Study of growth ring formation in scales of mullet *Liza saliens* in the Caspian Sea

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Abstract

This study is attempted to compare the number of rings and circular scales that are formed during various ages on *Liza saliens*. Sampling was carried out monthly during 2012-2013 using beach sine fishing nets. 102 specimens of different sizes were collected and transferred to the laboratory in boxes containing ice. The age of fish was determined by the number of annual rings as well as, the number of rings in each annual area. The distance between rings in each annual area was also measured. The results showed that the maximum growth was demonstrated in the first and second years. In the first year of life, the scale radius was nearly 2823.3±366.5(µm) which decreased to 1223.9±236.0(µm). The result indicated that 48 percentage of growth scales occurred in the first year and this value is only 21.8% in the second year. The number of growth rings in the annual regions decreased with increase in age. The result demonstrated that the average number of rings was 95.5±17.6 in the first life year of the fish. If you take into account the number of growth ring through years in comparison with the number of days in a year, it is clear that one ring was nearly made in four days in the first life year and it gradually reached 7.5, 15.9, 21.9 and 31.7 in the second, fourth and sixth years of life, respectively. One ring was approximately made in each month at higher ages.

Keywords: Caspian Sea, *Liza saliens*, Growth rings, Scales, Circular

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Introduction

Three millions of mullet of yearlings which belonged to *Liza auratus* Risso, *Liza saliens* Risso and *striped mullet, Mugil cephalus* were introduced into the Caspian Sea from the Black Sea during 1930 to 1934. *M. cephalus* did not adapt to the Caspian Sea conditions (Karpevich, 1975). Mullet succeeded to extend to all areas of the Caspian Sea in ten years (Zablotski, 1966 ; Belyayoa *et al*., 1989). *L. auratus* (*gold mullet*) and *L. saleins* were reported from Iranian coastal of the Caspian Sea where the composition of bony fish was 79 percent in 1981 (Razavi, 1990).

Since 1973, the catch of mullet started at 60 tons in the former USSR. Its catch value with an exception in 1956 was always lower than one thousand (Ghadirnezhad, 1996). However, *L. auratus* was dominant during these years. The annual catch made up over 75% of the total catch (Khorshko, 1989). In the Iranian coasts, the catch of mullet was dedicated to over 90 percentage of the total catch in the Caspian Sea. This was attributed to wintering in the Iranian coastal regions of the Caspian Sea which corresponds to the catch season of bony fishes. Temperature is one of the main factors that affect the catch of mullet. The highest quota of mullet catch was dedicated to Mazandaran Province, belonging to the Iranian coasts of the Caspian Sea. It should be noted that this province has high depths in the sea as well as the high heat was stored in the south and east areas of the Iranian coasts of the Caspian Sea (Alizadeh, 2004). Mullet does not have special feeding habits and it utilizes detritus, animals and plants attached to substrate pryphiton and small benthic aquatic organisms (Kudelina, 1950). Mullets feed through the year but the black mullet does not usually feed during migration and wintering periods (Khorshko, 1989).

Age determination and growth are directly determined in mullet by using scales (Hotos, 2003). The principle work is related to a procedure which is based on the rings formed on scales; in fact, it is attributed to fast and slow periods in relative to rings on scales (Elaine *et al*., 2005 ; Pannela, 1974). This means that fish growth makes a concentric circular on the scale. In fact, a gap or distance is shown with fish growth. The speed of growth of fish is dependent on stage of growth, and the growth speed is based on feeding state, the abundance of food in the environment, biological capacity and water temperature, etc.

This study attempted to compare the number of lines and circles on the scale that are yielded in various years. This identifies how long it takes to make the interval on scales. On other hand, the distance between rings was measured by comparing the growth rate in various years.

Materials and methods

Sampling was carried out monthly during 2012-2013 using beach sine fishing nets (Fig. 1).

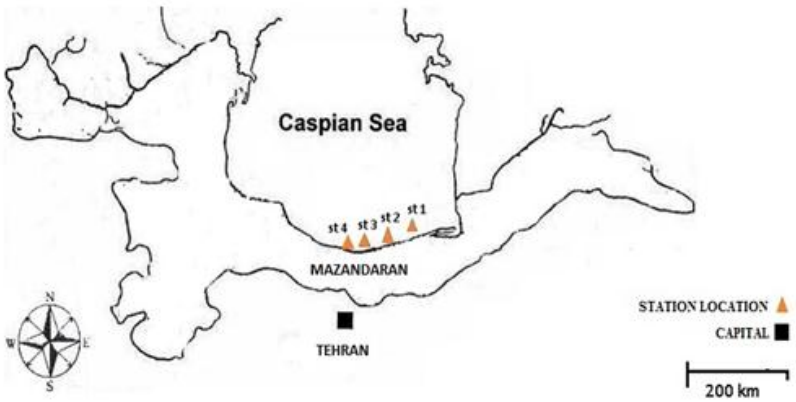

Figure 1: The location of sampling stations of fishing cooperative during 2012- 2013.

102 specimens were collected in different sizes and transferred to the laboratory in boxes containing ice.

The total and fork length were measured to the nearest 0.1mm. The fish weight was recorded to the nearest 0.01 g using an electronic balance. Three or five scales were taken from under the dorsal fin for age determination. The scales were cleaned with a soft cloth and warm water. When the scale is washed outdoors in open air, it is exposed to dryness. The scale was mounted on a slide, and then it was studied under a stereomicroscope. The age of the fish was determined by the number of annual rings as well as by calculating the number of rings in each annual area. Also, the distance between rings in each annual area was measured using Motic Digital Microscope (Fig. 2).

After collecting data from the Mo tic Image Advanced software, they were analyzed using SPSS software (19) and the data were evaluated.

Results

During sampling and biometry, 102 samples of *L. saliens* were studied. The average fork length for *L. saliens* was 24.3±3.3 cm. The maximum and minimum fork lengths were 34.2 and 16.4 cm, respectively (Table 1).

The Length frequency shows that the peak abundance was 24 cm (Fig. 3)

In view of age composition, the mean age of *L. saliens* was 3.5±1.0 years, and the oldest and youngest ages recorded were 6 and 2 years, respectively. The mean age classes showed separate mean lengths. The mean length was 19.6 cm at age 2. Their mean length increased by 2.7 cm reaching 22.3 cm at 3 years (Table 2).

With an increase in fish length and weight, the scales get larger. During the growth period of fish the bright and dark color rings made on scales are used for age determination.

Figure 2: Measuring the distance of scale center to the annual growth rings (left) and the distance of growth rings in each annual areas (right).

Table 1: Mean total and fork length in *Liza saliens* from Mazandaran Province during 2011 – 2012.

	Number	Mean (cm)	Standard deviation	Min, (cm)	Max. (cm)
Fork length (cm)	102	24.3	3.3	16.4	34.2
Total length (cm)	102	26.3	3.7	17.3	37.0

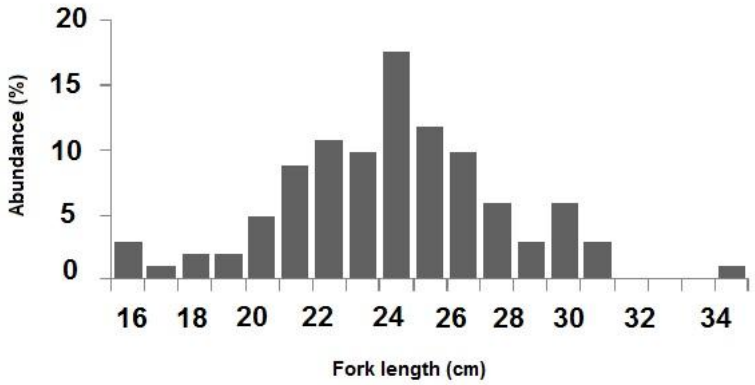

Figure 3: Length frequency of *Liza saliens* from Mazandaran Province during 2011-2012.

Table 2: The average fork length shown separately for the age classes from Mazandaran Province during 2011- 2012.

Age (Year)	2	3	4	5	6
Mean length (cm)	20.1	23.0	25.2	29.2	29.5
Standard deviation (SD)	2.2	2.2	1.6	2.4	2.9
Number	17	34	38	11	2

As shown in Table 3, in fact, R_1 and R_2 values demonstrate the distance from the scale center to the first annual ring and the distance from the scale center to second annual ring, respectively.

The results show that the maximum growth was demonstrated in the first and second years. In first year of life, the scale radius was nearly 2823.3±366.5 (µm) and it decreased to approximately half in the second year. To reach 1223.9±236.0 (µm). The growth of scales showed a tendency to reduce at 6 years of age to reach 201.3±101.5 (µm).

In this study, the difference of scale sizes was considered. The ratio was calculated on scale radius value (R) in comparison with the total of scale radius value (R_t), that was briefly illustrated in Table 4.

The results indicate that the scales are formed at one year of age when the estimated growth was approximately 48 percent. Growth increase in the second year was only 21.8%. With an increase in age, this tendency decreased and the growth recorded was only 2.69 percent at 6 year of age. In the present study, it was demonstrated that *L. saliens* reached maturity more slowly, in fact, the maximum growth occurred at 3 years of age.

The comparison of available differences in the distance was demonstrated as well as the difference in growth size was significant in some ages. The extent of increment showed significant differences in the first and second years in comparison with other years of life (p<0.05). This difference was a significant at 3 years (p<0.005). However there was a significant difference in the growth of scales in the fourth year in comparison with the second and third years (p<0.05). No significant differences in growth were observed in the fifth and sixth years.

The number of rings at different ages is given in Table 5. In the present study, it was demonstrated that the average ring number was 95.5±17.6 in the first life year of fish. The maximum and minimum number of rings were recorded which were 151 and 40 rings, respectively.

The number of growth rings decreased with increase in age in the annual growth areas, and the number of rings in the third and fourth months reached 32.2±7.8 and 22.9±5, respectively. The number of rings only reached 11.5±0.7. When the number of rings was taken into account in accordance with the number of annual growth days, it was recognized that it formed one ring per four days. The number of rings is generated from the second year to the sixth years reached 7.5, 15.9, 21.9 and 13.7 per day, respectively.

Table 3: The distance between the annual rings and the scale center (µm) in *L. saliens* during 2012 -2013.

	R_1	R_2	R_3	R_4	R_5	R_6
Mean	2823.0	1223.9	958.5	736.4	454.7	201.3
Standard deviation (SD)	366.5	236.0	219.5	205.9	173.3	101.5
Max.	3742.7	1905.5	1351.7	1223.0	734.2	273.1
Min.	2062.9	859.8	228.9	189.4	232.2	129.5
Number	102	102	85	51	13	2

Table 4: The percentage of radius value in each year (Ri) in comparison with the total scale radius (Rt) in *Liza saliens* during 2011-2012 (%).

	R_1 / Rt	R_2 / Rt	R_3 / Rt	R_4 / Rt	R_5 / Rt	R_6 / Rt
Mean	48.04	21.08	15.28	9.05	4.18	2.69
Max.	70.57	37.02	23.85	18.79	10.31	3.55
Min.	34.91	13.69	6.14	4.14	4.47	1.76
Standard deviation (SD)	7.75	4.55	2.85	3.07	2.12	1.26
Number	102	102	85	51	13	2

Table 5: The number of rings in annual growth areas in *Liza saliens* during 2012 – 2013.

	N_1	N_2	N_3	N_4	N_5	N_6
Mean	95.5	48.8	32.2	22.9	16.7	11.5
Max.	157	85	50	32	25	12
Min.	40	11	12	11	10	11
Standard deviation (SD)	17.6	15.2	7.8	5.0	4.6	0.7

Discussion

The bony fish fisheries of two species of mullet, *L. auratus* and *L. saliens,* were observed and compared in Iran. In the present decade, the catch of *L. saliens* has dramatically decreased. The catch percentage of *L. saliens* was 2 percent and 10% in 2010–2011 and 2011– 2012, respectively.

In the recent decades, on the whole, the shares of *L. saliens* caught were lower than 59% but with an increase in catch, diseased fish were added to the catch from Nowshahr and Kiashahr regions in the first decade of 2001. One of the reasons for the considerable decrease in the relative catch of *L. saliens* was attributed to ctenophore (*Mnemiopsis leidyi*) that had entered into the Caspian Sea.

In recent years, cetenophora (*M. leidyi*) has entered into the Caspian Sea, on account of the favorable environmental condition, and extended in the Caspian Sea as well as (Ivanovo *et al*., 2000). Unlikely this change can cause fluctuations in the ecological conditions which have been helpful in the study of population dynamics. The surveys of mullet growth from the periods and models which were made on the basis of age classes' were utilized. It is very important that the age determination was done on scales and the time of catch because the growth ring is usually formed after the delay of several months. The annual growth ring

has not been recognized yet but it will be applied in lower than one year of age for determination. On other hand, fish are caught in May or March and their age determination was performed though it may be that their age differences were 2 to 8 months.

Growth is reflected in the effects of altering bio conditions. The difference of altering growth was very important. On the whole the survey of the growth extent was based on scales. The greatest extent of growth occurred in the first year of age as it was approximately estimated at 40% but the increment in growth, area that was only 21.8% was attributed to the second year.

Also, with an increase in fish age, this trend decreased and the extent of growth on scale in six year olds was only about 2.09%. There were no significant differences in the growth value in 3 year olds (age). It can be said that *L. saliens is* matured when most of its growth is achieved.

In the present study, it was demonstrated that *L. saliens* grows more slowly after it matures. In fact, its growth was completed in three years of age. The comparison of available differences in the distance between rings demonstrated that there were significant differences in the growth region areas in some ages. For example, there was a significant difference in the growth area in the second year in comparison with other years (ages). Also fish growth was more in this year than in other years. This issue also appeared in the third year of life and there were significant differences in the growth value in the fourth year of age in comparison with that in the second and third years.

However, no significant differences were observed in the fifth and sixth years of life ($p>0.05$). The number of rings of annual growth regions was enumerated by the dark color rings. The average number of rings established at different ages is presented in Table 5. In the present study, it was demonstrated that the average number of rings was 95.5±17.6 in the first year of life. Maximum and minimum the number of rings in this year were recorded as 151 and 40, respectively. The number of annual growth ring regions decreased with increasing age. The number of growth rings in the third and fourth years of age only reached 32.2±7.8 and 22.9±5.0, respectively, and it was only 11±0.7 in the sixth year of age. If you take into account the number of growth rings through a year in comparison with the annual number of days we find that one ring was made in nearly four days in the first year of life and it gradually reached 7.5, 15.9, 21.9 and 31.7 days from the second to sixth years of life, respectively. One ring was approximately made in one month at higher ages.

Totally, it is said that in the present study, the extent of growth regions was nearly 48% in the first year. An increase of 21.08% of growth area on scales occurred in the second year. This trend reduced as the growth of scales was only nearly 2.69% in the 6 year olds. After three years, there was no

significant growth, so, it can be said, that most of the growth occurred before *L. saliens* matured. After maturation, its growth slowly decreased. In fact, growth occurred mainly in the first three years of life.

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