

Morphometrics and Maturity Indices of the Spiny Lobster, *Panulirus penicillatus* (Decapoda: Palinuridae) at Al-Wajh Waters of the Red Sea

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ABSTRACT

The morphometrics and maturity indices of the spiny lobster *Panulirus penicillatus* found in Al Wajh waters of the Red Sea were studied from June to November 2010. The collection totally included 112 animals composed of 37% males and 63% females registering a male: female sex ratio of 1:1.7. The data also indicated higher size range with males. Analysis of total population indicated that highest number of animals (n=14) were in the smaller size range of 49 to 54 mm followed by 55 to 60 mm size class (n=13). Results also indicated that male-female ratio varied between sampling months. The percentage of females carrying eggs was highest in June (65%) and showed a declining phase touching 50% in September. In October, the value again climbed to 57% but followed by steeper drop to 25% of females in November. The CL/TL (Carapace length/Total length) ratio ranged from 0.33 to 0.50 and the significant correlation coefficient observed between CL and TL in both male and female.

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دراسة الشكل الظاهري ومؤشر النضج الجنسي للإستاكوزا الشوكية بانوليوس بينسيلاتس (عشرية الأرجل: بالينوريدي) في مياه الوجه من البحر الأحمر

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المستخلص

تمت دراسة الشكل الظاهري ومؤشر النضج الجنسي للإستاكوزا الشوكية بانوليوس بينسيلاتس والتي وجدت في مياه الوجه من البحر الأحمر من يونيو إلى نوفمبر 2010. تم جمع عدد 112 من هذه الحيوانات، تمثل الذكور في هذه العينة نسبة (37 %) والإناث (63 %)، وكانت نسبة الذكور إلى الإناث 1 : 1.7. كما أشارت البيانات أن أحجام الذكور كانت أكبر منها في الإناث. عدد الأحجام الصغيرة من 49 مم إلى 54 مم من هذه الحيوانات كانت تمثل العدد الأكبر في هذه العينة (ن = 14) عند تحليل مجموع السكان، تليها الأحجام الأكبر 55 مم إلى 60 مم (ن = 13). وأوضحت النتائج اختلاف نسبة الذكور والإناث بين الشهور المختلفة لأخذ العينات. نسبة الإناث حاملة البيض كانت أعلى في شهر يونيو (65 %) ثم ظهرت مرحلة تراجع لتصل إلى (50 %) في شهر سبتمبر، ثم ارتفع عدد الإناث حوامل البيض في شهر أكتوبر مرة أخرى لتصل إلى (57 %)، تلاه انخفاض حاد وصل إلى (25 %) من حاملات البيض في شهر نوفمبر. تراوحت نسبته معدل طول الدرقة إلى الطول الكلي من 0.33 إلى 0.50 وكان معامل الارتباط بينهما كبير في كل من الذكور والإناث.

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الكلمات الدالة

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بانوليوس بينسيلاتس؛ القشريات؛ مؤشر
النضج

Introduction

The spiny lobster *Panulirus penicillatus* Olivier (1791) (Decapoda: Palinuridae) is widely distributed in Southeastern Africa and the Red sea, Southern India, the Southeastern Asian Archipelago, Japan, Northern Australia, Southern and Western Pacific Islands to Hawaii, the Galapagos Islands and the other islands of the Eastern Pacific (Williams, 1988). *Panulirus penicillatus* shows strong habitat specificity as it is restricted mainly to windward surf zones of oceanic reefs (George, 1974). *Panulirus penicillatus* is the only spiny lobster and most common in Al-Wajh area, Saudi Arabian coast (Red Sea). The stock population increases during summer months and totally disappears during winter. The reproductive biology (i.e., size at maturity and brood size) has been previously studied for *Panulirus penicillatus* in Hawaii (MacDonald, 1979), Philippines (Juinio, 1987) and Taiwan (Chang *et al.*, 2007). In the Red Sea, Plaut (1993) investigated the sexual maturity, reproductive season and fecundity of the spiny lobster *P. penicillatus* from the Gulf of Aqaba. Later on, Salama (2003) gave data about the reproductive strategy of the common spiny lobster *Panulirus penicillatus* in the northern Saudi coast of the Red Sea.

Red sea lies between is reported to have the average depth of 500 m and the maximum of greater than 2000 m (Behairy, 1992). The total surface area is estimated at about 438,000-450,000 km², while the volume varies between 215,000 km³ and 251,000 km. The coastal shelf in the northern part of the Red Sea less expanded than in the southern part, where the shelf extends up to 80 km offshore. For the purpose of fisheries studies, the red sea (figure 1) is divided into three sectors - the Northern Sector, the Middle Sector and the Southern Sector. Saudi Arabia possesses the longest shoreline of any country on the Red Sea, which is about 1,740 km and covers 13 degrees of Latitude. From the environmental viewpoint: the area is divided into four biogeographic zones: The Gulf of Aqaba, the Northern Zone, the Central Zone, and the Southern Zone.

The determination of sex ratio in commercially important marine organisms is a useful tool to

understand the composition as well as variations in its abundance (Pinheiro *et al.*, 2003). In brief, this parameter is estimated by the numerical ratio of males to females, and it can be expressed as a coefficient or percentage (Aguilar and Malpica, 1993; Pinheiro *et al.*, 2003). Biometric relationships also provide regression equations that correlate linear body measurements with body weight and this can be used to infer dependent variables that are necessary to manage the fishing (Ivo, 1996). Due to the exploitation of lobster resources around the world, research on the biological characteristics is required, so that the reproductive potential can be protected. The objective of this study is to analyze the morphometry and maturity indices of the *Panulirus penicillatus* in the Al Wajh waters of the Red sea. A study of this kind will improve our knowledge on the life history parameters of the *P. penicillatus* in this region.

Materials and Methods

The spiny lobster specimens of *Panulirus penicillatus* Oliver were collected monthly for a period of six months (June to November 2010) from Al-Wajh area at the North part of the Red Sea of the Saudi coast (figure 1).



Figure 1: Map of the Red Sea Showing the Study Area (Courtesy: Google Earth)

Lobsters picked up, at night by hand during low tide, from the shallow exposed fringing reefs or coral patches close to deep water, which occurs around some of the offshore islands. The fished

lobsters kept in net bags and transferred orbital horns of the carapace to the posterior end alive to the laboratory for the following measurements:

- (i) Total length (TL); from the anterior edge at the base of the supra- of the telson (in mm), using a Vernier caliper.
- (ii) Carapace length (CL); the distance from the anterior edge to the posterior edge of the carapace at the midline.
- (iii) Total weight (TW); in grams by using a standard electric balance.

After these measurements, specimens were dissected and the gonads were removed and weighed (GW) in gram using a sensitive electric balance. The sex (M/F), colour of the gonads (GC) and case of carrying eggs (CE) listed in tables. The surface water temperature and salinity of the coastal waters also monitored throughout the study period.

A piece of the gonadal tissue was taken, immediately fixed in 10% neutral formalin, dehydrated in ascending series of alcohol and cleared in xylene. The tissue then embedded in paraffin wax, sectioned at about 5µm, double stained with Harriss alum haematoxyline and eosin, mounted in Canada balsam and photographed using a research microscope fitted with imaging system.

Results and Discussion

A total of 112 animals composed of 37% males and 63% females registering a male and female sex ratio of 1:1.7 were collected during this study period (table 1).

The data also indicated higher size range with males. All the males collected were mature and in the case of females, 99% of them were mature. The analysis of population (table 2) indicated that the male-female ratio varied between different sampling months ranging from 1:1 (September and November) to a ratio of 1:4.3 (August), indicating very low number of males in total population collected during the study period. Domination of males could not be noticed in any of the sampling months (June-Nov) of this study. Analysis for trend fail to show a clear trend in male-female ratio, however it is generally evident that initial

three months of collection included higher number of females and then there is a sudden decline in female contribution with ratio abruptly coming down from 1:4.3 in August to 1:1 in September.

Table 1: Review of Total Population Analyzed Study Period (June-Nov 2010)

Factors	No. of Shrimps	%
Total population	112	100
Males	41	36.7
Females	71	63.3
Sex ratio	1:1.7 (M:F)	000
Egg bearing females	38	53.52
Egg-less females	33	46.48
White gonad females	06	8.45
Egg bearing female size	40.5-101 mm	000
Mature females	70	099
Mature female size	40.5-101 mm	000
Immature gonad female size	37.9 mm	000
Males size range	42-113 mm	000

Table 2 : Difference in Male-Female Ratio During Different Months

Months	Male &Female Ratio
June, 2010	1 : 2.4
July, 2010	1 : 1.8
August, 2010	1: 4.3
September, 2010	1 : 1
October, 2010	1 : 1.1
November , 2010	1 : 1

Results from female population size class analyses based on CL measurement are given in figure 2.

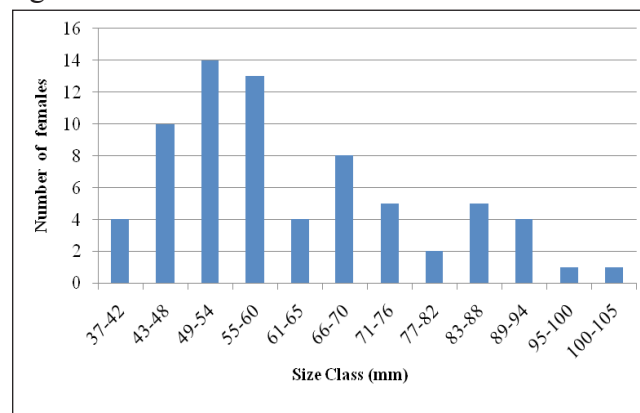


Figure 2: Size Class Distribution of Female Lobster Collected during This Study

Analysis of total population indicated that highest number of animals ($n=14$) were in the smaller size range of 49mm to 54mm followed by 55mm to 60mm size class ($n=13$). The highest size ranges recorded the lowest number of animals. There was a clear trend in the occurrence of size classes, with smaller size range (37mm to 60mm) contributing to 88% of collected population in June followed by increase in size in July then declining smoothly till September coming closer to June size range. October and November population showed a slight increase in size range. In June and September 100% of animals were within 37mm to 70mm size range. The collection in month of July recorded animals in highest size range falling between 71mm and 105mm.

The CL/TL ratio ranged from 0.33 to 0.50 and averaged $0.37 (\pm 0.04)$. Regression analysis of total length on carapace length was determined (figure 3) and were calculated as $TL = 1.7164CL + 60.643$ with a coefficient of determination (R^2) of 0.796. The CL and TL values were significantly ($P < 0.001$) correlated with a correlation coefficient (r) value of 0.89.

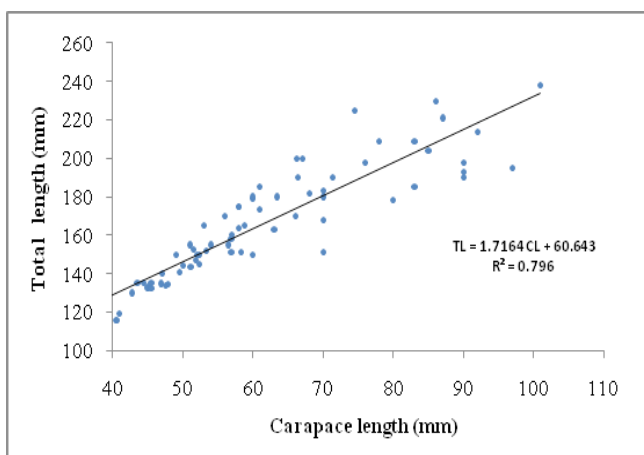


Figure 3: Relationship between Female Total Length (TL) and Carapace Length (CL)

The percentage composition of mature and egg carrying females was assessed for each month and is depicted in figure 4. As mentioned earlier except for June where one of the female was found to be immature all the females collected in remaining 5 months were all mature. The percentage of females carrying eggs was highest in June (65%) and showed a declining phase touching 50% in

September. In October the value again climbed to 57% but followed by steeper drop to 25% of females in November.

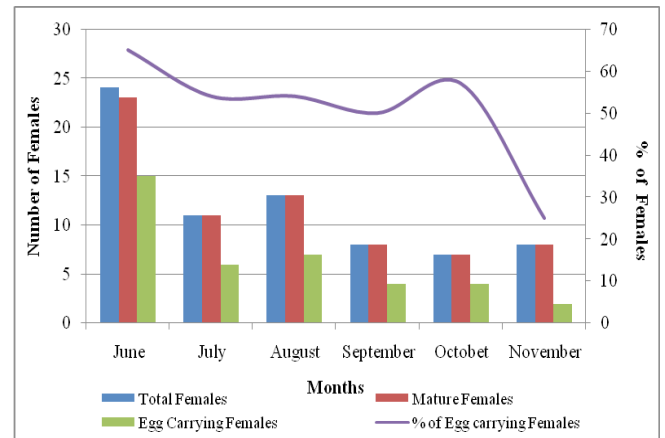


Figure 4: Percentage of Mature and Egg Carrying Females on Different Months

The gonado-somatic index (GSI) of females from each sampling month was estimated and is tabulated in table 3. Correlating with higher percentage of egg carrying females, the highest average GSI value was also noticed in June. With rest of the months also the GSI values followed a similar trend to that of percentage of egg carrying females. No gonadal weight values were recorded for the month of July and so GSI values could not be calculated.

Table 3: Temporal Variation of Gonado Somatic Indices (GSI) of Female and Male Lobsters

Month	Female			Male		
	GW	TW	GSI	GW	TW	GSI
June	2.51	126.73	1.85	1.23	177.017	0.62
July	2.38	93.45	1.72	1.18	156.23	0.98
Aug.	1.47	219.5	0.75	1.8	183.3	1.11
Sept.	1.64	93.53	1.77	0.75	137.16	0.56
Oct.	2.06	181	0.94	0.67	144.81	0.5
Nov.	0.91	166.97	0.51	1.71	304.59	0.58

It is to be noted that the total number of males collected per month is comparatively much lower than females. Results from male population size class analyses based on CL measurement are given in figure 5. Analysis of total population indicated that highest number of animals ($n=12$) were in the smaller size range of 55mm to 60 mm.

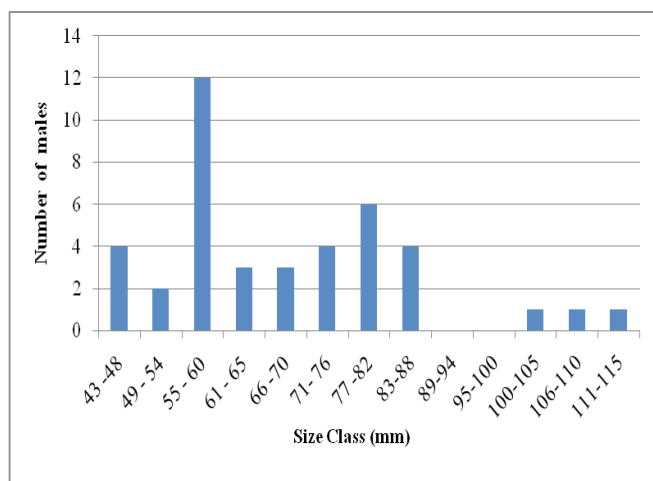


Figure 5: Size Class Distribution of Male Lobster Collected during the Study Period

The next highest number of males ($n=6$) in a size class was with 77mm -82mm range. As in the case of females, the lower size classes dominated population in the months of June and September and highest size dominating July collection. Though the size class distribution trend was nearly similar to females, the highest sizes with males in July are higher than that of females and the size range was also much wider. Another noticeable difference with male population was in November where the size range was much better (61mm -88 mm) against females (43mm -76 mm).

The CL/TL ratio ranged from 0.33 to 0.50 and averaged 0.37 (± 0.04). Regression analysis of total length on carapace length was determined as $TL = 1.7258CL + 60.311$ with a coefficient of determination (R^2) of 0.821 (figure 6).

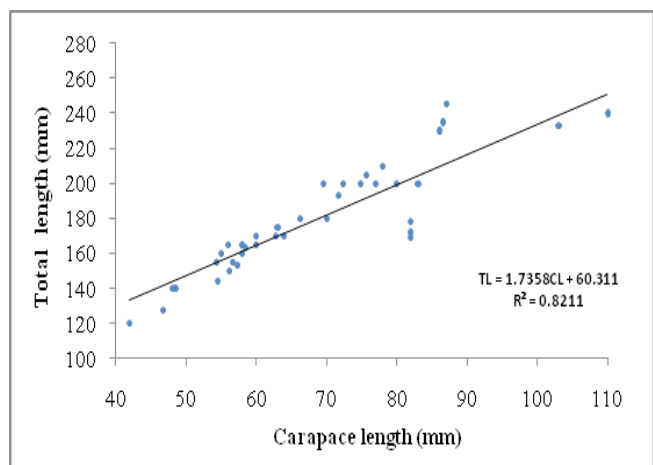


Figure 6: Relationship between of Male Total Length (TL) and Carapace Length (CL)

The CL and TL values were significantly ($P < 0.001$) correlated with a 'r' value of 0.91. The GSI values obtained with males collected are presented in Table 3. Unlike with females the males registered highest average GSI value in August followed by sharp decline in October and then recording a moderate increase in November. It is also to be mentioned here that the GSI value of 1.1 in August was from a single male collected.

(Hogarth and Barratt, 1996) studied the size distribution, maturity and fecundity of the spiny lobster *Panulirus penicillatus* (Olivier, 1791) in the Red Sea. *Panulirus penicillatus* (Olivier 1791). Lobsters ($n = 355$) were caught by trapping in the Saudi Red Sea between Port Sharma and Yanbu. For a subsample of 60 of these, measurements were made of Carapace Length (CL), length of 2nd and 3rd pereopods, and the number of eggs carried by ovigerous females. The allometric relationship between (CL) and the lengths of the second and 3rd pereopods differs after sexual maturity, and between males and females: allometry of leg length can therefore be used to estimate the size of sexual maturity. *Panulirus penicillatus* in Saudi Arabian coastal waters appear to mature at carapace lengths of 40-50 mm. The relationship between (CL) and egg number is given by the equation $E = 7.43 (CL)^{(2.30)}$. Size distribution and fecundity were combined to indicate the relative contribution to reproduction of different size classes. (Plaut, 1993) stated that the breeding season of *Panulirus penicillatus* in the Red Sea starts from February to October, and attains maturity at a carapace length (CL) of 50 mm. He also reported that the incubation period of eggs was 35.5 ± 1 day at the temperature of $24^\circ\text{C} - 27^\circ\text{C}$. This indicate that samples for the for the present study were collected during the active breeding season of *Panulirus penicillatus* in Red Sea region. Morphometry has frequently been used to define the size at maturity of male or female lobsters. For males, the sexual maturity can be defined by direct observation (presence/absence) of a secondary sexual characters (Kulmiye *et al.*, 2006), than in females, where it is more complicated to define. In addition, analysis of morphometry alone also provides little information on the reproductive activity of the lobsters in terms of eggs. In conclusion, results of the present study

indicate that the spiny lobster *Panulirus penicillatus* distributed in Red Sea exhibited high reproductive activity during June and the male: female ratio in the population showed temporal variation. Further studies on morphometry and maturity indices by including spatial and temporal scales by provide more details on this commercially significant lobster.

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