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Coenological and habitat affinities of *Cobitis elongatoides*, *Sabanejewia balcanica* and *Misgurnus fossilis* in Slovakia

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A b s t r a c t . Three species of the Eurasian family *Cobitidae* are distributed in Slovakia. In the present paper, we describe the coenological affinity of *Cobitis elongatoides, Sabanejewia balcanica* and *Misgurnus fossilis* in two distinct zoogeographical regions, Slovak Tisza and Danube basins and discuss possible differences of their biotop affinity and habitat preferences. The occurrence of *S. balcanica* is restricted to primary biotopes with harder substratum particles. Typical species assemblages for the rheophilic *C. elongatoides* are eurytopic and limnophilous species. *C. elongatoides* is mostly distributed in primary biotopes, such as rivers and channels. It also occurs in secondary biotopes (drainage canal or pit). *M. fossilis* is distributed mostly in the secondary biotopes, but it is also found in the primary biotopes. Both species prefer fine substratum, but spatial distribution of the two species is different. *C. elongatoides* prefers harder substratum of sandy particles mixed with mud or detritus and living vegetation, whereas *M. fossilis* prefers muddy substratum mixed with detritus and dead vegetation.

Key words: Cobitidae, loaches, habitat preferences, species assemblage, ecology

Introduction

Three species of the Eurasian family *Cobitidae* have been found in Slovakia. These are: *Cobitis elongatoides, Sabanejewia balcanica* and *Misgurnus fossilis*. Their conservation and distribution on the Slovak territory was discussed by K o š č o et al. (2008). In Slovak populations, *C. elongatoides* occurs as a diploid-polyploid hybrid complex (*Cobitis elongatoides* x *Cobitis tanaitica*) (L u s k et al. 2003, L u s k o v á et al. 2004, P a p o u š e k et al. 2008) mostly distributed in lowland rivers and derived oxbow lakes, pits and drainage canals. A polyploid population with female dominance occurs in lower river reaches what is in contrast to a pure diploid population mostly found in upper reaches of rivers (L u s k et al. 2003). *S. balcanica* in Slovakia belongs to Dunabian-Balkan complex (P e r d i c e s et al. 2003, B a r t o ň o v á et al. 2008) and occurs mostly in foothill rivers of which habitats are characterised by a lower water velocity, as well as pebbles and gravel as bottom substratum. *M. fossilis* inhabits lowland rivers, including their oxbow lakes, pits and drainage canals with muddy substratum.

Only a few data on coenological affinity of the three species are available (P o v ž & Š u m e r 2000, D e l i ć et al. 2003, M u s t a f i ć et al. 2003), except for the Slovak part

of Tisza River basin (Košč o et al. 2006). On the other side, studies on habitat use of *Cobitis taenia* in Europe (Robothan 1978, Culling et al. 2003, Przybylski et al. 2003, Copp & Vilizzi 2004) offer an incomplete information on habitat preference of *C. elongatoides* (Slavík et al. 2000). Although habitat preferences of *M. fossilis* were analysed (Meyer & Hinrichs 2000), no comparable study is available for *S. balcanica.*

In the present paper, we describe and verify coenological affinity of loaches in two distinct zoogeographical regions of Slovakia and discuss differences of their biotop and substratum affinity.

Material and Methods

The most of Slovak river system belongs to the Black Sea basin (96%). Only drainage area of Poprad and Dunajec rivers belongs to the Baltic Sea basin (4%). Based on zoogeographical data from the Black Sea basin, associated Slovak rivers are assigned into two sub-systems, Danube and Tisza basins (for details see Košč o et al. 2008).

Information on fish species assemblage and habitat structure were extracted from papers published in the last 60 years (131 sites analysed) and from our data obtained between 2005–2006 (95 sites analysed) using electrofishing sampling technique. To analyse coenological affinity we applied cluster analysis of Ward's method in Past statistical software (Hammer et al. 2001) and methods of Struass (1982) on presence/absence data matrix of fish species occurring together on 226 sites. Non-random occurrence test with all species was calculated using χ^2 test of Euclidean distances following methods of Prybilszky et al. (2003). Differences found between the Tisza basin and other Danube drainages were tested as comparison of non-random occurrence with all species in the drainages.

The species affinity to the primary biotopes (rivers, oxbow lakes, channels) and to the secondary biotopes without fish stocking (pits, drainage canals) was analysed as relative species occurrence in the habitat type. As to substratum type categories, we used modified categorisation from habitat use study of Copp & Vilizzi (2004). Biotope and substratum electivity was evaluated using Ivlev's index of electivity modified by Jacobs (Lechowicz 1982), of which value approaching 0.5 indicates preferences, while value approaching -0.5 indicates avoidances (Copp 1992). To test significance of the electivity index, the Fisher's exact test was performed (Copp 1992). Species ecological guilds were defined according to Schiemer & Waidbacher (1992).

Results

Altogether, 65 fish and lamprey species were recorded on the analysed sites that representatives of Cobitidae occur. *C. elongatoides* was found on 117 sites (with *M. fossilis* on 35 sites; with *S. balcanica* on 17 sites). *M. fossilis* was found on 85 sites and *S. balcanica* on 76 sites. The average number of species occurring together with *C. elongatoides* is 12.03 species (from 1 to 25 species). The most frequent species include *Leuciscus cephalus* (70.09 %), *Perca fluviatilis* (59.83 %), *Rutilus rutilus* (58.97 %), *Alburnus alburnus* (57.26 %), *Esox lucius* (56.41 %), *Gobio gobio* (54.70 %) and *Rhodeus sericeus* (50.43%). The average number of species occurring together with *M. fossilis* is 8.74 species (from 0 to 25 species). The most frequent species include *E. lucius* (67.06 %), *R. rutilus* (65.88 %) and *P. fluviatilis* (54.12 %). The average number of species occurring together with *S. balcanica* is 12.03 species (from 3

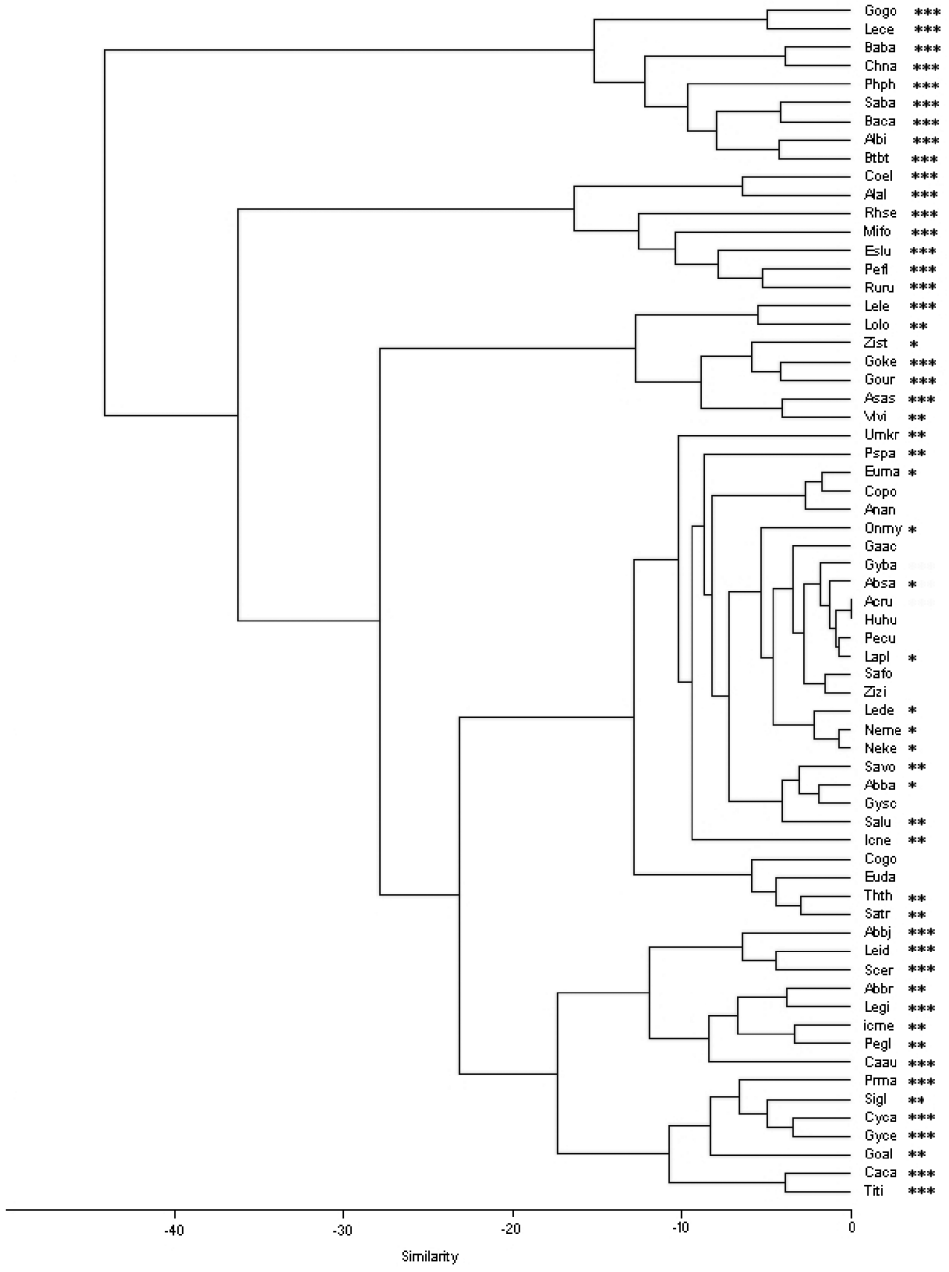

Fig. 1. Cluster analysis of coenological affinity for *C. elongatoides*, *S. balcanica* and *M. fossilis* in Slovakia with the results of χ^2 test for non-random clades position (* - p<0.1; ** - p<0.05; *** - p<0.01). Species abbreviations are: first two letters of generic name and first two letters of specific name. Exception Baba – *Barbus barbus*, Btbt – *Barbatula barbatula*.

to 24 species). The most frequent species include *L. cephalus* (96.05 %), *Barbatula barbatula* (86.84 %), *Alburnoides bipunctatus* (85.53 %), *G. gobio* (75.00 %), *Chondrostoma nasus* (75.00 %), *Barbus carpathicus* (72.37 %) and *Phoxinus phoxinus* (53.95 %).

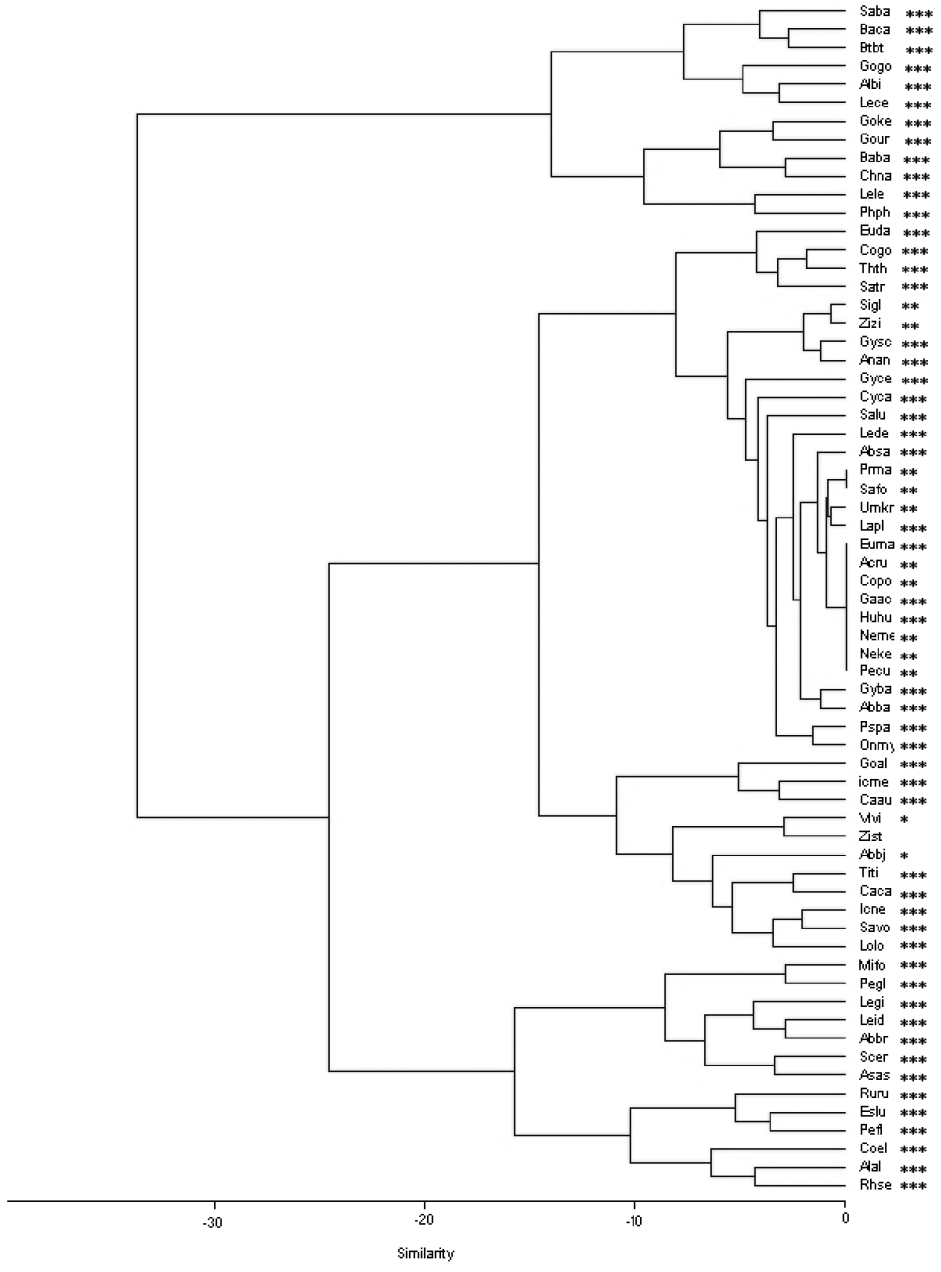

Fig. 2. Cluster analysis of coenological affinity for *C. elongatoides*, *S. balcanica* and *M. fossilis* in Tisza River basin with the results of χ^2 test for non-random clades position (* - p<0.1; ** - p<0.05; *** - p<0.01). Species abbreviation are: first two letters of generic name and first two letters of specific name. Exception Baba – *Barbus barbus*, Btbt – *Barbatula barbatula*.

The results are in agreement with cluster analysis (Fig.1) showing several separated clusters. *S. balcanica* and the most frequent rheophilic species form the first cluster that is considerably separated from the other clades. The second cluster includes *C. elongatoides,*

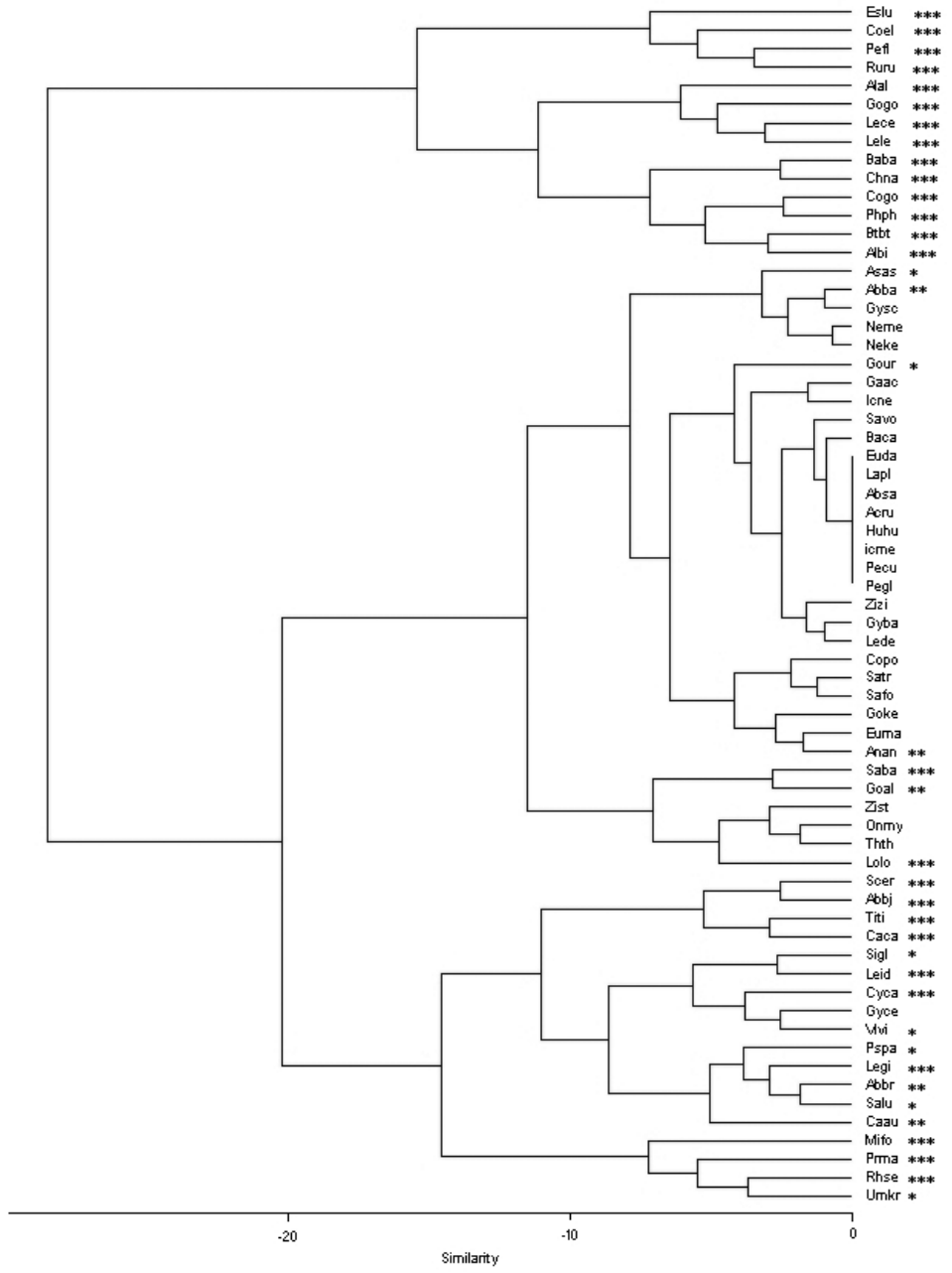

Fig. 3. Cluster analysis of coenological affinity for *C. elongatoides*, *S. balcanica* and *M. fossilis* in the Danube River basin with the results of χ^2 test for non-random clades position (* - p<0.1; ** - p<0.05; *** - p<0.01). Species abbreviation are: first two letters of generic name and first two letters of specific name. Exception Baba – *Barbus barbus*, Btbt – *Barbatula barbatula*.

M. fossilis and limnophilous and eurytopic species. Our results show that a typical species assemblage of *C. elongatoides* consists of *R. rutilus*, *P. fluviatilis, E. lucius, R. sericeus* and *A. alburnus* in the Tisza basin (Fig. 2) and *R. rutilus*, *P. fluviatilis* and *E. lucius* in the

Danube basin (Fig. 3). A typical species assemblage of *M. fossilis* consists of *R. sericeus*, *Proterorhinus marmoratus* and *Umbra krameri* in the Danube basin (Fig. 3) and *Perccottus glehnii* in the Tisza basin (Fig. 2). A typical species assemblage of *S. balcanica* consists of *Romanogobio albipinnatus* in the Danube basin (Fig. 3) and *B. barbatula*, *B. carpathicus*, *G. gobio*, *A. bipunctatus* and *L. cephalus* in the Tisza basin (Fig. 2).

We found that occurrence of *S. balcanica* is restricted to primary biotopes, to rivers in the Tisza basin and to rivers and oxbow lakes of the Danube with flowing water and gravel substratum in the Danube basin. Preference of river habitats and avoidance of drainage canal, channel and pit habitats is significant (Fig. 4). Our data suggest that *C. elongatoides* was in most cases distributed in primary biotopes. However, *C. elongatoides* also occurs in secondary biotopes (drainage canal channel or pit). Occurrence points of *C. elongatoides* in pits is higher in the Tisza River than in the rest of the Danube basin. No preference or avoidance has been found significant (Fig. 4). We found that *M. fossilis* was distributed mostly in secondary biotopes, but regularly also found in primary biotopes. Contrary to data from the Danube basin, occurrence points of *M. fossilis* in the Tisza basin was higher in pits, but lower in drainage canals. Our results show that the preference of drainage canal habitats (in the Tisza basin, oxbow lake and pit) and avoidance of river habitats was significant (Fig 4). We found that *S. balcanica* prefers

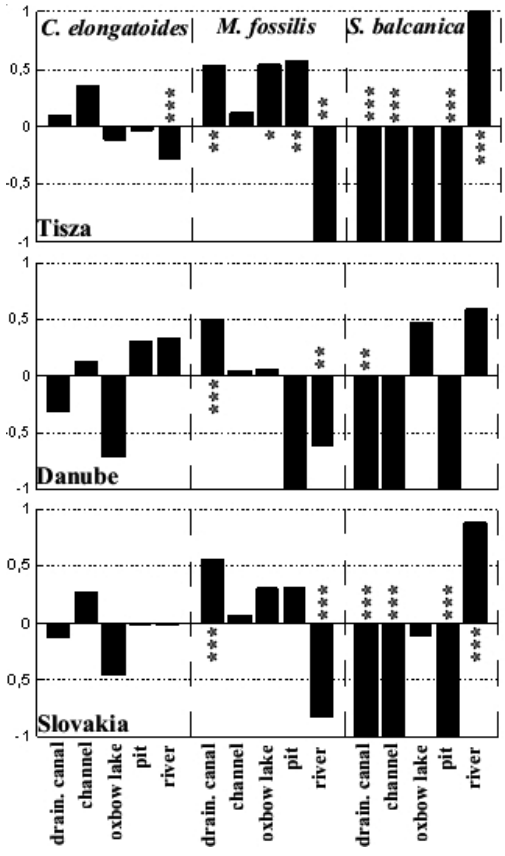

Fig. 4. Graphical expression of electivity index for 5 biotpes type for *C. elongatoides*, *M. fossilis* and *S. balcanica* in Tisza basin (upper), Danube basin (middle) and Slovakia (bottom) with the results of Fisher exact test (* - p<0.1; ** - p<0.05; *** - p<0.01).

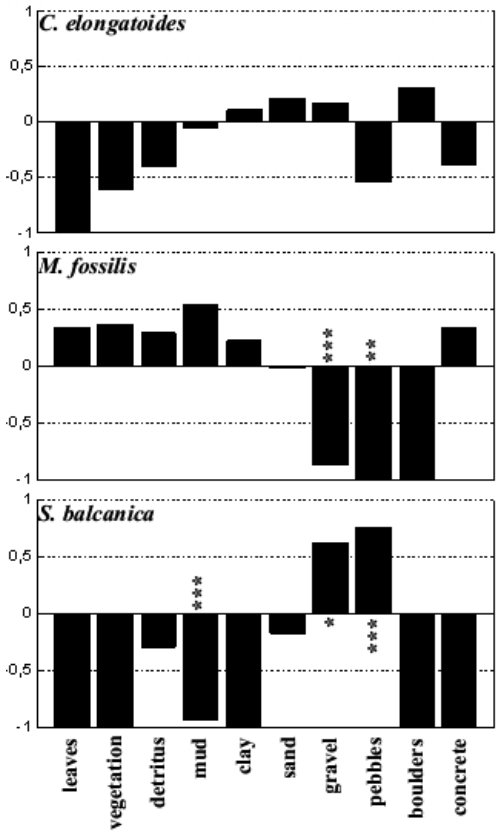

Fig. 5. Graphical expression of electivity index for substratum categories for *C. elongatoides* (upper), *M. fossilis* (middle) and *S. balcanica* (bottom) with the results of Fisher exact test (* - p<0.1; ** - p<0.05; *** - p<0.01).

larger and harder substratum particles, such as gravel and pebbles (Fig. 5). One the other hand, *C. elongatoides* and *M. fossilis* prefer fine substratum (Fig. 5). As for *M. fossilis,* our results show that its substratum preference is shifted into detritus, vegetation and leaves, what is in a contrast to harder substratum (sand, gravel and pebbles) preferred by *C. elongatoides*.

Discussion

Almost three quaters (73.86 %) of 88 fish and lamprey species, known from the Slovak territory (H o l č í k 1998), were associated with *C. elongatoides*, *S. balcanica* or *M. fossilis*. Except for small mountain creeks, foothill rivers in some regions and rheophilic sections of large rivers, these species were present in all biotope types. Majority of species that have not been recorded in our investigation represent rare species inhabiting large lowland rivers and several rare introduced and exotic species. The most frequent species occurring together with loaches are eurytopic and rheophilic species with a wide distribution in Slovakia. Despite their ecological characteristics, both *L. cephalus* and *G. gobio* were periodically found also in limnophilous biotopes and highly regulated rivers. The number of species occurring together with each loach species are nearly the same (up to 25 species). The average number of the species is lower only for *M. fossilis*. This can be explained by lower species diversity on many sites due to extreme environmental conditions.

We did not find any common species that occurs with frequency higher than 50%. However, *L. cephalus* and *G. gobio* were present in more than 50% of investigated localities that were also inhabited by *S. balcanica* and *C. elongatoides*. These four species represent the rheophilic species assemblages of primary biotopes. As to *C. elongatoides* and *M. fossilis*, *P. fluviatilis* and *R. rutilus* were found in more than 50% of their common localities. These species represent the eurytopic species assemblages of lowland rivers, their oxbow lakes and several secondary biotopes.

The typical species assemblage for rheophilic *S. balcanica* is composed by the species belonging to the same ecological guild. Differences that we found for *S. balcanica* in Tisza and Danube basins are not significant due to small data sets from the Danube basin. *S. balcanica* is distributed only in primary biotopes (mostly in rivers). Only several oxbow lakes with gravel substratum and water current that are remnants of a Danube inland delta system, offer suitable microhabitat conditions for *S. balcanica*.

The typical species assemblage for the rheophilic *C. elongatoides* is composed by species from eurytopic and limnophilous ecological guilds. However, the species assemblage in the Danube basin is formed only by eurytopic species. This is in contrast with the situation in the Tisza basin where the species assemblage is formed also by limnophilous species. *C. elongatoides* occurs in both primary and secondary biotopes with the centre of distribution in channels, but this species has also spread to secondary biotopes. Differences in distribution of *C. elongatoides* in the Tisza and Danube basins are most striking in pits. This finding may reflect co-occurrence of *C. elongatoides* with limnophilous species in the Tisza basin.

The typical species assemblage for limnophilous *M. fossilis* consists of species from the same ecological guild as well as the eurytopic species. The typical species assemblage in the Danube basin is formed by limnophilous and rheophilic species, whereas it is formed by species from all ecological groups in the Tisza basin. The most preferred biotop of *M. fossilis* represent secondary biotopes in lowlands (mainly drainage canal). This may reflect an environmental adaptability of *M. fossilis*.

In Slovenia, the typical species assemblage for all three loaches consists of fish from all ecological guilds, where rheophilic species are the most frequently associated with *S. balcanica,* while eurytopic and limnophilous species with *C. elongatoides* and *M. fossilis* (Povž & Šumer 2000). In Croatia, the typical fish species assemblage for *S. balcanica* and *C. elongatoides* consists of rheophilic and eurytopic species (Mustafić et al. 2003, Delić et al. 2003). As relative occurrence of fish species and the hierarchical cluster analysis was not considered by these studies, we cannot compare our results with results from Croatia and Slovenia.

Our substratum preferences analysis document ecological characteristics of loaches found in Slovakia. *S. balcanica* prefers gravel and pebbles as substratum particles that are found in non-regulated flowing parts of rivers. Both *C. elongatoides* and *M. fossilis* prefer a fine substratum that is found in the river parts with low water velocity and in biotopes without water current. Spatial distribution of the two species is different. *C. elongatoides* prefers sandy particles mixed with mud or detritus (Slavík et al. 2000) and living vegetation. *M. fossilis* prefers muddy substratum mixed with detritus and dead vegetation parts (Meyer & Hinrichs 2000) of *Typha* and *Phragmites*.

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