Growth pattern and reproductive biology of *Acanthopagrus latus* from the Persian Gulf

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Abstract

The growth pattern and reproductive biology of *Acanthopagrus latus* were studied to derive information required for their management in the south part of Iran, Persian Gulf. Samples collected monthly from October 2014 to September 2015. Parameter values of the Von Bertalanffy growth function fit to length frequency data (males and females combined) were estimated as k = 0.23 per year, $L\infty$ =50.4 cm (*L*F), t_o = −0.7 years.

Total, natural and fishing mortality (males and females combined) calculated as Z=0.87 per year, M=0.57 per year and F=0.3 per year, the exploitation rate were estimated for this species as E=0.45 per year. According to collected length data, *A. latus* exploited below the mean size at which females achieved first sexual maturity (24.4 cm *L*F). The length-weight relationships of males and females together estimated as, $W=0.0939*LF^{2.57}$ and exhibited negative allometric growth. Gonado-somatic index estimation indicated February as a spawning time for this species, with the main spawning period enduring to Jun. In general, parameters values obtained, characterized this species of relatively slow growing and long lived, which should be taken into consideration for sustainable management and exploitation for preventing overexploitation.

Keyword: Mortality, Growth, Reproductive, Persian Gulf

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Introduction

The family Sparidae, commonly known as sea breams, inhabits both tropical and temperate coastal waters (Randall *et al*., 1997). Many species of the family have been shown to be hermaphroditic, some have both male and female gonads developing simultaneously (Smale, 1988) but others change sex from male to female (protandrous) or from female to male (protogynous) (Randall, 1995). Most sea breams are excellent food fish and are of notable importance to both commercial and recreational fisheries throughout their range (Sommer *et al.*, 1996).

The Yellow fin sea bream, *Acanthopagrus latus* is one of the widest species which distributed in the Persian Gulf and along the coast of India to the Philippines, north to Japan, and south to Australia. The diet consists of mainly on echinoderms, worms, crustaceans and mollusks. *A. latus* is particulary exploited with a variety of gears including hook and line and sometimes taken by trawlers (Allen *et al*., 2002).

Overall, sparids form a small component of landings in the Persian Gulf representing about 3% of the total annual catch of demersal fishes. During 2013, 5410.50 tons of sparids were landed in the coastal area of the Persian Gulf. Numerous studies attempted to explain population dynamic and biology of sparidea family (Atz, 1964; Druzhinin, 1976; Hussain and Abdullah, 1977; Mathews and Samuel, 1991; Edwards *et al.*, 1985; Morgan, 1985; Lee and Al-Baz, 1989; Al Sakaff and Esseen, 1999; Grandcourt *et al*., 2004; Hoseini, Savari, 2004; Al-Mamry *et al*., 2009). However, far too little attention has been paid to stock status and reproduction biology in the Persian Gulf.

The aim of this investigation was to assess the population biology of *A. latus* with emphasis on growth pattern and reproduction to provide information required for sustainable management of this species in the study area.

Methods and Material

A total of 401 samples were taken monthly from six fish landing stations (Fig. 1) in the coastal area of Bushehr province, south part of Iran (Persian Gulf) from October 2014 to September 2015. Samples were selected randomly and fork length recorded to the1 nearest cm (LF cm) using a measuring board and wet weight was measured using an electronic balance which recorded fish to the nearest 0.1 g. Fish were sexed by macroscopic examination of the gonad which was dissected out and then weighed to 0.1 g using an electronic balance. The maturity development stage was classified into five stages according to the criteria provided by Afonso-Dias *et al*. (2005) in from which the size and color of the gonads and oocytes were taken into consideration (I=immature, II= developing/resting, III= mature, IV= spawning, V=spent).

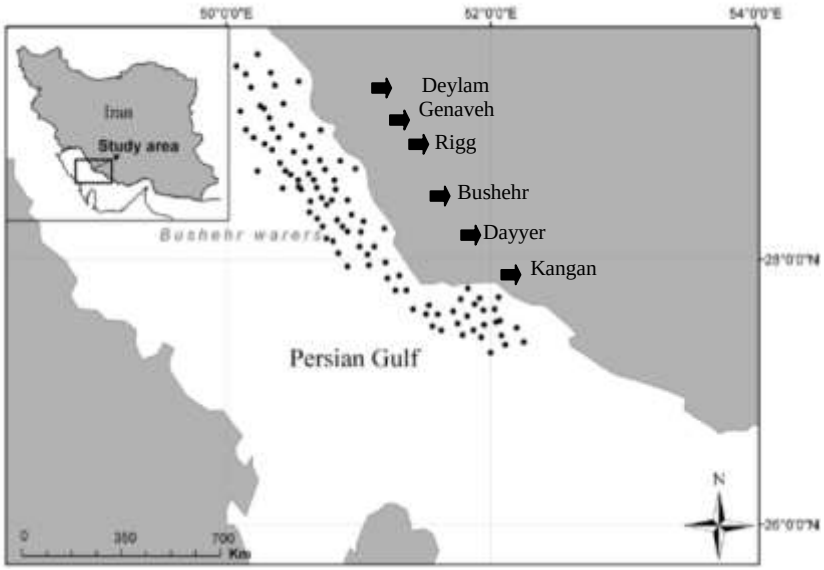

Figure 1: Location of sampling in coastal waters of Bushehr province, Persian Gulf, Iran.

The spawning period established from the analysis of two variables: (1) percentage frequency of the maturity stages and (2) Gonadosomatic index ($GSI = \frac{GNW}{BW} * 100$) where GNW is gonad weight and BW is body weight. Fork length of all individuals was used to estimate the size at first maturity. These are defined as the sizes (FL) at which 50 and 95%, respectively, of all fish sampled, are at the relevant maturity stage (II, III or IV). The proportions were estimated at length classes of 2 cm, and the data fitted to a logistic curve (Pope *et al*., 1983):

$$P = \frac{1}{1+e^{-(a+b*L)}}$$

Where p is the percentage of mature individuals as a function of size class (FL). Population sexual structures were examined using χ^2 goodness of fit tests. Independent tests were conducted to determine whether sex ratios differed significantly from unity for whole samples and size categories within samples (Sokal and Rohlf, 1995; Sadovy, 1996).

The Von Bertalanffy growth function is defined as follows (Sparre and Venema, 1992):

$L_t = L_\infty (1 - e^{-k (t-t0)})$

Where L_t is the length at time t, L_∞ the asymptotic length, k the instantaneous growth coefficient and t_0 the hypothetical time at which length is equal to 0.

Growth parameters (K and L∞) were estimated using FiSAT II software (FAO-ICLARM Stock Assessment Tools) (Gayanilo *et al*., 1996). The standard nonlinear optimization methods was used to fit Von Bertalanffy growth function to size at length data

The growth performance index (Φ′) was calculated using the following formula (Pauly and Munro, 1984):

$\Phi' = \log K + 2 \log L_\infty$

The natural mortality coefficient (M) was estimated following Pauly's empirical formula (Pauly 1980), linking the natural mortality with the Von Bertalanffy parameters, K per year, L_∞ (cm) and mean annual temperature (T, °C) of water in which fish stock lives (in this case 26.5°C):

$M = 0.8 * \exp [-0.0152 -0.279 * \ln L_\infty + 0.6543 * \ln K + 0.463 \ln T]$

The annual instantaneous rate of total mortality (*Z*) was obtained using the Powell–Wetherall method. Fishing mortality coefficient (F) was calculated from the equation (Sparre and Venema, 1992):

$F=Z-M$

Where M is the instantaneous rate of natural mortality and F the instantaneous rate of fishing mortality. The existing exploitation rate (*E*) was calculated as the proportion of the fishing mortality relative to total mortality (Sparre and Venema, 1992), $E=F/Z$.

Parameters of the length-weight relationship were obtained by fitting the power function $W=a*LF^b$, where W is the total wet weight, the constant determined empirically, *L*F the fork length and b is the slope of the function, b is close to 3.0 for species with isometric growth.

The probability of capture estimated, according to Sparre and Venema (1992) and Gayanilo *et al.* (1996) and the mean size at first capture (Lc) derived by plotting the cumulative probability of capture against mid length. From the resultant curve, Lc was taken as corresponding to the cumulative probability at 50%. Relative yield per recruit (Y/R) and biomass per recruit (R/B) values as a function of E were determined from the estimated growth parameters and the probability of capture by length (Pauly and Soriano, 1986; Pauly, 1978).

Results

Growth parameter

Table 1 demonstrates results of Von Bertalanffy growth parameters estimation. The 95% confidence regions around the Von Bertalanffy growth function parameter estimates overlapped for this species suggesting that the growth characteristics between males and females were similar.

The length-weight relationship equation was: $W=0.0939*LF^{2.57}$, $R^2=0.87$ for mixed sexes. The values of (b) were significantly different from the value of 3.0, indicating an allometric growth.

Mortality and selectivity

The results obtained from the annual instantaneous rates of fishing-induced mortality (F), natural mortality (M) and total mortality (Z) are presented 0.30, 0.57 and 0.87 $year^{-1}$ respectively. The size of the probability of capture was calculated employing FISAT II program.

Table 1: The parameters of the Von Bertalanffy growth function for *Acanthopagrus latus*

Parameter	*Acanthopagrus latus*		
	Female	**Male**	**All**
sample sizes (N)	204	197	401
L_∞ (cm)	46.9	50.4	50.4
K ($year^{-1}$)	0.3	0.23	0.23
t_0	-0.51	-0.7	-0.7
Φ′	2.8	2.76	2.76

From the graph below we can see that the size at which fish were fully recruited to the fishery were 18 cm (LF) which were moderately greater than the actual mean sizes at first capture 16.32 (Fig. 2).

The relative yield–per-recruit (Y′/R) and biomass-per-recruit (B′/R)

As shown in Fig. 3, The relative yield and biomass per recruit calculated from the knife edge selection of size at first capture. Input data for calculating yield-per-recurit were L_C/L_∞ and M/K which calculated as 0.32 and 2.47. The exploitation rate in the Persian Gulf gave an $E_{max=}$ 0.46, $E_{0.1=}$ 0.30 and $E_{0.5=}$0.58 per year.

Reproduction

During summer (July to September), the gonads of *A. latus* possess no macroscopically identified ovaries or contain relatively considerable amounts of both immature ovarian. The lengths of all of these fish lay between17.50 cm and 45 cm. In August, the number of fish ovotestes containing large of both immature testis and ovary increased due to the process of sex change. In Autumn (October to December), the fourth type of gonad detected, the lengths of all of these fish were between 14.5 cm and 44 cm. Late winter and during spring, the mature and spawning gonads increased. The contributions made by the number of females increased substatially in winter. The lengths at 50% maturity (Lm_{50}) calculated as 24.4 cm (*L*F) for females (Fig. 4). As can be seen from the Fig. 2, fish were fully recruited to the fishery at a size which was significantly smaller than the mean size at which fish reach its sexual maturity.

The overall sex ratio (M: F) was 1:1.03, not significantly different from 1:1. The result, as shown in Fig. 5, indicates that there was a peak in the Gonado-somatic index for both males and females *A. latus* in February, with the main spawning period enduring to June.

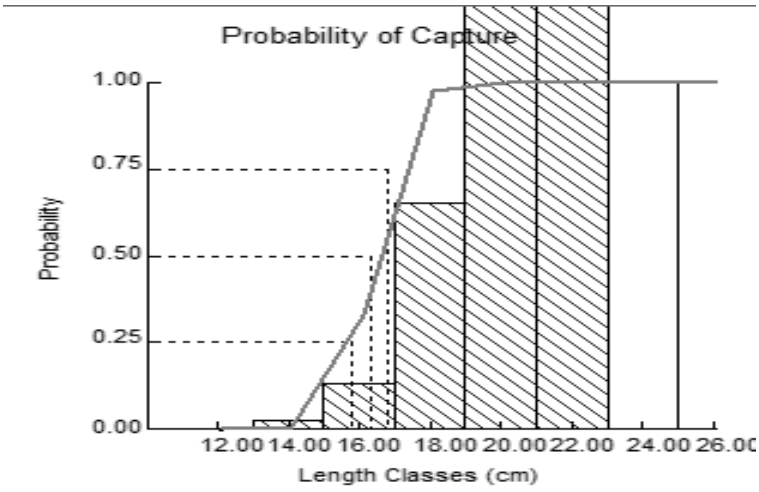

Figure 2: Analysis of capture probability for *Acanthopagrus latus* showing the average size at first capture at the probabilities of 0.5 (L_{50}), 0.75 (L_{75}) and the size at which fish are fully recruited to the fishery (L_{100}) in the Persian Gulf.

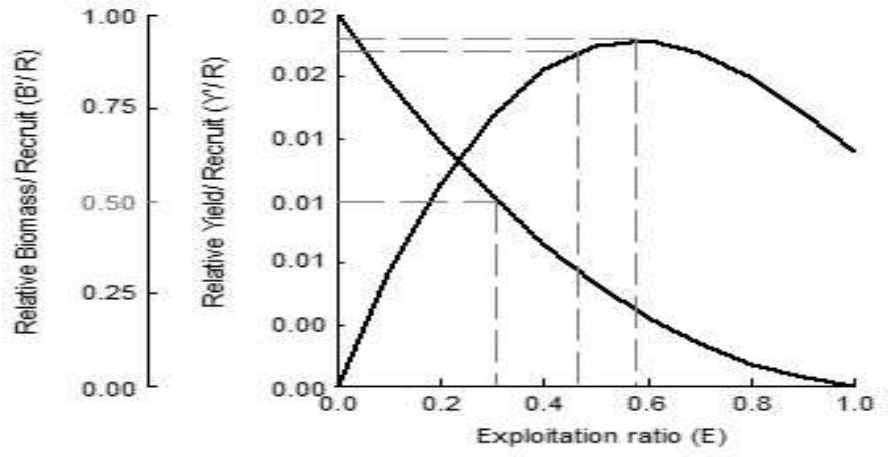

Figure 3: The relative yield and biomass per recruit from the knife edge selection of *Acanthopagrus latus.*

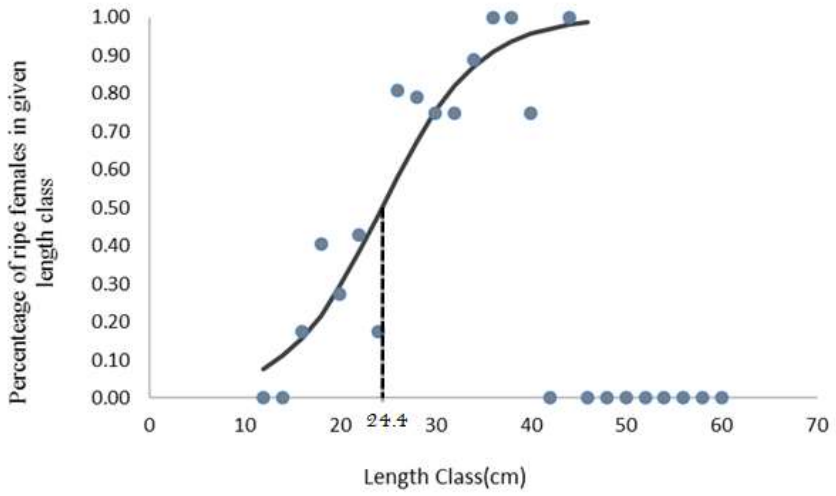

Figure 4: Changes in the proportion of mature *Acanthopagrus latus* females with size.

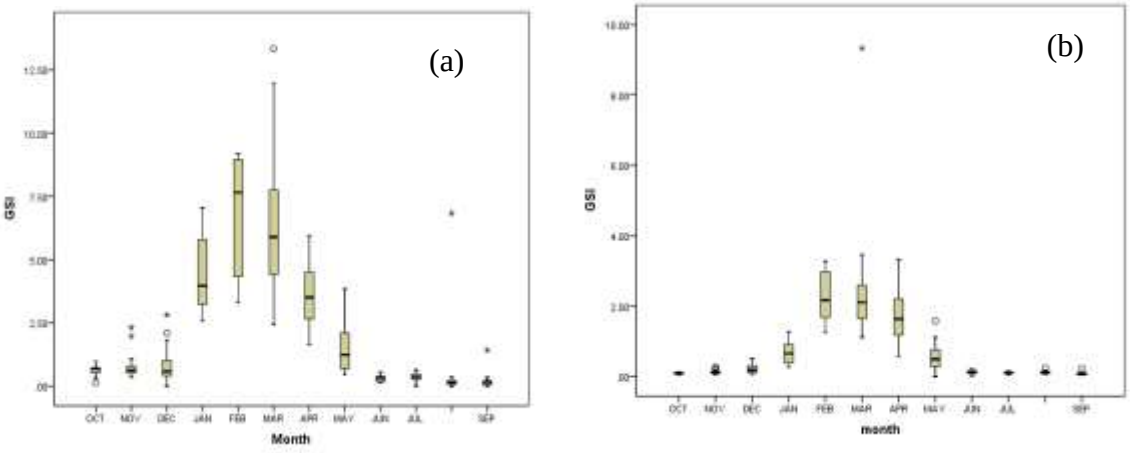

Figure 5: Mean monthly Gonado-somatic indices (Mean ±SE) for Female (a) and Male (b) *Acanthopagrus latus*.

Discussion

The present study has established key population parameters and biological characteristics of one of the commercial species from family Sparidae which are exploited in the Persian Gulf.

Based on the results of the current study and those reported by Grandcourt *et al.* (2004), it seems that *A. latus* like other species of family Sparidea is relatively long-lived fish. Our findings on growth parameter are also in agreement with Jarzhombek (2007) study who showed combined sexes with $L\infty$ = 52.4 cm and k = 0.17 per year, Mathews and Samuel (1991) and Morgan (1985) recorded a range of infinity length between 43 to 44.5 cm and growth rate between 0.23 to 0.23 per year, which consistency of our results with other research results.

Similarly, Grandcourt *et al.* (2004) noted, $L\infty$=55 cm and k=0.23 per year,

in the Abu Dhabi waters. Edwards et al (1985) recorded L∞=57.8 cm and k=0.21 per year in the Gulf of Aden, in the southern Persian Gulf, and Al-Mamry *et al*. (2009) recorded Loo=64.6 cm and k=0.14 per year for the *A.latus*.

The b exponent of the length-weight relationship obtained 2.57 which indicate a negative allometric growth status. The value of b exponent showed a slightly different with the finding of some previous studies. For example, Mathews and Samuel (1991) and Hussain and Abdullah (1977) reported a value of 2.79 and 2.85. It is important to note that points out that the parameters of L-W relationships in fishes are affected by factors such as, environmental conditions, gonad maturity stages, sex, stomach fullness, health condition, season, population and differences within species (Froese, 2006).

The length at first sexual maturity of female demonstrated that the gonad of *A. latus* at the length less than 24.4 cm begins maturation process and developing maturity stages. Results of the first length maturity for *A. latus* seem to be almost consistent with, Lee and Al-Baz (1989) who observed the value of 23.7 FL in the Kuwait waters.

According to the result of our study, females attained higher length and weight comparing with males, which is in agreement with other studies (Al Sakaff and Esseen, 1999; Grandcourt *et al.,* 2004). The finding may support hermaphroditism mechanism that is common among Sparids (dAncona, 1950; Atz, 1964).

The presence of mature fishes during the winter and spring months, and absence of spawning activity in the summer indicates that Sparid's species in Iranian waters have a prolonged spawning season. The spawning season spans February to Jun. This timing also agrees with spawning period observed for *A. latus* in the Persian Gulf by Karimi *et al.,* 2015, and Abou seedo *et al*. (2003) in Kuwait bay.

The results of the present study showed the exploitation of sparid species below the mean size which likely increase the risk of overfishing in the region. Therefore to sustainably harvest this species, it is necessary to give them chance to spawn 2-3 time before elimination from ecosystem.

The present level of exploitation rate of *A. latus* (E = 0.45) is close to the value produces the maximum relative yield-per-recruit (E_{max} = 0.46). Also the present level of exploitation rate was higher than the exploitation rate for *A. latus* ($E_{0.5}$ = 0.58) which maintains 50% of the stock biomass as spawning stock. To ensure that at least 50% of the individuals can be retained for spawning and recruitment, the present level of exploitation rate should be preserved.

We showed that the current exploitation rate (E) is lower than defined values of reference points i.e. $E_{0.1}$ and $E_{0.5}$. Accordingly, the stock of *A. latus* in the Persian Gulf appears to be safe, if the current fishing pressure is

maintained, Additionally, the results of length analysis showed a high frequency of immature fish in the composition of the catches, which indicate capture of fish before at least the first spawning event, therefore increasing the mesh size of the nets is suggested for sustainable exploitation and management of the fish stock.

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