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# MONITORING OF THE FISH COMMUNITY IN THE HUNGARIAN REACH OF RIVER TISZA IN 2009

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**Abstract**
The fish community of River Tisza was assessed in 24 sampling areas of the river between 9 and 18 September 2009. The fish community and the fish species were monitored by electric fishing. During the survey, 24 760 specimens of 47 species belonging to 13 families were caught. The individuals of only two species, *Alburnus alburnus* and *Aspius aspius*, were found in all of the 24 sampling areas. *Leuciscus idus*, *Perca fluviatilis*, *Proterorhinus semilunaris*, *Lota lota*, *Silurus glanis* and *Esox lucius* were found to be frequent species, occurring in at least two-thirds of the sampling areas. In the majority of the samples, the fish community is dominated by one, maximum two species. The total species richness of the community, as estimated using the second-order jacknife procedure, was 72. According to the EFI+ index, two sampling areas have high ecological quality, eleven are good, six moderate, four poor and one bad.
**Keywords:** River Tisza, fish community, diversity indices, characteristic species, EFI+ index

## INTRODUCTION

The scientific research on River Tisza dates back to 1847 (Heckel, 1847), although there are much earlier data on the river's fish fauna (e.g. Matthias Bel). Tisza belongs to the few exceptional cases where the changes in the fish fauna can be followed from as long ago as the mid-19th century. The more regular research has been expanding the species list, while the human nature transforming activities have been contracting it.

The number of species ever detected in the Hungarian reach of River Tisza was 65 before 1999. After the cyanide pollution, the species number increased, partly due to habitat changes (*Eudontomyzon danfordi, Telestes souffia, Carassius auratus, Barbatula barbatula, Cottus gobio*). A total of 74 species are known from the river from its source to its confluence with the Danube. A total of 77 species have been proven from the entire catchment of the Tisza (main channel + tributaries + backwaters), with only two of them, *Eudontomyzon vladykovi* (Bega) and *Sabanejewia romanica* (Mureş), missing from the main channel.

## Material and Methods

### *Sampling areas*

In accordance with the taken obligations, we assessed the fish community of the river in 24 sampling areas of the Tisza reach between Tiszabecs and Szeged on 9–18 September 2009 (Figure 1). The sampling areas designated during the studies of 2000 were used during the current monitoring as well. In relation to the water flow, the length of the first (Tiszabecs) sampling area was determined as 5 000 m, that of the others as 1 000 – 2 500 m, but the actually sampled length was 5x200 m in all cases.

### *Sampling*

With the only exception of the sampling area TI-01 (Tiszabecs), the sampling areas were fished using a generator-powered EL63 II-type pulsed-DC electric fishing gear. The 5x200 m of the uppermost area were fished wading in the water, using a battery-powered SAMUS 725MP-type pulsed-DC electric fishing gear. The time of the fishing events was measured to the nearest minute. The caught fish were released into their natural habitat after identification and counting, the data were registered immediately, on the spot, to an OLYMPUS WS-200S digital voice recorder.

### *Data analysis and processing*

The species names are listed according to the nomenclature by Kottelat & Freyhof (2007). Of the diversity indices, the species richness (S), Menchinick's index ($S/\sqrt{N}$), the Berger-Parker dominance index ($(n_{max}/N)$, the Shannon-Wiener index (H), the effective species number (expH), Pielou's evenness [$H_{max}/\ln(S)$], the total species richness calculated with the second-order jacknife method, as well as the expected number of species in a rarefied sample, ES(m). The diversity indices were estimated using the Species Diversity and Richness IV programme package (Seaby & Henderson, 2006). In addition, the new European Fish Index (EFI+) was calculated for each sampling area using the online http://efi-plus.boku.ac.at/software web site (EFI+ Consortium, 2009). The sampling area groups characterized by similar environmental variables (m.a.s.l., wetted width, longitudinal slope of the river channel, distance from source, size of the drainage area, mean annual temperature, mean temperature in January, mean temperature in July, pH, conductivity, dissolved oxygen) were studied with a hierarchic classification of the Euclidean distance matrix

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of the variables previously standardized using standard deviations with the help of the group mean method, using the SYNTAX 2000 programme package (Podani, 2001). The characteristic species of the fish communities (habitat type indicators) were identified with the method suggested by Dufrêne & Legendre (1997), using the IndVal 2.0 manual programme. Species having a value of $p<0.05$ in 499 randomization cycles were considered characteristic.

## RESULTS

Of the designated 27 sampling areas, those of Tivadar (TI-02), Tiszaörvényes (TI-14) and Vezseny (TI-21) were not sampled. During the sampling done in late summer of 2009, 24 760 specimens of 47 species belonging to 13 families were caught. No new fauna element was found compared to the post-disturbance Hungarian species list (62 fish species). The number of endemic species is relatively high, 7 (*Eudontomyzon danfordi, Gobio carpathicus, Romanogobio uranoscopus, Romanogobio kessleri, Rutilus virgo, Sabanejewia bulgarica, Gymnocephalus schraetser*). The number of legally protected species is 18, more than 38% of the found species. The number of protected species shows a characteristic variation among the sampling areas (Figure 2).

The specimens of only two fish species, *Alburnus alburnus* and *Aspius aspius* were found in all of the 24 sampling areas (Table 1). Frequent species, occurring in at least two-thirds of the sampling areas were *Leuciscus idus* (19 sampling areas), *Perca fluviatilis* (19), *Proterorhinus semilunaris* (19), *Lota lota* (17), *Silurus glanis* (16) and *Esox lucius* (16). The Gergelyiugornya (TI-03) sampling area was found to be the richest in species, where the presence of bigger or smaller populations of 22 species was proven. Other river sections rich in species were the following: Tiszalök, downstream of the barrage (TI-09: 21 species), Kisköre, downstream of the barrage (TI-18: 19 species), Tiszabecs (TI-01: 19), Tiszaroff (TI-19: 18), Balsa (TI-07: 17) and Tiszaug (TI-23: 17). The species numbers of the Algyő (TI-26: 8), Mindszent (TI-25: 10) and Tiszadorogma (TI-12: 11) sampling areas were far below the average 14.9.

The Shannon-Wiener index ranged between 0.33 and 2.00 in the different sampling areas. The diversity was the highest in the Dinnyéshát (TI-18) fish community with 21 species, the lowest in the Tiszadorogma (TI-12) fish community having 11 species. Based on all samples, the average value of the index was 1.03. The diversity index, obviously along with the effective species number and the evenness, was the lowest in the region of the reservoir, with the only exception of the Dinnyéshát sampling area. In the majority of the samples, the fish community is dominated by one (4 sampling areas), or maximum two species (9 sampling areas) (see also the Berger-Parker dominance). The number of species in the rarefied samples in the individual sampling areas (= expected species number) was calculated for the n=210 abundance level of the Szolnok sampling area. Compared to the original number of species, the expected species number was the lowest in the Balsa sampling area, the reduction is 61%. The reduction was the lowest in the Hungarian lower Tisza reach, between the Kisköre downstream (TI-18) and the Mindszent (TI-26) sampling areas.

On the basis of the 24 samples, the total species number, rounded to the nearest integer, of the fish community in the Hungarian reach of River Tisza was 72. The total species number of the fish community was estimated from the species number data of the individual sampling areas in a non-parametric way, using the so-called second-order jacknife method (taking into consideration the species in two samples). The experience shows that this relatively easy estimation can be used well (Burnham & Overton, 1978; Tóthmérész, 2002). Other methods yielded other results. Three methods for species richness estimation (Chao & Lee 1, Chao & 2, Michaelis-Menten) resulted in species numbers of 47-48, three others (Bootstrap, Chao quantitative and first-order Jacknife) estimated the species number between 52-60. The highest total species number of the fish community, 96(!), was estimated with a method based on Chao's presence/absence data.

This latter estimate is the least probable one as this is approximately the number of all the fish fauna elements in Hungary. The species numbers of 47-48 are unacceptable, too, as such numbers could be caught even during the individual monitoring events. The species numbers between 52 and 60 also underestimate the real value, as the number of the species described to date, not including the beluga, is 69, as it was reported in a previous chapter of our report. The most realistic estimate was accepted as the total species number of the fish community in the Hungarian reach of River Tisza. Knowing the range and the current rapid dispersal of several Ponto-Caspian, Black Sea goby species, it can be predicted that the currently „*missing*" 3 fish species will soon be detected.

On the basis of our late summer sampling of 2009, Guti's absolute natural value was 89, while the relative one, 1.935.

The sampling areas having similar habitat conditions were determined by hierarchical clustering of environmental variables (Figure 3). The 25 sampling areas (including the Tivadar sampling area as well) could be grouped in three classes, the biggest of which includes further subclasses. Of course, the pairwise distances (ultrametrics) determined in the dendrogram differ from the original distances. The clusters of the two uppermost sampling areas (TI-01 and TI-02) join to the others at a much lower similarity level. The next major group of sampling areas (TI-03 – TI-08) also makes


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a well-distinguished class. The dendrogram clearly demonstrates our previous observation that the limits of the geographic Upper Tisza and the fisheries biological one are different. Keeping the name of the Upper Tisza but indicating the difference, the two reaches in question were named Object Upper Tisza/I and Object Upper Tisza/II. The biggest cluster includes the Middle Tisza (TI-10 and TI-11), the Reservoir in a broader sense (TI-12 – TI-19) and two well-distinguishable reaches of the Lower Tisza, Lower Tisza/I (TI-20 – TI-24) and Lower Tisza/II (TI-25- TI-27). It is interesting that, in contrast with our expectations, only one of the two barrages, that of Tiszalök (TI-09), was distinguishable on the basis of its environmental parameters, the other one did not emerge from the reservoir cluster. The dendrogram of the typology file of the IndVal programme (Figure 4) was determined on the basis of clusters determined according to environmental variables.

The uppermost sampling reach (Upper Tisza/I) has 12 characteristic species (Table 3), many of which (*Telestes souffia, Barbus carpathicus, Romanogobio uranoscopus, Zingel streber, Cottus gobio*) are characteristic only to this area, their occurrence has not been reported from other places along the Hungarian section of the river or it has been reported rarely. The characteristic species of the next reach (Upper Tisza/II) are *Rutilus virgo* and *Silurus glanis*. The latter could be surprising, but even so, over 73% the specimens of this species sampled in 2009 were from the reach between Gergelyiugornya and Tokaj. Of the collected specimens, 98% were of the same year. According to fishermen's reports, a preferred spawning area of this fish species is in River Szamos. The spectacular abundance of wels may be attributed to this fact. On the basis of the 2009 sampling series, the characteristic species of the separate reach downstream of the Tiszalök barrage are *Ballerus ballerus, Gymnocephalus schraetser* and *Lepomis gibbosus*. The programme could not find a characteristic species for the Middle Tisza at the selected significance level. The Reservoir habitat, in a broader sense, is indicated only by *Ameiurus melas*, although it is significantly shown a characteristic species only by one of the tests. The programme could not find a characteristic species for the Lower Tisza/I sampling reach either. The indicator species of the lowermost area (Lower Tisza/II) was *Leuciscus idus*. We do not have any basis for a comparison, as studies on characteristic species and calculation of indicator values have been done in Hungary only in smaller waterflows yet (Sály et al., 2009).

The value of the new EFI+ index in the studied 24 sampling areas ranged in the interval between 0.158 and 0.973, which puts the ecological quality of the waterflow between high and bad classes (*Figure 5*).

On the basis of the index, the uppermost reach can be classified among high ecological quality water bodies. According to the qualification, the ecological quality decreases one class in the reach between the mouth of River Szamos and Tuzsér. Near Balsa, the index already shows only Class 3 quality. Slightly upstream of the sampling area is the mouth of the heavily loaded Lónya Channel (Nagy et al., 2004; Nagy et al., 2005; Takács et al., 2005), which, as it seems, has a significant negative effect on the ecological quality. The reach from Tokaj to Tiszaújváros again belongs to Class 2. Approaching the Reservoir, the ecological quality of the river becomes moderate, then poor and, finally, near Tiszaszőlős, bad. Downstream of the reservoir, below the barrage, the EFI+ index of the waterflow improved significantly and reached Class 1 in the Tiszaroff area, similarly to that of Tiszabecs! Thereafter, the ecological quality of the lower reach was classified moderate to poor, with the exception of the Csongrád reach.

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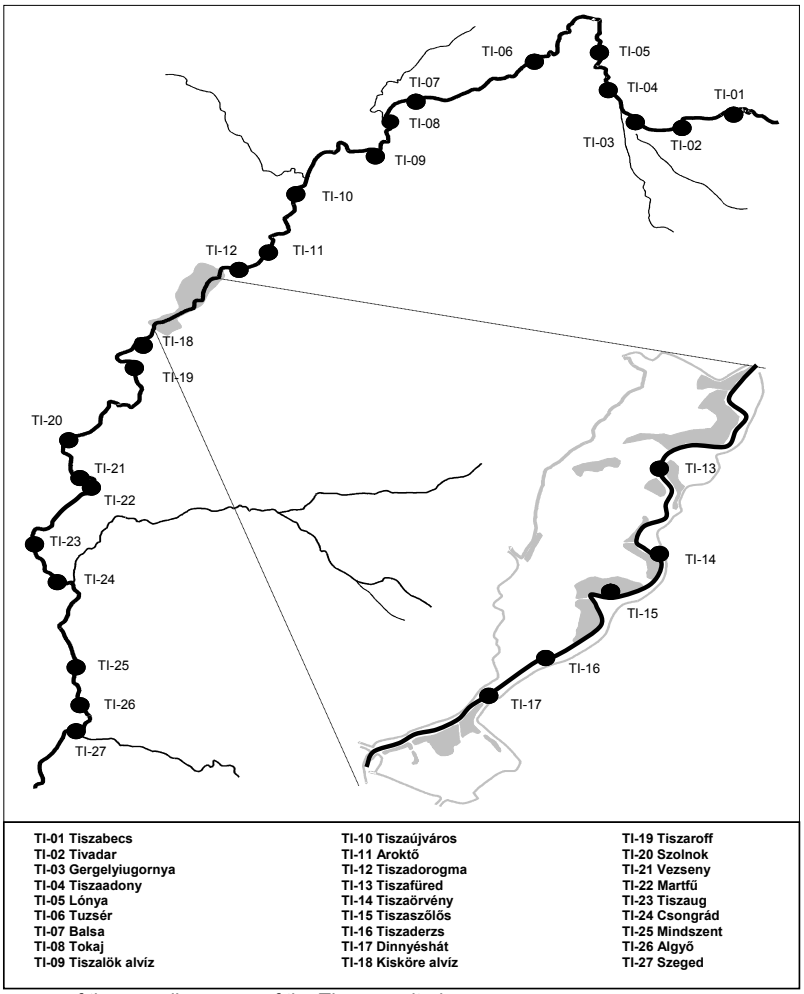


Fig. 1 Outline map of the sampling areas of the Tisza monitoring

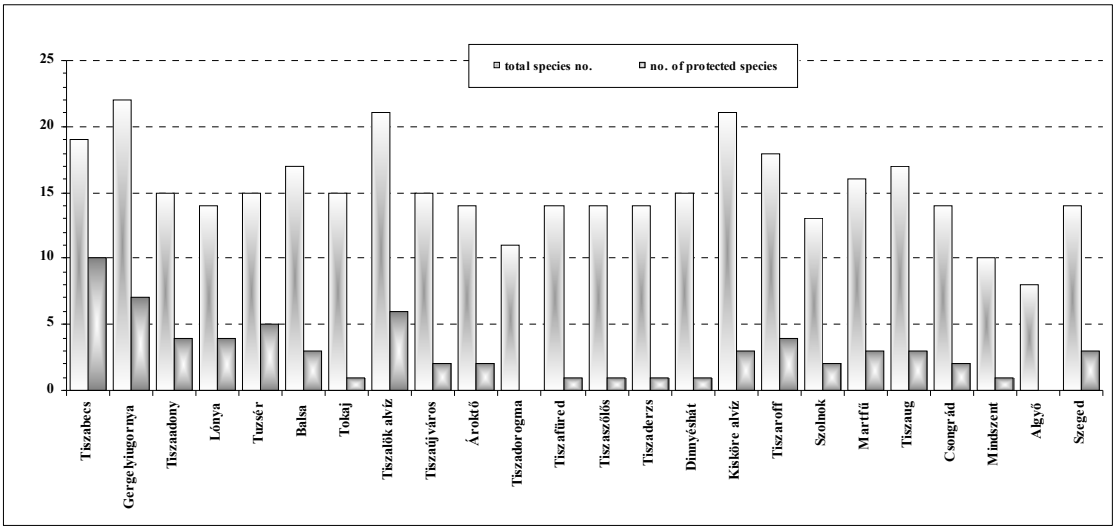


Fig. 2 Number of protected species and total species number per sampling area in late summer of 2009

**Table 1 Structure of the fish communities of the Tisza sampling areas (< = relative abundance below 0.001)**

| Species name | Code of the sampling area | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TI-01 | TI-03 | TI-04 | TI-05 | TI-06 | TI-07 | TI-08 | TI-09 | TI-10 | TI-11 | TI-12 | TI-13 |
| *Eudontomyzon danfordi* | | < | | | | | | | | | | |
| *Anguilla anguilla* | | | | | | | | 0.001 | | | | |
| *Rhodeus amarus* | | | | | | | | 0.001 | 0.001 | | | |
| *Gobio carpathicus* | 0.010 | | | | | | | | | | | |
| *Pseudorasbora parva* | | | | | | | | | | | | |
| *Romanogobio kessleri* | 0.010 | | | | | | | | | | | |
| *Romanogobio uranoscopus* | 0.167 | | | | | | | | | | | |
| *Romanogobio vladykovi* | | < | | | 0.010 | 0.001 | 0.008 | 0.001 | | | | 0.001 |
| *Barbus barbus* | 0.034 | 0.001 | 0.004 | 0.019 | 0.074 | 0.003 | 0.020 | 0.006 | 0.027 | 0.001 | 0.015 | |
| *Barbus carpathicus* | 0.031 | | | | | | | | | | | |
| *Carassius gibelio* | | < | | | | 0.001 | | | 0.001 | 0.001 | | 0.001 |
| *Cyprinus carpio* | | | | | | | 0.002 | | | | | |
| *Abramis brama* | | < | | 0.001 | | | | | 0.006 | | | 0.001 |
| *Alburnoides bipunctatus* | 0.067 | 0.033 | 0.041 | 0.029 | 0.093 | | | | | | | |
| *Alburnus alburnus* | 0.157 | 0.845 | 0.805 | 0.785 | 0.669 | 0.936 | 0.794 | 0.845 | 0.919 | 0.941 | 0.942 | 0.939 |
| *Aspius aspius* | 0.002 | 0.002 | 0.002 | 0.003 | 0.003 | 0.012 | 0.027 | 0.007 | 0.007 | 0.004 | 0.001 | 0.001 |
| *Ballerus ballerus* | | | | | | | | 0.001 | | | | |
| *Ballerus sapa* | | 0.004 | 0.001 | | | | | | | | | |
| *Blicca bjoerkna* | | | | | | 0.001 | 0.001 | < | 0.004 | | | 0.001 |
| *Chondrostoma nasus* | 0.026 | 0.026 | 0.032 | 0.029 | 0.005 | 0.001 | 0.002 | 0.017 | | | 0.001 | |
| *Leuciscus idus* | | 0.004 | | | | | 0.007 | 0.005 | 0.002 | 0.011 | 0.004 | 0.014 |
| *Leuciscus leuciscus* | 0.005 | | | | | | | | | | | |
| *Rutilus rutilus* | | < | 0.001 | | | 0.001 | 0.008 | 0.004 | | 0.005 | | 0.013 |
| *Rutilus virgo* | | 0.005 | 0.001 | 0.001 | 0.001 | | | | | | | |
| *Scardinius erythrophthalmus* | | | | | | | | 0.001 | | | | 0.006 |
| *Squalius cephalus* | 0.342 | 0.035 | 0.081 | 0.073 | 0.032 | 0.027 | 0.074 | 0.027 | 0.016 | 0.001 | | |
| *Telestes souffia* | 0.007 | | | | | | | | | | | |
| *Vimba vimba* | 0.002 | 0.001 | | | | | | | | | | |
| *Cobitis elongatoides* | 0.008 | | | | | | | 0.001 | | | | |
| *Misgurnus fossilis* | | | | | | | | | | 0.001 | | |
| *Sabanejewia bulgarica* | 0.121 | 0.004 | | | 0.001 | 0.001 | | | | | | |
| *Ameiurus melas* | | | | | 0.001 | 0.001 | | | | | 0.001 | 0.001 |
| *Silurus glanis* | 0.002 | 0.005 | 0.005 | 0.004 | 0.010 | 0.005 | 0.019 | | | 0.005 | 0.005 | 0.003 |
| *Esox lucius* | | | 0.001 | | | 0.001 | 0.001 | | | 0.001 | 0.001 | 0.001 |
| *Lota lota* | | 0.005 | 0.010 | 0.005 | 0.028 | | 0.002 | 0.042 | 0.007 | | 0.003 | |
| *Cottus gobio* | 0.002 | | | | | | | | | | | |
| *Lepomis gibbosus* | | | | | | | | 0.002 | | 0.001 | | |
| *Gymnocephalus baloni* | | | | | | | | 0.001 | | | | |
| *Gymnocephalus cernua* | | | | | | | | | | | | |
| *Gymnocephalus schraetser* | | < | 0.001 | 0.002 | | 0.000 | | 0.006 | | | | |
| *Perca fluviatilis* | 0.003 | | | 0.003 | 0.002 | 0.002 | 0.001 | 0.003 | 0.001 | | 0.017 | 0.004 |
| *Sander lucioperca* | | 0.002 | 0.001 | 0.001 | 0.002 | 0.000 | | | | | | |
| *Zingel streber* | 0.007 | | | | | | | | | | | |
| *Zingel zingel* | | 0.021 | 0.015 | 0.047 | 0.073 | | | 0.002 | 0.002 | 0.001 | | |
| *Perccottus glenii* | | | | | | | | | 0.001 | | | |
| *Neogobius fluviatilis* | | | | | | | | 0.010 | 0.002 | 0.001 | | |
| *Proterorhinus semilunaris* | | | | | | 0.008 | 0.035 | 0.017 | 0.005 | 0.024 | 0.008 | 0.015 |

**Table 1 (continued) Structure of the fish communities of the Tisza sampling areas**

| Species name | Code of the sampling area | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TI-15 | TI-16 | TI-17 | TI-18 | TI-19 | TI-20 | TI-22 | TI-23 | TI-24 | TI-25 | TI-26 | TI-27 |
| *Eudontomyzon danfordi* | | | | | | | | | | | | |
| *Anguilla anguilla* | | | | | | | | | | | | |
| *Rhodeus amarus* | | | | 0.003 | 0.003 | | | 0.003 | | | | 0.004 |
| *Gobio carpathicus* | | | | | | | | | | | | |
| *Pseudorasbora parva* | | | | 0.008 | | 0.010 | 0.023 | 0.031 | | | 0.006 | 0.004 |
| *Romanogobio kessleri* | | | | | | | | | | | | |
| *Romanogobio uranoscopus* | | | | | | | | | | | | |
| *Romanogobio vladykovi* | | | | 0.011 | | | 0.020 | 0.003 | 0.011 | | | 0.001 |
| *Barbus barbus* | | 0.002 | | 0.016 | 0.054 | | | 0.003 | | | | |
| *Barbus carpathicus* | | | | | | | | | | | | |
| *Carassius gibelio* | 0.005 | 0.007 | 0.002 | 0.003 | | | | | | | | |
| *Cyprinus carpio* | | | | | | | | | | | | |
| *Abramis brama* | 0.005 | 0.009 | 0.003 | | 0.011 | | 0.003 | 0.003 | 0.003 | | | 0.001 |
| *Alburnoides bipunctatus* | | | | | | | | | | | | |
| *Alburnus alburnus* | 0.833 | 0.621 | 0.821 | 0.320 | 0.321 | 0.643 | 0.726 | 0.651 | 0.544 | 0.804 | 0.857 | 0.898 |
| *Aspius aspius* | 0.005 | 0.132 | 0.008 | 0.025 | 0.011 | 0.019 | 0.003 | 0.010 | 0.021 | 0.002 | 0.014 | 0.012 |
| *Ballerus ballerus* | | | | | | | | | | | | |
| *Ballerus sapa* | | | | 0.005 | 0.005 | | 0.003 | | | | | |
| *Blicca bjoerkna* | 0.001 | 0.020 | 0.001 | 0.014 | | | | | | | | |
| *Chondrostoma nasus* | | | | 0.005 | | | | | | | | |
| *Leuciscus idus* | 0.019 | 0.020 | 0.007 | 0.038 | 0.073 | 0.029 | 0.007 | 0.065 | 0.055 | 0.087 | 0.098 | 0.029 |
| *Leuciscus leuciscus* | | | | | | | | | | | | |
| *Rutilus rutilus* | 0.070 | 0.081 | 0.045 | 0.003 | | | 0.003 | 0.003 | 0.003 | 0.018 | | |
| *Rutilus virgo* | | | | | | | | | | | | |
| *Scardinius erythrophthalmus* | 0.019 | 0.059 | 0.072 | | | | | | | | | 0.001 |
| *Squalius cephalus* | | | | 0.008 | 0.016 | | | | 0.005 | | | |
| *Telestes souffia* | | | | | | | | | | | | |
| *Vimba vimba* | | | | | | | | | | | | |
| *Cobitis elongatoides* | 0.001 | 0.002 | | | | | | | | 0.002 | | 0.001 |
| *Misgurnus fossilis* | | | 0.001 | | | | | | | | | |
| *Sabanejewia bulgarica* | | | | | | | | | | | | |
| *Ameiurus melas* | 0.018 | 0.002 | 0.028 | 0.005 | | | | 0.003 | 0.018 | | | |
| *Silurus glanis* | | 0.002 | 0.001 | 0.011 | 0.016 | 0.005 | | | | | | 0.001 |
| *Esox lucius* | 0.007 | | 0.005 | 0.016 | 0.003 | 0.010 | 0.010 | | 0.003 | 0.006 | 0.004 | 0.001 |
| *Lota lota* | | | 0.002 | 0.257 | 0.296 | 0.200 | 0.104 | 0.079 | 0.145 | 0.050 | 0.006 | |
| *Cottus gobio* | | | | | | | | | | | | |
| *Lepomis gibbosus* | 0.001 | | | | | | | 0.003 | | | | 0.001 |
| *Gymnocephalus baloni* | | | | | 0.011 | 0.005 | 0.007 | | 0.013 | | | |
| *Gymnocephalus cernua* | | | | | | | | 0.003 | | | | |
| *Gymnocephalus schraetser* | | | | 0.005 | 0.003 | | | | | | | |
| *Perca fluviatilis* | 0.002 | 0.004 | 0.002 | 0.005 | 0.013 | 0.014 | 0.010 | 0.003 | 0.008 | 0.009 | | |
| *Sander lucioperca* | | | | | 0.003 | 0.005 | 0.013 | | | | | |
| *Zingel streber* | | | | | | | | | | | | |
| *Zingel zingel* | | | | | 0.032 | 0.005 | 0.003 | 0.003 | | | | |
| *Perccottus glenii* | | | | | | | | | | | | |
| *Neogobius fluviatilis* | | | | 0.131 | 0.113 | 0.048 | 0.054 | 0.116 | 0.156 | 0.015 | 0.004 | 0.010 |
| *Proterorhinus semilunaris* | 0.015 | 0.039 | 0.001 | 0.109 | 0.016 | 0.010 | 0.010 | 0.014 | 0.016 | 0.007 | 0.010 | 0.033 |



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**Table 2 Diversity indices of the fish communities of the individual sampling areas [S = species richness, $n_{max}/N$ = Berger-Parker dominance, $S/\sqrt{N}$ = Menchinick index, H = Shannon-Wiener index, expH = effective species number, $H_{max}/ln(S)$ = Pielou evenness, ES(m) = number of species in the rarefied sample (n = 210)]**

| Sampling area | S | $n_{max}/N$ | $S/\sqrt{N}$ | H | expH | $H_{max}/lnS$ | ES(m) |
|---|---|---|---|---|---|---|---|
| TI-01 | 19 | 0.3415 | 0.7680 | 1.99 | 7.3 | 0.68 | 15.0 |
| TI-03 | 22 | 0.8448 | 0.4838 | 0.78 | 2.2 | 0.25 | 11.2 |
| TI-04 | 15 | 0.8052 | 0.3971 | 0.83 | 2.3 | 0.31 | 8.7 |
| TI-05 | 14 | 0.7855 | 0.3889 | 0.91 | 2.5 | 0.35 | 9.0 |
| TI-06 | 15 | 0.6686 | 0.4636 | 1.26 | 3.5 | 0.46 | 10.3 |
| TI-07 | 17 | 0.9358 | 0.2787 | 0.36 | 1.4 | 0.13 | 6.6 |
| TI-08 | 15 | 0.7940 | 0.4255 | 0.91 | 2.5 | 0.34 | 10.0 |
| TI-09 | 21 | 0.8448 | 0.5120 | 0.79 | 2.2 | 0.26 | 11.9 |
| TI-10 | 15 | 0.9190 | 0.3998 | 0.45 | 1.6 | 0.17 | 8.3 |
| TI-11 | 14 | 0.9405 | 0.4981 | 0.34 | 1.4 | 0.13 | 7.1 |
| TI-12 | 11 | 0.9422 | 0.4033 | 0.33 | 1.4 | 0.14 | 6.8 |
| TI-13 | 14 | 0.9387 | 0.2908 | 0.35 | 1.4 | 0.13 | 7.0 |
| TI-15 | 14 | 0.8331 | 0.3892 | 0.76 | 2.1 | 0.29 | 9.5 |
| TI-16 | 14 | 0.6206 | 0.6556 | 1.37 | 3.9 | 0.52 | 11.3 |
| TI-17 | 15 | 0.8206 | 0.4816 | 0.78 | 2.2 | 0.29 | 8.9 |
| TI-18 | 21 | 0.3197 | 1.0980 | 2.00 | 7.4 | 0.66 | 18.6 |
| TI-19 | 18 | 0.3208 | 0.9345 | 1.93 | 6.9 | 0.67 | 15.9 |
| TI-20 | 13 | 0.6429 | 0.8971 | 1.22 | 3.4 | 0.48 | 13.0 |
| TI-22 | 16 | 0.7258 | 0.9253 | 1.15 | 3.2 | 0.41 | 14.3 |
| TI-23 | 17 | 0.6507 | 0.9948 | 1.32 | 3.7 | 0.46 | 14.2 |
| TI-24 | 14 | 0.5435 | 0.7191 | 1.50 | 4.5 | 0.57 | 12.3 |
| TI-25 | 10 | 0.8044 | 0.4295 | 0.80 | 2.2 | 0.35 | 8.3 |
| TI-26 | 8 | 0.8574 | 0.3585 | 0.57 | 1.8 | 0.28 | 6.9 |
| TI-27 | 14 | 0.8981 | 0.5196 | 0.52 | 1.7 | 0.20 | 8.2 |

Fig. 3 Clustering of the sampling areas according to environmental variables

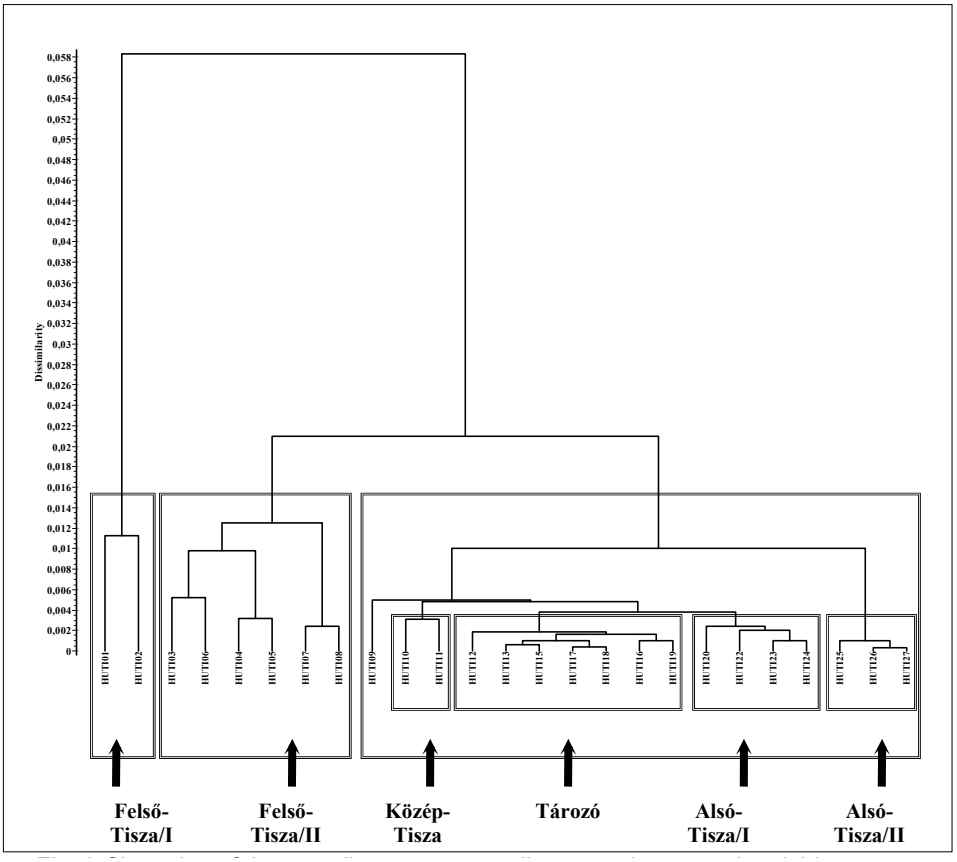


Fig. 4 Hierarchical dendrogram (node formation) of the Tisza sampling areas with the typology levels

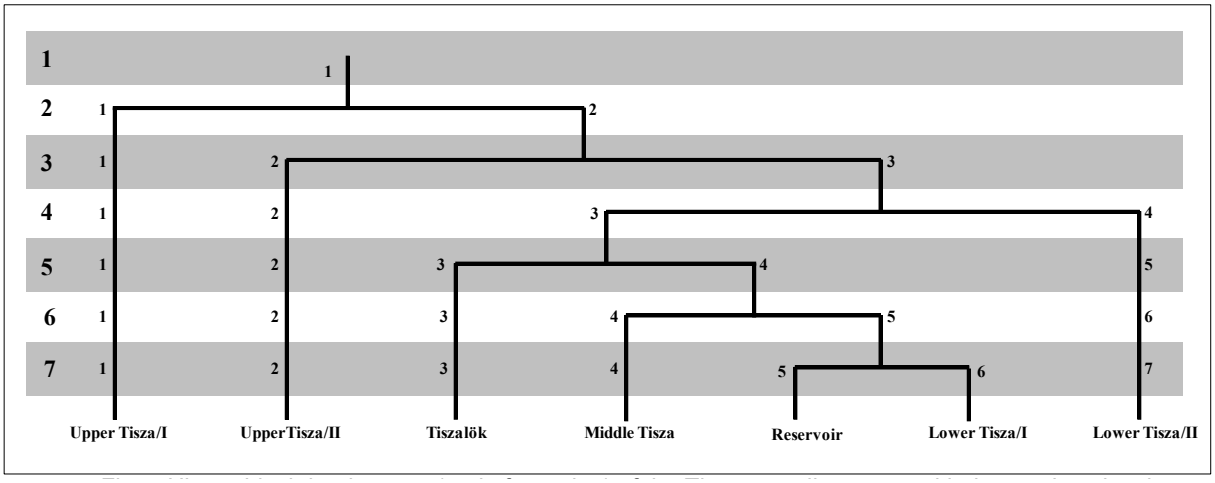




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**Table 3 Characteristic species of individual sampling areas on the basis of the 2009 sampling (✶ significant according to one test, ✶✶ significant according to two tests)**

| Species name | Typology | IndVal value | Rank | Significance |
|---|---|---|---|---|
| Leuciscus leuciscus | Upper Tisza/I | 100.00 | 94 | í í |
| Telestes souffia | | 100.00 | 94 | í í |
| Barbus carpathicus | | 100.00 | 94 | í í |
| Gobio carpathicus | | 100.00 | 94 | í í |
| Romanogobio uranoscopus | | 100.00 | 94 | í í |
| Romanogobio kessleri | | 100.00 | 94 | í í |
| Zingel streber | | 100.00 | 94 | í í |
| Cottus gobio | | 100.00 | 94 | í í |
| Sabanejewia bulgarica | | 96.94 | 19 | í í |
| Vimba vimba | | 66.67 | 155 | í |
| Cobitis elongatoides | | 62.87 | 114 | í |
| Squalius cephalus | | 59.27 | 40 | í í |
| Rutilus virgo | Upper Tisza/II | 66.67 | 104 | í |
| Siluris glanis | | 65.02 | 1 | í í |
| Ballerus ballerus | Tiszalök, downstream of the barrage | 100.00 | 75 | í í |
| Gymnocephalus schraetser | | 87.50 | 1 | í í |
| Lepomis gibbosus | | 76.54 | 66 | í í |
| Ameiurus melas | Reservoir | 65.31 | 164 | í |
| Leuciscus idus | Lower Tisza/II | 45.59 | 23 | í í |

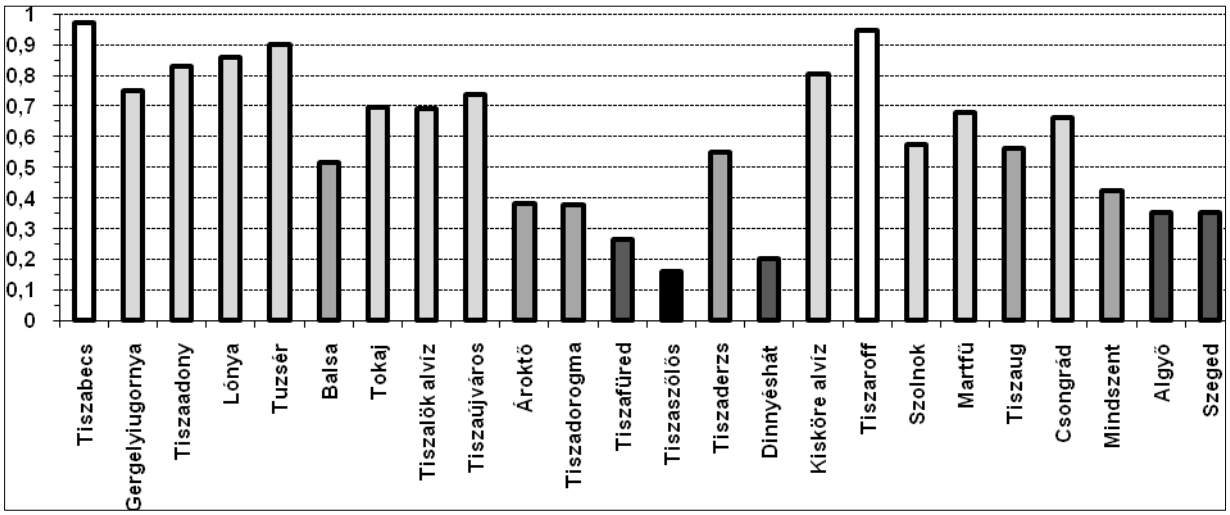


Fig. 5 Values of the new Európean Fish Index (EFI+) in the Hungarian reach of River Tisza (ecological quality: □high, ▒ good, ▒ moderate, ▒ poor, ▒ bad)