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Captive populations of fishes in the Crişul Repede River (Tisa River Basin)

Elszigetelődő halpopulációk a Sebes-Körösben (Tisza vízgyűjtője)

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Abstract

During the latest decades several hydropower plants were built along the rivers of the eastern Tisa (Tisza) River Basin. The tributary Crişul Repede (Sebes-Körös) seems to be the most affected river from that area of Tisa (Tisza). There are three hydropower dams and numerous sills on the river bottom that prevent the migration of potamodromous fishes. There are a number of 15 species that are more or less affected and form captive populations along this river. The populations of *Chondrostoma nasus, Vimba vimba, Barbus barbus* and *Aspius aspius* seem to be significantly affected by river damming. There are no previous studies regarding the captive fish population in Crişul Repede River. We consider that the most harmful effects related to the dam and sill construction are the changes in spawning behaviour (less aggregation of fishes at spawning sites, alteration of water velocity and temperature in the spawning area, increased prevalence of paired mating and inbreeding due to genetic pool losses) and in population survival rates. Our observations carried out in the last two decades refer to the increasing number of affected species and to the mechanisms of population isolation along the river. Another observation concerns the natural "drift" of juveniles, which we hypothesize that it can reduce the negative effects of isolation. Regarding the intensification of the inbreeding process further studies on the integrity and morphological variability of fish populations are needed.

Kivonat

A legutóbbi évtizedekben számos vízerőművet építettek a Tisza folyó keleti vízgyűjtőjén, és ebben a Sebes-Körös különösen érintett. Három vízerőmű és több fenéklépcső akadályozza a potamodrom halak migrációját. Az akadályok 15 halfajt érintenek kisebb-nagyobb mértékben, amelyeknek helyi, elszigetelődő populációi alakulnak ki a folyó egyes szakaszain. A negatív hatás különösen a *Vimba vimba, Chondrostoma nasus, Barbus barbus* és *Aspius aspius* populációi esetében tűnik jelentősnek. Korábbi tanulmányok a Sebes-Körös helyi elzárt halpopulációiról nem állnak rendelkezésünkre. Úgy gondoljuk, hogy a vízlépcsők és küszöbök legkárosabb hatása az ívási viselkedés módosításában mutatkozik meg (kisebb a víz sebessége, megváltozik a hőmérséklete, csökken az ívó halak száma, nő a páros ivás gyakorisága, a genetikai elzártság miatt beltenyészetek alakulnak ki), és emiatt a túléles esélye csökken. A megfigyeléseket az utóbbi két évtizedben végeztük, s megállapítottuk, hogy az érintett folyószakaszokon a halpopulációk elszigetelődése növekedett, a fajok száma ellenben csökkent. Más megfigyelések arra utalnak, hogy az ivadékok leúsznak a gátakon és lépcsőkon, csökentve az elszigetelés negatív hatásait. A beltenyésztés fokozodására vonatkozóan további vizsgálatokra van szükség, amelyek a halpopulációk épségére és morfológiai variabilitására vonatkoznak.

Introduction

During the last decades, the changes in the river channel of Crişul Repede/ Sebes Körös due to river damming, water amount reduction, pollution and eutrophication caused a strong modification of the fish fauna. The earliest ichthyological studies on the fish fauna of the three Crişuri Rivers (Crişul Repede, Crişul Negru and Crişul Alb), from their springs until the confluence with Tisa (Tisza) River, reported a number of 49 native and 12 adventive fish species (Bănărescu 1981, Bănărescu et al. 1997). On the upper reach of Crişul Repede and downward, close to the Hungarian border, there were built numerous hydrotechnical constructions that affect the fish fauna along the entire river. These are indirectly a real long-term threat for fish species due to river habitat fragmentation and water fluctuations.

Between the localities of Aleşd and Oradea two dams and reservoirs were constructed in the recent past and they affect the natural river flow. In the subsequent period, after the last published ichthyological data from the region in 1997, a new hydropower barrage and reservoir was built up close upstream to Oradea in the locality of Fughiu. On the river stretch that crosses the city of Oradea there are also two weirs and few bottom sills. Due to the presence of numerous hydrotechnical constructions along the river, Crişul Repede can be considered as the most affected tributary on the eastern part of Tisa (Tisza) River Basin.

The negative effect of barrages and hydropower reservoirs were previously mentioned based on the riverbed modifications and hydrological changes of Romanian rivers (Telcean 1997, Telcean & Bănărescu 2002, Telcean et al. 2006). Such studies have also been performed in other European rivers and they pointed out the negative impacts of river damming (Elvira 1996, Navarro et al. 2007, Freyhof et al. 2015). Although the studies on dammed rivers are numerous, the observations regarding captive populations of fishes in rivers affected by hydro-energetic constructions remain obscure. Several papers deal with the spawning of fish species in the different rivers (Keckeis 2001, Peňáz 1996). Our studies point out the complex impact of hydropower reservoirs on the fish fauna, deriving from river habitat fragmentation. Barrages and weirs limit fish mobility especially of potamodromous species that need to make short migration along the river channel. The lower mobility of such species affects their spawning behaviour and the localization of optimal feeding habitat. The shoals formed in the spawning period are characteristic for some common species like *Chondrostoma nasus, Vimba vimba, Barbus barbus* and *Squalius cephalus*. The ripe male and female are swimming lot of kilometres to spawn on favourable sites, characterized by gravelled bottom, lower depth and moderate water velocity (Keckeis 2001). River damming causes modification in the spawning behaviour and lower aggregation of ripe specimens. Along these river sectors we have observed a number of 11 species which despite their small size use to reach the upper river during their spawning season. The repeated spawning in a small community has negative effects on long term. These species are registering an increasing prevalence of paired mating and inbreeding due to genetic pool losses.

The fish-passage facilities are not effective for all fish species and growing stages. Small-sized fishes and also their hatchlings are not able to reach these facilities and remain downstream the dam. Many hatchlings and juveniles are drifted by flow far away downstream. This phenomenon, important in diminishing population isolation is less studied at the present, and however it was not studied from the Tisa (Tisza) river system. The negative effects of river damming are focussed mainly on the genetic effects upon the fragmented populations (Laroche et al. 1999, Heggenes & Röed 2006, Neraas & Spruell 2001). Until now, there are not performed efficient studies which point out the ameliorative effect of juvenile drift upon the populations from rivers affected by connectivity disruption. We refer to the missing of quantitative estimations regarding to the juveniles inflows along the isolated populations. Many fish populations remain captive between the hydropower reservoirs and are forced to spawn only on a short stretch of a river channel. Depending on the river peculiarities, a number of small specimens (juveniles and sub-adults) are drifted downstream and probably they represent a natural source for a genetic inflow to lowland river populations (Neraas & Spruell 2001).Beside barrages, bottom sills represent another obstacle to fish mobility. Along the Crişul Repede River numerous bottom sills are located transversely on the river course, especially in the river stretch from Oradea. As a result of these hydrotechnical arrangements, the isolation of fish population has amplified. A synergy of river damming and climatic change events (drought periods and warm summers) can lead to rapid modification of river fish fauna.

Material and Methods

The study on the captive fish populations *in situ* was realized through 15 collecting trips over the entire river channel and a supplementary 8 surveys only for the Zone III during the

last decades (1998-2014). The seasonal fluctuation of specimens number was observed especially for the less mobile and small tailed species (*Romanogobio spp., Alburnoides bipunctatus* and *Rhodeus amarus*). Their population fluctuations is affected also by river debits and changes that modifying their preferred habitats. It was necessary a long period to observe the fish fauna changes caused by population isolation. The collecting methods were combined and consisted of the use of fishing nets (small mesh size 0.5x0.5 cm) and electronarcosis (a fishing gear type Samus MP 750). In some cases the information from angler fishermen was useful. All studied specimens were released at the sampling sites.

The studied sector of Crişul Repede River expands on approximately 60 km between the localities Aleşd and Cheresig and totalizes more than 20 sampling sites. The results were grouped into three zones according to the presence of barrages and bottom sills: Zone I – with three barrages and reservoirs, corresponds to the river stretch between localities Aleşd and Fughiu, Zone II - with two weirs and bottom sills, corresponds to the river stretch upstream and downstream of the city of Oradea, and Zone III – downstream of the city of Oradea to the locality Cheresig, with one weir which directs the water into an artificial channel (*Fig. 1*).

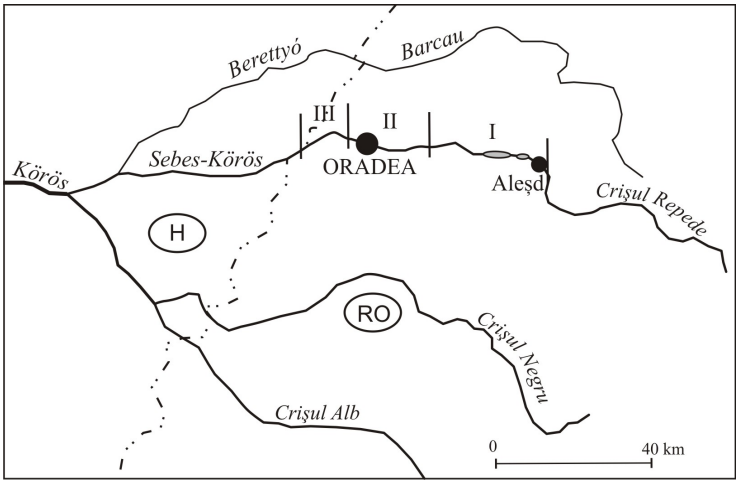

Fig. 1. Stretches of the Crişul Repede River affected by hydropower dams
I: River stretch Alesd–Fughiu, II: Oradea (upstream and downstream), III: Oradea–Cheresig

The common fish species, which are largely distributed along the river and which were identified in the stretches between the barrages and reservoirs were considered captive in those river sectors. The fragmentation degree was established according to the distribution of populations along the modified river stretches and the population density and tendency observed for each species. This metric comprises an index that consists in three degrees, from 1 to 3, the maximal value corresponding to the highest fragmentation level (*Table 1*).

Table 1. Fragmentation index of captive fish populations in Crişul Repede River

Index	Degree of population fragmentation	Tendency of population density
1	Low	Stable or increasing
2	Medium	Fluctuating
3	High	Decreasing to upstream

Of the identified species, only the less mobile ones and the potamodromous fish species had formed local populations along the affected river channel. For these, a medium or high fragmentation degree (corresponding to indexes 2 or 3) was established. The tendency of

population fluctuations was interpreted here as a result of habitat alteration. It was evidenced in similar seasonal samples. The most fragmented populations manifest also the tendency of diminishing their effectives upstream the barrages. For the species distributed predominantly along the zone III (downstream of Oradea) where population fragmentation is lower, the established index was 1. To that category belong also the adventive species that have the capacity to establish large populations starting with a low number of specimens.

Results

According to the obtained results in the studies on the impounded populations of fishes along Crişul Repede River, a number of 29 species were identified (*Table 2*). *Pseudorasbora parva, Carassius gibelio, Ameiurus nebulosus* and *Lepomis gibbosus* are adventives and were not considered in this study. Our findings regarding the species distribution along the studied river have confirmed that potamodromous fishes occur mainly in downstream river stretches and their populations are affected by fragmentation. A number of 11 species occur predominantly in the river stretch downstream of the city of Oradea (sectors II and III according to the *Fig. 1*.) and are less affected by hydrotechnical constructions as a consequence of their large populations. Such species are also considered to be less affected by barrages and reservoirs. Another 15 common species, largely distributed along the river channel, are considered to be moderately or highly influenced by hydropower dams (*Table 2*).

Insular populations of these species have been identified in each river sector. The small-sized species like *Romanogobio uranoscopus, R. kessleri* and Cobitidae representatives maintain their natural populations in the river stretches downstream of the reservoirs. These species do not occur in the standing waters from reservoirs. In these populations the fragmentation is occasionally also observed in natural conditions due to the riverbed peculiar conditions. In our classification these species are considered to be moderately or highly fragmented (index value 2 or 3). The populations of large-sized fishes which belong to ecological group of potamodromous species (*Chondrostoma nasus, Barbus barbus* and *B. petenyi*) are considered to be more affected by barrage construction.

In the case of former populations of large distributed species we have observed the general tendency to occupy the former areal through insular small populations. These insular populations are remains derived from the natural population. The following six small-sized fish species were observed to form small insular population between the dammed stretches of the river: *Rhodeus amarus, Romanogobio uranoscopus, R. kessleri, R. vladykovi*, *Cobitis elongatoides* and *Sabanejewia balcanica*. Despite the presence of fish-passage facilities, these species are not able to reach the upper river channel.

Regarding the river bottom structure, the majority of fishes prefer the stones and gravels associated with fast running waters. *Romanogobio uranoscopus* and *Sabanejewia balcanica* were identified only in these specific biotopes. The river stretches from downstream of the barrages present an intense process of sediment accumulation due to the reduction of water velocity. The silt accumulation process can disturb the actual location of these species in affected rivers.

Discussions

The barrage construction along the middle and lower Crişul Repede River influences directly the distribution of fish species and also affects the density of natural populations. Of the 29 species identified along the affected channel of Crişul Repede River a number of 9 species are strongly affected by the isolation process and population fragmentation due to hydropower facilities. In order of threat these are: *Chondrostoma nasus, Barbus barbus*, *B. petenyi, Rhodeus amarus, Romanogobio uranoscopus, R. kessleri, R. vladykovi*, *Sabanejewia balcanica* and *Cobitis elongatoides.* The barrages and their reservoirs are very harmful for fishes even in the presence of dedicated facilities such as fish-passages. The negative influence affects differently the population structure: perturbation of spawning, destruction of eggs and juveniles, and decrease of aggregation.

Table 2 .Fish species identified in the middle and lower Crişul Repede River and the degree of population fragmentation

Species	Occurrence			Degree of population fragmentation*
	I	II	III	
Rutilus rutilus	+	+	+	1
Scardinius erythrophthalmus	-	+	+	1
Squalius cephalus	+	+	+	2
Leuciscus leuciscus	+	+	-	2
Aspius aspius	-	-	+	1
Chondrostoma nasus	+	+	+	3
Alburnus alburnus	+	+	+	2
Alburnoides bipunctatus	+	+	+	3
Abramis sapa	-	-	+	1
A. ballerus	-	-	+	1
Vimba vimba	-	-	+	2
Rhodeus amarus	+	+	+	3
Gobio gobio	+	+	+	1
Romanogobio uranoscopus	+	-	-	3
R. kessleri	+	+	+	3
R. vladykovi	-	-	+	2
Pseudorasbora parva	+	+	+	1
Barbus barbus	+	+	+	3
Barbus petenyi	+	+	+	3
Cyprinus carpio	-	-	+	1
Carassius gibelio	-	-	+	1
Barbatula barbatula	+	+	+	1
Cobitis elongatoides	+	+	+	3
Sabanejewia balcanica	+	+	+	3
Ameiurus nebulosus	-	-	+	1
Esox lucius	-	+	+	1
Lepomis gibbosus	+	+	+	1
Perca fluviatilis	-	+	+	1
Gymnocephalus schraetser	-	-	+	2
Total	17	19	27	-

River stretches: **I**- between Aleșd and Fugiu; **II** – around Oradea; **III** – downstream from Oradea to Cheresig
* Population fragmentation 1 – low, 2 – moderate, 3- strongly affected

Among the main negative events that were observed in the affected river stretches we mention:

- Fragmentation and isolate upstream resident fish populations. The population fragments become captive on those rivers stretches;
- Due to slow water flow, most dams increase water temperatures. During water releasing when the electric turbine is working the water temperature decrease. This is caused by releasing cool water from the reservoir bottom. Fish and other species are sensitive to these temperature fluctuations, which often destroy their juveniles.
- Fish-passage facilities available at some hydropower dams are inefficient for the majority of species. Thus population fragmentation increases.
- Natural drift of juveniles is the only process than can reduce population isolation. This phenomenon is unidirectional and depends on river debit.
- Decrease in water velocity causes an amplification of sediment accumulation on the riverbed, which is harmful for most rheophilic species.

Concerning the potamodromous species *Chondrostoma nasus,* our findings regarding its captive populations are as follows:

- The typical spawning behaviour is altered and the affected populations lose the migration intensity;
- There are less abundant fish aggregations on spawning sites;
- A substitution of specific spawning substrates occurs in many biotopes;

- Spawning is characterized by transition from polyandric types of mating to pairing ones;

- Loss of spawning synchronization of ripe specimens and possible lower fertilization rate due to lower sperm concentration and quality and also the lower genetic exchange and erosion of the gene pool (Peňáz 1996). Regarding the negative effects of barrages and reservoirs on the fish fauna, we conclude that river damming has at least as harmful effect on the fish fauna as water pollution (Bănărescu 1994). Further studies regarding the isolated population of fishes in hydropower-affected rivers need to be done in order to establish the ecological costs of green energy.

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