Biological studies and assessment of the exploitation status of the green tiger shrimp *Penaeus semisulcatus* from Jizan Area, Red Sea

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Abstract, The present study was undertaken to investigate some biological aspects of the green tiger shrimp *Penaeus semisulcatus* in order to provide the biological information required for its proper management of the fishery in Jizan area, Red Sea. Growth parameters were calculated as ($L_{\infty} = 94.40$; $K = 0.81$; $t_0 = -0.2$); maximum age $t_{max} = 3.7037$ years; growth performance indices ($\phi_L = 3.86$; $\phi_{wt} = 1.36$). Carapace length at which *P. semisulcatus* females attained 50% of maturity was 38 mm. The annual mortality coefficients were ($Z = 3.124$ year⁻¹; $M = 1.163$ year⁻¹ & $F = 1.961$ year⁻¹). Carapace length and age at first capture were 35.73 mm and 0.387 year, while carapace length and age at recruitment were 28.52 mm and 0.24 year, respectively. The length at first sexual maturity was found to be 38 mm, while the carapace length at first capture L_{50} was estimated as 35.73 mm. This indicates that there is a poor opportunity for the recruits of *P. semisulcatus* in Jizan area to spawn before fishing which is considered an important factor that would lead to overexploitation the stock. The estimated exploitation ratio (0.628) was higher than E_{max} (0.581) which indicates that, the fisheries status of this species under study is in overexploited.

Keywords: Tiger shrimp, *Penaeus semisulcatus*, shrimp, biology, fisheries, growth, Jizan, Red Sea.

Introduction

The green tiger shrimp *Peneaus semisulcatus* (De Haan, 1844) dominates the commercial catches from trawlers operated in both the Red Sea and the Arabian Gulf fishing grounds (Boerema, 1969). Although extensive studies on *P. semisulcatus* have been carried out in the Gulf region Al-Atter and Ikenous (1974); Price and Jones, (1975); Mohamed *et al.*, (1981); van Zaling, (1984); Buqis and Abdulqader (1993 & 1994), little information is available on this species in the Red Sea as Ghamrawy (1988 & 1990) and Abdallah and Abushusha (2003) which stated that, the catch of *P. semisulcatus* showed a sharp decline over the six fishing seasons from 1995/1996 to 2000/2001.

In Saudi Arabian Red Sea water, the distribution of *P. semisulcatus* is associated with the extension of the continental shelf where the bottom is muddy, especially in three regions; the Jizan area in the south (as shown in Fig., 1), Al-Qunfedah area, and in Al-Khoribah area in the far north, its resources is concentrated and fished commercially (PERSGA-GEF 2002).

Jizan region which extends from Latitude 17° 40' N southwards to the Yemeni border covering an estimated total area of about 10,000 square kilometers consider the most important fishing ground in Saudia Arabia,

where more than 90% of the shrimp trawlers operate Abdallah and Abu-Shoushah (2003).

The aim of the present study was to study some biological aspects of *P. semisulcatus* including gonads maturity and growth and to assess the current exploitation status of this target species in Jizan fisheries.

Fig. (1): A map showing the study area off the Saudi coast.

Materials and Methods

A total of 652 individuals, 342 females and 310 males of *P. semisulcatus* ranging from 20 to 85 mm carapace length (CL) were collected from shrimp trawlers at Jizan landing site twice a month during the study period (2015 – 2016). Shrimp species were identified according to the FAO species identification sheets, Fischer and Blanchiceds (1984). Females and males were sorted. All

individuals were weighed to the nearest 0.01g and measured the carapace length (CL) from post the orbital margin to the posterior end of the mid-dorsal line of the carapace using a Vernier caliper.

Length weight relationship was estimated according to Le Cren (1951), while the condition factor was calculated according to Hile (1936). Carapace length frequency distribution of *P. semisulcatus* was determined and the percentage of occurrence of each length class was investigated.

The monthly Carapace length frequency distributions were analyzed by ELEFAN program Pauly and David (1981) incorporated in LFDA software for the estimation of growth parameters (L_{∞} , K & t_0) for the sexes combined, where L_{∞} is the asymptotic total length, K is the curvature parameter and t_0 is the Age at length zero. The maximum age was obtained according to Pauly (1981) equation. According to Moreau *et al.* (1986), the following two equations were adopted to estimate the growth performance of length and weight for the species under study.

Growth performance in length: $\Phi_L = \text{Log } K + 2(\text{Log } L_{\infty})$

Growth performance in weight: $\Phi_W = \text{Log } K + \frac{2}{3}(\text{Log } W_{\infty})$

The gonadal maturity of *P. semisulcatus* was determined by visual examination of the maturity stages of the female gonads (ovaries) based on the color and size of ovaries of the collected samples Shaikhmahmud, (1961), Rao. (1968) and Metin *et al.* (1999) to estimate the length at first sexual maturity.

The instantaneous total mortality coefficient “Z” of the species under study in Jizan area was obtained by the cumulated catch curve which is based on length composition data Jones and van Zalinge (1981). Natural mortality (M) was derived through the empirical equation of Pauly (1980) considering the mean annual habitat temperature as 29.9°C world sea temperature, (2016). Instantaneous fishing mortality values “F” can be easily calculated by subtracting “M” from “Z” Beverton and Holt (1957).

Length and age at first capture (L_c & t_c) were investigated from the equation of Beverton and Holt (1956 & 1957). Length and Age at recruitment (L_r & t_r) were estimated by applying Von Bertalanffy growth equation.

The current exploitation rate "E" was computed according to the formula of Gulland (1971): $E = F/Z$. The relative yield per recruit "Y/R" and relative biomass per recruit "B/R" were estimated by using the model of Beverton and Holt (1956) as modified by Pauly and Soriano (1986) and incorporated in the FiSAT software package. Relevant values of exploitation rates (E_{10} , E_{50} & E_{max}) were estimated to assess the rate of exploitation of *P. semisulcatus* in Jizan area.

Results

Six shrimp species were recorded in the commercial landing of Jizan region. Two of them, *Penaeus semisulcatus* and *Metapenaeus monoceros* (Fabricius, 1798) are the most commercially important species while the others, *Penaeus japonicas* (Bate, 1798), *Penaeus monodon* (Fabricius, 1798), *Penaeus latisulcatus* (Kishinouye, 1896) and *Trachypenaeus curvirostris* are landed in very small quantities. This study shows that, the green tiger shrimp constitutes the majority of the annual total shrimp catch taken by bottom trawlers in the Jizan area as its abundance percentage ranged from 84.5 % to 93.24 % during the years from 2010 to 2016.

Carapace length total weight relationship:

The Carapace length - weight relationship for combined sexes of *P. semisulcatus* in Jizan area (Fig. 2) is represented by the formula: $W = 0.0008 L^{2.6694}$, $R^2 = 0.9242$.

Length frequency distribution

Length frequency data of *P. Semisulcatus* was arranged in one mm length intervals and the results are expressed the numbers as percentages (Table1). Carapace length groups of *P. Semisulcatus* covered a length range between 20 mm to 85 mm; the majority of individuals were in length groups between 40 mm and 60 mm and the dominant one is with 50 mm (10%).

Fig. (2): Carapace length-total weight relationship of *P. semisulcatus* in Jizan area.

Table (6): Length frequency distribution of *P. Semisulcatus* between 2015/2016.

Carapace Length (mm)	No.	%	Carapace Length (mm)	No.	%
20	5	0.77	50	65	9.97
21	3	0.46	51	12	1.84
22	5	0.77	52	25	3.83
23	16	2.45	53	33	5.06
24	6	0.92	54	15	2.30
25	3	0.46	55	23	3.53
26	3	0.46	56	7	1.07
27	2	0.31	57	8	1.23
28	5	0.77	58	14	2.15
29	1	0.15	59	7	1.07
30	23	3.53	60	20	3.07
31	8	1.23	61	5	0.77
32	18	2.76	62	17	2.61
33	12	1.84	63	5	0.77
34	14	2.15	64	5	0.77
35	12	1.84	65	15	2.30
36	6	0.92	67	4	0.61
37	5	0.77	68	1	0.15
38	6	0.92	69	1	0.15
39	5	0.77	70	17	2.61
40	15	2.30	71	6	0.92
41	7	1.07	73	3	0.46
42	17	2.61	75	4	0.61
43	38	5.83	76	2	0.31
44	24	3.68	78	1	0.15
45	18	2.76	79	3	0.46
46	13	1.99	80	7	1.07
47	12	1.84	81	1	0.15
48	11	1.69	83	1	0.15
49	11	1.69	85	1	0.15

Growth parameters

The parameters of Von Bertalanffy growth model of *P. semisulcatus* in Jizan area were

Fig. (3): Growth parameters (L_{∞} , K & t_0) for *P. semisulcatus* in Jizan area

The maximum age ($t_{\max}$) was computed as 3.70 year. The growth performance indices (ϕ_L and ϕ_{wt}) could be considered a good index of shrimps growth. The growth performance in length and weight were 3.86 and 1.36 respectively.

Length at first sexual maturity (L_{m50})

Penaeus semisulcatus females less than 26 mm of carapace length were collectively immature (Fig. 4). Larger individuals showed an increase in the frequency of mature specimens and all females longer

estimated to be as follows: $L_{\infty} = 94.40$ mm, $K = 0.81$ year⁻¹ & $t_0 = -0.20$ year⁻¹, as shown in Figure (3).

than 46 mm carapace length were fully mature. It is also clear that females of *P. semisulcatus* attained its 50% of sexual maturity at carapace length of 38 mm. as shown in Fig. (4).

Fig. (4): Carapace length (mm) at first sexual maturity for females *P. semisulcatus*.

Instantaneous mortality coefficients

The instantaneous natural mortality coefficient (M) for *P. semisulcatus* in Jizan area was estimated as 1.163 year⁻¹. The estimated total mortality coefficient depends on the cumulated catch curve which is based on length composition data Jones and van Zalinge, (1981) was 3.124 year⁻¹ (as shown

in Fig. 5). Fishing mortality coefficient was found to be 1.961 year^{-1} .

Fig. (5): Jones and van Zalinge plot for *P. semisulcatus*.

Carapace length and age at first capture and at recruitment

The carapace length at first capture (L_{50}) was estimated as 35.73 mm. In addition, the t_c was 0.387 year. Length at recruitment " L_r " was 28.52 mm, where the age at recruitment t_r was 0.24 year.

Current Exploitation rate

In the present study the exploitation ratio of *P. semisulcatus* in Jizan area was found to be 0.628.

Relative yield / recruit, biomass / recruit and prediction of the maximum exploitation ratio:

Relevant values of exploitation rates were ($E_{10} = 0.502$, $E_{50} = 0.328$ & $E_{\max} = 0.581$) where; E_{10} is the exploitation rate at which the marginal increase of Y'/R is 1/10 of its value at $E = 0$; E_{50} is the exploitation rate under which the stock has been reduced to 50% of its unexploited biomass; and $E_{\max}$ is the exploitation rate which produces maximum yield. The results showed that, E_{cur} (0.628) was higher than E_{10} (0.502) and $E_{\max}$ (0.581) which indicates that, the fisheries status of this species suffer from overexploitation (Fig. 6).

Fig. (6): Relative yield / recruit (Y'/R) and relative biomass / recruit (B'/R) for *P. semisulcatus*.

Discussion

The asymptotic total lengths for combined sexes ($L_{\infty} = 94.4$) were higher than most of the corresponding values (54.3, 37.0 mm during the fishing season 1985/86; 49.5, 36.1 mm during 1986/87; 52.1, 36.8 mm during 1987/88; 50.9, 37.1 mm during 1988/89 &

49.0, 36.1 mm during 1989/90) that estimated by Hussain *et al.*, (1996). This can be attributed to that maximum observed size of shrimp caught in this study were greatly higher than those of other localities. The above mentioned different values of females and males asymptotic carapace lengths indicate that the specifications of the trawl fishing gear (especially, the code end mesh size) contribute higher effort on females than males.

It is also clear that female *P. semisulcatus* attained its 50% of sexual maturity at carapace length of 38 mm. On the other hand, Niamaimandi, *et al.* (2008) investigated the reproductive cycle of the green tiger prawn *P. semisulcatus* the coastal waters of Bushehr, Iran, Persian Gulf. They found that the minimum size at maturity was 24 mm carapace length (CL), and 50% were mature at 40 mm CL.

The length or age at first sexual maturity helps in the determination of the minimum legal size that must be avoided in fishing in order to protect an adequate spawning stock and ensure at least one spawning for the mature individuals Zaki *et al.* (1995). The length at first sexual maturity of *P. semisulcatus* in Jizan area was found to be 38

mm., while the carapace length at first capture L_{50} was estimated as 35.73 mm which indicates that, there is a poor opportunity for the recruits of *P. semisulcatus* in Jizan area to spawn before fishing which is considered an important factor that leads to the overexploitation of the stock.

The annual mortality coefficients of *P. semisulcatus* were ($Z = 3.124 \text{ year}^{-1}$, $M = 1.163 \text{ year}^{-1}$ & $F = 1.961 \text{ year}^{-1}$). These results are quite consistent with the findings of Mohamed and El-Aiatt, (2012) who studied the population dynamics and fisheries management of *P. semisulcatus* in Bardawil lagoon, North Sinai, Egypt. They estimated the mortalities coefficients as; total (Z : 3.24 & 5.34 yr^{-1}), natural (M : 1.05 & 1.16 yr^{-1}) and fishing mortality (F : 2.18 & 4.17 yr^{-1}) for male and female respectively. They also found the exploitation rates (E) = 0.67 for males, and (E) = 0.78 for females.

Estimation of the relative yield per recruit (Y'/R) indicated that the current exploitation rate is higher than $E_{\max}$ which generates the maximum yield. This result agrees with the findings of Abdullah and Abushusha (2003) who mentioned the overexploitation of tiger shrimp stock in the same area during the year

2000. Rao, *et al.*, (1993) studied the stock assessment of *P. semisulcatus* off the east coast of India. They stated that in both males and females the landings were lower than the Maximum Sustainable Yield (MSY), estimates although MSY should be realized at a far lower F (0.4 and 0.563) than the present F (1). An analysis of other data on landings of *P. semisulcatus* in the same area indicated that landings exceeded MSY in some years as in 1988 creating a necessity to reduce the effort to maximize landings.

This study recommends the development of a national management strategy for fisheries resources consistent with the international FAO Code of Conduct guidelines. This strategy requires the cooperation between all stakeholders involved in the fisheries sector in order to develop a system for the continuous monitoring and evaluation of the management plan for the justifications and inspection of the fishing gears currently used in the shrimp fisheries.

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دراسة بيولوجية لروبيان ام نعيرة (بينبوس سميلاكيتس) في مصائد منطقة جازان (البحر الاحمر ، المملكة العربية السعودية)

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المستخلص: اجريت هذه الدراسة للتحقق من الجوانب البيولوجية لروبيان ام نعيرة – النمر الاخضر (بينبوس سميلاكيتس) ذلك من اجل توفير المعلومات البيولوجية اللازمة لادارة سليمة لهذا النوع في منطقة جازان، البحر الاحمر حيث يحتل المركز الاول من حيث الكم في مراكب الصيد التجاري التي تعمل في المنطقة محل الدراسة .

امتدت منطقة الدراسة من خط عرض ١٧ درجة و ٤٠ دقيقة جنوبا الى الحدود اليمنية، حيث تشكل ما يتجاوز ٩٠% من سفن الصيد العاملة بطريقة الجر القاعي التي تستهدف صيد الروبيان في ساحل البحر الاحمر للملكة العربية السعودية خلال الفترة من ١ سبتمبر ٢٠١٥ الى 31 مارس ٢٠١٦ م. تم تحديد انماط النمو و المعاملات المرتبطة للذكور و الاناث.

كما تم تحديد الثوابت مثل طول الدقة النهائي (L_{∞}) ومعامل النمو (K) ونطاق النمو على التوالي 94.40 مم، 0.81 سنة.

تم تحليل مراحل نمو المبايض، و طول الدقة (مم). ٥٠ % من الروبيان ام نعيرة يدخل مرحلة النضج عند طول ٣٨ مم وطول الدقة عند اول صيد ٣٥,٣٧ مم وبعمر ٠,٣٨٧ سنة، بينما وجد في منطقة الدراسة ان طول الدقة والعمر عند المصيد كان ٢٨,٥٢ مم و ٠,٢٤ سنة، على التوالي. ذلك يعني ان لاتوجد فرصة للتكاثر واطافة احيال جديدة قبل الصيد والذي يعتبر مهم للمحافظة على المخزون للروبيان ويؤدي الى الصيد الجائر.

تم تقدير معامل الاستغلال للصيد الحالي عند ٠,٦٢٨، بينما معامل الاستغلال الامثل لروبيان ام نعيره هو ٠,٥٨١ مما يعني بان الروبيان محل الدراسة في منطقة جازان حسب نتائج الدراسة يعد في نطاق الصيد الجائر.