CHANGES IN SPECIES RATIOS FROM ICHTHYOFAUNA AND STRUCTURE OF THEIR AREAS IN THE PROCESS OF ECOLOGICAL SUCCESSION OF CUCIURGAN RESERVOIR

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Abstract: Cuciurgan estuary, before the regulation of its flow, was a part of the ancient estuary of the Dniester and served as spawning area and feeding pond for phytophilic fishes of the river (common bream, roach, common carp, European pikeperch, northern pike etc). Construction of the dam contributed to its ecological succession and natural estuary turned into an artificial pond with inlet recycling water supply of MGRES (Moldavian State Regional Electric Station). The purpose of this study was to investigate changes in the ratios of species from ichthyofauna and the structure of their areas in the process of ecological succession in Cuciurgan reservoir.

Keywords: Cuciurgan reservoir, diversity ecosystem, ecological succession, fish, ichthyofauna, population density, storage reservoir, structure areas, thermal and hydrological regimes.

Introduction:

Cuciurgan estuary, before the regulation of its flow, was a part of the ancient estuary of the Dniester and served as a spawning area and feeding pond for the phytophilic fishes of the river (common bream, roach, common carp, European pikeperch, northern pike etc). In addition, food migration of such rheophils as beluga, stellate sturgeon, sterlet, herring, Black Sea roach, ide, asp, barb, vimba, common nase has occurred in Cuciurgan estuary. There were 46 species and subspecies of fish belonging to 13 families prior to the flow regulation in the pond, (Egherman 1926; Zambriborsci 1960; Cepurnov and Kubrak 1965). The construction of the dam contributed to its ecological succession and the natural estuary turned into an artificial pond with inlet recycling water supply of MGRES (Moldavian State Regional Electric Station). MGRES exploitation has influenced the environmental conditions of Cuciurgan reservoir, further contributed to its ecological succession and was accompanied by a change in the number of different fish ecological groups.

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The purpose of this study was to investigate the changes in the ratios of species from ichthyofauna and the structure of their areas in the process of ecological succession in Cuciurgan reservoir.

Materials and methods:

Investigations regarding major fish species' ratios and their spatial distribution in the ichthyofauna of Cuciurgan reservoirs were conducted in 2012-2013. There was analyzed information from the specialty literature over many years. A collection of ichthyological material was carried out on control fishing catches using fishing nets of differents sizes (218 occasion), fish traps and fishing lifts (10 occasion) and dragnet for whitebait 40м (39 occasion) in different parts of the reservoir, as well as on catches of fishermen. The volume of the collected ichthyological material amounted to 14 thousand individuals of different species, sex and age. For 1421 fish individuals there were determined the age, gender and linear-weighted indices. Ichthyologic analysis of the collected material was performed using conventional standard methods in ichthyology (Tipovye metodik 1974-1976; Metodika prognozirovania 1982). Identification of fish species was done using determinators (Koblitskaya 1981; Kottelat and Freyhof 2007). Systematics and nomenclature of fishes used in these work have taxonomic status, which is considered valid at the present stage of ichthyological research (Bogutschaia and Naseka 2004; California Academy of Sciences. Ichthyology 2008: www.calacademy.org/research/ichthyology).

Results and discussion:

At the beginning of the exploitation of MGRES (1964-1965), sturgeons disappeared from ichthyofauna and there was a fast depletion in the population density of reophilus species - asp (0.4 %), ide (0.1 %), herring (0.1 %), nase (0.1 %), minnow (0.1 %), chub (0.1 %), vimba, sabre fish, Black Sea roach (single individuals) and others (Tab. 1, Annexes). Limnophilic species population maintained or increased their number - roach (18.3 %), silver bream (11.3 %), crucian carp (9.1 %), perch (11.0 %).

During the weak thermofication of the reservoir in 1969-1970 were observed an increase in food base for fish, which contributed to an increase in the population density of such species as bream (14.0 %), roach (30.1 %) and smartweed (16.2 %). However, the number of other species dwindled significantly – European pikeperch (1.0 %), tench (0.2 %), crucian carp (0.2 %), pike (0.6 %), common carp (0.1 %). Despite the large amounts of small fish, a reduction in the number of predators was observed, owing to the location of its main spawning areas in front of water intakes and for pike due to the modification of the sexual product's quality under the influence of higher temperatures.

Changes in the environmental conditions, which occurred due to the reservoir's intensive thermofication in 1981-1985, led to a decrease in primary bioproduction and had negative influence on the populations of some native fish species. The bream population depleted to 2.2 %, roach - to 9.3 %, perch - to 2.2 %. However, in general, changes in environmental conditions in Cuciurgan reservoir in a period of station intense work had positive impact on its ichthyofauna. Rapid water exchange and increase of the average water temperature contributed to the extension of the period of intensive growth to 2 months, inhabitation of the reservoir with new fish species (silver carp, bighead, grass carp and black carp) and allowed to form a new ichthyocomplex with high bioproduction. Silver carp (29.0 %) and bighead (10.0 %) took the leading position in the fish fauna, and accounted for over 90 % from the fishery reserve of the pond. Any significant change in its ichthyofauna had not been observed until mid-90s. Silver carp and bighead (26 %) still dominated by number. The number of perch (10.9 %) and gobies

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(9.1 %) was increased. Other species (roach, bream, silver roach, European pikeperch, pike) showed a tendency to decrease the number. In the period of 1991-1995 in the pond, new invasive noncommercial species – Black Sea silverside appeared. Its population became numerous (14.2 %) due to euribiontic characteristics and high rate of reproduction.

Since the mid-1990s, as a result of MGRES work intensity reduction, in the Cuciurgan reservoir occurred disturbance in regulation of abiotic and biotic environmental conditions. This led to a further reduction in the number of commercial fish populations. Vimba, herring, Black Sea roach, sabre fish, crucian carp, gobio and needlefish, completely disappeared from the catches. Catfish, asp, tench, grass carp were found in single copies in catches, and populations density of other species such as – silver carp (0.8 %), Azov roach (0.5 %), bighead (0.3 %), bream, pike, European pikeperch (0.1 % each) decreased significantly. Conversely, silverside (21.2 %), bleak (20.1 %), gobies (16.4 %), perch (11.7 %) were the most adapted species to changing environmental conditions.

Further changes in thermal and hydrological regimes of the reservoir in 2004-2006 led to mass overgrowing of macrophytes. As a result, there occurred another ecological succession and the pond turned into an overgrown lake with poor water exchange. During this period, there was observed successful reproduction of pike (2.1 %), perch (16.9 %), crucian carp (13.2 %), rudd (13.8 %), tench (2.9 %) populations. In catches appeared isolated specimens of rare fish species – herring, mudminnow, sunfish. On the other hand, it was noted a further decline in populations of roach (1.8 %) and bighead and silver carp (0.1%). The European pikeperch and Azov roach were represented in catches single copies. In 2007-2009, under the influence of changing environmental conditions, ichthyofauna has continued its alteration in the reservoir. The number of sprat (8.0 %), belica (7.6 %), rudd (17.4 %), common ruff (3.7 %) and sunfish (1.6 %) populations increased significantly.

Currently, regarding fish fauna the highest population density was observed for bleak (12.9 %), rudd (11.6 %), perch (9.0 %), crucian carp (8.3 %), belica (7.8 %) and silver bream (7.1 %). Over the past three years the number of sunfish (13.5 %) increased significantly and it represents serious competition to native species now. However, it was a marked tendency to restore populations of Azov roach (0.7 %), European pikeperch, chub, asp, catfish (0.1 % each) and a number of other valuable species that indicates the beginning of the normalization of the reservoir environmental conditions.

According to the purpose of this research there were studied particularities of spatial distribution changes and the structure of the population ranges of the main species from Cuciurgan reservoir during its ecological succession. Analysis of the literature showed that before the regulation of Cuciurgan estuary water flow and in the first years after the construction of the dam, the population areas of major fish species had been uniformly distributed, and the numerical density would vary during the spawning and feeding migrations from the Dniester river (Yaroshenko 1973; Karlov and Krepis 1988).

After the start of the active exploitation of the MGRES, in the reservoir were noted specific changes in the spatial distribution of some fish species and the structure of their areas. For example, bream, European pikeperch, crucian carp and silver bream concentrated in the middle section, which seems to create for them a more comfortable environment (Tab. 2, Annexes).

However, their ranges still covered the entire area of the pond. The numerical density of the common carp and bleak increased in the lower section but maintained the same areas structure. Azov roach migrated in mass from upper to lower section, where there was marked an overwarming and areas of its population have been reduced to the waters of lower and middle sections now. On the other hand,

species such as pike, tench, rudd, south small stickleback were focused in the upper portion of the reservoir, although a small number of these was also observed in other parts of pond. For belica and *Acerina rossica* were marked an almost complete shift of the areas in upper section.

After the reduction of the thermofication's intensity in 90s, it began the redistribution in numerical density of some species due to changed environmental conditions. For example, the populations of breams and Crucian carp are relatively evenly distributed throughout the water area. Azov roach extended ranges for all water areas with the largest density in the middle section of the pond. The highest concentration of European pikeperch, bitterling, silver bream and perch was also noticed in the middle section. Pike, tench, rudd maintained most part of the population in the upper portion and have begun to increase the numerical density at other sites. Stickleback area continued to shift towards the upper section, belica and *Acerina rossica* populations remained stable in the upper part of the pond. During this period, invasive species – Black Sea silverside formed a numerous population, which was concentrated in the lower area, but already began to spread to the middle site.

During the reservoir's mass overgrowing with water plants, organic water pollution with products of their decomposition and disturbance of reservoir self-cleaning process, another distribution of the numerical density of some species and the structure of their areas was observed. The most polluted site was left by most part of bream, Azov roach, common carp, which were focused on other areas. For the same reason numerical density of pike, tench, crucian carp, perch, silver bream, rudd decreased significantly as a result of their migration to the upper and middle zones. The highest adaptive capacity to unfavorable environmental changes was proper to South small stickleback, belica and *Acerina rossica* populations, although they have expanded their areas for the entire pond.

Currently, the ongoing biomelioration work on the reservoir and the improvement of its hydrological regime triggered marked positive changes in the ecological conditions of the reservoir. This is evidenced by the increase in concentration in the upper section of such fish species as pike, tench, common carp, silver bream, bitterling. Stickleback population areas still cover the upper part, but it is noted the extension of these to the side of the reservoir middle section. Belica and *Acerina rossica* significantly expanded their areas due to the massive reservoir overgrowing. The highest number density of these species is observed in the upper part now. Recently there has been established an invasion of the Dniester River with noncommercial sunfish, which has high adaptive capacity and reproduction intensity, and which spreads in the pond and becomes, though, a massive species harmful for native fish fauna.

Conclusions:

In this work there were studied peculiarities of changes in the species' ratios in fish fauna, as well as their spatial distribution and structure of the areas in the process of ecological succession of Cuciurgan reservoir.

It was established that after the transformation of Cuciurgan estuary in an inlet artificial pond with recycling water supply of MGRES from fish fauna sturgeons disappeared and the number of populations of rheophilous fish species (asp, ide, herring, common nase, chub, vimba, sabre fish and Black Sea roach) was reduced. The populations of limnophilic species (roach, Azov roach, silver bream, crucian carp, perch) maintained or increased their numbers.

Improvement of food base for fish in conditions of pond weak thermofication determined an increase in the population density of bream, Azov roach and roach, but a number of other species decreased significantly. It was observed a dwindling in the number of predators, despite the large

amounts of small fish. For the European pikeperch it was due to the location of its main spawning areas in front of water intakes and for pike as a result of disturbance of the sexual products' quality under the influence of elevated temperature.

Changing environmental conditions had a negative impact on populations of some native fish species during the intensive thermofication of the reservoir. However, the rapid water exchange and increase of the average water, the temperature contributed to the extension of the fishes' intensive growth period and inhabitation of new fish species in the reservoir. All these allowed to form a highly productive ichthyocomplex. Bighead and silver carp took the leading position a number of individuals from fish fauna and accounted for more than 90 % of the fishery reserve of the pond.

Reduced work intensity of MGRES led to a disturbance in the regulation of abiotic and biotic environmental conditions and to major changes in the ichthyofauna of the pond. Some species occurred in single copies (catfish, asp, tench, grass carp), and others – had significantly depleted their numbers (bighead and silver carp, Azov roach, bream, pike, European pikeperch). The most adapted ones to changing environmental conditions were silverside, bleak, gobies and perch.

As a result of the mass development of macrophytes and filamentous algae, the reservoir turned into an overgrown lake with poor water exchange. During this period, it was noted the successful reproduction of pike, perch, Crucian carp and tench populations. The number of sprat, belica, rudd, common ruff and sunfish soared. On the other hand, it was observed a further decline in the number of roach, European pikeperch and Azov roach.

Recently the highest populations number in ichthyofauna was observed for non-target (bleak, belica) and low value (rudd, perch, crucian carp) fish species. Over the past three years the number of sunfish (up to 13.5 %) has soared and it is a serious competitor to native species now. However, there was a trend to an increase in the populations of Azov roach, European pikeperch, chub, asp, catfish and several other valuable species, indicating that positive changes have occurred in the reservoir ecosystem.

It was established that after the beginning of active MGRES exploitation in the reservoir occurred specific changes in the spatial distribution of some fish species and the structure of their areas. For example, bream, European pikeperch, crucian carp and silver bream concentrated in the middle part, which apparently found a more comfortable environment. Azov roach migrated in mass from the upper to the lower area of the pond which is warmer. Species such as pike, tench, rudd, south small stickleback were spotted in the upper site of the reservoir.

Redistribution of species' numerical density occurred in the reservoir after the reduction of thermofication intensity. For example, the populations of bream and crucian carp are relatively evenly distributed across the pond. Azov roach expanded its areas all over the reservoir with the highest numerical density in the middle section. The highest number of European pikeperch, bitterling, bleak, silver bream and perch was also observed in the middle stretch. Pike, tench, rudd, while maintaining most of the population in the upper stretch, have begun to increase their numerical density at other sites of the reservoir.

Bream, Azov roach, common carp left the most polluted upper sector during the mass overgrowing of reservoirs. For the same reason there is a significant decrease in the numerical density of pike, tench, crucian carp, perch, silver bream, rudd. The highest adaptive capacity to environmental changes showed south small stickleback, belica and *Acerina rossica* populations, although they have expanded their areas throughout the entire pond.

Currently, as a result of the ongoing activity on MGRES and the reservoir biomelioration works and improvement of hydrological regime, there have been marked positive changes in the ecological conditions of the reservoir, as evidenced by the increase in concentration of pike, tench, common carp

and others valuable species in the upper section.

Rezumat:

MODIFICĂRI ÎN RAPORTUL SPECIILOR DE PEȘTI ȘI A STRUCTURII ARIILOR LOR DE RĂSPÂNDIRE ÎN PROCESUL DE SUCCESIUNE ECOLOGICĂ A BAZINULUI CUCIURGAN

Estuarul Cuciurgan, înainte de regularizare, a făcut parte din vechiul estuar al râului Dniester, servind ca arie de depunere a icrelor și de hrănire pentru peștii fitofagi din râu (plătică, babușcă, crap, șalău, știucă etc.). Construirea barajului a contribuit la succesiunea ecologică, estuarul transformându-se într-un lac artificial cu un sistem de alimentare a apei prin recirculare asigurat de SERSM (Stația Electrică Regională a Statului Moldova). Scopul acestui studiu a fost să investigheze modificările survenite în raportul speciilor de pești și a structurilor ariilor lor de răspândire în procesul de succesiune ecologică din bazinul acvatic Cuciurgan.

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Annexes:

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Table no. 1 Dynamics of fish species ratios changes in the ichthyofauna of Cuciurgan reservoir.

Years / Fish species	1964-1965	1969-1970	1981-1985	1991-1995	1997-2000	2004-2006	2007-2009	2012-2013
Black Sea herring	0.1	-	si	-	-	si	-	-
Danube shad	0.5	si	-	0.7	0.1	0.1	0.2	0.2
Sprat	3.5	0.6	-	0.5	0.1	1	8.0	3.6
Pike	8.5	0.6	0.6	0.2	0.1	2.1	1.2	1.2
Mudminnow	-	-	-	-	-	si	si	-
Roach	18.3	30.1	14.0	5.7	4.0	1.8	1.2	1.3
Azov roach	18.3	30.1	9.3	1.7	0.5	si	si	0.7
Black Sea roach	si	-	-	-	-	-	si	-
Dace	0.1	-	si	si	si	-	0.1	si
Chub	0.1	si	0.2	0.2	0.5	-	si	0.1
Ide	0.1	0.1	si	si	-	-	-	-
Acerina rossica	-	-	-	-	-	-	0.2	0.4
Rudd	3.8	2.4	4.5	6.2	9.7	13.8	17.4	11.6
Asp	0.4	0.1	0.3	0.1	si	si	si	0.1
Tench	1.9	0.2	si	0.1	si	2.9	1.0	0.7
Belica	2.4	1.8	-	si	-	si	7.6	7.8
Bleak	3.4	6.5	11.0	11.7	20.1	19.2	12.3	12.9
Silver bream	11.3	12.7	14.1	3.9	4.0	2.8	1.9	7.1
Bream	7.4	14.0	2.2	0.8	0.1	0.7	0.9	0.8
Vimba	si	si	si	si	-	-	-	-
Bitterling	5.7	16.2	-	4.0	5.3	7.0	3.4	3.5
Common carp	1.9	0.1	si	0.1	0.1	0.5	0.8	0.5
Crucian Carp	0.2	si	si	si	-	-	-	-
Prussian carp	9.1	0.2	1.0	0.9	0.6	13.2	7.7	8.3
Silver carp	-	si	29.0	19.5	0.8	0.1	0.3	0.9
Bighead	-	si	10.0	6.5	0.3	0.1	si	0.1
Grass carp	-	-	0.8	0.3	si	si	0.1	0.2
Black carp	-	-	si	si	-	-	-	-
Sabre fish	si	si	-	-	-	-	-	-
Nase	0.1	si	-	-	-	-	-	-
Common gobio	0.1	-	-	-	-	-	-	-
European pikeperch	5.3	1.1	0.6	0.2	0.1	si	0.1	0.1
Perch	11.0	10.3	2.2	10.9	11.7	16.9	15.8	9.0
Common ruff	0.2	si	-	-	si	0.2	3.7	2.5
Gobies	4.2	2.5	-	9.1	16.4	6.9	5.8	5.3
Round goby	-	-	-	3.5	5.2	3.5	1.5	1.2
Monkey goby	-	-	-	3.1	7.8	2.0	3.6	2.0
Goad goby	-	-	-	2.0	2.8	0.8	0.5	0.9
Mushroom goby	-	-	-	0.2	0.4	0.5	si	0.7
Tube-nosed goby	-	-	-	0.3	0.3	0.1	0.2	0.5
Bighead goby	-	-	-	si	si	si	si	si
Bighead nude	-	-	-	-	-	-	-	si
Gobio caspiosoma	-	si	si	si	si	si	-	si
Gobio of knipovich	-	-	-	-	-	-	si	si
Catfish	-	si	0.2	0.1	si	0.1	si	0.1
Mudfish	0.3	0.1	-	si	0.9	0.4	0.3	0.2
Loach	si	si	si	si	-	-	-	-
Stickleback	si	si	si	si	si	0.1	0.4	0.3
Needlefish	0.1	0.6	-	2.1	2.1	0.6	1.5	0.9
Silverside	-	-	-	14.2	21.2	9.5	5.9	6.8
Sunfish	-	-	-	-	-	si	1.6	13.5

Channel catfish	-	-	-	si	0.1	si	0.3	si

Note: si-single individuals

Table no. 2 Dynamics of the numerical density in fish populations from different parts of the Cuciurgan reservoir (%).

	1981-1982			1991-1992			2001-2003			2011-2013		
Fish species	us	ms	ls	us	ms	ls	us	ms	ls	us	ms	ls
Bream	33	53	14	36	34	30	1	47	52	5	30	55
Azov roach	1	21	78	27	48	25	5	45	50	5	45	50
Pike	80	15	5	60	12	28	10	40	50	20	30	50
European pikeperch	16	52	32	17	53	30	unit	unit	unit	-	unit	unit
Prussian carp	25	55	16	35	38.5	26.5	10	40	50	10	45	45
Perch	35	20	45	32	48	20	10	40	50	10	35	55
Tench	70	10	20	60	18	22	30	20	50	45	15	40
Common carp	14	30	56	16	36	48	1	66	33	10	60	30
Rudd	60	13	27	50	18	32	15	35	50	15	35	50
Silver bream	10	52	38	29.5	42.5	28	5	50	45	15	35	50
Bleak	14	30	56	15	52	33	20	40	40	20	40	40
Bitterling	42	23	35	12	54	34	10	50	40	40	30	30
Stickleback	63	34	3	79	19	2	70	20	10	80	20	0
Silverside	0	0	0	0	5	95	10	40	50	5	55	45
Acerina rossica	100	0	0	100	0	0	95	0	5	40	10	50
Belica	99	1	0	100	0	0	80	5	15	20	21	59
Sunfish	0	0	0	0	0	0	0	0	0	0	20	80

Note: us-the upper section; ms-the middle section; ls-the lower section

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