

The state of the main biological indicators of roach (*Rutilus rutilus*, Linnaeus, 1758) in the upper part of the Volga reach of the Kuibyshev reservoir

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Abstract. The size-age structure and weight of roach in catches in the autumn period of 2022-2023 are considered in the upper part of the Volga reach of the Kuibyshev reservoir. The correspondence of the biological indicators of roach to the characteristics inherent in the destabilization period of the ecosystem of the Kuibyshev reservoir was established.

1 Introduction

The Kuibyshev reservoir is located in the central part of the Middle Volga region, between the borders of the forest-steppe province of the Volga Upland and the lowland Trans-Volga region, it runs in the meridional direction, and continues from the forest landscape zone in the north to the steppe in the south, passing through the entire forest-steppe zone [1].

In accordance with the zoning scheme proposed by N.A. Dzyuban (1960), the reservoir is divided into several regions (reaches) [2].

The Volga reach is located in the upper part of the Kuibyshev reservoir. It stretches from the top of the reservoir to the place where the Kama flows into it, which is the upper boundary of the next one - the Volga-Kama reach. The Volga reach, especially its upper part, belongs to the narrowest part of the Kuibyshev reservoir.

Sviyaga Bay is located in the upper part of the Volga reach of the Kuibyshev Reservoir and is one of the most important areas for the reproduction of many fish species, including the roach *Rutilus rutilus* (L.).

The roach is a widespread freshwater fish species that lives in water bodies of the Eurasian continent. It is found in rivers, lakes, reservoirs and other bodies of water, excluding only a few of them, for example, semi-mountain tributaries of the river. Kama. Roach is a eurybiont species, well adapted to living in altered conditions, including reservoirs.

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In the Kuibyshev Reservoir, roach is a common species and an important commercial target among other species of small-sized fish. In the 1980s, roach catches ranged from 829.8 tons (1980) to 533.5 tons (1987) [3]. In the 90s of the last century and in 2000, the roach fishery relatively stabilized, but the share of roach in catches in the Kuibyshev Reservoir decreased and only by 2020, against the backdrop of an increase in the total catch, the share of roach in catches began to increase [4].

The distribution of roach across the reservoir areas is uneven. This is due to the absence of significant areas of shallow water in some areas, which is determined by the narrowing of the reservoir bed (Tetyushi reach, upper part of the Volga reach). In 1986, in the catches carried out in the upper part of the Volga reach, roach by weight was 2.3%, in the lower part of the reach 9.8% [5]. An increase in the abundance of roach in certain areas of the reservoir, especially in the shallow zone, occurs in the pre-spawning and spawning periods and is associated with the preparation or passage of spawning, after which the roach is distributed over other areas of the reservoir.

The development of the reservoir ecosystem from the moment of its creation to the present time has included several stages. In the first years of its existence, starting from 1956, the ecosystem of the reservoir was in a phase of “explosion of biota”, which was replaced by a phase of depression, until the mid-80s the phase of “relative stabilization” continued, and in the early 90s a phase of destabilization of the ecosystem began. Each phase was characterized by certain changes in the biology of the fish in this artificial reservoir. Therefore, the study of the biological indicators of roach, as an important structural element of the ichthyofauna, is a significant factor in assessing the current ecological state of the reservoir ecosystem.

2 Materials and methods

The material was collected in the autumn during expeditions organized by the Department of Zoology and General Biology of the Institute of Fundamental Medicine and Biology, Kazan (Volga Region) Federal University in the upper part of the Volga reach of the Kuibyshev reservoir in 2022-2023. Adult fish were caught using a set of gill nets with mesh sizes ranging from 24 to 65 mm. The age of the fish was determined by cuttings of hard rays of the dorsal fin and scales. The material was processed using generally accepted methods [6,7]. Statistical processing of the material was carried out according to the guidance of G.F. Lakin [8].

The following statistical indicators are presented in the text and tables: $M \pm m$ – mean value and its error; σ – standard deviation, t – Student’s test, CV, % – coefficient of variation [6-8]. The volume of material used is given in the text.

3 Results and Discussion

Between 1962 and 1999 in the Sviyaga Bay, the average size of roach ranged from 17.3 to 24.0 cm, then from 2003 to 2008 the average size of roach in catches decreased [9-10].

The maximum size of roach in 2022 was 27.0 cm (Table 1), the minimum body length was 12.5 cm, with an average value of 16.8 ± 0.5 cm ($\sigma = 3.6$ cm; CV=21,4%). The sizes of females varied from 12.5 to 27 cm, with an average length of 17.1 ± 0.5 cm, ($\sigma = 3.8$ cm; CV = 22.0%) the sizes of males ranged from 13.0 cm to 17.5 cm, with an average length of 15.0 ± 0.4 cm ($\sigma = 1.4$ cm; CV = 9.3%). The average sizes of males and females differed, and these differences were reliable for significance level of 0.01.

In roach catches in the autumn season of 2023, maximum size of roach was 33.0 cm, the minimum was 11.0 cm. The average was 20.2 ± 1.2 cm, standard deviation was 5.8 cm (CV

= 28.7%). This range of variation was typical for females, but the average length was higher - 22.3 ± 1.3 cm ($\sigma = 5.2$ cm; CV = 23.3%), the maximum body length of the males was 15.0 cm, the minimum was 11.0 cm. The average size of males is 14.1 ± 0.6 cm ($\sigma = 1.6$ cm; CV = 11.3%). The average indicators of females and males had reliable differences, for a significance level of 0.001. It should be noted that when comparing the average sizes of roach from the period 2022-2023. (our data) with earlier periods 2003-2004 and 2007-2008 no dramatic changes in the size of this species were observed in the Sviyaga Bay (Table 1) [4, 9-10].

The average weight of roach according to the catches of 2003-2004 and 2007-2008 ranged from 82.8 g to 193.3 g (Table 2) [4-5].

The average mass of roach individuals in catches in the upper part of the Volga reach of the Kuibyshev reservoir in 2022 was 121.7 ± 13.6 g, standard deviation 104.2 g (CV = 85.6%). The weight of individuals ranged from 42.0 to 486.0 grams (Table 2). The weight composition of females varied from 42.0 to 486.0 g, and the average value was 133.0 ± 16.0 g ($\sigma = 111.2$ g; CV = 83.6%). The weight of males ranged from 42.0 to 88.0 g, with a mean of 67.4 ± 4.6 g ($\sigma = 14.8$ g; CV = 21.9%). Differences in weight between the males and the females were reliable at a significance level of 0.001.

Table 1. Size composition of roach catches in the Volga reach of the Kuibyshev reservoir.

Years of observation	Oscillations, cm	M \pm m, cm	CV, %	n	Source
2000	14.0-32.0	22.2 \pm 0.3	14.8	160	Kuznetsov V.A. et al., [10]
2003	8.0-26.0	16.8 \pm 0.3	17.3	93	
2004	14.0-30.0	17.2 \pm 0.2	11.5	132	
2007	12.0-24.0	16.4 \pm 0.3	14.5	60	
2008	8.0-26.0	14.2 \pm 1.1	36.3	24	
2022	12.5-27.0	16.8 \pm 0.5	21.4	58	Our materials
2023	11.0-33.0	20.2 \pm 1.2	28.7	23	Our materials

The body weight of roach in catches in the fall of 2023 averaged 227.3 ± 40.7 g ($\sigma = 195.3$ g; CV = 85.9%), with a maximum value of 832.0 g and a minimum of 28.0 g. Average body weight of females was 287.4 ± 47.0 g ($\sigma = 194.1$ g, limmin-max = 30.0-832.0 g; CV = 67.5%), males 57.0 ± 5.9 g ($\sigma = 14.6$ g, limmin-max = 28.0-68.0 g; CV = 25.6%). Differences in weight between males and females were reliable at a significance level of 0.001.

Table 2. Weight composition of roach catches in the upper part of the Volga reach of the Kuibyshev reservoir.

Years of observation	Oscillations, cm	M \pm m, cm	CV, %	n	Source
2000	45.0-550.0	193.3 \pm 7.4	48.5	160	Kuznetsov V.A. at al. [10]
2003	40.0-310.0	94.9 \pm 5.8	59.3	93	
2004	30.0-300.0	82.8 \pm 4.1	56.7	132	
2007	70.0-250.0	95.2 \pm 6.1	49.2	60	
2008	30.0-350.0	83.8 \pm 15.9	90.7	24	
2022	42.0-486.0	121.7 \pm 13.6	85.6	58	Our materials
2023	28.0-832.0	227.3 \pm 40.7	85.9	23	Our materials

A comparison of the average indicators of roach individuals over two years of observation (2022-2023) shows the presence of significant differences in the size of roach ($t=2.6$; $n=81$ specimens) for a significance level of 0.05. The weight of roach t in 2022 and 2023, when compared, also had reliable differences ($t=2.5$; $n=81$ specimens) for a significance level of 0.05.

Female roaches, when comparing individuals in 2022 and 2023, had reliable differences in body length ($t=3.7$; $n=65$ specimens) for a significance level of 0.01, and males had no significant differences in body length ($t=1.3$; $n=16$ specimens). Weight of female roach caught in 2022 and 2023 differed at a significance level of 0.01 ($t=3.1$; $n=65$ specimens), no reliable differences were found in males ($t=1.3$; $n=16$ specimens).

The age of roach in catches in 2022 ranged from 2+ to 9+ years, in 2023 from 3+ to 8+ years (Table 3).

The main age groups in the catches of 2022 were roach from 3+ to 6+ years (82.6%), in 2023 from 3+ to 4+ (48.0%) and from 6+ to 7+ years (34.8%).

Table 3. Age composition (%) of roach catches in the upper part of the Volga reach of the Kuibyshev reservoir.

Years	Age, years										n
	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+ and st.	
2000*	-	-	0.6	5.6	23.8	23.1	10.6	22.5	9.4	4.1	160
2003*	-	4.8	34.9	34.9	4.8	6.2	7.2	4.8	2.4	-	83
2004*	-	12.9	35.6	32.6	9.8	3.0	5.3	-	0.8	-	132
2007*	-	23.3	41.7	15.0	16.6	1.7	1.7	-	-	-	60
2008*	45.8	8.3	29.2	12.5	4.2	-	-	-	-	-	24
2022**	1.7	15.5	24.0	21.0	22.4	8.6	3.4	3.4	-	-	58
2023**	-	21.7	26.2	13.0	17.4	17.4	4.3	-	-	-	23

Note: * - data taken from the article by Kuznetsov V.A. and others [10]; ** - our data.

4 Conclusion

Currently, in the upper part of the Volga reach of the Kuibyshev Reservoir, there is a stabilization of the average size of roach, at the level of indicators characteristic of 2003-2008, when there was a decrease in the size characteristics of roach compared to the average indicators characteristic of the period 1962-1999.

Comparison of the average values of body length and mass of male roach individuals, catches of 2022 and 2023, shows the absence of reliable differences in these indicators, while when comparing similar indicators of females, reliable differences in body length are found ($t = 3.7$; $n = 65$ specimens) and weight ($t=3.1$; $n=65$ specimens) for a significance level of 0.01.

Analysis of the age composition of the roach population in the Sviyaga Bay shows the dominance of young individuals over older individuals. This is an unfavorable circumstance for the reproduction of this fish species.

The state of biological indicators of roach found in the catches of the upper part of the Volga Reach corresponds to the ecological processes of the reservoir ecosystem during the period of destabilization.

The size of roach has decreased, and there has been a tendency for the role of older age groups in the population to decrease. All this is a reflection of the influence of anthropogenic pressure on the ecosystem of the reservoir.

The state of biological indicators of roach obtained during the research, based on catches in the upper part of the Volga reach, corresponds to the ecological processes occurring in the ecosystem of the reservoir, characteristic of the period of destabilization.

Compared to the periods of “explosion of biota” and “relative stabilization” of the reservoir ecosystem, the average body size of roach and average weight indicators have decreased, and there is a stable trend towards a decrease in the role of older age groups in the population. This indicates that even for such a eurybiont species, which is the roach, the

impact of anthropogenic pressure on the ecosystem of a reservoir leads to negative processes that significantly reduce the productivity of this species

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