.12). Based on one-way ANOVA, the differences were significant. Difference between non-ovigerous and ovigerous females was also found significant based on t-test for independent samples. There was a non-conspicuous bi-modal size distribution for all the crabs, with non-normal distributions for all crabs and for males, but not when all females or ovigerous females only were grouped together. The size-frequency distributions of males and females are significantly different from each other similar with that observed between the size-frequency of ovigerous and non-ovigerous females. There were more ovigerous crabs belonging to the first year age class (CL = 16 - 33) (53.13 %) than those that belong to the older class (CL = 34 - 43) (46.88 %). Fecundity ranged from 4400 (CL = 16 mm) to 26400 (CL = 43 mm) eggs. Egg volume ranged from 0.40 ml to 2.40 ml, egg diameter from 1.1 µm to 5.0 µm with an average diameter of 3.170 µm and egg count from 4400 to 26400 with a mean of 12684 eggs. Egg number was positively correlated with female size.

Keywords *Grapsus tenuicrustatus*; brachyuran crab; fecundity; ovigerous; reproductive characteristics.

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1 Introduction

In the Philippines, brachyurans (true crabs) are among the most widespread and diverse groups of invertebrates. One of the interesting brachyurans are the Sally-lightfoot crab or natal sally-lightfoot or shore crab, *Grapsus tenuicrustatus*, locally called "Katang", because these are known to be harvested and processed by fermentation as a delicacy and crab roe fat.

A random search of previous studies on brachyurans in the Philippines showed a paucity of research on their reproductive ecology and the environmental and biological constraints that influence them as a population. Indeed, while crab population structure and reproduction of subtropical species have become major research agenda (Spivak et al. 1991; Mouton and Felder 1995), such studies on the tropical ones are still needed (Litulo, 2005).

Understanding the breeding potential of many well-dispersed marine invertebrates, like crabs, entails determining intraspecific variation of reproductive characteristics (Dugan, 1991). Incomplete knowledge of the life history of the organisms that comprise communities is one of the principal problems in understanding how marine ecosystems function. For crab populations, understanding the environment and biological constraints that are shaping them (Oshiro, 1999; Litulo, 2005) remains one important aspect of marine ecology.

In most marine invertebrates, the newly laid eggs contain all the energy and reserves for embryonic development (Holland, 1978; Jaeckle, 1995). In species with complex life cycles, larval survival and growth may depend on the energy reserves that remain after hatching (Paschke, 1998; George, 1999). Consequently, these depend on the initial egg reserves and their utilization during embryogenesis. The embryonic development occurs in a variety of modes, e.g. free developing, encapsulated, incubated (Sastry, 1983; Levin and Bridges, 1995), and under a particular combination of environmental factors that may affect the embryonic energy budget and thus, larval reserves (Giménez and Anger, 2001). For decapods, the marine benthos is the typical environment. The larvae hatch from the eggs attached to the female's abdominal appendages (pleopods) and develop in the marine plankton for several weeks (Diesel, 1989).

The present study determined some reproductive characteristics of *G. tenuicrustatus* (Herbst, 1783). Specifically, it described the following: (*i*) total number and sex ratios of collected crabs; (*ii*) the size and age distribution of ovigerous crabs; (*iii*) the female size at maturity and age classes based on carapace length (CL, mm) and their size-frequency distribution, and (*iv*) an estimate of population fecundity (e.g., volume, number, and diameter of eggs; relative number of females carrying various egg stages; estimate number of age in different size groups of ovigerous crabs, and the relationship between egg number and female size). Broadly, results of this study could provide insights on the relative plasticity or conservation of different reproductive characteristics and the effects of intraspecific variation in those characteristics on the reproductive potential of a well-dispersed marine invertebrate (Dugan, 1991).

2 Materials and Methods

2.1 Study site

Samples of *G. tenuicrustatus* were collected in rocky areas near seagrass beds at Talim Point (13^0 57' 55.43'', 120^0 36' 20.36'' E), a portion of Talim Bay, Barangay Ligtasin, Lian, Batangas, Philippines. Talin Bay is located between latitude 13^0 58.8' North and longitude 120^0 38.0' East of DLSU Br. Alfred Shields FSC Marine Biology Station, approximately 200 km. south of Manila fronting South China Sea.

Laboratory activities were conducted at the Biology Laboratories of Ateneo de Naga University, Naga City, Philippines.

2.2 Sampling method

G. tenuicrustatus were collected opportunistically with a shovel and by hand from aggregations of crabs in the wash and surf zones of the bay following previous methods (Wenner et al., 1987; Dugan, 1990; Dugan et al., 1991). The crabs were retained and separated from the sand by washing through mesh bags. A total number of 153 crabs were collected.

2.3 Female size and age

Size-frequency distributions were determined by individual measurement of carapace lengths (CL), to the nearest millimeter, using a vernier caliper. The sex and reproductive condition of all crabs were recorded (i.e., ovigerous or non-ovigerous). The size-frequency distributions of female crabs were examined for modal breaks. Since there were two non-overlapping size modes, the mode of larger ovigerous crabs were assigned to the older overwintered age class (Years 2 and 3) and the mode of smaller ovigerous crabs were assigned to the first year class (young of one year) following Dugan et al. (1991).

The size at maturity, and the minimum (5th percentile) and maximum (95th percentile) sizes of ovigerous female crabs were determined from size-frequency distributions for each sample. The 5th and 95th percentile sizes of ovigerous crabs were determined from the cumulative number of ovigerous crabs and were used as estimates of the minimum and maximum sizes of ovigerous female crabs. For the whole sample, the proportions of ovigerous crabs were calculated for three categories, as follows: (1) the proportion of ovigerous crabs above the size of the smallest ovigerous crab; (2) the proportion of ovigerous crabs assigned to the older age class; and (3) the proportion of ovigerous crabs assigned to the first year class.

The developmental stage of each clutch was determined using the method of Eickstaedt (1969), which divides egg development into ten stages. Stages 1-4 were of most interest. The amount of cleavage and the proportion of the egg that is free of orange yolk distinguish these stages. Stage l eggs are uncleared or in a state of cleavage; in Stage 2 cleavage is complete; in Stage 3 up to I/4 of the egg is free of yolk, and in Stage 4 up to 1/3 of the egg is free of yolk. Stage 5 eggs have visible embryonic eye pigment and were not used in fecundity estimates. Forty (40) eggs were randomly selected and their diameter was measured with an ocular micrometer. Finally, descriptive statistics (e.g., mean, mode, median, standard error of the mean, minimum, maximum, range, standard error of the sizes) of egg diameter were reported.

2.4 Population fecundity

The present study adopted Dugan's (1991) definition of fecundity which states that fecundity refers to the number of eggs present in a single clutch of an individual crab at the time of analysis (e.g., clutch size). The ovigerous crabs were preserved in a mixture of ethanol, isopropyl alcohol, and acetone. Volumetric determinations of fecundity were made on female crabs with newly extruded eggs (no eyespots evident upon microscopic examination).

Litulo's (2005) method of estimating fecundity was adapted in the study. Twenty (20) ovigerous females with eggs were randomly selected for egg. Pleopods were removed from the females, placed in petri dishes filled with water, and had their eggs detached by gradually adding a solution of sodium hypochlorite. Bare pleopods were then discarded by being gently stirred in a beaker filled with 50 ml of seawater. With a pipette, five sub-samples of 1 ml were taken from the water with eggs. The eggs in each sub-sample were counted under a dissecting microscope. The average value obtained was extrapolated for the whole suspension in order to estimate the number of eggs (Bezerraa and Matthews-Cascona, 2007).

An estimate of population fecundity was made for the whole sample. Population fecundity is defined in this study as the number of eggs carried by a representative female crabs at or above the size of the smallest ovigerous crab at the time of sampling. Pearson correlation was used to test the relationship between egg volume and number of eggs with carapace length (CL, mm). To further analyze fecundity, data were analyzed using the power function ($Y = aX + b$) of egg number (EN) vs. CL.

2.5 Statistical analysis

Data were analyzed using SPSS for Windows 11.0 (Copyright © SPSS Inc., 1989-2001). Descriptive statistics (e.g., mean, mode, median, standard error of the mean, minimum, maximum, range, standard error of the sizes) were calculated for the ovigerous, non-ovigerous and for male crabs for the purpose of comparison. T-test for independent samples and one-way Analysis of Variance (ANOVA) were used to test significant differences among groups (males vs. ovigerous females vs. non-ovigerous females; ovigerous vs. ovigerous) in terms of mean carapace length (CL, mm). No estimates of density or abundance were made. To test the null hypothesis that each group of sample comes from a normal distribution, one-sample Kolmogorov-Smirnov (KS) procedure was used. This goodness-of-fit test assesses whether the observed cumulative distribution function for a variable with a specified theoretical distribution, which in this case, normal distribution. Two-sample KS test was also used to test the null hypothesis that male and female samples, as well as ovigerous and ovigerous samples have the same distribution. Lastly, Pearson correlation was used to test the relationship between egg volume and number of eggs with carapace length (CL, mm).

3 Results

3.1 Female size and age

There were more male *Grapsus tenuicrustatus* (52.94%, n = 81) than females (47.06%, n = 72) collected with a sex ratio of 1:1.13. Thirty percent (30%, n = 32) of the samples were ovigerous females (Table 1).

Table 2 and Fig. 1 present the comparison of the carapace length (CL, mm) of the males and non-ovigerous and ovigerous female *G. tenuicrustatus*. Ovigerous female crabs have the largest CL (mean ± SE: 31.25 ± 1.43) compared with the males (mean ± SE: 22.14 ± 0.726) and non-ovigerous females (mean ± SE: 26.63 ± 1.12). The differences were significant (F = 20.383, df = 2, $p < 0.01$). Difference between non-ovigerous and ovigerous females was also found significant (t = 2.582, df = 70, $p < 0.05$). The CL (mm) of all samples showed a mean ± SE of 25.22 ± 0.636. A sample with the smallest CL (12 mm) was found among male crabs while the largest was from the ovigerous females (43 mm).

Fig. 2 (a-d) shows the size frequency distributions of all the crabs, males crabs only, female crabs only and ovigerous females only, respectively. There was a non-conspicuous bi-modal size distribution for all the crabs, with non-normal distributions for all crabs (KS = 1.735, $p < 0.05$) and for males (KS = 1.464, $p < 0.05$), but not when all females or ovigerous females only were grouped together. When the size-frequency distribution of males was compared with females, the distributions are significantly different from each other (KS = 2.582, $p < 0.0001$). The same was observed between the size-frequency of ovigerous and non-ovigerous female crabs (KS = 1502, $p < 0.05$).

Based on the size at maturity, and the minimum (5th percentile) and maximum (95th percentile) sizes of ovigerous female crabs determined from size-frequency distributions for the whole sample, the largest among the samples is an ovigerous female crab (CL = 43 mm) while the smallest is also from the same group (CL=16). From the cumulative number of ovigerous crabs, the minimum and maximum sizes of ovigerous female crabs are estimated as CL = 16.65 mm and CL= 42.35 mm, respectively (Table 3).

There are more ovigerous crabs belonging to the first year age class (CL = 16 - 33) (53.13 %) than those that belong to the older class (CL = 34 – 43) (46.88 %). About 97% of the female ovigerous crabs are above the size of the smallest crabs (CL = 17 – 43). Moreover, overlapping size modes were shown among the ovigerous female crabs (23 mm, 34 mm, 35 mm (Table 4 and 5).

3.2 Population fecundity

The fecundity of *G. tenuicrusttus* ranged from 4400 (CL = 16 mm) to 26,400 (CL = 43 mm) eggs. Egg volume ranged from 0.40 ml to 2.40 ml. The egg diameter ranged from 1.1 µm to 5.0 µm with an average diameter of 3.170 µm (Table 6; Fig. 4). There are more crabs belonging to CL class of 11-20 mm and 21-30 mm that carry eggs at different stages (Table 7).

As shown in Table 8, egg count ranged from 4400 to 26400 with a mean of 12684 eggs. Forty-four percent (44%) of the ovigerous crabs have eggs ranging from 4400 to 8800. Egg number was positively correlated with female size (r = 0.794, n = 32) and the resulting scatter plot shows a linear trend (Fig. 3).

Table 1 Total number and sex ratios of collected *G. tenuicrustatus* at Talim Bay, Lian, Batangas.

	Males	Non-ovigerous females	Ovigerous females	Male and Female	Sex ratio
Total	81	40	32	153	1:1.13
Percentage	52.94	26.14	20.92	100	

Table 2 Carapace length (CL, mm) of collected *G. tenuicrustatus* at Talim Bay, Lian, Batangas.

Parameters	Males	Non-ovigerous females	Ovigerous females	ll
n	81	40	32	153
Mean ± SE[a, b]	22.14 ± 0.726	26.63 ± 1.12	31.25 ± 1.43	25.22 ± 0.636
S.D.	6.532	7.080	8.104	7.872
Median	20	24	33	23
Mode	18	23	23[c]	18
Minimum	12	14	16	12
Maximum	40	42	43	43
Range	28	28	27	31

a. Difference between groups is significant based on ANOVA ($F = 20.383$, $df = 2$, $p < 0.01$).
b. Difference between non-ovigerous and ovigerous females is significant based on t-Test for independent samples ($t = 2.582$, $df = 70$, $p < 0.05$).
c. Multiple modes, the smallest value is shown.

Table 3 Size data for *G. tenuicrustatus* collected at Talim Bay, Lian, Batangas.

Category of crab	Carapace length (CL, mm)
Largest male	40
Largest non-ovigerous female	42
Smallest ovigerous female	16
Largest ovigerous female	43
Minimum (5th percentile) sizes	16.65
Maximum (95th percentile) sizes	42.35

Table 4 Size at maturity of ovigerous female *G. tenuicrustatus* at Talim Bay, Lian, Batangas.

	Carapace Length (CL, mm)	Total	%
Ovigerous crabs above the size of the smallest ovigerous crabs	17 – 43	31	96.88
Ovigerous crabs assigned to older age class	34 – 43	15	46.87
Ovigerous crabs assigned to the first year class	16 – 33	17	53.13

Table 5 Age classes of female *G. tenuicrustatus* collected at Talim Bay, Lian, Batangas based on modal breaks of Carapace Length (CL, mm) (n=32).

Age class	Carapace Length (CL, mm)	Mode	Total	%
First year	16 – 33	23	17	53.13
Year 2 and 3	34 – 43	34, 35	15	46.87

Table 6 Egg volume (ml), number of eggs, and diameter of eggs sampled from collected *G. tenuicrustatus* at Talim Bay, Lian, Batangas.

Parameters	Carapace Length (CL, mm)	Egg volume (ml)	No. of Eggs	Egg Diameter (µm)
n	32	32	32	40
Mean ± SE	31.25±1.43[a,b]	1.15±0.10[a]	12684.38±1153.04[b]	3.170±0.18
S.D.	8.104	0.592	6522.572	1.146
Median	33	1.05	11550.00	3.55
Mode	23[b]	0.60	6600	3.5
Minimum	16	0.40	4400	1.1
Maximum	43	2.40	26400	5.0
Range	27	2.00	22000	3.9

a, b. Positive correlation based on 2-tailed Pearson Correlation (r^2 = 0.794, n =32).

Table 7 Numbers of ovigerous females of *G. tenuicrustatus* in different size groups (expressed as a percentage of total numbers of females collected) and relative number of females carrying various egg stages.

Carapace width class (mm)	No. of females	Ovigerous females (%)	No. of ovigerous females carrying egg stage			
			1	*2*	*3*	*4*
11 - 20	5	60.0	5	4	4	2
21 - 30	7	71.4	6	5	5	0
31 - 40	8	87.5	5	0	1	1
41 - 50	3	100.0	0	1	0	0

Table 8 Estimate number of age in different size groups of ovigerous *G. tenuicrustatus* collected at Talim Bay, Lian, Batangas (n=32).

Estimate No. of Eggs	Number of ovigerous females	%
4,400 – 8,800	14	43.75
8,801 – 13,200	6	18.75
13,201 – 17,600	4	12.5
17,601 – 22,000	4	12.5
22,001 – 26,400	4	12.5
Total	32	100

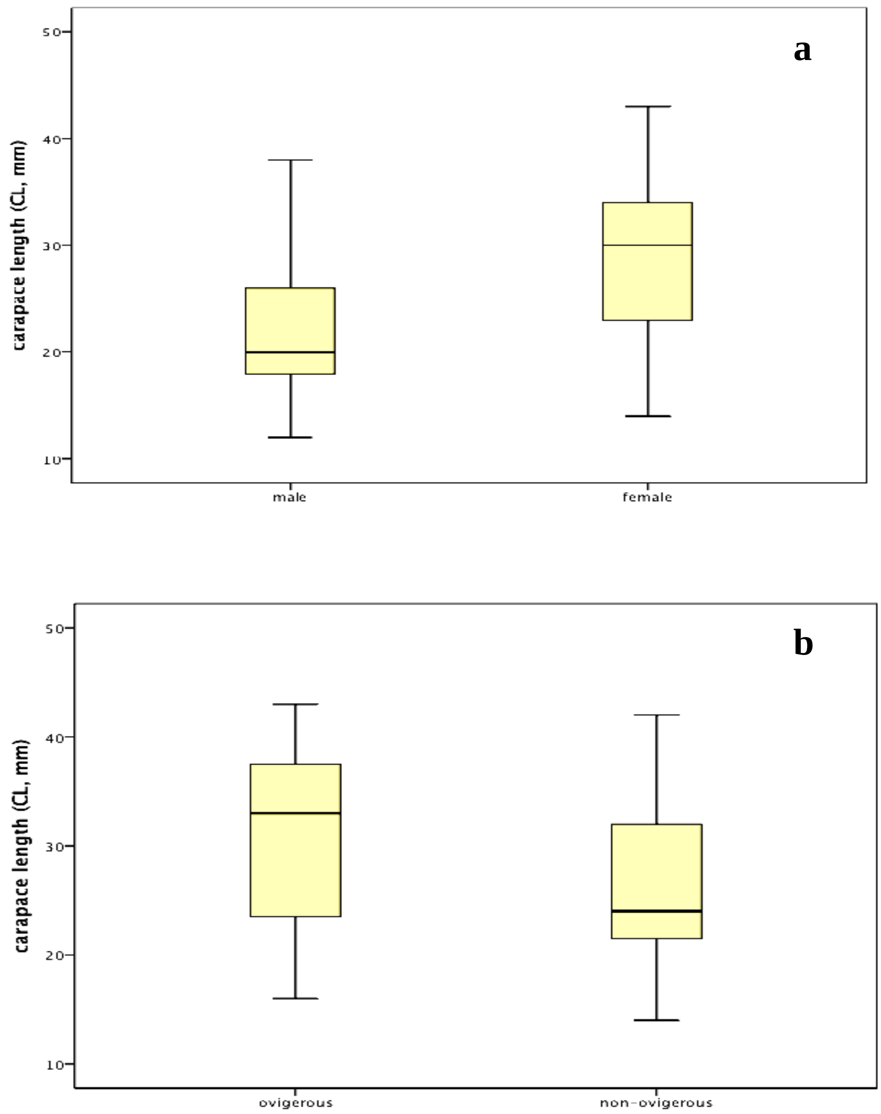
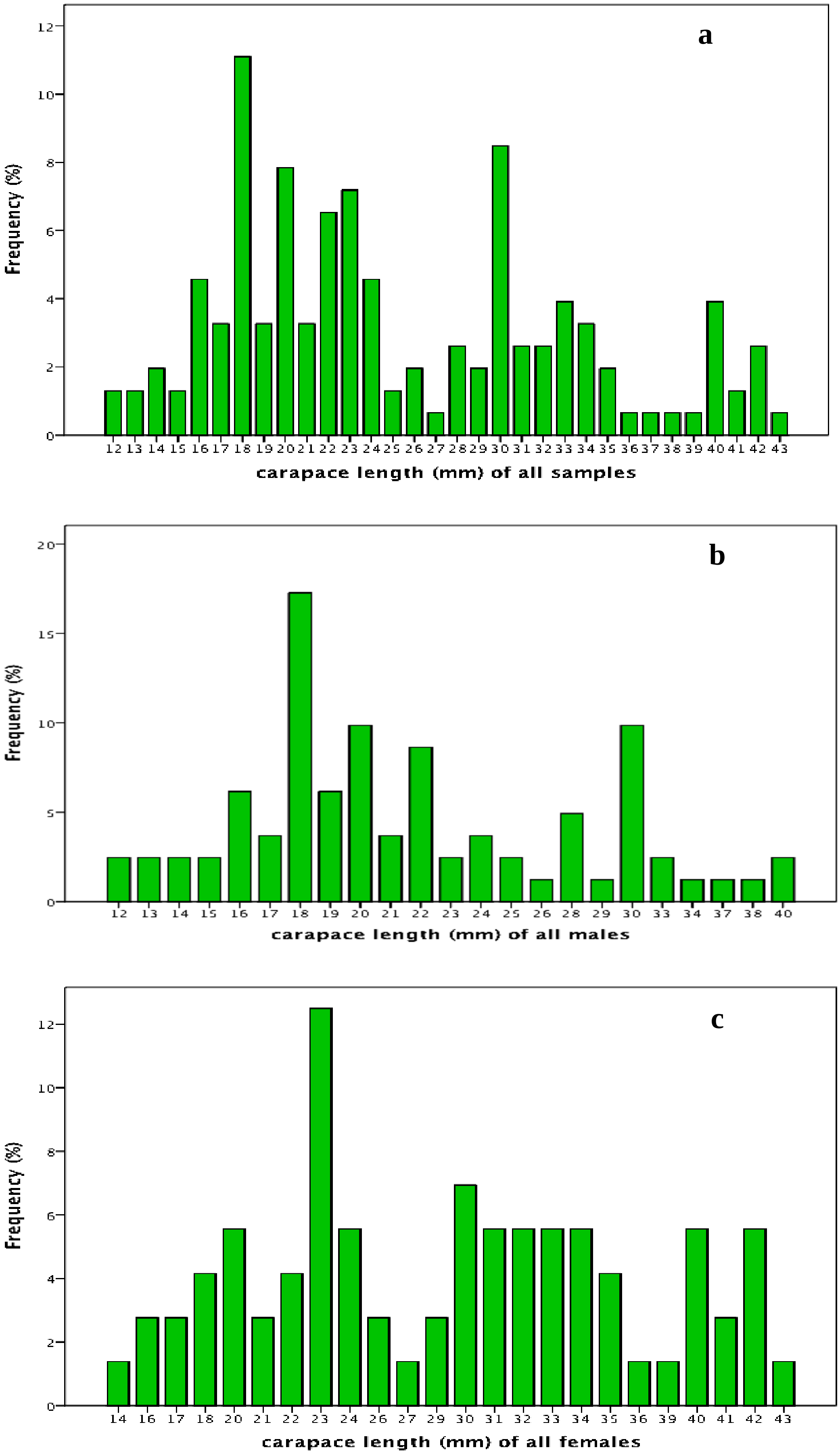


Fig. 1 Sizes of (a) male and female *G. tenuicrustatus* and (b) female ovigerous and non-ovigerous *G. tenuicrustatus* collected at Talim Bay, Lian, Batangas.


a
Frequency (%)
0
2
4
6
8
10
12
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
carapace length (mm) of all samples
b
Frequency (%)
0
5
10
15
20
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28 29 30 33 34 37 38 40
carapace length (mm) of all males
c
Frequency (%)
0
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14 16 17 18 20 21 22 23 24 26 27 29 30 31 32 33 34 35 36 39 40 41 42 43
carapace length (mm) of all females

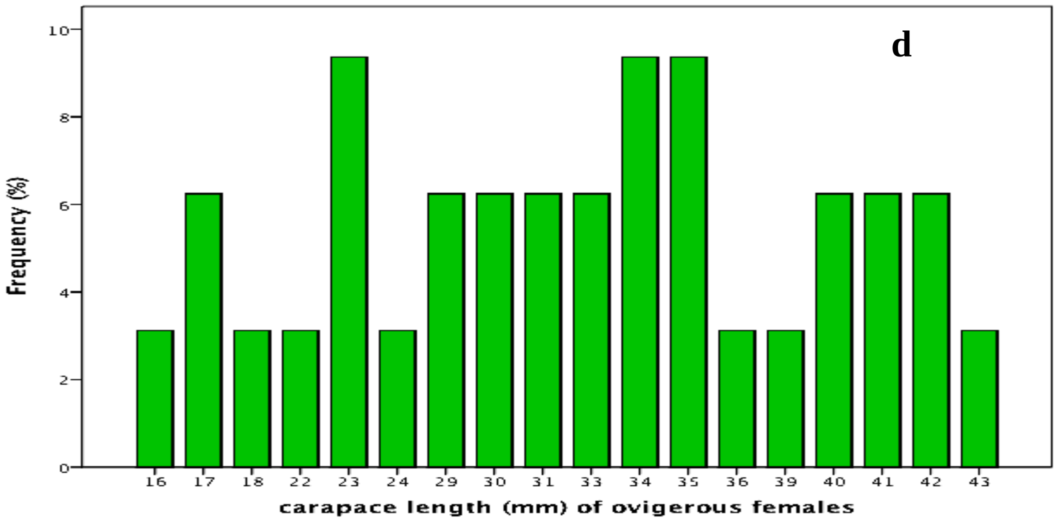

Fig. 2 Size-Frequency distribution of (a) all *G. tenuicrustatus* (n=153), (b) all the male *G. tenuicrustatus* (n=81), (c) all the female *G. tenuicrustatus* (n=72), and (d) all the ovigerous female *G. tenuicrustatus* (n=32) collected at Talim Bay, Lian, Batangas.

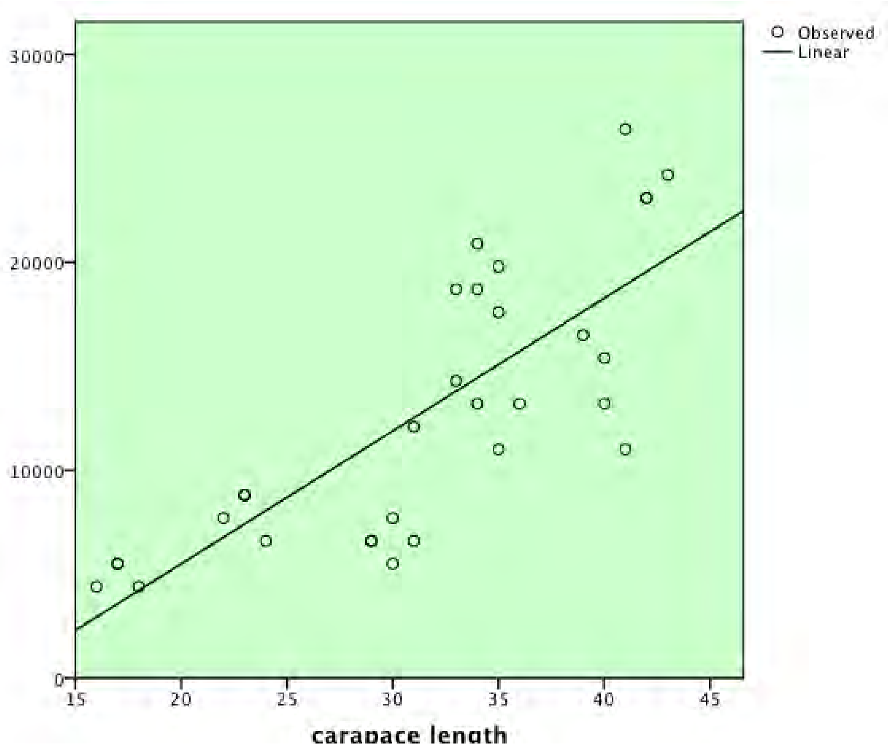

Fig. 3 Scatter plot for the relationship between egg number (EN) and female size (CL, mm) of *G. tenuicrustatus* collected at Talim Bay, Lian, Batangas.

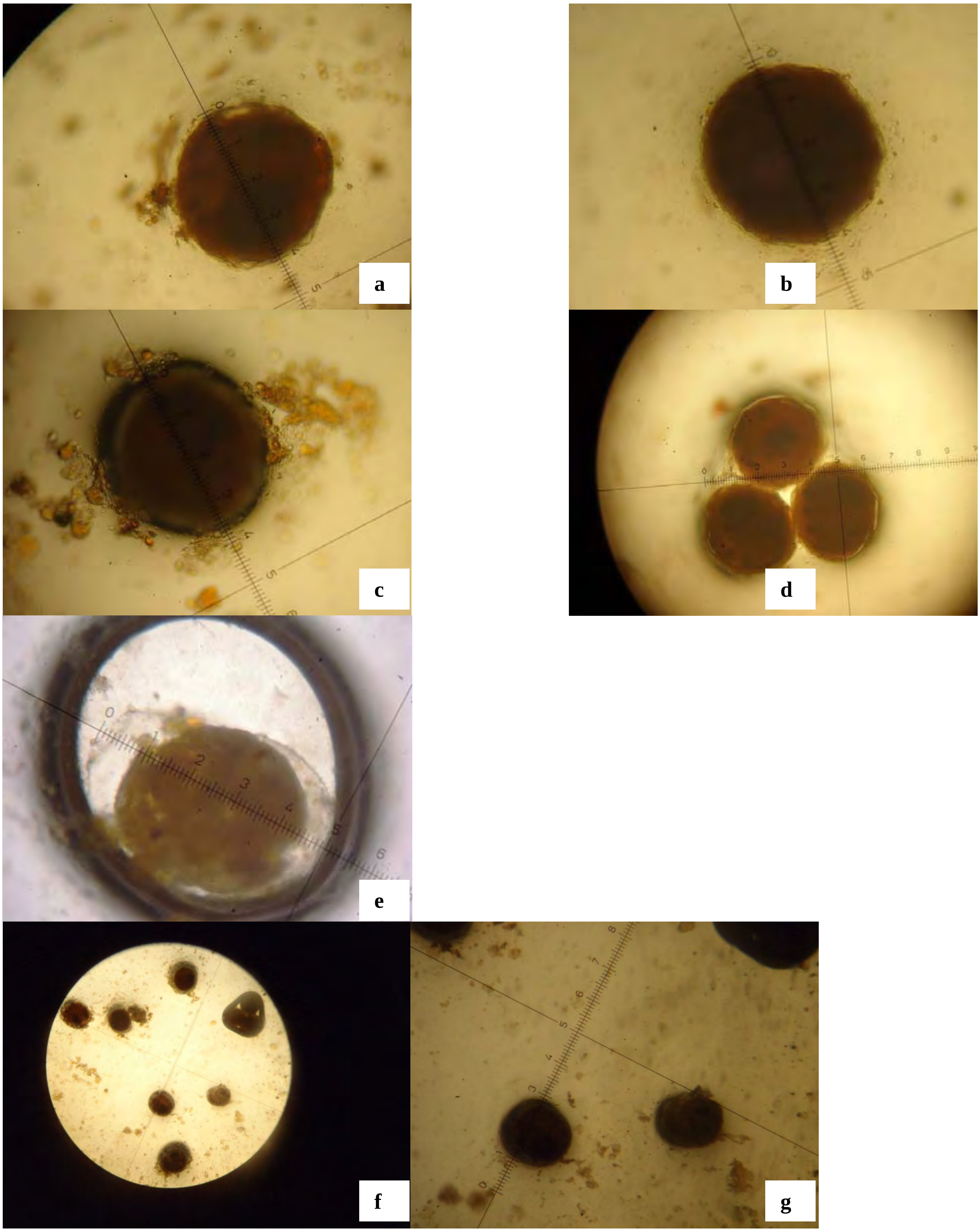

Fig. 4 Eggs of *G. tenuicrustatus* collected at Talim Bay, Lian, Batangas. (a) egg still undivided, fully filled with yolk; (b to e), the free region of yolk is just visible; free area of yolk is conspicuously larger than earlier periods and ocular lobes are already visible; (f & g) overview of egg microscope.

4 Discussion

There are many reasons for the observed differences in total number collected and sex ratio among the *G. tenuicrustatus* in the study site. First, in crustacean populations, sexual differences in distribution and mortality may be responsible for unbalanced sex ratios (Johnson, 2003). Based on previous reports, differences between male and female are not only exhibited by their spatial distributions and mortality rates but also on the effect of predation on crab sex ratio (Montague, 1980; Wolf et al., 1975; Spivak et al., 1991).

Second, it was observed that the physiologic and behaviorally homeostatic crab populations living in constant environments present a 1:1 sex ratio, or slightly male-biased. On the other hand, populations that inhabit variable environments present deviations toward the females, in order to maximize the evolutionary potential due to unequal selection between males and females (Geisel, 1972). Hence, it can be inferred that the study site provided a rather male-biased environment wherein a more stable and constant conditions are present.

In 1930, Fisher predicted that in random mating populations the evolutionary stable sex ratio would be 1:1. Several studies supported this hypothesis. For instance, Bezerra and Matthews-Cascon (2007) found out that the overall sex ratio of *Uca thayeri* population did not differ significantly from the expected 1:1 ratio and therefore showed that this population is physiologic and behaviorally adapted to the habitat, besides also being evolutionary stable.

Lastly, Costa (2000) observed that the low number of ovigerous females might also be due to the fact that ovigerous females hide inside deep burrows in order to incubate their eggs. Thus, as observed in the present study wherein the sex ratio did not differ significantly from the expected 1:1 ratio, indeed in a majority of species is close to unity, despite some variations between populations of a species, and from year to year in the same population (Nikolsky, 1963; Ofori-Danson, 1990).

Mantelatto and Fransozo (1996) explained that size at the onset of sexual maturity is a crucial variable to be taken into account while investigating the reproductive ecology of a given organism. For crustaceans there are not always outer characteristics such as color and size that clearly indicates when an individual reaches sexual maturity In brachyuran crabs, this is easier in females due to unambiguous signals of breeding competency, such as the presence of eggs attached to pleopods (Flores and Paula, 2002).

Among ocypodid crabs, sexual dimorphism is evidenced by males reaching larger sizes than females (Lopez Greco et al., 2000). Females may have reduced somatic growth compared to males because they concentrate their energy budget for gonad development. Moreover, males may reach larger sizes for successful competition for copulation with more than one female, since larger male ocypodid crabs may have greater chances of obtaining females for copulation and win more intra-specific fights (Christy and Salmon, 1984; Christy, 1987). This may not be applicable in the case of *G. tenuicrustatus*, which was shown to have larger females than males. Aside from reproductive pressure, other environmental and physiological factors might explain why females are larger than males among *G. tenuicrustatus*.

Estimates based on the smallest egg-bearing female are dependent on the sample size and do not indicate the average size at which females in a given population reach maturity (Lopez Greco and Rodriguez, 2004; Ituarte et al., 2004). Hence, comparative studies using a morphological (macroscopic and histological) and morphological analysis could be used for more precise estimates in determining the size at which males and females reach maturity (Litulo, 2005).

The results also support the notion that size at sexual maturity and fecundity are the key parameters that should reflect the lifetime investment in reproduction (Ramirez Llodra, 2002; Lopez Greco and Rodriguez, 2004). Certainly, fecundity and the size at the onset of sexual maturity of a species influence the periodicity and duration of breeding season. Other important factors include temperature, salinity, food availability, rainfall, photoperiod and lunar cycles. (Colpo and Negreiros-Fransozo, 2003; Costa and Negreiros-Fransozo, 2003; Litulo, 2004), but such variables were not explored in the present study and thereby merit further investigation.

Fecundity is the number of eggs per female and a determinant of the reproductive potential of a species and the stock size of its population (Mantelatto and Fransozo, 1997). It is an important parameter measured in crustaceans for the estimation of the reproductive potential and future stock size of a given species or population (Hattori and Pinheiro, 2001). Further, fecundity is directly related to life-history traits such as egg size, age at maturity, life span and reproductive effort (Ramirez Llodra, 2002). The variation in fecundity is very common in crab and has been reported by many workers like Erdman and Blake (1988); Melville Smith (1987); Pauley et al. (1986); Hill et al. (1989); Gray (1969), and Ong (1966).

Hines (1982) explained that fecundity of crabs varies from species to species and also varies within the same species due to different factors such as age, size, nourishment, ecological conditions of the water body etc. Variation in fecundity was primarily a reflection of variation in the size of the crab at maturity.

The relationship between fecundity and size at sexual maturity depends on the life-history strategies of a species (Ramirez Llodra, 2002). Earlier maturing species usually have a shorter generation because of the shorter generation time needed to reach first reproduction and, the cost may be observed in a reduction in future fecundity. In contrast, species with delayed maturity live longer, allowing them to grow larger and therefore have a higher fecundity (Ramirez Llodra, 2002). Moreover, the longer lifespan may also give the possibility of undergoing a higher number of lifetime fecundity and spawnings, which are characteristic in tropical species (Emmerson, 1994).

In genus of Brachyurans, the *Uca* species, Thurman (1985) reported that the greatest egg amount (25012) was registered for a female with 26.5mm of CW but concluded that the fecundity of the species in temperate and tropical areas vary greatly, where the size and the amount of eggs are in close association with the environmental conditions. More specifically in other studies, it was recorded that for a subtropical *Uca thayeri* population that females from 23 to 26 of CW carried more than 45000 eggs, showing that in *U. thayeri* fecundity is correlated with environmental conditions (Costa, 2000).

With the range of 3.9 mm in the diameter of eggs of *G. tenuicrustatus* as revealed by the findings of the current study (see Table 6), the common observation that brachyuran show a great diversity of embryonic development, especially owing to a significant variation in egg size (Hines, 1982) is supported. For blue crabs, *C. sapidus*, a mean fecundity of 3.2 million eggs was revealed (Guillory et al., 1996). Shields et al. (1990) mentioned that such variations in fecundity among brachyuran crabs may be caused by many factors including climatic regimes, habitat and biological constraints.

Strong size-fecundity relationships are found in brachyuran families (Hines, 1982; Hartnoll, 1985). The results of the present study are not an exception as shown by the results.

The results of the present study suggest that of an increase in number of eggs as the crabs grow larger. A positive allometry between egg number and female size implies of an increase in fecundity of an increase of female size. The relationship between female size and fecundity is a major characteristic of reproduction in many crustaceans, and is related to morphological and physiological constraints in energy allocation and gonad maturation (Ramirez Llodra, 2002). Litulo (2005) reported similar results for other brachyurans summarized by Hines (1982) and studies done by Erdman and Blake (1988) on female golden crab, *Geryon fenneri*; Kumar et al. (2000) on blue swimming crab, *P. pelagicus*, and Kyomo on sesarmid crab, *Sesarma intermedia*.

Carapace shape affects the volume reserved for gonadal development and spawn size (Hines, 1982; Mantelatto and Fransozo, 1997; Koga, 1982). The allometric relationships between fecundity and crab size variables is explained by the fact that egg mass is limited by the space available for the accumulation of reserves as well as the gonadal development inside the cephalothorax of the crabs (Litulo, 2004). Similarly, in the present study, it has been found that the number of eggs increased linearly with the increase of carapace length.

5 Conclusion

The significant reproductive characteristics of *G. tenuicrustatus* in Talim Bay, Batangas include: (a) a slightly male-biased ratio of 1:1.13; ovigerous female crabs having the largest CL compared with the males and non-ovigerous females; more ovigerous crabs belonging to the first year age class than the older classes; fecundity ranged from 4400 (CL = 16 mm) to 26,400 (CL = 43 mm) eggs; and the number of eggs increased with increase in female size.

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