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RESEARCH ARTICLE

Growth rate and condition of common bream (*Abramis brama)* from the Iskar Reservoir in Bulgaria

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Abstract. The paper determines two basic parameters of the bream population from the Iskar Reservoir: age structure and growth rate. Material was collected in the fall, spring, and summer months from 2012 to 2016. A total of 174 bream specimens were caught. The analysis of this sample found that 10 age groups were represented. Fish weight from age groups was approximately as follows: from age group 1 – 5 g; 2 – 32 g; 3 – 108 g; 4 – 218 g; 5 – 265 g; 6 – 374 g; 7 – 534 g; 8 – 651 g; 9 – 867 g; 10 – > 1,000 g. The back calculated standard length was as follows: year 1 – 55 mm; 2 – 108 mm; 3 – 161 mm; 4 – 205 mm.; 5 – 230 mm; 6 – 252 mm; 7 – 286 mm; 8 – 296 mm; 9 – 340 mm; 10 – 367 mm. The findings support the conclusion that the linear growth rate of bream from Iskar Reservoir is slower than that of fish from the Danube River basin. Some of the reasons that explain this difference include the dam's high altitude and the mountainous climate of the surrounding area, which mean the fish growth period is shorter.

Keywords: age, common bream, linear growth, weight

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Introduction

The common bream (*Abramis brama* L.) is distributed widely in European rivers and lakes from Britain and Ireland to the Urals, but it is not found in the Apennines or the Iberian Peninsula (Maitland 1977, Kottelat and Freyhof 2007). Initially introduced in North Africa, this species has now acclimatized there (Guettaf et al. 2019). The natural distribution of *A. brama* in Bulgaria includes the Danube River and the lower reaches of its tributaries, as well as the Maritsa River, especially in the southern part of the country (Kovachev 1921, Drensky 1951, Karapetkova and Živkov 1995, Kottelat and Freyhof 2007, Stefanov 2007). However, the most recent scholarship does not confirm the presence of this species in the Maritsa River basin (Kovachev 1921, Drensky 1951, Michaylova 1965, Karapetkova and Živkov 1995, Veltcheva and Mehterov 2005, Stefanov 2007). During the twentieth and early twenty-first centuries, bream was introduced into many of the largest Bulgarian reservoirs, such as Iskar, Ogosta, Jrebchevo, Sopot, Ticha, Vucha, Ovcharitsa, and Dushantsi. Živkov and Raikova-Petrova (1996) conducted a study of bream population biology in Ovcharitsa Cooling Reservoir in southern Bulgaria, and Belomacheva et al. (2005) also investigated the population biology of this species in the Iantra, Osam, and Vit rivers (Danube River drainage). Scientists have also developed a classification of bream populations based on data about the linear growth rate of 464 populations from different European locations. The aim of this study was to determine the length growth rates and the condition of bream from Iskar Reservoir and to compare these results with some published data regarding this species.

Study area

The study area includes the Iskar Dam, situated to the south of the city of Sofia, in southwest Bulgaria (Fig. 1). The dam was built in the upper and middle zones of the Iskar River. This is the longest river flowing entirely in Bulgaria, and it is a right tributary of the Danube River. The Iskar Reservoir collects waters from the northern slopes of Rila Mountain, the highest Bulgarian mountain, and from the southern slopes of Vitosha Mountain, both of which are located in southwest Bulgaria. The dam has been in operation since 1954. The reservoir provides drinking and municipal water for the city of Sofia; the outflow is used for generating electricity, and the reservoir itself is used for recreational purposes. The water surface and shoreline are divided into two zones: the northern part of the reservoir is designated as a non-visiting sanitary protection zone, while the southern part is a recreational zone. The dam's water catchment area is 1,046 km^2 with an average surface altitude of 818 m. Maximum water depth reaches 75 m. With a surface of 30 km^2 and water volume of 63 billion m^3, this is the largest Bulgarian water reservoir.

Materials and methods

The study sample included 174 fish caught by angling. Fishing was performed from the lakeshore. All the fish were caught with the ledgering fishing technique. Six fishing rods were used, each of which was 4

Figure 1. Location of the sampling sites along the shore of Iskar Reservoir (Google Maps). Legend of fish specimen sampling sites: 1 – Ichtiman Bay; 2 – Cement bunker; 3 – Willows Bay; 4 – Shipochene Bay; 5 – Fish farm dike.

Table 1
Sampling sites in Iskar Reservoir

No	Location	Geographic coordinates N	E	Sampling period
1	Ihtiman Bay	42°46'63.11''	23°61'87.32''	21.07.2012-08.04.2016
2	Cement bunker	42°43'43.31''	23°60'06.78''	30.08.2012 – 05.11.2016
3	Willows Bay	23°58'74.90''	42°43'94.11''	13.04.2013-16.04.2016
4	Shipochene Bay	42°42'76.69''	23°61'47.49''	06.04.2013
5	Fish farm dike	42°44'30.41''	23°55'01.11''	08.04.2016-10.04.2016

m long, with stainless steel no. 10–12 limerick hooks and fixed spool reels of 0.30 mm fishing monofilament line. Red worms and maggots were used as bait. Specimens were collected over the course of a 50-day fishing season over a five-year period from 2012 to 2016. Five sampling areas located within the authorized fishing zone of Iskar Reservoir were designated (Table 1). All fish were measured immediately after catch. Each fish specimen was measured for standard length (*L)* to the nearest mm. Total weight (*W*) to the nearest g was measured for 124 specimens. Fish age was determined by counting scale annual rings on the diagonal caudal radius of the scales. Scale reading was done in the laboratory using an Olympus CX 31 microscope at 40× magnifications.

Fish linear growth was determined with back-calculations of length (*L)* from the diagonal caudal radius of the scales (*S)* (Živkov 1993). This relation was well described by the linear equation:

$$L = a+bS \qquad (1)$$

where: L is fish length (mm), S is diagonal caudal radius of the fish scales, *a* is intercept, and *b* is slope.

The weight growth (*W*) were estimated, using the equation used by many authors (Živkov and Raikova-Petrova 1996, Kukushkin 1997, Belomacheva et al. 2005) and recommended by Živkov (1993, 1999).

$$W = aL^b \qquad (2)$$

where: L is fish length (mm), W is weight of the fish, *a* is intercept, and *b* is slope of L-W relationship.

A comparison of the length growth of different bream populations was done by ranking them according to the average lengths at the same age (Živkov 1972).

To compare the weight gain (*W*) of fish from different populations, the method proposed by Živkov (1993, 1999) and Živkov and Raikova-Petrova (1996) was used. The relationship was expressed by the following equation:

$$logW = loga + blogL \qquad (3)$$

where: L is fish length (mm), W is weight of the fish, *a* is intercept, and *b* is slope of L-W relationship. Equation 3 was obtained by taking the logarithm of the equation: $W = aL^b$

In order to obtain comparable values of W in equation 3, pre-selected rounded values of L ($L = 50$; $L = 100$; $L = 150$; $L = 200$; $L = 250$; $L = 300$; $L = 350$; $L = 400$ mm) were successively substituted in place of L. Using equation 3 with the listed values of L *(mm)* permitted obtaining the corresponding values of weight, as follows: W - $W_{L=50}$; $W_{L=100}$; $W_{L=150}$; $W_{L=200}$; $W_{L=250}$; $W_{L=300}$; $W_{L=350}$; $W_{L=400}$. The weight values obtained ($W_{L=50}$; $W_{L=100}$; $W_{L=150}$; $W_{L=200}$; $W_{L=250}$; $W_{L=300}$; $W_{L=350}$; $W_{L=400}$) for each of the studied populations were then compared.

Results

The results show that young fish, from the second to sixth age groups, dominated the catch. There were comparatively few old specimens. Only two age-10 fish were caught. The fishing method did not permit catching age-0 and age-1 fish (Fig. 2). The catch was

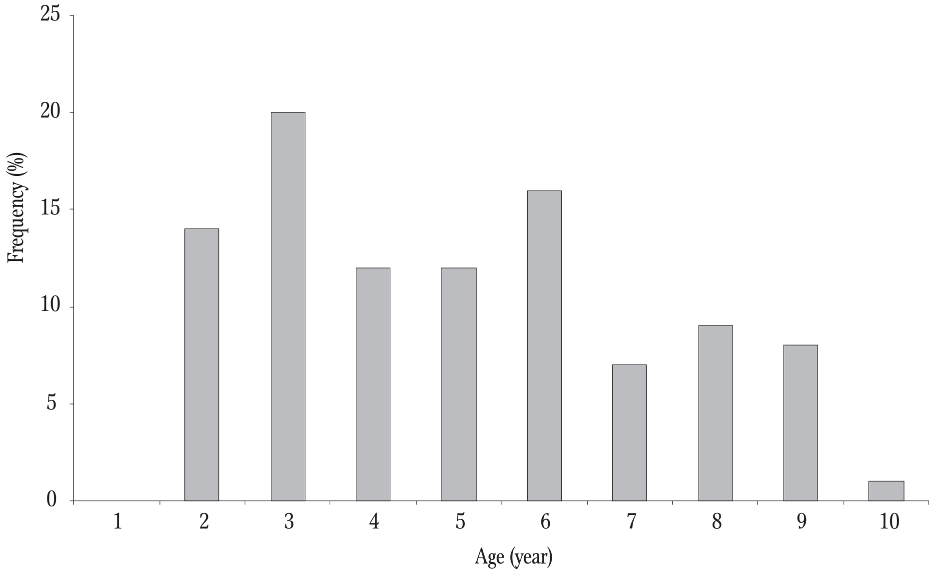

Figure 2. Age structure of the common bream (*A. brama*) population from Iskar Reservoir.

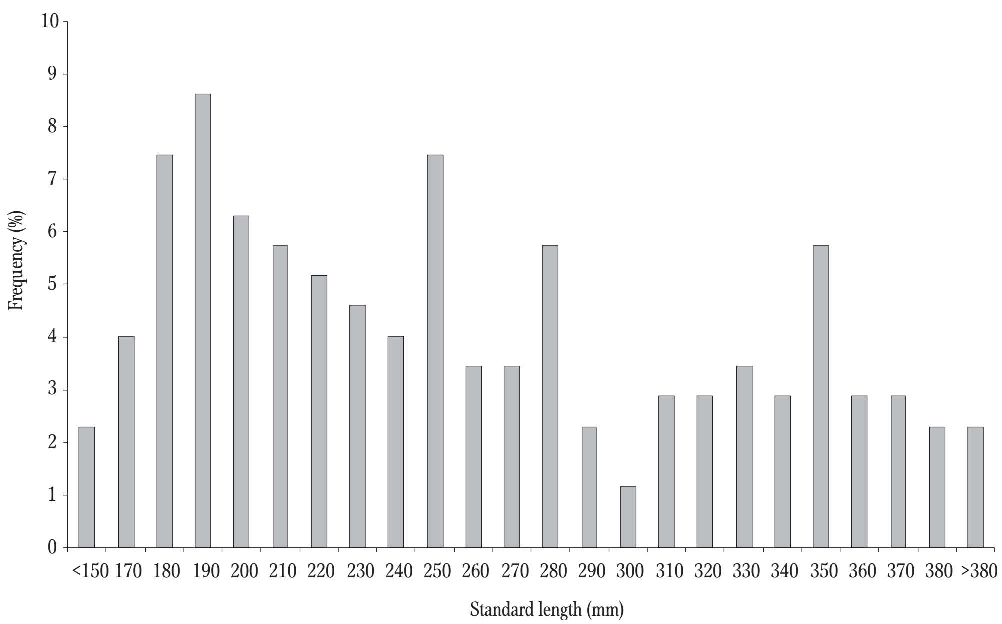

Figure 3. Size classes of the common bream (*A. brama*) population from Iskar Reservoir.

dominated by fish with lengths of up to 300 mm (Fig. 3). The smallest fish in the sample was an age-2 specimen with a length of 130 mm and a weight of 100 g. The largest specimen caught was an age-8 fish weighing 1,520 g and 415 mm in length.

Scale radius was linearly related to fish length. The regression of standard length (*SL*) on radius length (*S*) was:

$$SL = 6.739 + 2.862\,S\ (r^2 = 0.7688,\ n = 174,\ P < 0.05)$$

Length-weight relationship indicated negative allometric growth ($W = 0.0001\ SL^{2.7329}$, $r^2 = 0.9797$, $n = 124$, $P < 0.05$). Based on these equations, the mean length (Table 2) and weight (Table 3). Ten age groups were calculated from the study sample (Table 2). In the first three years of life cycle, length growth is faster than that from ages 5 to 8, but in age 4 fish, length growth remained relatively high. Growth weight was very slow in the first two years of the bream life cycle. Annual growth increment increased in the oldest age groups.

Discussion

In the first three years of the bream life cycle, the linear growth rate was the fastest of all the age groups (Table 2). This was an expression of the need for young fish to escape faster from predation pressure. Length growth in bream older than age-4 slowed down. This was probably because of fish maturation and sex product production. The very slow weight gain of age-1 fish indicated that there was likely little food for the youngest fish in the reservoir (Table 3). The data presented here indicated there were some differences in the length growth and weight gain in some years. For example, in 2006 length growth and weight gain were very slow. At the same time, bream length and weight gain in 2012 and 2016 were relatively fast. Growth differences in 2006, 2012, and 2016 were observed in all age groups. Growth differences were probably caused by annual changes in weather conditions and water temperatures, both of which affect food abundance. These differences could have led to the emergence of so-called weak and strong generations with different reproductive capacity in subsequent years (Nikolsky 1965).

The back calculated body length of bream from Iskar Reservoir showed better gradual length growth than did the actual body length, which was determined by measuring the specimens. Young fish clearly demonstrated faster length growth in the first four years of their life before reaching maturity (Fig. 4). In Iskar Reservoir, during the first year of the bream life cycle, length growth was two times slower than that of bream inhabiting other Bulgarian water bodies (Živkov and Raikova-Petrova 1996, Belomacheva et al. 2005). The length of Iskar Reservoir bream approached that of bream from the Danube catchment area only in the fourth year of its life cycle (Fig. 4). According to the Belomacheva et al. (2005) classification of bream populations, Iskar Reservoir bream belongs to the low growth rate category.

The comparison of the length of fish inhabiting different water bodies clearly demonstrated that bream grows faster in countries with warmer climates (Table 4). In Algeria (Guettaf et al. 2019) and especially in Uzbekistan (Kamilov et a. 2017), bream aged 1 are more than two times longer than those caught in Poland (Załachowski and Więski 1998), Belarus (Kukushkin 1997), and in Iskar Reservoir. Similar faster length growth is observed in bream from the Ovcharitsa Cooling Reservoir (Živkov and Raikova-Petrova 1996), because of its specific temperature regime (Fig. 4) and year-round high

Table 2
Back calculated standard length (mm) of common bream (*A. brama*) Iskar Reservoir

Year	Age group	N	Mean back calculated SL (mm) at age									
			L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}
2016	V	2	64	141	219	287						
2015	VI	2	55	100	154	216	279					
2014	VIII	11	61	121	167	184	210	216				
2013	VIII	20	47	87	141	219	216	250	293			
2012	IX	21	61	138	161	210	256	290	313	316		
2011	X	54	61	118	173	190	233	264	270	299	330	
2010	XI	13	61	107	164	213	239	264	310	307	333	367
2009	IX	11	55	110	161	213	256	284	307	327		
2008	X	12	50	104	153	201	239	259	282	307	350	
2007	VIII	20	47	87	138	167	190	236	310			
2006	IX	3	58	107	158	193	219	236	264	247		
2005	IX	2	50	87	141	176	196	219	227	256		
2004	X	3	47	93	158	201	227	256	287	307	347	
Mean SL (mm)		174	55	108	161	205	230	252	286	296	340	367
Mean observed SL (cm)		174		168	197	227	256	280	313	354	361	380
Annual increment (mm)			55	53	53	44	25	22	34	10	44	27

Table 3

Body weight (W, g) at age calculated based on the back calculated standard length of common bream (*A. brama*) Iskar Reservoir

Year	Age group	N	Mean back calculated body weight (g) at age									
			W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_8	W_9	W_{10}
2016	V	2	7	70	240	515						
2015	VI	1	7	21	75	223						
2014	VIII	12	7	35	114	146	208	359				
2013	VIII	10	5	33	127	310	252	401	632			
2012	IX	14	5	37	103	223	487	759	934	1255		
2011	X	36	4	26	101	157	265	368	413	537	688	
2010	XI	27	4	24	88	164	223	223	796	796	947	1020
2009	IX	8	7	40	109	205	315	346	460	559		
2008	X	9	4	29	80	159	224	356	332	447	926	
2007	VIII	4	2	21	80	164	240	364	544	621	905	
2006	IX	1	2	19	70	136	169	191	232	339		
Mean calculated BW (g)		124	5	32	108	218	265	374	543	651	867	1020
Mean measured BW (g)		124		113	204	273	407	559	731	1028	1213	1293
Annual increment (g)			5	27	76	110	38	109	169	108	216	153

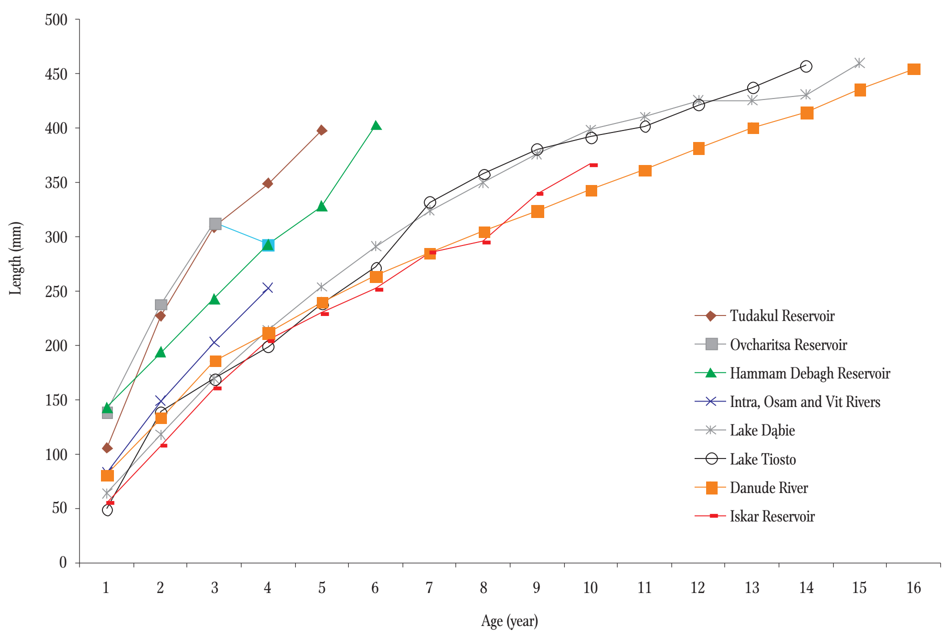

Figure 4. Mean length-at-age data for common bream (*A. brama*) in Iskar Reservoir with comparison of others populations: Tudakul Reservoir, Uzbekistan, (Kamilov et al. 2017), Ovcharitsa Reservoir, Bulgaria (Živkov and Raikova-Petrova 1996), Hammam Debagh Reservoir, Algeria (Guettaf et al. 2019), Intra, Osam and Vit Rivers, Bulgaria (Belomacheva et al. 2005), Lake Dąbie, Poland (Załachowski and Więski 1998), Lake Tiosto, Belarus (Kukushkin 1997), and Danube River, Croatia (Treer et al. 2003). Data are for SL, except for Guettaf et al. (2019) which is for TL.

temperature. Although the lengths of bream from Tudakul Reservoir, Hamm Debagh Reservoir, and Lake Dąbie were measured to the end of the caudal fin, the data about length growth showed a clear trend. Age 5 fish from Tudakul Reservoir reach a length of 485 mm (Kamilov et al. 2017), while those from Lake Tiosto reach a length greater than 450 mm only in year 14 of life (Kukushkin 1997). The length of Danube River bream exceeded 450 mm at age 16 (Treer et al. 2003).

Data about the bream length growth in Iskar Reservoir and from the Danube River, Lake Tiosto, and

Table 4

Comparison of the average altitude, geographic coordinates, and climate characteristics of several water bodies (Dimitrov 1973, Živkov and Raikova-Petrova 1996, Guettaf et. al. 2019)

Area	Altitude (m a.s.l.)	Climate
Danube catchment area – Vit, Osam, and Yantra rivers, Bulgaria	<200 m	Moderate, continental
Danube River, near the Drava River mouth, Croatia	<200 m	Moderate, continental
Ovcharitsa Reservoir, Bulgaria	200 m	Transitional, mediterranean
Iskar Reservoir, Bulgaria	818 m	Moderate, continental mountain
Lake Tiosto, Belarus	150 m	Moderate, continental
Lake Dąbie, Poland	131 m	Oceanic
Tudakul Reservoir, Uzbekistan	223.5 m	Continental dry
Hammam Debagh Reservoir, Algeria	720 m	Mediterranean

Table 5

Mean weight of common bream (*A. brama*) from different water bodies calculated at the same body length (*L*=50, *L*=100, *L*=150 etc., mm) ($W_{L=50}$, $W_{L=100}$, $W_{L=150}$… etc., g)

Locality/ Author	Equation	Mean body weight (g) at the same length							
		W_{50}	W_{100}	W_{150}	W_{200}	W_{250}	W_{300}	W_{350}	W_{400}
Iantra, Osam and Vit rivers, Bulgaria (Belomacheva et al. 2005)	log W = -5.247 + 3.265 logSL; r^2 = 0.956; n = 29	2	19,2	72,1	184	382	693	1147	1778
Ovcharitsa Reservoir, Bulgaria (Živkov and Raikova-Petrova 1996)	log W = - 5.058 + 3.180 logSL; r^2 = 0.988; n = 3378	2,2	20	72,6	181	368	658	1074	1642
Iskar Reservoir, Bulgaria	log W = -4.0 + 2.733 logSL; r^2 = 0.980, n=124	4,4	29,2	88,5	194	358	588	897	1292
Lake Tiosto, Belarus (Kukushkin 1997)	log W = -4.752 + 3.022 logSL; n = 140	2,4	19,6	66,7	159	312	542	863	1292

Lake Dąbie clearly showed that length growth decreased with age (Kukushkin 1997, Załachowski and Więski 1998, Treer et al. 2003). Length growth was 50–55 mm per year during the first three years of the bream life cycle, while in fish age-6 and older, length growth decreased to 16–30 mm annually. The length growth of Iskar Reservoir bream was much closer to that of fish from Lake Dąbie and the Danube River. The smallest length of age-1 fish was one of the reasons for the small length of Iskar Reservoir bream in comparison with fish from the other water bodies mentioned above. The length of Iskar Reservoir bream was similar to that of Polish and Belarusian bream, even though the dam is located in southeastern Europe. The water body's high altitude is the probable the reason for its colder climate and shorter fish growth period (Table 4). Thus, at the same age, the length of Iskar Reservoir bream is much shorter than that of bream from the Danube catchment area. However, after the third year of the bream life cycle, its linear growth accelerates, even if fish were located in the Iskar Reservoir, so at age-8 or 9 these fish caught up with the growth observed in the Danube catchment area.

A comparative analysis shows that for the last length classes, L_{300}, L_{350}, L_{400}, the weight of Iskar Reservoir bream was close to that of fish from Lake Tiosto in Belarus (Kukushkin 1997). This small difference was because the total weight of Iskar Reservoir fish was measured. The Ovcharitsa Cooling Reservoir had better growing conditions for bream; however, the best growth possibilities were in the fish's natural range, which is the Danube River catchment area (Table 5). Our sample included egg-bearing female fish that were caught in the spring, which increased their weight. The weight of all specimens was measured including entrails. However, despite this inaccuracy, the comparison of weight data at different length values clearly showed the trend of slower bream weight gain compared with that of bream inhabiting other Bulgarian water bodies (Živkov and Raikova-Petrova 1996, Belomacheva et al. 2005). Despite the harsher climate conditions in Iskar Reservoir, resident bream successfully adapted to the environment there. The fish's breeding period occurs earlier in the spring, before the period of the greatest water use, so fish spawning locations never dry out, and species reproduction is not compromised by decreased water level. This is why bream has adapted to the reservoir more successfully than other economically valuable species, such as carp. Regardless of its slow growth rate, the species offers good opportunities for recreational fishing in Iskar Reservoir.

Conclusions

The data about the Iskar Reservoir bream population presented by this study led to several important conclusions. The linear growth rate of Iskar Reservoir bream is slower than that of the bream inhabiting its natural range. This was a consequence of introducing this species into a water body located at a higher altitude with a shorter growth period and different feeding conditions. Consequently, bream growth in the Iskar Reservoir is closer to that of bream observed in some Northern European countries.

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