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The thermal brook Peţa (Pece) as shelter for wintering of fish species in lower Crisul Repede (Sebes-Körös) River Basin

A Pece (Peţa) termálpatak mint a Sebes-Körös (Crisul Repede) alsó szakaszán élő halfajok téli menedéke

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Abstract

The winter study upon the ichtyofauna from the thermal rivulet Peţa located in the lower sector of Crişul Repede has shown the importance of the thermal waters as a shelter for the fish species during the winter. A number of 14 species of fish (most of them belonging to cyprinids) was found during the research in the thermal waters as opposed to the cold waters from the place where that brook drains in the Crişul Repede River, where no fish specimens were found. Some of the species entered in the thermal brook near the place of discharge are considered as refugees for wintering. During the winter, they accept the narrow and shallow water of the thermal brook, where the water temperature remains between 10-12 °C. In this warm water enter even the representatives from the large rivers (*Barbus barbus, B. biharicus* and *Chondrostoma nasus*). Together with them enter some limnophil species (*Tinca tinca and Rutilus rutilus*). Those observations prove that the wintering in small thermal waters is an option for the species with different ecological requirements.

Kivonat

A Sebes-Körösbe Nagyváradnál/Oradea torkolló Pece/Peţa termálpatak téli halfaunáját vizsgálva arra a következtetésre jutottunk, hogy az téli menedéket jelent a Sebes-Körös halai számára. A termálvizű patakban 14 halfajt találtunk (többségük a Cyprinidae családba tartozik), míg a Sebes-Körösnek a patak torkolatához közeli szakaszán, ahol a víz hideg volt, egyetlen faj egyetlen egyedét sem sikerült fognunk. Ebből arra következtetünk, hogy a Körös torkolatközeli halai felúsznak a patakba, melyet téli menedékhelynek tekintenek. A téli hónapokban azok a halfajok is elfogadják a 10–12 °C-os termálpatak keskeny medrét és sekély vizét, amelyek tavasztól őszig erre nem hajlandóak. Az erősebb sodrást kedvelő márna (*Barbus barbus*), bihari márna (*B. biharicus*) és paduc (*Chondrostoma nasus*) mellett néhány lassabb vizeket kedvelő faj, így például a compó (*Tinca tinca*) és a bodorka (*Rutilus rutilus*) is előkerült. A vegyes fajösszetétel bizonyítja, hogy a kicsiny termálpatak különböző ökológiai igényű halfajok számára is telelőlehetőséget kínál.

Introduction

Finding a wintering habitat is important for fish surviving and for reducing their physiological decline in many rivers such those from Crisul Repede/ Sebes-Körös watershed. Suitable wintering habitats for fish have been less surveyed due to difficulties associated with the sampling during the winter season. Such studies were performed on some tiny tributaries with non-thermal water regime and these revealed their importance as shelters for fish wintering (Weber et al 2013, Koizumi et al 2017). Moreover, the researches based on this subject prove that the juvenile (young-of-the year) specimens are taking refuge in that tributary. On opposite of that, the mature adult fishes prefer to spend the winter period in the main channel of the rivers (Koizumi et al 2017).

Naturally, during the harsh winter season many of fish species are occupying the backwaters and river habitats with quiet deep waters which maintain not iced bottoms

(Weber et al. 2013). Those are available for good swimming species as the potamodromous fishes and large size stream-fishes. The fish fauna from Crisul Repede/ Sebes-Körös watershed which includes also that from Peta brook comprises numerous species from this category which belongs mainly to Cyprinidae. These species and their ecology were studied by numerous ichthyologists (Bănărescu 1964, 1981, Bănărescu et al. 1997, Harka 1996, 2006, Telcean and Cupşa, 2007, Györe et al. 2012, 2013). Other researches were focused on both Crisul Repede/ Sebes-Körös and the thermal brook Peta (Telcean and Cupsa 2006, Mag et al. 2008, Telcean and Cupşa 2013). Studies on the reproductive behavior of the endemic species *Scardinius racovitzai* were made under artificial conditions (Crăciun 1997). The ichthyofauna of the thermal brook and the spread of species have been studied (Telcean 1999). They identified a number of 14 species, of which 3 were exotic species. Occasionally, several studies have been done with students interested in the ichthyofauna of the Peta brook. They contributed to the knowledge of the fish species assemblage. However, the wintering behavior of fish species in the Peta thermal stream has remained little known. Given that the Peta stream is unique due to its flowing thermal waters and its natural riverbed, this study was of increasing importance.

Materials and methods

The Peta brook is a small tributary with thermal waters in the lower basin of the C.R. The length of its riverbed is about 15 km and it flows into the Crisul Repede/ Sebes-Körös downstream the city of Oradea. The research was carried out in three sectors of the riverbed located near the place of discharge, then at a distance of 1.7 km and 10 km upstream, respectively (*Table 1.*). In all these sampling sites the water of the brook is thermal, but its temperature gradually increases towards the upstream sector. This is due to the penetration of hot water through the springs in the riverbed. The substrate of the riverbed is in some places stony with some portions covered with mud. The water flow is slow and relatively uniform.

Table 1. Sampling sites from Peta brook

Sampling sites	Peta 1	Peta 2	Peta 3	Peta 3 (2017)
GPS location upstream site	47°04'15.5"N 21°52'43.2"E	47° 3'22.48"N 21°52'48.83"E	47° 0'18.29"N 21°58'48.66"E	47° 0'18.12"N 21°58'49.13"E
GPS location downstream site	47° 04'20.50"N 21°52'38.23"E	47° 3'25.81"N 21°52'48.91"E	47° 0'20.49"N 21°58'47.13"E	47° 0'21.59"N 21°58'45.45"E
Distances from previous sampling site	-	1.7 Km	10 Km	
Sampling site total length	190 m	115 m	85 m	
Water temperature at study date (05.12.2019)	8,5 °C	10 °C	21°C	

The water depth ranged between 0.5 and 1 m across the riverbed that not exceed 3 m in width. Peta 1 is the first sampling site located near the Peta brook shedding mouth in Crisul Repede/ Sebes Körös River. Peta 2 is located at 1.7 km upstream from Peta 1 and distinctively there is a riverbed threshold of 45 cm in height which seems to be limiting for the fish passing upstream. Moreover, the researches based on this subject prove that the juvenile (young-of-the year) specimens are taking refuge in that tributary and seems to be limited on this area. Peta 3 is located at the shedding mouth of small thermal tributary named Hidisel valley, actually the main source of thermal water that flows in Peta brook after the desiccation of its thermal springs. This sampling site is most upstream the Peta brook shedding in Crisul Repede/ Sebes Körös River.

During the sampling date, the external air temperature was constantly at around -5°C.

Although the fish samples were collected in December 2019, complementary for our study we used also the previous data obtained from the sampling site Peta 3, during the late October 2017. It allows us to compare the number of species with permanent occurrence on that site. The previous data obtained on the occasion of some studies carried out together with the students during the completion of their graduation theses were also useful. These allow us to identify the fish species permanently or occasionally present in this brook.

The fish samples were collected using electro-fishing gear type Samus MP 750 and a supplementary catching net held behind the anode (mesh size 0.5 cm). The sampling methods and procedures were accomplished adopting the standard normative (CEN 2003 Water quality).

The collected fish specimens were identified at the sampling site and immediately released back to the water. The occurrence of species was registered using a voice recorder, and the final counting of specimens was performed after the sampling procedure.

Results

We recorded 14 fish species in Peta brook, along the three sampling sites. The majority of species (12 species) belong to Cyprinidae family and two species to Cobitidae (*Table 2*.). The occurrence of *Cobitis elongatoides* was recorded only in the source area of the brook where the water is not of a thermal origin. Comparing to the number of fish species recorded in thermal water in cold water of the main channel of Crisul Repede/ Sebes-Körös only two species of Cyprinidae were found (*Alburnus alburnus* and *Squalius cephalus*).

Table 2. Fish species and the sampling sites along the Peta brook

Species	Peța 1 (relative abundance)	Peța 2 (relative abundance)	3 Peța + Hidisel 2019 (relative abundance)	3 Peța + Hidisel 2017 (relative abundance)
Alburnoides bipunctatus	5.99	65.96	-	-
Alburnus alburnus	69.46	5.36	8.90	29.21
Barbus barbus	-	1	-	-
Barbus biharicus	7.19	-	-	-
Carassius gibelio	-	0.62	8.22	20.54
Chondrostoma nasus	0.60	10.97	0.68	-
Gobio gobio	1.20	1.87	1.37	1.49
Pseudorasbora parva	-	-	6.16	-
Rhodeus amarus	-	2.62	23.29	21.53
Rutilus rutilus	-	1.50	2.05	0.25
Sabanejewia balcanica	2.99	-	-	-
Squalius cephalus	12.57	9.98	49.32	26.98
Tinca tinca	-	0.12	-	-
Total number of species	7	10	8	6
Total number of specimens	167	802	146	404

Fish species and their behavior during the wintering in Peta brook

The species distribution along the thermal brook during the winter suggests several species preferences for thermal water habitats, and also their ability to tolerate the inappropriate conditions in narrow and shallow water. All the fish species remain active during the wintering in this thermal water and occupy a specific biotope with gravels bottom and shallow water along the riverbed (*Fig. 1*).

According to our results, the fish species can be split into three categories according to their behavior in winter conditions:

Refugee species - the category groups together 4 species with a high relative abundance in Peta brook (*Tab. 2*). These are commonly good swimmers, *Chondrostoma nasus, Squalius cephalus, Alburnoides bipunctatus* and *Alburnus alburnus* in which seasonal migration from the main channel of Crisul Repede / Sebes-Körös for wintering has been observed. Together with the adult specimens, a lot of juvenile individuals resulting from the latest reproduction (young of the year) take the refuge for wintering in this water. Most specimens of *Chondrostoma nasus* (93%) captured at Peta 2 sampling site consists of juveniles.

Other two rheophilic potamodromous species that reach the Peta brook during the winter are *Barbus barbus and B. biharicus*. Especially *B. barbus* is characteristic for rivers with a wider riverbed and a higher flowing rate. In case of both *Barbus* species, the presence of juveniles and adults was rare.

A special remark deserves the species *Barbus biharicus* which was captured only in the sampling site Peta 1 at a short distance from the shedding of the thermal brook. This fish is characteristic for fast waters with a stony substrate such as those from the hilly sector of Crisul Repede (Antal et al. 2016). Its presence on a gravel dominated substrate at a short distance from the main channel of Crisul Repede / Sebes-Körös River was surprising and meant its recent entry into the thermal water at the study date. This species did not occur on the other sampling sites upstream.

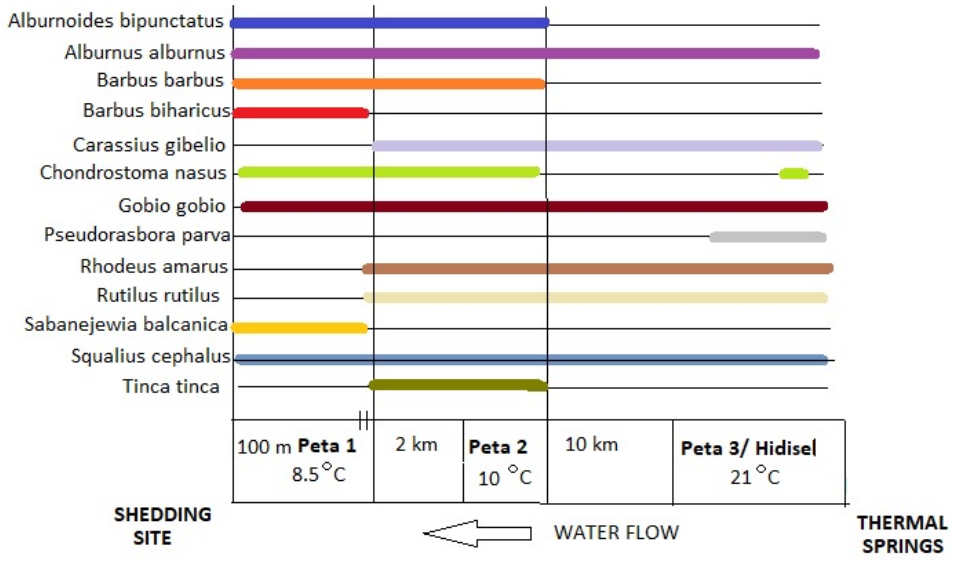

Fig.1. The diagram of species spreading and water temperature along the Peta brook riverbed

Occasional species category which consists from a number of 4 species whose presence has been found in small number (excepting *Rhodeus amarus* which has a grouped distribution). These fish are *Rutilus rutilus, Rhodeus amarus*, *Tinca tinca* and *Sabanejewia balcanica* (*Tab. 2*). They reach the Peta brook also in the other seasons nonspecifically. These species not belongs to the group of "good swimming species" and can be found also in habitats with different conditions from those in the thermal brook.

Common and exotic species - the category groups three species - one native *Gobio gobio,* and two non native (alien) species *Pseudorasbora parva* and *Carassius gibelio*, which are spread along the riverbed according to a presence of their suitable habitats and are also permanent species throughout the year. The two non native species *C. gibelio* and *P. parva* were found mostly at the sampling site Peta 3 at the confluence of Hidisel tributary. The site

is situated more than 10 km upstream from the Peta brook mouth. During the last two years, the abundance of *Carassius gibelio* decreased markedly compared to 2017 data (*Table 2.*).

Our observations upon the number of fish specimens along the riverbed during the winter showed the maximal agglomeration of individuals on Peta 2 sampling site which is located approximately at 2 km upstream the brook mouth. Here we have identified about 802 specimens belonging to 10 species. The number of species and specimens resembles in the other two sampling points (Peta 1 and 3) where 167 and respectively 146 specimens were identified.

Among the species with the most numerous individuals sampled in Peta 2 are: *Alburnoides bipunctatus* (65,96%), *Chondrostoma nasus* (10,97%), *Squalius cephalus* (9,98%), and *Alburnus alburnus* (5,36%). We mention that *Squalius cephalus* was identified in large number (49,32%) at the sampling site Peta 3 (*Table 2.*).

Discussion

Out of the total of 14 fish species sampled during the winter in the thermal water of Peta brook, a number of 13 are active throughout this season due to the high water temperature which ranged here 8.5 to 21 ^{o}C. An exception is the species *Cobitis elongatoides* from the former thermal lake which is forced to winter in authentically winter conditions after the desiccation of thermal springs.

The large majority of species which migrate in the thermal brook have a large number of individuals and they can be considered as refugees in this habitat for wintering. (4 species including 998 specimens). Along with them are 4 other species with occasional presence (total 76 specimens). This indicates on the one hand the importance of the Peta brook as a natural refuge for the fishes from Crisul Repede/ Sebes-Körös, and on the other hand the important role of thermal habitats for rearing juveniles and especially those in the young of the year category. Previous data on thermal brook species include 2 other species *Perca fluviatilis* and *Ictalurus nebulosus* that were not found during this study.

Regarding the behavior of the species:

- *Squalius cephalus* is the most representative species along this thermal brook and its presence denotes the great ability of this species to adapt to different environmental conditions. However, in the last 2 years there has been registered a slight reduction in the number of specimens in the sampling site Peta 3.

- *Chondrostoma nasus* behaves as immigrant species in the thermal water of the thermal stream. There was recorded a number of 84 juveniles of this species and it find shelter and good feeding conditions during the winter. Mature adults (only 6 specimens identified) leave the thermal habitat with the arrival of spring. This indicates that the Crisul Repede / Sebes-Körös riverbed from the shedding point of the Peta brook together with the lower sector of the proper brook represents an optimal habitat for reproduction of *Chondrostoma nasus*. This species prefers such habitats for breeding and also for rearing juveniles in the early stages of development (Keckeis 2001, Keckeis et al. 1997).

- The small species *Alburnus alburnus* and *Alburnoides bipunctatus* are common in the main channel of Crisul Repede/ Sebes-Körös from where they reach and refuge in winter on the thermal water of Peta. A different situation is observed in the case of representatives of *Barbus* genus that take refuge exclusively in winter in the narrow riverbed of Peta and leave this habitat early in the spring season. These potamodromous and rheophilous species do not spawn in the area with thermal waters.

- Occasional species encountered in the winter season in the thermal water have a patchy distribution, so some such as *Rutilus rutilus*, *Sabanejewia balcanica* and *Tinca tinca* are predominantly distributed in the lower section of the brook at a greater proximity to Crisul Repede/ Sebes-Körös. In contrast, the *Rhodeus amarus* occupies the riverbed in small groups, sometimes spaced apart (Peta 2 and 3). It prefers habitats with shallow waters and sandy or muddy substrate and during the winter it tolerates even the substrate with gravels. Surprisingly, some captured specimens of *Rhodeus amarus* (at Peta 3) had visible specific

characteristics to the reproduction period (color and genital papilla of the female). This phenomenon is probably induced due to the high temperature in the thermal water. We also assume that the transition from the particularly cold water of the river Crisul Repede / Sebes-Körös (5.4°C) to the thermal one (21°C) determines in the case of this species the start of the gonad function (personal observations –not published data).

-The species *Tinca tinca* is an exception for the fishfauna of Peta brook due to its rarity. The only specimen was captured at the Peta 2 sampling site and probably it comes from Crisul Repede/ Sebes-Körös. Also, the species *Sabanejewia balcanica*, which was found only on a short stretch of the gravel covered riverbed near the brook shedding, belongs in the fish fauna of Crisul Repede/ Sebes-Körös.

Regarding to species spreading and their number:

Fish species occupy the riverbed differently, according to their affinities for certain conditions in the local biotope (Fig. 1). Our data reveals that only about half of the species we identify are found throughout the riverbed where the suitable conditions are finding. Those species that spreads along the entire brook are *Alburnus alburnus, Carassius gibelio, Gobio gobio, Rhodeus amarus, Rutilus rutilus* and *Squalius cephalus.* The other species (*Alburnoides bipunctatus, Barbus barbus, B. biharicus, Chondrostoma nasus, Sabanejewia balcanica* and *Tinca tinca*) are found only on the last about 2 km of the brook chanel (sampling site Peta 1 and Peta 2). Their presence in lower sector is correlated with the connection of Crisul Repede / Sebes-Körös River where they are originated from.

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Decemberben fogott, szaporodásra felkészült szivárványos öklék (hím és nőstény). Szaporodási időszak alatt a hímek orrtájéka jellegzetes sajátosságot mutat. (Fotó: A. Togor)

Specimens of Rhodeus amarus (male and female) ready to spawn in December. The muzzle of male with distinctive specific characteristics to the reproduction period. (Photo: A. Togor)