The Trichoptera larvae communities’ functional feeding structure analysis – indicator of the matter cycling processes in the lotic ecosystems. A Carpathian river basin case study.

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Abstract: - In the circumstances of a constant increasing of anthropogenic use of the lotic systems natural resources and services, this paperwork main goal is to underline the relevance of the functional feeding groups’ structure and biodiversity of macro invertebrate communities, quantifying the evaluation of the homeostasis degree and of the support capacity of rivers. This paper analyzed the functional feeding structure of the caddisfly larvae communities of the Târnava Basin (Romania). The functional feeding structure analysis of the Trichoptera communities of the Târnave rivers shows that in the sectors situated downstream the big rural and urban areas only collectors are present, while in the river sectors where the human impact is insignificant, in the upper courses of the rivers Târnava Mare and Târnava Mică, we found an equilibrated structure of the trophic functional groups – the proportion of grazers, shredders, predators and collectors varying between 15 to 30%.

The Trichoptera larvae communities’ functional feeding structure analysis can be successfully used as a reliable indicator of the lotic systems integrality.

Key-Words: - Trichoptera communities, functional feeding groups, Carpathian rivers, biodiversity.

1 Introduction
The benthic macro invertebrates have a major role in nutrient cycling processes, especially in taking over the alochtonous organic matter and its introduction in the lotic ecosystems trophic chains [1, 2, 3, 4, 5, 6, 7]. The populations of these macro invertebrates form communities with adequate structure for the environmental conditions and for the available trophic resources use [8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21].

Thus, the analysis of the benthic macro invertebrate communities from the trophic functional perspective can be useful for the evaluation of the nutrient cycling capacity, an important component of the natural self regulation and self-cleaning processes of rivers.

In addition, the benthic macro invertebrates are a trophic resource for most fish species of the Carpathian rivers belonging to the category studied in this paper [22, 23, 24], making nutrients accessible for the fish stock, being a main component in conditioning the fish production and the lotic ecosystems productivity.

Depending on the way of feeding (food purchasing mechanisms and nutrition behavior), the benthic macro invertebrates can be classified in the following functional feeding groups [25]: shredders - organisms that consume vegetal scraps and other organic materials with dimensions bigger than 1 mm, thus have important role in taking the organic matter that gets into the river from adjacent terrestrial ecosystems; grazers – organisms that consume algae and associated materials from periphyton, with dimensions between 0,45 µm and 1 mm; collectors – organisms that consume fine particulate organic matter (particles smaller than 0,25 mm) from the water body (filtrating collectors) or from the substrate of the aquatic basin (picking collectors); predators – organisms that consume benthic or planktonic invertebrates; omnivorous - organisms with mixed nutrition.

The caddisfly larvae communities include the categories of functional feeding groups with an essential role in the matter cycling in the Carpathian lotic ecosystems: shredders, grazers, collectors and predators.

This paper analyzes the functional feeding structure of the caddisfly larvae communities of the Târnava Mare, Târnava Mică and Târnava rivers (Mureș Basin, Danube Basin). In the circumstances
of constant increasing of anthropogenic use of the lotic systems natural resources and services, this paperwork main goal is to underline the relevance of the functional feedings groups’ structure and biodiversity, quantifying the evaluation of the homeostasis degree and of the support capacity of rivers.

The Târnava River was selected for this analysis due to its dimensions, high variability of biotopes and also high variability of human impact presence. It has a basin surface of 6157 km$^2$, a length of 249 km and a dropping elevation of about 1250 m. Târnava River is formed at the confluence of Târnava Mare River (221 km length, 3606 km$^2$ watershed surface) and Târnava Mică River (191 km length, 2049 km$^2$ watershed surface). The first one springs on the western slopes of the volcanic mountain Harghita Șumuleului at 1441 m altitude, and the second on the southern slope of the volcanic mountain Saca (1777 m) at 1190 m altitude [26].

2 Methods

The results of this paper are based on quantitative benthic macro invertebrates’ samples data from 24 stations of the reference zone (Fig. 1). The sampling stations were chosen according to the valley morphology, the type of the river substratum, the confluence with the main tributaries and the human impact types on the river (pollution sources, hydro technical works, riverbed mineral resources exploitation and riverine lands exploitation).

![Fig. 1. The sampling stations locations, in the Târnava rivers basin.](image)

In each station quantitative samples were taken from five points, in order to highlight the local micro-habitats specific diversity. In the study period, 120 quantitative benthic macro invertebrates’ samples were collected and analyzed. The sampling was carried out with an 887 cm$^2$ surface Surber Sampler, with a 250 µm mesh net. The sampled biological material was fixed in 4% formaldehyde solution and was analyzed in the laboratory with an Olympus (150X) stereomicroscope.

The analyzed biological material included a total of 2522 Trichoptera larvae in life cycle periods which allowed their identification down to species level.

The Trichoptera community’s diversity is expressed through Menhinik and inversed Simpson indexes [27]. The assessed biotope variables were altitude, slope, riverbed width, depth, substratum, pools diversity, riffles, runs and bends, bank vegetation, channel modification, riverine land use, multi annual average water discharge and chemical characteristics of the water: pH, total hardness, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, Cl$^-$, SO$_4^{2-}$, NO$_3^-$, PO$_4^{3-}$, total N, total P, Pb, Zn, Cu, Cd and Mn. Habitat factors – structure and diversity of caddisfly communities conditionality were analyzed using Principal Component Analysis – PCA [28] and Canonical Correspondence analysis – CCA [29].

3 Results

In the reference zone, the highest diversity of Trichoptera larvae communities is associated with the river sectors in which the human impact is insignificant, and the biotope characteristics favor
the development of several species of caddisfly. In the Târnavă Mare River case, the caddisfly presents the highest specific diversity (nine species) in the sector located one km downstream the Zetea dam lake (S4) (Fig. 2). In the Târnavă Mică case, the highest specific diversity of caddisfly (nine species) is registered in the sector located at 0.5 km upstream the Praid locality (S17) (Fig. 3), at around seventeen km downstream the springs. The caddisfly presents a low diversity or are absent in the river sectors highly affected by the organic pollution (S8, S22, S24) and by the heavy metal pollution (S11, S12) [30].

![Fig. 2](image-url)
**Fig. 2.** The inversed Simpson index for the Trichoptera larvae communities’ dynamic, along (1 – 249 km) the Târnavă Mare and Târnavă rivers (cubic spline interpolation).

![Fig. 3](image-url)
**Fig. 3.** The inversed Simpson index for the Trichoptera larvae communities’ dynamic, along (1 – 191 km) the Târnavă Mică River (cubic spline interpolation).

The longitudinal dynamic of the caddisfly larvae communities in the three studied rivers reveals that in the upper courses these communities present a high specific diversity, and the species with highest relative abundances are litho-rheo-oxiphilous, while the communities from the middle and lower sectors are characterized by low specific diversity, the dominant species being the eurivalent ones.

The functional feeding structure analysis of the Trichoptera communities of the Târnavă rivers (Fig. 4, Fig. 5) shows that in the sectors situated downstream the big rural and urban areas (S8, S11, S12, S22, S24) only collectors are present, while in the sectors where the human impact is insignificant, in the upper courses of the rivers Târnavă Mare and Târnavă Mică (S4, S17), we found an equilibrated structure of the feeding functional groups – the proportion of grazers, shredders, predators and collectors varying between 15 to 30%.

![Fig. 4](image-url)
**Fig. 4.** Trichoptera larvae communities functional feeding groups structure dynamic along Târnavă Mare River (S3 – S12 – sampling stations).
The PCA reveals that the collectors abundance is positively correlated with the CBO₅ and CCO₇Mn values (indicators of the oxidable substances quantities from the water), while grazers, shredders and predators abundances are negatively correlated with the values of these indicators (Fig. 6).

The numerical dominance of the collectors is an indicator of the organic pollution generated especially by the discharges into rivers of the domestic sewage, food industry and farms wastewaters.

If the Trichopterans biodiversity is higher, the matter cycling rate is higher, due to the fact that the resources are used more efficient, situation which offer homeostasis to the lotic system, and the natural self cleaning processes are better. The high diversity of the Trichoptera communities is associated with the water which presents moderate quantities of nutrients (P, PO₄³⁻, N, NO₃⁻). (Fig. 7)
Fig. 7. CCA for Trichopterans biodiversity (expressed through the inversed Simpson–SimpT and Menhinik–MenhT indexes) and the chemical characteristics of the water (DO – dissolved oxygen, CBO$_5$ – biochemical oxygen demand, CCO – chemical oxygen demand, DT – total hardness, SO$_4$ – sulphates, NO$_3$ – nitrates, PO$_4$ – phosphates, P – phosphorus, N – nitrogen, Cl – chlorides).

3 Conclusions
The organic pollution caused by the discharge of waste water into the river, the riparian vegetation deforestation, the slopes vegetation deforestation, the intensive agriculture practice in the major riverbed, induce the increasing of abundance of the collectors and the decreasing of Trichoptera diversity, with negative effects on the homeostasis and resilience of these lotic sectors.

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References:


