Indian Journal of Geo Marine Sciences
Vol. 46 (08), August 2017, pp. 1667-1672

Carapace width-weight relationship of the mud crab (*Scylla tranquebarica* Fabricius, 1798) from the waters of Peninsular Malaysia

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Received 10 March 2015; revised 06 April 2016

Carapace width-body weight relationships of 300 mud crabs (*S. tranquebarica*) collected from Terengganu, Johor and Perak state of Peninsular Malaysia between September 2011 and October 2012 were examined. Exponential form of relationship was expressed in the logarithmic form, Log W = Log a + b log L. The male crabs showed positive allometric growth (b > 3) while the females exhibited negative allometry (b < 3) at all sampling locations. Student's t-test comparing the slopes of the regressions was used to test for possible significant differences between the sexes at each sampling location. Significant sexual dimorphism were seen in samples from Perak and Johor. Covariance analysis within sex indicated that the regression slopes of carapace width-body weight relationship among the sampling locations were homogeneous which suggests that the slopes did not differ significantly as a function of the sampling locations.

[Keywords: Allometric growth; Crab; Length-weight relationship; Regression parameters**]**

Introduction

The mud crabs or mangrove crabs of the genus *Scylla* are widely distributed in the Indo-Pacific[1]. The genus belongs to the member group of swimming crab, the portunid which is characterized by a flattened hind pair of legs[2] and is distributed over a wide range of salinity, from the coast to interior brackish waters. Crab lives in mud burrows, which occur densely in intertidal mangrove swamps, a little above the low tide mark.

Despite the fact that *Scylla* are very fecund and have extended spawning seasons, the crabs have suffered a negative impact such as recruitment overfishing that resulted from the uncontrolled fishing of the juveniles. Conservation of mud crabs primary habitat is important in order to support their population against their overfishing[3]. At present, there are no management policies or regulations for this genus. To provide a proper conservation and management of mud crab, a proper knowledge on its biology is essential.

The length-width/weight relationship is an important prerequisite in fishery biological investigations[4]. According to Tabash[5], the relationship is suitably used in assessing the fish and crustaceans. It can detect the variation in expected weight based on known length and acts as indicators to the fatness, breeding and feeding states, and the adaptability of the species to the environment[4]. Information on the population biology of the mud crab in Malaysia is relatively scarce and limited[6,7,8]. The mud crabs in Malaysia consist of three species, namely *S. olivacea* (Herbst), *S. paramamosain* Estampador and *S. tranquebarica* (Fabricius). To date studies on *Scylla* in Malaysia are limited to either on a single species in a locality[7] or between species in a locality[8,9] but no attempts are made to compare growth between localities. Furthermore, research on *S. tranquebarica* in Malaysia is lacking. Present study is for providing additional information on the width-weight relationship of *S. tranquebarica* populations in Peninsular Malaysia.

Materials and Methods

Samples of mud crabs (*S. tranquebarica)* were obtained from commercial crabs fishers at three locations in Peninsular Malaysia. The locations were Kuala Ibai in the east coast state of Terengganu, Mersing in the southern state of Johor and Bagan Datok in the west coast state of Perak (Fig. 1). Samplings were carried out from

September 2011 to October 2012 and at each location, multiple samplings were done to ensure adequate numbers of crabs were collected. Samples of *S. tranquebarica* were identified based on the keys of Keenan et al.[10], primarily through the observation of the shape of the frontal lobes and the presence of obvious spines on the cheliped. A total of 142 males and 158 females *S. tranquebarica* collected from all locations were placed in synthetic polyethylene bags, kept in a cool box and taken to the laboratory for further analysis.

Fig.1– Sampling locations

The body weight (W) of the crab was measured to the nearest 0.1 g using a weighing balance (AND EK-1200i MODEL) while the carapace width (CW), taken as the distance between the tips of the posterior-most lateral carapace spines, was measured with a vernier caliper (Mitutoyo MODEL) to the nearest 0.1 mm. The data collected was used to evaluate the relationship of the CW and W of *S. tranquebarica*. The CW-W relationship was estimated using the equation $W = aL^b$ [11] where W is the body weight, L is carapace width, a is the intercept and b is the slope. The exponential form of relationship can be expressed in the logarithmic form, Log W = Log a + b log L. The values of a and b were calculated for CW-W relationship using the log-log relationship. Student's t-test[12] comparing slopes of the regressions were used to test for possible significant differences between the sexes at each sampling location. The analysis of covariance (ANCOVA) was applied to compare more than two slopes when testing for differences in CW-W relationships of crabs from different sampling locations. A general linear model was run in which log W was modeled as a function of the location of sampling, covariate (*i.e.* log CW), and their interaction. The interaction term tested for homogeneity of the slopes. The computer software SPSS Version 11 (Statistical Package for the Social Science) was used for the analyses. Statistical differences are significant when $P < 0.05$.

Results and Discussion

CW and W statistics obtained for males and females crabs from each location are given in Fig. 2. The variability of the CW, measured by the interquartile range (IQR), was relatively similar for females in all samples (17.5 cm – 20.5 mm) while males from Perak showed the least variability (10.5 mm) compared to males from Johor (16 mm) and Terengganu (18.5 mm).

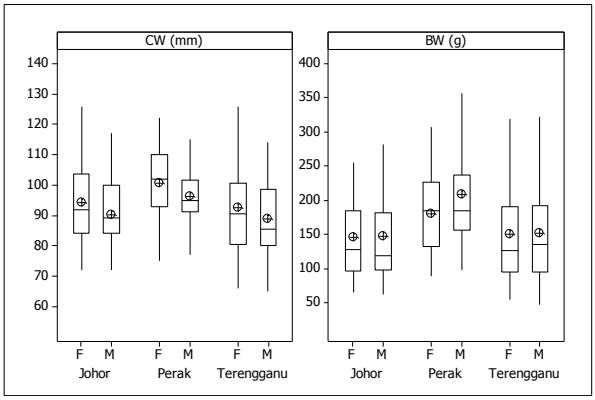

Fig.2– Box-plot of carapace width (CW) and body weight (BW) of male (M) and female (F) *S. tranquebarica* from three sampling locations. Ø indicate mean values

The variability of W for females was similar across the sampling locations (IQR = 87.8 g – 94.6 g) while males showed some variability, Perak the least variable at 81.6 g and Terengganu showing the most variable, 97.1 g. Two-sample t-test showed that only males and females from Perak differ both in their CW and individual weight ($P < 0.05$) with males heavier but more compact than females.

The highest mean CW was recorded for Perak's samples (male = 96 mm; female = 100 mm) while the mean CW of both Johor and Terengganu were relatively similar (male = 90 mm; female = 95 mm). The mean CW of 90 – 100 mm indicated that the majority of the crabs were sub-adults and adults. Overton et al.[4] reported comparable mean CW of *S. serrata* for samples from Thailand, Vietnam and Sarawak

while Ikhwanuddin et al.[8] reported similar range of values for *S. olivacea*, *S. paramamosain* and *S. tranquebarica* found in Setiu wetlands in Terengganu. Kosuge[6] found that nearly 80% of the mud crabs collected in Matang Mangrove Forest Reserve in Perak were immature (CW < 90 mm) which suggests heavy exploitation of the crab resources. Overfishing in Bangladeshi mangroves was postulated as the most likely cause of the low modal size of 81-90 mm CW in males, while the maximum frequency of females was observed at 71-90 mm CW[13]. Prasad and Neelakantan[14] reported that female *S. serrata* in India attained maturity after reaching 80 mm CW and above. The size at first maturity based on CW was estimated at 91-100 mm in India and 100-114 mm in Malaysia[6]. In Thailand, the mean size at first sexual maturity of male *S. olivacea* and *S. paramamosain* were 103 mm and 109 mm, respectively[15]. However, female *S. paramamosain* attained 50% maturity size at about 110 mm[16] whereas female *S. olivacea* at 100 mm[17]. Ikhwanuddin et al.[8,9] however reported that the size at maturity of female *S. olivacea* and *S. tranquebarica* were 86 mm and 92 mm, respectively. The size at maturity of male crabs was postulated to be similar to females. Size at mating for female and male *S. olivacea* was 96 mm and 113 mm, respectively while for female and male *S. tranquebarica*, size at mating was 108 mm and 131 mm, respectively.

The general finding indicates though maturity size does not vary widely with the sexes but it may vary with the species in the particular area. Thus, the legal size of capture for mud crab should be species-specific which was also suggested by Overton and Macintosh[18]. The high demand for the crab coupled with the absence of sound management policies and regulations results in overfishing and smaller size crabs. However, in countries such as Australia where there are regulations in terms of minimum legal size and maximum bag limits, the size at maturity is generally at 120-150 mm of CW[19].

Linear regressions of the CW-W relationship were significant for all samples with R^2 values greater than 0.80. The pattern of growth (isometric / allometric) in *S. tranquebarica* was determined from the slopes of the regressions or the *b* values. According to Bagenal and Tesch[20], when *b* is 3, the growth is isometric and when *b* is below and above 3, the growth is allometric[21]. The result of carapace width-weight relationship study using the log-log least squares regression analysis are presented in Table 1. The *b* values (2.509 - 3.513) were within the range of 2.5 to 4.0 suggesting that the results of this study were valid[22,23]. The *b* values in this study were supported by the results obtained for *S. tranquebarica* (0.218 – 0.344) and *S. paramamosain* (0.266 – 0.342), both from Ikhwanuddin et al.[7] and also on *S. serrata* at Chalna regions of the Sundarban, Bangladesh (1.893 – 3.060)[13] and 2.751 – 3.220 in Orissa, India[24].

Pronounced sexual dimorphism in CW-W relationship was observed for Perak and Johor samples with significant differences in the slopes between males and females (Perak: males = 3.485, females = 2.509; T = 3.89, P < 0.05) and (Johor: males = 2.509, females = 2.984; T = 2.12, P < 0.05). However, there was no significant difference in slopes between males and females of Terengganu samples (Table 1 and Fig. 3 to 5). In this study, all the samples exhibited an allometric growth pattern. The *b* values for males in all the samples showed positive allometry ($b > 3$) while all the females samples exhibited negative allometry ($b<3$) indicating that females *S. tranquebarica* becomes relatively thinner as it grows larger while males gets plumpier as it grows. The *b* values obtained in this study proved the tendency of males being heavier than females in mud at all sampling locations which is in conformity with other observations on mud crabs. Covariance analysis found that the slopes of the regressions within each sex were homogeneous among the sampling locations (Table 1). In other words, analysis evaluating the homogeneity of regression slopes (H_o: $\beta_1 = \beta_2 = \beta_3$) indicated that the relationship between the log CW (i.e. covariate) and log W did not differ significantly as a function of the sampling locations.

Table 1– Carapace width-weight relationship for *S. tranquebarica* for both sexes combined, males and females from the three states and covariance analysis to test for homogeneity of slopes.

Location	Sex	Parameter of relationships[a]					Covariance analysis[b]
		a	b	SE (b)	R^2	T-value	
Johor	Both	- 4.035	3.140	0.131	0.85		
	Males	- 4.739	3.513	0.200	0.87		
	Females	- 3.751	2.984	0.153	0.88	-2.12*	
Perak	Both	- 2.986	2.635	0.167	0.82		
	Males	- 4.616	3.485	0.219	0.85		
	Females	- 2.782	2.509	0.136	0.87	-3.89*	
Terengganu	Both	- 3.443	2.854	0.116	0.86		
	Males	- 3.926	3.114	0.204	0.82		
	Females	- 3.186	2.711	0.095	0.95	-1.81	
							Males: $F = 1.32$, $P = 0.271$
							Females: $F = 3.01$, $P = 0.053$

[a]a and b are parameters of the equation (log W = a + b log CW), SE(b) is the standard error of the slope, R^2 is the coefficient of determination, and T-value is for the t-test comparing the slopes of the regression for males and females within the location, and significance difference ($P < 0.05$) is indicated by *.
[b]Covariance analysis tests for differences in slopes (Ho: $\beta_1 = \beta_2 = \beta_3$) across locations in males and females.

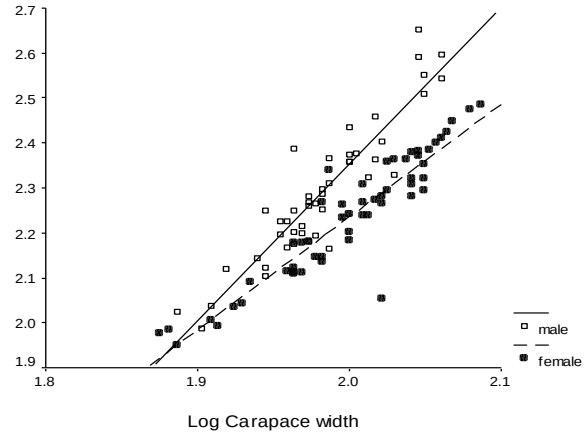

Fig.3– Logarithmic relationship between carapace width and weight of male and female *S. tranquebarica* for Perak populations

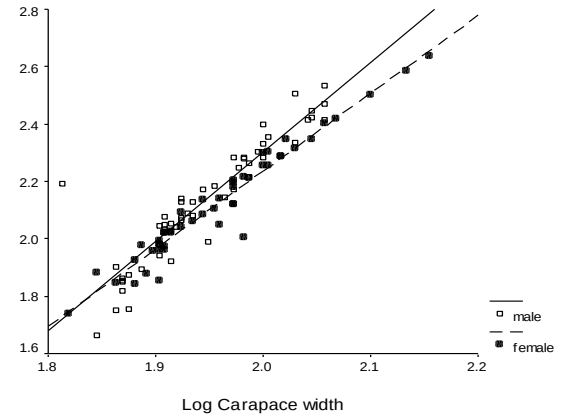

Fig.4– Logarithmic relationship between carapace width and weight of male and female *S. tranquebarica* for Johor populations

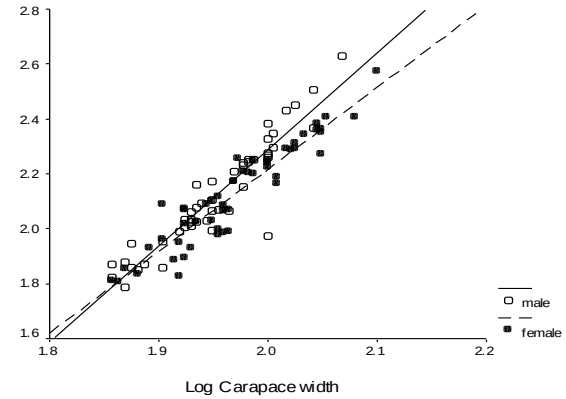

Fig.5– Logarithmic relationship between carapace width and weight of male and female *S. tranquebarica* for Terengganu populations

Even though the values of *b* reflect the shape and fatness of the crabs, various factors may be responsible for the differences in the parameters of the width-weight relationship[25]. According to the study done by Miyasaka et al.[26] on varunid crab species in Japan, larger *b* values in males was attributed to the allometric enlargement of male chelae with sexual maturation. A similar situation was observed on the mud crab *S. tranquebarica* at Parangipettai coast in India. The slight differences in *b* values may also possibly due to differential diet, changed in cheliped strength, foraging behavior, metabolic rate of animal and stage of maturity[27].

Conclusion

The carapace width-body weight relationship presented here would be useful to crab biologists to derive estimates of carapace width based on body weight. Carapace width is important in crab fishery, as it is often the measure used in predicting size at maturity and subsequently the determination of the minimum landing size of the crab.

Acknowledgements

This study was supported by Ministry of Higher Education, Malaysia through the Fundamental Research Grant FRGS-0238-2010.

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