Population parameters and length-weight relationship of deep flounder (*Pseudorhombus elevatus*) in northwest of Persian Gulf (Khuzestan coastal waters, Iran)

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Received 10 October 2012; revised 11 November 2012; accepted 3 December 2012

**ABSTRACT:** During this study from December 2009 to November 2011, 363 deep flounder fish were caught and their weight and length were measured. The caught fish included 18 males, 200 females and 155 immature fishes. The mean, maximum and minimum total lengths were 264 ± 57 (mean ± SD), 415 mm and 115 mm respectively. The mean, maximum, and minimum total weights for this species were 238 ± 150 g, 827 g and 14 g respectively. The calculated length-weight relationships were $W=0.000007FL^{3.09}$ ($n=200$, $R^2=0.96$) for the female, $W=0.00002FL^{2.90}$ ($n=18$, $R^2=0.94$) for the male and $W=0.000009FL^{3.04}$ ($n=363$, $R^2=0.96$) for total fish. With a verified calculated $b$ as 3 Student t-test showed no significant difference between calculated $b$ and 3 ($P>0.05$), demonstrating that the growth pattern is isometric. Population parameters calculated for total fish were $L_\infty=42$ (cm); $K=1$ (year$^{-1}$); $t_0=-0.14$ and $F'=3.24$. Based on the results, this species is classified as mediate vulnerable group fish.

**Keywords:** Population parameters; *P. elevatus*; Persian Gulf

**INTRODUCTION**

The Persian Gulf is a semi enclosed sea lying almost between the latitudes of 25°-32° N and longitudes of 48°-56° E. This water basin is a shallow continental shelf with a depth average of 35 m increasing from Arvend estuary reaching to its maximum in strait of Hormuz. This locale is considered as one of the richest areas in fishery resources where large quantities of fish and shrimps are concentrated in different locations, particularly in the territorial waters of Iran (Hashemi et al., 2011).

The Deep flounder, *Pseudorhombus elevatus* (ogilby, 1912), is a member of the family Paralichthyidae and is widely distributed throughout the Indo-West Pacific, from the Red Sea and East Africa to Japan and New Caledonia (Fischer and Bianchi, 1984; Carpenter et al.,1997). Adults are found in shallow coastal waters and the diet of this species consists of bottom-living animals. Consequently it is exploited throughout its range with a variety of gears, including trawls (Fischer and Bianchi, 1984). This species has a gonochoristic reproductive mode and spawning occurs annually with one clear seasonal peak during April to June (Hashemi et al., 2011).

Overall purpose of fisheries science is to provide decision-makers with advice on the relative merits of alternative management. Demography rates are fundamental to fisheries stock assessment and estimated of potential yield (King, 2007). In tropical waters, lack of distinct seasonality has made such analyses more difficult (Spare and Venema, 1998).

Different aspects of biological parameters of Deep flounder have been studied in Persian Gulf by Bawazeer (1989) in Kuwait waters. However, no study, so far, has been made on this species biology in Khuzestan Coastal Waters (northwest of Persian Gulf). In this context, the aim of the present study was twofold: (i) to estimate its population parameters via length frequency methods, (ii) to determine the length-weight relationship of the population of this species in Khuzestan Coastal Waters (northwest of Persian Gulf). Results will
greatly contribute to elaborate management programs for this economically important fish species of the region under study.

MATERIALS AND METHODS

The main fishing areas of *P. elevatus* in the northwest of Persian Gulf are located in Liphe-Busafe and Bahrekan fishing area between 29° 44' to 07 'N and 48° 45' to 49° 50' (Fig. 1).

A total number of 469 *P. elevatus* were caught during 2009 to 2011 using bottom trawl and gill net. There were also some samples collected from recreational fishermen that were transferred in icebox to the laboratory. In the laboratory, fork length (±1.0 mm), sex, and weight (±0.001 g wet weight) were recorded for each fish. Parameters of the length weight relationship were obtained by fitting the power function $W = a \times FL^{b}$ to length and weight data where: $W$ is the total wet weight, $a$ is constant determined empirically and $FL$ is the fork length (Biswas, 1993). In order to verify if calculated $b$ was significantly different from 3, the Student t-test was employed (Zar, 1996).

The data were then pooled monthly from different landing sites and subsequently grouped into classes of three centimeter intervals. The data were analyzed using FiSAT II (FAO-ICLARM Stock Assessment Tools) as explained in detail by Gayanilo et al. (1996).

The growth was calculated by fitting the von Bertalanffy growth function to length frequency data. The von Bertalanffy growth equation is defined as follows (Sparre and Venema, 1998): $L_t = L_\infty \left[1 - \exp(-K(t-t_0))\right]$, where $L_t$ is length at time $t$, $L_\infty$ the asymptotic length, $K$ the growth coefficient and $t_0$ is the hypothetical time at which length is equal to zero. The $t_0$ value was estimated using the empirical equation (Pauly, 1979).

$$\log_{10}(t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$$

Fitting the best growth curve was based on the ELEFAN I programm (Pauly and David 1981), which allows fitting the curve through the maximum number of peaks of the length-frequency distribution. With the help of the best growth curve, growth constant ($K$) and asymptotic length ($L_\infty$) were estimated.

The growth performance ($\Phi'$) of Deep flounder population in terms of length growth was computed using the index of Pauly and Munro (1984).

$$\Phi' = \log_{10} K + 2 \log_{10} L_\infty$$

Statistical analyses were performed with SPSS 14 software package and a significance level of 0.05 was adopted.

RESULTS AND DISCUSSION

The caught fish included 18 males, 200 females and 155 immature fishes. The mean, maximum and minimum total lengths were 264 ± 57 (mean ± SD), 415 mm and 115 mm respectively. The mean, maximum, and minimum total weights for this species were 238 ± 150 g, 827 g and 14 g respectively (Table 1).

Fig. 1: Location of two landing sites of Deep flounder in Khuzestan Coastal Waters (Iran)
Length frequency distribution

The total length of 369 fish were 110 to 410 mm (Fig. 2), (2±mm). Maximum and minimum lengths of caught fish were in range of 250-270 and 390-410 mm respectively. Length frequency percentage groups of *P. elevatus* during April 2009 to March 2011 are presented in Fig. 2.

Length-weight relationship

The calculated length-weight relationships were $W=0.000007FL^{3.09}$ (n=200, $R^2=0.96$) for the female, $W=0.00002FL^{2.90}$ (n=18, $R^2=0.94$) for the male and $W=0.000009FL^{3.04}$ (n=363, $R^2=0.96$) for total fish.

With a verified calculated $b$ as 3 Student t-test showed no significant difference between calculated $b$ and 3 ($P>0.05$), demonstrating that the growth pattern is isometric. (Fig. 3).

<table>
<thead>
<tr>
<th>Month</th>
<th>N</th>
<th>Male</th>
<th>Female</th>
<th>Immature</th>
<th>MeanW ±S.D (g)</th>
<th>Min – max</th>
<th>MeanTL ±S.D (mm)</th>
<th>Min– max</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>44</td>
<td>-</td>
<td>30</td>
<td>13</td>
<td>183±135</td>
<td>41-518</td>
<td>245±54</td>
<td>165-370</td>
</tr>
<tr>
<td>February</td>
<td>26</td>
<td>5</td>
<td>18</td>
<td>3</td>
<td>224±133</td>
<td>73-507</td>
<td>260±41</td>
<td>198-335</td>
</tr>
<tr>
<td>March</td>
<td>46</td>
<td>7</td>
<td>30</td>
<td>9</td>
<td>201±132</td>
<td>42-827</td>
<td>256±41</td>
<td>171-396</td>
</tr>
<tr>
<td>April</td>
<td>25</td>
<td>3</td>
<td>20</td>
<td>2</td>
<td>338±141</td>
<td>112-629</td>
<td>306±40</td>
<td>225-380</td>
</tr>
<tr>
<td>May</td>
<td>23</td>
<td>1</td>
<td>14</td>
<td>8</td>
<td>315±169</td>
<td>128-581</td>
<td>300±54</td>
<td>222-375</td>
</tr>
<tr>
<td>July</td>
<td>63</td>
<td>-</td>
<td>50</td>
<td>13</td>
<td>287±135</td>
<td>110-693</td>
<td>285±39</td>
<td>205-375</td>
</tr>
<tr>
<td>August</td>
<td>35</td>
<td>-</td>
<td>5</td>
<td>30</td>
<td>96±60</td>
<td>14-785</td>
<td>180±63</td>
<td>115-415</td>
</tr>
<tr>
<td>September</td>
<td>9</td>
<td>-</td>
<td>5</td>
<td>4</td>
<td>250±88</td>
<td>162-378</td>
<td>272±26</td>
<td>245-312</td>
</tr>
<tr>
<td>October</td>
<td>31</td>
<td>-</td>
<td>25</td>
<td>6</td>
<td>310±151</td>
<td>77-532</td>
<td>293±56</td>
<td>190-380</td>
</tr>
<tr>
<td>November</td>
<td>27</td>
<td>-</td>
<td>9</td>
<td>18</td>
<td>237±86</td>
<td>93-345</td>
<td>273±31</td>
<td>210-305</td>
</tr>
<tr>
<td>December</td>
<td>33</td>
<td>-</td>
<td>23</td>
<td>10</td>
<td>208±128</td>
<td>85-479</td>
<td>258±44</td>
<td>202-342</td>
</tr>
<tr>
<td>Average</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>150±238</td>
<td>14-827</td>
<td>57±264</td>
<td>115-415</td>
</tr>
</tbody>
</table>

Fig. 2: Percentage frequency length of *P. elevatus* in Coastal Waters of Iran during 2009-11
Population parameters and length-weight relationship

Fig. 3. The length-weight relationship curve for total fish of Deep Flounder in Khuzestan Coastal Waters (Iran, 2009-11).

Fig. 4: Growth curve of *P. elevatus* from Iran by ELEFAN I superimposed on the restructured length-frequency diagram ($L_\infty = 42$ cm and $K = 1$ yr$^{-1}$).

**Growth Studies**

Growth parameters of von Bertalanffy growth formula for *P. elevatus* were as follows: $L_\infty = 42$ cm and $K = 1$ yr$^{-1}$ (Fig. 4). For these values obtained through ELEFAN I, the response surface ($R_n$) was 0.178. The growth curves are shown over its restructured length distribution in Fig. 3. The $\Phi'$ and $t_0$ were found to be 3.24 and -0.14 year respectively (Fig. 4). Based on the results, this species is classified as mediate vulnerable group fish.

**CONCLUSION**

The length-weight relationship in fish is of great importance in fishery assessments (Haimovic and Velasco, 2000). Length and weight relationship in conjunction with age data can give information on the stock composite, age at maturity, life span, mortality, growth and production. The relative robustness or degree of well-being of a fish expressed as the coefficient of condition (condition factor) is an important tool for the study of fish biology, mainly when the species lies at the base of the higher food web (Diaz et al., 2000).

The $b$ values in the weight-length model were measured to be close to 3 for *Penaeus indicus* indicating that weight increased isometrically with length (King, 2007). However, no study, so far, has been done on some of species length-weight relationships (*Pseudorhombus elevatus*) in Khuzestan Coastal Waters (northwest of Persian Gulf). Length–weight relationship is a practical index of the condition of fish, and may vary over the year according to several exogenous and endogenous factors such as food availability, feeding rate, health,
sex, gonad development, spawning period and preservation techniques (Bagenal, 1978; Tesch, 1968). According to Marthin (1994) the range of “b” could be from 2.5 to 4 and Tesch (1968) believed “b=3 in fish with isometric growth”.

The values of L∞ and K were calculated as 42cm and 1 (year⁻¹). L∞ and K of Deep flounder were calculated in Kuwait waters for both male and female, which were 44 and 0.16, respectively (Bawazeer, 1989). These parameters for Euryglossa orientalis were reported to be 41.9 and 0.2 in Khuzestan (Mohamadi and Khodadadi, 2007).

The difference between L∞ and K influenced by ecological characteristics, population size and gene frequency of species which is affected by their habitat and natural selection causes different adaptation patterns (Hashemi et al., 2011). L∞ and K values have reverse correlation, whilst with decreasing L∞, K value increases and vice versa (Sparre and Venema, 1998). Differences in growth rates between regions indicated a stock separation (Devaraj, 1981) which has, in some cases, supported a genetic difference (Begg and Sellin, 1998).

Φ was reported to be 2.43 in researches made in Kuwait waters (Bawazeer, 1989). In general, the correlated parametric values adjust themselves to provide a similar growth pattern represented by Φ (Sparre and Venema, 1998). Age at zero length (to) was as -0.14 year. With negative to values, juveniles grew more quickly than the predicted growth curve for adults, and with positive to values, juveniles grew more slowly (Sparre and Venema, 1998). Regarding Tmax= 3/k (King, 2007), the maximum age for this species was found to be 3 year. Absorbed energy is used for body maintenance, activity, reproduction and less than 1/3 for growth. In different species, growth ratio and life cycle is different (King, 2007). The results indicated that this species has a short life span.

According to biological characteristics and American Fisheries Society (AFS) indices (Chenung et al., 2005), Deep flounder is classified as mediate vulnerable group fish. Further stock assessment research is needed to obtain an adequate and comprehensive understanding of biology and ecology in this important order.

ACKNOWLEDGMENTS

The present study was carried out within the framework of the research project “Determination of the ecological relationship among economic fishes in the coastal area of the Persian Gulf” funded by Iranian Fisheries Research Organization (IFRO) and Iran National Science Foundation. Special thanks for presentation of material and spiritual supportive aids and services for this national project and all colleagues that helped during field work. We thank Dr. Maramazi, the manager of the South of Iran aquaculture fishery research center, Ahwaz. We are also very grateful to the experts of the South of Iran aquaculture fishery research center, Ahwaz for helping the project work.

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