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Biological Aspects of Berried Coconut Crab (*Birgus latro*, Linnaeus, 1767) from the Islands of Batanes Province, Philippines

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Abstract

Coconut crab (*Birgus latro*) is one of the economically important aquatic resources in the Philippines and classified as vulnerable by International Union for Conservation Network due to its declining population. The objective of the study is to investigate the biological aspects of the species particularly on its growth, fecundity, and condition factor. The collection of samples lasted for three months obtaining thirty nine (39) berried samples at Batanes Province. Thoracic length (TL) and total body weight (TBW) were obtained and used in determining the growth. Statistical Package for Social Sciences Tool and Microsoft Excel were used in processing the Linear Regression Equation, log transformation, and analysis of variance (ANOVA). Values obtained from log transformed length and weight indicates that crab matures and reproduces early at small sizes. Length-weight relationship (W = a + Lb) was W = 1.69 + L (0.44) indicating a negative allometry growth which means that the weight of the species is lighter than length which could be attributed to the reproductive and maturity stages of the samples. The coefficient for determination of the female coconut crab population (r^2= 0.82) showed a strong correlation between the TL and TBW. ANOVA confirmed that the values obtained are statistically significant. Fecundity was estimated at 2,722 to 259, 346 eggs with a minimum and maximum TL of 62 mm and 90 mm, respectively. Mean condition (0.10) was low indicating poor health during maturity stage. The result of the study could be used as baseline information in formulating policies for the protection and conservation of the resource.

Keywords: *Birgus latro*, coconut crab, growth, length-weight, Batanes Province

INTRODUCTION

The coconut crab *Birgus latro* of Family Coenobotidae locally known as “Tatus” in Batanes Province is the largest of the land crabs which is closely related to hermit crabs. Adult crabs can grow to a weight of 4 kg (Brown and Fielder, 1991). It is a nocturnal species of crustacean which is classified as omnivores. They stay hidden during daytime in burrows and crevices to protect themselves from predators and reduce water loss. They are slow growing terrestrial crustaceans with an estimated longevity between 40 to 60 years and an asymptotic length of 80 mm for males and 50 mm for females (Fletcher et al., 1991). It is widely distributed in the Indian Ocean, Central Pacific Ocean, and other areas in the tropics’ which includes the Philippines. Globally, the population of coconut crab is rapidly declining and considered as rare and classified as vulnerable by International Union for Conservation Network (IUCN) Red List of endangered species. In the Philippines, the resource is found mostly on large and small islands of Luzon, particularly in Batanes Islands, and some part of the Visayas and Mindanao Regions.

In addition, coconut crab is economically important species with high market demand. It is high valued food item in Batanes particularly for tourists because of its flesh delicate

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flavor. The presence of the resource boosts tourism in the area, a reason why gathering and hunting of “Tatus” still persist despite several management and conservation measures were implemented on the ground. The status in terms of species population has not been exactly identified, but it tended to decline because of local people consumption and habitat quality degradation.

Several foreign studies on coconut crab have already been published but when it comes to population dynamics, literatures are very limited and currently no studies on coconut crab in the Philippines. The study determined the biological aspects of berried coconut crab (*B. latro*) from the islands of Batanes Province, Philippines. It specifically determined the relationship of length and weight frequency distribution, growth and estimate fecundity and condition factor of the species. The information presented is vital for the resource managers in formulating policies for the conservation and protection of coconut crab populations in the country. The information is also helpful in fisheries biology and management, fish population dynamics, and stock assessment of the resource.

MATERIALS AND METHODS

Study site

Batanes Province is composed of a group of islands with coordinates of 20° 32’ 30” N and 121° 53’ 46” E. It is strategically located between the Babuyan Islands and Taiwan (Fig. 1). The islands are situated between the vast expanse of the waters of Bashi Channel and Balintang Channel, where the Pacific Ocean merges with the West Philippine Sea. It is the sea lane between the Philippines and Japan, China, Hongkong, and Taiwan. The province experiences below the normal low temperature of 55°F (13°C) in the months of December to February with no pronounced dry season.

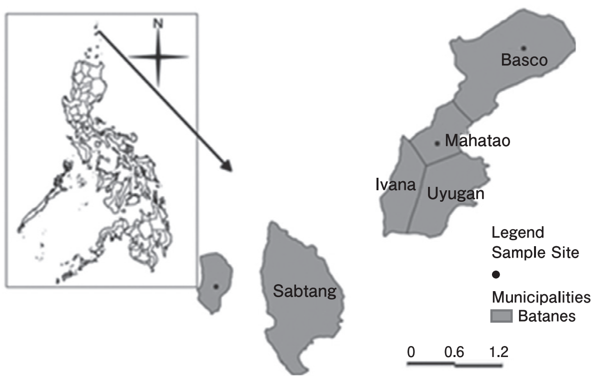

Fig. 1. Map of Batanes Province showing the location of collection sites.

Data collection

A total of 39 samples were collected from May 2013 to July 2013 from fisherfolk who collected female coconut crab species from the three municipalities of Batanes namely: Sabtang, Basco, and Mahatao. This was done every month at ten days interval. The length distribution pattern was determined from the thoracic length measurements. Each crab was measured and recorded for its thoracic length (TL) with the corresponding total body weight of the species. Thoracic length (Fig. 2) is the linear distance between anterior and posterior borders of the thoracic groove (Helfman 1973). This is the linear measurement least subject to measurement error or to variation caused by damage to the crab (e.g., broken rostrum) and it refers as the length of the thoracic region. Weight was the total live weight of the coconut crab. The thoracic length was measured in millimeter using a vernier calliper and total weight was recorded in grams using an electronic weighing balance of 0.1 grams accuracy.

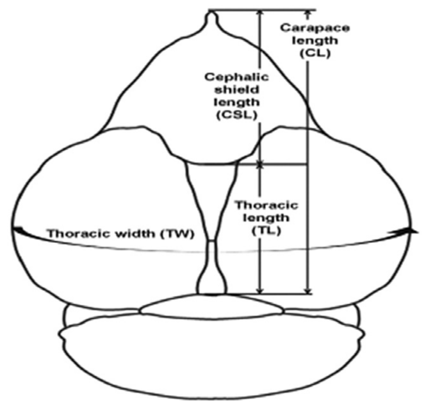

Fig. 2. Morphometric carapace of the coconut crab showing the thoracic length.

Data analysis

The data collected were encoded in Excel spreadsheet and analyzed using the Statistical Package for Social Sciences (SPSS) Software and Microsoft Excel formulas.

Length-weight relationship

The length-weight relationship was determined using the general formula of Ricker, (1973) used in the study of Lawson and Oloko (2013).

$$W = a L^b \qquad \text{(Equation 1)}$$

Values of ‘a’ and ‘b’ was estimated from logarithmic transformation of equation using the Linear Regression equation:

$$\ln W = \ln a + b \ln L \qquad \text{(Equation 2)}$$

where W represent the weight in grams and L represent the length in centimeter of a coconut crab while ln is the natural logarithm of a number, 'a' is the intercept on the y-axis and "b" is the slope. The correlation (r^2) is the degree of association between the length and weight and was computed from the linear regression analysis at 95% confidence using the formula:

Slope: $$b = \frac{n \sum x_i y_i - (\sum x_i)(\sum y_i)}{n \sum x_i^2 - (\sum x_i)^2} \quad \text{(Equation 3)}$$

Sum square of error: $$SSE = (n-1)(s_y^2 - b^2 s_x^2) \quad \text{(Equation 4)}$$

Correlation coefficient: $$r^2 = 1 - \frac{SSE}{(n-1)\, s_y^2} \quad \text{(Equation 5)}$$

The values of b determined the growth allometry ($b < 3$ or $b > 3$) or isometry ($b = 3$) (Lawson and Oloko, 2013) of coconut crabs in this study. From the log transformed data, length-weight relationship was analyzed using linear regression with 95% confidence using the formula.

Fecundity estimates

Fecundity was determined by total counts according to Bagenal (1978) and Radhkrishnan (2000). The relationships between fecundity and thoracic length, and body weight measurements were expressed as:

$$LogF = Loga + LogL \quad \text{(Equation 6)}$$
$$LogF = Loga + LogW \quad \text{(Equation 7)}$$

Where, F is the fecundity estimates (eggs), L is the thoracic length (in mm), W is body weight (in grams) and "a" and "b" are derived from the intercept and slope, respectively.

Condition factor

The Fulton's condition factor (cf) was calculated according to Bagenal (1978) using the formula:

$$K = 100W/L^3 \quad \text{(Equation 8)}$$

Where K is the condition factor (cf), W is the total body weight (BW), L is the carapace length (CL) and 3 is a constant.

RESULTS AND DISCUSSION

Length and body weight frequency distribution

As observed, the minimum and maximum thoracic length of the gravid coconut crab was 40. 6 mm and 90 mm, respectively (Fig. 3) with a mean of 69.43 mm, total median of 70 mm, and mode of 66 mm (Table 1).

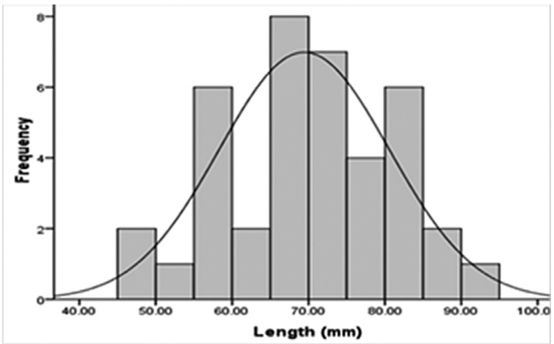

Fig. 3. Histograms on the size frequency distribution of gravid female coconut crab (*Birgus latro*) in Batanes Province, Philippines.

Table 1. Estimated morphometric values of thoracic length and body weight of gravid female coconut crab (*Birgus latro*) in Batanes Islands, Philippines.

Measurements	Statistical Values		
	Mean ± SD	Median	Mode
Thoracic length (mm)	69.4 ± 1.11	70	66
Total body weight (g)	329.9 ± 105.85	324	325

mm = millimeter g = grams
± SD = plus/minus standard deviation

This indicates that large sizes of berried coconut crab to carry eggs measures 70 mm, hence a unimodal size group appeared. Early studies of coconut crab by Fletcher (1973) in different environments showed different length measurements from 25 mm (Guam and Palau), 27 mm (Enewetak), and 27.5 mm and above 40 mm (Pagan Island, Northern Marianas) of all berried crabs. Fletcher (1993) also noted that the length range of coconut crab in Marianas Island is within the range of 50 mm to 200 mm. According to Amesbury (1980), a carapace total length of 100 mm would already correspond to a weight of about 720 g. Meanwhile, body weight observed in this study ranges from 150 g to 550 g (Fig. 4) with a mean of 329.89 g, median of 324 g, and mode of 325 g.

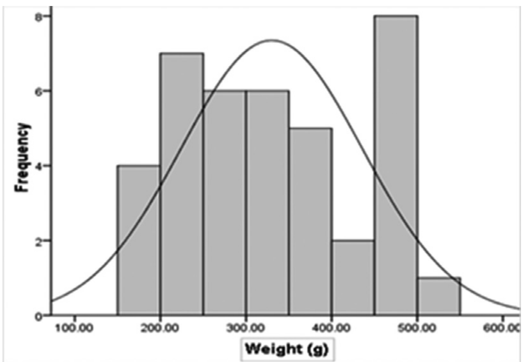

Fig. 4. Histograms on the body weight (g) distribution of gravid female coconut crab (*Birgus latro*) in Batanes Province, Philippines.

Generally, the result of the study only showed that most of the recorded total length (TL) and total body weight (TBW) are within 66 mm and 325 g., respectively. This implies that most of the sizes are small to carry an egg mass and are already caught at small sizes. Likewise, the weight of the crabs is lighter with the corresponding lengths observed. Hence, it was presumed that the weight could be affected by the maturity stage of the samples and the small sizes could be the result of continuous gathering activities despite the fact that the species slowly grows. The high pressure on the resource due to demand of hotels and restaurants despite several management measures (i.e. R.A. 8550 as amended by R.A. 10654, FAO 208 Series of 2001, FAO 223, and the international treaty, CITES) being implemented in the Province significantly contributed to the decline of coconut crab populations.

Thoracic length (TL) − total body weight relationship (TBW)

The length-weight relationship was calculated on the basis of 39 crabs measured and weighted in the field. As observed, the logarithm transformation showed a linear relationship between thoracic length and body weight measurements (Fig. 5) which indicates that the weight of the coconut crab increased logarithmically with an increase in length. This relationship can already be used as indicators to assess the condition of the species, calculating the biomass and estimating the recovery of the edible meat crabs of various sizes and can be used to convert length into weight and vice versa (Lagler, 1968). Meanwhile, the b value obtained on this study was 0. 44 indicating a negative allometry growth (Table 2).

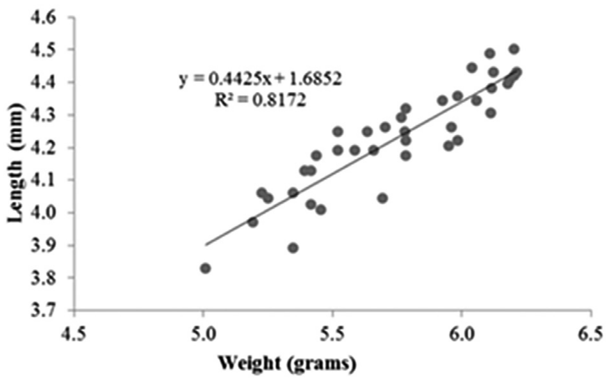

Fig. 5. Logarithmic relationship between thoracic length and body weight of gravid female coconut crab.

Table 2. Estimated regression parameters of the relationship between body weight and thoracic length (TL) of berried *Birgus latro* caught in Batanes Province, Philippines.

Parameters	Statistical Values
Number of samples	39
Slope coeff. (b)	0.44
Intercept coeff. (a)	1.69
Antilog of a	3.92
R	0.9
r^2 value	0.82
S.E. “a” (standard error)	0.198
S.E. “b”	0.044
P value “a”	0.00014
P value “b”	0.009

This only indicates that berried coconut crabs are lighter with their corresponding lengths. This also implies that the growth of coconut crab highly depends on the location, maturity stages, and season where the species are present. The low value obtained could be attributed to the maturity of the species since all the samples were already on their ovigerous stage. At this stage, the crabs do not feed and only relies entirely on its body reserve for survival, thus affecting its weight. Meanwhile, the small number of sample size obtained, the length intervals of the samples and the sex might also account for the low value observed since all samples subjected for analysis are all female berried crabs. Wooton (1998) suggested that the growth coefficient (b) values have also some implications and significant impacts on the well-being of fishes (including shellfish and fishery). The negative allometry ($b < 3$) means the crabs were lighter than their body length (Wootton 1998) and positive allometry indicates the heaviness and by implication the crabs are heavier than their lengths. It was further suggested by Carlander (1969), that in fish, the b value was used to find out whether the species is growing allometrically ($b < 3$ or $b > 3$) or isometrically ($b = 3$) where $b < 3$ means fish grows with weight increasing at slower rate and $b > 3$ means fish grows with weight increasing relative to the increase in length.

The b values obtained in the study were slightly close to the values observed from the study of Supyan (2013) in Utah Island North Mollucas Province where the growth of female coconut crab is negative allometry (0. 97). The different b values obtained in different environment could only suggests that the values obtained varies daily and seasonally between habitats because this is affected by numerous factors like stage of maturity, diet, sex, stomach fullness, health, as well as season and habitat (Bagenal and Tesch, 1978; Goncalves, et al.,1997; Taskavak and Bilecenoglu, 2001; and Ozaydin and Taskavak, 2007) amount of food intake (i.e. quantity, quality and size) (Qasim, 1973; Bal and Rao, 1984) and physical (i.e.

shape and fatness of species) and environmental conditions (i. e. temperature and salinity) (Pauly 1984; Sparre, 1992). Other includes food availability (Mommsen, 1998; Henderson, 2005) sample size and length interval within different areas (Morey et al., 2003) or habitat suitability (Nieto-Navarro et al., 2010). The length-weight parameters also vary within same species due to feeding and fishing activities (Bayhan et al., 2008) environmental changes, sexual metabolism and age activities (Franco-Lopez et al., 2010).

In addition, length-weight data taken by Pauly (1984), Miyasaka et al., (2007) and Mohopatra et al., (2010) from a wide variety of crustaceans suggested that values of $b < 2.5$ or $b > 3.5$ are generally based on very small range of sizes and or such values of b are most likely to be an error. In this case, the b value of 0.44 in this study which is slightly closer to the values obtained by Supyan (2013) could be attributed to small number of population sizes which resulted to small size ranges aside from the several factors already mentioned earlier.

On the contrary, there was a high correlation (r2 = 0.82) between the thoracic length and body weight of female coconut crabs which implies that there is a strong positive correlation between the total body weight and the thoracic length of the species. Values obtained are statistically significant ($p < 0.05$). This indicates that species of coconut crabs in Batanes Province increased in length and weight at slow rate.

Meanwhile, the data were further treated to ANOVA which statistical analysis was estimated at 95% level of confidence (Table 3) to check the reliability of the result.

Table 3. Estimated analysis of variance (ANOVA) for comparison of regression line of thoracic length-weight relationship of female coconut crab in Batanes, Province, Philippines

Parameters	SS	df	MS	F	Significance F (95%)
Regression	0.85	1	0.85	165.38	0.009
Residual	0.19	37	0.005		
Total	1.04	38			

SS = Sum of squares df = degrees of freedom
MS = Mean square

Fecundity estimates

Fecundity is often an important parameter to measure the reproductive output of species or even population (Mantelatto and Fransozo, 1997). The fecundity of the coconut crab at Batanes Province was estimated at 2,722 − 259,346 ova (75,388.38 ± 67229.89) in one spawning period with an average offspring of 75,388 pieces. The number of eggs per individual or the average offspring is low as compared to the study of Helfman (1973) in Palau and Enewetak where 50,000-138,000 eggs with 100,000 offspring were recorded. Similarly, the recorded TL median in Batanes Island was 4.25 mm while in the study of Helfman (1973) was 27 mm and 40 mm.

On the contrary, Figure 6 showed that there was a weak relationship between the fecundity and TL ($r^2 = 0.10$), and fecundity and TBW ($r^2 = 0.16$). Coconut crab fecundity appears to have a weak correlation with length and weight. The latter could be attributed to the use of fats reserves in the body of the coconut crabs as survival during the berried stage and as reflected in their body weight. Similarly, sizes of coconut crab during maturity and the fecundity could vary from different environments and locations and could further be aggravated by different environmental factors like climate, food intake and availability, and habitat type.

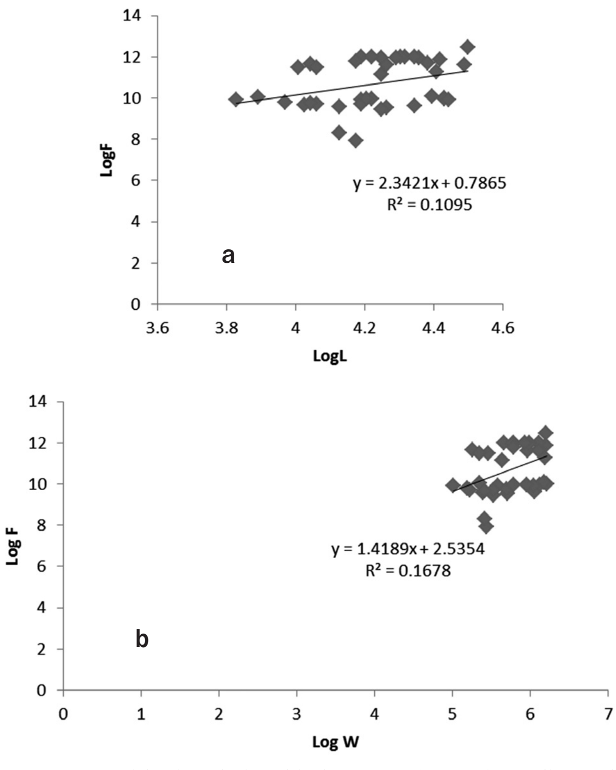

Fig. 6. Logarithmic relationship between a) Log fecundity and Log TL and b) Log Fecundity and Log TBW of female coconut crab in Batanes Province, Philippines.

Condition factor

The condition factor (K) was used to determine the health of individual species in the population. The recorded K value of the all berried females in this study ranges from 0.06 to 0.18 with a mean of 0.10. According to Frederick and Thomas, (1987) cited by Wootton (1999), K has an impact on the well-being of some aquatic organisms but varies from species to species, and it changes according to morphology, sex, age, reproductive state associated with gonadic maturity stages of the species. Variations in K may also be an indication of food abundance, adaptation to environment and gonadal development of fish (King, 1995). Low K means the fish are light for their lengths, and indication of low feeding intensity and spawning activity while high K value is an assumption of high feeding intensity and gradual increase in accumulated fat that also suggests preparation for a new reproductive period (Braga and Gennari-Filho, 1990). In addition, some factors also affect the condition of fish which includes data pulling, sorting into classes, sex, stages of maturity and state of the stomach (Gayanilo and Pauly 1997) season, type of food consumed, and amount of fat reserve (PSM and Baxter 1998).

Generally, the low K value obtained in the study could presumably be attributed to the maturity stages of the analyzed samples. It was noted that most of the species are already berried and are nearly to shed their eggs. As already mentioned earlier, during this stage crab do not feed and only use the fat reserve in its body for survival and eventually its weight is affected as reflected by the light weights and low condition factor.

SUMMARY

Thirty nine (39) samples of coconut crab (*Birgus latro*) were subjected for analysis. The minimum and maximum thoracic length observed was 40.6 mm and 90 mm, respectively with a mean of 69.43 mm showing a unimodal size group appearance. It was noted that most of the species are already mature to carry an egg. However, the weight is lighter with the corresponding thoracic lengths. Similarly, there is a significant correlation (r = 0.8) between the thoracic length to the body weight of the coconut crab in which the total body weight of the coconut crab increased logarithmically with the increase in thoracic length. The growth value obtained (b = 0.44) indicates a negative allometric growth indicating that the species is lighter with their corresponding lengths. There was also a high correlation between ($r^2 = 0.82$) between TL and BW where values obtained were statistically significant ($p < 0.05$). The fecundity was estimated at 2,722 − 259,346 eggs with an average offspring of 75,388 pieces. On the other hand, there was a weak correlation between fecundity and TL ($r^2 = 0.10$), and fecundity and TBW ($r^2 = 0.16$).

CONCLUSION

Coconut crabs (*Birgus latro*) a unique resource in Batanes Province, Philippines is being caught at small sizes. The species matures and reproduces early leading to high fishing pressure. Weight of the species is highly affected with the status and growth of the species like maturity stages and feeding habits. The low k value (condition factor) obtained could be due to low feeding intensity during ovigerous stage or spawning activity and the samples are light for their lengths.

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