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SOME ASPECTS OF POPULATION BIOLOGY OF EDIBLE ORANGE MUD CRAB, *Scylla olivacea* (HERBST, 1796) DURING PRE AND POST MONSOON IN SETIU WETLANDS, TERENGGANU, MALAYSIA

NADIRAH MUSA[*1,2], MOHAMMAD TAJUDDIN ABDUL MANAF[1], NUR AZNA SAARI[1], NORHAZWANI HAMZAH[1], WAN NORHAFIZAH WAN IBRAHIM[1], ALIA SYAFIQAH AZNAN[1], KHAIRULBARIYYAH ZAKARIA[1], SHAHRUL HAFIZ ABD GHANI[1], LAITH ABDUL RAZZAK[2], NAJIAH MUSA[1,2], SANDRA CATHERINE ZAINATHAN[1,2],MOHD EFFENDY ABDUL WAHID[1,3], FAIZAH SHAHAROM-HARRISON[1,4], MOHD AZMI AMBAK[1,2], MHD IKHWANUDDIN[2] AND MAZLAN ABD. GHAFFAR[1,2,5]

[1]School of Fisheries and Aquaculture Sciences, [2]Institute of Tropical Aquaculture, [3]Institute of Marine Biotechnology and[4]Institute of Kenyir Research, Universiti Malaysia Terengganu 21030 Terengganu. [5]Marine Ecosystem Research Center, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor

[*]Corresponding author: nadirah@umt.edu.my

Abstract: Population biology is regarded as one of the important domain for nature resource management particularly when any species of economic and social importance is involved. In this study, the population structure of tropical orange mud crab, *Scylla olivacea* (Herbst 1796) was investigated in a tropical mangrove forest in Setiu Wetlands, Terengganu, Malaysia. This study specifically address some aspects of population biology of this species particularly of sex ratio, carapace width-weight and growth pattern. Mud crabs were sampled during pre and post monsoon season i.e. during October 2014 and January 2015, respectively. Mud crabs were collected using crab-baited collapsible traps in the identified areas. A total of 30 crabs were captured, of which 18 were male (60.0%) and 12 were female (40.0%). The overall sex ratio, male to female for pre monsoon and post monsoon were (and 3:1, respectively. Male's mud crab were bigger and heavier than females. Positive correlation was observed between carapace width and body weight in both sexes (r^2= more than 0.8). Negative allometric growth (b<3) was observed in females during pre-monsoon month. Significant difference (P<0.05) was found between the condition factor (K) of pre monsoon and post monsoon month of both sexes. As such, our results provide some important biological information on the population biology of mud crabs in Setiu Wetlands which may help to reduce the fishing pressure on this crustacean species.

Keywords: Carapace width-weight, condition factor (K), *Scylla olivacea*, sex ratio

Introduction

Mud crabs, genus *Scylla* are exploited both commercially and for subsistence by artisanal fishermen of tropical Indo-Pacific region including Malaysia (Mirera, 2013). Market demand, good price and ease of capture have led to over exploitation of this crustacean species (Le Vay, 2001). All these combined with loss of mangrove habitat has led to reduction in both landings and size captured in which the annual catch has fallen from 109 tonnes in 1989 to 65 tonnes in 1995 (Jirapunpipat & Pradissan, 2005).

In Malaysia, most mudcrabs that are consumed and marketed are from wild catches. Four species of mud crabs are recognized globally (*Scylla serrata, S. paramamosain, S. tranquebarica* and *S. olivacea*) (Keenan *et*

al., 1998), with orange mud crab, *S. olivacea* predominate most of the mangrove area and peat swamps in Peninsular Malaysia (Ikhwanuddin *et al*., 2010). Mud crab population in Setiu Wetland of Terengganu constitute as a valuable component for consumption (Ikhwanuddin *et al*., 2011) and also provide income to support the livelihood of the local fishery communities.

Given their importance in Setiu Wetlands, it is noteworthy that very little is known on its population biology or structure due to little attention has been focussed concerning the ecological factors that may regulate the population structure of this species. Furthermore, the capture of wild marketable size adults, if not well managed, may affect their stock recruitment. As such the biological information on the population biology of this commercial mud crabs species is important for its future management and conservation purposes.

Therefore this study will provide some important information on the sex ratio and carapace width-weight relationship of *S. olivacea* of Setiu Wetlands, Terengganu during pre-monsoon and post-monsoon. In addition, this information will help fulfil the gap of knowledge on the biology of mud crabs from Setiu Wetlands, Terengganu, Malaysia.

Materials and Methods

Study site

Setiu Wetlands is situated in the northeast of Terengganu, a unique wetlands area which covers nine inter-connected ecosystems; sea, beach, mudflat, lagoon, estuary, river, islands, coastal forest and mangrove forest (Nakisah & Fauziah, 2003) of 23,000 hectares of land and 880 hectares of water body (Jamilah, 2013). Salinity in the estuary-lagoon ranges from 0 to 30ppt.The depth of water in the estuary-lagoon ranges from 0.5 to 3.0 m. Mangrove plants such as *Nypa fruticans*, *Avicennia alba* and *Rhizophora apiculata* are commonly found (Culver *et al*., 2015). We sampled *S. olivacea* in October 2014 (pre-monsoon) and January 2015 (post-monsoon) from various locations identified by the fishermen (Table 1).

Table 1: Sampling location of *Scylla olivacea* at Setiu Wetlands, Terengganu

Station	Name of location	Coordinate
1	Sg. Limau Nipis 1	N 05° 41. 288’ E 102° 42. 429’
2	Sg. Limau Nipis 2	N 05° 41. 204’ E 102° 42. 348’
3	Pulau Semut	N 05° 41. 151’ E 102° 42. 457’
4	Teluk Kuala	N 05° 40. 629’ E 102° 43. 118’
5	Pulau Stopa	N 05° 40. 591’ E 102° 42. 967’
6	Pulau Che Amid	N 05° 40. 527’ E102° 43. 087’
7	Sg. Ular	N 05° 40. 713’ E102° 42. 731’

Mud crab species were determined following Keenan *et al*. (1998). Mud crabs were sampled using collapsible baited traps with fish flesh was used as baits to lure the crabs. Traps were laid in the morning prior to tidal inundation and recovered at low tide. Live specimens were immediately brought back to the laboratory for further analyses. The physico-chemical parameters of water (pH, dissolve oxygen (DO), temperature and salinity) were measured in-situ using Multi Probe Systems at the time of samples collection for each sampling location. All the data from various sampling locations were grouped as a single sample for each season.

Sex Ratio

The sex ratio for each pre and post monsoon season was given as males/females (M/F) calculated using the formula: total number of males/total number of females. As the samples size were small, temporal variations in the sex ratio were examined by Fisher`s exact test in order to determine if sex differences existed between pre and post monsoon months.

Carapace width and weight relationship

Briefly, Carapace Widths (CW) were measured using digital callipers to obtain measurements to 0.01mm. Body Weight (BW) measurements were made using OHAUS OH-400 electronic balance to 0.01g. The CW-BW relationships were determined separately for males and females of *S. olivacea* by using the logarithmic forms (log y = log a + b log x). For this purpose, the observed values of CW (x) and BW of individual crabs (y) were transferred into logarithmic values and regression analysis was carried out to calculate the 'a' and 'b' values where a is the intercept, and b is the slope of the regression line (Ricker, 1975).

The square of the coefficient (r^2) was determined to identify the degree of association of the two variables. Growth pattern related to value of coefficient (b) was defined; the isometric growth (b=3), negative allometric (b<3) and positive allometric (b>3) following Araujo and Lira (2012). The Fulton's condition factor was calculated from (W/L^3)*100 for females and males, where W and L are BW and CW of a blue crab (Bagenal & Tesch, 1978). Any statistical significance values was tested at p of 0.05.Analyses were carried out using the SPSS version 20.0 program.

Results

Sex Ratio

The sex of the mud crabs captured were identified following Keenan et al. (1998) as illustrated in Figure 1 and Figure 2.

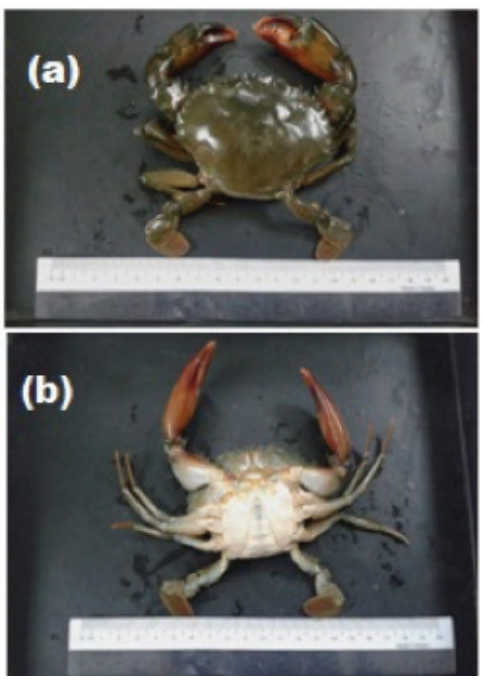

Figure 1: Male orange mud crab of *Scylla olivacea* (a) dorsal view, (b) ventral view

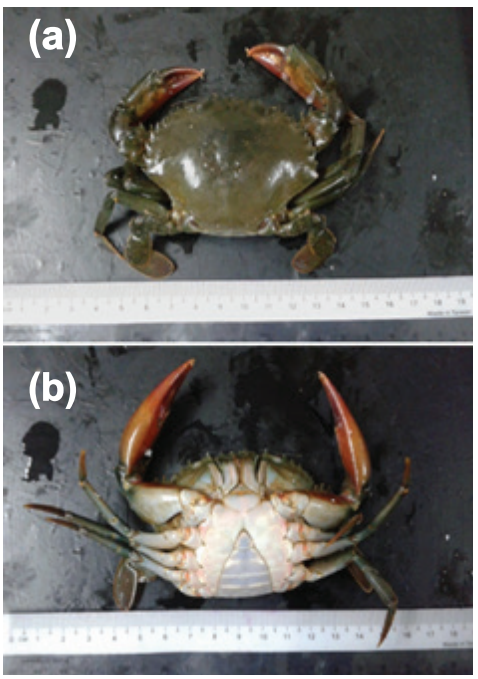

Figure 2: Female orange mud crab of *Scylla olivacea* (a) dorsal view, (b) ventral view

A total of 30 mud crabs were sampled of which 18 and 12 mud crabs were sampled during pre-monsoon and post monsoon months, respectively. The percentage of mud crabs captured during pre-monsoon and post monsoon are displayed in Figure 3.

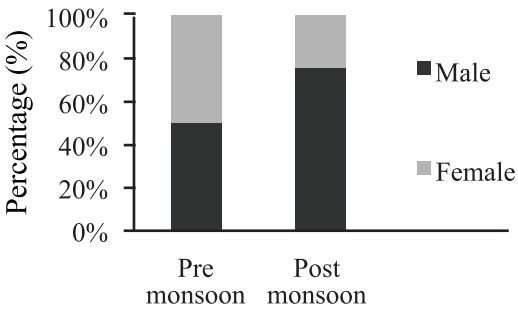

Figure 3: Percentage of mud crabs captured during pre-monsoon (October 2014) and post-monsoon (January 2015)

During pre-monsoon, the number of mud crabs captured for both sexes were equivalent however, during the post monsoon, males were more numerous (75%) compared to females (15%). Sex ratios of males to females were 1:1 in pre monsoon season and 3:1 in post monsoon season. However, sex ratio did not differ significantly (Fisher`s exact test, p=0.2599, P>0.05) so there is no evidence of association between the number of mud crabs captured and season i.e. pre and post monsoon.

Carapace width and body weight relationship

CW and BW of males crab specimens caught in the study area ranged from 6.70 to 11.16 mm and 53.0 to 317.0 g; females range from 6.55 to 10.13 mm and 47.0 to 188.0 g. (Table 2 and Table 3).

Table 2: Carapace width (CW) (mm) for each sex of *Scylla olivacea* according to season

Season	**CW $_{males}$**				**CW $_{females}$**			
	n	**Min**	**Max**	***x̄±SD***	***n***	**Min**	**Max**	***x̄±SD***
Pre-monsoon	9	7.33	11.16	9.47±1.25	9	7.37	10.13	8.85±0.94
Post-monsoon	9	6.7	10.93	8.28±1.27	3	6.55	7.6	7.03±0.53

Table 3: Body weight (BW) (g) for each sex of *Scylla olivacea* according to season

Season	**BW $_{males}$**				**BW $_{females}$**			
	n	**Min**	**Max**	***x̄±SD***	***n***	**Min**	**Max**	***x̄±SD***
Pre-monsoon	9	68	285	179.56±81.46	9	91	188	136.78±41.12
Post-monsoon	9	53	317	135.22±92.62	3	47	75	62.33±14.19

In both pre and post monsoon, females are smaller in terms of CW and BW compared to males. There was no significant difference between CW of males (p= 0.1107; P>0.05) during pre and post monsoon month and similar observations was also shown for BW (p=0.2971; P>0.05). However, for females, significant differences were observed for both CW (p=0.0049; P<0.05) and BW (p=0.0009; P<0.05) where bigger size females individual were observed during pre-monsoon month i.e. October.

A scatter diagram for males and females of *S. olivacea* was obtained by plotting the CW against BW of individual crabs (Figure 4 and Figure 7).

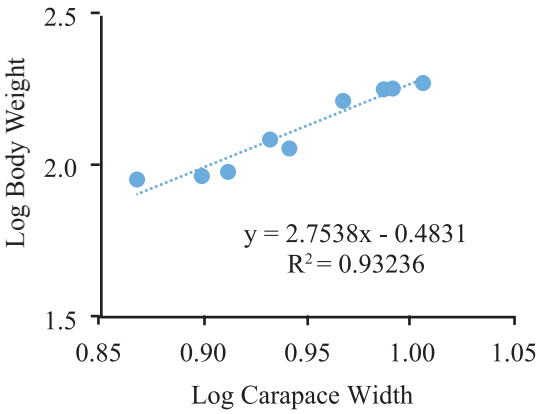

Figure 4: Logarithmic relationship between carapace width *vs.* body weight for females *Scylla olivacea* during pre-monsoon (October 2015)

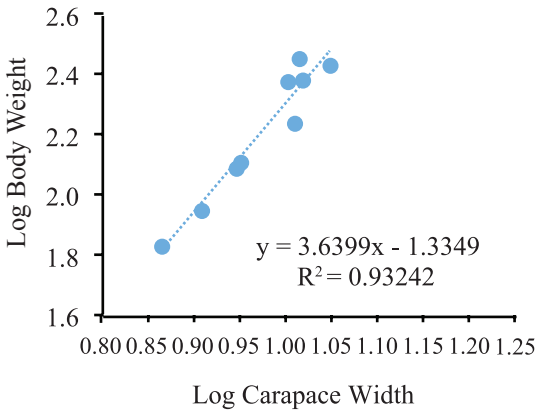

Figure 5: Logarithmic relationship between carapace width *vs*. body weight for males *Scylla olivacea* during pre-monsoon (October 2015)

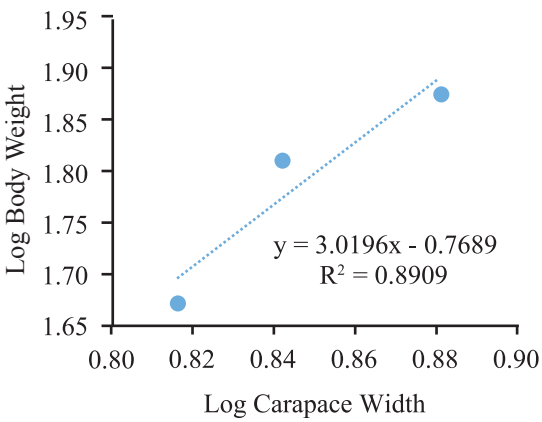

Figure 6: Logarithmic relationship between carapace width *vs.* body weight for females *Scylla olivacea* during post-monsoon (January 2015)

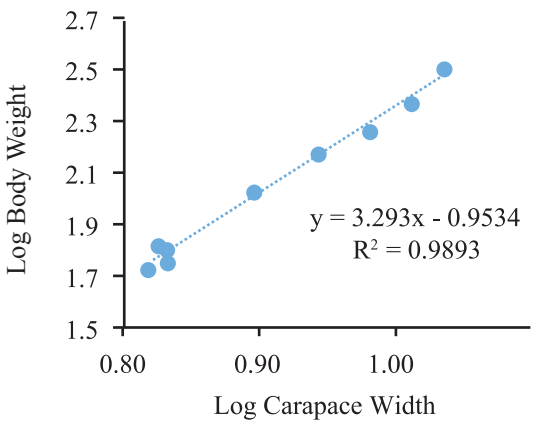

Figure 7: Logarithmic relationship between carapace width *vs*. body weight for males *Scylla olivacea* during post-monsoon (January 2015)

The square of correlation coefficient (r^2) obtained for the CW and BW of males and females were nearly equal to 1 indicating that a high degree of positive correlation was evident between CW-BW. The exponential values (*b*) of the relationship of female and male CW-BW were 2.7538, 3.6399 and 3.0196, 3.293 for pre monsoon and post monsoon respectively, thereby indicating that males are heavier than females at a given width. Departure from isometric growth was evident in females (b<3) only during pre-monsoon, whereas males showed an isometric increase in weight with increasing CW (b>3) in both pre monsoon and post-monsoon.

The condition factor K of all *S. olivacea* taken together varied from 0.016 to 0.025. In pre-monsoon and post-monsoon, K of females mud crab ranged from 0.017 to 0.021 (mean 0.019±0.001) and 0.016 to 0.019 (mean 0.017±0.001), respectively which significantly reduced (P<0.05) during post-monsoon. In males, however, K was significantly higher (P<0.05) during post monsoon with K value ranged from 0.017 to 0.024 (mean 0.021±0.001) compared to pre-monsoon with K ranged from 0.016 to 0.025 (mean 0.019±0.003).

Water quality

Water temperature was fairly constant between 28 and 30 °C. The highest temperature was observed at during pre-monsoon with 30.2±0.7°C. Salinity remained around 30ppt during pre-monsoon but a lower salinity was prevalent during post monsoon with 6.0±2.7 ppt. Dissolve oxygen was lower during pre-monsoon (4.0±0.8 mg/L) but slightly higher during post monsoon 5.0±0.6 mg/L). pH was also slightly higher (alkaline) during pre-monsoon compare to post monsoon (Table 4).

Table 4: Water quality parameters at mud crab sampling stations in Setiu Wetlands during pre-monsoon (October 2014) and post-monsoon (January 2015)

Parameter	Pre-monsoon	Post-monsoon
Temperature (°C)	30.2±0.7	28.8±0.8
Dissolve oxygen (mg/L)	4.0±0.8	5.0±0.6
Salinity (ppt)	30.0±2.9	6.0±2.7
pH	8.1±0.3	7.5±0.3

Discussion

In our study, the sex ratio of *S. olivacea* during pre-monsoon is not significantly different from the hypothetical distribution of 1:1. However, during the post monsoon (January), the males mud crabs outnumbered the females. The dominance of males over females occurs frequently in crab populations (Warburg *et al*., 2012). Similarly, our results are consistent with the report of Ikhwanuddin *et al*. (2010) who reported that male's mud crabs are more abundant compare to female's mud crabs sampled from Setiu Wetlands. Jirapunpipat (2008) also reported that higher proportion of *S. olivacea* males were collected from Ranong Province, Thailand with sex ratio 1.3:1 with the number of males mudcrabs were comparatively higher between October to February. The author also suggests that the less abundance of female mud crabs during post monsoon season are probably linked with the offshore migration patterns of mature females for spawning. This occurrence of spawning migration by female mud crabs has been reported to take place at various locations (Le Vay, 2001). In addition, Heasman *et al*. (1985) reported that the berried

females stop feeding when they migrate offshore thus may also explain the less number of females mud crabs captured during post-monsoon.

The tendency of males being larger and heavier than females is a common pattern across many portunids (Pinheiro & Fiscarelli, 2009). This is in accordance with other observations of Sukumaran *et al*. (1986) and Sukumaran and Neelakantan (1997). It is assumed that a higher weight implies a better condition. This condition factor is influenced by both exogenous and endogenous factors which may varies among seasons and also populations (Froese, 2006; Pinheiro & Fiscarelli, 2009). We found that the salinity at the sampling location were almost three times lower during post monsoon which may be coincide with the less number of females mud crabs. It is known that different species of mud crabs require different salinity for spawning. For instance, *S. serrata*, is dominant in mangroves inundated with salinity above 34 ppt for most of the year (Le Vay, 2001).

Our result shows that negative allometric growth patterns only occurs in female during pre-monsoon. This negative allometric trends were also reported in females of *Rhithropanopeus harrisii* (Hegele-Drywa*et al*., 2014), *Ocypode macrorera* (Dubey *et al*., 2014) and *S. tranquebarica* (Thirunavukkarasu & Shanmugam, 2011). In contrast, Susanto and Irnawati (2014) reported negative allometric pattern in both males and females of spiny rock crab. Sukumaran and Neelakantan (1997) reported an isometric growth in males and females of *P. pelagicus* and *P. sanguinolentus*.

In the present study, most of the samples collected were of undersized crabs. For *S. olivacea*, the marketable size is more than 300 g (Shelley, 2008). The CW *vs.* BW relationship is important for sustainable exploitation of any species with socio-economical value (Froese, 2006). In various studies, the exponent b often calculated to be close to three (Jones *et al*., 1999). In the present study, the calculated values for the exponent (b) were below 3 in females' mud crabs during pre-monsoon season. Various factors may be responsible for the differences in parameters of the CW-BW relationships such as temperature, salinity, food (quantity, quality and size), sex, and time of year and stage of maturity (Sparre, 1992). In another study, the exponent 'b' was found to be 1.3, 2.9 and 3.2 (CW-BW relationship) in juvenile, adult male and female *S. serrata* respectively (Prasad *et al*., 1989). In *S. tranquebarica*, the 'b' values of width - weight relationships were found to be 3.2718 and 3.0202 for male and female crabs respectively (Thirunavukkarasu & Shanmugam, 2011).

Based on the condition factor, males of *S. olivacea* from Setiu Wetlands sampled during post monsoon is in a better condition compared to pre-monsoon. However, for females' mud crabs, a lower condition factor was found during post monsoon compared to pre-monsoon. Therefore, it is possible that the ecological factors may also affect the condition factor (K). The condition factor is reported to be varies among species and populations (Pinheiro & Fiscarelli, 2009).

Conclusion

The results of this present study give an insight into the abundance of *S. olivacea* during pre and post-monsoon months in Setiu Wetlands. Due to possible migrations or reproductive season by the female mud crabs during post monsoon, management strategies should not only focussed in the intertidal areas but should also include offshore areas. It is hoped that this information could facilitate the local agencies to impose the fishery regulation of mud crabs of Setiu Wetlands particularly of under-sized crabs for stock enhancement purpose**.**

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