Biological Features of Mud Spiny Lobster, *Panulirus polyphagus* (Herbst, 1793) from Johor Coastal Water of Malaysia

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Abstract: Biological features of size at maturity, size distribution, carapace length (CL) - body weight (BW) relationship and sex ratio were studied from 300 lobsters (231 males and 69 females) ranging from 4.72 - 11.34 cm CL sampled from Johor coastal water of Malaysia from July to December 2010. The results indicate that the lobster can attain sexual maturity (CL_{50}) at 6.02 cm CL for male and 6.59 cm CL for female. Size distribution was found to be abundance at range of 4.72 - 11.34 cm CL for male and 5.32 - 11.98 cm CL for female. The mean CW and BW of male *P. polyphagus* are 7.51 cm ± 1.42 and 189.75 g ± 124.05 respectively, while mean CW and BW for female lobster were 7.39 cm ± 1.83 and 186.98 ± 121.49 respectively. The CL-BW relationship for males was attained as BW = $4.4592e^{0.4681CL}$ (R^2 = 0.8908) and for females was estimated as BW = $12.438e^{0.3404CL}$ (R^2 = 0.949). Finally, the overall sex ratio was identified as 1:0.3. The data obtained from this study can be used as baseline data which is helpful in aquaculture field and fisheries management hence helps to ensure the population sustainability of the species.

Key words: Mud spiny lobster · *Panulirus polyphagus* · Size at maturity · Size distribution · Sex ratio · Carapace length-body weight

INTRODUCTION

Panulirus polyphagus (Herbst, 1793) is commonly known as mud spiny lobster or formerly known as long-whiskered rock lobster [1]. *P. polyphagus* is reported to live mainly at the river influenced shelf where the water is shallow, turbid and heavy moderate run-of [2] and usually found from 3 to 90 m depths and distributed throughout Indo-West Pacific Ocean including Thailand, India, Pakistan and South East Asia [3] including Malaysia [4]. This lobster occasionally caught by bottom trawls and beach seines [5].

Biological information such as size at sexual maturity, size distribution, carapace length (CL) - body weight (BW) relationship and sex ratio are important criterion to study the behavior and characteristics of *P. polyphagus* and significantly estimating the size of

lobster population in relation to the number taken by the fishery. With reference to physiological maturation of female lobster, the size for physiological maturity is defined as the size at which ovaries are in developing stage or higher during reproductive season and the size for functional maturity are defined as the size at which females are involved in the reproductive activity and berried [6]. Population features has been evaluated by several methods including density, size frequency distribution, spatial dispersion, sex ratio, juvenile recruitment and reproductive season among others [7].

As this species has become an economic value to the market, hence it sufficient data and information on the distribution and growth of this species are needed. However, previous studies indicate that there is no up-to-date information can be shared in terms of physiological,

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biological, morphological, fishery and behavior of *P. polyphagus* especially in Malaysia. This the objectives of this study is to determine the biological features by analyzing the size at sexual maturity, relationship between carapace length and body weight, size distribution and sex ratio of *P. polyphagus* from Johor coastal water of Malaysia.

MATERIALS AND METHODS

Lobster Sampling: All samples were collected from sampling activities done from July 2010 to December 2010 from Teluk Ramunia (1.37°N; 104.25°E), Sungai Rengit (1.35°N; 104.22°E) and Kampung Jawa (1.34°E; 104.38°N) of Johor coastal water, Malaysia (Figure 1). A total of 300 random individuals of *P. polyphagus* were collected for the study. The lobster samples were measured and weighed which also being used to determine size at maturity, size distribution and carapace length - body weight relationship and sex ratio of *P. polyphagus*.

Lobster Morphometric and Sexes: All lobsters were measured and sexed. The lobsters were separated into male and female based on the size of the swimmerets. The swimmerets of females are larger than those males since females need to hold the eggs when they got berried. Lobster sizes were measured as carapace length (CL) to the nearest 0.1 cm with vernier calliper. CL was measured as the distance along the dorsal midline from the transverse ridge between the supraorbital horns to the posterior extremity of the cephalothorax (Figure 2) Body weight (BW) was measured to the nearest gram by using digital electronic balance (Figure 3). The population were analyzed as a function of the size frequency distribution of the individuals [7]. All samples were grouped in 0.5 cm size intervals from 4.5 - 11.9 cm. The dominant and uncommon size ranges in both sampled sexes were then being described after plotting the graph. The relationship between the CL and BW were determined after plotting the linear regression morphometric graph [8].

Size at Maturity: In order to obtain size at maturity, measurement of CL, the second and third meropodite length (ML) which is the longest segment of the limb of the right walking leg were measured [9] (Figure 4 and Figure 5).
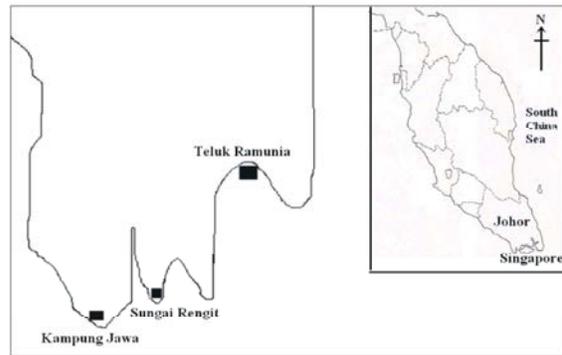

Fig. 1: Map of Johor coastal water showing the lobster sampling sites.

Fig. 2: Measuring the lobster CL using vernier calliper.

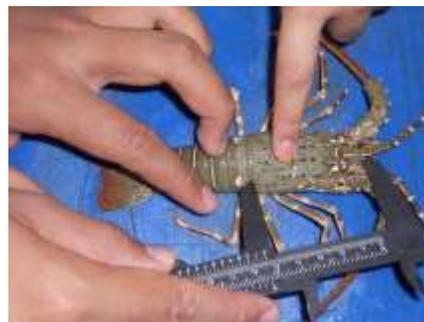Fig. 3: Measuring the lobster BW using the electronic balance.

Fig. 4: Measuring the lobster CL using vernier calliper.

Fig. 5: Measuring the lobster 2nd ML using vernier calliper.

Fig. 6: Percentage of size distribution of male and female *P. polyphagus.*

RESULTS

Size Distribution and Sex Ratio: The dominant male size range was 7.0 - 7.4 cm CL with 16.5% of the male crab sampled while the dominant size range for female was 5.5 - 5.9 cm CL with 26% of female lobster sampled (Figure 6). The mean size range of male *P. polyphagus* was 7.39 cm CL ± 1.83 while in female was 7.51 cm CL ± 1.42 (Table 1). A significant variation in sex ratio of male and female lobsters was detected where male lobster were relatively abundant than the female. The sex ratio (male: female) was 1: 0.3, where male lobsters contributed 77% of the population.

Carapace Length (CL) and Body Weight (BW) Relationship: The study showed that male *P. polyphagus* was relatively heavier and bigger than the female (Table 1). The mean CL and BW of male *P. polyphagus* were 7.51 cm CL ± 1.42 and 189.75 g BW ± 124.05 respectively. For female *P. polyphagus,* the mean CL and BW were 7.39 cm CL ± 1.83 and 186.89 g BW ± 121.29 respectively (Table 1). The CL-BW relationship for male *P. polyphagus* was attained as BW = $4.4592e^{0.4681CL}$ (R^2 = 0.8908) and for female was estimated as BW = $12.438e^{0.3404CL}$ (R^2 = 0.949) (Figure 7 and Figure 8).

Size at Maturity: Among a total of 261 male lobsters sampled, 189 individuals were classified as mature and another 42 individuals were immature based on the relationship between 2nd ML and 3rd ML of the longest right walking leg with CL. The regression lines between 2nd ML and 3rd ML with CL were obtained by which y = 0.783x - 1.501 (R^2 = 0.9677) for 2nd ML and y = 0.347x - 1.105 (R^2 = 0.949) for 3rd ML (Figure 9 and Table 2). Range of maturity of male occurred between 5.8 cm CL to 6.2 cm
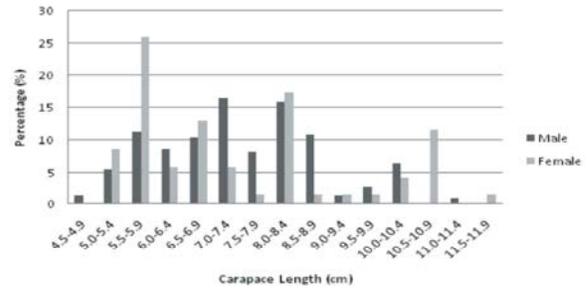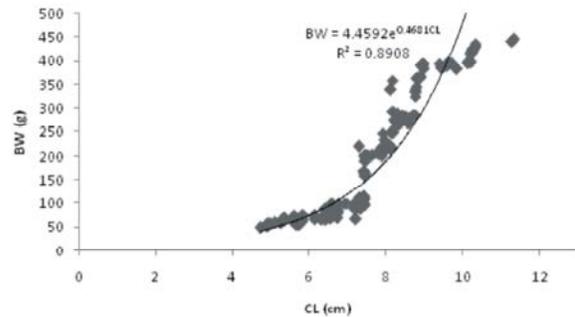

Fig. 7: Morphometric relationship between body weight (BW) and carapace length (CL) of male *P. polyphagus*
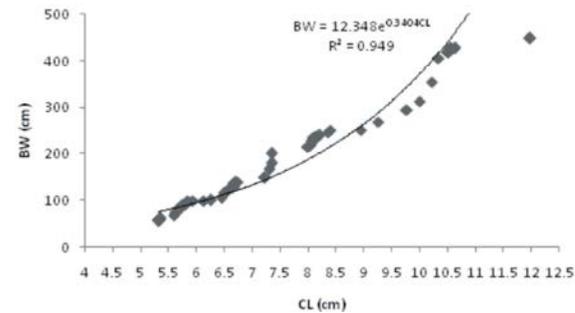

Fig. 8: Morphometric relationship between body weight (BW) and carapace length (CL) of female *P. polyphagus*

Table 1: Mean, maximum and minimum size of CL and BW of male and female *P.polyphagus.*

	Male		Female	
	CL (cm)	BW(g)	CL (cm)	BW (g)
Mean	7.51	189.57	7.39	186.98
Max	11.34	445	11.98	448
Min	4.72	48	5.32	56
sd	1.42	124.05	1.83	121.49
N		231	69	
Sex ratio		1: 0.3		

Table 2: Relationship between carapace length and meropodite length in *P. polyphagus*.

| Meropodite Length Studied	Size group	Linear regression equation of CL vs ML	R^2 value
		MALE	
Length of 2nd meropodite	<6.0 cm	y = 0.3557CL - 0.6591	0.8963
	>6.0 cm	y = 0.7149CL - 0.6591	0.9561
Length of 3rd meropodite	<6.0 cm	y = 0.5585CL - 2.5957	0.8489
	>6.0 cm	y = 0.2870CL - 0.5955	0.9656
		FEMALE	
Length of 2nd meropodite	<6.5 cm	y = 1.4777CL - 5.2949	0.8542
	>6.5 cm	y = 0.5935CL + 0.2818	0.9343
Length of 3rd meropodite	<6.5 cm	y = 0.5255CL - 2.3606	0.8861
	>6.5 cm	y = 0.0939CL + 0.560	0.9304
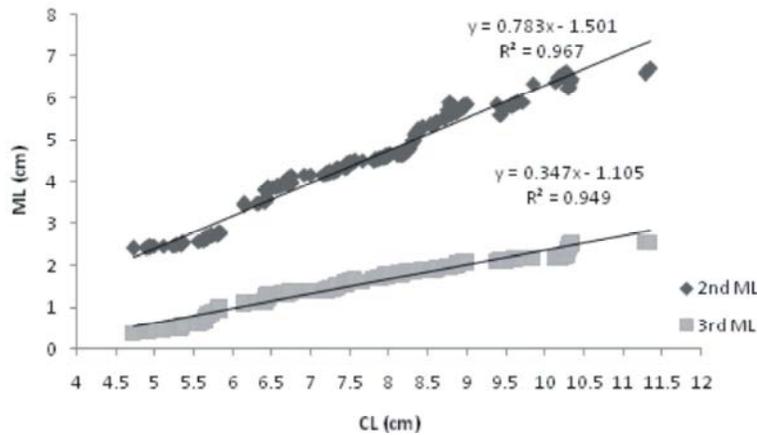
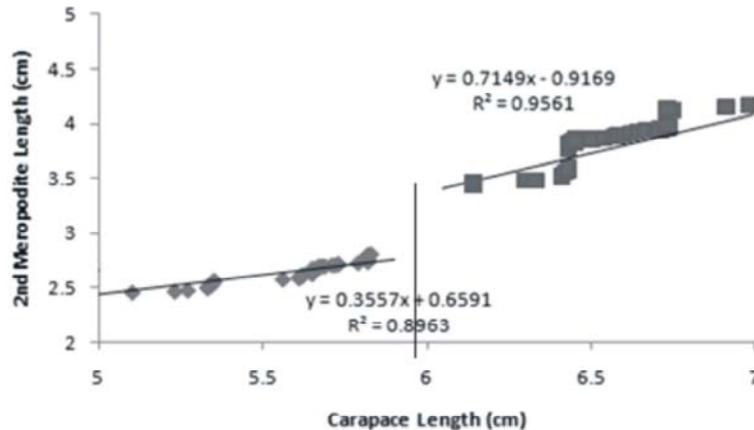Fig. 9: Relationship between 2nd and 3rd ML with CL of male P. polyphagus.

Fig. 10: Intersection point between 2nd ML with CL of male P. polyphagus to obtain size at maturity.

CL (Figure 10, Figure 11 and Table 2) based on the intersection point between 2nd ML and 3rd ML and thus, the estimated male CL_{50} to fall at the intersection point of 6.02 cm CL.

38 female individuals were found to have mature abdomen if compared to another 31 individuals which immature. The linear regression of relationship between 2nd ML and 3rd ML with CL was attained as y = 0.711x - 0.784 (R^2 = 0.940) for 2nd ML and y = 0.195x - 0.368 (R^2 = 0.824) for 3rd ML (Figure 12 and Table 2). Range of maturity of female occurred between 6.3 - 6.6 cm CL (Figure 13, Figure 14 and Table 2) based on the intersection point between 2nd ML and 3rd ML with CL. Thus, the estimated female CL_{50} at the intersection point is 6.59 cm CL.

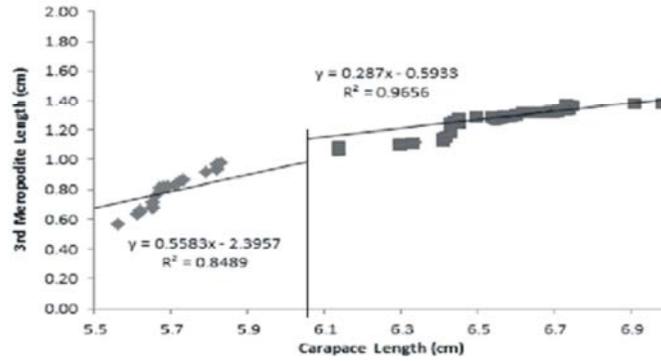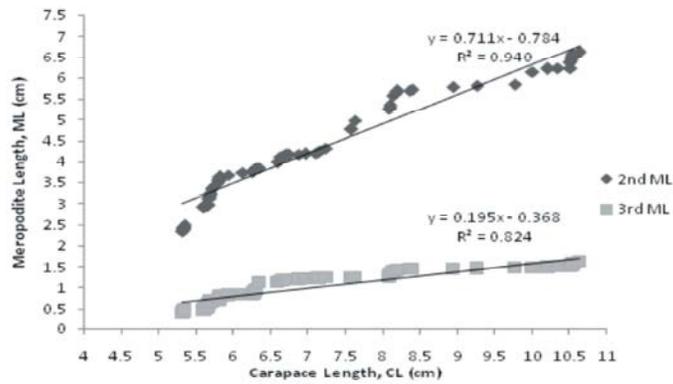Fig. 11: Intersection point between 3nd ML with CL of male P. polyphagus to obtain size at maturity.

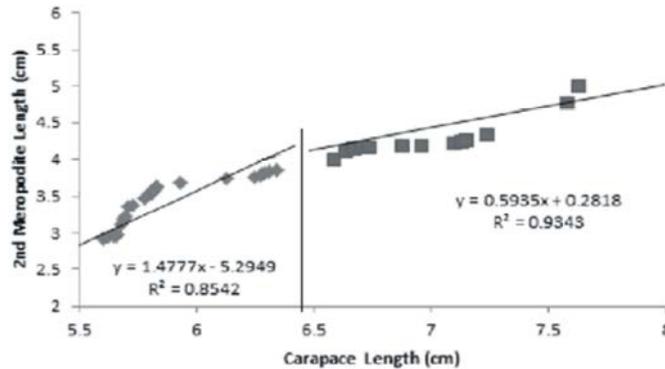Fig. 12: Relationship between 2nd and 3nd ML with CL of female P. polyphagus

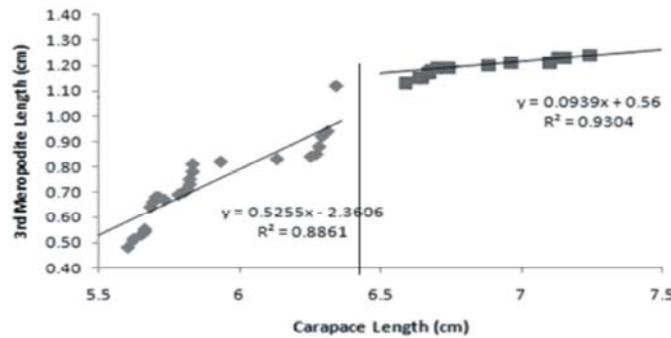Fig. 13: Intersection point between 2nd ML with CL of female P. polyphagus to obtain size at maturity.

Fig. 14: Intersection point between 3nd ML with CL of female P. polyphagus to obtain size at maturity.

DISCUSSION

Estimation of size at first maturity in lobster is often limited due to several factors [10]. The probability of the sampled population representing only a small section of the size groups or variability in the catch ability of mature and immature lobsters are likely to make the estimates vulnerable to bias [11]. The size at which physical maturity occurs in lobster has been identified by examining discontinuities in the linear relationships between BW and certain externally visible features. Female maturity has been associated with allometric changes in the length of pleopods, the length of the pleopodal setae, telson length or the width of the abdomen relative to CL, which all change in relation to preparation for first spawning [12-14]. In the present study, size at maturity in male and female *P. polyphagus* was attained from 2nd and 3rd ML of right longest walking leg. Male functional maturity has often been associated with a change in the dimensions of the first cheliped in the clawed lobsters or off the second or third pereiopods in spiny lobsters, relative to CL [15]. Besides, there is a method of determining the size at maturity by plotting the leg size against CL [16]. The size at maturity was then indicated by the point of upward deflection or the point of intersection of the regression lines of both immature and mature lobsters.

Results from the present study had pointed to a possible sexual dimorphism in *P. polyphagus*. Study on *P. argus* and *P. laevicauda* from the Coast of Ceará showed the same pattern where males were larger than female [17]. Males of palinurids reach considerably greater TL than females [18, 19]. In addition, females attain larger body sizes than males in most metazoan species [20, 21]. Females attained larger size if compared to males due to several factors such as breeding season where female grew larger in size in order to carry the eggs [22]. Besides, predators also affects on benthic macrofauna may also vary seasonally with lobster abundance and possibly diminish with distance from shelter sites [23, 24].

On the other hand, weight is a function of length and is expressed by the equation W = CL", where W is the weight, L is the CL while C and n are constants. The mean CL and weight of the experimental males and females plotted graphically resulted in an exponential curve. Table 3 shows the morphometric ratios comparison between *P. polyphagus* from Johor coastal water in 2010 (present study) with *P. echinatus* from São Pedro and São Paulo Archipelago between June 1998 and September 1999 [25]. From the table, it can be concluded that the differential growth rate may also due to deceleration of growth rate in females after attainment of sexual maturity resulting in an increasing divergence of the growth curves of males and females associated with increasing of body size [26].

The sex ratio of *P. polyphagus* was 1: 0.3 in the present study which was relatively biased on males. The same pattern was observed in *P. argus* during the months of higher reproductive intensity, whereas during periods lower reproductive intensity, sex proportions tended towards 1:1 [27]. Males dominated large size classes in the present study which might result from sex-specific growth rate [3] or the reproductive cost of females [28]. The differences in sex ratio between size classes are relatively common and may be explained by differences in longevity, mortality and growth [29]. Besides, the lessening of female lobsters instead of male lobsters was probably due to the spawning season period during sampling because in the wild, egg-bearing female of many spiny lobster species migrate to deep seaward edge of reefs or beyond on to the deep sand flats and may form aggregations consisting almost entirely of females to hatch the larvae [26, 30, 31].

CONCLUSION

The size at maturity of *P. polyphagus* was 6.02 cm CL for male and 6.59 cm CL for female. In terms of size distribution, male lobsters size range between 4.5 to 11.4 cm CL and 5.0 to 12.0 cm CL for female. The CW-BW relationship for males' *P. polyphagus* was attained as BW $= 4.4592e^{0.4681CL}$ ($R^2 = 0.8908$) and CW-BW for females was estimated as BW $= 12.438^{e0.3404CL}$ ($R^2 = 0.949$). The sex ratio of male to female showed that male-biased with 1: 0.30. Information regarding biological features can be used to established guidelines for legalization of a great number of fishery resources for sustainable development and rational exploration of resources in Malaysia coastal water especially and within Asia generally.

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