FISH ASSOCIATIONS - HABITATS QUALITY RELATION IN THE TÂRNAVE RIVERS (TRANSYLVANIA, ROMANIA) ECOLOGICAL ASSESSMENT

Doru BĂNĂDUC *

* Natural History Museum, 1 Cetății Street, Sibiu, Sibiu County, Romania, RO - 550160, banaduc@yahoo.com

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ABSTRACT

This paper summarize a three years (2001 - 2003; July - September) fish survey and put in relation these results to natural and human factors that affect these lotic systems ichthyofauna.

The presence and structure of fish assemblages were related to human influences (urban, industrial, hydro technical and land-use activities) to provide a picture of the fish fauna habitats quality across the Târnava rivers watershed.

Mapping out the ichthyologic component as an element of the river continuum allow assertions concerning fish assemblages structure variation along the last few decades and cause - effect relations identification as an important informational element in the construction of a needed integrated management plan for the whole Târnava rivers lotic systems.

ZUSSAMMENFASUNG: Fisch Assoziationen in Relation zur Habitatqualität im Fluss Târnava (Transsilvanien, Rumänien), eine ökologische Einschätzung.

Diese Arbeit fasst die Resultate von drei Jahren (2001 - 2003; Juli - September) Fisch Beobachtungen zusammen und stellt die Ergebnisse in Relation zu natürlichen und menschlichen Faktoren dar, die diese Fischfauna des lotischen Systems beeinflussen.

Die Präsenz und Struktur der Fisch-Assoziationen wurden auf menschliche Einflüsse bezogen (urbane, industrielle, wassertechnische und Flächennutzungen), um ein Bild über die Lebensraumqualität für Fische entlang der Wasserscheide des Flusses Târnava zu erhalten.

Die Zusammensetzung der Fischarten als ein Element des Flusses wurden erarbeitet, um eine Aussage über die Schwankungen der Fischassoziationen während der letzten Jahrzehnte treffen zu können. Dabei wurden die Wirkungsbeziehungen identifiziert als ein wichtiges informatorisches Element in der Aufstellung eines benötigten integrierten Managementplans für das gesamte lotische Târnava-Fluss-Systems.

REZUMAT: Relația asociații de pești - calitatea habitatelor, în evaluarea ecologică a râurilor Târnave.

Lucrarea sintetizează rezultatele unui sudiu de trei ani (2001 - 2003; iulie - septembrie) şi le relaționează cu factorii naturali şi antropici care afectează ihtiofauna acestor sisteme lotice.

Prezența şi structura asociațiilor de pești au fost analizate în raport cu influențele antropice (urbane, industriale, hidrotehnice, utilizarea terenurilor) pentru a oferi imaginea calității habitatelor ihtiofaunei Târnavelor. Urmărirea componentei ihtiologice ca element al continuumului lotic a permis reliefarea unor concluzii referitoare la variația structurii asociațiilor de pești în ultimii zeci de ani şi identificarea relațiilor cauză - efect, ca element informațional important în construcția unui necesar plan de management integrat pentru bazinul Târnavelor.

INTRODUCTION

Târnava River Watershed (Fig. 1) is placed in the inner part of the Romanian Carpathians arch, drain the Transylvania Depression, respective its southern division the Târnavelor Plateau, and vary substantial in climate, geology, relief and hydrology.

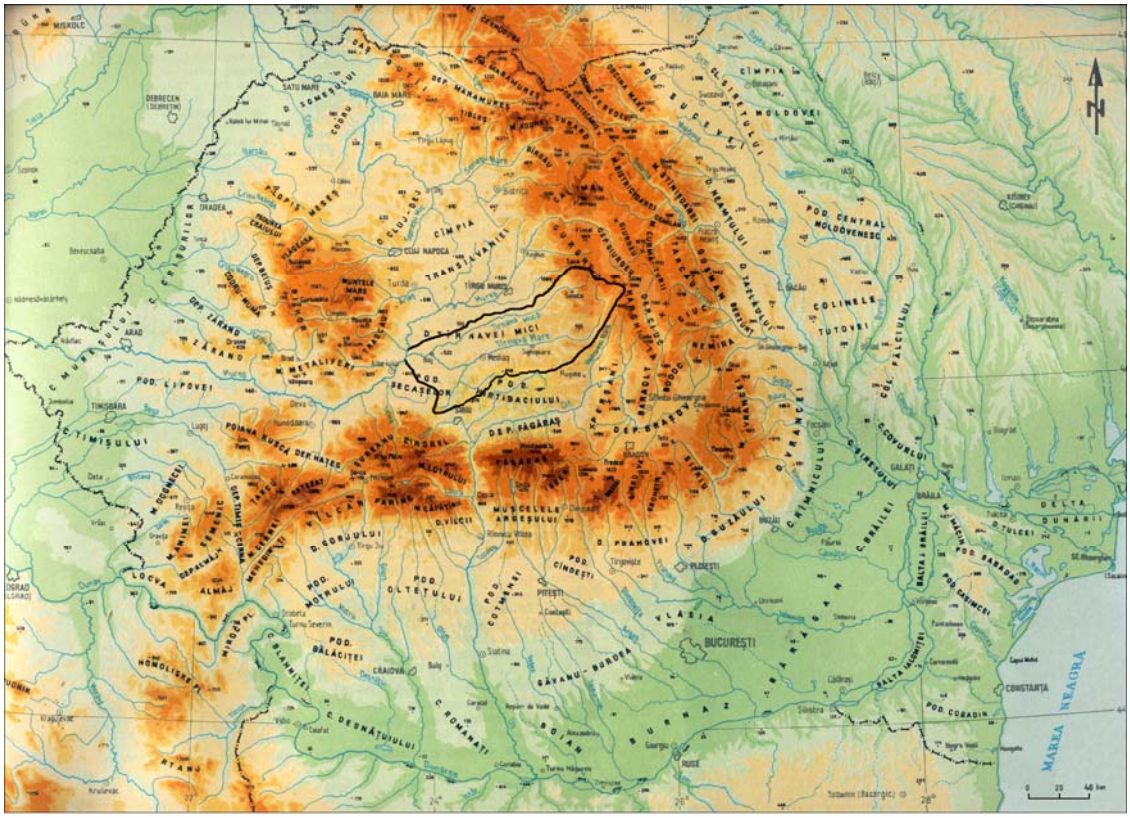

Fig. 1: The Târnava River Watershed study unit location (Badea et al., 1983 - modified).

With a watershed surface of 6157 km^2, a length of 249 km and a dropping elevation of about 1250 m, Târnava River is one of the main tributary of the Mureş River, representing 21% of its watershed. It is properly formed at the confluence of Târnava Mare River (3606 km^2 watershed surface, 221 km length) and Târnava Mică River (2049 km^2 watershed surface, 191 km length) near Blaj locality. The first one springs on the western slopes of the volcanic mountain mass Harghita Şumuleului at 1441 m altitude and the second one on the southern slope of the volcanic mountain mass Saca (1777 m) at 1190 m altitude.

This depression area geological sinking and its unequal tectonic compartmentalization, lythologic diversity (pebbles, sands, sandy clay and less marns and tufs) of sedimentary deposits, as well as their thickness and tectonization, determined two main characteristics of these two rivers, their valleys parallelism and their northeast to southwest general orientation, likewise with of their neighbouring rivers: Mureş, Hârtibaciu and Olt, characteristics with an important potential primary impact on the studied lotic ecosystems zonation.

This study unit is divided unequally into two main physiographic areas: the smaller mountainous part in the eastern, high-elevation part (between Târnava River springs and Praid/Brădeşti locality) and the larger one, the Târnavelor Plateau in the central and western, lower-elevation part (between Praid/Brădeşti locality and the confluence with Mureş River).

The precipitations conditions and the subterranean water sources, provide a relatively constant multi annual average water flow (Târnava Mare 14.7 m^3/s, Târnava Mică 9.8 m^3/s). Târnava River, flow into the Mureş River near Mihalţ locality, with a multi annual average water discharge of about 25 m^3/s. The multi annual average alluvial suspensions discharge is about 20 kg/s, the most of them coming from the upper part of the basin. The river slope is generally reduced and the major riverbed is developed, reaching few kilometers in the periods of maximum floods (for example the flood of 1970). Both rivers are more of meandering streams particularly where winds across Târnava Plateau, excepting the anthropogenic modified sectors. (Tufescu, 1966; Roşu, 1980; Badea et al. 1983; Posea et al. 1982; Curtean - Bănăduc et al. 2001).

Stream habitats vary from cool, clear, and forested headwater streams that have coarse volcanic bedrock with high slope gradients in the mountainous physiographic area, to intermediate coarse substrates in the Sub-Carpathian area, to warmer, sluggish, meandered, and less/not forested streams banks with low slope gradients and sandy-silty substrates in Târnavelor Plateau.

Both watersheds are dominated by very similar land uses, forestry/small rural localities characteristics in the mountainous areas and agriculture/industry/medium sized localities (of maximum 65000 inhabitants) characteristics in over three third of the watersheds (lower) areas.

In the upper sectors of Târnava Mare River the natural hydrological conditions are affected by Zetea Dam Lake management and by hydro technical works (cut of meanders, marshes and floodplain drainages, river banks reshaping and embanking - the last ones realised in 1970 period), and extensive deforestation, intensive agriculture and the riverain (industrial and urban) wastewater discharges affected the natural hydrological conditions in the lower sectors.

Although the fish associations may have a high degree of natural variability, they can be useful indicators of the aquatic ecosystems status/health (Karr, 1981; Moyle and Herbold, 1987; Kleynhans, 1999; Bănăduc and Curtean - Bănăduc, 2002). Also, is recommended fish be given consideration in biological water-quality surveys of streams because they generally are discerned by the public to be ecologically relevant, and they are in direct relation to legislative mandates because of human health and endangered species concerns.

These rivers dimensions, natural and economic importance, aggressive types of human impact and also the scarcity of previous studies, justify an ichthyologic survey in the area.

The main purpose of this study is to provide baseline data on fish species occurrences and abundances for these three major streams that drain an important surface in the middle of Romania, based on the results of the three months (July - September, 2003) fish survey data.

With their almost parallel courses in similar relief units and with many physico-chemical and hydrological similarities, these two rivers offer an important opportunity for a comparative study concerning the cause-effect interrelations among fish associations and their environment.

The Târnava Mare, Târnava Mică and Târnava rivers ecological status are assessed in terms of the following analysis elements: the fish association's structure in terms of relative abundances, indicators species in terms of their life stages and ecological preferences, the dominance of some species on particularly habitat types, and species distribution in space and time where historical data were available. Based on these items, the rivers general quality conditions were identified, and also the areas of concern or deficiency were flagged.

All the biotic information, were related to water and habitat quality and human activities, to provide a picture of the lotic system quality across the whole river, and used for the mapping of the ichthyologic elements of the river which allow assertions concerning fish assemblages structure and cause - effect relations identification as a part of a needed integrated management plan for the whole Târnava rivers watershed.

MATERIAL AND METHODS

The presented fish assemblages survey, through time (one hour) on effort unit quantitative and qualitative samplings were made with a hand - net, in a total of 23 sites in July - September 2003, in Târnava Mică, Târnava Mare and Târnava rivers (Fig. 2; Tab. 1).

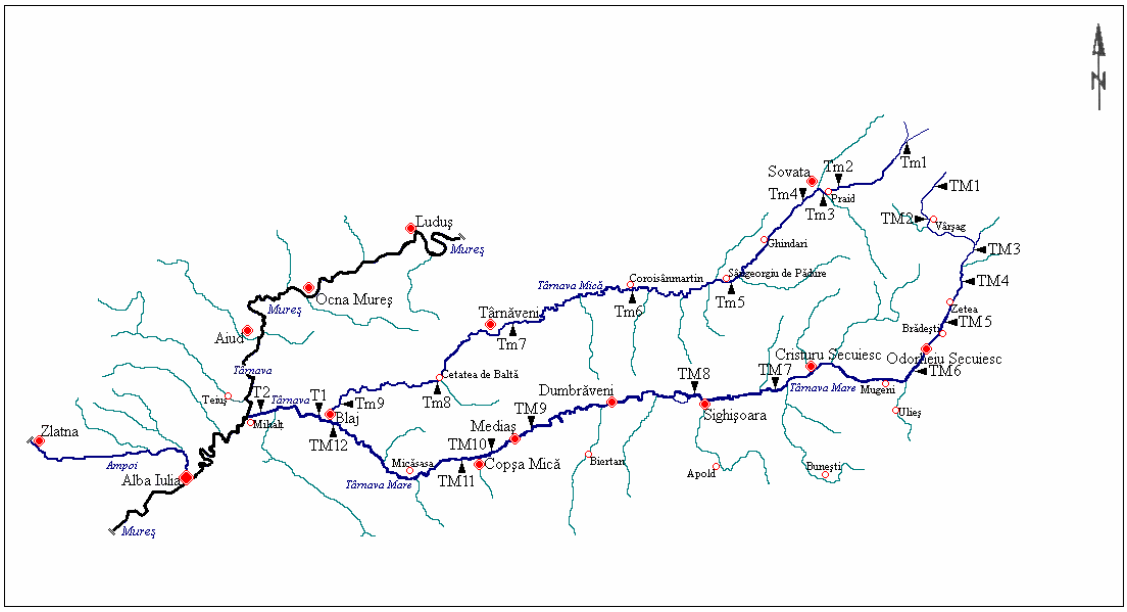

Fig. 2: the quantitative sampling stations on Târnava Mare River (◄ TM), Târnava Mică River (◄ Tm) and Târnava River (◄ T).

The studied sampling stations were chosen according to: the valley morphology, the type of rivers substratum, the confluence with the main tributaries, and to the human impact presence bias (land use, hydro technical works, urban and industrial pollution sources). Only two sites (Tm_1 and Tm_2) represent background conditions and generally are unaffected by human activities.

The fish were identified, counted and partially released back to the stream and partially fixed in a 4% formaldehyde solution, than preserved in alcohol 70% and included in the collections of the Natural History Museum of Sibiu, of the Aquatic Biology Laboratory within the Department of Ecology and Environmental Protection of "Lucian Blaga" University of Sibiu, and of Mr. Dr. Petru M. Bănărescu personal collection.

The studied biological material (in quantitative samples) is formed of the following species: *Eudontomyzon danfordi* (Regan, 1991); *Salmo fario* Linnaeus, 1758; *Cyprinus carpio* Linnaeus, 1758; *Carassius gibelio* (Bloch, 1783), *Barbus barbus* (Linnaeus, 1758), *Barbus petenyi* Heckel, 1852; *Rhodeus amarus* (Bloch, 1782), *Gobio gobio* (Linnaeus, 1758); *Gobio kessleri* (Dybowsky, 1862); *Gobio vladykovi* (Fang, 1943); *Pseudorasbora parva* (Schlegel, 1842); *Squalius cephalus* (Linnaeus, 1758); *Phoxinus phoxinus* (Linnaeus, 1758); *Scardinius erythrophthalmus* (Linnaeus, 1758); *Alburnoides bipunctatus* (Bloch, 1782); *Alburnus alburnus* (Linnaeus, 1758); *Chondrostoma nasus* (Linnaeus, 1758); *Orthrias barbatulus* (Linnaeus, 1758); *Sabanejewia balcanica* (Karaman, 1922); *Perca fluviatilis* Linnaeus, 1758; *Lepomis gibbosus* Linnaeus, 1758; and *Cottus gobio* Linnaeus, 1758 (Tab. 1). In the local fishermen captures (Tab. 1, *) the following species were identified: *Esox lucius* Linnaeus, 1758; *Aspius aspius* (Linnaeus, 1758); *Silurus glanis* Linnaeus, 1758.

RESULTS AND DISCUSSIONS

In the 1120 sampled individuals 25 species belonging to 22 genera and 10 families were identified.

Table 1: The relative abundance (A%) of the sampled (in time/effort unit) fish species in Târnava Mică River (Tm), Târnava Mare River (TM) and Târnava River (T); * - species identified in the local fishermen captures.

Sampling station	Species	Specimens	A%
Tm_1 (confluence with Craca Mică)	*Salmo fario*	3	100
Tm_2 (1 km upstream Praid)	*Salmo fario*	9	100
Tm_3 (1 km downstream Praid)	*Barbus petenyi*	11	10.28
	Gobio gobio	5	4.67
	Squalius cephalus	5	4,67
	Alburnoides bipunctatus	55	51.43
	Chondrostoma nasus	2	1.86
	Orthrias barbatulus	26	24.29
	Sabanejewia balcanica	3	2.80
Tm_4 (1 km downstream Sovata)	*Barbus petenyi*	8	7.76
	Gobio gobio	4	3.88
	Squalius cephalus	1	0.97
	Alburnoides bipunctatus	57	55.36
	Orthrias barbatulus	24	23.30
	Sabanejewia balcanica	9	8.73
Tm_5 (1 km upstream Sângiorgiu de Pădure)	*Barbus barbus*	1	3.44
	Barbus petenyi	4	13.79
	Rhodeus amarus	6	20.68
	Gobio gobio	6	20.68
	Squalius cephalus	6	20.68
	Orthrias barbatulus	1	3.44
	Sabanejewia balcanica	5	17.29
Tm_6 (1 km upstream Coroisânmartin)	*Barbus petenyi*	4	13.79
	Gobio kessleri	14	48.29
	Alburnoides bipunctatus	10	34.48
	Orthrias barbatulus	1	3.44
Tm_7 (1 km upstream Târnăveni)	*Carassius gibelio*	1	9.09
	Barbus barbus	1	9.09
	Barbus petenyi	1	9.09
	Gobio kessleri	5	45.46
	Squalius cephalus	2	18.18
	Scardinius erythrophthalmus	1	9.09
Tm_8 (Cetatea de Baltă)	*Barbus barbus*	1	8.33
	Barbus petenyi	1	8.33
	Gobio kessleri	5	41.69
	Squalius cephalus	2	16.66
	Scardinius erythrophthalmus	1	8.33
	Silurus glanis	*	-
	Perca fluviatilis	1	8.33
	Lepomis gibbosus	1	8.33

Sampling station	Species	Specimens	A%
Tm_9 (1 km upstream Blaj)	*Barbus barbus*	1	11.11
	Barbus petenyi	1	11.11
	Gobio kessleri	4	44.45
	Squalius cephalus	2	22.22
	Perca fluviatilis	1	11.11
TM_1 (5 km upstream Vârşag)	*Salmo fario*	5	62.50
	Squalius cephalus	3	37.50
TM_2 (500 m upstream Vârşag)	*Gobio gobio*	1	4.34
	Squalius cephalus	7	30.46
	Phoxinus phoxinus	4	17.39
	Orthrias barbatulus	1	4.34
	Cottus gobio	10	43.47
TM_3 (1 km upstream Zetea Lake)	*Salmo fario*	1	4.76
	Barbus petenyi	1	4.76
	Gobio gobio	1	4.76
	Squalius cephalus	14	66.68
	Phoxinus phoxinus	2	9.52
	Cottus gobio	2	9.52
TM_4 (1 km downstream Zetea Dam)	*Eudontomyzon danfordi*	2	3.50
	Barbus barbus	4	7.01
	Barbus petenyi	16	28.07
	Gobio gobio	6	10.52
	Squalius cephalus	25	43.90
	Alburnoides bipunctatus	2	3.50
	Chondrostoma nasus	1	1.75
	Sabanejewia balcanica	1	1.75
TM_5 (between Zetea and Odorhei)	*Salmo fario*	1	1.56
	Squalius cephalus	1	1.56
	Phoxinus phoxinus	27	42.20
	Alburnoides bipunctatus	16	25.00
	Chondrostoma nasus	1	1.56
	Orthrias barbatulus	9	14.06
	Cottus gobio	9	14.06
TM_6 (downstream Odorhei)	*Barbus petenyi*	10	15.87
	Gobio gobio	38	60.34
	Squalius cephalus	3	4.76
	Alburnoides bipunctatus	3	4.76
	Chondrostoma nasus	5	7.93
	Sabanejewia balcanica	4	6.34
TM_7 (Vânători)	*Barbus barbus*	2	1.50
	Barbus petenyi	16	12.12
	Rhodeus amarus	1	0.75
	Gobio gobio	49	37.18
	Squalius cephalus	25	18.93
	Alburnoides bipunctatus	14	10.60
	Chondrostoma nasus	19	14.39
	Orthrias barbatulus	2	1.50

Sampling station	Species	Specimens	A%
TM_8 (downstream Sighişoara)	*Barbus petenyi*	16	41.05
	Gobio gobio	3	7.69
	Gobio kessleri	1	2.56
	Squalius cephalus	3	7.69
	Alburnoides bipunctatus	14	35.89
	Chondrostoma nasus	1	2.56
	Sabanejewia balcanica	1	2.56
TM_9 (2 km upstream Mediaş)	*Barbus barbus*	1	2.77
	Barbus peteny	5	13.88
	Gobio gobio	1	2.77
	Gobio kessleri	4	11.11
	Squalius cephalus	2	5.55
	Alburnoides bipunctatus	21	58.37
	Sabanejewia balcanica	2	5.55
TM_{10} (1 km downstream Mediaş)	*Barbus petenyi*	5	62.50
	Gobio gobio	1	12.50
	Squalius cephalus	2	25.00
TM_{11} (2 km downstream Copşa Mică)	*Barbus petenyi*	2	100
TM_{12} (1 km upstream Blaj)	*Barbus petenyi*	7	10.14
	Gobio gobio	5	7.24
	Gobio kessleri	2	2.89
	Squalius cephalus	5	7.24
	Alburnoides bipunctatus	20	28.98
	Sabanejewia balcanica	30	43.51
T_1 downstream Blaj	*Barbus barbus*	20	28.61
	Rhodeus amarus	4	5.71
	Gobio gobio	8	11.42
	Gobio kessleri	7	10.00
	Squalius cephalus	11	15.71
	Scardinius erythrophthalmus	4	5.71
	Alburnus alburnus	3	4.28
	Sabanejewia balcanica	12	17.14
	Perca fluviatilis	1	1.42
T_2 in the Mihalţ proximity	*Esox lucius*	*	-
	Cyprinus carpio	4	1.85
	Carassius gibelio	12	5.55
	Barbus barbus	43	19.90
	Gobio gobio	24	11.11
	Gobio kessleri	26	12.03
	Gobio vladykovi	9	4.16
	Pseudorasbora parva	8	3.70
	Squalius cephalus	27	13.00
	Scardinius erythrophthalmus	6	2.77
	Alburnus alburnus	11	5.09
	Aspius aspius	*	-
	Sabanejewia balcanica	32	14.81
	Silurus glanis	*	-
	Lepomis gibosus	14	6.48

Târnava Mică River ichthyofauna

The presence in Târnava Mică River case, on the top length of flow in the **Tm_1 - Tm_2** river sector of only typically intolerant native coldwater species *Salmo fario*, clearly emphasize the existence of the upper sector of the trout zone. This fact, point out some biotope characteristics: the river pass through an uneven relief with rapids and stony riverbed, healthy riparian zone with good pool and riffle presence, water with a high concentration of the dissolved oxygen, low and relatively invariable water temperature, high and very high main current velocity.

Salmonid species are in general considered as being associated with high quality rivers habitat. The *Salmo fario* species individuals high number reveal the presence of a river sector with an excellent ecological status, with no or insignificant environmental stress, characterized by a high biotic integrity, and in fact the single undisturbed lotic sector of the studied rivers, comparable with pristine conditions. The permanent human settlements missing, and the present of very rare semi-permanent or seasonal houses, favour this unique situation in Târnava Watershed.

The overlapping of Praid locality influence on the river habitats quality and of important relief modifications effects, river passing from one type of relief from Tm_1 - Tm_2 sector (with mountainous characteristics) to **Tm_3 - Tm_4** river sector (with pre-mountainous characteristics), produce a sudden major fish associations composition changing. In a distance of only 2 km long river sector, the single upstream species *Salmo fario* is no more present, being replaced by seven other species. Supplementary reasons for the *Salmo fario* extirpation may be also the human fishing pressure on this species in the proximity of the locality and the increased anthropogenic pooled areas along the river sector, which provides habitat conditions favourable to downstream characteristic species.

The *Alburnoides bipunctatus*, *Orthrias barbatulus* and *Barbus petenyi* dominance in this sector, show the Balkan barbel zone presence mixed with a not very well defined (in comparison with the different situation on Târnava Mare River) nase zone (only two *Chondrostoma nasus* individuals were found in the local samples).

This major changing in ichtiofauna's structure sharply highlighting the replacement of a sector, with no or low environmental stress, characterized by a high biotic integrity, with an anthropogenic affected sector with a lower biotic integrity.

Throughout the sampled species and their proportions in the local fish associations, the Barbel zone can be accepted as starting in **Tm_5 - Tm_6** river sector and continuing downstream the river. In this river sector the stream has experienced moderate environmental degradation, and biotic integrity has been significantly reduced.

In **Tm_7 - Tm_8 - Tm_9** sector the appearance of deep river zones with sandy and muddy substrate offer proper conditions, and explain the presence too of some species characteristic for lower ichthyologic river zones: *Carassius gibelio, Scardinius erythrophthalmus, Silurus glanis, Perca fluviatilis* and *Lepomis gibbosus*.

In this river sector the species richness is not high, the biotic integrity is moderate to reduced, a situation which show the fact that this last river sector has experienced also moderate environmental degradation.

Târnava Mare River ichthyofauna

Theoretically, the only presence of the native intolerant species *Salmo fario* is considered a normal situation in $\mathbf{TM_1}$ river sector natural habitats, revealing the trout zone presence and an undisturbed and high quality habitat. The actually dominance of *Salmo fario* in the condition of *Squalius cephalus* presence too in TM_1 river sector, reveal the existence of an environmental stress in this river area.

Although, *Squalius cephalus* exceptionally appear in the trout zone too (Bănărescu, 1964), the presence of this species in this sector is considered based on historical data as abnormal. *Squalius cephalus* as pointed out 50 years ago (Bănărescu, 1964), was present only starting with the upstream Odorhei locality sector till the Mureş River, actually is present closer to the springs area due to the construction of some small concrete hydro technical works in the river bed and of an important Dam Lake formation at Zetea. The small hydro technical works in the riverbed offer shelter areas in this "unfriendly natural habitat" for *Squalius cephalus* and Zetea Dam Lake situated in a relative proximity induce an important biotic influence, as a permanent "nursery" especially for this species.

In the condition of a spatial very limited modified habitat, *Squalius cephalus* act for longer than initially estimated sectors like an indirect introduced species, revealing the break-up of the initial, natural optimum structured fish assemblage.

The local natural ichthyofauna structure modification as an indirect introduced species invading results is clearly determined by the anthropogenic biotope modifications. These indirect introduced species compete with or prey upon native species or can represent a possible source of diseases and parasites. Establishment of non-native fish species is an indicator of the local reduced biotic integrity. Normally, the streams with habitat conditions that are similar to historic conditions will favour native species over non-native ones (Williams and Hohler, 2000).

As the trout distribution shrinks (see below) this area that continues to support trout populations becomes increasingly vital to their survival. Given that *Salmo fario* distribution in Târnava Mare is considered below 25% of its previous natural area, protecting this small zone where trout still reproduce and continue to support juveniles is critical to this species in the basin.

In $\mathbf{TM_2}$ sampling station area, the *Cottus gobio* dominance, reveal the lower sector of the trout zone existence. The drastically lower trout abundance than might be expected is mainly related with *Cottus gobio* (better adapted for the local habitat) and *Squalius cephalus* (indirect introduced species) species competition. If the presence of *Phoxinus phoxinus* and *Orthrias barbatulus* is natural in the local habitat context, *Gobio gobio* belong here to the same category of indirect introduced species, its presence being justified too by the same anthropogenic habitat modifications.

As the local river sector is seemingly modified and degraded, trout populations are pushed toward the headwaters of the stream.

The proximity of the Zetea Lake in $\mathbf{TM_3}$ sector, respectively the increasing of this lake influence as "nursery" for permanent new generations of mainly *Squalius cephalus*, followed by *Gobio gobio* and for the first time *Barbus petenyi*, keep at a very low abundance *Salmo fario* and determine an accentuated decreasing in *Cottus gobio* individuals abundance.

From the fish associations' analysis perspective, the trout lower sector was replaced by an "unnatural" fish association, situation favoured by the downstream and upstream anthropogenic circumstances.

It must be also noted the fact that downstream migration is more or less possible, beyond the dam.

The most important impact of the dam and the lake upon river fish fauna, is present immediately downstream the dam at **TM_4**. In natural conditions (initial the dam construction), a passing area from the lower sector of the trout zone to the Balkan barbel zone it should to be found. Surprisingly and evidence for environmental degradation, reduction in biotic integrity and lotic continuum fragmentation, here *Salmo fario* and *Cottus gobio* are absent, also both of them reappear, the last species in high number, in the following downstream sector. The local fishermen offer information concerning the local presence of *Thymallus thymallus*, but it wasn't catch any individual in the samplings. Resident *Eudontomyzon danfordy* individuals have been found in a stretch of the mainstream. While this last species is not abundant and is localized only here, it is considered as a possible unique such a presence in these studied rivers.

The local ichthyofauna presents a high level of unnatural association, which reflect a superposition of the Balkan barbel zone, nase zone and Barbel zone. Also unnatural is the *Squalius cephalus* dominance due to this species input from the lake and of *Barbus petenyi* in the condition of its disappearance in the immediately downstream sector. A too upstream appearance is considered that of *Sabanejewia balcanica* which also disappear in the following downstream sector, and of *Barbus barbus*, in the conditions of its reappearance only downstream at TM_7.

There were high populations of *Squalius cephalus* and *Barbus petenyi* (which are more tolerant of high water temperatures), but no adult or juvenile salmonids were found.

The dam and the lake act like an in-stream anthropogenic barrier, which inhibit upstream migration and limit the distribution of the local natural fish fauna (including the valuable salmonids) through diminishing the specific spawning and rearing habitat. The upstream migration is disconnected, migratory fish and specialized fish (*Salmo* and *Cottus*) are particularly affected. As a consequence some unspecialised ones even might increase in numbers.

It can be considered that the salmonids are confined to smaller areas than the natural potential by a combination of factors including: low summer and fall flows, summer high water temperatures, lack of in-stream natural habitat structure, low frequency of natural pools, low pools depth, lack of adequate spawning substrate culverts, unnatural sediment transportation and loading, lack of habitat complexity, low levels of hiding cover and a lack of refuge habitat.

The present survey and analysis results suggest that there are two critical areas or "hot spots" for salmonids in Târnava Mare River. These include both TM_4 and TM_3 sectors. If in the TM_4 sector is less probable that the Zetea Dam officials to change its management system in one more permissive for other unconventional natural resources, in TM_3 the negative impact of the lake as "nursery" for lower valuable fish species, which replace the valuable salmonids, can be done with low investments in some barriers construction. The upstream lake areas all have confirmed salmonids populations and offer good potential for habitat restoration and species recovery. At least TM_3 - TM_1 sector should receive special attention in terms of restoration, protection and monitoring. If trout cannot be retained in these sectors, then they cannot continue to exist with an economically profit in this river watershed. The Zetea dam and lake may be temporarily (upstream to downstream) and permanently (downstream to upstream) block fish migration.

A first sector with significant lower influence, of the dam and lake upon the ichthyofauna appear in **TM_5**. After the TM_3 - TM_4 sector where the lower trout zone has important structural modifications, so far as to its disappearing, TM_5 area appears again like a quite marginal habitat of this trout zone, through the dominance of *Phoxinus phoxinus*, *Alburnoides bipunctatus*, *Cottus gobio* and *Orthrias barbatulus* species. Also, resident *Salmo fario* is present again and *Squalius cephalus* and *Barbus petenyi* has a drastic decrease in abundance. This overlapping of species still pointed out a small remaining portion of a natural ichthyologic transition zone, which is naturally located along the division area of the two physiographic provinces.

After an anthropogenic induced spatial diminishing of the lower sector of the trout zone and the unnatural appearance of some species characteristic for much downstream sectors, in **TM_6 - TM_7** sector can be observed a clear nase zone, unlikely the general regress of *Chondrostoma nasus* was reported in the last few decades in many Romanian rivers, here it has important and well structured populations. The obviously dominance, in this sector, of the organic pollution resistant *Gobio gobio* individuals, show an important input of such sewage water in the Odorhei locality area.

The decreasing in fish species number in **TM_8** sector case, indicate the worsen water aquatic life condition in the industrialized part of Târnava Mare Watershed also with high density of settlements, here the negative influences coming from Sighişoara. From the fish zonation point of view the Balkan barbel zone is present. This stream reach has experienced moderate environmental degradation, and the biotic integrity can be considered as significantly reduced.

The present species, the decreasing trend in species number and fish individuals continue in **TM_9 - TM_{10}**, and become more accentuated in **TM_{11}** river sector due to the Mediaş and especially to the Copşa Mică industrial localities. If in the similar sectors of Târnava Mică River (**Tm_7 - Tm_9**) the appearance of deep river zones with sandy and muddy substrate offer conditions, and explain the presence of some species characteristic for lower ichthyologic river zones, here the worse water quality and life condition create a barrier for the downstream characteristic species to move upstream, only the upstream characteristic species coming notably down the river especially in floods periods. It is obvious that major environmental degradation has occurred, and the biotic integrity has been severely reduced.

The most accentuated anthropogenic pressure downstream Copşa Mică is very well defined by the only two individuals of *Barbus barbus* omnivorous and tolerant species presence in samplings. Two more sampling campaigns were made in 2001 and 2002 and no fish was sampled here, a fact which can sustain the hypothesis that here the fish can be only accidentally.

The *Alburnoides bipunctatus*, *Barbus petenyi* and *Gobio kessleri* species numerical dominance show in TM_9 sampling station, the beginning of the Barbel zone.

In this river case too, in the context of the Romanian rivers (Bănărescu, 1960) *Barbus barbus* was replaced by *Barbus peteny*.

Târnava River ichthyofauna

Târnava River ichthyofauna is not only the result of its different habitats in comparison with Târnava Mare and Târnava Mică rivers but also of its short length and as a consequence of the important fish diversity inputs of these two rivers and mainly of the Mureş River, which is few times bigger than Târnava River and is in a good ecological condition at their confluence (Bănăduc, unpublished data), consisting a "fish diversity reservoir".

In Târnava River the existence of large and deep river zones with sandy and muddy substrate offer proper conditions, and explain the presence of some species characteristic for lower ichthyologic river zones, species which frequently came upstream from the confluence with Mureş River: *Esox lucius, Cyprinus carpio, Carassius gibelio, Scardinius erythrophthalmus, Aspius aspius, Silurus glanis, Perca fluviatilis, Lepomis gibbosus*. Here the *Silurus glanis* individuals over 20 - 30 kg were often seen in the local fishermen captures.

The Târnava River well balanced fish association structure in quantitative and qualitative aspects reveal a good ecological status of this river, as a consequence of the fact that the better qualitative water of Târnava Mică River ameliorate the bad water of Târnava Mare River in its lowest sections, and also as a result of the missing of major pollution sources on the 24 km length of Târnava Mare River.

One important aspect of these streams habitats is the substrate type. The relative abundances of coarse (boulder/cobble/ gravel) and fine (sand/silt/clay) bed materials significantly vary at sites in the two physiographic areas. Insectivore species are more abundant in streams sectors with cobble, gravel, and boulder substrates because these substrates provide space for invertebrates and, thus, provide food for fish. Most of the cold-water species need gravel and cobble to shelter their eggs during reproduction. As streams leave the headwater regions of the mountainous area, where substrates consist mostly of coarse material, the substrate changes and includes finer materials mixed with some coarse materials. These finer materials account for most of the substrate in streams of the Târnava Plateau area. Sand, silt and clay are a natural part of the stream bottom, having been deposited mainly as a result of erosion and runoff from fields and stream bank material.

In general for these three rivers, insectivore species are commonly present in the swift, clear, cold-water streams with boulder/cobble/gravel substrates, a high variable substrates, a high amount of shade and relatively complex habitats in the mountainous area, omnivore, herbivore and piscivore species are commonly present in slow, turbid, warm-water sectors with sand/silt substrates in the plateau areas.

The common presence of the top carnivorous species *Esox lucius* and *Aspius aspius* especially at the confluence with the Mureş River indicate a high local biotic integrity status and also pointed out once again the positive influence of Târnava River upon Mureş River.

CONCLUSIONS

Due to its dimensions, biotope variability and diverse human impact, Târnava rivers are characterized by a diverse fish assemblages along their courses.

The Târnava rivers ichthyofauna through its structural composition, as a respond at the natural and anthropogenic habitats elements variation influence, is a reliable general indicator for this watershed ecological status.

The distribution patterns of fish assemblages and some species low abundances and the unnatural presence of some fish species in the studied fish association's structures represent the associated effect of stream habitat and water quality.

The two main characteristics of Târnava Mică and Târnava Mare rivers, their valleys parallelism and their northeast to southwest general orientation, have an important impact on the studied lotic ecosystems zonation. This situation can induce the opinions that the two parallel rivers must have similar/parallel fish associations strongly influenced by the local habitats as an only reflection of the local physiographic areas characteristics. The present study reveal the fact that the macro habitat conditions similarities are not so important as the microhabitat conditions differences are, importance which is increased by the presence of different degree and types of local human impact variation.

The studied rivers assessment point out the sectors with values of referential systems, the degraded sectors and their degree of degradation, the sectors with value for water selfcleaning proceses and also with value for biodiversity conservation. In spite of the existing hot spots, Târnava rivers lotic systems are stressed, but not ruined ecosystems due to the following arguments: fish still make use all sectors of these rivers, excepting the still questionable Zetea dam and lake proximity and Copşa Mică areas where native and non native too for the second case fish species find no more suitable habitat conditions; the hot spots for local fish fauna had well known deterministic causes; excellent and good river sectors are still existing which can spread the proper natural fish diversity all over the river; the upper Târnava Mare River and Târnava Mică River as well as Mureş River are "fish diversity reservoirs"; the river habitats types found in these watershed are relatively resilient and can be restored.

The following main problems related to the ichthyofauna structure variation/lotic systems ecological status were found:

- riparian areas have been either reduced or even completely eliminated by the agriculture development and bad agricultural practices, especialy in the plateaou area, with the effects of reducing stream shading and increasing the water temperatures;
- severe sedimentation problems result from erosion, chanel incisions, and stormwater runoff aggravated by a lack of riparian vegetation;
- constant inputs of non-point and point source pollutants at important levels;
- erosion and sedimentation problems result from a lack of riparian vegetation along large sections of stream corridors in both rivers and can lead to siltation of gravel beds critical to insectivorous species;
- unnatural hidrologic regime in some river sectors;
- the artificial stream barrier which influence the fish migrations;
- some sensitive native fish species are no longer or rarely found in some of the studied rivers sectors; habitat loss induced native fish species decline and the appearance of nonative fish species that are tolerant of degraded habitats;
- some unique for the basin fish poplations are restricted to limited areas and under a high risk of extirpation;
- as the distribution shrinks for some key fish species, each area that continues to support them becomes increasingly vital to their survival;
- the flood plains important at least for the cyprinids species have been drasticaly reduced;
- the habitat loss facilitate overcrowded conditions which may lead to outbreaks of diseases;
- overchanelisation; almost all the stream sectors were channelized and isolated from their natural floodplains.

Nevertheless the ichthyologic survey indicate that Târnava Mică River have better fish associations, habitats and ecological status than does Târnava Mare River, both in the mountainous and in plateaus areas, mainly due to the different human impact presence. Even in Târnava Mică River only two sites (Tm_1 and Tm_2) represent background conditions and generally are unaffected by human activities.

This situation, prioritise the efforts for the resident fish communities restoration, that could be carried out in sub-basin plans. Stopping the actual trend of diminishing water quantities on river course, river water meeting of national and international quality standards and increases in the amount of in stream cover, are the high priority recommendations for these rivers habitats enhancement and to stop the detrimental changes in the resident fish communities and loss of the ecological integrity.

Likewise, while there is insufficient water quality monitoring data to indicate the presence of specific chemicals, herbicides and pesticide, are likely to have impacts on water and habitat quality and aquatic biota, further complex studies are required

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