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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

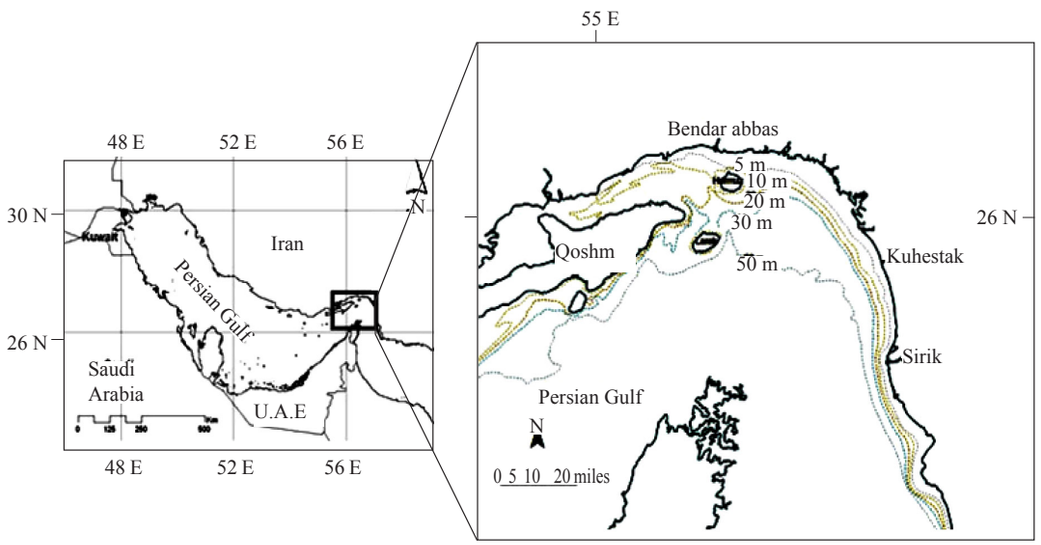

Fig. 1. Study area in the northern Persian Gulf

area extended from 26º 25′ E, 57º29′ N to 27º 07′ E, 56º06′ 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 α 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 ($\log W = \log a + b \log L$) 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_∞ were estimated for each sex by the von Bertalanffy growth equation:

$$Lt = L_\infty (I - e^{-K(t-t_0)})$$

where, Lt is the total length at time t, L_∞ 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 φ was calculated using the formula:

$\varphi = \text{Log } K + 2^* \text{Log } L_\infty$ (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):

$$\ln M = -0.0152 - 0.279 \times \ln L_\infty + 0.6543 \times \ln K + 0.463 \times \ln T$$

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

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).

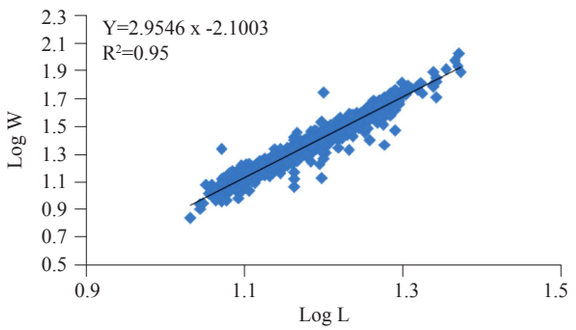

Fig. 2. Length-weight relationship of *S. sihama* in the Persian Gulf

The growth parameters estimated using male, female and pooled data are shown in Table 1. The values obtained for K were 0.46 and 0.43 y^{-1} and L_∞ = 26 and 30 cm respectively for males and females. The growth performance index (φ) of the species estimated was 2.49 for males and 2.59 for females.

The values of K and L_∞ obtained in this study are close to that estimated for *Sillago schomburgkii* from Australia (Hyndes and Potter, 1997). Studies on *S. sihama* from south-west coast of India have also reported differential growth between sexes. K value for both sexes in this study are higher and L_∞ values are lower than those reported for the species (Annappaswamy *et al.,* 2007; Shamsan and Ansari, 2010).

Mean φ values estimated for *Sillago* spp. in Australia, India and Japan were between 2.36-2.77 for both sexes, and were similar to the findings in this study, suggesting that these estimates of the von Bertalanffy growth parameters are reliable (Table 2). Also, the growth parameters estimated in present study suggest that

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

Sex	L_∞ (cm)	K (y^{-1})	Rn	T_0	Z (y^{-1})	M (y^{-1})	F (y^{-1})	E
Male	26	0.46	0.336	- 0.37	3.55	1.09	2.46	0.69
Female	30	0.43	0.257	- 0.38	3.03	1.00	2.03	0.67
Total	30	0.43	0.199	- 0.38	3.15	1.00	2.15	0.68

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

Species	φ	t_0	K (y^{-1})	L_∞ (cm)	Sex	Region	Reference
S. sihama	2.57	0.2745	0.2226	40.68	Pooled	India	Krishnamurthy and Kaliyamurthy (1976)
S. schomburgkii	2.71	-0.22	0.49	32.47	Male	Australia	Hyndes and Potter (1997)
	2.77	- 0.16	0.53	33.33	female		
S. robusta	2.37	-1.272	0.479±0.042	22.2±0.04*	Pooled	Australia	Butcher and Hagedoorn (2003)
S. aeolus	2.49	-0.58	0.70	20.96**	Male	Japan	Rahman and Tachihara (2005)
	2.57	-0.61	0.42	29.77**	Female		
S. sihama		-1.14	0.16	50.09***	Male	India	Annappaswamy *et al.* (2007)
		-1.13	0.15	55.10***	Female		
S. maculate	2.61	-0.09	0.70	24.04*	Male	Australia	Kendall and Gray (2009)
	2.65	-0.04	0.72	25.01*	Female		
S. sihama	2.36	-1.6	0.153	38.80	Pooled	India	Shamsan and Ansari (2010)
S. sihama	2.49	-0.37	0.46	26.00	Male	Iran	Present study
	2.59	-0.38	0.43	30.00	Female		

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

S. sihama has a longivity 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} and fishing mortality rate (F) were 2.46 and 2.03 y^{-1} for males and females respectively. The natural mortality rate (M) for males and females of *S. sihama* were 1.09 and 1.00 y^{-1} respectively. Natural mortality is related to life history pattern and longevity in the approach of stock assessment (King, 2007; Sparre and venema, 1998). Many environmental factors such as predation, disease, parasitism, and other natural causes act to survival of individuals during their life span and so the values of natural mortality may change accordingly (Allen and Hightower, 2010). Fishing mortality (F) is affected from fishing effort and catchability coefficient (Sparre and Venema, 1998) 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.

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