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Some Biological Aspects of the Sharpnose Mullet *Liza saliens* (Risso, 1810) in Gorgan Bay-Miankaleh Wildlife Refuge (the Southeast Caspian Sea)

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Abstract

The present study investigated age, growth and reproduction of the sharpnose mullet *L. saliens* by regular monthly collection throughout one year from April 2002 to March 2003 in Gorgan Bay (the southeast Caspian Sea). Based on scale readings, the maximum ages of the population observed were 6^+ years for males and 7^+ years for females. Both sexes grew allometrically (b=2.478 males; b=2.545 females) and rapidly during first year, achieving more than 40% of their growth. The von Bertalanffy growth functions were $L_t=30.415(1-e^{-0.275(t+0.645)})$ for males and $L_t=34.832(1-e^{-0.211(t+1.009)})$ for females. Monthly examination of condition factor showed that similar condition cycle is evident in both sexes, peaking in May (1.135 for males and 1.136 for females). Overall sex ratio was balanced, but males were predominant in smaller sizes, and females in larger sizes. The GSI indicated that reproduction of sharpnose mullet in Gorgan Bay occurred around May-July, with the highest average value of 1.996 for males and of 5.973 for females in June. Absolute fecundity varied from a minimum of 135014 for age 3^+ to a maximum of 389790 eggs for age 7^+. The absolute fecundity to fish size (length and weight) and age were positively correlated.

Key words: Liza saliens, age and growth, reproduction, Gorgan Bay, Caspian Sea.

Introduction

Mullets have a world-wide distribution and inhabit mainly tropical and temperate seas. In total, family Mugilidae includes 17 genera and 80 species in the world (Nelson, 1994). Three Mugilid species including golden mullet *Liza auratus* (Risso, 1810), sharpnose mullet *Liza saliens* (Risso, 1810) and striped mullet *Mugil cephalus* Linnaeus, 1758 were first transplanted from Black Sea to the Caspian Sea between 1930 and 1934 by the Soviet authorities (Dmitriev, 1964; Berg, 1965) and the first two species are now common in the Iranian coast of Caspian Sea and get their maturity earlier than those inhabiting the Balck Sea (Beliaeva *et al.*, 1989). Along southeast Caspian Sea, Sharpnose mullet occurs in the Gomishan wetland, Gorgan bay and coastal sea areas frequently (Kiabi *et al.*, 1999a; Naderi and Abdoli, 2004). Despite its abundance, sharpnose mullet, because of its small size in comparison with other commercial target species especially golden mullet, has a limited economic value in Iran. It is captured all year around with significant seasonal differences in the landings (Ghadirnejad *et al.*, 1993).

The references available on the biology of sharpnose mullet in the Iranian waters of the Caspian Sea are that of Fazli (1999) and Irani (2001) who studied age, growth and reproduction in the coastal sea areas of southeastern Caspian Sea and Gomishan Wetland (the southeast Caspian Sea) respectively. In addition, Ghaninejad *et al.* (1993) and Ghadirnejad and Ryland (1996) investigated stock variations and feeding of sharpnose mullet in the southern Caspian Sea, respectively. However, no study so far has been made on sharpnose mullet biology in Gorgan Bay (the Southeast Caspian Sea).

Sharpnose mullet is among the most abundant fish occurring in the coastal lagoons, estuaries and open sea areas of the south Caspian basin (Kiabi *et al.*, 1999a; Naderi and Abdoli, 2004; Abbasi *et al.*, 1998). Within such a broad distribution, the species populations are subject to variety of environmental conditions, resulting in variations in life history parameters. In spite of its abundance, information is still too scarce to provide us with a detailed life history of the species in its whole distribution range in the south Caspian Sea. Many studies have shown phenotypic plasticity of life history traits not only between different stocks but also within the same stock among its different components (Fernandez-Delgado and Rossomanno, 1997). Therefore, this paper attempts to test whether sharpnose mullet population in Gorgan Bay that is the main part of Miankaleh Wildlife Refuge (Scott, 1995; Kiabi *et al.*, 1999b), has its own life history characteristics, especially those related to growth and reproduction. The findings may serve as a guideline for management actions and conservation programs in the Miankaleh Wildlife Refuge.

Study Area

The present study was carried out in Gorgan Bay, a main part of Miankaleh Wildlife Refuge. The bay is a large, shallow, brackish inlet (S‰=12.56-14.95) at the extreme southeast corner of the Caspian Sea (Figure 1), almost totally cut off from the open sea by the 60 km long sandy peninsula except at its eastern end. The whole part of the bay is protected in the Miankaleh Wildlife Refuge. The bay has a surface area of about 23,000 ha, maximum depth of 3.8 m in the eastern parts, and has a muddy bottom. It receives freshwater inflow from a number of seasonal small streams rising on the humid north slope of the Alborz Mountain to the south (Kiabi *et al.*, 1999b; Scott, 1995).

Material and Methods

Between April 2002 and March 2003, a total of 573 specimens were captured monthly. Fish were sampled with gillnets (20m long and 2m depth) of various mesh size (16, 18, 20, 22, 24, 28, 32, 36, 40, 45, 50, 55 mm knot to knot). Each unit of effort consisted of 24 overnight gillnet sets containing two gillnets of each mesh size with equal lengths and depths which were set in the mid parts of the bay randomly, maintaining a space of 2 m. In the laboratory, total length was measured to the nearest mm for all fish sampled. Total weight, ovary weight and its sub-samples were recorded by an electronic analytical balance (±0.001 g). 5-7 scales were removed from a standard position (second-third rows of scales just under the front edge of dorsal fin) from right side of the body (Mann, 1973). Scales were mounted on glass slides and reviewed for banding patterns using a binocular microscope under reflected light at 10-25×. Growth annuli from each glass slide were counted three times, each time by a different person. The relationship between the total length and total weight were determined by fitting the data to a potential relationship in the form of $W=aL^b$, where W is the weight in grams, L the total length in centimeters, a and b are the parameters to be estimated, with b being the coefficient of allometry (Pauly, 1984). The lengths were back-calculated with the equation $L_i=S_iS_c^{-1}(L_c-c)+c$, where L_i is the total length of the fish at age i, L_c the total length of the fish at capture, S_i the largest radius of the scale at age i, S_c the largest radius of the scale at capture and c intercept of the regression of body lengths on scale radius (Johal *et al.*, 2001). The condition factor (Kn) was calculated monthly by $Kn=W/aL^b$ (Biswas, 1993). The growth model adopted was the specialized von Bertalanffy growth function, whose expression is: $L_t = L_\infty(1 - e^{-k(t-to)})$ with L_∞ being the predicted asymptotic length, L_t the size at age t, k the instantaneous growth coefficient, and t_o the point at which the von Bertalanffy curve intersects the age axis. The parameters were estimated using the method of Ford-Walford (Everhart and Youngs, 1975) and phi-prime (ϕ') was used to study overall growth performance (Munro and Pauly, 1983): $\phi'=\ln K+2\ln L_\infty$.

Sex was determined by examination of the gonad tissue either with eye or with the aid of a binocular (25-40×). The number of eggs (fixed in Gilson's fluid to facilitate the separation of eggs) was estimated by gravimetric method (Bagenal, 1978). To determine the number of eggs, pieces were removed approximately 0.02 g each, from the anterior, medial and posterior positions of both ovarian lobes. The pieces were weighed and the eggs in them counted under a binocular microscope. The number of eggs in each female, absolute fecundity was calculated as the proportion of eggs in the sample to the weight of the whole ovary. To calculate fecundity, ovaries recognized as IV or V stage were used. The stage of gonad maturity was determined visually following the

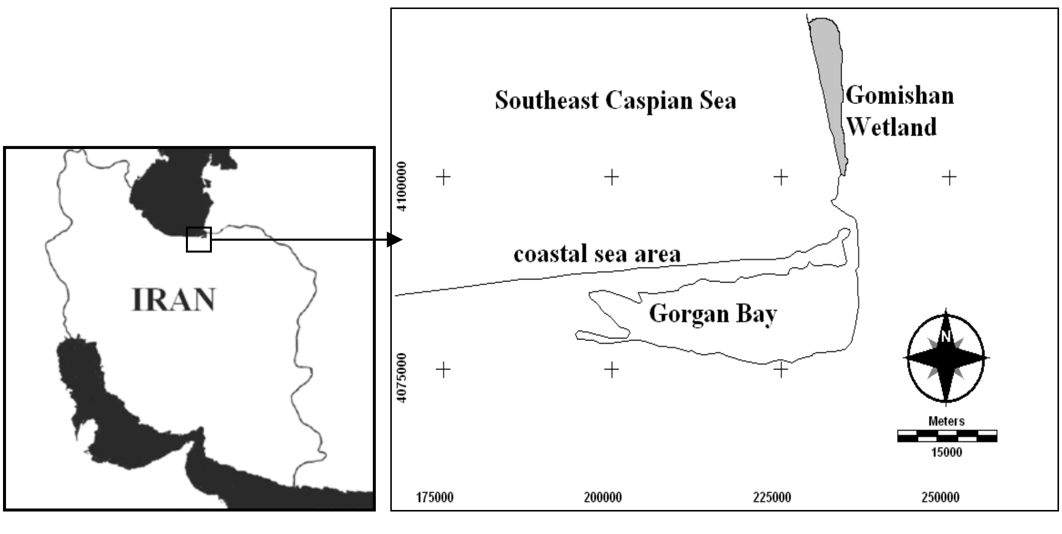

Figure 1. Location of Gorgan Bay in the southeast Caspian Sea.

Nikolsky scale (1963). Gonadosomatic index (GSI %) = (gonad weight / total body weight)×100 was calculated for each fish and all values were averaged for each sampling date.

An analysis of co-variance (ANCOVA) was performed to test significance differences in length-at-age and exponents of length-weight relationship between sexes (Zar, 1984). The significance of any difference of *b* from 3 was tested by using the equation given by Pauly (1984). Comparison of GSI values during reproductive period, condition factor between sexes, and its temporal variation in each sex carried out by analysis of variance (ANOVA). The overall sex ratio was assessed using Chi square test (Zar, 1984). Statistical analyses were performed with SPSS 11.5 software package and a significance level of 0.05 was adopted.

Results

Age, Growth and Condition

During 12 sampling efforts, a total of 573 specimens were sampled. The size of the male individuals ranged between 15.10 and 28.20 cm, and females between 15.50 and 31.50 cm. Scale readings, which were validated by opercula and cleithra readings revealed that the oldest ages recorded were 7^+ for females and 6^+ for males. There were no 1^+ aged specimens in the catches. Observed length-at-age were significantly different between sexes (ANCOVA, F= 174.51, P<0.05), with females being longer than males. The length frequency distribution of the fish from Gorgan Bay (Figure 2) indicated that the most frequent size classes in the samples were 19 cm and 20 cm both belonging to the 3^+ years old specimens, represented by 14.52% and 19.32% of total specimens for females and males, respectively.

The relationship between somatic weight and total length of the fish (Figure 3) were calculated separately for male and females. Significant differences were obtained between the *b* exponents and 3 for isometric growth in the sexes separately (t-test, t_{male}= 4.52, t_{female}=3.67, P<0.05), indicating negative allometric nature of growth (b<3) in the population. Moreover, there was a significant difference in the *b* exponent between males and females (ANCOVA, F=7.11, P<0.05).

Mean back-calculated total length-at-age showed rapid growth during the first year of life (43.09% in males and 41.15% in females). However, there was a sharp decline in growth in the following years (Table 1). The mean back calculated total lengths of each group were smaller than observed lengths. The von Bertallanfy growth parameters were estimated as: L_∞=30.415cm, K= 0.275 year^{-1}, t_0 = -0.645 years for males, and L_∞ =34.832cm, K=0.211 year^{-1}, t_0=-1.009 for females. The values of L_∞ were higher than the maximum observed lengths (Figure 4). The ratio between maximum recorded lengths (L_{max}) and asymptotic length (L_∞) were 0.927 and 0.904, and growth index ϕ' were 5.539 and 5.545 for males and females, respectively.

Significant changes were observed in the temporal variation of somatic condition (ANOVA, F=506.25, P<0.05) and almost a similar condition cycle was evident in both sexes (Figure 5). In fact, two phases could be identified in the condition cycle in both sexes: the first phase takes place from January to July, reaching a maximum in May (1.135±0.117 for males and 1.136±0.188 for females) which coincides with beginning of the spawning period in the area under consideration; second phase, from July to January, peaking in October (1.107±0.079 for males and 1.100±0.109 for females). Minimum values of condition factor were observed in July (end of spawning season) and January (almost the coldest period in the study area). A comparison of fish condition between sexes in each of different phase pointed to no significant differences (ANOVA, F=1.40, P>0.05).

Sex Ratio and Reproduction

Even though the number of females was slightly higher than that of males in sharpnose mullet samples

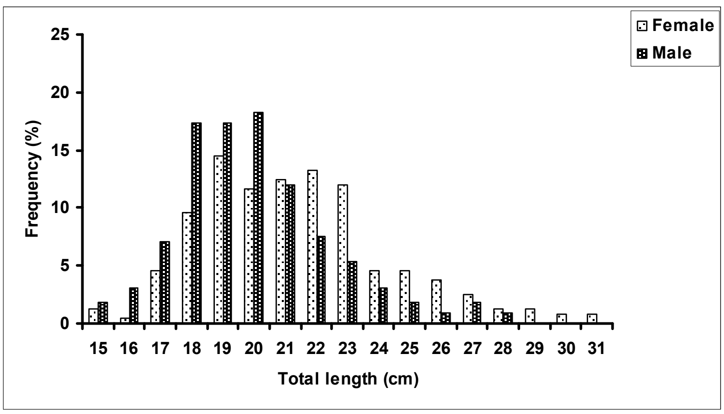

Figure 2. Length frequency distribution for sharpnose mullet *L. saliens* from Gorgan Bay (the Southeast Caspian Sea).

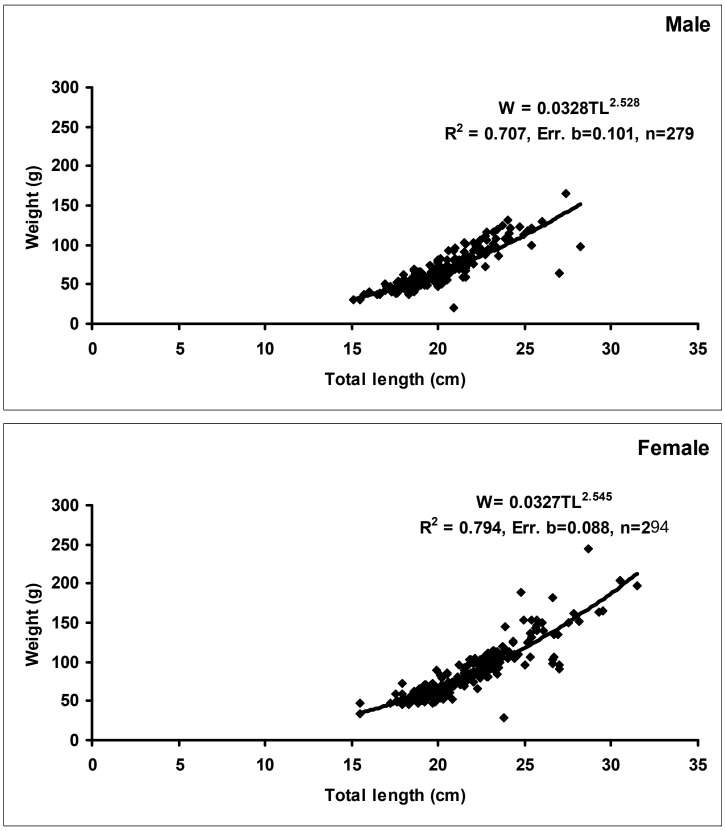

Figure 3. Length-weight relationship curves for males and females of sharpnose mullet *L. saliens* from Gorgan Bay (the Southeast Caspian Sea).

Table 1. Back-calculated total lengths (cm) at age for sharpnose mullet *L. saliens* from Gorgan Bay (the Southeast Caspian Sea)

	Age (years)						
	1	2	3	4	5	6	7
Male							
Mean observed TL(cm)	---	16.144	19.286	22.341	23.760	25.644	---
Back-calculated TL(cm)	11.011	15.837	18.950	22.074	23.704	25.555	---
Female							
Mean observed TL(cm)	---	16.817	20.224	23.217	24.820	26.061	28.527
Back-calculated TL(cm)	11.71	16.342	19.199	22.989	24.601	25.970	28.454

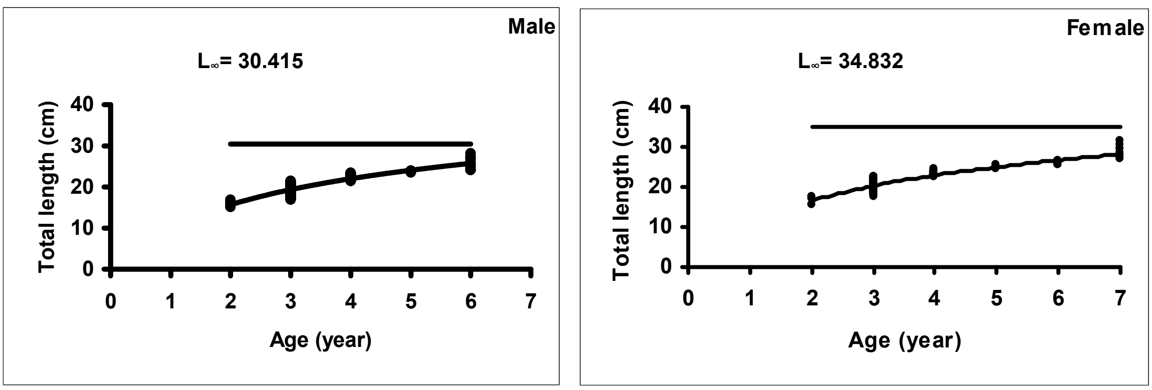

Figure 4. Relationship between total length and age of sharpnose mullet *L. saliens* from Gorgan Bay (the Southeast Caspian Sea).

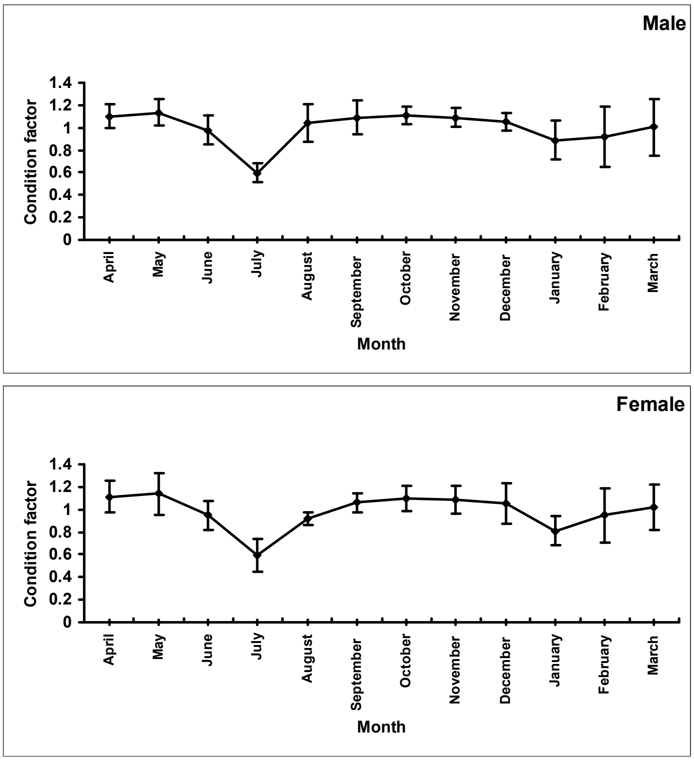

Figure 5. Monthly mean condition factor distribution of sharpnose mullet *L. saliens* from Gorgan Bay (the Southeast Caspian Sea).

collected in this study, the overall sex ratio was not different from 1:1 (χ^2= 0.393, P>0.05). Gonads were macroscopically visible for individuals ≥16.90 cm TL for males and ≥ 17.60 cm TL for females corresponding to 3^+ years old specimens. Following the seasonal cycle of the gonadosomatic index (Figure 6), three phases were identified in gonad activity: quiescence, maturation and the reproduction phase. The ovary began to develop between February and May after a quiescent period of 6 months (August - January). Reproduction phase is extended and last from May to July, peaking in mid June, with the highest average values of 1,996 for males and of 5,973 for females. It thereafter decreases sharply in August. The GSI of both sexes followed the same pattern, but during the reproductive period, the average values of males were significantly lower than those of females (ANOVA, F=131.293, P<0.05).

Absolute fecundity determined on 71 ripe females caught in June and July increased from ages 3^+ to 7^+. A maximum value of 389,790 eggs was recorded in a 7^+ year old fish weighing 197.32 g and a minimum value of 135,014 eggs was calculated for a 2^+ years old fish weighing 66.64 g. The absolute fecundity to fish size (length and weight) and age were positively correlated (Figure 7).

Fecundity relative to total weight fluctuated from 1,364 to 4,281 eggs/g, with a mean value of 2,225.438 ± 493.1646 (SD) (CV= 22.160), and relative to total length from 6,854 to 12,993 eggs/cm, with a mean value of 9,659.254 ± 1,616.4204 (SD) (CV= 16.73). The relationships of relative fecundity (per gram) with body size (either to length or weight) and age were not found to be statistically significant (R^2<0.50, P>0.05).

Discussion

The scales that are highly readable were chosen in this study in order to facilitate comparison with available studies using the similar method for aging this species in the south Caspian Sea (Fazli, 1999; Irani, 2001). The maximum length (TL) observed in Gorgan Bay was 31.50 cm, corresponding to a 7-year-old female. This species was reported from the coastal sea areas of southeast Caspian Sea to reach 32.90 cm FL with age of 8^+ years (Fazli, 1999).

In this study, the most abundant age group in the catches was 3^+, which is in agreement with findings of Irani (2001), who found that most individuals were 3^+ years old in a population from the Gomishan wetland, located at a distance about 30 km from the bay. The maximum age of *L. saliens* in this study was less than that of observed by Fazli (1999) and Irani (2001) in the southeast Caspian Sea. Fazli (1999) found a maximum age of 8^+ years for sex combined samples in the coastal sea areas of southeast Caspian Sea, and Irani (2001) noted the maximum age of the mullet to be 6^+ years for males and 8^+ years for females in the Gomishan wetland.

The estimated *b*-values (b= 2.478-2.545) in our study differ from the results reported by Fazli (1999) and Irani (2001). Fazli (1999) found a negative allometric growth (b=2.940) for sex combined

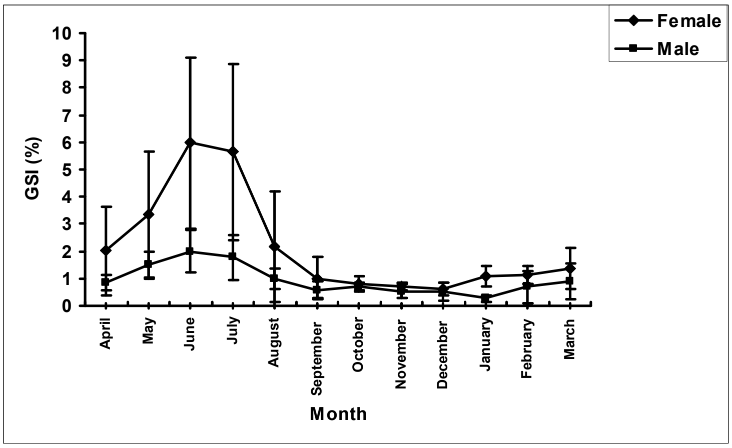

Figure 6. Monthly distribution of GSI in sharpnose mullet *L. saliens* from Gorgan Bay (the Southeast Caspian Sea).

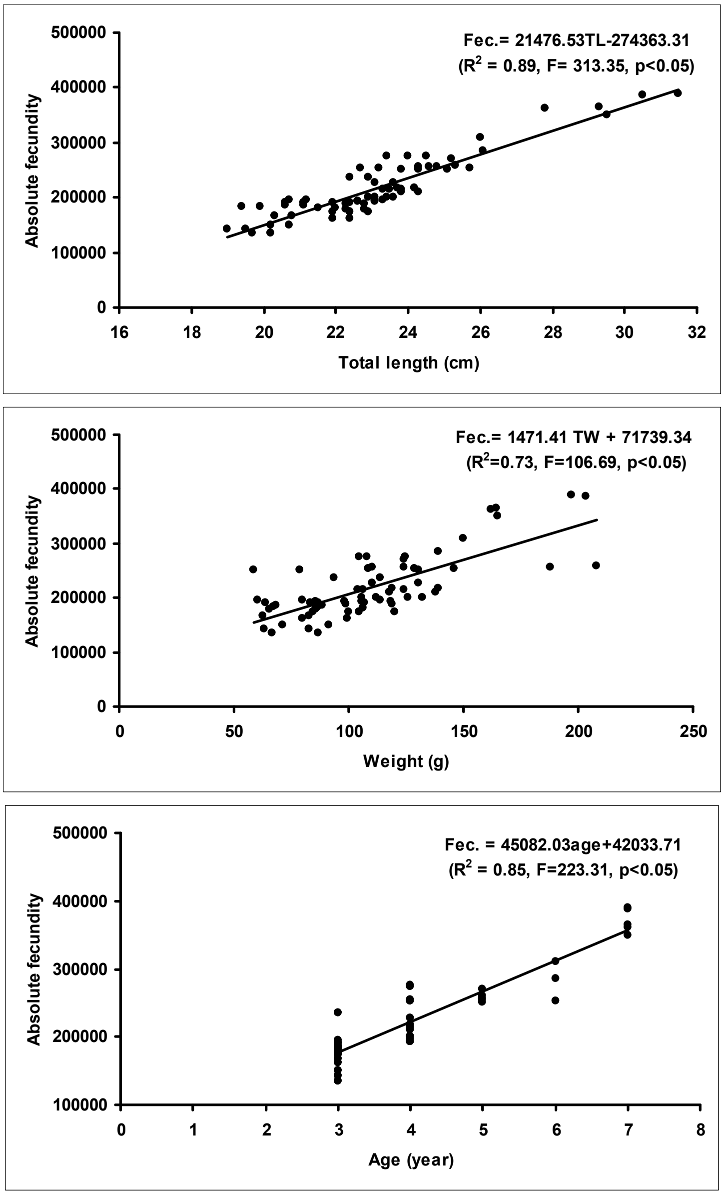

Figure 7. Relationship between egg number and fish length, total weight and age in sharpnose mullet *L. saliens* from Gorgan Bay (the Southeast Caspian Sea).

samples using fork length-weight relationship in the southeast Caspian Sea: but Irani (2001) who studied the total length-weight relationship of this species in the wetland of Gomishan, reported positive allometric growth (b_{male}=3.015, b_{female}=3.108) for both sexes. This variation in the *b* exponent could be attributed to the different environmental conditions and nutrition state that vary between sites and influence as local selective pressure on the populations. Different *b*-value among neighboring sites apparently suggest a different fish condition or fitness. Specimens of *L. saliens* caught in Gorgan Bay seem to have a worth fitness (*b*<) than those from coastal sea areas of the southeastern Caspian Sea and Gomishan wetland.

In the present study, theoretical asymptotic length seems to be realistic, since the largest specimens sampled during the survey were smaller than those calculated asymptotic lengths for both sexes. The L_∞ value of female was calculated to be higher than that of males. The reason for this may be that females grow faster than males and live longer (Weatherly, 1972). The higher coefficient (*k*) for males emphasizes that they grow rapidly initially and approaches their asymptotic length (L_∞) earlier in life. In Gorgan Bay, asymptotic lengths calculated for each sex separately were higher than those reported for the population from the Gomishan wetland. According to Irani (2001), the growth parameters of von Bertalanffy growth function were estimated as L_t=28.22 (1-$e^{-0.54(t-0.66)}$) and L_t=29.324(1-$e^{-0.46(t-0.34)}$) for males and females, respectively. Fazli (1999) calculated the equation as L_t=32.24 (1-$e^{-0.362(t-0.013)}$) for combined sexes in the coastal sea areas of the southeastern Caspian Sea.

The index of growth performance (ϕ') is to be considered as a useful tool for comparing the growth curves of different populations of the same species and/or of different species belonging to the same family (Sparre *et al*., 1987). In general, the values of the growth performance index from different geographical areas show that growth patterns are different for the different stocks, but similar for the stocks of neighboring localities. Calculated from the data of *K* and L_∞ (Fazli, 1999; Irani, 2001), the index was 5.93 for sexes combined from the coastal sea areas, and 6.06 for males and 5.98 for females from the Gomishan wetland, which are almost close to that for Gorgan Bay population. This evidence confirms the reliability of the sharpnose mullet growth curves, as the overall growth performance had a minimum variance among neighboring populations.

The ratio of L_{max} to L_∞ is an important parameter in the context of life history theory (Stergio, 2000). The computed values for sharpnose mullet in Gorgan Bay were 0.927 and 0.904 for males and females respectively, while according to Irani (2001), the values of L_{max}/L_∞ ratio are 0.946 for males and 0.979 for females.

The range of values of condition factor observed for females in this study was different from that given for sharpnose mullet population from the Gomishan wetland (Irani, 2001), which is between 0.65 and 1.15. In addition, the condition cycle of the population under consideration is not similar to that reported by Irani (2001). He did not observe a decline in *CF* in January, and the observed second peak in *CF* of sharpnose mullet population in Gorgan Bay was in August-November (growing season).

During this study, sex ratio did not differ significantly from parity, while Fazli (1999) and Irani (2001) proposed the dominance of females (male: female ratio of 1:3.17 in Gomshan wetland and of 1:3.14 in southeastern coastal sea areas of Caspian Sea). In the present study, females were dominant only in older age groups.

There is a widespread trend for fecundity in fish to be positively correlated with length (Peters, 1983) and the fecundity-body weight relationship can probably be used to discriminate between the different stocks of the same species of Mugilid fish due to variable growth rates in different localities (Alvarez-lajonchere, 1982). Fecundity of sharpnose mullet was positively correlated to fish size (length or weight). Maximum and mean fecundities (absolute and relative) estimated in this study were less than the values obtained previously by Fazli (1999) and Irani (2001) (Table 2). Fecundity is affected by many factors, such as the size and age of the females (Thrope *et al*., 1984), life history strategy (Morita and Takashima, 1998), food supply and temperature (Fleming and Gross, 1990). Information on these topics for studied regions in the southeast Caspian Sea is not sufficient to be discussed.

Related to differences in the GSI between reproductively active males and females, in reviewing the reproductive biology of the mugilids it is noted that values of males are commonly lower than those of females. Buxton (1990) pointed out that the cost of producing sperm is thought to be less than for producing eggs. The difference in male and female gondosomatic indices suggests that energy invested in gamete production by male is probably less than that invested by females. Fazli (1999) and Irani (2001) calculated markedly higher GSI values (the highest

Table 2. Results of fecundity for sharpnose mullet *L. saliens* from Gorgan Bay (the southeast Caspian Sea)

Author	Absolute Fecundity		Relative Fecundity	
	Range	Average±sd	Range	Average±sd
Fazli (1999)	----	387,000	---	----
Irani (2001)	166,144-587,230	352,922±103,893	1,950-4,161	3,147.1±533

average value of 6.40 for females from the coastal areas of southeastern Caspian Sea, and the highest average value of 2.9 for males and of 6.8 for females from the Gomishan wetland) than in this study. Lower GSI values coupled with lower fecundity in Gorgan Bay could be interpreted as lower energetic investment in reproduction.

In conclusion, the life-history pattern of sharpnose mullet in Gorgan Bay differs markedly from those of other the southeastern Caspian Sea populations of the species (Fazli, 1999; Irani, 2001), and is characterized by high growth rate during first year of life (>40% TL), reduced lifespan (6^+ for males; 7^+ for females), significant temporal variation in the condition factor, low number of egg production (low absolute fecundity) and low reproductive investment (low GSI). There are several possible explanations for the varied life history parameters. Habitat quality is an important factor on the growth of fish, but information to assess this hypothesis is unavailable. Furthermore, information on the effect of illegal fishing on recruitment and migration pattern of sharpnose mullet in Gorgan Bay is also lacking. Therefore, comparison of growth estimates should be taken with caution for the populations from the southeast Caspian Sea.

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