Reproductive biology of the golden grey mullet, *Liza aurata* in the Iranian coastal waters of the Caspian Sea

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Abstract

The paper focuses on some of the biological characteristics of the golden grey mullet, *Liza aurata* in the Iranian waters of the Caspian Sea. Samples of commercial catch of mullet obtained by means of beach seine fishing cooperatives along the Iranian coasts of the Caspian Sea (2007-2008) as monthly interval. Samples were subjected to biometric measurement to specify their biological characteristics. The male/female ratio in the present study was 1:1.22 which deviated significantly from 1:1 common sex ratio (X2=7.7, Sig, level=0.006). During this study, the peak of the spawning time for the golden grey mullet occurred in October in waters off- Gilan shore whereas it occurred in November off Mazandaran and Golestan provinces. The highest Gonado-Somatic Index (GSI) was found to occur during late September and October which declined to its lowest level in November and December and remained relatively stable during January to April. Therefore, spawning of *L. aurata* started earlier in Gilan and ended later in Golestan Province. The average absolute fecundity of the golden grey mullet was 700881±429987 (±SD) eggs with a range of 200112 to 2282862 eggs. The length of females at 50% sexual maturity of the golden grey mullet was estimated 28.4 cm.

Keywords: *Liza aurata*, Gonado-Somatic index, Fecundity, Sex ratio, Caspian Sea, Iran

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Introduction

The golden grey mullet, *Liza aurata* (Risso,1810), are found in the Atlantic Ocean, from England up to the South Africa, Mediterranean, Black and Azov seas (Kuliev and Ragimov, 2003). Mullet are not native species of the Caspian Sea and in order to increase fish productivity of this water body, 3 million individual of *Liza aurata*, *L. saliens* and *Mugil cephallus* were caught from the Black Sea and were introduced into the Caspian Sea during 1930-34 (Konovalov, 1959; Oren, 1981; Belyaeva et al., 1989; Kosarev and Yablonskaya, 1994). In general, during the past 65 years, mullet catch in the Iranian waters has undergone fluctuations with an initial increase and a catch obtain of 138000 tones. Between 1995 and 2006, the mullet catch composition from the Caspian Sea was also greatly changed from 76% to 98% (Fazli and Ghaninejad, 2004). Based on the report by Tereshenko (1950), the male golden grey mullet reach maturity at the age of 3 followed by female fish which attains sexual maturity at the age of 4. The spawning peak for mullet in the Caspian Sea occurs in late August (Avanesov, 1972). Abdoli et al. (1996) studied the fecundity and sexual maturity of the golden grey mullet in the eastern part of the Iranian waters of the Caspian Sea. Population dynamics and biology of this species was also investigated by Ghadirnejad (1996). Sexual maturity of the species in the western part of the Iranian waters of the Caspian Sea (off Gilan Province) was studied by Abdolmakaki et al. (1998). In addition, Fazli et al. (2008) also investigated the fecundity and sexual maturation of the golden grey mullet in the Iranian waters of the Caspian Sea. Considering the ecological changes occurred in the Caspian Sea and the increase in golden grey mullet landings, attempt was made in this research to shed more lights to the reproductive biology of the species.

Materials and methods

The commercial catch of bony fish including golden grey mullet along the Iranian waters of the Caspian Sea is carried out through beach seine operation by cooperatives in fishing region (Fig. 1).

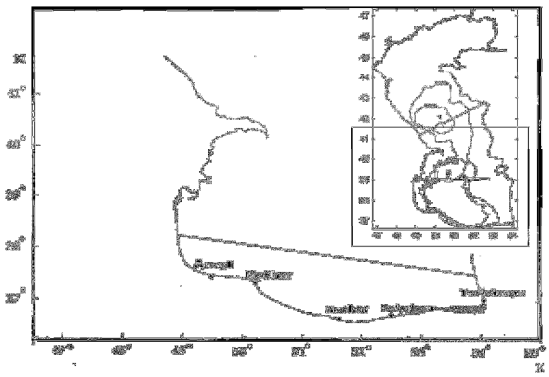

Figure 1: Map of the Caspian Sea showing the location of fishing regions in the Iranian coastal waters

Sampling was carried out weekly from beach seine cooperatives (with 30 mm mesh size in code end) in the Iranian coastal waters of the Caspian Sea during

2007-2008. In this study, a total of 669 *Liza aurata* were examined. For each sample, the fork length (FL) was measured to the nearest 0.5 cm and the total weight (W) to the nearest 5 g. Age was determined by reading scale rings under a stereoscopic zooms microscope at 40x magnification. Age was determined on the basis of formed annular counts. From each specimen, scales were removed from the second row of scales just under the front edge of the first dorsal fin from the left side of the body (Chugunova, 1959).

The overall sex ratio of males to females was evaluated with $\chi 2$ - test (0.05) (Sokal and Rohlf, 1995). Sexual maturation, were determined via the six-stage maturation criteria (Haddy and Pankhurst, 1998). In order to determine fecundity, ovaries from 57 ripe females (stage V and VI) covering the available size range of individuals collected during the study, were used. Whole fixed ovaries weighed to the nearest 0.001 g. A small section of ovaries was removed midway along the length of either the left or right ovarian lobe (chosen at random), weighed (0.5–0.7 g) and then placed in a separate Petri dish with 70% alcohol solution. The eggs in each sample were separated using scalpel and forceps and then were counted. The absolute fecundity calculated using the gravimetric method (*i.e.*, simple proportion; Hunter et al*.,* 1985).

GSI was calculated for each fish according to the following formula:

(GSI %) = (gonad weight/total body weight) X 100

and all values were averaged monthly. For this calculation, fish samplings was done from August till April next year (It is to be noted however, that due to the lack of commercial catch and the required research fishing facilities during May-July, it was impossible to have access to golden grey mullet samples during these months).

The length at 50% of maturity was calculated through devising a logistic trajectory on the proportion of the matured female and the fork length which was computed through the following logistic equation (King, 2007):

$P=1/1+\exp [-r (L-Lm)]$

Where:

r, represents the slope of the trajectory.

Lm, the mean length in sexual or length maturity which is equal to 50% ratio under reproductive condition.

The $\chi 2$ test was utilized for specifying the sex deviation ratio from the 1:1 ratio. SPSS and Excel software's were used for data analysis.

Results

The length of the mullets ranged from 19 to 50.2 cm with the mean of 32.7 ± 6.4 cm and their weight also varied from 67 up to 1475 g with the mean weight of 411 ± 255 g. The age range of the examined fish was from 2 to10 years with mean age of 4.42 years. The age groups of 3, 4 and 5 years constituted 62% of the age composition.

The male: female ratio of the population of golden grey mullet was 1:1.22 in this study showing that sex ratio deviated significantly from1:1 ($\chi 2$=7.7, Sig.level=0.006). The sex ratio did not show any significant difference during November, January, February and April to that of the typical 1:1 ratio, whereas it was significantly different from the 1:1 ratio for the rest of the year.

Meanwhile the male: female ratio of the examined fish in Gilan and

Mazandaran provinces were 1: 0.9 and 1:1.28, respectively. The sex ratio of the golden grey mullet in these provinces did not deviate significantly from 1:1 ratio (Gilan : $\chi 2$=1.36, Sig. level = 0.243 and Mazandaran: $\chi 2$=2.08, Sig. level= 0.149, respectively). But this ratio in Golestan Province was 1:0.46 which was significantly different from 1:1 ratio ($\chi 2$=25.5, Sig. level= 0.000).

Table 1 shows the sex composition of the golden grey mullet in different age groups. The male fish account for the bulk of the sex composition in younger age groups whereas the female constitute the greater share of population in age group of 6-10 years old. The peak of *L. aurata* spawning in waters of Gilan Province occurred in October, whereas in Mazandaran and Golestan provinces spawning took place in November. The most proportion of spawning in December was in Golestan Province.The highest value of Gonado-Somatic Index (GSI) both in males and females observed in September and October, whereas it declined during November and December and remained relatively stable during January till April (Fig. 3).

Table 1: Sex composition (%) of *L. aurata* in the present study

Age groups(year)	Females	Males
2	46	54
3	36	64
4	53	47
5	42	58
6	66	34
7	92	8
8	75	25
9	60	31
10	100	-

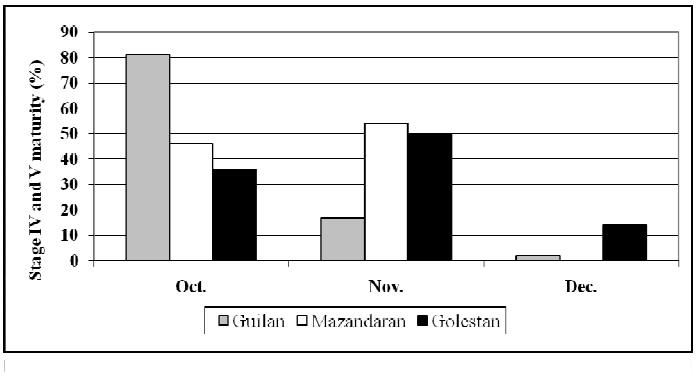

Figure 2: Spawning condition of *L. aurata* in autumn 2007 in Gilan, Mazandaran and Golestan provinces

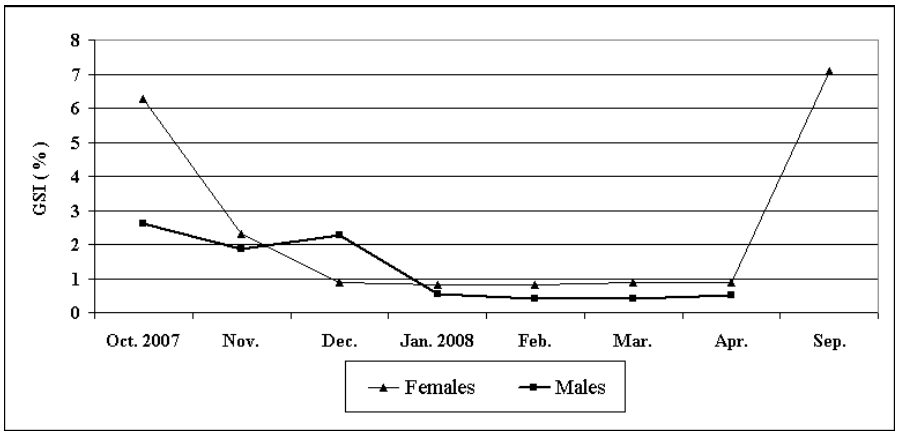

Figure 3: The trend of monthly variations of GSI in male and female of *L. aurata* in the Iranian coats of the Caspian Sea

The mean absolute fecundity of the golden grey mullet was 700881±429987 eggs with range of 200112 to 2282862 eggs as the minimum and maximum number, respectively. The mean absolute fecundity of the golden grey mullet in provinces of Gilan was 919237±539383 eggs, in Mazandaran 678732±437819 and in Golestan 587434±252249 eggs. No significant difference was found between different provinces (F=1.84, sig. level=0.169).The average length and weight of the examined fish were 34.6 cm and 522 g, respectively. The smallest spawner *L. aurata* had a length and weight of 23.6 cm and 180 g, respectively, whereas the figures for the largest sample fish were 47.8 cm and 1082 g, respectively.The mean relative fecundity of *L. aurata* amounts to 1363± 519 pieces of egg with 354 and 3126 pieces of eggs per one gram of body weight, respectively.The relationship between fork length and fecundity of *L. aurata* was F=50203.73 FL-1043288.25 (Fig. 4, R2=46%, n=56). As illustrated in the Figure 4, the absolute fecundity has positive correlation with fork length. The result of the analysis of covariance showed that the interaction of province and the logarithmic fork length on absolute fecundity was not significant (R2=%50.8, P=0.605), thus making it possible to consider a common regression slope for all the above-mentioned provinces.The relationship between body weight and absolute fecundity of *L. aurata* was as follows: F=1216.7w-58286 (R2=0.52, n=56). There also appeared to be a positive relationship between fecundity and body weight of the *L. aurata* in such a way that the fecundity increased as body weight increased. The relationship between the number of eggs per each gram of golden grey mullet's ovary (egg/g) with condition factor (CF) was as follow:

Egg/g= -10720CF+25979
(R2=0.06, n=56).

Obviously there is negative correlation between the CF and the number of eggs per each gram of the fish's ovary. Fitting the logistic equation for the female maturity data gave an estimate of Lm50 =28.4cm for *L. aurata* in the Iranian waters of the Caspian Sea (Fig. 5)

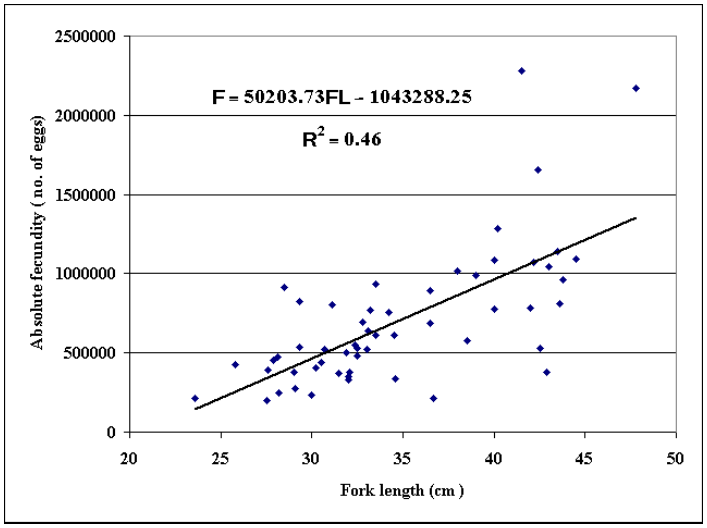

Figure 4: Relationship between absolute fecundity and fork length (FL) for *L. aurata* in the Iranian waters of the Caspian Sea

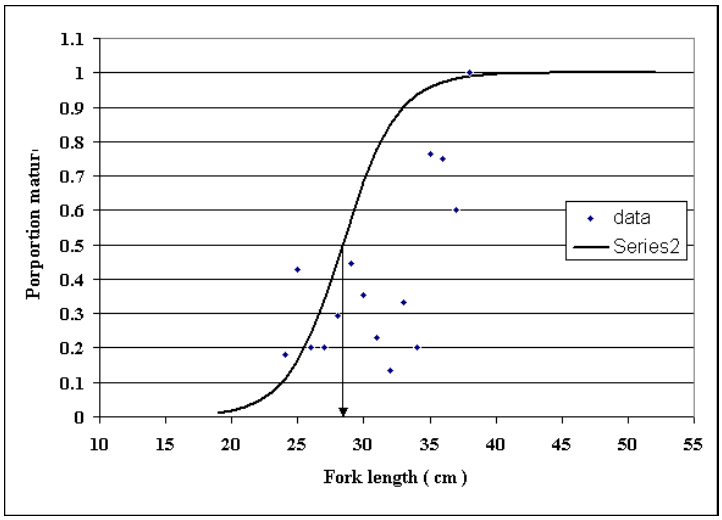

Figure 5: Fork length of female *L. aurata* at 50% maturity (Lm50) in the Iranian waters of the Caspian Sea

Discussion

The male: female sex ratio in this study shows there is not a homogenous sex composition among the mullet catch within species and age groups. Abdolmalaki et al. (1998) reported that females *L.aurata* constituted 80% of the mullet landings in the western part of the Gilan coastal waters. In addition Ghadirinejad (1996) reported that females constitute 73% of sex composition of golden grey mullets catch in the Iranian coastal water of the Caspian Sea.

According to Belyaeva et al. (1989), the females account for 82% of the mullet landings. But in recent years, the sex composition of females decreased in the catch and closed to the typical 1:1 ratio. The research carried out in coastal

waters of Mazandaran Province in Oct 1993 showed that the sex composition of the females in the catch was 61.5 (Abdoli et al., 1996). The mean sex composition of females in republic of Dagestan was about 65% (Abdolsamadove et al., 2004).

In this study it was found that the number of female golden grey mullet greatly exceeded the number of males during the autumn, which could, perhaps be accounted by their being heavier than male as the result of less movement, ripening eggs in the ovary. Laevastu and Favorite (1988) reported that behavior of the fish in relation to the fishing gears might vary according to their body size, age and physiological condition that can have some effects in sex composition. In this study the sex composition of the mullet catch in winter was only slightly different from the sex composition of catch in the rest of the fishing season. In winter the mullet tend to become less active due to cold water and making them to be caught easily and the possibility of escapement from the mesh of fishing gear decreased for males and those of smaller length groups. It should be pointed out that the lowest mean length of golden grey mullets was recorded in winter.In this study the spawning peak for golden grey mullet in the waters off Gilan waters was in October whereas this peak was in November in Mazandaran and Golestan waters. The magnitude of mullet spawning in October tends to decline from west (Gilan waters) to east (Golestan Province) in Iranian coastal water of the Caspian Sea. The most of the spawning in December was in Golestan waters.

The GSI of both sexes followed the same pattern and were highest in September and October 2007. It there after decreases slightly in November and Decmber and approaches the low values similar to the rest of the year. It was also reported by Fazli (1998) in Mazandaran coastal waters that *L. aurata* continue spawning from early November till December.

Vanesov (1972) also reported that the spawning peak for *L. aurata* in central part of the Caspian Sea occurred in September, during which the surface water temperature decreases down to 20-22°C. In the middle Caspian Sea *L. aurata* spawn in 20-50 miles off-shore during August-October where the depth is 400-600 m deep waters and water temperature ranges 20-22°C (Askerov et al., 2003).Upon comparison of the sexual maturity pattern of *L. aurata* during the past years and in different areas, it is reasonable to conclude that sexual maturity and the subsequent spawning by the species differ in space and time and depend on water temperature.

In this study, the mean absolute fecundity of the golden grey mullet was 700881 ± 429987 eggs with range of 200112 and 2282862 eggs. Mullet fish has high reproductive capacity. The absolute fecundity of 25-30cm long mullet is an average 500-600 thousands eggs which increased to 2-3 million eggs among those of 45-50 cm long (Askerov et al., 2003). Kazancheyev (1981) reported that absolute fecundity of *L. aurata* is about 740000 to 4.82 million eggs. The absolute fecundity of *L. aurata* with a length of 33.8 cm was found to be 981850 ranging from 254700-2925600 eggs (Khoroshko, 1989). However, Belyaeva et al. (1989) reported a fecundity range of 500000 to 3 million eggs. This is while Abdolmalaki et al.

(1998) recorded a fecundity value of 1026920 eggs for *L. aurata* along the Gilan Province coastal waters of the Caspian Sea with a range of 270811 to 2699590 eggs. In a research by Ghadirnejad (1996) the absolute fecundity of this fish was found to be around 888668 eggs. Abdoli et al. (1996) gave a fecundity of 773400 eggs for the golden grey mullet caught in Mazandaran waters that had a mean length of 32.8 cm.

The result of the examination revealed that the fecundity of this species in Mazandaran Province was lower than that of Gilan and that such a fecundity was also found to be lower in Golestan Province than that of Mazandaran. It was also appeared to be a downward trend in terms of the number of eggs per each gram of *L. aurata* ovary as we move from west (Gilan waters) to east parts of the Sea (*i.e.*, Golestan Province) and also the eggs grow larger in size. According to our study the absolute fecundity was found to be both positively and linearly related to fork length and body weight. Khoroshko (1989) reported that the fecundity of female golden grey mullet increased considerably as the fork length increased, but that the relative fecundity remained stable. It is evident that absolute fecundity increases with fish length, weight and age. Such a relation is quoted by Oren (1981) for other mugilid species.

The mean relative fecundity of golden grey mullet was observed in this study to be 1363 of eggs per each gram of body weight which correlates well with the figure provided by Khoroskho (1989), *i.e.*, 1347 eggs of per each gram of body weight. The comparison of results of Ghadirnejad (1996) with that of the present study which was confined to the Iranian coastal waters and those of Khoroshko (1989) that covered the areas has by the former Soviet union showed a difference in terms of the absolute fecundity of golden grey mullet in different parts of the Caspian Sea and at varied period of time.

Results of this study showed that the fork length (FL) at 50% sexual maturity of *L. aurata* was 28.4 cm. Fazli et al. (2008) reported that the fork length at 50% sexual maturity was 26 cm in Iranian coastal water of the Caspian Sea and Daryanabard (2008) estimated the fork length at 50% sexual maturity as 26.6 cm in Mazadaran Province.

Considering the flourishing mullet resources, it seems that the excessive fecundity and large scale fishing of the mullet stocks do not bear any major problems in terms of the number of laid eggs which are released into the sea.

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