Growth, Mortality and Exploitation of *Penaeus semisulcatus* in Jizan Fisheries, Saudi Arabia

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**Abstract.** The growth parameters, mortality coefficients and exploitation rate of *Penaeus semisulcatus* in Jizan fisheries were determined during the fishing season 2015/2016. The growth curves and parameters were estimated using length-frequency data for combined sexes (pooled data). The growth parameters (L∞, K & to) for the sexes combined are estimated as L∞ = 94.40 mm, K = 0.81 year^-1, t_o = -0.20 year, M=1.634 year^-1, Z=3.124 year^-1, and F=1.961 year^-1. The results indicated that, the current exploitation rate 'Ecur = 0.628' was higher than that required to get the maximum sustainable yield per recruit 'E_Rmax=0.581'. In the present study B/R was found 5.98 gm. The current biomass per recruit ratio indicates that the current exploitation rate is not suitable for maintaining a sufficient spawning stock biomass of *P. semisulcatus* in Jizan area which indicates that the stock status of fisheries is currently overexploited.

Keywords: Red Sea, *Penaeus semisulcatus*, growth, mortality, fisheries. Jizan.

**Introduction**

Six shrimp species were recorded in the commercial landings of Jizan region (Abdallah and Abushusha 2003, PERSGA/GEF. 2002). The green tiger shrimp *Peneaus semisulcatus* is the most dominant species constituting between 85-90% of the commercial catches taken by bottom trawlers operated in the Red Sea coast of Saudi Arabia (Abdallah & Abushusha, 2003). Due to the highest market value, the Red Sea fishing fleet targets mainly *P. semisulcatus*. This species is widely distributed in the Indo-Pacific region (Holthuis, 1980), and is fished commercially from Southeast coast of India to the Arabian Gulf and the Red Sea. In the Red Sea waters, the distribution of *P. semisulcatus* is associated with the extension of the continental shelf where the bottom is muddy, especially in three regions; Jizan area in the south, Al-Qunfedah area, and in Al-Khoribah area in the far north. The Jizan region is by far the most important fishing ground where more than 90% of the shrimp trawlers operate (Abdallah and Abu-Shoushah 2003).

However, limited data are available on *P. semisulcatus* in the Red Sea indicated that the stock of the green tiger prawn fishery in the Jizan was overexploited during the fishing season 2000. Therefore, this study aims mainly to assess the fishery status of *P. semisulcatus* in Jizan fisheries (Ghamrawy, 1988, 1990; Abdallah and Abushusha, 2003). Previous work carried out by Abdallah and Abushusha (2003).

**Materials and Methods**

**Sampling:**

Samples were collected twice monthly (first and third week of the month) from the landed
catch of shrimp trawlers at Jizan landing site during the study period (Aug 2015–Mar 2016). Shrimp species were identified according to FAO species identification sheets, for shrimp trawl catch (Fischer and Blanchiceds, 1984). Species composition of the commercial landing of shrimp trawl in Jizan region was determined and the samples of *P. semisulcatus* were separated to take the different measurements (Figs.1-2). Females and males were determined. For all individuals, Vernier calipers were used to measure lengths to the nearest 0.1 mm, and weight measurements were recorded using a digital balance having a sensitivity of 0.01g.
Data Analysis

The FiSAT II software was used to estimate growth parameters through the analysis of length-frequency of *P. semisulcatus*. The maximum theoretical length $L_\infty$, growth coefficient $K$, growth amplitude $C$, and winter point WP were estimated in the ELEFAN I routine (Pauly and David 1981). The instantaneous total mortality coefficient $(Z)$ was estimated using Jones and van Zalinge (1981) plot implemented in the ELEFAN II routines of the FiSAT II Package. The coefficient of natural mortality $(M)$ was estimated by the method of Pauly (1980) considering the mean annual temperature as 28°C (Morcos, 1970). The Fishing mortality coefficient $(F)$ was considered as the difference between $Z$ and $M$.

Carapace length at first capture $(L_{50})$ was estimated using the plot of probability of capture by length (Pauly, 1984). Total length at first capture was derived from the estimated carapace length according to Pauly and Soriano, (1986). ELEFAN II program was used to calculate the relative yield-per-recruit $(Y'/R)$ and biomass-per-recruit $(B'/R)$.

$$Y'/R = E \cdot \frac{UM}{K} [1 - \frac{3U}{1 + m}] + \frac{3U2}{1 + 2m} - \frac{U3}{1 + 3m}.$$  

Where:  
$$m = \frac{K}{Z} = \left( \frac{1 - E}{M/K} \right)$$

$$U = 1 - \left( \frac{Lc}{L_\infty} \right)$$  

$$E = \frac{F}{Z}$$

$$K = \text{von Bertalanffy growth parameter.}$$  

$$Z = \text{Total mortality coefficient.}$$  

$$F = \text{Fishing mortality coefficient.}$$  

$$L_\infty = \text{von Bertalanffy constant}$$  

‘$Lc’$, the length at first capture, the length at which all fish of that length and longer are under full recruitment.

The relative biomass per recruit was computed as:

$$B'/R = \frac{Y'/R}{F}.$$

The exploitation ratios $E10$, $E50$ and $E_{\text{max}}$ were determined by using FiSAT software program.

Results

Growth Parameters

The restructured carapace length frequency of *P. semisulcatus* is shown in Figure (3), with superimposed growth curves. The monthly length frequency distributions were analyzed by ELEFAN program (Pauly and David 1981) incorporated in LFDA software for the estimation of growth parameters $(L_\infty, K & t_0)$ for the sexes combined. Where $L_\infty$ is the asymptotic total length, $K$ is the curvature parameter and $t_0$ is the Age at length zero. They are estimated as $L_\infty = 94.40$ mm, $t_{\text{max}}=3.70$ year, $K = 0.81$ year$^{-1}$ and $t_0 = -0.20$ year.
Mortalities rates:

Fishing mortality coefficient was calculated as a result of subtraction of $M=1.163 \text{ year}^{-1}$, $F=1.961 \text{ year}^{-1}$, and $Z=3.124 \text{ year}^{-1}$ from (Beverton and Holt, 1957). This was found to be $1.961 \text{ year}^{-1}$.

Fig. 3. Growth parameters ($L_\infty$, $K$ & $t_0$) of *P. semisulcatus* in Jizan area (output of the LFDA software).

Fig. 4. Jones and van Zalinge plot for *P. semisulcatus*.
Carapace length and age at first capture:
The corresponding age at first capture “tc” was calculated by the following equation (Beverton & Holt, 1957):
\[ tc = \frac{-1}{K} \ln \left( \frac{1 - L_c / L_\infty}{t_0} + 1 \right) \]
where “K, L_\infty & t_0” are the Von Bertalanffy constants and “Lc” is the length at first capture.
The carapace length at first capture L_{50} (the carapace length at which 50% of individuals at that size are vulnerable to capture) was estimated as 35.73 mm for combined sexes, and the corresponding age at first capture (t_c) was 0.387 year.

Relative yield / recruit (Y'/R), relative biomass / recruit (B'/R)
The plot of relative yield per recruit “Y’/R” and relative biomass per recruit “B’/R” of *P. semisulcatus* in Jizan fisheries against the exploitation rate “E” are graphically represented in fig. (5) and table (1). The yield-based biological reference points E-10 (the exploitation rate at which the marginal increase of Y’/R is 1/10 of its value at E=0), E-50 (the exploitation rate under which the stock has been reduced to 50% of its unexploited biomass), and E-max (the exploitation rate which produces maximum yield per recruit) of exploitation rates were found to be E-10 = 0.502, E-50=0.328 and E-max = 0.581 year^{-1}. The current level of exploitation E-cur was estimated to be 0.628 year^{-1}, and both E-10 and E-max are lower than the current exploitation rate.

Fig. 5. Relative yield / recruit (Y’/R), and relative biomass / recruit (B’/R) for *P. semisulcatus* in Jizan fisheries.
Table 1. Yield / recruit and average biomass / recruit of *P. semisulcatus* as a function of fishing mortality.

<table>
<thead>
<tr>
<th>F</th>
<th>Y/R</th>
<th>B/R</th>
<th>% Bv</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.0000</td>
<td>33.477</td>
<td>100.00</td>
</tr>
<tr>
<td>0.845 (0.1)</td>
<td>10.8808</td>
<td>12.880</td>
<td>38.46</td>
</tr>
<tr>
<td>1.000</td>
<td>11.2999</td>
<td>11.300</td>
<td>33.75</td>
</tr>
<tr>
<td>1.200</td>
<td>11.6149</td>
<td>9.680</td>
<td>28.91</td>
</tr>
<tr>
<td>1.601</td>
<td>11.8040</td>
<td>7.373</td>
<td>22.02</td>
</tr>
<tr>
<td>1.607 (max)</td>
<td>11.8041</td>
<td>7.345</td>
<td>21.94</td>
</tr>
<tr>
<td>1.612</td>
<td>11.8040</td>
<td>7.323</td>
<td>21.87</td>
</tr>
<tr>
<td>1.800</td>
<td>11.7770</td>
<td>6.543</td>
<td>19.54</td>
</tr>
<tr>
<td>1.961 (cur)</td>
<td>11.7230</td>
<td>5.979</td>
<td>17.86</td>
</tr>
<tr>
<td>2.500</td>
<td>11.4340</td>
<td>4.574</td>
<td>13.66</td>
</tr>
<tr>
<td>3.000</td>
<td>11.1160</td>
<td>3.705</td>
<td>11.07</td>
</tr>
</tbody>
</table>

**Discussion**

Due to the developing technology and fishing equipment, the fishing effort exerted on fishery resources has been increasingly modified leading to overfishing problems which may result in reducing fish stocks to biologically and ecologically harmful levels. Investigating the population dynamics such as age, growth and mortalities are very important to assess the current status of any given population.

In the present study, the asymptotic total length for combined sexes ($L_{\infty} = 94.4\text{mm}$) was higher than those estimated in previous study reported by Hussain et. al. (1996) in Jizan area for females and males, respectively (54.3mm and 37.0 mm during the fishing season 1985/1986; 49.5mm and 36.1mm during 1986/1987; 52.1mm and 36.8mm during 1987/1988; 50.9mm and 37.1mm during 1988/1989, and 49.0mm and 36.1mm during 1989/1990).

The above mentioned different values of asymptotic carapace lengths for females and males may be attributed to the excess fishing effort exerted by trawling on the stock of this species in Jizan fisheries. In the present study, the growth coefficient “K” of *P. semisulcatus* in Jizan area during the fishing season 2015/2016 was found to be 0.81. Hotzhausen and Kirchner (2001) reported that as the value of “K” increases the rate of growth increases. This would explain the higher growth rate of *P. semisulcatus*. Abdul-Wahab (2014) studied the population dynamics of *P. semisulcatus* in the Yemeni Red Sea water, and found that the current exploitation rate, E, is the best compromise resulting in higher stock biomass and higher catch rate than that obtained at $E_{\text{max}}$ and $E_{0.1}$. In the present study, results of the relative yield per recruit ($Y'/R$) indicated that the current exploitation rate is higher than $E_{\text{max}}$ which generates the maximum yield per recruit. In addition, the current values of “E” are higher than the values of “$E_{0.5}$” which consider the exploitation level that maintains
the spawning stock biomass at 50% of the virgin spawning stock biomass for the species under study. The current biomass per recruit ratio indicates that the current exploitation rate is not suitable for maintaining a sufficient spawning stock biomass of *P. semisulcatus* in Jizan area. **Conclusion**, Based on that, this study recommended the eduction of exploitation rate from $E_{-R} = 0.628$ to $E_{-R} = 0.502$ yr$^{-1}$ and further monitoring and management through estimation of the optimal exploitation rates, female spawner relative stock biomass as targeted reference points.

**References**


النمو والنفوق والاستغلال لمصايد روبيان أم نعيرة (بينيوس سميسلكيتيس) في مصايد جيزان، المملكة العربية السعودية

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النفوق والрост والاستغلال لمصايد روبيان أم نعيرة (بينيوس سميسلكيتيس)، وذلك من خلال تحليل عينات تم جمعها من منطقة جيزان (البحر الأحمر، المنطقة الجنوبية للمملكة العربية السعودية) خلال الفترة من أغسطس 2015 وحتى مارس 2016. تم استخدام بيانات التكرار الطولى للعينات الشهرية، وذلك لتحديد أطوال النمو والمعاملات المرتبطة بها، طول الدرجة النهائية، معدل النمو. من الدراسة كان طول الدرجة النهائية 444 سم ومعامل النمو = 0.81، وال願 = 2.0 سنة، الفوق الطبيعي = 1.34 سنة، الفوق بسبب الصيد = 1.98 سنة وألف الفوق الكلي = 3.14 سنة. معامل الاستغلال الحالي بلغ 39.0٪. في حين أن الاستغلال الأثيوبي للجنيبي 0.58٪. من الدراسة الحالية معدل نسبة الكثافة إلى أجيال جديدة 0.98 جرام. الاستغلال الحالي غير يؤدي إلى ضعف إمكانية دخول أجيال جديدة لمنطقة المصيد مما يعني أن مخزون بينيويس سميسلكيتيس الحالي تحت الصيد الجائر.

الكلمات الدالة: روبيان أم نعيرة، بينيوس سميسلكيتيس، النمو، الفقود، المصائد، جيزان، البحر الأحمر.