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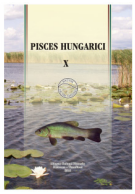

The fish fauna of Čiližský potok (Csiliz patak) stream and related water bodies

A csallóközi Csiliz patak (Čiližský potok) és mellékvizeinek halfaunája

J. Hajdú[1], L. Pekárik[2]

[1]*University of Prešov in Prešov, Prešov, Slovakia*

[2]*Institute of Botany, Slovak Academy of Sciences, Bratislava, Slovakia*

Keywords: cluster analyses, habitat fragmentation, threatened species, stream restoration

Kulcsszavak: klaszteranalízis, élőhelyfragmentáció, veszélyeztetett fajok, mederfelújítás

Abstract

Čiližský potok (Csiliz patak) stream represents a former flowing side arm of the Danube River. Already in the 18th century it was separated from the Danube inundation at its upper end by former dyke line. After 1960 its discharge was diverted into artificial network of drainage canals and its whole lower section became dry. Despite the negative interference with the hydrology, valuable remnants of original water habitats have been preserved within the former meandering channel inhabited by fish communities with an important proportion of the limnophilic fish species, such as the European mudminnow (*Umbra krameri*), weatherfish (*Misgurnus fossilis*) and crucian carp (*Carassius carassius*), confirming its high importance for the nature conservation. Presence of several alien species, such as *L. gibbosus*, *A. melas*, *C. auratus*, should be taken into account by the planned restoration actions aimed at the reconnection of the middle and lower reaches.

Kivonat

A Csiliz patak (Čiližský potok) a Duna egykori mellékágának maradványa, amelyet a felső részén épült gátakkal már a 18. században elzártak a Dunától. 1960 után a folyását elterelték egy mesterséges lecsapoló csatornarendszerbe, és így a patak teljes alsó része állandó víztáplálás nélkül maradt. A korábbi kanyargós csatornából azonban a kedvezőtlen hidrológiai beavatkozás ellenére is értékes élőhelyek maradtak fenn, amelyeket olyan veszélyeztetett halfajok természetes populációi népesítenek be, mint a lápi póc (*Umbra krameri*), a réticsík (*Misgurnus fossilis*) és a széles kárász (*Carassius carassius*), bizonyítva a terület természetvédelmi értékét. A patakban azonban idegenhonos fajok is élnek, így például a naphal (*Lepomis gibbosus*), a fekete törpeharcsa (*Ameiurus melas*) és az ezüstkárász (*Carassius auratus*), és ezt figyelembe kell venni a tervezett helyreállítást célzó munkálatoknál, például a középső és alsó patakszakaszok összekötésénél.

Introduction

Čiližský stream (Csiliz patak, Čiližský potok) represented one of the longest (at least 50 km long) and geographically significant Danube river side arm, that formerly originated near the Čilistov (Csölösztő) village (Pišút 2006) and entered the Danube near the village of Číčov. From historical maps it is clear that already in the 18th century it was not directly connected to Danube at its upper mouth due to a presence of the original dyke line. These dykes, however, have not been stable enough, thus they did not withstand the water pressure during the large floods and periodic ruptures enabled the lateral connectivity with the floodplain area and the main channel. Around 1862 the continuous dyke line was built closer to the main Danube channel and the river arm lost its upstream connection with the inundated area. At its lower mouth the arm was separated from the Danube after 1899, when the Danube dykes were strengthened on entire route (Kurjak et al. 2001). Approximately until 1960, the Čiližský potok flowed directly to Číčovské oxbow lake through the floodgate in the initial dyke. Even in the second half of the 18th century

extensive marshes were present along the lower part of the arm, between the villages of Ižop and Čiližská Radvaň (Arcanum 2004). These marshes were connected to Čiližský potok via the system of veins (*ér, ere*) and ditches (*árok*) creating the unique ecosystem, with the high degree of lateral connectivity (Ward & Stanford 1995). Due to a large-scale land drainage (mostly after 1960) these marshes were converted to a cropland and preserved till today only in fragments (Randík 1960). According to Balon (1967), however, the area was affected adversely at that time. After 1960 the stream was intersected by deeper channels at several sites, as a result of the channel system reconstruction. The water discharge from the upper part has been diverted into the Little Danube (Malý Dunaj) and the rest of the stream has started to be supplied via the new channel SVII built between 1960 and 1962 (Gyalokay 1972). Near the village of Pataš the stream flow from the middle part is diverted into the canal system and near the Čiližská Radvaň it is crossed by another canal Vrbina - Holiare, built also after 1960. As a result of the multiple flow interruptions, the entire lower part of the stream dried up (Druga & Hajdú 2006) and originally continuous flowing arm had changed to several isolated lakes, which local names (eg. *Káposztás örvény*, *örvény* = meander) reveal they represent deeper parts of the original stream bed. After 1970, the upper section of the stream was destructed substantially by the construction of the Gabčíkovo hydropower dam (Šoltész 1999). After 1985, the stream was intersected by deeper canal near its original mouth to Číčovské oxbow lake (Kurjak et al. 2001) and already at that time it was altered to an oxbow lake (Hensel 1984). Today only a 16.9km long section between Gabčíkovo and Pataš villages is supplied by permanent water flow from the artificial canal system, with the average flow rates of about 200 l/s, depending on a water level in the canal system (Druga & Hajdú 2006).

Only a few works are dealing explicitly with the ichthyofauna of the Čiližský potok. Little attention was devoted mainly to the upper part of the stream, and therefore almost no data retained from the period before the construction of the Gabčíkovo hydropower plant (Balon 1967, Brtek 1956). Only a limited data are available from the middle section also, which only at a small number of sites has been sampled (Nagy & Bastl 1992, Hajdú & Kováč 2002). The lower section has been surveyed on several locations in the second half of the 20th century for the last time (Balon 1967, Hensel 1984). The aim of this study is to provide up-to-date information on the fish community composition in the longitudinal stream profile of the Čiližský potok and its related water bodies, considering the changes compared to the past and taking into account the planned stream restoration actions.

Materials and methods

Fish were sampled between 2010 and 2015, at 32 sampling sites within the study area (*Fig 1.*) using one-way electrofishing (electroshocker type: Hans Grassl ELT60IIHI, 32 kW/pulse max., 580-940V, max. 2A). The length of sampling sites and the duration of sampling depended on the habitat conditions. Fish counts converted to Catch per unit of effort (CPUE) and expressed to 15 minutes of electrofishing per sample were used to create the species relative abundance data matrix. Fish were identified *in situ*, and all released back to water. The English nomencalture of fish is according to Froese & Pauly (2016), scientific names are according to Kottelat & Freyhof (2007). We used the working title *Carassius auratus* complex (Rylková et al. 2013) for the dwarf forms of goldfishes from isolated lakes, as they were not genetically analysed during the study. Species are considered as alien in compliance with Koščo et al. (2010).

All statistical analyzes were conducted in R environment, version 3.2.3 (R Core Team 2015). Ward hierarchical clustering (Borcard et al. 2011) was used to determine dissimilarities within the fish CPUE data and to define the groups matching the particular fish community types within the area under the study. The clustering was performed using "hclust()" from "stats" package, R version 3.2.3 (R Core Team 2015). CPUE data were

transformed before clustering by means of chord transformation (Borcard et al. 2011) followed by computation of the Euclidean distance (Legendre & Gallagher 2001). These two steps were done by vegan (Oksanen et al. 2016) functions "decostand" and "vegdist".

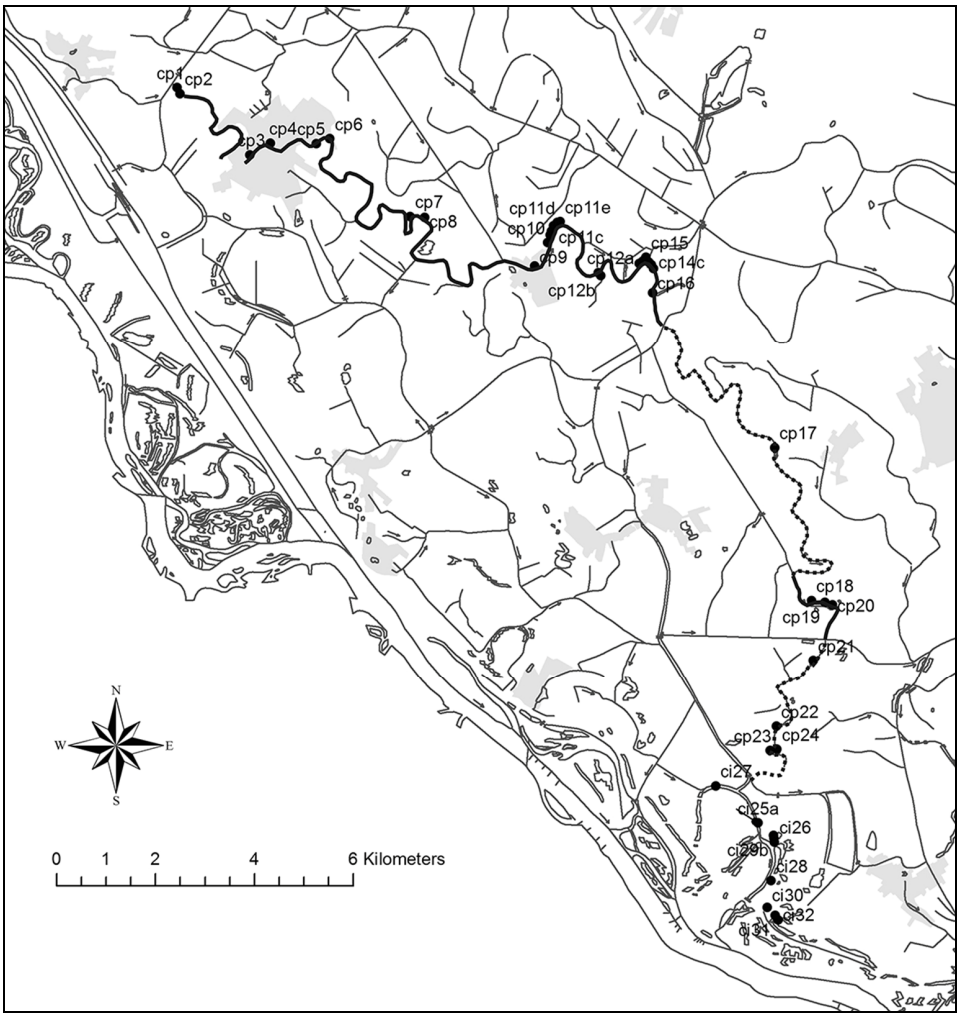

Fig. 1. Map of the sampling sites

Results and discussion

Overall 34 fish species and one natural hybrid (*Rutilus rutilus x Blicca bjoerkna*) were recorded in the study area belonging to 10 families (*Table 1.*). 25 species were indigenous and 8 non-native, 7 considered as alien for the Slovakian basins (Koščo & Holčík 2008). Roach (*R. rutilus*), European mudminnow (*Umbra krameri*) and bleak (*Alburnus alburnus*) were the eudominant species as regards the total species relative abundance. Crucian carp (*Carassius carassius*), pike (*Esox lucius*), rudd (*Scardinius erythrophthalmus*) and roach were the most frequent fish species within the study area (*Table 1.*).

Table 1. List of the species in the study area, D = total dominance (%), F = frequency of occurrence (%), Rep = reproductive guilds (modified according to Schiemer and Waidbacher 1992): Cat – catadromous, Lit – lithophil, Os – ostracophil, Phy – phytophil, PL – phytolithophil, Po – polyphil, Ps – psammophil, Spe – speleophil, NS – Nest spawner; FG = feeding guilds (modified according to Aarts and Nienhuis 2003): Be – benthivor, In – insektivor, Ph – phytophag, Pi – piscivor, Pl – planktivor, Po – polyphag, Pp – periphytophag; Status: Eu – Annex species according to Council Directive 92/43/EEC, Sk – species protected in Slovakia on national level; EN, VU, NT, LC – IUCN Red list categories according to Koščo and Holčík (2008); U – upper section of the stream, M – middle section, L – lower section

Species	D	F	Rep	FG	Status	U	M	L
Umbra krameri Walbaum, 1792	12,9	31,7	Phy	Be, Pl	Eu, EN	-	+	+
Esox lucius Linnaeus, 1758	2,3	63,4	Phy	Pi	LC	+	+	+
Abramis brama (Linnaeus, 1758)	0,1	7,3	PL	Be	LC	+	-	+
Alburnus alburnus (Linnaeus, 1758)	10,0	22,0	PL	In, Pl	LC	+	+	-
Barbus barbus (Linnaeus, 1758)	0,0	2,4	Lit	Be	LC	+	-	-
Blicca bjoerkna (Linnaeus, 1758)	2,1	19,5	PL	Be	LC	+	+	+
Carassius carassius (Linnaeus, 1758)	6,4	65,9	Phy	Be, Pl	Sk, VU	+	+	+
Carassius gibelio (Bloch, 1782)	3,2	39,0	Phy	Be, Pl	alien	+	+	+
Carassius auratus (Linnaeus, 1758)	7,3	9,8	Phy	Be, Pl	alien	-	-	+
Cyprinus carpio Linnaeus, 1758	0,1	7,3	Phy	Be, Pl	LC	-	+	+
Gobio gobio (Linnaeus, 1758)	0,7	2,4	Ps	Be	LC	+	-	-
Chondrostoma nasus (Linnaeus, 1758)	0,1	2,4	Lit	Pp	NT	+	-	-
Leucaspius delineatus (Heckel, 1843)	0,7	2,4	Phy	Pl	Sk, EN	-	-	+
Leuciscus leuciscus (Linnaeus, 1758)	0,1	4,9	Lit	Be	NT	+	-	-
Leuciscus idus (Linnaeus, 1758)	0,3	9,8	Lit	Be, Pl	NT	+	-	+
Squalius cephalus (Linnaeus, 1758)	2,1	19,5	Lit	Po	LC	+	+	-
Pseudorasbora parva (Temminck & Schlegel, 1846)	0,1	2,4	Po	Po	alien	-	-	+
Rhodeus amarus (Bloch, 1782)	6,5	41,5	Os	Pl	LC	+	+	+
Rutilus rutilus (Linnaeus, 1758)	20,4	58,5	PL	Be	LC	+	+	+
R. rutilus x B. bjoerkna	0,0	2,4	PL	Be	LC	-	+	-
Rutilus virgo (Heckel, 1852)	0,1	4,9	Lit	Be	Eu, VU	+	-	-
Scardinius erytrophtalmus (Linnaeus, 1758)	5,1	61,0	Phy	Ph	LC	+	+	+
Tinca tinca (Linnaeus, 1758)	2,7	58,5	Phy	Be	NT	+	+	+
Vimba vimba (Linnaeus, 1758)	0,3	7,3	Lit	Be	NT	+	-	-
Cobitis elongatoides Băcescu & Mayer, 1969	0,1	2,4	Phy	Be	Eu, LC	+	-	-
Misgurnus fossilis (Linnaeus, 1758)	2,6	26,8	Phy	Be	Eu, NT	-	+	+
Perca fluviatilis Linnaeus, 1758	2,4	46,3	PL	Be, Pi	LC	+	+	+
Lepomis gibbosus (Linnaeus, 1758)	3,8	31,7	NS	Pl, Be	alien	+	+	+
Proterorhinus semilunaris (Heckel, 1837)	5,6	29,3	Spe	Be, Pl	LC	+	+	+
Neogobius melanostomus (Pallas, 1814)	0,6	4,9	Spe	Be	alien	+	-	-
Babka gymnotrachelus (Kessler, 1857)	0,2	4,9	Spe	Be	alien	+	-	-
Ponticola kessleri (Günther, 1861)	0,3	4,9	Spe	Be, Pi	alien	+	-	-
Anguilla anguilla (Linnaeus, 1758)	0,1	4,9	Cat	Be, Pi	LC	-	-	+
Ameiurus melas (Rafinesque, 1820)	0,6	9,8	NS	Po	alien	-	+	+
Silurus glanis Linnaeus, 1758	0,2	4,9	Phy	Be, Pi	LC	-	-	+
Σ						25	18	22

According to clustering results three community-like groups have been identified, corresponding to three separate stream sections (*Fig 2.*).

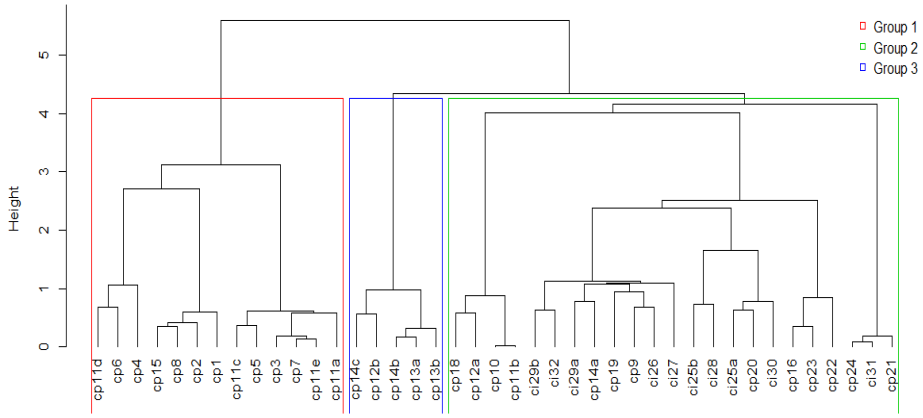

Fig. 2. Cluster analysis results

The first group corresponds to the stream upper section (Gabčíkovo-Pataš) and includes 24 species, among which *R. rutilus, A. alburnus, Rhodeus amarus* and *Proterorhinus semilunaris* were the eudominant (> 10%). *R. rutilus, R. amarus, Squalius cephalus, Perca fluviatilis* and *P. semilunaris* were the most frequent fish species in the upper reaches (75-100%). Four alien species, *Ponticola kessleri, Neogobius melanostomus, Babka gymnotrachelus, Lepomis gibbosus* and four protected species, *Rutilus virgo, R. amarus, C. carassius, Cobitis elongatoides* were recorded within the upper reaches.

In terms of flow preference, eurytopic species prevailed significantly (79.4%) in the upper reaches, followed by B reophilic species (11.3%). A-rheophils (5.02%) prevailed over the limnophils (4.3%). Phytolithophils were the most represented reproductive guild (65.9%), followed by ostracophils (12.2%) and speleophils (9.3%). Lithophils (5.6%) prevailed over phytophils (4.7%) and other low-represented groups (*Fig. 4.*).

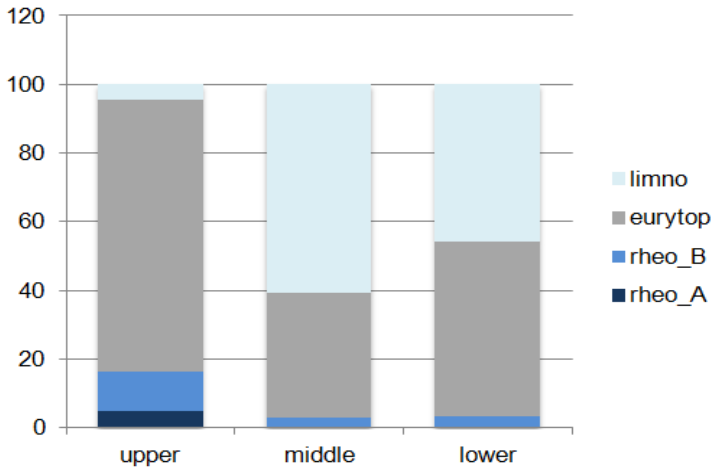

Fig. 3. Flow preference guilds representation (%) within the studied stream sections. Abbreviatons: limno – limnophilic species, eurytop – eurytopic species, rheo_A – A rheophilic species, rheo_B – B rheophilic species (flow preference guilds are according to Schiemer & Waidbacher 1992)

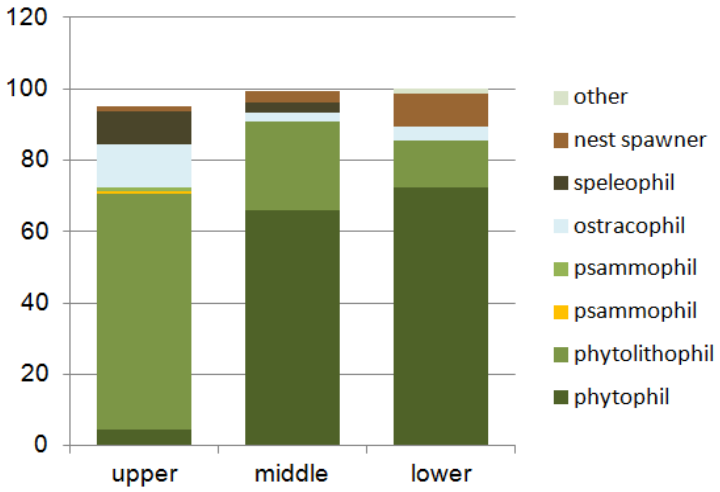

Fig. 4. Reproductive guilds representation (%) within the studied stream sections (reproductive guilds are according to Aarts & Nienhuis 2003, Schiemer & Waidbacher 1992)

Within the middle section between Patas and Csilizradvány 17 fish species were recorded. *U. krameri* and *C. carassius* were the eudominant (> 10%). Accompanied by *E. lucius*, the same species occurred most frequently as well (60-70%). Three non-native (alien) fish species were present, *L. gibbosus*, *A. melas* and *C. auratus* - complex. Four species are listed as threatened and protected *U. krameri, C. carassius, R. amarus* and *Misgurnus fossilis.* Limnophils were the most represented group (60.6%), followed by eurytopic species (36.5%). Phytophils dominated among the reproductive guilds (66.04%), followed by phytolithophils (24.97%).

Within the lower reaches (Csilizradvány-Kulcsod), represented mostly by lenitic and isolated lakes, 19 species were recorded, among which *C. auratus* complex, *C. carassius, S. erythrophthalmus* were the eudominant. *S. erythrophtalmus, Tinca tinca* and *C. carassius* were the most frequently occurring species within this section (>80%). Among the alien species – *C. auratus* complex, *L. gibbosus*, *A. melas* and *P. parva* were present. Three protected species – *R. amarus*, *L. delineatus*, *C. carassius* were recorded as well. Eurytopic (50.9%) and limnophilic (45.9%) species prevailed in terms of flow preference. Phytophils predominated strongly (72.18%) over the other reproductive guilds (*Fig 4.*).

Our data correspond with the previous studies, confirming the lower species richness for the downstream reaches. Balon (1967) reported 17 species in lower section of the stream, Hensel (1984) recorded only 8 species. Nagy & Bastl (1992) reported 9 species for the middle reaches. We found several new species within the Čiližský stream that were not reported by previous authors, *A. brama*, *B. barbus*, *Ch. nasus*, *L. leuciscus*, *R. virgo* and *V. vimba* are among the native reophilic species, that colonized the upper section of the stream after putting the Gabčíkovo power plant into operation. These species most likely penetrate into the canal system via the inlet structure on the derivation channel. Among the alien species, pontocaspian gobies (*N. melanostomus, P. kessleri* and *B. gymnotrachelus*) have recently been found in the upper section of the stream. *C. gibelio*, *P. parva* and *A. melas* were recorded as well, but mainly in the lower reaches. Among the stocked species *A. anguilla* and *C. carpio* were confirmed in a low proportions. Among the threatened and protected species *U. krameri* and *C. carassius* reached the eudominant position at several sampling sites,

within the middle section. The presence of *L. delineatus* was confirmed at the same sampling site (the isolated lake near Číčovské oxbow lake) as reported by Hensel (1984).

A noticeable gradient is apparent in the longitudinal stream profile of the Čiližský potok in terms of the flow preference and reproductive guilds. In the upstream reaches eurytopic and B - rheophilic species dominate, compared to middle and lower stretches where the limnophilic and eurytopic species prevailed at a lower species richness. Among the reproductive guilds phytolithophils dominated in upstream reaches and phytophilic species in the middle and lower reaches. Especially in the middle and lower sections valuable nature-like habitats are preserved, populated by threatened limnophilic fish species, such as *C. carassius*, *U. krameri* and *M. fossilis*. The number and relative abundance of several alien fish species, such as *L. gibbosus*, *A. melas*, *C. auratus* complex is the largest in the lower stream section, what should be taken into account by the planned restoration actions aimed at the reconnection of the middle and lower reaches.

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Authors:

Juraj HAJDÚ (hajdu.juraj@gmail.com), Ladislav PEKÁRIK (ladislav.pekarik@savba.sk)