Allometric Relationship in the Adult Population of the Malaysian Horseshoe Crab (Tachypleus tridentatus; Leach)

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ABSTRACT

Mature pairs of the horseshoe crab migrate regularly towards the beaches for breeding purpose. The continuous depletion of the population of horseshoe crab in several places is also directly related to the degradation and destruction of the habitat especially the breeding grounds of the animal. In the present study an attempt was made to use allometric tool to demonstrate the length and weight relationship in the matured pair of Tachypleus tridentatus (Leach) collected from Papar Sabah in Malaysia. In males, the weight was 2.89 times higher than total length (r=0.86) whereas in females it was 10.90 times more than the total length (r=0.96). The correlations of variance (CV) of 6.68 for males and 16.26 for females showed that the magnitude of increase in weight in females was much higher than increase in weight of the males.

Keywords: Allometry, population, horseshoe crab, *Tachypleus tridentatus*

1.1 INTRODUCTION

The horseshoe crab is the oldest living marine creature and commonly called as “living fossil” as the animal has not shown any significant phenotypic change even after a span of 350 million years (Mikkelsen, 1988; Chatterji and Abidi, 1994). The most important Paleozoic group is represented by only four species with discernible morphology and three genera confirmed, so far, all over the world. Among these four extant species, *Limulus polyphemus* (L) and *Tachypleus tridentatus* (Leach) occur in a north-south-north direction whereas, *Tachypleus gigas* (Müller) and *Carcinoscorpius rotundicauda* (Latreille) in east-west-east direction (Mikkelsen, 1988; Chatterji, 1994). The indiscriminate exploitation of the horseshoe crab for medicinal and other purposes threatens its population towards extinction all over the world. As the horseshoe crab has assumed great significance in biomedical research, it is essential to protect this valuable creature from extinction along the Malaysian and other coasts.

Marine organisms, in a more stable environment, show isometric growth in all their body parts. However, any drastic change in environmental conditions greatly influences their morphometrical, biological and physiological characteristics (Bas, 1964). Use of allometric tool in animal biology provides information about the life history and physiological behaviour of the organisms. The information on allometry besides providing a mathematical relationship between parameters such as length and weight of an animal, it also helps in inter-converting one parameter to other. These relationships are useful in getting valuable information on general well being of the animal, stock

assessment models, estimation of biomass from length observations and comparing the life histories of species from different regions. The correlation between the two variables like length and weight is the degree of association between these parameters. This degree of association is expressed by a single value which is called as correlation coefficient (r) and the computation of 'r' shows whether the correlation that is being identified is significant or not? The objective therefore, in the present study was to study the length and weight relationship among the population of the horseshoe crab (*Tachypleus tridentatus*; Leach) collected from Papar Sabah, Malaysia with the aim of using this information for stock assessment model of this animal in near future.

2.0 MATERIALS AND METHODS

Papar Sabah is located in the west-coast division of east of Malaysia ($5^{o}43'48$ N, $15^{o}55'48$ E). The sandy beaches of Sabah are found most suitable for active spawning of one of the important species of the horseshoe (*Tachypleus tridentatus;* Leach). The beach generally experiences a tidal fluctuation between -0.04 and 2.10 m where a considerable number of the matured pair of *T. tridentatus* migrate regularly for spawning. On the 2 May' 2008, a higher density of *T. tridnetatus* population was observed that was in coincidence of unusual attainment of tidal amplitude ($H\infty$ = 2.26 m). At that time, 50 numbers of live specimens of horseshoe crab were collected and their total length (from the tip of the anterior most part of the carapace to the tip of telson) was recorded up to the nearest mm using Vernier Callipers for both the sexes separately. The average body weights in gram for both males and females were also recorded using a single pan electronic balance (Sartorius : accuracy 0.01 g). After recoding these measurements, the brooders were released back to the sea.

Data collected on length and weight of both sexes were analysed according to the method of Chatterji *et al.* (1977) where log transformed and the regression of log length to weight were calculated by least square method. The equation *ln*W = *ln*a + b *ln*L was calculated separately for each sex and a straight line was fitted to scatter diagram using OriginPro v7.0. Covariance analysis (Chatterji *et al.*, 1977) was used to describe differences, if any, in the regression of *ln* weight on *ln* total length in male and female populations of horseshoe crab. The comparison between slope was carried out by means of ANOVA ($P < 0.05$) (Sokal and Rohlf, 1979).

3.0 RESULTS

The length and weight relationship of males and females of *T. tridentatus* is presented in Figs. 1 & 2. The smooth curves in Fig 1a and Fig. 2a represented the calculated weight at each total length interval whereas the straight lines in Fig. 1b and Fig. 2b represented the calculated regression lines. The weight of the males was 2.89 times higher than total length and the relationship was not very significant (r=0.86). However, in females the increase in weight was 10.90 times more than the total length of the matured specimen. The length and weight relationship was highly significant in the population of horseshoe crab collected from Papar Sabah (r=0.96). The correlations of variance (CV) values were;

6.68 for males and 16.26 for females which showed that the magnitude of increase in weight of females was much higher than weight of the males with respect to total length.

4.0 DISCUSSION

Application of length and weight relationships in most of crustaceans is the simple alternative to estimate body weight from the length measurements that are less variable and more easily measurable way to be used in the field to study the growth rate, feed conversion ratio, harvestable weight and productivity (Dall *et al*., 1990). The length-weight relationship data is also routinely used for the estimation of numbers of fish landed for the stock assessments (Wigley and Serchuk, 1992).

Total body weight of females in all species of the horseshoe crab has been reported to be heavier than males (Chatterji, 1994). In the present study both males and females had shown an exponential growth as relationships between total length and body weight yielded smooth curves. The rate of increase of body weight in females was of higher magnitude to that of total length as compared to body weight and total length of males. The relationship between total length with body weight was statistically highly significant ($p< 0.05$) in female of *T. tridentatus* as compared to male specimens. However, Vijayakumar *et al*. (2000) observed that relationships observed between total length with body weight were statistically significant ($p< 0.05$) both in the male and female *T. gigas* collected from the north-east coast of India. Though the increase in the body weight was of higher magnitude than that of total length of *T. gigas* (Vijayakumar *et al*., 2000) but it was of lesser magnitude as compared to *T. tridentatus* where the 'b' value was 10.90. However, in juvenile blue crabs (*Callinectes sapidus*) the regression equation did not show any significant difference between males and females specimens of crab (Linda, 1985; Gokhan *et al*., 2006) whereas the length and weight relationship in males of *Portunus validu* (Herklots) exhibited negative allometric growth. The correlation coefficient (r) in *P. validu* has been reported to be between 0.88 and 0.91 that showed relatively a lower significance level (Omolara and Barakat, 2009). Miyasaka (2008) also reported that the length-weight relationships between dry weight and carapace width of two varunid crab did not show significant difference between species, sexes and populations. In juveniles of *T. tridentatus* and *C. rotundicauda,* prosomal width and wet weight relationship showed a positive allometric growth ($b=2.97$) which indicated that body weights gained by *T. tridentatus* and *C. rotundicauda*, were faster than the growth of prosomal width after each ecdysis (Christine and Morton, 2005).

There have been many studies which showed that in a population of aquatic animals, the relationship between length and weight did not follow a linear relationship which could be represented by a parabolic equation i.e $W=aL^b$ where the weight (W) is proportional to a certain power (b) of the length (L). However, length and weight data when fitted to a regression equation after converting the length and weight values into their logarithmic forms, it showed a linear relationship and can be thus expressed as $\text{Log } W = a + b \text{ Log } L$ or

*ln*Y = *ln*a + b *ln*X (Chatterji *et al*., 1988). In crustaceans, a parabolic relationship has been obtained while comparing the length-weight relationship of the animal. In the laboratory reared penaeid shrimp (*P. monodon*), the regression coefficient showed an isometric growth (b=~2.0) where the weight of the shrimp increased at the rate of more or less cube of the length (Saldanha and Chatterji, 1997). In the present study, the length and weight relationship was also non-linear and strictly followed parabolic equation in both the sexes. However, in *T. gigas,* the body weight and total length relationship was observed to be linear where body weight increased sharply within the length range of 300-400 mm (Vijayakumar *et al*., 2000). The weight of females of *C. rotundicuada* collected from the Sunderbans area of West Bengal (India) showed relatively a lower weight gain as compared to males up to the size of 130 mm (Chatterji *et al.*, 1988). The length-weight relationship data of females also revealed that the weight in females was increased gradually more than the cube of the carapace length as observed in *T. tridentatus* but no doubt it was of much of higher magnitude as compared to *T. gigas* and *C. rotundicauda*. In males of *T. gigas*, the length weight relationship did not follow the cube law but the relationship has been reported to be highly significant (Chatterji *et al*., 1988; 1994).

In fisheries research, the allometric relationship has been considered to be an important tool as it helps in converting one parameter into another which often requires during monitoring of field measurements (Goncalves *et al.,* 1996; Froese and Pauly, 1998: Moutopoulos and Stergiou, 2002). Generally, for a population study, aggregated average weight of a sample can be expressed as the average of weights predicted for the individual length using allometry. Zar (1968) and Hayes and Shonkwiler (1996) strongly suggested the use of allometric modelling in fisheries research. Xiao and Ramm (1994) observed that the use of log-transformed data is appropriate for describing length and weight relationships in aquatic animals. In the present study, the small sample size might not be sufficient in expressing asymptotic variance properties of nonlinear regression however; allometric application describing the linear regression using log transformed data facilitated statistical comparisons of the gender relationships adequately regardless of the sample size. The length-weight relationship data currently being used in audit applications are also derived from the studies with small sample size, combined genders, incomplete length ranges, restricted seasonal or geographical coverage or even unknown origin of the samples (Moutopoulos and Stergiou, 2002).

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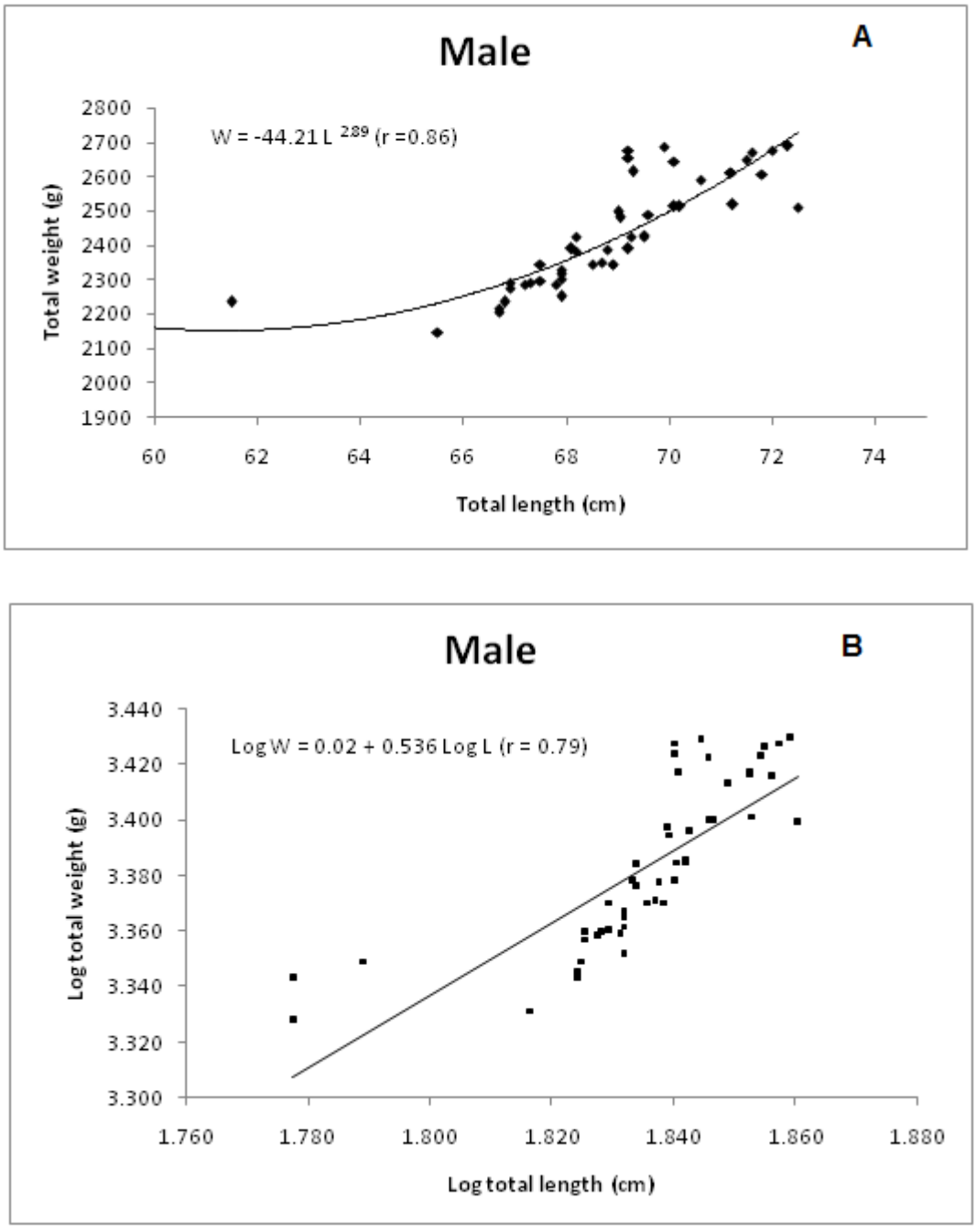
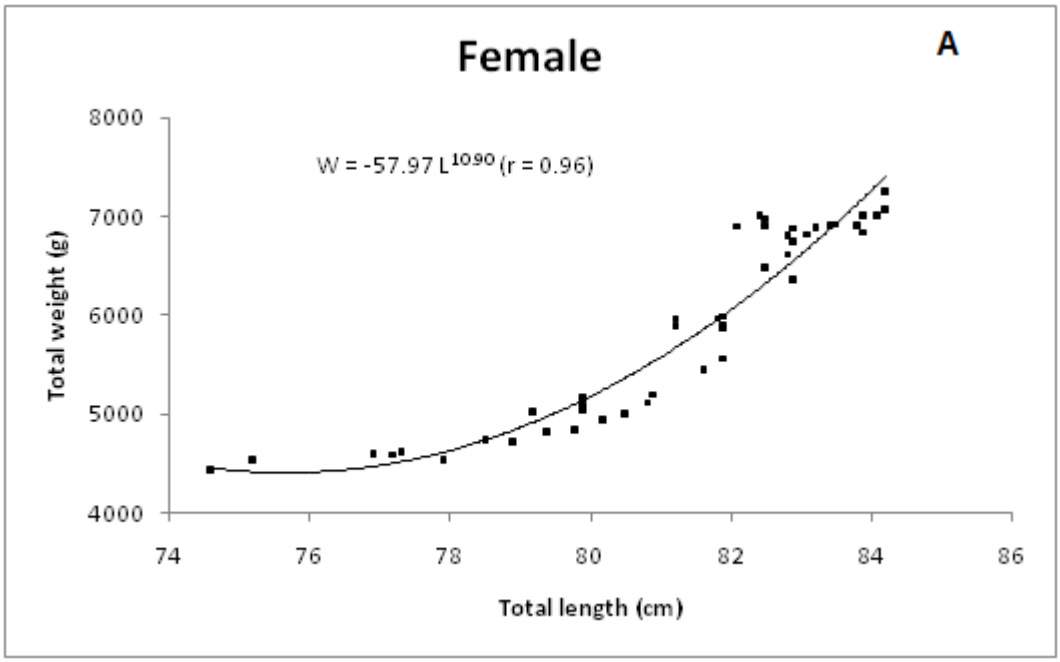


Fig. 1: Length-weight relationship in males of *T. tridentatus*

(A) Smooth curve represents the calculated weight
(B) Straight line represents the calculated regression line of log weight on log length



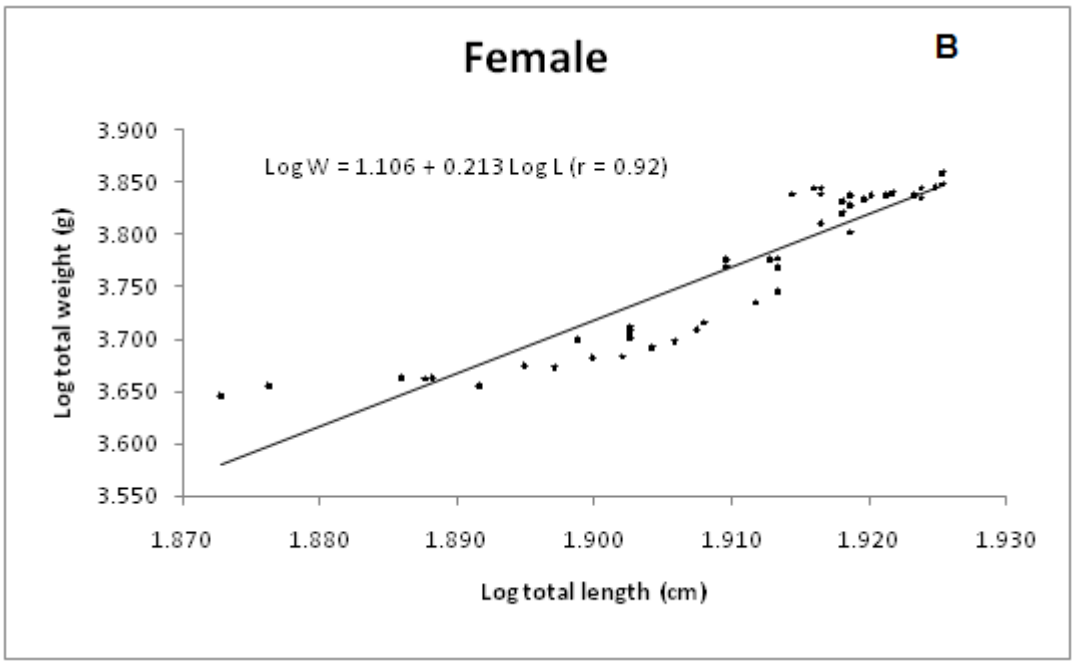


Fig. 2: Length-weight relationship in females of *T. tridentatus*

(A) Smooth curve represents the calculated weight
(B) Straight line represents the calculated regression line of log weight on log length