Note

Growth and mortality parameters of *Sillago sihama* (Forsskal, 1775) in coastal waters of the Hormozgan Province, Iran

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ABSTRACT

Monthly total length frequency data of silver sillago *Sillago sihama* were collected from the coastal waters of Hormozgan Province, Persian Gulf, from July 2011 to July 2012. ELEFAN-I module of FISAT II was used to analyse the length frequency data. The length-weight relationship derived, demonstrated that growth in this species is allometric. The asymptotic length (*L*∞) was estimated as 26 and 30 cm for males and females, respectively. The growth parameter K was calculated as 0.46 y⁻¹ for males and 0.43 y⁻¹ for females. The total mortality, natural mortality and fishing mortality rates estimated were: 3.55, 1.09 and 2.46 for males and 3.03, 1.00 and 2.03 for females, respectively. The exploitation rate E being more than 0.50, indicates *S. sihama* stock is currently being overexploited from the Persian Gulf.

Keywords: Growth and mortality parameters, Iran, Persian Gulf, *Sillago sihama*

*Sillago sihama* (Forsskal, 1775) is an economically important species that inhabits shallow coastal waters up to a depth of 20 m and rarely up to 60 m (Carpenter et al., 1997). In the northern Persian Gulf, they are often caught in hooks and incidentally in shrimp trawls. Earlier studies on *S. sihama* stock from the region have focused on their food and feeding habits (Taghavi Motlagh et al., 2012) and reproductive characteristics in the southern coast of Iran (Mirzaei et al., 2013). Despite their high fishery potential in the northern Persian Gulf and Sea of Oman, no detailed study has been carried out on the population characteristics of this species in the area. Hence, the present study was undertaken to estimate the important population characteristics of the species viz., asymptotic length (*L*∞), growth coefficient (K), mortality (natural and fishing) rates and exploitation rate (E) which are essential for developing fishery management plans for the resource.

A total of 302 male and 681 female specimens of *S. sihama* were collected during a period of 13 months (July 2011 to July 2012) from commercial catches landed from coastal waters of the northern Persian Gulf, Iran (Fig. 1). Species was caught by shrimp trawls with 40 mm mesh at wings and 20 mm at the cod end. Fishing

Fig. 1. Study area in the northern Persian Gulf
area extended from 26° 25 E, 57°29 N to 27° 07 E, 56°06 N. Total length of the fish was measured to the nearest mm from the tip of the snout to the end of the upper caudal lobe and the individual body weight was taken on a physical balance with a precision of 0.01 g.

The relationship between the length and weight was determined by fitting the data to a potential relationship in the form of : \( W = \alpha L^b \), where \( W \) is the fish weight; \( L \) is the total length; and \( \alpha \) and \( b \) are the parameters estimated, with \( b \) being the coefficient of allometry (Pauly, 1980). Prior to regression analyses, log-log plots of length and weight values were performed for visual inspection of outliers (Froese, 2006). A linear equation (\( \log W = \log \alpha + b \log L \)) was fitted to the log-transformed data. Deviation of the estimated 'b' value from the isometric value of 3 was tested using t test (Pauly, 1980). Input data were separated by sex and values of \( K \) and \( L_\infty \) were estimated for each sex by the von Bertalanfly growth equation:

\[
L_t = L_\infty (I - e^{-Kt})
\]

where, \( L_t \) is the total length at time \( t \), \( L_\infty \) is the asymptotic length (cm), \( K \) is the growth coefficient (y\(^{-1}\)), and \( t_0 \) is the hypothetical age when the size of fish is zero.

ELEFAN I module of FISAT II software program was used to estimate the growth parameters from the length frequency data. To find the best growth curve passing through the maximum number of peaks, different starting samples and starting lengths were subjected to goodness-of-fit tests by assessing the ESP/ASP ratio (Rn).

In order to compare the growth of \( S. sihama \) from the study area with those from other studies, the growth performance index \( \phi \) was calculated using the formula:

\[
\phi = \log K + 2\log L_\infty \quad \text{(Pauly and Munro, 1984)}
\]

The growth parameters obtained from ELEFAN1, were used as input values to estimate the instantaneous rates of total mortality (\( Z \)) from length converted catch curve method in the FiSAT II package. The instantaneous rate of natural mortality (\( M \)) was obtained using Pauly’s empirical formula (1980):

\[
\ln M = -0.152 - 0.279 \times \ln L_\infty + 0.6543 \times \ln K + 0.463 \times \ln T
\]

where, \( T \) is the mean water temperature (°C) in the distribution area of \( S. sihama \) (taken as 27°C).

Table 1. Growth, mortality and exploitation rates of \( S. sihama \) in the Persian Gulf

<table>
<thead>
<tr>
<th>Sex</th>
<th>( L_\infty ) (cm)</th>
<th>( K ) (y(^{-1}))</th>
<th>Rn</th>
<th>( T_0 )</th>
<th>( Z ) (y(^{-1}))</th>
<th>( M ) (y(^{-1}))</th>
<th>( F ) (y(^{-1}))</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>26</td>
<td>0.46</td>
<td>0.336</td>
<td>-0.37</td>
<td>3.55</td>
<td>1.09</td>
<td>2.46</td>
<td>0.69</td>
</tr>
<tr>
<td>Female</td>
<td>30</td>
<td>0.43</td>
<td>0.257</td>
<td>-0.38</td>
<td>3.03</td>
<td>1.00</td>
<td>2.03</td>
<td>0.67</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>0.43</td>
<td>0.199</td>
<td>-0.38</td>
<td>3.15</td>
<td>1.00</td>
<td>2.15</td>
<td>0.68</td>
</tr>
</tbody>
</table>

The fishing mortality rate (\( F \)) was obtained as \( F = Z - M \) and the exploitation rate (\( E \)) was calculated as \( E = F / Z \).

The length-weight relationship (Fig. 2) of \( S. sihama \) had a high R\(^2\) value and the exponent ‘b’ was significantly lower from 3 (p<0.05), indicating that growth in this species is negatively allometric. Similar results of allometric growth for this species were reported in south-west coast of India (Annappaswamy et al., 2007), in Zuari Estuary, Goa (Shamsan and Ansari, 2010) and from southern coast of Iran (Mirzaei et al., 2013).

![Fig. 2. Length-weight relationship of \( S. sihama \) in the Persian Gulf](image-url)
S. sihama has a longevity of 6.9-7.4 years in the Persian Gulf. In Japanese waters, the longevity of the species Sillago aeolus is 3 years (Rahman and Tachihara, 2005), while for S. schomburgkii in Australian waters it is 4-7 years (Hyndes and Potter, 1997). Differences in ecological conditions due to latitudinal differences can have impact on the value of K and L∞ (King, 2007).

Total mortality rates (Z) were 3.55 and 3.03 y⁻¹ for both sexes in this study are higher than those reported for S. sihama in south-western Australian (Butcher and Hagedoorn, 2003) and the value of F may be different for different fishing areas or at different times in the same fishing area.

Total mortality, natural mortality and fishing mortality rates of S. sihama were higher for males than females. The estimated natural and fishing mortality rates of S. sihama for both sexes in this study are higher than the values reported for S. sihama in south-west coast of India (Annappaswamy et al., 2007) and for S. robusta in southern Queensland, Australia (Butcher and Hagedoorn, 2003). The exploitation rate (E) was 0.69 for males and 0.67 for females (Table 1). The exploitation rate (E) for both sexes indicate that S. sihama stock is currently being overexploited in the Persian Gulf.

Acknowledgements

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References


Table 2. Growth parameters of Sillago spp. from different regions

<table>
<thead>
<tr>
<th>Species</th>
<th>φ</th>
<th>t₀</th>
<th>K (y⁻¹)</th>
<th>L∞ (cm)</th>
<th>Sex</th>
<th>Region</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. sihama</td>
<td>2.57</td>
<td>0.2745</td>
<td>0.2226</td>
<td>40.68</td>
<td>Pooled</td>
<td>India</td>
<td>Krishnamurthy and Kaliyamurthy (1976)</td>
</tr>
<tr>
<td>S. schomburgkii</td>
<td>2.71</td>
<td>-0.22</td>
<td>0.49</td>
<td>32.47</td>
<td>Male</td>
<td>Australia</td>
<td>Hyndes and Potter (1997)</td>
</tr>
<tr>
<td>S. robusta</td>
<td>2.77</td>
<td>-0.16</td>
<td>0.53</td>
<td>33.33</td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. schomburgkii</td>
<td>3.37</td>
<td>-1.272</td>
<td>0.479±0.042</td>
<td>22.2±0.04*</td>
<td>Pooled</td>
<td>Australia</td>
<td>Butcher and Hagedoorn (2003)</td>
</tr>
<tr>
<td>S. maculate</td>
<td>2.67</td>
<td>-0.04</td>
<td>0.72</td>
<td>25.01*</td>
<td>Female</td>
<td>India</td>
<td>Kendall and Gray (2009)</td>
</tr>
<tr>
<td>S. sihama</td>
<td>2.76</td>
<td>-0.61</td>
<td>0.42</td>
<td>29.77**</td>
<td>Female</td>
<td>India</td>
<td>Annappaswamy et al. (2007)</td>
</tr>
<tr>
<td>S. sihama</td>
<td>2.57</td>
<td>-1.14</td>
<td>0.16</td>
<td>50.09***</td>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. sihama</td>
<td>2.61</td>
<td>-0.09</td>
<td>0.70</td>
<td>24.04*</td>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. schomburgkii</td>
<td>2.36</td>
<td>-0.04</td>
<td>0.72</td>
<td>25.01*</td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. sihama</td>
<td>2.49</td>
<td>-0.37</td>
<td>0.46</td>
<td>26.00</td>
<td>Male</td>
<td>Iran</td>
<td>Present study</td>
</tr>
<tr>
<td>S. sihama</td>
<td>2.59</td>
<td>-0.38</td>
<td>0.43</td>
<td>30.00</td>
<td>Female</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Fork length, ** Standard length, *** Total length.

Growth and mortality parameters of Sillago spp. from different regions


