STRUCTURAL AND FUNCTIONAL ADAPTATIONS OF FISH POPULATIONS OF THERMAL POWER STATION COOLING RESERVOIR IN THE PROCESS OF DESTRUCTIVE SUCCESSIONS OF ITS ECOSYSTEM

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Abstract: The present paper is the result of years of research on fish populations in a destructive succession of ecosystems of the Cuciurgan cooling reservoir of the Moldavian State Regional Electric Power Station (MGRES). It was found that at the beginning of the reservoir operation there existed the highest population number of Common bream, pike, roach, zander and perch, consisting of six to nine age groups, with a normal rate of linear growth and weight and a high level of reproduction. During the period of the greatest termofication of the reservoir the population of Crucian carp has significantly increased in number in the presence of nine age groups and normal rate of linear growth and weight. Zander population also responded positively to ecosystem succession, maintaining good reproductive potential. However, their number quickly began to decline due to the close location of the main spawning grounds in front of the intakes of the coastal pumping stations. The greatest negative impact of termofication was on pike (structural degradation of pike population, a sharp decline in its numbers and a reduction in area). Since the mid-1990s, the reservoir has changed to become a lake overgrown with weak water exchange. For zander population, the changes in environmental conditions went beyond its adaptive capabilities, undergoing degradation and decline in numbers. Structural and functional adaptation of populations of Common bream, roach, perch and Crucian carp to adverse environmental conditions manifested in the increased share of slow-growing and diminutive forms in the lower and middle age groups.

Keywords: adaptation, Cuciurgan reservoir, ecosystem succession, fish populations

Introduction:

Cuciurgan cooling reservoir of the MGRES (Moldavian State Regional Electric Station) was built in 1964 because of the regulation of the Cuciurgan estuary. The water supply in the estuary has been mainly taken from the Dniester River – during floods through its sleeve Turunchuk and then Stoyanovo Arm. Depending on the dryness of the year its water area extended to 1500 - 3200 hectares with depth - from 1.7 to 3.2 m (Iaroshenko 1950). The Cuciurgan estuary was spawning and feeding the pond with phytophilic fish from the Dniester River. The MGRES functioning affected the ecological conditions in the Cuciurgan reservoir, contributed to its ecological succession and was accompanied by a change in the structure of the fish populations. During the period of the reservoir`s existence there have

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been significant changes in its thermal regime (in 1981-1985 the temperature of the water in the lower section exceeded the natural from 6 to 10 °C) and other abiotic factors (dissolved gases, nutrients and organic matter, ionic composition and mineralization of water) as well as the accumulation and transformation of organic matter in the ecosystem (Zelenin 1988). On the other hand the optimal hydrological conditions combined with high temperature enhanced the self-purification of water and maintained a normal gas and salt regime of the reservoir and the turnover of the main nutrients (nitrogen, phosphorus), as well as the rate of production-destruction processes etc. (Germanov 1971; Andriushenko et al. 1999).

Since the 90s, there has been a distortion in the regulation of the system of abiotic and biotic environmental conditions in the Cuciurgan reservoir. In the past 15 years, the temperature regime of the reservoir has been almost indistinguishable from the natural regime and significantly decreased the intensity of the circulation of water flows. Mass development of macrophytes and algae in the reservoir prevented the normal horizontal and vertical movement of the water masses, circulation of nutrients in the pond, and hampered the work of the electric power plant (Crepis et al. 2008). The purpose of this research was to investigate the peculiarities of the structural and functional adaptation of the commercial fish populations in the process of destructive changes of the Cuciurgan`s reservoir ecosystem.

Materials and methods:

Investigations were conducted in 2012-2014. There was analyzed information from the academic study literature over many years. The collection of ichthyologic material was carried out from control fishing catches using different nets (218 times), fish traps and lifting nets (10 times) and whitebait seine 40м (39 times) in different parts of the reservoir, as well as from catches from fishermens. The volume of collected ichthyologic material amounted to 12 thousand individuals of different species, sex and age. For 1200 fish individuals, the age, gender and linear-weighted indices were determined. An ichthyologic analysis of the collected material was performed using conventional standard methods in ichthyology (Tipovie metodiki… 1974-1976; Metodika prognozirovania… 1982). The identification of fish species was done using the guidance of Koblitskaia (1982) and Kottelat and Freyhof (2007). Systematics and nomenclature of fishes employed in this work taxonomic status, which is considered valid at the present stage of ichthyologic research (Bogutskaia and Naseka 2004; California Academy of Sciences 2008).

Results and discussion:

Analysis of data on changes in the structural and functional state of the ichthyofauna in the evolution of Cuciurgan reservoir ecosystems allowed the identification of the commercial fish species groups, which could serve as informative reliable indicators of modifications in the ecological status of the reservoir: Common bream, pike, zander, roach, perch, and Crucian carp. Thereby, we studied the dynamics of changes in the age, linear-weighted and sex structure of the populations of these species in the historical aspect from the beginning of the construction of Cuciurgan reservoir to the present days.

Studies show that prior to the construction of the reservoir, on the background of high numbers of bream, its population consisted of seven age groups, with the numerical predominance of adults (Tab. 1).

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Table no. 1 Dynamics of the Common bream population structure in the Cuciurgan reservoir

		Age groups								
Years	Ind.	0+	1-1+	2-2-+	3-3-+	4-4+	5-5+	6-6+	7-7+	8-8+
1922-	2	s.sp.	14.2	19.8	25.7	31.1	34.8	39.3	-	-
1925*			49	163	336	592	784	1001		
1966-	1	s.sp.	26.1	9.3	17.0	16.5	22.4	5.4	3.3	-
1970	2	5.4	14.7	18.1	23	28.5	31.3	34	37	-
		10.4	37.4	122	256	486	620	769	1018	
	3	J	J	J	J+F	J+F+M	F+M	F+M	F+M	-
1981	1	24.6	27.7	28.7	14.3	3.0	0.7	0.5	-	-
	2	5	11	15	19.5	25.5	30.9	33	37	47
		9	39.4	65	160	370	528	700	800	1500
	3	J	J	J	J	J+M+F	J+M+F	F+M	F+M	M
1985	1	11.7	29.0	32.4	22.7	1.8	1.6	0.5	0.2	0.09
	2	6	13	17	20	25	28	32	34	44
		9	52	102	160	350	490	700	804	1500
	3	J	J	J	J	J+M+F	J+M+F	F+M	F+M	F+M
1991-	1	17.2	27.6	13.8	4.6	7.0	12.6	9.2	5.7	2.3
1995	2	6	12	17	21	26	31	34	38	48
		7.5	50	96	200	400	570	836	990	1650
	3	J	J	J	J	J+M+F	J+M+F	F+M	F+M	F
2001-	1	26.5	14.7	23.5	23.5	11.8	s.sp.	-	-	-
2003	2	6	13	17	20	23	28	-	-	-
		9	52	102	150	240	500			
	3	J	J	J	J+M	J+M+F	J+F+M	-	-	-
2012-	1	44.9	10.2	16.0	12.0	8.7	4.1	4.1	s.sp.	-
2014	2	5.8	11.1	13.5	19.6	21.2	24	30.2	33	-
		5.7	34.2	72	198	235	337	535	805	
	3	J	J	J	J	J+M+F	J+F+M	F	F	-

Notes: *-before the regulation of estuary (Egerman 1926); Ind.-indicators: 1-ratio between the age groups of population (%); 2-body length (cm)/body weight (g) by age groups; 3-F: females, M: males, J: immature individuals; s.sp.-single specimen.

In this period the Common bream was characterized by the normal rate of the linear weight growth, reaching the seventh year of the body length`s growth of 39.3 cm and weight of more than 1kg. Females matured at 4-5 years old. In 1966-1970s in the reservoir existed the largest population of Common bream, consisting of eight age groups with the numerical predominance of tiny fishes indicative of a high level of reproduction in favorable environmental conditions. However, the rate of linear weighted growth of Common bream was slightly lower than before the construction of the dam, and in the seventh year of life they reached a body length of 34 cm and weight of 769 g. This can be explained by the fact that before the construction of the dam there used to be a massive migration of bream from the Dniester River, where they were growing faster than in lakes. Bream puberty period was more extended in time due to the presence in the population of fast-maturing (3-4 year) and slow-maturing (5 year) fish groups (Tab. 1).

Throughout 1981-1985, the period of the greatest thermofication in the reservoir, despite the reduction of food stocks in the lake, the Common bream population was still fairly large and consisted of nine age groups. However, reduction of food base affected the rate of individual's linear weight growth, which decreased significantly. For example, in the fourth year the Common bream reached a body length of 20 cm at a weight of 160 g, and in the seventh year the

body length was 32 cm with a weight of 700 g (Tab. 1). Puberty starts in the 4th year and ends in the 6th year. Thus, in the said period the change of environmental conditions in the reservoir led to an increase in the population of slow-growing and slow-maturing individual fish.

Since 1991, against the background of unfavorable changes in the ecosystem of the reservoir there occurred a sharp decline in the number of Common bream (caused by the dwindling of the female population and low reproduction). In this small population the food supply increased, which resulted in some rise in the rate of linear weight growth of individuals. The rate of puberty growth has not changed, but the number of producers declined sharply in older age groups.

As a result of negative changes in the ecosystem in 2001-2003, there appeared a reduction in the number of species with distortion in the age structure of its population, which reduced to six age groups, where the number of older individuals was insignificant. An investigation of linear weight growth on Common bream highlights the prevalence in the population`s slow-growing forms. For instance, in the fifth year Common bream reached 23 cm body length with a medium weight of 240 g, and in the sixth year a body length of 28 cm with a weight of 500 g (Tab. 1). Sex structure of the Common bream population was also significantly disturbed.

Currently, the number of age groups increased in the Common bream population, but its adaptive response to adverse environmental conditions was expressed by a numerical predominance of small slow-growing individuals. For example, in the second year of growth fish body length was reduced to 11 cm, and weight up to 34 g, in the third year the length of the body was not more than 13.5 cm, with a medium weight of 72 g, and in the sixth year the body length was 24 cm with medium weight of 337 g (Tab. 1). The rate of puberty also decreased, resulting in all bream individuals becoming sexually mature only when becoming six years old.

Based on the analysis of the obtained data, the pike was the most sensitive to changes in environmental conditions. According the estuary regulation in-between 1966-1970, in the reservoir were numerous populations of pike, consisting of nine age groups featuring a large number of females and a high level of reproduction (Tab. 2). Puberty for females began at the age of two years, and all fish matured in the second year of life. However, in the period of intense thermofication of reservoir (1981-1985), as a result of distortion of the functioning of the reproductive system, the population of pike almost disappeared in most parts of the water area.

After the decrease in the thermofication level and eutrophication with macrophytes a reverse pattern emerged. Since 1995, the pike had begun to restore the structure of the population and to increase its number of individuals due to early maturing and a high rate of reproduction. The rate of linear weight growth in most age groups was significantly higher than in the 60s - 70s. Therefore, pike yearlings reach a body length of 17 cm with a mass of 72 g, the two-year old individuals have the body length of 24.2 cm, with a medium weight of 160 g, and four-year old individuals the body length of 37.5 cm and the weight of 510 g (Tab. 2). Analysis of the sex structure showed that the population has accelerated the rate of puberty growth and most female matured at the age of two-years old.

As a result of adverse changes in the environment and intensive fishing in 2001-2003, the number of individuals reduced and a disturbance of the age structure of pike population was observed which consisted of seven age groups. It was also noted that there

was a tendency to decrease the rate of linear weight and puberty growth in individuals (Tab. 2). Currently, from the seven age groups two older groups are represented by single females and the number of four-five-year old individuals is low. The rate of linear weight growth has changed little since 2000, the rate of puberty has increased slightly, resulting in the sexual maturity of the majority of pike at the two-year old age.

Table no. 2 Dynamics of the pike population structure in the Cuciurgan reservoir

		Age groups								
Years	Ind.	0+	1-1+	2-2-+	3-3-+	4-4+	5-5+	6-6+	7-7+	8-8+
1922-1925*	2	-	23 199	31 251	41,6 780	-	-	-	-	-
1966-1970	1	-	11.1	12.5	20.8	41.7	6.9	2.8	2.8	1.4
	2	14.6 43	23.3 125	32 294	36.7 467	42.3 690	51.3 1315	57 1711	65 2925	66.5 3925
	3	J	J+F	F+M	F+M	F+M	F+M	F+M	F+M	F
1981	1	-	-	s.sp.	-	-	s.sp.	-	-	-
1985	1	-	-	-	-	-	s.sp.	-	-	-
1995	1	29.2	58.4	7.3	3.6	1.5	s.sp.	s.sp.	s.sp.	-
	2	17.0 72	24.2 160	32.0 370	37.5 510	42.0 860	53.0 1300	57.5 1800	64 3100	-
	3	J	J+F+M	F+M	F+M	F+M	F+M	F+M	F+M	-
2001-2003	1	2.4	75.9	19.3	1.2	1.2	s.sp.	-	s.sp.	-
	2	15.5 54	25 210	32 315	36.7 575	42.5 845	45 1260	-	60 3300	-
	3	J	J+F+M	F+M	F+M	F+M	F+M	-	F	-
2012-2014	1	18.4	25.0	24.0	19.7	10.6	1.0	1.3	-	-
	2	16.1 61.2	26 230	33 416	36.1 492	46.4 1076	45 1550	60 3500	-	-
	3	J	J+F+M	F+M	F+M	F+M	F	F	-	-

Notes: *-before the regulation of estuary (Egerman 1926); Ind.-indicators: 1-ratio between the age groups of population (%); 2-body length (cm)/body weight (g) by age groups; 3-F: females, M: males, J: immature individuals; s.sp.-single specimen.

Studies showed that at the beginning of the reservoir`s life, zander population had a normal abundance and consisted of seven age groups (Tab. 3). The rate of its linear weight growth was slightly higher than before the regulation of the reservoir. For example, for a two year old individual, it increased from 21.9 cm to 23.1 cm in body length and from 133 g to 167 g in body weight, for the three-year olds, from 28.2 cm to 31.0 cm in body length and up to 286 g 458 g in body weight, while for the four-year olds – from 34 cm to 37 cm in body length and 556 g to 627 g in body weight. The puberty of zander started at the three-year age and ends at four years.

Zander, being a thermophilic species, has normally undergone the thermofication of the reservoir, kept the reproductive ability and formed eight age groups (Tab. 3).

Linear weight growth of older age groups was slightly higher than before the thermofication of the reservoir. For instance, for the five-year old individuals the body length increased from 40.5 cm to 45 cm and weight from 956 g to 1250 g; for the six-year old individuals the body length increased from 47.1 cm to 53 cm and weight from 1.4 kg to 2.5 kg, and for the seven-year individuals the body length increased from 56.2 cm to 57.7 cm and weight from 2.1 to 3.5 kg.

Sexual structure changed to an earlier maturation of females. However, the number of species in the specified period began to decline rapidly due to the location of the main spawning areas for zander along the coastal pumping station intakes and ingestion of their fry by non-target fishes.

Table no. 3 Dynamics of the zander population structure in the Cuciurgan reservoir

		Age groups								
Years	Ind.	0+	1-1+	2-2-+	3-3-+	4-4+	5-5+	6-6+	7-7+	8-8+
1922-1925*	2	-	21.9 133	28.2 286	34 556	39 827	-	-	-	-
1966-1970	1	s.sp.	57.3	22.6	9.6	4.9	s.sp.	5.6	-	-
	2	16.5 60	23.1 167	31 458	37 627	40.5 956	47.1 1484	56.2 2120	-	-
	3	J	J	J	J+M	F+M	F+M	F+M	-	-
1981 1985	1	24.6	27.7	28.7	14.3	3.0	0.7	0.5	-	s.sp.
	2	17 49.2	22 180	29.7 404	36.4 680	45 1250	53 2500	57.7 3500	-	70 5500
	3	J	J	J	J+ F+M	F+M	F+M	F+M	-	M
1991-1995	1	79.0	10.5	6.0	2.0	1.0	1.0	0.5	-	-
	2	17.5 45	21 171	30.0 400	40.0 760	46 1380	53 2020	59 3725	-	-
	3	J	J	J	J+F+M	F+M	F+M	F+M	-	-
2001-2003	1	s.sp.	s.sp.	s.sp.	s.sp.	s.sp.	s.sp.	s.sp.	-	-
	2	15 45	21 150	28.5 350	40 760	46 1400	51 2000	56 3000	-	-
	3	J	J	J	J +M	F	M	F	-	-
2005-2010		Population degradation								
2012-2014	1	-	s.sp.	-	-	s.sp.	s.sp.	-	-	-
	2	-	20 150	-	-	40 1500	42 2000	-	-	-
	3	-	J	-	-	F	F	-	-	-

Notes: *-before the regulation of estuary (Egerman 1926); Ind.-indicators: 1-ratio between the age groups of population (%); 2-body length (cm)/body weight (g) by age groups; 3-F: females, M: males, J: immature individuals; s.sp.-single specimen.

Eutrophication worsened the ecological conditions for reproduction of zander and after 2004 the age, linear- weight and sex structure/distribution of its population have degraded, whilst its population has reduced. Nowadays, thanks to the efforts MGRES on the environmental-industrial breeding of zander in the control catches individuals from different age groups have emerged. But for the recovery of the species it is necessary to conduct collective works with commercial fishery organizations to obtain a large zander fry with subsequent stocking in the reservoir.

The significance of this issue increased especially due to the massive development in the reservoir of the harmful Pumpkinseed sunfish, which could be blocked up – not sure what blocked up means only by zander.

It has been a significant increase in the number of perch and a change in the structure of its population after the regulation of the reservoir. At the beginning of the reservoir`s existence, on the background of high numbers of perch, its population consisted of nine age groups (Tab. 4), with the numerical predominance of young

individuals, indicating a high level of reproduction in favorable environmental conditions. However, the rate of linear weight growth of perch was smaller than before the construction of the dam. This can be explained by a decrease in food supply caused by an increase in the population size. Perch puberty began at three-years and ends at four years.

Table no. 4 Dynamics of the perch population structure in the Cuciurgan reservoir

		Age groups								
Years	Ind.	0+	1-1+	2-2-+	3-3-+	4-4+	5-5+	6-6+	7-7+	8-8+
1922-1925*	2	-	10.7 45	18.6 145.5	24.3 277.3	27.8 522	31.9 754	-	-	-
1966-1970	1	s.sp.	15.2	7.6	22.7	18.1	15.2	15.2	6.0	s.sp.
	2	6.0 4.2	9.4 16.4	14.2 66	18.2 120	19.6 206	26.3 351	29 527	31 810	-
	3	J	J	J	J+F+M	F+M	F+M	F+M	F+M	-
1991	1	44.9	8.4	25.0	13.8	4.4	2.0	1.3	-	-
	2	6.8 6.6	13.3 29.4	17.3 117	20 174	23.3 240	28.4 585	32.9 844	-	-
	3	J	J	J	J+F+M	F+M+J	F+M	F+M	-	-
1995	1	48.1	28.9	12.9	4.5	4.1	1.2	0.2	0.1	-
	2	5.0 3.5	8.1 14.5	15.0 83.3	18.8 158	22.0 332	28.0 480	31.4 670	33.1 1050	-
	3	J	J	J+F+M	J+F+M	F+M	F+M	F+M	F+M	-
2007	1	43.6	13.8	21.0	13.2	7.4	0.5	0.3	0.2	-
	2	6.5 7.3	10.1 27	13.3 55	17.0 109	18.5 170	25.3 395	30.5 670	32 950	-
	3	J	J+M	J+F	J+F+M	F+M	F+M	F+M	F	-
2012-2014	1	29.7	15.0	16.3	22.9	12.8	2.4	0.7	0.2	-
	2	5.5 6.2	10.5 22.4	11.8 40.1 16.5 109	12.9 48.2 17.5 122	13.6 65.1 19.5 210	21.3 330	25.5 590	32 700	-
	3	J	J	J+M	J+F+M	F+M	F+M	F+M	F+M	-

Notes: *-before the regulation of estuary (Egerman 1926); Ind.-indicators: 1-ratio between the age groups of population (%); 2-body length (cm)/body weight (g) by age groups; 3-F: females, M: males, J: immature individuals; s.sp.-single specimen.

The dynamics of the population structure of perch in the Cuciurgan reservoir indicates its highly adaptive capacities in a changing environment. Studies shown its adaptive response to the adverse effects of the anthropogenic factors manifested in the increase of the slow-growing and dwarf form numbers in the population. For example, in 1991, there was noted the maturation of the perch at the age of five; in 2007, part of the males matured at two years, and some females also at two years. Currently, it has been seen clearly that there are two linear weighted forms of fish in three age groups of perch: for three-year-old individuals a body length of 11.8 cm, a weight of 40.1g and a body length of 16.5 cm and weight of 109 g; for four-year-old individuals a body length of 12.9 cm, a weight of 48.2 g, a body length of 17.5 cm and a weight of 122 g; for the five-year old individuals the body length of 13.6 cm and weight of 65.1 g and a body length of 19.5 cm and weight of 210 g (Tab. 4).

Studies showed that at the beginning of the reservoir exploitation, on the background of high numbers of roach, its population consisted of six age groups, with the numerical predominance of adults (Tab. 5). The reason for this could have been a massive intake of female from the Dniester river before the regulation of the estuary, which remained there after the regulation and continued to reproduce. The rate of linear weight growth of the roach was relatively low compared to that before the regulation. Puberty of roach mainly occurred and was completed at four years of age.

Table no. 5 Dynamics of the roach population structure in the Cuciurgan reservoir

		Age groups								
Years	Ind.	0+	1-1+	2-2-+	3-3-+	4-4+	5-5+	6-6+	7-7+	8-8+
1964-1965	2	s.sp.	10.8	16.1	19.7	-	-	-	-	-
			29.4	96	174					
1966-1970	1	s.sp.	40.5	41.4	6.6	6.6	3.9	-	-	-
	2	5.4	9.5	15.5	19.6	24.6	27.1	-	-	-
		10.4	17.7	79	159	317	459			
	3	J	J	J	J+F+M	F+M	F+M	-	-	-
1981-1985	54.1	26.7	11.5	4.4	2.6	0.4	0.3	0.03	54.1	-
	6.5	10.7	15	19.5	23.5	26	29	32	6.5	-
	10.3	44.0	95	168	295	410	530	820	10.3	
	J	J	J	J+F+M	F+M	F+M	F+M	F+M	J	-
1991-1995	1	59.0	18.7	10.2	7.2	4.1	0.6	0.2	-	-
	2	6.9	11.8	17.7	20	23.1	25	28	34	-
		7.5	34.4	128	180	255	380	500	950	
	3	J	J	J+F	J+F+M	F+M	F+M	F+M	F+M	-
2001-2003	1	12.8	3.4	42.7	36.8	4.3	s.sp.	-	-	-
	2	6.5	11.0	15.0	19.0	23.0	26.0	-	-	-
		10.5	35	100	160	270	400			
	3	J	J	J+M	J+F+M	F+M	F+M	-	-	-
2012-2014	1	45.6	15.2	2.2	31.6	3.3	2.2	-	-	-
	2	6.9	10.1	13.5	17.5	19.0	23	-	-	-
		8.9	27	83	166	201	270			
	3	J	J	J+M	J+F+M	F+M	F	-	-	-

Notes: Ind.-indicators: 1-ratio between the age groups of population (%); 2-body length (cm)/body weight (g) by age groups; 3-F: females, M: males, J: immature individuals; s.sp.-single specimen.

During the period of maximum thermofication of the reservoir throughout the years 1981 - 1985 the roach remained an abundant species and preserved the normal linear weight and sex structure of the population with the presence of the eight age groups (Tab. 5).

Since 1995, against the background of unfavorable changes, in the ecosystem of the lake a rapid decline in the roach number has taken place (due to overfishing of females and reduced reproduction). As a result, since 2001, in the roach population there have been identified only five-six age groups, where the number of older individuals was small and there was a decreasing trend in the rate of linear weight growth. For example, in the third year of life the roach reached a body length of 15 cm, with a weight of 100 g, and in the fourth year a body length of 19 cm, with a medium weight of 160 g (Tab. 5).

Currently, the roach population displays a marked predominance of slow-growing forms, as evidenced by the slowdown in the linear weight growth. For example, in the second year of life the roach reaches a body

length of 10.1 cm, with a body weight of 27 g, and in the sixth year a body length of 23 cm, with a medium weight of 270 g. In the population there was noted a significant presence of the small males, which mature at the age of two, indicating that the emergence of dwarf forms of fish adapt to adverse environmental conditions.

The Crucian carp population consisted of six age groups and had a sufficiently high rate of linear weight growth before the regulation of the Cuciurgan estuary (Tab. 6).

Table no. 6 Dynamics of the Crucian carp population structure in the Cuciurgan reservoir

		Age groups								
Years	Ind.	0+	1-1+	2-2-+	3-3-+	4-4+	5-5+	6-6+	7-7+	8-8+
1960-1965	2	10 31.7	18.1 162.3	21.7 338.5	26.4 677.7	29.2 830	36.1 1125	-	-	-
1966-1970	1	4.6	4.7	11.1	25.6	25.6	13.9	13.9	-	-
	2	8.8 26	12.5 70	18.3 219	24 441	26.9 696	31 965	34.3 1395	-	-
	3	J	J	J+F+M	F+M	F+M	F+M	F+M	-	-
1981-1985	1	40.0	34.0	14.0	8.0	3.0	0.9	0.01	-	-
	2	9 32	15 125	21 260	25 420	28 620	29 760	33 1140	-	-
	3	J	J+F+M	J+M+F	F+M	F+M	F+M	F+M	-	-
1991-1995	1	56.3	12.9	4.0	7.9	7.9	4.0	4.0	2.0	1.0
	2	8.5 25	15 130	20 256	24 424	27 575	29 745	32 922	38 1725	41 2250
	3	J	J+F+M	J+M+F	F+M	F+M	F+M	F+M	F	F
2001-2003	1	2.9	11.6	47.8	33.3	4.4	-	s.sp.	-	-
	2	6.0 24	14.0 100	20.0 230	24.0 350	26.0 500	-	30.0 820	-	-
	3	J	J+F+M	J+M+F	F+M	F+M	-	F	-	-
2012-2014	1	24.8	23.2	22.8	17.0	7.4	2.9	1.7	0.2	-
	2	5.4 9.7 8.5 18.3	10.5 57.5 15 135	11.5 71 17.2 197.5	14 125 21.4 324	19.1 232 24.6 494	20.7 350 27.0 709	28.9 890	35 1100	-
	3	J	J	J+M+F	F+M	F+M	F+M	F+M	F	-

Notes: Ind.-indicators: 1-ratio between the age groups of population (%); 2-body length (cm)/body weight (g) by age groups; 3-F: females, M: males, J: immature individuals; s.sp.-single specimen.

After the reservoir intake regulation, there was recorded an important increase in the Crucian carp number and the changes in the structure of its population. Studies showed that at the beginning of the reservoir exploitation its population consisted of seven age groups with the numerical predominance of juveniles indicative of a high level of reproduction in favorable environmental conditions. However, the rate of the linear weight growth of Crucian carp was lower than before the construction of the dam. For example, in the second year of life their length decreased from 18.1 cm to 12.5 cm with a decrease in medium weight from 162.3 g to 70 g. This can be explained by a decrease in food supply due to an increase in the population size.

During the studied period of the active life of the electric power station, the Crucian carp population grew significantly in size and became a massive species, while maintaining close to the normal age structure of the population. Hence, in the 1990s, the

population consisted of nine age groups with a normal rate of linear weight growth.

The study of Crucian carp population dynamics in the Cuciurgan reservoir indicates its highly adaptive capacities in a changing environment. Studies shown its adaptive response to the adverse effects of anthropogenic factors manifested in the increase of slow-growing and dwarf form numbers in the population. Therefore, since the 1980s part of the Crucian carp already matured at age of two years, and the other is fully matured at two or three years of age.

Currently, there has been observed the presence of two linear weighted forms of fish in five age groups of the Crucian carp: for the two years old a body length of 10.5 cm with a weight of 57.5 g and a body length of 15 cm with a weight of 135 g; the three years old a body length of 11.5 cm with a weight of 71 g and a body length of 17.2 cm with a weight of 197.5 g; for the four years old a body length of 14 cm at a weight of 125 g and a body length of 21.4 cm at a weight of 324 g; for the five years old a body length of 19.1 cm with a weight of 232 g and a body length of 24.6 cm and weight of 494 g; for the six-year old a body length of 20.7 cm with a weight of 350 g and a body length of 27 cm with a weight of 709 g (Tab. 6).

Conclusion

This study has looked at the dynamics of changes in the age, linear weight and sex structure of commercial fish species populations in the historical aspect from the start of construction of Cuciurgan reservoir and till the present day.

Studies show that at the beginning of the reservoir operation, on the background of high numbers of Common bream, pike, roach, zander and perch, their populations consisted of six to nine age groups, with a normal rate of linear-weight growth and a high level of reproduction.

Throughout 1981-1985, the period of the greatest thermofication in the reservoir, the Common bream and roach populations were still large, however, reduction of food base affected the rate of individual's linear weight growth, which decreased significantly. During this period the Crucian carp population grew significantly in size and became a massive species. Zander has normally undergone the thermofication of the reservoir, kept the reproductive ability, high linear weight growth and formed eight age groups. However, the number of individuals began to decline rapidly due to the location of the main spawning areas for zander in front of the intakes of the coastal pumping stations. Based on the analysis of the obtained data, the pike was the most sensitive to changes in temperature conditions. As a result of distortion of the functioning of the reproductive system, the population of pike almost disappeared in most parts of the water area.

Since the mid-1990s, as a consequence of reduction in the intensity of the power station work, the reservoir became a lake overgrown with weak water exchange. In the new environmental conditions the pike had begun to restore the structure of the population and to increase its number of individuals due to early maturing and a high rate of linear weight growth and reproduction. Eutrophication worsened the ecological conditions for reproduction of zander and after 2004 the age, linear- weight and sex structure of its population have degraded, whilst its population has reduced.

The dynamics of the population structure of perch in the Cuciurgan reservoir indicates its highly adaptive capacities in a changing environment. Structural and functional adaptation of populations of Common bream, roach, perch and Crucian carp to adverse environmental conditions have resulted in the increased percentage of slow-growing and diminutive forms in the lower and middle age groups.

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Rezumat:

ADAPTĂRI STRUCTURALE ŞI FUNCŢIONALE ALE POPULAŢIILOR DE PEŞTI DIN LACUL DE RĂCIRE AL CENTRALEI TERMOELECTRICE ÎN PROCESUL DE DEGRADARE SUCCESIVĂ A ECOSISTEMULUI

Lucrarea prezintă rezultatul cercetărilor asupra populaţiilor de peşti din lacul de răcire Cuciurgan al Centralei Termoelectrice din Moldova (CTEM) pe perioada degradărilor succesive a ecosistemelor. S-a constatat că la începutul funcţionării lacului de răcire existau populaţii mari de plătică, ştiucă, babuşcă, şalău şi biban, cu o structură formată din şase până la nouă grupuri de vârstă, cu o rată normală de creştere liniară, precum şi un nivel înalt de reproducere. În timpul perioadei de maxim a termoficării lacului, populaţia de crap a crescut semnificativ, prezentând nouă grupuri de vârstă şi o rată de creştere liniară. Populaţia de şalău a răspuns, de asemenea, pozitiv sucesiunii ecosistemului, menţinând un bun potenţial reproductiv. Totuşi, în timp, populaţia de şalău a început să intre în declin datorită prezenţei în apropierea principalelor zone de reproducere a conductelor de captare, aferente staţiilor de pompare de pe mal. Cel mai semnificativ impact negativ al termoficării a fost asupra ştiucii (printr-o degradare structurală a populaţiei, un declin acut al efectivelor şi o diminuare a zonei de răspândire). De la jumătatea anilor 1990, structura ecologică a lacului s-a schimbat devenind un lac invadat de o bogată vegetaţie acvatică, cu un schimb de apă redus. Pentru populaţia de şalău, schimbările survenite în condiţiile de mediu au depăşit capacitatea de adaptare a speciei, rezultând o degradare şi un declin al efectivelor. Adaptarea structurală şi funcţională a populaţiilor de plătică, babuşcă, biban şi crap la condiţiile adverse de mediu s-a manifestat în ratele de creştere mult mai scăzute, cu forme diminuate pentru grupurile de vârstă mijlocie şi mică.

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