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THE EFFECTS OF ANTHROPIC ACTIVITY ON ICHTYOFAUNA DIVERSITY IN SOME RESERVOIRS OF THE BISTRIȚA RIVER

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INTRODUCTION

The changes in the Bistrița river course have been initiated with the building of the Izvoru Muntelui-Bicaz dam, which was inaugurated in 1960. Later on, six other reservoirs have been built along the river course (Pângărați, Vaduri, Bâtca Doamnei, Racova, Lilieci, Gârleni, Şerbăneşti), forming the first hydropower system of Romania.

The appearance of these reservoirs has led to profound changes in the ecological conditions and, implicitly, to an alteration of the structure and functionality of aquatic biocenoses. The most affected biocenosis component appears to have been the ichtyofauna, whose specific structure was modified. Lots of rheophile stenobiontic species have disappeared or reduced their area, whereas rheophile eurobiotic and stagnophile species have proliferated. The paper intends to highlight the changes in ichtyofauna structure under the impact of hydrotechnical works and to expose the current situation of the fish population from some reservoir areas of the Bistrița River.

MATERIAL AND METHODS

The monitoring of the fish fauna of the Bistrița River was achieved by controlled catches in four reservoirs, considered to be ichtyiologically significant: Pângărați, Bâtca Doamnei, Racova and Lilieci. Experimental fishing was conducted from August to September 2005, with simple and compound fixed nets with mesh openings of 20 mm, 30 mm and 40 mm. The length of each gill net was 37.5 m and a height of 2 m. In each lake, the gill nets were kept in water for 12 hours, usually at night. After the time set for fishing elapsed, the gill nets were removed from water, the fish was collected from the nets, sorted by species, counted and weighed and then preserved in formalin. In the laboratory, biometric and gravimetric measurements were performed on all samples.

On the basis of the field-referenced and laboratory data, we have established the list of species and their numerical abundance in each reservoir studied. By calculating the index of ecological significance for each lake, we could determine the structure of the fish population in ecological categories. In setting the index of biological integrity, lakes could be classified into different categories of integrity.

RESULTS AND DISCUSSIONS

The ichtyocenosis structure on species

The fish zoning of the Bistrița River before the building of its reservoirs, comprised three main fish zones (table 1):

- the trout zone, stretching from the river mouth to Cârlibaba, populated by five species of rheophile fish;
- the grayling zone, from Cârlibaba to Piatra Neamt, inhabited by 14 species of fish;
- the barbell zone, from Piatra Neamt to Bacau, where 12 species were commonly encountered.

After its hydropower system has been built, the river's environmental conditions have dramatically changed, the former fish zoning not corresponding to the real one anymore; therefore, it required a new configuration of the Bistrița basin (Battes, 1970):

- the trout zone, from the river mouth to Cârlibaba (preserving the location held before);
- the grayling zone, much narrower than before, and lying between Zugreni and Cârlibaba;
- the broad snout area includes Bicaz lake and Bistrița River up to Zugreni;
- the chub zone from Pângărați to Bacau, replacing the barbell area which existed before this fish zoning of the river, based on the predominance of one or some species, is relative. There are significant differences from one lake to another in the ichthyofauna structure, depending on the specific environmental conditions of each lake.

Table 1. The fish zoning of the Bistrița river before the hydrotechnical works
(apud Motaş and Anghelescu, 1944)

No.	Species		The trout zone	The grayling zone	The barbel zone
1.	*Salmo fario*	Trout	+	+	-
2.	*Salvelinus fontinalis*	Brook trout	+	-	-
3.	*Thymallus thymallus*	Grayling	-	+	-
4.	*Hucho hucho*	Danube salmon	-	+	-
5.	*Barbus petenyi*	Mediterranean barbel	-	+	-
6.	*Phoxinus phoxinus*	Minnow	+	+	+
7.	*Cottus gobio*	Bull head	+	-	-
8.	*Noemacheilus barbatulus*	Loach	+	+	-
9.	*Leuciscus cephalus*	Chub	-	+	+
10.	*Barbus barbus*	Barbel	-	+	+
11.	*Alburnus alburnus*	Bleak	-	+	-
12.	*Gobio obtusirostris*	Gudgeon	-	+	-
13.	*Chondrostoma nasus*	Undermouth	-	-	+
14.	*Vimba carinata*	Vimba bream	-	-	+
15.	*Lota lota*	Burbot	-	+	+
16.	*Cobitis aurata*	Golden spined loach	-	+	-
17.	*Cyprinus carpio*	Carp	-	-	+
18	*Carassius gibelio*	Gold fish	-	-	+
19.	*Perca fluviatilis*	Perch	-	-	+
20.	*Silurus glanis*	European catfish	-	-	+
21.	*Alburnoides bipunctatus*	Schneider	-	+	+
22.	*Rhodeus amarus*	Bitterling	-	-	+
23.	*Gobio uranoscopus*	Danube gudgeon	-	+	-
Total			5	14	12

The four reservoirs on the Bistrița we have studied can be divided according to their hydrobiological characteristics into two categories:

- Typical mountain reservoirs: Pângărați and Bâtca Doamnei;
- Hill reservoirs: Racova and Lilieci.

The data obtained through fishing in sampling sites in 2005 were compared with those reporded by scientific studies on the ichthyofauna of the Bistrița reservoirs during the 1970-1975 period. Of the approximately 17 species of fish living in the Bistrita lakes in the first 10-15 years after their building, less than half still exist (table 2). Thus, in the Pangarati Reservoir, 10 species were identified, of which three species (river trout, bleak, bream) form a numerically reduced populations. The emergence of stagnophile cyprinids (carp and rudd) and piscivorous fish may well explain this phenomenon.

Table 2. The list of fish species present in Bistrița reservoirs from 1970-1975 and in 2005

No	Species	1970-1975	2005			
			Pângărați	Bâtca	Racova	Lilieci
1	*Salmo fario*	+	(+)	-	-	-
2	*Hucho hucho*	(+)	-	-	-	-
3	*Esox lucius*	+	+	+	+	+
4	*Rutilus rutilus*	+	-	-	-	-
5	*Leuciscus cephalus*	+	+	+	-	-
6	*Phoxinus phoxinus*	+	-	-	-	-
7	*Alburnus alburnus*	+	(+)	-	-	-
8	*Alburnoides bipunctatus*	+	-	-	-	-
9	*Abramis brama*	+	(+)	-	-	-
10	*Chondrostoma nasus*	+	+	-	-	-
11	*Gobio obtusirostris*	+	+	-	-	-
12	*Gobio kessleri*	+	-	-	-	-
13	*Barbus barbus*	+	-	-	-	-
14	*Barbus petenyi*	+	-	-	-	-
15	*Cyprinus carpio*	+	-	-	-	-
16	*Carassius carassius*	+	-	-	-	-
17	*Cobitis aurata*	+	-	-	-	-
18	*Scardinius erythrophthalmus*	-	+	+	+	+
19	*Perca fluviatilis*	-	+	+	+	+
20	*Carassius gibelio*	-	+	+	+	+
21	*Gymnocephalus cernua*	-	+	-	+	+
Total		17	10	5	5	5

- abstent species; + present species; (+) rare species;

In Bâtca Doamnei, the number of fish species is even lower, being composed of five taxa: pike, chub, carp, rudd and perch. The ecological conditions similar to the first lake have allowed the development of stable and relatively numerous populations of rudd and perch.

The two hill reservoirs, Lilieci and Racova are very similar in terms of morphometric (area, volume, basin, substrate), hydrological (hydrological regime, water circulation factor) and hydrobiological characteristics. This leads to similar ichthyofauna represented only by five species: two stagnophile cyprinids (rudd and crucian carp) and three species of predatory fish (pike, perch and ruff).

The numerical abundance of the fish species

The numerical abundance of fish species in a water basin expresses the numerical ratio of one species to the total number of individuals of all species collected and gives precise indications on fish population and ichtyocenosis structure.

In the Pângărați Reservoir, in numerical terms, the rudd holds 94%, followed by pike (2%) and chub (1.5%). In Bâtca Doamnei, the numerical abundance percentage is significantly different. Rudd and pike are present in a proportion of 30%, perch – 20% and chub and carp – 10% (table 3). In the hilly lakes downstream, Racova and Lilieci, the number of species is totally changed. The numerically dominant species in Racova Reservoir is the perch (50%), followed by rudd (37.5%). The other three species (pike, carp, ruff) are present in equal proportions, of about 4%. In Lilieci Reservoir , the highest numerical abundance is reached by rudd (74%), followed by perch (16%). The other three species (pike, carp, crucian carp) are present in proportions ranging between 5% and 2.5%.

Table 3. The numerical abundance of the fish species in some reservoirs on the Bistrita River

Nr.	Species	The numerical abundance (%)			
		Pângărați	Bâtca	Racova	Lilieci
1	*Scardinius erythrophthalmus*	94	30	37,5	74
2	*Esox lucius*	2	30	4	5
3	*Leuciscus cephalus*	1,5	10	-	-
4	*Carassius gibelio*	0,5	-	4	2,5
5	*Chondrostoma nasus*	0,5	-	-	-
6	*Gobio obtusirostris*	0,5	-	-	-
7	*Alburnus alburnus*	0,5	-	-	-
8	*Perca fluviatilis*	0,5	20	50	16
9	*Gymnocephalus cernua*	-	-	4,5	-
10	*Cyprinus carpio*	-	10	-	2,5

The fish populations of the reservoirs

The ichtyocenosis structure of the four reservoirs in the middle and low course of the Bistrita River was determined by calculating the ecological significance index (W). Depending on the value of this index, the species were divided into the following categories: dominant species (W> 20%), specific species (W <20%), additional species (W <10%), associated species (W <5 %), accompanying species (W <1%) and accidental species (W <0.1%).

Table 4. The structure of the fish associations in some reservoirs on the Bistrita river and the ecological significance index (W)

Type	Pângărați		Bâtca Doamnei		Racova		Lilieci	
	Species	W	Species	W	Species	W	Species	W
1. Leading species	*Scardinius erythrophthalmus*	94,2	*Esox lucius*	60	*Perca fluviatilis*	50	*Scardinius erythrophthalmus*	74
2. Characteristic species	-		*Scardinius erythrophthalmus*	10	*Scardinius erythtrophthalmus*	37,5	*Perca fluviatilis*	16,2
			Leuciscus cephalus	10				
3. Complementary species	-	-	*Cyprinus carpio*	8	*Gymnocephalus cernua*	6,3	-	-
4. Associated species	*Esox lucius*	2	*Perca fluviatilis*	5	*Esox lucius*	3,1	*Esox lucius*	4,6
	Leuciscus cephalus	1,5			*Carassius gibelio*	3,1		
5. Accompanying species	*Chondrostoma nasus*	0,5	-	-	-		*Cyprinus carpio*	0,6
	Carassius gibelio	0,5						
	Alburnus alburnus	0,5					*Carassius gibelio*	0,6
	Gobio obtusirostris	0,5						

Table 5. The classes of biological integrity of the ichtyocenoses of some reservoirs from the Bistrița River

Parameters		Pângărați	Bâtca	Racova	Lilieci
Species composition and richness	Total number of species	3	1	1	1
	Total number of cyprinids	5	5	3	3
	Total number of salmonids	1	1	1	1
	Number of other species	3	5	5	5
	Total number of native species	5	5	5	5
	Number of introduced species	1	1	1	1
	Number of extinct species	1	1	1	1
Trophic structure	Procent of benthivorous species	1	1	1	1
	Procent of piscivore species	3	5	5	5
	Procent of euryphagous species	1	1	1	1
	Procent of herbivore species	5	5	3	3
Fish stock and general status	Weight stock (g/100 m^2)	5	3	3	3
	Numeric stock (ex / 100 m^2)	5	1	3	3
	Procent of hibrids	5	5	5	5
	Individuals with of anomalies, tumor, sick fishes	5	5	1	1
Score		49	45	39	39
Integrity levels		IV	IV	V	V

The data presented in table 4 indicate that the dominant species in Pangarati Reservoir is the rudd (W = 94.2%), the associated species being represented by pike (W = 2%) and chub (W = 1.5%) and the accompanying species are broad snout, crucian carp, gudgeon and bleak (W = 0.5%). In Bâtca Doamnei pike species can be considered as leading (W = 60%), whereas rudd and chub species are specific (W = 10%). The carp can be considered as a complementary species (W = 8%), while the perch is the associated species (W = 5%).

In the Racova Reservoir, the dominant species is represented by the perch, the specific species is the rudd, the additional species is the ruff and the associated species are pike and crucian. In Lilieci lake, the environmental groups are closer to normality. Rudd is the dominant species (W = 74%), the perch is specific (W = 16.2%) and the pike is the associated species. The accompanying species are represented by carp and crucian carp.

The index of biological integrity (IBI)

The determination of the index of biological integrity (IBI) indicates the equilibrium state of the aquatic ecosystem, as a result of the interaction of organisms with the biotic and abiotic environment. The setting of this index is based on the analysis and quantification of factors which determine species number and composition and ichtyocenosis abundance in that ecosystem.

The ichtyocenosis degree of reliability is assessed by 15 environmental parameters, grouped into three categories (Karra et al., 1986, Miller et al., 1989): species number and composition, trophic structure of the ichtyocenosis; abundance, biomass and fish health condition.

After obtaining the concrete results of fishing from a specific sampling site, the 15 parameters analyzed are scored by 5 points if they register the highest values, with 3 points for moderate values and 1 point for low values. The points obtained are collected resulting in a final score. On thier basis, the ichtyocenosis is placed into one of nine classes of integrity, from excellent (class I) to very poor (class IX). The placement into different classes of integrity is achieved, depending on the size and type of investigated basins (small rivers, large rivers, lakes, etc.).

Based on the total score achieved by assessing the 15 environmental parameters, the four reservoirs were placed in classes of biological integrity (table 5). It appears that the first two lakes, Pângărați and Bâtca Doamnei, fall in Class IV of integrity (moderately good), with a total score of 49 and, respectively, 45 points. These two lakes are less affected by human activities in the area, the sources of pollution are few and insignificant.

The disruption of the normal development of the ichtyocenoses of these lakes is caused by frequent fluctuations in water levels, especially during the breeding periods, as well as by poaching, even during fishing closures. The other two lakes, located in the hilly area of the Bistrita Valley, Racova and Lilieci, are classified as Class V of integrity (moderate). These ecosystems are affected by multiple causes, of anthropogenic origin: the chemical pollution from the Roznov-Săvineşti industrial platform, dripping water that washes the deposits of domestic waste dumps in Piatra Neamt and Buhuşi and the surrounding villages, the leakage from sewage treatment plants in P. Neamt and Buhuşi.

The development and stability of the ichtyocenoses of these lakes is severely disrupted by intensive poaching at all times of the year, with small mesh nets that capture everything that is in the lake, from young fish of 10-15 cm to breeders.

CONCLUSIONS

The building of the dam lakes on the middle and low courses of the Bistrița river has irreversably affected the development conditions of the hydrobionts from the basin. The ichtyofauna has suffered a change in species structure and a quantitative modification, namely, a decrease in the numebr of rheophile species and an increase in the amount of snagnofil ciprinid and piscivorous species. Ichthyofauna monitoring by controled fishing along the year 2005 shows that, compared to the first 10 to 15 years after the lakes were built, the number of species was reduced to less than a half. 10 species have been identified in the Pângărați Reservoir and 5 each species in other lakes. The percentage of numerical abundance indicates that, in most lakes, the numerically dominant species are represented by the rudd, a eurobiont cyprinid that quickly adapted to the conditions of these lakes. Within 25 years, the species has spread to all the dam lakes, becoming the dominant species. In close connection to the large amount of food offered by this species, the perch has much developed, holding a a share between 16% and 50% of the fish population in the lakes studied.

The structure of the fish communities, established by calculating the index of ecological significance, has indicated the rudd as the dominant species in two lakes (Pângărați and Lilieci) and as the specific species in the other two. The two piscivorous species, the pike and the perc,h are the dominant species in the Bâtca Doamnei and Racova Reservoirs. In calculating the index of biological integrity, the first two reservoirs upstream, Pângărați and Bâtca Doamnei, have been placed in Class IV of integrity (moderate - good). They are less affected by human activities, but ichthyofauna development is adversely affected by extensive and frequent changes in water levels in these lakes. The lakes in the hilly area of the Bistrița Valley, Racova and Lilieci asre classified as Class V of biological integrity (moderate). The ichthyofauna development is severely affected by chemical and organic pollution and by intense poaching of these lakes. The lack of protection and conservation measures for the fish fauna of these two lakes can lead to a drastic drop in fish population and to a serious disruption of the general equilibrium of these aquatic ecosystems.

ABSTRACT

The paper presents the modification of the ichtyofauna structure from the Bistrița River basin under the influence of hydrotechnical works, through the quantitative and qualitative monitoring of the piscicultural fauna of four reservoirs built along this river (Pângărați, Bâtca Doamnei, Lilieci and Racova).

In determining the ecological significance index (W), we have established the structure of the fish populations from these reservoirs. The calculation of the index of biological integrity (IBI) of the fish communities has permitted emphasizing the anthropic effect on these aquatic ecosystems.

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