ECOLOGIA BALKANICA
2020, Special Edition 3 pp. 177-184

Relationships between Size, Weight, Age and Fecundity of the Chelon auratus and Chelon saliens (Mugilidae) from the Bulgarian Black Sea Coast

Radoslava I. Bekova*, Galerida Raikova-Petrova, Marina D. Panayotova, Bogdan K. Prodanov

Institute of Oceanology- Bulgarian Academy of Science,
"Parvi may"40 Str., P.O.Box 152, 9000 Varna, BULGARIA
*Corresponding author: radoslavabekova@gmail.com

Abstract. The study is aimed to demonstrate the relationships between the fecundity, length, weight and age of *Chelon auratus* and *Chelon saliens* from the Bulgarian Black Sea coast. Absolute fecundity of *Ch. auratus* varied from 327126 oocytes for age 3 (L-16.0 cm, EW-55 g) to a maximum of 4103879 for age 9 (L-32.4 cm, EW-321g). For *Ch. saliens*, absolute fecundity varied from 162890 oocytes for age 2 (L-16.9 cm, EW-52 g) to a maximum of 892441 oocytes for age 6 (L-33.7 cm, EW-315 g). The mean estimated fecundity was 213642 eggs for *Ch. auratus* and 54882 eggs for *Ch. saliens*. Relationship between absolute fecundity-weight, fecundity-length was best fitted by the following equations: *Ch. auratus* - F=9476+10241*W, r2=0.921 and F=-2384206+152333*L, r2=0.906; *Ch. saliens*: F=215473+1698.7*W, r2=0.916 and F=-457777+36837*L, r2=0.924. The relationship between fecundity and age was best described by the exponential equation: *Ch. auratus* - F=106354e1.5475, r2=0.969 and *Ch. saliens* - F=103041e1.1264, r2=0.994. The average weighted relative fecundity was calculated as 492 for *Ch. auratus* and 272 for *Ch. saliens*. A more accurate indicator to describe the relative fecundity is the coefficient b from the equation F=a+b*W. For *Ch. auratus* the coefficient b was 10241, and for *Ch. saliens* was 1698.

Key words: absolute fecundity, relative fecundity, Black Sea, *Chelon auratus, Chelon saliens*.

Introduction

Fecundity is a significant biological indicator characterizing both - the condition of individuals and the reproductive capacity of the population. This is a species attribute which values change in the course of ontogenesis and depending on the environmental conditions. Knowledge of fecundity makes it possible to judge the effectiveness of natural fish reproduction.

The golden grey mullet (*Chelon auratus*) is the most common among mullet fish along our Black Sea Coast (Stoyanov et al., 1963; Zashev, 1961). Like grey mullet (*Mugil cephalus*), it is a pelagic, shoaling and highly mobile fish. The leaping mullet (*Chelon saliens*), like the golden grey mullet, is a pelagic, shoaling and extremely agile fish. In summer, they make significant leaps over the water. They slightly tolerate changes in water

salinity and are somewhat sensitive to temperature decrease (Minos et al., 1995). The maximum length of the golden grey mullet is around 60 cm and a weight of 1.5 kg (Harrison, 2003; Stoyanov et al., 1963). The maximum sizes of the golden grey mullet in the Black Sea reach up to 43 cm, but the commercial ones usually range from 18 cm to 25 cm (Harrison, 2003). The leaping mullet reaches a length of up to 35 cm, but here it is caught in sizes of 16-18 cm and weight up to 0.8 kg (Harrison, 2003). Spawning starts at 2 - 3 years of age (Stoyanov et al., 1963). The golden grey mullet reaches sexual maturity at 2-3 years of age (Harrison, 2003; Stoyanov et al., 1963). It spawns from August to October in both the nearby coastal zone and the high seas at a water temperature of 18.4 - 22.2°C (Stoyanov et al., 1963; Zashev, 1961). The juveniles, after reaching the length of 2.5-3.5 cm, move to the shore for feeding (Stoyanov et al., 1963). Its fecundity is very high. According to Stoyanov et al. (1963), the fecundity of the golden grey mullet is from 0.16 to 4 million, and according to Pavlovskaya (1969) from 0.86 to 2.41 million. The leaping mullet reaches sexual maturity at the age of 2-3 years (Stoyanov et al., 1963; Zashev, 1961). It spawns from June to the end of September in both the near-coastal zone and the high seas (Stoyanov et al., 1963; Zashev, 1961). At a temperature of 24-27°C, the spawning takes place in the open sea. Its fecundity, according to Stoyanov et al. (1963), ranges from 500,000 to 2,100,000 eggs and according to Pavlovskaya (1969) from 0.97 to 3.71 million eggs. The larvae hatch within 24 hours (Stoyanov et al., 1963).

The economic importance of the golden grey mullet is significant (Zashev, 1961). Of all mullets, it is the most caught one. Its annual catch in the Azov-Black Sea basin and the Caspian Sea amounts to about 4 500 tons (Zashev, 1961). In Bulgaria, its average annual catch, along with that of the leaping mullet, amounts to about 100 tons. In some years it reaches 300-400 tons (Zashev, 1961). The catch of Leaping mullet is not reported separately from that of Golden grey mullet. In Bulgaria, they go under the name leaping mullet. In fact, the main share belongs to the golden grey mullet, and the leaping mullet is only a co-catch (in NAFA statistics).

Given the environmental changes and the anthropogenic pressure affecting the Black Sea ecosystems and the constant fluctuation in population numbers of these fish species, it is necessary to shed more light on their reproductive biology.

Material and Methods

Ch. auratus and *Ch. saliens* specimens were collected during the period May 2010 – July 2018 from different areas of the Bulgarian Black Sea Coast (Fig. 1 - sampling sites in red points). The samples were taken by cast nets fishing - mesh size 22-38 mm, length 50 m and height of the nets between 1.5 m and 2 m. Fish fecundity was studied on 582 specimens. Standard length (SL ± 1mm), total weight (TW ± 1g), gutted (somatic) weight (W ± 1g) and gonad weight (g ± 0.1 g) were measured. The age was determined by counting the number of annuli (rings) on a scale at a magnification of 17.5x using Projector Dokumator, Lasergeret (Carl Zeiss, Jena).

As input parameters for the analysis of fecundity the total individual fecundity (the number of mature eggs, ready to be spawned from one individual during one spawning season) and the total fecundity (the average number of eggs of the individuals from one egg, size or weight group) were used (Anohina, 1969; Spanovskaya & Grigorash, 1976).

The relative fecundity was measured in two ways: 1. As a relation between the total fecundity and the gutted weight of the fish RF=F/W (Spanovskaya & Grigorash, 1976);

2. By the coefficient b from the equation F = a+b*W (Zotin, 1961).

Data were statistically processed in XLSTAT, version 2019.1.1.56334.

Results and Discussion

The absolute fecundity of *Ch. auratus* and *Ch. saliens* populations varied between

327 126 – 3 627 876 and between 198 421 – 778 930 eggs, respectively. The averagely weighted fecundity of the golden grey mullet was 213 642 and 54 882 of the leaping mullet. The specimen of *Ch. auratus* with the lowest individual fecundity had a size of 16.0 cm and mass without guts of 55 g, and the one of *Ch. saliens* with the lowest individual fecundity was 16.9 cm with mass without guts 52 g. The fishes with the highest fecundity (3 627 876 - *Ch. auratus* and 778 930 - *Ch. saliens*) were 32.4 cm and 33.7 cm, respectively and 321 g and 315 g weight without guts but were not the largest examined specimens. The youngest specimens of *Ch. auratus* and *Ch. saliens* tested for this indicator were respectively 3 and 2 years old. In these age groups, the average fecundity was 534 981 eggs for *Ch. auratus* and 199 809 eggs for *Ch. saliens*.

The absolute fecundity of both mullet species by size groups is presented in Table 1. The fecundity range in the smaller size groups was smaller and increased with increasing fish sizes.

Increasing the length of the fish increased fecundity values (Table 1). Graphically this relation is shown in Fig. 2 - A, B. The most appropriate function for its description is the linear one. The degree of correlation between the average values of F and L was very high (r2 = 0.906 – *Ch. auratus*; r2 = 0.924 - *Ch. saliens*).

The absolute fecundity of mullet fish by weight classes is presented in Table 2. There was a tendency to increase fecundity by increasing fish mass with the highest average values observed in the last weight group (251-500 g for *Ch. auratus* and 301-320 g for *Ch. saliens*). The dependence of fecundity on the mass of mullets is best described with a linear function (Fig. 3 - A, B). The degree of correlation between the average values of F and W was very high (r2 = 0.92 - *Ch. auratus*; r2 = 0.92 - *Ch. Saliens*).

The change in absolute fecundity with the age of the fish is shown in Table 3. The fecundity range of *Ch. auratus* was the highest at four and five years of age specimens (2.2 times), and at three, seven and nine-year-olds were significantly lower (1.3 times). For *Ch. saliens* the highest fecundity range was at four and five-year-olds (1.5 times).

The relation F-t in the population of mullet fish along the Bulgarian Black Sea Coast is shown in Fig. 4 - A, B. Here also the degree of correlation between the studied parameters was very high (r2=0.97 - *Ch. auratus*; r2 = 0.99 - *Ch. saliens*).

Apart from the size and age of the fish, fecundity depends also on how many times the female has participated in the breeding process. Typically, the specimens which spawn for the first time are characterized by lower values of fertility. This is probably one of the reasons for the high variability of the indicator in some of the studied size, weight and age groups. Table 3 shows the distribution of absolute fecundity by age groups. In *Ch. auratus* fecundity values of three and seven-year-old fish were nearly the same (1.3 and 1.5); in *Ch. saliens* the differences in three and six years olds were minimal. In the third age group, in both species, females that spawn for the first or second time were united. In older age groups, all individuals had already participated in the breeding process more than twice. The greater fecundity range at 4 and 5 years old mullets was probably because there were included both fishes spawning for the first time and those spawning for the third or fourth time.

In the Caspian Sea, the absolute fecundity of the golden grey mullet in a 25-30 cm size group varied from 500-600 thousand to 2-3 million eggs with a length of 45-50 cm (Askerov et al., 2003). Belyaeva et al. (1989) has published an absolute fecundity range from 740 thousand to 4.82 million eggs. The absolute fecundity of the golden grey mullet with an average size of 33.8 cm was in the field from 254,700 to 2,925,600 eggs (Khoroshko, 1981). Belyaeva et al. (1989) have reported fecundity ranging from 500

thousand to 3 million eggs. These values are close to those reported by Abdolmalaki et al. (1998), namely from 270 811 to 2 699 590 eggs. For *Ch. saliens* along the northeastern coast of the Caspian Sea, Patimar (2008) has reported absolute fecundity ranging between 135 014 (for 3+) and 389 790 (for 7+) eggs. For the same species, but in the Aegean Sea, Koutrakis (2011) has reported absolute fecundity ranging from 245 000 to 555 000 eggs.

Our values for the absolute fecundity of mullets are close to those reported by Ghaninejad et al. (2010) for the golden grey mullet and Koutrakis (2011) for the leaping mullet.

Table 1. Change of absolute fecundity in different length classes of *Ch. auratus* and *Ch. saliens* from the Bulgarian Black Sea Coast.

Species	Length class (L, cm)	Average length (L, cm)	Absolute fecundity (F, eggs)		n
			Range	Mean	
Chelon auratus	20.1 - 21	20.84	327126 - 578642	499362	29
	21.1 - 22	21.46	428290 - 902441	711543	39
	22.1 - 23	22.8	810002 - 1409007	1210483	45
	23.1 - 26	25.31	949998 - 2009875	1597256	66
	26.1 - 30	28.11	1423877 - 2884955	2372642	72
	30.1 - 38	36.92	2799483 - 3627876	2982170	51
Chelon saliens	19.1 - 20	19.71	198421 - 284002	203640	32
	20.1 - 25	21.89	319942 - 500 144	410958	74
	25.1 - 30	26.32	349933 - 601472	541222	98
	30.1 - 35	31.88	572941 - 778930	689433	76

Fig. 1. Location of sampling sites along the Bulgarian Black Sea Coast.

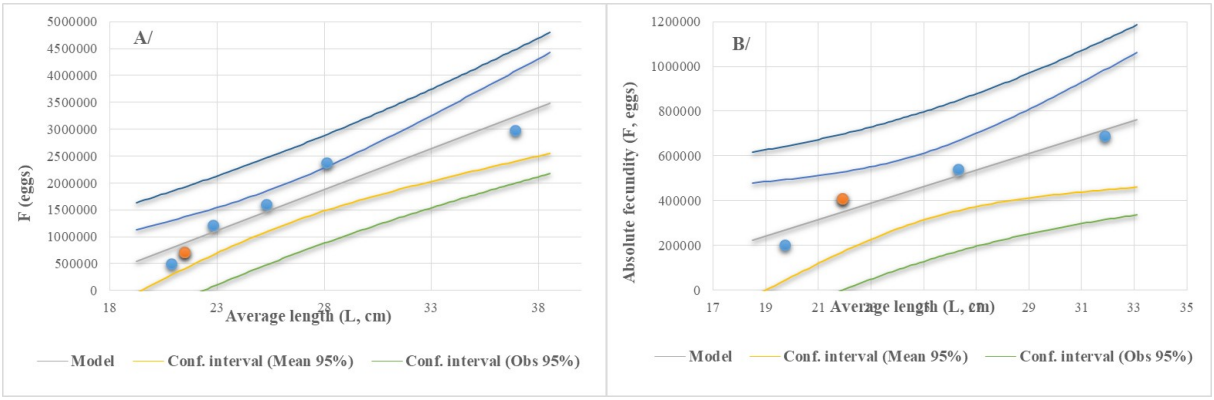

Fig. 2. Relationship between the absolute fecundity (F, eggs) and the average length (L, cm) of A/ *Ch. auratus* and B/ *Ch. saliens* from the Bulgarian Black Sea Coast.

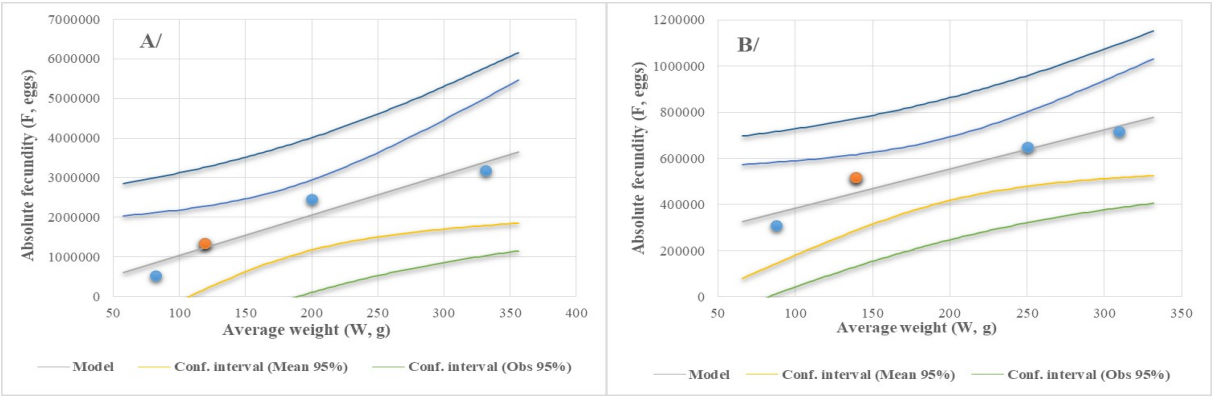

Fig. 3. Relationship between the absolute fecundity (F, eggs) and the average weight (W, g) of A/ *Ch. auratus* and B/ *Ch. saliens* from the Bulgarian Black Sea Coast.

Table 3. Change of absolute fecundity (F) in different age classes (t) of *Ch. auratus* and *Ch. saliens* from the Bulgarian Black Sea Coast.

Species	Age (t)	Absolute fecundity (F, eggs)		n
		Range	Mean	
Ch. auratus	3	488290 - 622733	534981	39
	4	612982 - 1300443	8999793	64
	5	821712 - 1787563	1246874	95
	6	1468557 - 2324902	1991981	55
	7	1676354 - 2422937	2000189	20
	8	1525634 - 3233409	2412860	12
	9	2199346 -3490371	3201002	17
Ch. saliens	2	162890 - 228439	199809	36
	3	331982 - 402138	319081	69
	4	397452 - 598218	490933	88
	5	498176 - 721982	601985	59
	6	690768 - 892441	729946	28

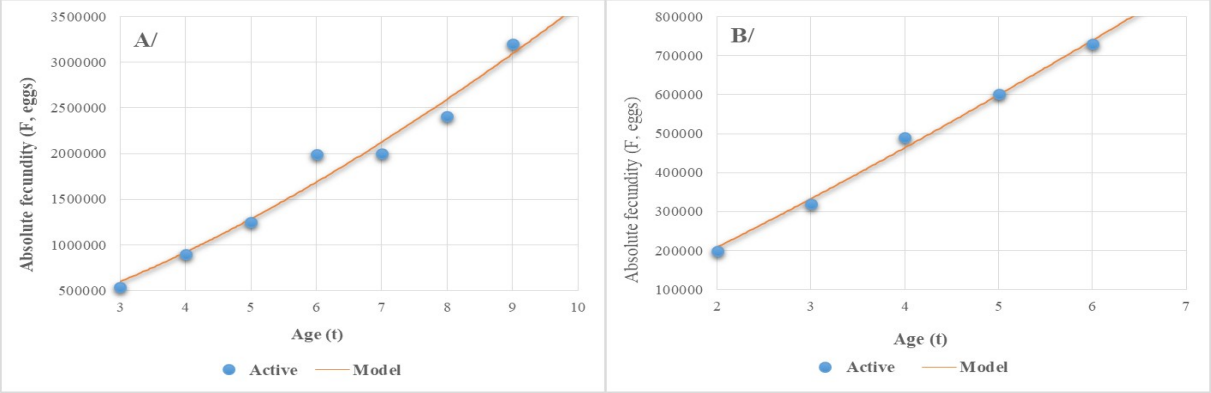

Fig. 4. Relationship between the absolute fecundity (F, eggs) and the fish age (t) of A/ *Ch. auratus* and B/ *Ch. saliens* from the Bulgarian Black Sea Coast.

The average weighted relative fecundity of both mullet species populations from the Bulgarian Black Sea Coast was as follows for *Ch. auratus* - 492 and *Ch. saliens* - 272. The average values of the relative fecundity in different weight groups are shown in Table 4. The regression line between F and W passes over the origin of the coordinate system. It is for this reason that Živkov et al. (1999) has suggested using the coefficient b (10241 - *Ch. auratus*, 1698 - *Ch. saliens*) from the equation F = a + bW (Fig. 2) as an indicator of relative fecundity. This coefficient indicates the average relative rate of increase of the absolute fecundity depending on the weight of fish and describes with sufficient mathematical accuracy the relation between the values F and W.

Table 4. Changes in the relative fecundity by weight classes for *Ch. auratus* and *Ch. saliens* from the Bulgarian Black Sea Coast.

Species	Weight class (g)	Mean weight (g)	Relative fecundity	n
Ch. auratus	61 - 100	82.2	6614.61	29
	101 - 150	119.2	11324.94	98
	151 - 250	199.9	12295.57	122
	251 - 500	331.2	9634.14	53
Ch. saliens	71 - 100	87.8	3557.53	37
	101 - 200	138.9	3750.01	67
	201 - 300	250.1	2604.81	108
	301 - 320	309.5	2326.77	68

The data on the relative fecundity of the populations studied by us could not be compared with data of other populations of the same species as such data were not available in the literature we knew. Only Koutrakis (2011) has reported data on the relative fecundity of *Ch. saliens* from the northern part of the Aegean Sea, an average value of 1822 in the range 1507-2501, which is lower than that obtained by us.

Conclusions

The absolute fecundity of *Ch. auratus* and *Ch. saliens* populations varied between 327 hurat126 – 4 103 879 and between 162 890 – 892 441 eggs, respectively. The averagely

weighted fecundity of the golden grey mullet was 213 642 and 54 882 of the leaping mullet. The values of the fecundity rose with increasing the fish length, weight and age. The average weighted relative fecundity of both mullet species populations from the Bulgarian Black Sea Coast was as follows for *Ch. auratus* - 492 and *Ch. saliens* - 272. The regression line between F and W passes over the origin of the coordinate system. It is for this reason the coefficient b is an indicator of relative fecundity. This coefficient indicates the average relative rate of increase of the absolute fecundity depending on the weight of fish and describes with sufficient mathematical accuracy the relation between the values F and W.

Acknowledgments

The study was realized with the financial support of the National Scientific Fund of Bulgaria through a project entitled: "The influence of environmental condition of Varna and Burgas bays on population-biological parameters of mullets species (*Mugil cephalus, Liza aurata* and *Liza saliens*)" contract No DM11/2 from 15 Dec 2017.

References

Anohina, L. (1969). *Patterns in changing fish fecundity*. Moscow: Science. (In Russian).

Abdolmalaki, S., Amirkhani, A., Borani, M., Ghaninejad, D., Rastin, R., Porgholami, A. & Moradkhah, S. (1998). *A survey on catch status and sexual maturity of mullets in the Iranian coastal waters of the Caspian Sea (Gilan Province) in October 1998.* Research report. Fisheries Research Center of Gilan Provinces, Bandar Anzali. 1-13.

Askerov, F., Zaytsev, Y., Kasimov, R. & Kuliyev, Z. (2003). *Biodiversity: Amazing Caspian Fishes.* Baku: Bashar XXI Publishing house. (In Russian).

Belyaeva, V.N., Kazancheev, E.N. & Raspopov, V.M. (1989). *The Caspian Sea: Ichthyofauna and Commercial Resources.* Moscow: Nauka. (In Russian).

Ghaninejad, D., Abdolmalaki, S., Kuliyev, Z.M. (2010). Reproductive biology of the golden grey mullet, *Liza aurata* in the Iranian coastal waters of the Caspian Sea. *Iranian Journal of Fisheries Sciences*, *9*(3), 402-411.

Harrison, I.Y. (2003). Mugilidae. In Miller P.Y. (Ed). *The Freshwater Fishes of Europe: Mugilidae, Atherinidae, Atherinopsidae, Blnniidae, Odontobutidae, Gobiidae.* (Vol. 8, pp 1-42),. Aula-Verlag. Wiebelsheim.

Koutrakis, M. (2011). Reproductive biology of two grey mullet species (Actinopterygii: Mugiliformes: Mugilidae) in a northern Aegean Sea estuarine system. *Acta Ichthyologica Et Piscatoria, 41*, 37-46. doi: 10.3750/AIP2011.41.1.06.

Khoroshko, A.I. (1981). Population abundance and structure in the long-finned mullet (genus *Liza*, Mugilidae) during acclimation in the Caspian Sea. *Journal of Ichthyology, 22*(6), 62-69.

Minos, G., Katselis, G., Kaspiris, P. & Ondris, I. (1995). Comparison of the change in morphological pattern during the growth in length of the grey mullet *Liza ramada* and *Liza saliens* from western Greece. *Fisheries Research, 23,* 143-155. doi: 10.1016/0165-7836(94)00334-S.

Pavlovskaya, R.M. (1969). On the features of the dynamics of fat content and fertility of three species of the Black Sea mullets. *YugNIRO Proceedings, 26*, 62-67.

Patimar, R. (2008). Some biological aspects of the sharp nose mullet *Liza saliens* (Risso, 1810) in Gorgan Bay-Miankaleh Wildlife Refuge (the Southeast Caspian Sea). *Turkish Journal of Fisheries and Aquatic Sciences*, *8*, 225-232.

Stoyanov, St., Georgiev, Zh., Ivnov, L., Hristov, D., Kolarov, P., Alexandrova, K. & Karapetkova, M. (1963). *The fishes from the Black Sea.* Varna: State Publishing House. (In Bulgarian).

Spanovskaya, V. & Grigorash, V. (1976). On the methodology of fish fecundity

determination for total spawners and batch spawners. In *Type methods for studying fish production in its area*, (Part 2, pp 54-62). Vilnius: Mosclass. (In Russian).

Zotin, Z. (1961). The relative fecundity of fish and egg size. *Journal of Ichthyology, 1,2*(19), 307-313.

Zashev, G. (1961). Family Mugilidae. In *Ichthyology* (pp. 399-404). Sofia: Science and Art Publishing House. (In Bulgarian).

Živkov, M, Trichkova, T. & Raikova-Petrova, G. (1999). Biological reasons for the unsuitability of growth parameters and indices for comparing fish growth. In *Environmental Biology of Fishes* (pp. 67-76). Dordrecht-Boston-London: Kluwer Academic Publisher. (In Bulgaria).

Received: 17.07.2020
Accepted: 20.12.2020