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# *TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH*

**2**

***The Târnava River Basin***

**Editors**

**Angela Curtean-Bănăduc, Doru Bănăduc & Ioan Sîrbu**

**Sibiu - Romania**

**2005**

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## *The Târnava River Basin*

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# IN MEMORIAM

## Univ. Prof. Dr. *Alexandru V. Grossu*

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## Preface

The impetus for such work has arisen from the specialists' major concern over the declining quality of rivers as complex resources, on the Romanian territory, over the past seven decades.

In spite of the fact that Târnava rivers were, are and will be very important in the urban and rural development in both valleys watersheds, and in the development of the Târnăveni, Odorhei, Cristuru, Sighişoara, Mediaş, Copşa Mică and Blaj localities complex industry by serving as main water supply, and an important human impact presence it has to be aspect, seldom acknowledged is the fact that this area was not approached through integrated ecological studies till now.

The "Lucian Blaga" University of Sibiu/Faculty of Sciences/Ecology and Environment Protection Department together with other invited specialists („Babeş-Bolyai" University Cluj-Napoca/Department of Biology/Ecology-Genetics Chair; NERC Centre for Ecology and Hydrology Cambridgeshire; University of Oradea/Faculty of Sciences/Department of Biology; Ecotur Sibiu N.G.O; Sibiu Regional Agency for Environment Protection; "Bolyai Farkas" Theoretical School Târgu Mureş; Sibiu Natural History Museum; Romanian Academy/Bucharest Institute of Biology/Department of Biosystematics; "Mircea Eliade" College Mediaş; "Sapientia" University, Miercurea - Ciuc; Romanian Bat Protection Association; „Babeş-Bolyai" University Cluj-Napoca/Faculty of Biology and Geology; Milvus Group); chose to allocate important resources to Târnava River Watershed ecological study and assessment, along 1999 - 2004 period and in the end to this volume come into being.

A part of these studies results were presented at the Symposium "Târnava and Ampoi rivers ecological assessment and their impact upon the Mureş River".

The following objectives conduct these studies: to better understand the dynamics of Târnave rivers, to be a catalyst for the enhancement and protection of wildlife habitat in the area, to induce actions to improve water quality for different human uses and wildlife, and to facilitate discussion on the future of anthropisation in this watershed.

These dynamic, creative and cooperative assessment results were offered to the landowners, the businesses groups, the government agencies, and the local communities to stimulate the creation of a real watershed community, where all can have access to the best possible natural areas and resources.

This assessment summarizes the findings of a special designed new studies in the area, represent a snapshot of our current knowledge regarding Târnava Mare, Târnava Mică and Târnava rivers watersheds, develop the knowledge and understanding concerning this watersheds and provide a context for moving forward with these rivers restoration and protection, and also generate the need for new studies.

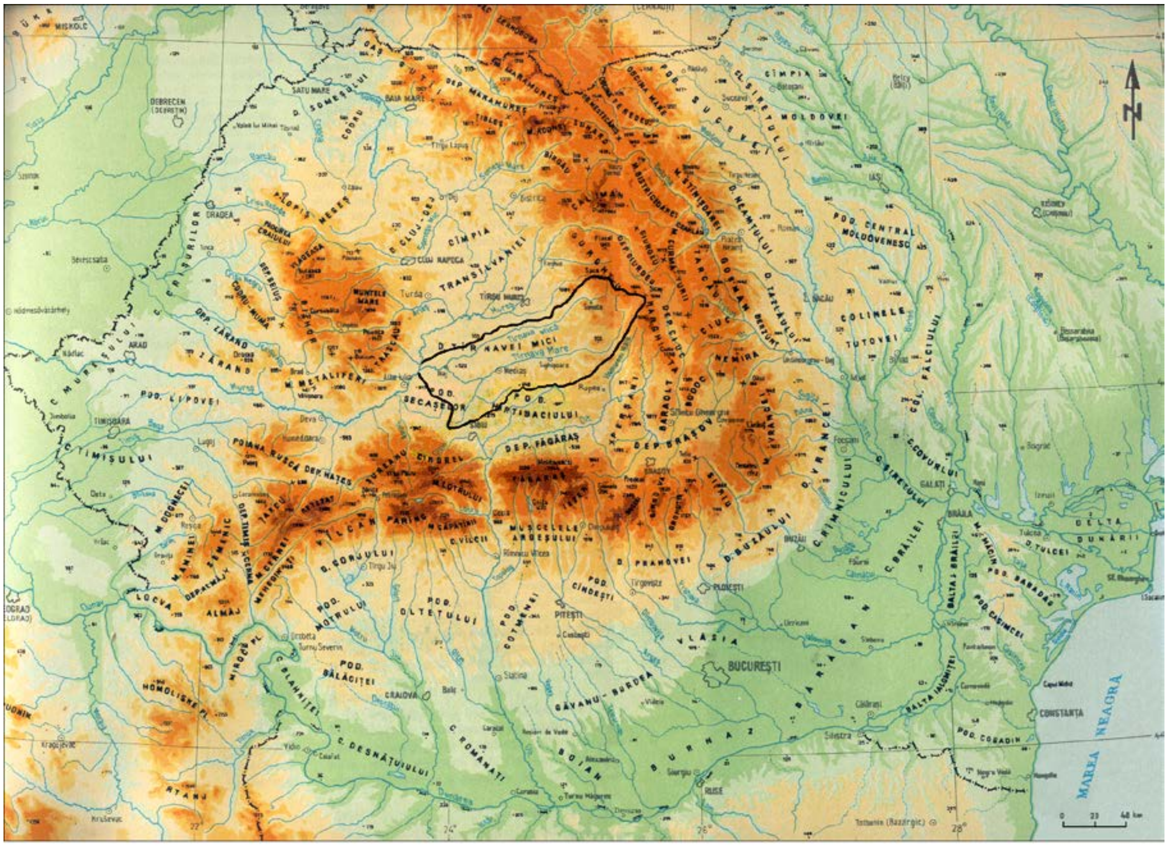
Basically, the intent of this volume is to provide a first Târnava Basin - wide perspective and a framework for action based on many recent studies that have been completed in this area.

No doubt that this new data, will develop knowledge and understanding of the status and conditions of these watersheds and will continuing to evolve.

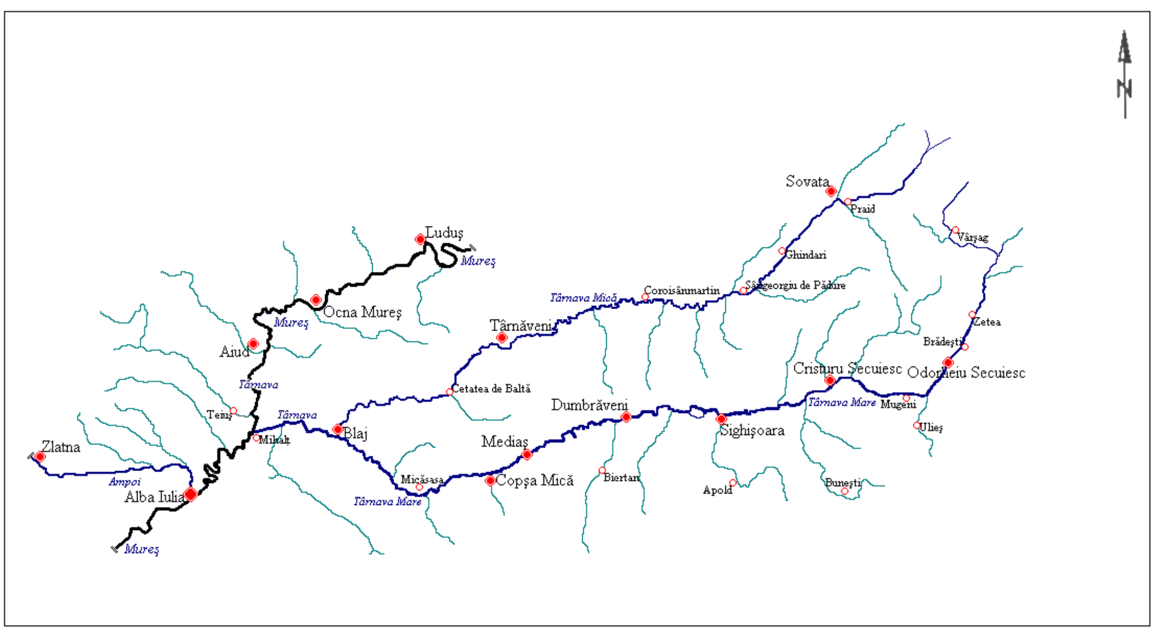
## Acknowledgements

The editors would like to express their gratitude to the authors and scientifical reviewers of which work made possible the appearance of this volume, and to the Romanian Environmental Partnership Foundation and Ecotur Sibiu N.G.O. which support the Program "A clean Mureş River through clean tributaries" based on which a part of the needed work were basically realized.

***The Editors***



***The Târnava River Watershed study unit location (L. Badea et al., 1983 - modified).***




***The Târnave rivers sampling area (D. Bănăduc).***

ISI – quoted volume

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The series of this publication will continue with the following volumes:

Transylvanian Review of Systematical and Ecological Research - “Retezat Mountains Biodiversity”;

Transylvanian Review of Systematical and Ecological Research - “Wetlands Biodiversity”;

Transylvanian Review of Systematical and Ecological Research - “Saxon Villages Region of Transylvania Biodiversity”.

***The Editors***

# ASPECTS CONCERNING THE LIQUID FLOW IN TÂRNAVA MICĂ RIVER HYDROGRAPHIC BASIN (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: geology, relief, climate, hydrological regime, Transylvania, Romania.

**ABSTRACT**

The superficial liquid flow analyse (mean, minimum and maximum) in Târnava Mică River hydrographical basin, was done through the hydrological parameters analyse, parameters took over from the Romanian Meteorology and Hydrology National Institute archive, statistically handled, and also based on the original hydrological data obtained by the author in field campaigns.

This analyse emphasize the torrential character of the superficial flow in the basin, set off in high maximum flows in rainy periods and insignificant minimum flows, with run dry periods in drought periods of the year.

**RÉSUMÉ**: Aspectes concernant l'écoulement liquide dans le basin hydrographique du rivier Târnava Mică.

L'analyse de l'écoulement superficielle liquide (moyene, minime et maxime) a été réalise par l'analyse des parameters hydrologiques, les donnees provenant de l'archive de l'Institute National de Météorologie et Hydrologie et aussi les données de l'autouer obtenues pendant les déplacements sur le terrain.

Cette analyse montre le character torrentiel de l'écoulement superficiale dans le basin, sougligné par des écoulement maximes dans les periodes pluviales, et des écoulements minimes, tres basses, même la séchage das les periodes sèches de l'année.

**REZUMAT**: Aspecte privind scurgerea lichidă în bazinul hidrografic al râului Târnava Mică.

Analiza scurgerii superficiale lichide (medii, minime şi maxime) în bazinul hidrografic Târnava Mică s-a făcut prin analiza parametrilor hidrologici preluaţi din arhiva Institutului Naţional de Meteorologie şi Hidrologie, prelucraţi statistic, şi a datelor hidrologice obţinute de autor în campaniile de măsurători executate.

Această analiză scoate în evidenţă caracterul torenţial al scurgerii superficiale din bazin, reliefat în scurgeri maxime de amploare în perioadele pluviale şi scurgeri minime nesemnificative, mergând până la secare în perioadele secetoase ale anului.

**INTRODUCTION**

The studied area is localized in the central and eastern - central Târnavelor Plateau, drained by Târnava Mică River, between Gurghiu - Harghita Mountains and the confluence with Târnava Mare River near Blaj locality. The river pass a mountainous zone, a hilly zone and a plateau zone, separating the Târnăvenilor Hills by Dumbrăveni and Blăjel plateaus, on 183 km distance, and draining a 203 $km^2$ land surface.

The superficial liquid flow analyze (mean, minimum and maximum) in Târnava Mică River hydrographical basin was done through the hydrological parameters analyze, parameters token over of the Romanian Meteorology and Hydrology National Institute archive, statistically remaked, and also based on the personal hydrological data obtained by the author in field campaigns.

**RESULTS AND DISCUSSIONS**

From the geological point of view, the studied area is formed of two different structural unities: Neogene vulcanite in the upper part of the river basin and Neogene sediments for the rest of the basin.

The Neogene vulcanite structures correspond to Gurghiu - Harghita mountainous heights. The volcanic eruptions started probably in Palaeocene, but continue with a maximum intensity in Neogene period, and had a mixed character, the lava flowed in alternation with volcanic explosions and the piroclastites sedimentation. The volcanic formations, penetrated by intrusive elements too (dyks, sills, laccoliths) are formed of piroclastites (agglomerates, cinerites, tufs) of andesitic nature and of effusive rocks, represented of diverse types of andezites. The whole volcanic - sedimentary complex overlap or a Carpathian crystalline - Mesozoic foundation or a Carpathian flysch type foundation, or a Transylvanian foundation formed of Mio - Pliocene sediments.

The Neogene sediments which occupy the largest part of the river basin, is formed of a crystalline foundation and patches of an old sedimentary lay, over which exist the proper sedimentary filling, formed of two distinct sedimentary cycles: Paleocene - inferior Miocene and superior Miocene - Pliocene. The Paleocene and inferior Miocene deposits have no contact with the surface, but the superior Miocene and Pliocene deposits had a large contact with the surface. The inter-fluviatile surfaces are covered with deposits belonging to Sarmatian (marns, clays, conglomerates, sands and tufs). The Tortonian with salt stones is standing out in bold relief in the diapires folders Sovata - Gurghiu zone. In the rest of the basin the domes and anticlinale structures are dominant. The highest presence is recorded for the last lay of Pliocene, the Panonian represented by clays, sands structured on two horizons (one with clay in the foundation and the second a sandy with clays intercalations one in the upper part). These deposits are spread on both sides of Târnava Mică River, excepting Deleni - Botorca - Cetatea de Baltă zone, where the inferior Sarmatian respectively the Buglovian and the Volhinian (an alternance of clay and sands) appear at the surface.

The central zone of the analyzed area (major river bed, river meadow and the first river terraces) is characterized by two layers of Quaternary: the superior Pleistocene represented by gravels and sands for medium terraces and Holocene represented by sands, sandy gravels, delluvial-colluvial and alluvial sediments, for the inferior terraces, river meadow and the Târnava Mare major river bed.

The basin's relief is formed of two different units: one mountainous (about 22% of the surface) and one hilly (about 78%), which are succeeding in steps from East to West and South West.

The relief units, border the river basin as following: at North - East the Gurghiu - Harghita Mountainous West side, at West the Niraj and Târnava Mică plateaus which decrease in altitude to 1100 - 1000 m. Between the mountainous and the hilly relief units an alternation of depressions is present, the most important one is Praid - Sovata Depression, which appear as a not so broad (4 - 6 km) corridor but long enough (about 30 km). This depression is dominated at the East by the volcanic plateau Sovata and the Corund Hills and at the West by the Bichiş - Firtuş Hill. This depression was modeled through erosion in Pliocene formations, with salt stones, at 560 - 630 m altitude, under the volcanic plateau (with rounded of peaks around 1000 m altitude). The superior level of the depression can be seen on the base of Bichiş - Firtuş Hill too, along the Târnava Mică corridor, which break through this hill and pass to North and South in the submontainous depressions Eremit and Corund.

The hilly unit belongs to Târnavelor Plateau with low interfluves at 500 - 600 m altitudes, separated by large valleys with river meadows and terraces, with asymmetrical sides (structural relief), influenced by erosion, gravitational processes, on the larger part of the basin. Târnavei Mici Hills are represented by Târnăvenilor Plateau and Niraj Hills as an interfluvial zone to Niraj and Mureş, forming the right side of Târnava Mică and Dumbrăvenilor Plateaou, between the two Târnave Rivers forming the left side of the basin. The dominant relief is characterized by the presence of asymmetric interfluves in form of North East - South Vest oriented cuestas (400 - 600 m altitude), very fragmented, at which steep sides are affected by torrents and land slidings. The right side is shorter and that is why it seems higher with the convergence through the interfluves with Niraj and Mureş, is affected largely by the degradation processes of the land (areal washings, streamings, torrents activity, solifluxional processes, land slidings), started and upkeep by the rare density of vegetation. The left side too is affected by degradations but at a lover degree, them became more intensified in the East, the central zone being affected by some settlings processes which generated small depressions.

The Târnava Mică River valley is asymmetrical (as a major influence of the left side), with a marked subsequent character, composed by terraces, river meadow, major river bed, (with meanders, drought river meanders, small islands, sandy zones), for the left side and meanders steep sides transformed in cuestas for the right side.

The relief synergy is low, reaching a maximum of 100 m, and the average fragmentation degree is 0.5 - 0.7 km/km$^2$.

The climatic regime, belong to the sector with a moderate - continental climate of the hilly area, characterized by warm summers, with relative frequent precipitation and cold winters, with a relatively stable snow layer, and rare warming intervals. The global solar radiation is of 115 kcal/cm$^2$/year. The general circulation of the atmosphere is characterized by the high frequency of the western and north western temperate - oceanic air advections (especially in the warm semester), and by the relatively low frequency of the North-East and East temperate continental air advections. Less frequent southwest and south Mediterranean air masses are present and also rare northern arctic air masses. The annual average temperatures are between +8°C and +9°C, with absolute values of +35°C and -32°C (the middle area of the basin). The average temperatures of July vary between +18°C and +20°C and of January between -3°C and -4°C. The atmospheric precipitation's had annual quantities of 500 - 700 mm. The annual average number of days with frost is 117 (middle area of the basin).

The hydrographical net is formed of the main collector Târnava Mică (L - 183 km; F - 2031 km$^2$) and its main tributaries: Corund (L - 22 km; F - 132 km$^2$); Sovata (L - 20 km; F - 119 km$^2$); Nadeş (L - 18 km; F - 67 km$^2$); Domald (L - 47 km; F - 62 km$^2$); Cuşmed (L - 25 km; F - 151 km$^2$); Cuşmed

(L - 17 km; F - 83 km$^2$); Balta (L - 19 km; F - 138 km$^2$). The basin asymmetry is characterized by the presence of one main right side tributary Sovata, other important tributaries being on the left side.

The hydrological regime can be characterized as not uniform, with a pluvial and underground predominant supply, a regime represented by important spring floods (see the years 1970 and 1975), but also by autumn - winter lower floods. It was noticed the levels variation high amplitude (3 - 4 m) and the relative short time in which these floods are happening, also the almost annual presence of the floods.

The minimum flow appear in autumn (September - October), with exclusively underground supply, some tributaries basins are dry up with diverse frequency and periods. Also related with the minimum flow was noted the fact that especially downstream Cetatea de Baltă locality the water loses in the sandy - muddy substrate are happened.

The multiannual (1950 - 1992) specific water discharge vary between 1,50 l/s km$^2$ for the lower sector - Cetatea de Baltă and 16 l/s km$^2$ for the upper sector - Sovata (Tab. 1).

The minimum flow was analyzed through the monthly (annual) average minimum discharge with 95% assured flow; dilution discharge - present obligatory in any situation in the river bed (Tab. 1).

The maximum flows are those with a 1% probability, possible to appear once in 100 years, for 10 basin representatives sections (Tab. 1).

Table 1: The hydrological parameters related with the natural river flow regime.

| Nr. crt. | River | Section | F (km$^2$) | $q_0$ (l/s km$^2$) | $Q_0$ (mc/s) | Q min 1 95% (mc/s) | Q max 1% (mc/s) |
|---|---|---|---|---|---|---|---|
| 1 | Târnava Mică | Upstream the confluence with Sovata | 317 | 13.9 | 4.40 | 0.950 | 300 |
| 2 | Sovata | Upstream the confluence with Târnava Mică | 119 | 16.0 | 1.90 | 0.300 | 170 |
| 3 | Târnava Mică | Hidrometric station Sărățeni | 454 | 13.8 | 6.31 | 1.25 | 390 |
| 4 | Târnava Mică | Upstream the confluence with Cuşmed | 609 | 11.0 | 6.70 | 1.35 | 425 |
| 5 | Cuşmed | Upstream the confluence with Târnava Mică | 151 | 9.00 | 1.36 | 0.040 | 215 |
| 6 | Târnava Mică | Upstream the confluence with Bălăuşeri | 1039 | 8.46 | 8.79 | 1.40 | 530 |
| 7 | Târnava Mică | Upstream the confluence with Zagăr | 1086 | 8.30 | 9.01 | 1.41 | 542 |
| 8 | Zagăr | Upstream the confluence with Târnava Mică | 62 | 3.00 | 0.186 | 0.00 | 130 |
| 9 | Târnava Mică | Hidrometric station Târnăveni | 1478 | 6.68 | 9.87 | 1.45 | 620 |
| 10 | Târnava Mică | Hidrometric station Blaj | 2031 | 5.15 | 11.0 | 1.48 | 660 |

This analyze emphasize the torrential character of the superficial flow in the basin, set off in high maximum flows in rainy periods and insignificant minimum flows, with run dry periods in drought periods of the year.

# THE STRUCTURE OF DIATOM COMMUNITIES INHABITING THE TÂRNAVA MICĂ AND TÂRNAVA MARE RIVERS (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: biodiversity, diatoms, human impact, Transylvania, Romania.

**ABSTRACT**

The present paper deals with the floristic composition of the diatom communities inhabiting several sampling sites located on the Târnava Mică and Târnava Mare rivers, as well as with some preliminary considerations on the water quality based on diatom floras. The samples were collected in November 2000, from the benthos of the rivers (epilithic, epipelic communities). The authors identified 143 species, 62 from the Târnava Mică and 133 from the Târnava Mare rivers. The structure of their diatom communities indicates eutrophication tendency, from upstream towards downstream in all investigated rivers. In the same time, the water of the rivers is turning from xeno-oligotrophic character to a critical saprobic level.

**RÉSUMÉ**: La structure des communautées de diatomées dans les riviers Târnava Mică et Târnava Mare.

Le travail présent la structure qualitative des communautés des diatomées dans quelques points de prélèvement situées sur les riviers Târnava Mică et Târnava Mare, et aussi quelques considérations concernant l'appréciation de la qualité de l'eau usant ces organismes. On a travaillé sur 7 échantions benthoniques prélevées en novembre 2000, dans lesquelles ont été identifiées 143 espèces, 62 en Târnava Mică et 133 en Târnava Mare. La composition des communautées des diatomées montre une tendance de l'eutrophisation de l'eau vers aval, dans chaque rivier, mais aussi le passage dans le même sens, des eaux xeno-oligosaprobes a des eaux avec un niveau saprobe critique.

**REZUMAT**: Structura comunităţilor de diatomee din râurile Târnava Mică şi Târnava Mare.

Lucrarea prezintă structura calitativă a comunităţilor de diatomee din câteva staţiuni situate pe râurile Târnava Mică şi Târnava Mare, precum şi unele consideraţii privind aprecierea calităţii apei pe baza acestora. S-a lucrat pe un număr de 7 eşantioane bentonice (epilitice, epipelice), prelevate în luna noiembrie 2000, din care s-au identificat un număr de 143 specii dintre care 62 în Târnava Mică şi 133 în Târnava Mare. Compoziţia comunităţilor de diatomee indică o tendinţă de eutrofizare a apei, din amonte spre aval, pe cele două râuri cercetate, precum şi trecerea, în acelaşi sens, de la ape xeno-oligosaprobe la cele de nivel saprobic critic.

## INTRODUCTION

The algae, a heterogeneous photoautotrophic group of aquatic organisms, are the main primary production producers in floating waters. In rivers the benthic algal assemblages, especially those inhabiting their upper/middle sectors, are dominated by diatoms, which sometimes form up to 80 - 90% of the community (Mimeo et al., 1999; Mimeo et al., 1988; Resign, Mimeo, Péterrify, 1995 - 1996, 1999 a, b). Due to a short life cycle, diatoms exhibit high renewal capacity, after being affected by external disturbances, of natural (flooding) or anthropogenic (pollution) character. They also possess a high adaptability between certain limits towards habitat conditions, which explain why diatoms, besides other algal groups, are widely used in water quality assessments.

The Colquitt and Masson (1909) saprobe system, subsequently improved by several authors, has widely been recommended. At the present the systems of Melina and Marvin (1961), or that of Slanderer (1973) are the best known. Some of the French authors like Lenoir and Costa (1994, 1995, and 1996), Phrygia and Costa (1997), Costa and Phrygia (2000), proposed the use of diatoms solely, for river water quality evaluation, especially for establishing their saprobe level. The most important condition, in using diatoms in water quality assessments, is the identification of taxi at least on species level, as well as the evaluation of their frequency and relative dominance. Of course, excellent results are obtained by correlating the above-mentioned data with waters and substratum physic-chemical parameters. The authors investigated the diatoms inhabiting the Târnave Rivers, knowing that the anthropogenic impact has markedly been diminished in the last decade, due to the reduction of industrial and agricultural activities. Some of the economic units, including the heavy metal factory of Copşa Mică, the main water pollution sources for the investigated rivers, ceased or highly reduced their activity.

## MATERIALS AND METHODS

Benthos (epilithic, epipelic) samples were collected during November 2000, using standard methods of scraping, brushing and sucking, according to substratum's nature. Two sites were selected on the Târnava Mică River, upstream Praid (Tm$_1$) and downstream Sovata (Tm$_2$) and 5 on the Târnava Mare River, upstream Vârşag (TM$_1$), upstream (TM$_3$) and downstream (TM$_4$) Zetea Lake, Odorhei (TM$_6$) and downstream Sighişoara (TM$_7$) (Fig. 1).

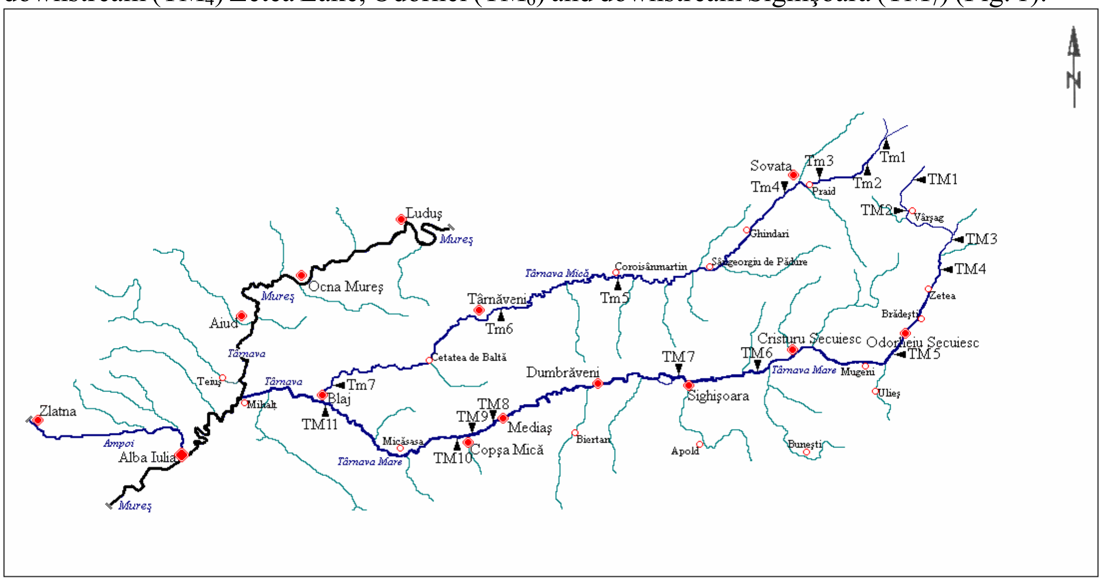

Fig. 1: The sampling stations on Târnava Mare River (TM$_{1-11}$) and Târnava Mică River (Tm$_{1-7}$).

**RESULTS AND DISCUSSIONS**

In the stand samples collected in 2000, there have been identified 143 diatom species, 62 inhabiting the Târnava Mică River and 133 the Târnava Mare River (Tab. 1). The highest number of taxa was recorded in the Târnava Mare, downstream Zetea dam reservoir (77 species) and downstream Odorhei (66 species). The lowest number of taxa has been found upstream Praid on the Târnava Mică River (25).

As a rule, the species diversity constantly raises from upstream towards downstream, in all two investigated river courses (Tab. 1), possibly due to eutrophication caused by allochtone organic materials washed into the rivers and by the inflow of polluting agents. This is especially evident in the case of the Zetea dam reservoir with deep outflow, which carry high amount of nutrients into the downstream river. The fact that in sampling site located downstream Sighişoara the authors recorded a low number of species (59), compared to the other sampling sites, and might be due to the sandy nature of the riverbed. Usually unconsolidated sands and mud exhibit low diatom diversity.

Table 1: Structure of diatom communities in the Târnava Mică and Târnava Mare rivers.

| Diatom species | Sampling sites | | | | | | |
|---|---|---|---|---|---|---|---|
| | Târnava Mică River | | Târnava Mare River | | | | |
| | $Tm_1$ | $Tm_2$ | $TM_1$ | $TM_3$ | $TM_4$ | $TM_6$ | $TM_7$ |
| *Achnanthes affinis* | | | | | | + | |
| *Achnanthes minutissima* | + | + | + | + | + | | |
| *Achnanthes lanceolata* | + | + | + | + | + | | |
| *Amphiprora pellucida* | | | | | + | | |
| *Amphora ovalis* | | | | | | + | + |
| *Amphora pediculus* | | | | + | | + | + |
| *Amphora veneta* | | | | | | + | |
| *Anomoeoneis sphaerophora* | | + | | | | + | + |
| *Caloneis amphisbaena* | | | + | + | + | + | + |
| *Caloneis silicula* | | | | + | | | |
| *Ceratoneis arcus* | + | + | | | + | + | + |
| *Cocconeis pediculus* | + | + | | + | + | + | + |
| *Cocconeis placentula* | + | + | | + | + | + | + |
| *Cyclostephanos invisitatus* | | | | + | | | + |
| *Cyclotella atomus* | | | | + | | | |
| *Cyclotella kuetzingiana* | | | | | + | | |
| *Cyclotella meneghiniana* | | + | + | + | + | | + |
| *Cymatopleura elliptica* | | | + | + | | + | + |

| | $Tm_1$ | $Tm_2$ | $TM_1$ | $TM_3$ | $TM_4$ | $TM_6$ | $TM_7$ |
|---|---|---|---|---|---|---|---|
| *Cymatopleura solea* | | | | | + | | |
| *Cymbella affinis* | | + | | | + | | |
| *Cymbella cistula* | | | | | + | + | + |
| *Cymbella lanceolata* | | | | | + | + | |
| *Cymbella minuta* | | + | + | + | + | + | |
| *Cymbella prostrata* | | | | + | | | + |
| *Cymbella silesiaca* | | | | | + | + | |
| *Cymbella sinuata* | + | + | | | + | | |
| *Cymbella ventricosa* | | + | | | + | + | + |
| *Cymbella tumida* | | | | | + | + | |
| *Denticula tenuis* | | | | | | | + |
| *Diatoma hiemale* | + | | | | + | | |
| *Diatoma mesodon* | + | | | | | | |
| *Diatoma moniliforme* | | | | | + | | |
| *Diatoma problematica* | | | | + | | | |
| *Diatoma tenuis* | | | | | | | + |
| *Diatoma vulgare* | | + | + | + | + | + | + |
| *Diploneis elliptica* | | | | | | + | |
| *Diploneis oblongella* | | | | | + | | |
| *Fragilaria bidens* | | | | | + | | |
| *Fragilaria capucina* | | + | | | + | | |
| *Fragilaria construens* | | | | | | + | |
| *Fragilaria intermedia* | | | | | + | | |
| *Fragilaria pinnata* | | | | | + | | |
| *Fragilaria pulchella* | | + | | | | | + |
| *Fragilaria vaucheriae* | | + | | | | | + |
| *Fragilaria virescens salina* | | + | | | | | |
| *Frustulia vulgaris* | | | | + | | | |
| *Gomphonema angustatum* | + | | | | + | + | |
| *Gomphonema augur* | | | | | | | + |
| *Gomphonema clavatum* | | | | | + | | |

| | $Tm_1$ | $Tm_2$ | $TM_1$ | $TM_3$ | $TM_4$ | $TM_6$ | $TM_7$ |
|---|---|---|---|---|---|---|---|
| *Gomphonema gracile* | | | + | | | | |
| *Gomphonema intricatum* | | | | | | + | + |
| *Gomphonema olivaceum* | | + | + | | + | + | + |
| *Gomphonema parvulum* | | | + | + | + | + | + |
| *Gomphonema rhombicum* | + | | | | | | |
| *Gomphonema tergestinum* | | | | | | + | |
| *Gomphonema truncatum* | | | | + | + | + | |
| *Hantzschia amphioxys* | + | + | + | + | + | + | + |
| *Gyrosigma attenuatum* | | | | + | | + | + |
| *Gyrosigma scalproides* | | | | + | | | |
| *Melosira varians* | | + | + | + | + | + | + |
| *Meridion circulare* | + | | | | + | | |
| *Navicula capitata* | | + | | | + | + | + |
| *Navicula capitatoradiata* | | + | + | + | + | + | + |
| *Navicula cincta* | | + | | + | | + | + |
| *Navicula cryptotenella* | | | | + | + | + | |
| *Navicula cuspidata* | | | + | + | | + | |
| *Navicula elginensis* | | | | | | | + |
| *Navicula goeoppertiana* | | | | | + | + | + |
| *Navicula lanceolata* | | + | + | | + | + | |
| *Navicula menisculus* | | + | | | | | |
| *Navicula mutica* | | | + | | + | + | + |
| *Navicula pupula* | | | + | + | | + | + |
| *Navicula pygmaea* | | + | | | + | | + |
| *Navicula radiosa* | | + | | | | | |
| *Navicula tripunctata* | + | + | + | + | + | | + |
| *Navicula trivialis* | | | + | | | + | |
| *Navicula veneta* | | | | | | + | |
| *Navicula viridula* | | | | | | + | + |
| *Nitzschia acicularis* | | | | | + | | |
| *Nitzschia amphibia* | | + | | | | + | + |

| | $Tm_1$ | $Tm_2$ | $TM_1$ | $TM_3$ | $TM_4$ | $TM_6$ | $TM_7$ |
|---|---|---|---|---|---|---|---|
| *Nitzschia dissipata* | | + | | | | + | |
| *Nitzschia dubia* | + | + | | | | | |
| *Nitzschia fonticola* | + | | | | | | |
| *Nitzschia frustulum* | | + | | | | + | |
| *Nitzschia graciliformis* | | | | + | | | + |
| *Nitzschia hantzschiana* | | + | + | | | | + |
| *Nitzschia inconspicua* | | | | | | + | |
| *Nitzschia linearis* | | + | + | | + | + | + |
| *Nitzschia palea* | + | + | + | + | + | + | |
| *Nitzschia sinuata* | | | | | | + | |
| *Nitzschia sigmoidea* | | + | | | + | + | |
| *Nitzschia sociabilis* | | | | | + | | + |
| *Nitzschia stagnorum* | | + | | | | | + |
| *Nitzschia umbonata* | | | + | | | | + |
| *Pinnularia borealis* | | | | + | + | | |
| *Pinnularia microstauron* | | | + | | | | |
| *Pinnularia rupestris* | | | | | + | | |
| *Pinnularia subcapitata* | | | | | + | | |
| *Rhoicosphaenia abbreviata* | + | + | + | | + | + | + |
| *Rhoicosphaenia curvata* | + | + | | + | + | + | + |
| *Stauroneis phoenicenteron* | + | | + | | | | |
| *Surirella angustatum* | | + | + | | + | | |
| *Surirella brebissonii* | | + | + | + | + | + | + |
| *Surirella capronii* | | | | | + | + | |
| *Surirella kuetzingii* | | | | | + | | + |
| *Surirella splendida* | | | | + | | | |
| *Synedra acus* | | | | | + | | |
| *Synedra rumpens* | | | | | + | | |
| *Synedra ulna* | | + | + | + | + | + | + |
| *Tabellaria flocculosa* | | | | | + | | |

Investigating the distribution of diatoms in the investigated stands, it became evident that only 52 species are common for these two rivers. Eight species were identified only in the Târnava Mică River and 78 only in the Târnava Mare River. The species widely distributed in these two courses are eurytopic, indifferent and cosmopolitan forms, like *Cocconeis placentula, Cymbella minuta*, *Gomphonema parvulum*, *Fragilaria capucina*, *Melosira varians, Navicula capitatoradiata, N. tripunctata* etc., or which occur mostly in waters with moderate or high mineral content (*Caloneis amphisbaena, Diatoma moniliformis, Cymatopleura solea, Navicula capitata, Surirella brébissonii, Rhoicosphaenia curvata* and others) (Tab. 1).

Similarly, on the upper course of the rivers, there are widely distributed many catarobic, xeno-oligosaprobic elements, some of them even microthermal, like *Ceratoneis arcus* and *Meridion circulare*, which are present everywhere, as well as others with local distribution, like *Gomphonema clavatum*, occurring only in the Târnava Mare River.

The diatom communities exhibit a high number of calciphiles and alkalibionts, some dominants: *Diatoma vulgare, Achnanthes minutissima, Melosira varians, Navicula lanceolata*.

The salt deposits located in both Târnava valleys might explain the appearance of halophilous elements like *Cyclotella meneghineana, Cocconeis pedicularis, Fragilaria virescens* var. *salina, Navicula cuspidata* and *Nitzschia frustulum*.

The influences of the Zetea dam reservoir explain the presence of a few euplankters like *Synedra acus* and *Nitzschia acicularis*.

Habitat - allochtonous elements washed in rivers from the surrounding soils (aerophytes) or wetlands are scarce in these communities (*Pinnularia borealis, P. rupestris, P. subcapitata*).

The increase or decrease of industrial and agricultural activities, favored the development of algal communities in the investigated rivers, as one can judge from the analysis of floras. In spite of recent improvements in community structure, because the lack of wastewater filtering plants, there is a permanent inflow of organic materials and pollutants (domestic wastes, textile industry wastes, hospital wastes, bakery wastes etc.), which spoil the quality of these waters. The presence of β-α, α-saprobic or α-polysaprobic elements (*Anomoeoneis sphaerophora, Navicula pygmaea, N. viridula, Nitzschia palea, N. sigmoidea*) clearly indicate the excess of organic materials in the water. The number of such elements has an increasing tendency from upstream to downstream, in these two watercourses.

The dominant species vary from one river to another; in some cases differ in the same river from one stand to another, according to local conditions.

In the sampling site upstream Praid on the Târnava Mică River the dominant species is *Achnanthes minutissima*, indicating water of good quality, downstream Sovata became dominants the *Navicula* species, most of them indifferent or preferring eutrophic conditions.

In Târnava Mare, in the Vârşag sampling site, the dominant elements are *Ceratoneis arcus, Achnanthes minutissima* and *Meridion circulare*, indicating excellent or good quality of the water, according to the methodological guidebook of Prijer and Coste (2000). The water quality is the same upstream Zetea dam reservoir, where the dominant diatom is *Diatoma vulgare*.

Downstream Zetea Dam, the number of species is doubled, due to eutrophication; the dominant species is *Melosira varians*, element characteristic for eutrophic habitat conditions.

In sampling sites downstream Odorhei and Sighişoara, the dominant species - *Diatoma vulgare* - suggests the improvement of water quality.

These results, are in accordance with the results of previous investigations dealing with Romanian and other European rivers (Rasiga, Momeu, Péterfi, 1999 a, b; Momeu et al., 1988, 1999; Kelly, Penny, Witton, 1995; Lenoir, Coste, 1995, 1996).

## CONCLUSIONS

Based on the present data, it became evident that there are no marked pollution in the investigated rivers, a fact underlined by high species diversity and the relative dominance of the floristic elements, characteristic for the various river courses (upper courses, middle courses and lower courses).

There is a tendency of graduate eutrophication of the rivers' water from their springs towards downstream, based on the "maturation" of watercourses, and doubled by the human influences.

The presence of algal elements indicating critical saprobic level should be a warning for local authorities to start monitoring these two rivers.

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# THE HYDROPHILOUS AND HYGROPHILOUS FLORA AND VEGETATION OF TÂRNAVE RIVERS (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: Aquatic, paludal, flora, red list, vegetation, protected area, Târnava Mare River, Târnava Mică River, Târnava River, Transylvania, Romania.

**ABSTRACT**

This paper present the cormophytes species and the aquatic and paludal vegetal groups of the Târnava Mare and Târnava Mică rivers courses, respectively 352 species and 69 vegetal associations. Both these parts of the paper work were realised based on the bibliography and on the original author's field investigations. For each species was indicate not only the chorology but also the sozological category to which it belong. The species are enumerated in alphabetical order, and the identified vegetal associations are presented as concordant with - with few exceptions - the L. Mucina and colab. (1993) and the A. Borhidi (1966) phytocenological critical revision.

**ZUSAMMENFASSUNG**: Die hydrophile und hygrophile Flora und Vegetation der Târnava (Kokeltal).

Die Arbeit beschreibt sowohl die Kormophyten wie auch Wasser- und Sumpfpflanzenzönosen entlang der zwei Târnava- oder Kokelflüsse mit 352 Arten und 69 Gesellschaften. Die beiden Verzeichnisse sind mit Hilfe der botanischen Literatur und der Felduntersuchungen des Autors verfasst worden. Für jede Art werden die Chorologie und die soziologische Kategorie angegeben. Die Arten sind alphabetisch geordnet, die Pflanzengesellschaften nach dem System, das kritisch von L. Mucina at al. (1993) und A. Borhidi (1966) bearbeitet wurde.

**REZUMAT**: Flora şi vegetaţia hidrofilă şi higrofilă a râurilor Târnava.

Lucrarea prezintă speciile de plante cormofite şi grupările vegetale acvatice şi palustre de pe cursul celor două Târnave, respectiv 352 specii şi 69 asociaţii vegetale. Cele două conspecte sunt alcătuite pe baza bibliografiei de specialitate şi a investigaţiilor autorului în teren. Pentru fiecare specie sunt indicate nu numai corologia ci şi categoria sozologică în care se încadrează. Speciile sunt enumerate alfabetic, iar asociaţiile vegetale identificate sunt prezentate respectând - cu mici excepţii - revizia critică fitocenologică făcută de L. Mucina şi colab. (1993) şi de A. Borhidi (1966).

## INTRODUCTION

In this paper work were enumerated the cormophytes species and the aquatic and paludal vegetal groups of the Târnava rivers courses, respectively 352 species and 69 vegetal associations. Both these parts of the paper work were realised based on the bibliography and on the personal author field investigations. For each species was indicate not only the chorology but also the sozological category to which it belong. The species are enumerated in alphabetical order, and the identified vegetal associations are presented as in concordance with - with few exceptions - the L. Mucina and colab. (1993) and the A. Borhidi (1966) phytocenological critical revision.

Chr. Baumgarten (1816) offered the oldest information regarding Târnava rivers flora, he studied especially the plants around Sighişoara locality. Also Fr. Fronius (1858) researched the Sighişoara flora. M. Salzer (1855) presented aspects concerning Mediaş locality. Valuable contributions at the lower course of Târnava Mare River flora (between Mediaş and Blaj localities) were offered by J. Barth (1866, 1867), Al. Borza and V. Lupşa (1964, 1965); the latter authors offered also phytocoenological data. L. Gonczy (1888, 1890) and Şt. Pall (1960, 1964, 1965) analyse the Odorhei locality flora (the last one, also the vegetation) and of the Odorhei Depression. Few data regarding the Târnava Mare River middle course vegetation was comprised in V. Sanda, A. Popescu and M. I. Doltu (1976) paper. E. Pop (1960) noted plant species of Harghitei Mountains and Şaeş marshes, and F. Tauber and P. Weber (1976) few rare species from Păucea. All these papers are concerning only to Târnava Mare River; the single important paper about Târnava Mică flora and vegetation belongs to I. Gergely, I. Füzi and A. Kacso (1977).

Both in the species and vegetal association's lists, the localities of the Târnava Mare River course are separated with the mark punctuation (;) by the localities of the Târnava Mică River course. The noted localities are all localized on the Târnave rivers sides, with the exception of Bazna, Păucea and Şaeş, which are situated few kilometres near the rivers courses, but were included due to their special flora and vegetation, with rare taxons.

The abbreviations in the Red List are: Ex - extinct, E - endangered, V - vulnerable, R - rare, I - (category) indeterminate, K - not known enough, nt - not threatened; and in the herbariums are: HB - Herbarium J. Barth, HF - Herbarium M. Fuss, HKA - Herbarium A. Kayser, HNY - Herbarium E. I. Nyarady, HS - Transylvanian Natural Sciences Herbarium, HU - Herbarium K. Ungar (all belonging to the Sibiu Natural History Museum patrimony).

The mark (!) indicates our own data.

## RESULTS

### Flora

**nt** - *Acer negundo L.*: Odorhei (22)

**V** - *Achillea ptarmica L.*: Odorhei (8, 29, 43); Praid (29), Corund (43)

**E**- *Acorus calamus* L.: Daneş (8), Albeşti (8)

**nt** - *Adoxa moschatellina* L.: Blaj (1, 5), Târnăvioara (1, 29, 32), Mediaş (1, 8, 27, 29, 32), Sighişoara (8, 29), Mureni (43)

**nt** - *Aegopodium podagraria* L.: Şeica Mică (1, 32), Târnava (1, 32), Târnăvioara (1, 32, !), Mediaş (1, 28, 32), Sighişoara (8); Bazna (26, 40), Târnăveni (!), Corund - Dealu (24)

**nt** - *Agrostis stolonifera L.*: Ţapu (!), Copşa Mică (15), Şaeş (38), Cădişeni (21, 23), Brădeşti (21, 23), Odorhei (21, 23), Zetea (23), Târnoviţa (23), Vârşag (21, 23, !); Bazna (40), Târnăveni (!), Abuş (10), Sângeorgiu de Pădure (10), Sovata (10)

**R** - *Alisma lanceolatum* With: Ghindari (10), Sărăţeni (10), Abuş (10), Trei Sate (10), **nt** - *A. plantago - aquatica* L.: Blaj (5), Valea Lungă (1, 5), Copşa Mică (1), Târnăvioara (1), Mediaş

(1), Sighişoara (8), Şaeş (24, 38), Odorhei (23); Bazna (26), Cerghid (10), Mica (10), Adămuş (10), Corund - Dealu (24)

**nt** - *Alnus glutinosa* (L.) Gaertn.: Blaj (5), Micăsasa (1), Ţapu (1), Sighişoara (8); Bazna (26), Abuş (10), Corund (24), **nt** - *A. incana* Moench.: Copşa Mică (6), Odorhei (8), Vârşag (!); Corund - Dealu (24)

**nt** - *Alopecurus geniculatus* L.: Blaj (5), Valea Lungă (1), Copşa Mică (1), Axente Sever (1), Sighişoara (8); Cerghid (10), Mica (10), **nt** - *A. pratensis* L.: Blaj (5), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Daneş (28), Odorhei (23), Zetea (23), Brădeşti (23), Târnoviţa (23), Vârşag (23); Târnăveni (!), Abuş (10), Trei Sate (10), Sărăţeni (10), Sângeorgiu de Pădure (!), Bălăuşeri (10), Corund - Dealu (24)

**R** - *Andromeda polifolia* L.: Corund - Dealu (24, 43)

**R** - *Angelica archangelica L.*: Sighişoara (8,29); Praid (29), Bucin (43) **V** - *A. palustris* (Besser) Hoffm.: Şaeş (38), **nt** - *A. silvestris* L.: Sighişoara (8), Băile Szejke - Odorhei (24), Vârşag (!); Bazna (26), Abuş (!), Sovata (29), Corund - Dealu (24) var. *elatior* Wahlbg.: Sovata (29), Corund (29)

**R** - *Asperula rivalis* Sibth. et Sm.: Odorhei (29), Sâncraiu (29)

**nt** - *Aster lanceolatus* Willd.: Sighişoara (!), **nt** - A. *novi belgii* L.: Odorhei (29), **nt** - *A. salignus* Willd.: Sighişoara (29) f. *angustatus* Borza et Nyar.: Bazna (29), **nt** - *A. sedifolius L.:* Ţapu (29), Copşa Mică (29), Odorhei (29) var. *squamosus* (Lallem.) Morariu et Nyar.: Ţapu (29), **R** - *A. tripolium* L.: Odorhei (23); Bazna (14, 26, 32, 40), Praid (8) ssp. *pannonicus* (Jacq.) Soo: Ţapu (29)

**nt** - *Berula erecta* (Huds.) Coville: Blaj (5), Axente Sever (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Albeşti (8)

**R** - *Betula pubescens* Ehrh.: Valea Lungă (1, 5), Micăsasa (5), Şaeş (24, 29, 38); Corund (24)

**nt** - *Bidens cernua* L.: Valea Lungă (1, 5), Mediaş (8), Sighişoara (8), Odorhei (21), f. *semiradians* Nyar.: Sovata (29), **nt** - *B. tripartita* L.: Mediaş (8), Sighişoara (8), Odorhei (21), Vârşag (21); Bazna (26), Târnăveni (!), f. *pumila* Roth: Sovata (29), Corund (29)

**R** - *Blysmus compressus* (L.) Panzer: Odorhei (23), Băile Szejke - Odorhei (24),Vârşag (23); Corund - Dealu (24, 29,43)

**nt** - *Bolboschoenus maritimus* (L.) Palla: Blaj (!); Bazna (HKA), Abuş (10) f. *didymus* Godr.: Blaj (5)

**nt** - *Bryonia alba* L.: Blaj (!),Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Odorhei (8); Bazna (26)

**nt** - *Butomus umbellatus* L.: Blaj (1), Veza (5), Copşa Mică (1), Mediaş (1), Sighişoara (8),

**R** - *Calamagrostis canescens* (Weber) Roth: Valea Lungă (1, 29), Mănărade (1, 29), Axente Sever (1), Târnăvioara (1), Mediaş (1), Sighişoara (8, 29), Şaeş (24, 29, 38),

**E** - *Calla palustris* L.: Mănărade (29), Dealu (29), Dealu (24); Praid (29), Corund (24, 29)

**nt** - *Callitriche cophocarpa* Sendtner: Copşa Mică (!), **R** - *C. palustris* L.: Valea Lungă (1, 5), Copşa Mică (1), Şeica Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8); Corund - Dealu (24), **I** - *C. stagnalis* Scop.: Blaj (5)

**nt** - *Caltha palustris* L. ssp. *laeta* (Schott, Nym. et Kotschy) Hegi: Blaj (5), Târnava (1, 32), Târnăvioara (!), Mediaş (1, 8, 27, 32), Sighişoara (8), Şaeş (24), Odorhei (23, 24), Vârşag (23, !); Bazna (26), Târnăveni (!), Abuş (10), Trei Sate (10), Sărăţeni (10), Ghindari (10); Corund - Dealu (24) var. pseudocornuta Zap.: Praid (29), var. *alpina* (Schur) Graebn.: Târnava (29), Târnăvioara (29), Mediaş (29), Sighişoara (29); Sovata (29)

**nt** - *Calystegia sepium* L.: Blaj (5), Ţapu (1), Copşa Mică (1), Axente Sever (1), Mediaş (1), Dumbrăveni (!),Sighişoara (8), Cădişeni (21), Feliceni (21), Odorhei (21, 23); Bazna (26), Târnăveni (!), Abuş (!)

**nt** - *Cardamine amara* L.: Blaj (29), Mănărade (29), Valea Lungă (29), Ţapu (29, 32), Copşa Mică (29, 32), Şeica Mică (1), Axente Sever (29, 32), Târnăvioara (1, 29, 32), Mediaş (29, 32), Sighişoara (29), Odorhei (29, 43), Vârşag (!); Sovata (29), Dealu (29), **nt** - *C. pratensis L.:* Târnava (1, 5, 15, 29, 32), Târnăvioara (1, 29, 32), Mediaş (1, 29, 32), Sighişoara (8, 29), Odorhei (23, 29, 43), Cădişeni (29), Vârşag (23,!), Dealu (23, 29); Ghindari (10), Abuş (10), Trei Sate (10), Sărăţeni (10), Sovata (10), Praid (43), Corund - Dealu (24) ssp. *matthiolii* (Moretti) Arc.: Dumbrăveni (29), Porumbenii Mari (29), Dealu (29)
**nt** - *Carduus crispus* L.
: Micăsasa (1), Târnăvioara (1), Mediaş (1); Bazna (8,26), **nt** - *C. personata* (L.) Jacq.: Sovata (29), Praid (29, 43)
**nt** - *Carex acutiformis* Ehrh.: Veza (5), Ţapu (1, 32), Copşa Mică (1, 32), Axente Sever (1, 32), Târnava (1, 32), Târnăvioara (1, 32), Mediaş (1, 32), Dumbrăveni (37), Sighişoara (8), Şaeş (24, 38); Abuş (10), Trei Sate (10), Sărăţeni (10), f. *spadicea* (Roth) A. et G.: Odorhei (29), **R** - *C. appropinquata* Schumacher: Şaeş (24, 29), Albeşti (3, 8); Corund - Dealu (24,29), **R** - *C. bueckii* Wimmer: Odorhei (29, 43); Sovata (29, 43), **R** - *C. caespitosa* L.: Blaj (5), Micăsasa (32), Ţapu (32), Copşa Mică (32), Şeica Mică (32), Axente Sever (32), Târnava (32), Târnăvioara (32), Mediaş (32), Sighişoara (8); Corund - Dealu (24,29), **nt** - *C. canescens* L. Sighişoara (8); Praid (43), Corund - Dealu (24, 29), **R** - *C. diandra* Schrank: Corund - Dealu (24), **nt** - *C. distans* L.: Copşa Mică (15), Dumbrăveni (8, 32), Sighişoara (8), Odorhei (23, 24), Târnoviţa (23), Brădeşti (23), Vârşag (23), Dealu (23); Coroisânmartin (10), Abuş (10), Sângeorgiu de Pădure (!), Bălăuşeri (10), **R** - *C. disticha* Hudson: Blaj (5, 29), Sighişoara (8, 29); Ghindari (10), **R** - *C. divisa* Hudson: Sighişoara (7, 8), **R** - *C. elata* All.: Valea Lungă (1, 5), Ţapu (1), Copşa Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1), Dumbrăveni (1, 8, 29), Şaeş (8); Dealu (29), **nt** - *C. elongata* L.: Sighişoara (8); Sovata (29, 43), Praid (43), Corund - Dealu (24, 29), **nt** - *C. flacca* Schreb.: Sighişoara (8), Cristuru Secuiesc (43), Băile Szejke - Odorhei (24), var. *clavaeformis* (Hoppe) Boeck: Sovata (29), f. *dinarica* (Heuff.) Kukenth: Sovata (29, 43), **nt** - *C. flava* L.: Blaj (5), Sighişoara (8), Cădişeni (21), Odorhei (21, 22, 23), Zetea (23), Vârşag (23), Dealu (23,24), Corund (43), **nt** - *C. gracilis* Curt.: Valea Lungă (29), Sighişoara (8, 29), Şaeş (38), Odorhei (29); Cădişeni (23), Brădeşti (23); Ghindari (10), Abuş (10), Sovata (29) var. *sphaerocarpa* (Uechtr.) Kukenth: Odorhei (29, 43), **nt** - *C. hirta* L.: Sighişoara (8), Şaeş (38), Odorhei (23), Brădeşti (23), Târnoviţa (23), Zetea (23); Cerghid (10), Mica (10), Sângeorgiu de Pădure (10), Sovata (10), Ghindari (10), Coroisânmartin (10), Bălăuşeri (10), **I** - *C. hordeistichos* Vill.: Odorhei (29), **R** - *C. hostiana* DC.: Băile Szejke - Odorhei (24, 29), **R** - *C. lepidocarpa* Tausch.: Şaeş (24, 29), Băile Szejke - Odorhei (24); Sovata (29), **nt** - *C. leporina* L.: Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Odorhei (23), Vârşag (23), Dealu (23); Sovata (10), **R** - *C. limosa* L.: Fekete Pálné - Dealu (24), Praid - Dealu (29, 43), **K** - *C. melanostachya* Bieb.: Şaeş (24), **nt** - *C. nigra* (L.) Rchb.: Şaeş (24); Corund - Dealu (24), **nt** - *C. pallescens* L.: Valea Lungă (1, 5), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Odorhei (23), Zetea (23), Târnoviţa (23), Vârşag (23), Dealu (23), **nt** - *C. panicea* L.: Şaeş (24), Băile Szejke - Odorhei (24), **R** - *C. paniculata* L.: Sighişoara (7, 8), Albeşti (3, 8), Porumbenii Mari (29, 43), Băile Szejke - Odorhei (24), Dealu (29), **V** - *C. pauciflora* Lightf.: Corund - Dealu (24, 29), **R** - *C. x pieperiana* P. Junge: Zetea (29), **nt** - *C. pseudocyperus* L.: Valea Lungă (29), **nt** - *C. remota* L.: Blaj (5), Copşa Mică (1), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (29); Sovata (29, 43), nt - *C. riparia* Curt.: Valea Lungă (1, 5), Copşa Mică (1, 32), Axente Sever (1, 32), Mediaş (1, 32), Sighişoara (8); Sărăţeni (10), Corund - Dealu (24), **nt** - *C. rostrata* Stokes: Sighişoara (8); Corund - Dealu (24, 29, 43), **nt** - *C. secalina* Willd.: Mănărade (1, 5, 29), Târnăvioara (29), Dumbrăveni (37), **nt** - *C. stellulata* Good.: Sighişoara (8), Şaeş (24, 38), Odorhei (29), Vârşag (23); Corund - Dealu (24,

29), **nt** - *C. vesicaria* L.: Şaeş (24, 38), Odorhei (29, 43), **nt** - *C. vulpina* L.: Valea Lungă (1, 5), Copşa Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Şaeş (24, 38), Cădişeni (23), Brădeşti (23), Odorhei (23), Zetea (23), Târnoviţa (23), Vârşag (23); Ghindari (10), Abuş (10), Coroisânmartin (10), Sângeorgiu de Pădure (!), Bălăuşeri (10).
**nt** - *Carpesium cernuum* L.: Blaj (29), Valea Lungă (29), Şeica Mică (1, 29, 32), Mediaş (1, 29, 32)
**R** - *Catabrosa aquatica* (L.) Beauv.: Blaj (5), Mănărade (5), Ţapu 32), Copşa Mică (32), Axente Sever (32), Târnava (32), Târnăvioara (32), Mediaş (32), Dumbrăveni (8, 32, HS); Sărăţeni (10), Abuş (10), Adămuş (10) f. *uniflora* S.F. Gray: Odorhei (43)
**R** - *Centaurium pulchellum* (Swartz) Druce: Blaj (5), Copşa Mică (15), Şeica Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1,29), Odorhei (8, 29, 41, 43), Cădişeni (23), Brădeşti (23); Bazna (26, 29, 32), Sovata (29), Corund (29) f. *meyeri* Bge.: Corund (29)
**nt** - *Ceratophyllum demersum* L.: Valea Lungă (29), Axente Sever (1, 29, 32), Dumbrăveni (!), **R** - *C. submersum* L.: Valea Lungă (29), Axente Sever (29), Sighişoara (8),
**nt** - *Chrysosplenium alternifolium* L.: Valea Lungă (1, 5), Micăsasa (1, 5), Ţapu (1), Axente Sever (1), Târnava (1), Mediaş (1, 8, 27, 29), Sighişoara (8, 29), Vârşag (!)
**nt** - *Cicuta virosa* L.: Blaj (29), Copşa Mică (1, 29), Axente Sever (1, 29), Mediaş (1, 29), Sighişoara (8, 29); Bazna (29)
**nt** - *Cirsium canum* ( L.) All.: Valea Lungă (1, 5), Sighişoara (8), Şaeş (38); Cerghid (10), Mica (10), Ghindari (10), Sângeorgiu de Pădure (10), Coroisânmartin (10), Bălăuşeri (10), **nt** - *C. erisithales* (Jacq.) Scop.: Feliceni (21), Odorhei (21, 23), **R** - *C. heterophyllum* (L.) Hill.: Zetea (29); Sovata (29), **K** - *C. oleraceum* (L.) Scop.: Axente Sever (1), Mediaş (1), Sighişoara (8), Şaeş (24); Bazna (26), **R** - *C. palustre* (L.) Scop.: Şaeş (24), Odorhei (23, 43), Brădeşti (23), Târnoviţa (23), Vârşag (23); Bazna (40), Praid (438, Corund (43), **nt** - *C. rivulare* (Jacq.) All.: Odorhei (8, 23, 43), Zetea, Vârşag (23); Bazna (26),
**R** - *Comarum palustre* L.: Şaeş (8, 24, 38), Saschiz (29); Corund - Dealu (24)
**nt** - *Crepis paludosa* (L.) Moench.: Corund - Dealu (24)
**nt** - *Cyperus flavescens L.:* Blaj (1), Valea Lungă (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Cădişeni (23), Brădeşti (23), Odorhei (23); Bazna (HKA), **nt** - C. *fuscus* L.: Blaj (1), Valea Lungă (1), Copşa Mică (HU), Sighişoara (8), Cădişeni (23), Brădeşti (23); Bazna (26, 29), *C. glomeratus L.:* Blaj (5)
**R** - *Dactylorhiza incarnata* (L.) Soo: Mediaş (29, 32), Şaeş (24), Odorhei (43), var. *extensa* Hartm.: Zetea (43), **R** - D. *majalis* (Rchb.) P. F. Hunt et Summerh.: Mediaş (1), Sighişoara (8, 29), Albeşti (29), Odorhei (8, 29) var. *extensa* Hartm.: Zetea (29) f. *subfoliosa* (M. Schulze) Borza: Odorhei (29)
**nt** - *Deschampsia caespitosa* (L.) Beauv.: Târnava (1), Târnăvioara (!), Mediaş (1), Sighişoara (8), Şaeş (24, 38), Odorhei (23, 24), Brădeşti (23), Zetea (23), Târnoviţa (23), Vârşag (21, 23), Dealu (23); Târnăveni (!), Ghindari (10), Chibed (10), Abuş (10), Sovata (10), Sângeorgiu de Pădure (!), Bălăuşeri (10), Corund - Dealu (24) var. *parviflora* (Thuill.) Hegi: Sovata (29)
**R** - *Dianthus superbus* L.: Micăsasa (1, 32); Corund (29)
**V** - *Drosera intermedia* Hayne: Saroş pe Târnave (35), **R** - *D. rotundifolia* L.: Şaeş (8, 24, 29, 38); Corund (24, 29)
**R** - *Dryopteris thelipteris* (L.) A. Gray: Sighişoara (29), Şaeş (24,29); Corund - Dealu (24)
**nt** - *Echinocystis lobata* (Michx) Torrey et Gray: Odorhei (21, 22), Feliceni (21)
**E** - *Elatine alsinastrum L.:* Blaj (1, 5, 29), Valea Lungă (1, 5, 29), Axente Sever (1, 29, 32)
**R** - *Eleocharis acicularis* (L.) Roem. et Schult.: Dumbrăveni (37), Sighişoara (7, 8), **R** - *E. carniolica* Koch: Odorhei (29); Corund (29), **nt** - *E. palustris* (L.) Roem. et Schult.: Blaj (5), Şeica Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1), Dumbrăveni (37), Sighişoara (8), Şaeş (24, 38), Odorhei (23, 24), Dealu (23); Cerghid (10), Ghindari (10),

Chibed (10), Sărăţeni (10), Abuş (10), Trei Sate (10), Sângeorgiu de Pădure (10), Sovata (!), **V** - *Eleocharis uniglumis* (Link) Schult.: Băile Szejke - Odorhei (24, 29)
**R** - *Empetrum nigrum* L.: Corund - Dealu (24)
**nt** - *Epilobium hirsutum* L.: Târnava (1), Târnăvioara (!), Mediaş (1), Sighişoara (8), Odorhei (8, 21, 23), Cădişeni (21), Feliceni (21), Vârşag (23); Praid (29), **nt** - *E. palustre* L.: Şaeş (8, 24), **R** - *E. parviflorum* Schreb.: Micăsasa (1), Târnava (1), Mediaş (1), Sighişoara (8), Vârşag (21, !)
**R** - *Epipactis palustris* (L.) Crantz: Blaj (5), Micăsasa (1, !), Ţapu (1), Copşa Mică (1), Mediaş (1, 29), Târnăvioara (1), Sighişoara (8, 29), Şaeş (24, 38); Sovata (29), Corund - Dealu (24)
**nt** - *Equisetum fluviatile* L.: Copşa Mică (15), Sighişoara (8, 29), Şaeş (24), **R** - *E. hyemale* L.: Sighişoara (8, 29), **nt** - *E. palustre* L.: Şaeş (24, 38), Odorhei (23), Vârşag (23), Dealu (23); Bazna (29, 40), Ghindari (10), Chibed (10), Sărăţeni (10), Cerghid (10), Mica (10), Abuş (10), Trei Sate (10), Sărăţeni (10), Sângeorgiu de Pădure (10), Bălăuşeri (10), Praid (29), Corund (29), **nt** - *E. telmateia* Ehrh.: Copşa Mică (15), Sighişoara (8), Şaeş (8); Sângeorgiu de Pădure (10), Sovata (29), **nt** - *E. sylvaticum* L.: Corund - Dealu (24), **V** - *E. variegatum* Schleich.: Sighişoara (29), Cădiceni (22, 23), Brădeşti (22, 23)
**nt** - *Eriophorum angustifolium* Honckeny: Şaeş (24), Băile Szejke - Odorhei (24, 43); Praid (43), Corund - Dealu (24), **R** - *E. gracile* Koch: Porumbenii Mari (29, 43), **nt** - *E. latifolium* Hoppe: Valea Lungă (1), Târnăvioara (1, 32), Mediaş (1,32), Dumbrăveni (8, 32, HF), Sighişoara (8), Şaeş (24), Porumbenii Mari (43), Odorhei (23, 43), Băile Szejke - Odorhei (24), Vârşag (23), Dealu (23); Bazna (26), **R** - *E. vaginatum* L.: Corund - Dealu (24)
**nt** - *Eupatorium cannabinum* L.: Blaj (5), Mediaş (28), Sighişoara (8), Şaeş (24, 38), Odorhei (23), Vârşag (23); Bazna (26, 29)
**K** - *Euphorbia palustris* L.: Valea Lungă (1, 5, 29), Târnăvioara (1, 5, 15, 29, 32), Sighişoara (8, 29)
**nt** - *Festuca pratensis* L.: Mediaş (28), Şaeş (38), Daneş (28), Cădişeni (21, 23), Brădeşti (23), Odorhei (23), Zetea (23), Târnoviţa (23), Vârşag (23); Bazna (40), Ghindari (10), Coroisânmartin (10), Sângeorgiu de Pădure (10), Bălăuşeri (10), Corund - Dealu (24)
**nt** - *Filipendula ulmaria* (L.) Maxim: Mediaş (1), Odorhei (23, 24), Zetea (23), Vârşag (23, !); Sovata (!), Corund - Dealu (24) f. *quinqueloba* (Bgt.) A. et G.: Sovata (29), f. *denudata* (J. et C. Presl.) Beck: Praid (29)
**nt** - *Frangula alnus* Miller: Mediaş (8), Sighişoara (8), Şaeş (24), Odorhei (8, 24); Bazna (26, 40), Corund - Dealu (24)
**nt** - *Galega officinalis* L.: Copşa Mică (HS)
**nt** - *Galium boreale* L.: Valea Lungă (1, 5), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Odorhei (22), Sâncraiu (29), var. *pseudorubioides* Schur: Sovata (29), **nt** - *G. palustre* L.: Valea Lungă (1, 5), Ţapu (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Şaeş (24, 38), Cădişeni (23), Brădeşti (23), Odorhei (23), Vârşag (23); Abuş (10), Trei Sate (10), Sărăţeni (10), Corund - Dealu (24), **R** - *G. rubioides* L.: Blaj (5), Mănărade (29), Copşa Mică (1, 29, 32), Târnăvioara (1, 29, 32), Mediaş (1, 29), Sighişoara (29), Odorhei (29), Sâncraiu (29); Bazna (HKA), **nt** - *G. uliginosum* L.: Blaj (5), Valea Lungă (29), Ţapu (1, 29), Mediaş (1, 29), Târnăvioara (29), Sighişoara (8, 29), Şaeş (24), Odorhei (23, 29), Sâncraiu (29), Vârşag (23), Dealu (23, 24)
**R** - *Gentiana pneumonanthe* L.: Tiur (5), Sighişoara (8)
**nt** - *Geranium palustre* L.: Mănărade (5), Ţapu (1, 5, 29), Micăsasa (1, 29), Mediaş (1, 29), Sighişoara (8, 29), Odorhei (43), Sovata (43), Corund (43)
**nt** - *Geum rivale* L.: Odorhei (29), Vârşag (29, 43, !); Praid (29, 43), Dealu (29), Bucin (43)
**R** - *Gladiolus imbricatus* L.: Mănărade (1, 5), Păucea (35), Târnăvioara (1), Sighişoara (8)
**nt** - *Glyceria fluitans* (L.) R.Br.: Blaj (5), Copşa Mică (1), Axente Sever (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Şaeş (24); Sărăţeni (10), **nt** - *G. maxima* (Hartm.) Holmberg: Blaj (5),

Țapu (1), Copşa Mică (1), Axente Sever (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Şaeş (38); Chibed (10), Sărăţeni (10), **nt** - *G. plicata* (Fries) Fries: Odorhei (22, 23); Cerghid (10), Mica (10)
**nt** - *Gnaphalium uliginosum* L.: Micăsasa (1), Copşa Mică (1), Şeica Mică (1), Axente Sever (1), Târnăvioara (1); Bazna (HKA), var. *strictum* Nyar.: Corund (29, 43)
**nt** - *Helianthus decapetalus* L.: Mediaş (!)
**nt** - *Holcus lanatus* L.: Mediaş (28,!), Dumbrăveni (!),Sighişoara (8), Odorhei (!), Vârşag (!); Ghindari (10), Sângeorgiu de Pădure (!), Bălăuşeri (10), Sovata (!)
**V** - *Hottonia palustris* L.: Sighişoara (8)
**nt** - *H. quadrangulum* L.: Târnava (28), Mediaş (29), Sighişoara (8),
**nt** - I*mpatiens glandulifera* Royle:Porumbenii Mari (42,!), Ghindari (42); Sovata (!), Praid (29), Şiclod (42), **nt** - *I. noli - tangere* L.: Mediaş (1), Sighişoara (8); Corund - Dealu (24)
**R** - *Inula helenium* L.: Blaj (5), Mănărade (1, 5, 29), Târnava (1, 29), Târnăvioara (1, 29), Mediaş (1), Sighişoara (8, 29), Odorhei (29); Bazna (26, 29, 40)
**nt** - *Iris pseudacorus* L.: Blaj (5, 29), Valea Lungă (1, 5), Copşa Mică (1), Sighişoara (8), Şaeş (24, 38); Târnăveni (!), Chibed (10), Sărăţeni (10), Abuş (10), Trei Sate (10)
**Ex** - *Isoetes setacea* Lam.: Sighişoara (7, 8)
**K** - *Juncus acutiflorus* Ehrh.: Sighişoara (8, 29), **nt** - *J. articulatus* L.: Blaj (5), Valea Lungă (1, 5), Târnăvioara (1), Şaeş (38), Băile Szejke - Odorhei (24), Cădişeni (23), Brădeşti (23); Ghindari (10), **R** - *J. atratus* Krocker: Sighişoara (29), Odorhei (43), Zetea (43), **nt** - *J. bufonius* L.: Blaj (5), Micăsasa (1, !), Țapu (1), Copşa Mică (1), Şeica Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Sighişoara (8), Cădişeni (23), Brădeşti (23); Bazna (26), **nt** - *J. compressus* Jacq.: Tiur (5), Blaj (1, 5, 29), Valea Lungă (1, 5, 29), Micăsasa (1, 29), Copşa Mică (1, 29), Şeica Mică (1), Axente Sever (1, 29), Mediaş (29), Târnava (1), Târnăvioara (1), Sighişoara (8,29), Cădişeni (23), Brădeşti (23), Dealu (24), **nt** - *J. conglomeratus* L.: Blaj (5), Micăsasa (!), Sighişoara (8), Vârşag (23), Odorhei (23), Zetea (23); Târnăveni (!), **nt** - *J. effusus* L.: Blaj (5), Valea Lungă (1, 5), Micăsasa (!), Târnava (1), Târnăvioara (1), Sighişoara (8, !), Şaeş (24, 38), Odorhei (21, 23), Zetea (23), Brădeşti (23), Cădişeni (21), Târnoviţa (23), Vârşag (21, 23, !), Dealu (23, 24); Bazna (26), Târnăveni (!), Sovata (10) **R** - *J. gerardi* Lois: Copşa Mică (15), Târnoviţa (23), Odorhei (29, 41, 43), Brădeşti (23); Bazna (29), Corund (29), **nt** - *J. inflexus* L.: Blaj (5); Cerghid (10), Mica (10), Ghindari (10), Sângeorgiu de Pădure (10), Sovata (!), **Ex** - *J. tenageia* Ehrh.: Sighişoara (8, 29), **R** - *J. thomassii* Ten.: Valea Lungă (29), Odorhei (22), Brădeşti (22), *J. triglumis* L.: Blaj (5)
**nt** - *Lathyrus palustris* L.: Sighişoara (29)
**R** - *Leersia oryzoides* (L.) Swartz: Valea Lungă(1, 5), Târnăvioara (1), Mediaş (1), Odorhei (22)
**I** - *Lemna gibba* L.: Țapu (5, 29), Sighişoara (8, 29), **nt** - *L. minor* L.: Valea Lungă (1, 5), Sighişoara (8), **nt** - *L. trisulca* L.: Valea Lungă (1, 5), Şaeş (24)
**R** - *Ligularia sibirica* (L.) Cass.: Corund-Dealu (24,29)
**R**- *Limonium gmelini* (Willd.) O. Ktze.: Tiur (29), Odorhei (29,41, 43)
**nt**- *Lychnis flos-cuculi* L.: Blaj (5), Târnava (1), Târnăvioara (1), Mediaş (1), Odorhei (23), Zetea (23), Târnoviţa (23), Brădeşti (23), Vârşag (23), Dealu (23); Ghindari (10), Sovata (10), Sângeorgiu de Pădure (!), Bălăuşeri (10), Corund - Dealu (24)
**nt** - *Lycopus europaeus* L.: Blaj (5), Valea Lungă (1, 5), Copşa Mică (1), Şeica Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1, !), Mediaş (1), Sighişoara (8), Şaeş (24), Feliceni (21), Odorhei (8, 21, 24), Vîrşag (21); Sângeorgiu de Pădure (10), Sovata (!), Ghindari (!), Abuş (!) f. *glabrescens* Schmidely: Corund (43), **R** - *L. exaltatus* L.: Mănărade (5), Sighişoara (8)
**nt** - *Lysimachia nummularia* L.: Blaj (5), Târnava (28), Târnăvioara (!), Mediaş (8, 27, 28), Daneş (28), Sighişoara (8), Şaeş (24, 38), Odorhei (8, 23), Zetea (23), Târnoviţa (23), Brădeşti

(23), Vârşag (23), Dealu (23); Bazna (26,40), Abuş (10), Trei Sate (10), Sărățeni (10), Sovata (10), **R** - *L. thyrsiflora* L.: Lacul Racului - Porumbenii Mari (24,29, 43); Bazna (HF), **nt** - *L. vulgaris* L.: Micăsasa (5), Copşa Mică (15), Axente Sever (1), Mediaş (1, 8, 28), Sighişoara (8), Albeşti (8) Şaeş (24), Odorhei (8, 23, 24); Abuş (10), Chibed (10), Sărățeni (10)f. *paludosa* Baumg.: Şaeş (8, 29)

**R** - *Lythrum hyssopifolia* L.: Blaj (1, 5, 29), Valea Lungă (1, 5), Axente Sever (1), Mediaş (1), Sighişoara (8, 29), Odorhei (8, 29, 43); Bazna (8, 26, 29), Sovata (29), Praid (29, 43), **nt** - *L. salicaria* L.: Blaj (5), Valea Lungă (5), Țapu (1), Copşa Mică (1, 15), Şeica Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1, !), Mediaş (1, 8, 29), Sighişoara (8, 29), Şaeş (24, 38), Odorhei (8, 23, 29), Zetea (23), Târnovița (23), Brădeşti (23), Vârşag (21, 23, !), Dealu (23); Bazna (26), Târnăveni (!), Chibed (10), Abuş (10), Trei Sate (10), Sărățeni (10), Sângeorgiu de Pădure (10), Ghindari (10), Bălăuşeri (10), **nt** - *L. virgatum* L.: Sighişoara (8, 29)

**nt** - *Matteuccia struthiopteris* (L.) Tod.: Vârşag (!)

**nt** - *Mentha aquatica* L.: Blaj (5), Copşa Mică (1), Axente Sever (1), Mediaş (1, 32), Sighişoara (8), Şaeş (8, 24), Odorhei (21, 23), Vârşag (21, 23, !), Dealu (23); Sărățeni (10), Cerghid (10), Mica (10), Adămuş (10), Abuş (10), Trei Sate (10), Sângeorgiu de Pădure (10), var. *riparia* Schreb.: Valea Lungă (29), Szeike-Odorhei (43), **nt** - *M. arvensis* L.: Mănărade (5), Valea Lungă (5), Târnăvioara (1), Sighişoara (8), Odorhei (43); Abuş (!) var. *duftschmidtii* Top.: Valea Lungă (29), Mănărade (29), Târnăvioara (29), Mediaş (36); Sovata (29), f. *confertidens* Top.: Mediaş (36), var. *nobilis*: Corund - Dealu (24), var. *foliicoma* (Op.) Top.: Valea Lungă (29), Târnăvioara (29), var. *austriaca* (Jacq.) Top.: Odorhei (29); Corund (29), var. *hostii* (Bor.) Top.: Mediaş (29), V. Târnava Mare (29), **K** - *M. x dalmatica* Tauisch: Mediaş (36), var. *bihariensis* (Borb.) Briq.: Blaj (29), **K** - *M. x dumetorum* Schult. var. *dissimilis* (Des.) Top.: Valea Lungă (29), Odorhei (43), f. *muscogena* Top.: Valea Lungă (29), **K** - *M. x gentilis* L.: Sighişoara (8), **K** - *M. x haynaldiana* Borb.: Satulung (29), **K** - *M. x laciniosa* Schur var. *diespasmena* Briq.: Odorhei (29), **nt** - *M. longifolia* L.: Blaj (5), Mediaş (28), Sighişoara (8), Odorhei (8); Târnăveni (!), Sângeorgiu de Pădure (10), Sovata (!), var. *wierzbickiana* (Op.) Briq.: Valea Lungă (29), Țapu (36), var. *balsaminiflora* (H.Br.) Top.: Valea Lungă (29), var. *barthiana* (Borb.) Top.: Valea Lungă (29), f. *graciliflora* Top.: Valea Lungă (29), var. *acuminata* Top.: Valea Lungă (29), var. *chaunanthera* Top.: Valea Lungă (29), var. *eclyanthera* Top.: Valea Lungă (29), var. *hallosyana* (Borb.) Top.: Valea Lungă (29), var. *retinervis* Borb.: Odorhei (43) var. *leioneura* (Borb.)Top.: Valea Lungă (29), Odorhei (43), f. *subfissidens* Borb.: Valea Lungă (29), var. *marisensis* (Simk.) Top.: Valea Lungă (29), var. *paramecophyllon* Top.: Valea Lungă (29), f. *prodani* Top.: Valea Lungă (29), var. *phaecoma* Briq.: Valea Lungă (29), var. *firmicaulis* Briq.: Valea Lungă (29), var. *viridescens* Borb.: Valea Lungă (29), **nt** - *M. pulegium* L.: Blaj (5), Micăsasa (1, !), Țapu (1), Copşa Mică (15), Şeica Mică (8), Axente Sever (1), Târnava (1), Târnăvioara (!), Mediaş (1), Sighişoara (8), Albeşti (8), **K** - *M. rotundifolia* L.: Mediaş (1), Târnava (1), Târnăvioara (1), Sighişoara (8), Daneş (8), Şaeş (8), **K** - *M. spicata* L.: Saroş pe Târnave (8), Sighişoara (8), **nt** - *M. verticillata* Bgt.: Sighişoara (8), Albeşti (8), f. *dorealis* Top.: V. Târnava Mare (29), **K** - *M. villosa* Huds.: Sighişoara (8), Daneş (8)

**R** - *Menyanthes trifoliata* L.: Țapu (1, 29, 32), Mediaş (29), Sighişoara (8, 29), Şaeş (8, 24, 29, 38), Porumbenii Mari (29, 43), Băile Szejke - Odorhei (24, 29), Fekete Pálné - Dealu (24, 29)

**nt** - *Molinia coerulea* (L.) Moench.: Blaj (5), Şaeş (24), Zetea (23) ssp. *arundinacea* (Schrank.) Pawl.: Sovata (29)

**nt** - *M. scorpioides* L.: Blaj (5), Mediaş (8, 27), Sighişoara (8), Şaeş (24, 38), Odorhei (8, 23, 24), Zetea (23), Târnovița (23), Brădeşti (23), Vârşag (23), Dealu (23); Abuş (10), Trei Sate (10), Sărățeni (10), Ghindari (10) var. *elatior* Opiz: Corund (29, 43) var. *memor* Kitt.: Cristuru Secuiesc (!)

**K** - *Myosurus minimus* L.: Copşa Mică (1, 29, 32), Sighişoara (8, 29), Şaeş (8)
**nt** - *Myricaria germanica* (L.) Desv.: Blaj (5), Axente Sever (1), Mediaş (14), Sighişoara (8),
**nt** - *Myriophyllum spicatum* L.: Blaj (5, 29), Valea Lungă (1, 5, 29), Sighişoara (8, 29), **nt** - *M. verticillatum* L.: Blaj (5, 29), Valea Lungă (1, 5, 29), Dumbrăveni (!), Sighişoara (8, 29)
**V** - *Narcissus angustifolius* Curt.: Odorhei (29, 43), Hoghia (43), Dealu (29); Sărăţeni (29), Sovata (29, 43)
**I** - *Nasturtium officinale* R. Br.: Blaj (1, 5), Valea Lungă (1, 5), Ţapu (1), Copşa Mică (1), Şeica Mică (1), Axente Sever (1), Târnăvioara (1), Mediaş (1),
**nt** - *Oenanthe aquatica* (L.) Poiret: Axente Sever (1), Mediaş (1), Sighişoara (8), Odorhei (23), **R** - *O. banatica* Heuff.: Sighişoara (29), Odorhei (43), Zetea (29, 43); Sovata (29), Praid (29, 43), Corund (29, 43), **nt** - *O. fistulosa* L.: Blaj (5, 29), Valea Lungă (29), Axente Sever (1), Mediaş (1, 29), Târnava (29), Sighişoara (8, 29), **R** - *O. silaifolia* Bieb.: Dumbrăveni (HS), Sighişoara (8); Praid (3, 8, 43), **R** - *O. stenoloba* Schur: Valea Lungă (29), Mediaş (29), Târnava (29)
**K** - *Ophioglossum vulgatum* L.: Odorhei (22)
**R** - *Orchis laxiflora* Lam.: Blaj (5), Mănărade (5), ssp. *elegans* (Heuff.) Soo: Târnăvioara (1), Mediaş (1), Sighişoara (8), Şaeş (24), Odorhei (43), var. *javorkae* Soo: Mănărade (29)
**nt** - *Parnassia palustris* L.: Spătac (5), Târnava (1), Mediaş (1), Sighişoara (8), Odorhei (23)
**R** - *Parthenocissus inserta* (A. Kern.) K. Fritsch: Mediaş (1); Bazna (40)
**nt** - *Pedicularis palustris* L.: Mediaş (29), Odorhei (23,29), Băile Szejke - Odorhei (24), Cădişeni (43), Corund (43)
**nt** - *Peplis portula* L.: Odorhei (!)
**nt** - *Petasites albus* (L.) P. Gaertn.: Valea Lungă (1,5), Târnăvioara (32), Mediaş (8,32), Sighişoara (8), Vârşag (43, !); Corund - Dealu (24), **nt** - *P. hybridus* (L.) P. Gaertn.: Valea Lungă (1, 5), Târnăvioara (1), Mediaş (1, 8), Sighişoara (8), Vârşag (!); Bazna (26), **R** - *P. paradoxus* (Retz) Baumg.: Sighişoara (29)
**R** - *Peucedanum palustre* (L.) Moench.: Sighişoara (8,29), Şaeş (24); Praid (29, 43), Corund-Dealu (24) f. *angustifolium* (Rchb.) Thell.: Sighişoara (29),
**nt** - *Phalaris arundinacea* L.: Valea Lungă (1), Sighişoara (8); Abuş (10), Trei Sate (10), Sărăţeni (10), Ghindari (10)
**nt** - *Phragmites australis* (Cav.) Trin. et Steudel: Blaj (5), Copşa (1, 28), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Şaeş (38), Porumbenii Mari (42), Odorhei (23, 24), Subcetate (42); Târnăveni (!), Abuş (10), Adămuş (10), Chibed (10), Sărăţeni (10), Trei Sate (10), Sângeorgiu de Pădure (10), Sovata (!)
**R** - *Plantago altissima L.:* Valea Lungă (29); Sovata (29), **R** - *P. cornuti* Gouan: Tiur (5), Târnăvioara (HNY); Bazna (26), Sovata (29), **R** - *P. maritima* L.: Tiur (5), Ţapu (HB), Târnăvioara (HNY), Odorhei (8, 29, 41); Sovata (29), Praid (8, 29) f. *leptophylla* Mert. et Koch: Odorhei (29); Sovata (29), Praid (29), Corund (29)
**nt** - *Poa palustris* L.: Blaj (1, 5), Târnăvioara (1), Mediaş (1), Cădişeni (23), Brădeşti (23); Ghindari (10), **nt** - *P. trivialis* L.: Blaj (5), Mănărade (5), Valea Lungă (1,5), Copşa Mică (1), Târnăvioara (1), Mediaş (1), Daneş (28), Cădişeni (23), Brădeşti (23), Odorhei (21, 23), Zetea (23), Târnoviţa (23), Vîrşag (21, !); Bazna (26), Adămuş (10), Chibed (10), Cerghid (10), Mica (10), Abuş (10), Trei Sate (10), Sărăţeni (10), Ghindari (10), Sângeorgiu de Pădure (10), Bălăuşeri (10), Corund - Dealu (24)
**nt** - *Polygonum amphibium* L.: Micăsasa (1), Şeica Mică (1), Mediaş (1), Sighişoara (8), Odorhei (23); Bazna (26), Abuş (10), Trei Sate (10), Sărăţeni (10), Bălăuşeri (10), **nt** - *P. bistorta* L.: Blaj (5), Târnăvioara (1,29), Sighişoara (8,29), Odorhei (8,29, 43), Vârşag (23); Corund - Dealu (24), **nt** - *P. cuspidatum* Sieb. et Zucc.:Secuieni (42), Porumbenii Mari (42), Mugeni (42), Odorhei (42, !),

Subcetate (42), Poiana Târnavei (42); Abuş (!), Bălăuşeri (42), Ghindari (42), Sovata (42), **nt** - *P. hydropiper* L.: Blaj (5), Copşa Mică (1, 15), Axente Sever (1), Mediaş (1), Sighişoara (8), Odorhei (23); Bazna (26), Târnăveni (!), Sovata (29), f. *ramosissimum* Zapal.: Sovata (29), **nt** - *P. lapathifolium* L.: Sighişoara (8), Cădişeni (21), Odorhei (21), Vârşag (21, !); Târnăveni (!), Abuş (!) var. *incanum* (F.W. Schidt) Koch: Sighişoara (8); Sovata (29) var. *tomentosum* (Schrank) Beck: Corund (29), **K** - *P. minus* Huds.: Odorhei (8, 29, 43); Sărăţeni (10), Corund (29), **nt** - *P. mite* Schrank: Sighişoara (29), Cădişeni (22), Brădeşti (22), Odorhei (21), Vârşag (21); Sovata (29), **nt** - *P. persicaria* L.: Blaj (5), Copşa Mică (1), Axente Sever (1), Mediaş (1,8), Daneş (28), Sighişoara (8); Târnăveni (!), Corund (29)

**nt** - *Populus alba* L.: Blaj (5), Micăsasa (!), Mediaş (8, 29), Sighişoara (8,29), **nt** - *P. canescens* Sm.: Sighişoara (8), **nt** - *P. nigra* L.: Sighişoara (8, 29), Odorhei (43); Corund (43)

**I** - *Potamogeton acutifolius* Link: Sighişoara (29), **R** - *P. compressus L.*: Sighişoara (8,29), **nt** - *P. crispus* L.: Valea Lungă (1, 5), Mediaş (1), Sighişoara (8), Albeşti (8), **I** - *P. gramineus* L.: Sighişoara (8,29), **R** - *P. lucens* L.: Sighişoara (29), **nt** - *P. natans* L.: Blaj (5), Mediaş (1, 29), Sighişoara (8, 29); Bazna (26), **nt** - *P. perfoliatus* L.: Sighişoara (8, 29 var. *densifolius* Mey.: Sighişoara (29), **nt** - *P. pusillus* L.: Sighişoara (8, 29)

**K** - *Potentilla anglica* Laichard.: Mediaş (29, 32), **nt** - *P. anserina* L.: Blaj (5), Micăsasa (!), Şaeş (24), Cădişeni (23), Brădeşti (21,23), Odorhei (23), Vârşag (!); Bazna (26), **nt**- *P. reptans* L.: Blaj (5), Valea Lungă (1, 5), Micăsasa (!), Mediaş (8), Sighişoara (8), Şaeş (38), Cădişeni (21), Vârşag (!); Bazna (26), Abuş (10), Trei Sate (10), Sărăţeni (10), Sângeorgiu de Pădure (!), Sovata (10), Ghindari (!), **nt** - *P. supina* L.: Blaj (1, 5), Mănărade (1, 5), Micăsasa (1, 5), Ţapu (1), Copşa Mică (1), Axente Sever (1), Mediaş (1, 8), Sighişoara (8)

**nt** - *Prunus padus* L.: Blaj (5), Mediaş (6, 27, 29, 32), Sighişoara (29), Cristuru Secuiesc (29, 43), Odorhei (29, 43), Zetea (29, 43)

**R** - *Puccinellia distans* (L.) Parl.: Tiur (5); Praid (8) var. *capillaris* (Lilj) Marss.: Sovata (29), **R** - *P. limosa* (Schur) Holmberg: Odorhei (41, 43); Sovata (29), Praid (29, 43), **R** - *P. transsilvanica* (Schur) Jav.: Praid (29) var. arenaria Schur: Odorhei (29)

**nt** - *Pulicaria dysenterica* (L.) Bernh.: Blaj (1, 5, 29), Mănărade (1, 5, 29), Valea Lungă (1, 5, 29), Ţapu (1, 29), Copşa Mică (15), Şeica Mică (29), Axente Sever (1, 29), Târnava (1, 29), Mediaş (1, 29), Târnăvioara (1, 29, !), Sighişoara (8, 29); Bazna (26, 29), Târnăveni (!), **nt** - *P. vulgaris* Gaertn.: Copşa Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1); Bazna (HF)

**K** - *Ranunculus aquatilis* L.: Blaj (5), Sighişoara (7, 8, 29), **R** - *R. circinatus* Sibth.: Blaj (1, 5), Valea Lungă (1, 5), **nt** - *R. flammula* L.: Sighişoara (8); Corund - Dealu (24), **K** - *R. fluitans* Lam.: Praid (8, 43), **R** - *R. lingua* L.: Ţapu (1, 5, 29), Şaeş (8, 24, 29, 38), **nt** - *R. repens* L.: Blaj (5), Copşa Mică (28), Târnava (28), Târnăvioara (!), Mediaş (28), Daneş (28), Sighişoara (8), Şaeş (24, 38), Odorhei (23), Vârşag (23), Dealu (23); Bazna (26,40), Târnăveni (!), Ghindari (10), Sărăţeni (10), Adămuş (10), Cerghid (10), Mica (10), Abuş (10), Trei Sate (10), Sângeorgiu de Pădure (10), Sovata (!), Coroisânmartin (10), **R** - *R. rionii* Lagger: Blaj (29), Valea Lungă (29), Axente Sever (29, 32), Târnava (1, 29), Târnăvioara (1, 29), Mediaş (1, 29, 32), Sighişoara (29), Odorhei (29, 43), **nt** - *R. sceleratus* L.: Blaj (1, 5), Valea Lungă (1, 5), Ţapu (1), Copşa Mică (1), Şeica Mică (1), Axente Sever (1), Târnava (1), Târnăvioara (1), Mediaş (1,8,27), Sighişoara (8), Odorhei (21) ; Sărăţeni (10), Adămuş (10), Cerghid (10), Mica (10), **nt** - *R. strigulosus* Schur: Valea lungă (29), Tiur (29), Mediaş (!), Daneş (28), Şaeş (24, 38), **nt** - *R. trichophyllus* Chaix: Axente Sever (HB), Sighişoara (8); Praid (29, 43)

**nt** - *Rorippa amphibia* (L.) Bess.: Blaj (29), Mănărade (29), Valea Lungă (1, 5), Ţapu (1, 29), Copşa Mică (1, 29), Şeica Mică (1, 29), Axente Sever (1, 29), Târnăvioara (1, 29), Mediaş (1, 29), Sighişoara (8), Şaeş (8); Bazna (26, 29), **K** - *R. x armoracioides* (Tsch.) Fuss var. *pinnatifida* (Tsch.) Borb.: Valea Lungă (29), **nt** - *R. austriaca* (Crantz) Bess.: Valea Lungă (1, 5), Târnăvioara (29), Odorhei (29, 43); Corund (29, 43), **K** - *R. x barbaraeoides* (Tsch.) Cel.: Odorhei (43), var. *reichenbachii* Knaf: Valea Lungă (29), **nt** - *R. islandica* (Oed.) Borb.: Sighişoara (29), **nt** - *R. sylvestris* (L.) Bess.: Şaeş (38), Odorhei (21); Bazna (26), Sovata (!), f. *dentata* (Koch) Borb.: Praid (29), Sovata (29)

**nt** - *Rudbeckia laciniata* L.: Abuş (10), Bălăuşeri (42), Ghindari (!), Chibed (42), Sovata (29, 43), Praid (8, 29, 42, 43), Chibed (29), Corund (29, 42, 43)

**R** - *Rumex x acutus L.:* Şaeş (29), **R** - *R. aquaticus* L.: Bazna (HF), **nt** - *R. conglomeratus* Murray: Mediaş (1, 28); Sovata (29), **nt** - *R. crispus* L.: Blaj (5), Axente Sever (1), Târnava (1, 28), Târnăvioara (1), Daneş (28), Sighişoara (8), Feliceni (21), Odorhei (21, 23); Târnăveni (!), Cerghid (10), Mica (10), Abuş (10), Trei Sate (10), Sărăţeni (10), Sângeorgiu de Pădure (10), Sovata (10), **nt** - *R. hydrolapathum* Huds.: Bazna (32), **R** - *R. maritimus* L.: Blaj (1, 5, 29), Valea Lungă (1, 5), Copşa Mică (1), Axente Sever (1,29), **nt** - *R. obtusifolius* L.: Blaj (5), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8); Sovata (29) ssp. *silvestris* (Lam.) Rech: Sovata (29), ssp. *agrestis* (Fr.) Danser: Sovata (29), ssp. *subalpinus* (Schur) Sik.: Sovata (29), **nt** - *R. palustris* Sm.: Valea Lungă (29), **nt** - *R. stenophyllus* Ldb.: Odorhei (29, 43)

**R** - *Sagittaria sagittifolia* L.: Şaeş (8, 24, 29); Bazna (26), Corund (29, 43)

**R** - *Salicornia europaea* L.: Tiur (5), Odorhei (8, 41); Bazna (14, 32, 39, 40), Sovata (29), Praid (8, 29)

**nt** - *Salix alba* L.: Blaj (5), Micăsasa (1), Mediaş (8, 27), Sighişoara (8), Odorhei (43); Bazna (26), var. *vitellina* (L.) Ser.: Sighişoara (8), Albeşti (8), **nt** - *S. aurita* L.: Şaeş (24), Dealu (29), **nt** - *S. cinerea* L.: Sighişoara (8), Şaeş (24, 38); Abuş (10, !), Corund - Dealu (24), **nt** - *S. fragilis* L.: Blaj (5), Sighişoara (8), Odorhei (23); Adămuş (10), Abuş (!), **R** - *S. pentandra* L.: Sighişoara (8, 29); Corund - Dealu (24), **nt** - *S. purpurea* L.: Blaj (1, 5), Valea Lungă (1, 5), Micăsasa (1, 5), Sighişoara (8), Băile Szejke - Odorhei (24); Bazna (26), **nt** - *S. rosmarinifolia* L.: Sighişoara (8, 29), Şaeş (24), Albeşti (8), Dealu (29), *S. x rubens* Schrk. var. *excelsio*r (Host) A. et G.: Odorhei (43), **nt** - *S. triandra* L.: Ţapu (1), Copşa Mică (1), Axente Sever (1), Mediaş (1), Sighişoara (8), Albeşti (8); Bazna (26), Abuş (!), **nt** - *S. viminalis* L.: Blaj (1, 5, 29), Valea Lungă (1, 5), Mănărade (29), Micăsasa (1, 5, 29), Sighişoara (8, 29)

**nt** - *Sanguisorba officinalis* L.: Blaj (5), Valea Lungă (1, 5, 29), Mediaş (29), Păucea (35), Sighişoara (8, 29), Băile Szejke - Odorhei (24)

**V** - *Scheuchzeria palustris* L.: Şaeş (8, 24, 38)

**nt** - *Schoenoplectus lacustris* (L.) Palla: Blaj (1, 5), Valea Lungă (1, 5), Copşa Mică (1, 15), Mediaş (1), Sighişoara (8), **R** - *S. tabernaemontani* (C.C. Gmel.) Palla: Blaj (5), Şeica Mică (29), Odorhei (23, 29, 43), f. *capitatus* Hausskn.: Băile Szejke - Odorhei (24, 43); Corund (29, 43), **R** - *S. triqueter* (L.) Palla: Blaj (5), Valea Lungă (29), Copşa Mică (1, 29), Mediaş (1, 14), Dumbrăveni (37), Sighişoara (7, 8, 29); Bazna (14, 26)

**R** - *S. nigricans* L.: Sighişoara (7, 8, 29)

**R** - *Scirpus radicans* Schkuhr: Sighişoara (8, 29), **nt** - *S. sylvaticus* L.: Blaj (5), Copşa Mică (1), Mediaş (1), Sighişoara (8), Şaeş (24, 38), Odorhei (23), Brădeşti (23), Târnoviţa (23), Vârşag (23, !), Dealu (23); Târnăveni (!), Chibed (10), Adămuş (10), Abuş (10), Trei Sate (10), Sărăţeni (10), Ghindari (10), Sângeorgiu de Pădure (10), Sovata (29)

**R** - *Scorzonera parviflora* Jacq.: Bazna (26, 29, 32, 40), Odorhei (41)

**nt** - *Scrophularia umbrosa* Dum.: Valea Lungă (1, 5), Târnava (1), Târnăvioara (1), Mediaş (1); Bazna (26)

**nt** - *Scutellaria galericulata* L.: Blaj (5), Axente Sever (1), Mediaş (1), Sighişoara (8, 29), Şaeş (24), Odorhei (8, 23, 29); Bazna (26), Abuş (!), Corund - Dealu (24), **nt** - *S. hastifolia* L.: Blaj (5), Mănărade (5), Şeica Mică (1), Târnava (1), Târnăvioara (1, !), Mediaş (1, !), Sighişoara (8, 29, !), Odorhei (21)

**R** - *Selinum carvifolia* (L.) L.: Valea Lungă (1, 5, 29), Mediaş (1); Sovata (29), Corund (29, 43)
**R** - *Senecio aquaticus* Hill. ssp. *barbaraefolius* (Wimm. et Grab.) Walters: Valea Lungă (1, 5), Micăsasa (1, 5), Târnava (1), Târnăvioara (1), Mediaş (1), Sighişoara (8, 29), **nt** - *S. doria* L.: Blaj (5), Sighişoara (8), Albeşti (8) ssp. *umbrosus* (W. et K.) Soo: Blaj (1, 5), Valea Lungă (1, 5); Bazna (HKA), **nt** - *S. fluviatilis* Wallr.: Blaj (29), Valea Lungă (29), Şeica Mică (1, 29), Târnava (1, 29), Mediaş (1, 29), Odorhei (23, 29, 43); Praid (29, 43)
**nt** - *Sium latifolium* L.: Blaj (5, 29), Valea Lungă (29), Copşa Mică (29, 32), Axente Sever (1, 29), Mediaş (1, 29), Sighişoara (8, 29), **R** - *S. sisarum* L.: Ţapu (HB)
**nt** - *Solanum dulcamara* L.: Mediaş (8, 27, 28), Sighişoara (8), Şaeş (24), Odorhei (8); Abuş (!)
**R** - *Solidago gigantea* Aiton: Sighişoara (29, 42, !), Secuieni (42), Bodogaia (42), Cristuru-Secuiesc (42), Porumbenii Mari (42), Odorhei (22); Bălăuşeri (42), Sovata (29)
**nt** - *Sonchus palustris* L.: Sighişoara (29); Sovata (29)
**nt** - *Sparganium emersum* Rehm.: Praid (29), Corund - Dealu (24,29), **nt** - *S. erectum* L.: Axente Sever (1), Mediaş (1), Sighişoara (8)
**nt** - *Spergularia marina* (L.) Griseb.: Odorhei (41); Sovata (29, 43), Praid (29, 43), **nt** - *S. media* (L.) C. Presl.: Tiur (29), **nt** - *S. rubra* (L.) J. et C. Presl.: Copşa Mică (1, 32), Axente Sever (1, 32), Odorhei (43); Sovata (43), Praid (43)
**nt** - *Spirodella polyrhiza* (L.) Schleich.: Blaj (5), Valea Lungă (1, 5), Şaeş (8, 24)
**nt** - *Stellaria aquatica* (L.) Scop.: Blaj (5, 29), Valea Lungă (29), Mediaş (29, 32), Sighişoara (8, 29), Odorhei (8,29); Sovata (29), **R** - *S. longifolia* L.: Corund (29), **R** - *S. palustris* Ehrh var. *laxmannii* (Fisch) Simnk.: Biertan (29)
**nt** - *Stachys palustris* L.: Tiur (5), Blaj (1, 5), Micăsasa (1, 5), Ţapu (1), Mediaş (1), Vârşag (21); Bazna (26)
**nt** - *Succisa pratensis* L.: Valea lungă (1, 5, 29), Târnava (1, 29), Târnăvioara (1, 29), Mediaş (1, 29), Sighişoara (8, 29), Şaeş (24), Odorhei (23), Zetea (23) var. *hirsuta* Rchb.: Băile Szejke - Odorhei (24); Praid (29)
**R** - *Suaeda maritima* (L.) Dumort.: Bazna (29, 32, 39)
**nt** - *Symphytum officinale* L.: Tiur (5), Ţapu (1), Şeica Mică (1), Târnava (1), Târnăvioara (1, !), Mediaş (1, 8), Sighişoara (8), Şaeş (24, 38), Odorhei (8, 23), Târnoviţa (23), Cădişeni (21), Brădeşti (23); Bazna (26, 40), Târnăveni (!), Abuş (10), Trei Sate (10), Sărăţeni (10), Sângeorgiu de Pădure (10), Sovata (!), Ghindari (10), Coroisânmartin (10)
**K** - *Taraxacum bessarabicum* (Hornem) Hand - Mazz.: Târnăvioara (HNY), **K** - *T. palustre* (Lyons) Symons: Blaj (29), Mănărade (29), Ţapu (1, 29), Axente Sever (1, 29), Mediaş (1, 29), Sighişoara (8, 29)
**nt** - *Telekia speciosa* (Schreb.) Baumg.: Valea Lungă (1, 5), Târnava (HF), Târnăvioara (1), Mediaş (1), Sighişoara (8); Bazna (26)
**K** - *Teucrium scordium* L.: Daneş (8)
**R** - *Thladiantha dubia Bunge*: Odorhei (22, 29, 43)
**Nt** - *Thalictrum aquilegiifolium L.:* Păucea (35), Mediaş (1, 8, 32), Dumbrăveni (!), Sighişoara (8), Şaeş (24), Odorhei (8, 43); Corund - Dealu (24) f. *atropurpureum* Jacq.: Sighişoara (8) f. *niveum* Bgt.: Sighişoara (3,8) **nt** - *T. flavum L.:* Sighişoara (8, 29), Odorhei (22), **nt** - *T. lucidum* L.: Axente Sever (1), Târnăvioara (1), Mediaş (1), Sighişoara (8), Şaeş (24), Albeşti (8), Odorhei (23); Bazna (26, 29, 32), var. *laserpitiifolium* (Willd.) Hay.: Zetea (29) var. *heterophyllum*: Bazna (29), f. *angustissimum* (Cr.) Nyar.: Mănărade (29) f. *peucedanifolium* Gris. et Schenk: Sighişoara (8), Odorhei (8); Bazna (26, 29)
**E** - *Thelypteris palustris* Schott: Porumbenii Mari (42)
**R** - *Trapa natans* L.: Blaj (29)

**Nt** - *Trifolium hybridum* L. Blaj (5), Copşa Mică (1, 15), Axente Sever (1), Mediaş (1), Sighişoara (29), Cădişeni (23), Brădeşti (23), Odorhei (8, 23, 29, 41), Zetea (23), Târnoviţa (23), Vârşag (23); Bazna (26, 29), Ghindari (10), Abuş (10), Trei Sate (10), Sărăţeni (10), var. *fistulosum* (Gilib.) Hegi: Sovata (29), **nt** - *T. repens* L.: Mediaş (28, !), Sighişoara (8), Şaeş (38), Daneş (28), Odorhei (21, 23, 41), Brădeşti (21), Cădişeni (21), Zetea (23), Târnoviţa (23), Vârşag (21, 23, !); Bazna (26, 40), Târnăveni (!), Abuş (10)

**nt** - *Triglochin maritima* L.: Odorhei (8, 23, 29, 41, 43), Băile Szejke - Odorhei (24); Bazna (26, 29, 39, 40), Sovata (29, 43), Praid (8, 24, 43), Corund (29, 43), **nt** - *T. palustris* L.: Blaj (1, 5, 29), Copşa Mică (15), Târnăvioara (1, 29), Mediaş (1, 29), Sighişoara (8, 29), Şaeş (8, 29), Cristuru Secuiesc (29, 43), Băile Szejke - Odorhei (24); Bazna (29, 32), Corund - Dealu (24)

**R** - *Trollius europaeus* L.: Păucea (35), Mediaş (29, 32), Sighişoara (29), Odorhei (29, 43), Vârşag (23, !); Sovata (29), Praid (29, 43), Corund (43)

**nt** - *Typha angustifolia* L.: Blaj (5), Sighişoara (8), Odorhei (43); Sângeorgiu de Pădure (10), Sovata (!), **nt** - *T. latifolia* L.: Blaj (5), Valea Lungă (1, 5), Axente Sever (1), Mediaş (1), Sighişoara (8), Şaeş (24, 38); Bazna (26), **R** - *T. schuttleworthii* Koch et Sonder: Mediaş (29, HB), Odorhei (29, 43)

**V** - *Utricularia minor* L.: Sovata (29), **nt** - *U. vulgaris* L.: Blaj (5, 29), Valea Lungă (1, 5, 29), Şaeş (8, 24, 29)

**nt** - *Vaccinium oxycoccos* L.: Vârşag (29) ssp. *microcarpum* (Turcz.) M.N. Blytt: Vârşag (29); Corund (24, 29, 43)

**nt** - *Valeriana collina Wallr.:* Dumbrăveni (29), **nt** - *V. officinalis* L.: Blaj (5), Valea Lungă (1, 5), Târnăvioara (1), Mediaş (1, 28), Sighişoara (8), Albeşti (8), Şaeş (24), Odorhei (8, 24), Zetea (23), Vârşag (23); Bălăuşeri (10), Corund - Dealu (24), **R** - V. *simplicifolia* (Rchb.) Kabath: Corund - Dealu (24)

**nt** - *Veratrum album* L. Sighişoara (8); Corund-Dealu (24)

**nt** - *Veronica anagallis-aquatica* L.: Micăsasa (!), Mediaş (8), Sighişoara (8); Bazna (26), Sărăţeni (10), Cerghid (10), Mica (10), Adămuş (10), Corund - Dealu (24), **nt** - *V. beccabunga* L. Blaj (5), Şeica Mică (1), Târnava (1), Târnăvioara (1, !), Mediaş (1, 8), Sighişoara (8), Odorhei (23, 43, !), Vârşag (21, 23, !); Dealu (23), Corund (43), var. *limosa* (Lej.) Math.: Sovata (29), f. *minor* Bgt.: Şaeş (29), **nt** - *V. scutellata* L.: Blaj (5,29), Copşa Mică (1,29), Axente Sever (1,29), Mediaş (1,29), Sighişoara (8, 29), Şaeş (8, 29); Sărăţeni (10), Sovata (!), Corund (29)

**K** - *Viola palustris* L.: Mediaş (1, 8, 29, 32), **R** - *V. persicifolia* Schreb.: Sighişoara (29)

**E** - *Zanichellia palustris* L.: Axente Sever (29) var. *aculeata* (Schur) Ţopa: Axente Sever (29), var. *major* (Boehnningh) Koch: Axente Sever (29)

## Vegetation

**LEMNETEA** de Bolos et Masclans 1955

LEMNETALIA de Bolos et Masclans 1955

**Lemnion minoris** de Bolos et Masclans 1955

1. *Lemnetum minoris* Oberd. ex T. Muller et Gors 1960: Valea Lungă (!), Copşa Mică (!)
2. *Lemnetum trisulcae* Knapp et Stoffers 1962: Valea Lungă (!)
3. *Lemno - Spirodeletum polyrrhizae* Koch 1954: Valea Lungă (!)

UTRICULARIETALIA MINORIS Den Hartog et Segal 1964

**Utricularion vulgaris** Passarge 1964

4. *Lemno - Utricularietum vulgaris* Soo (1928)1947: Blaj (!), Valea Lungă (!)

HIDROCHARIETALIA Rubel 1933

**Hydrocharition** Rubel 1933

5. *Ceratophylletum demersi* Hild 1956: Dumbrăveni (!)

**POTAMETEA** R. Tx. et Preising 1942
POTAMETALIA Koch 1926
**Ranunculion fluviatilis** Neuhausl 1959
6. *Callitrichetum cophocarpae* (Soo 1927) Pocs in Pocs et al. 1958: Copşa Mică (!)
**Potamion (Koch 1926) Gors 1977**
7. *Potametum crispi* Soo 1927: Mediaş (!)
**Nymphaeion albae Oberd. 1957**
8. *Potametum natantis* Soo 1928: Cursul superior al Târnavei Mari (42)
9. *Polygonetum natantis* Soo 1927: Cursul superior al Târnavei Mari şi Mici (42)
**PHRAGMITETEA** R. Tx. et Preising 1942
PHRAGMITETALIA Koch 1926
**Phragmition** Koch 1926
10. *Phragmitetum australis* Soo 1927 em. Schmale 1939: Blaj (!), Valea Lungă (!), Micăsasa (!), Copşa Mică (!), Târnava (!), Mediaş (!), Bratei (!), Dârlos (!), Dumbrăveni (!), Laslea (!), Sighişoara (!), Şaeş (24,38), Cristuru Secuiesc (!), Porumbenii Mari (!), Odorhei (23), Cădişeni (23); Abuş (10,!), Adămuş (10), Sărăţeni (10), Chibed (10)
11. *Schoenoplectetum lacustris* Chouard 1924: Blaj (!)
12. *Typhaetum angustifoliae* Pignatti 1943: Blaj (!); Sângeorgiu de Pădure (!)
13. *Typhaetum latifoliae* G. Lang 1973: Blaj (!), Copşa Mică (!), Mediaş (!), Dumbrăveni (!), Şaeş (38),
14 *Glycerietum maximae* Hueck 1931: Copşa Mică (!), Mediaş (!), Şaeş (38),
15. *Thelypteridi-Phragmitetum* Kuiper 1957: Porumbenii Mari (42)
NASTURTIO - GLYCERIETALIA Pignatti 1953
**Glycerio - Sparganion** Br. - Bl. et Sissingh 1942
16. *Glycerietum plicatae* Kulczynski 1928: Blaj (!), Odorhei (!); Cerghid (10), Mica (10)
17. *Glycerietum fluitantis* Eggler 1933: Blaj (!); Sărăţeni (!)
18. *Leersietum oryzoidis* Krause in R. Tx. 1955 em. Passarge 1957: Valea Lungă (!), Mediaş (!)
19. *Veronicetum beccabungae* Philippi 1973: Blaj (!), Târnăvioara (!), Mediaş (!), Odorhei (!)
20. *Catabrosetum aquaticae Rubel 1927:* Adămuş (10)
OENANTHETALIA AQUATICAE Hejny in Kopecky et Hejny 1965
**Oenanthion aquaticae** Hejny ex Neuhausl 1959
21. *Alismato - Eleocharitetum* M. Kovacs et Mathe 1967: Valea Lungă (!), Copşa Mică (!), Mediaş (!)
22. *Eleocharitetum palustris* Ubrizsy 1948: Blaj (!), Axente Sever (!), Târnăvioara (!), Mediaş (!), Şaeş (38), Odorhei (!); Cerghid (10), Ghindari (10), Chibed (10), Sărăţeni (10)
23. *Oenantho aquaticae - Rorippetum amphibiae* Lohmeyer 1950: Axente Sever (!)
**Magnocaricion elatae** Koch 1926
Caricenion rostratae (Bal. - Tul. 1963) Oberd. et al. 1967
24. *Calamagrostetum canescentis* Simon 1960: Valea Lungă (!), Şaeş (38)
Caricenion gracilis (Neuhausl 1959) Oberd. et al. 1967
25. *Caricetum gracilis* Almquist 1929: Şaeş (38); Cădişeni (23), Brădeşti (23); Abuş (10)
26. *Phalaridetum arundinaceae* Libbert 1931: Blaj (!),Valea Lungă (!)
27. *Caricetum distichae* Steffen 1931: Ghindari (10), Trei Sate (10)
28. *Caricetum vulpinae* Soo 1927: Şaeş (38)
29. *Caricetum acutiformis* Eggler 1933: Ţapu (!), Dumbrăveni (!), Şaeş (38); Abuş (10), Sărăţeni (10), Trei Sate (10)
30. *Caricetum ripariae* Soo 1928: Valea Lungă (!); Sărăţeni (10)
31. *Equisetetum variegati:* Cădişeni (23), Brădeşti (23)

**SCHEUCHZERIO - CARICETEA NIGRAE** R. Tx. 1937
CARICETALIA NIGRAE Koch 1926 em. Br. - Bl. 1949
**Caricion nigrae** Koch 1926 em. Klika 1934
32. *Junco - Caricetum nigrae* Tx. (1937) 1952
- *caricosum stellulatae:* Vârşag (23)
CARICETALIA DAVALLIANAE Br. - Bl. 1949
**Caricion davallianae** Klika 1934
33. *Carici flavae - Eriophoretum latifolii* Soo 1944: Odorhei (23, !), Vârşag (23, !), Dealu (23)
**ISOETO - NANOJUNCETEA** Br. - Bl. et R. Tx. ex Westhoff et al. 1946
NANOCYPERETALIA Klika 1935
**Nanocyperion flavescentis** Koch ex Libbert 1932
34. *Cyperetum flavescentis* Koch 1933: Blaj (!), Valea Lungă (!), Cădişeni (23), Brădeşti (23)
35. *Juncetum bufonii* Felfoldy 1942: Cădişeni (!)
**PUCCINELLIO - SALICORNIETEA** Ţopa 1939
PUCCINELIETALIA Soo 1947 em. Vicherek 1973
**Puccinelion limosae** Klika et Vlach 1937
36. *Puccinellietum limosae* Soo 1936: Odorhei (41)
CRYPSIDETALIA ACULEATAE Vicherek 1973
**Puccinellion peisonis** (Wendelbg. 1943) Soo 1957
37. *Puccinellietum distantis* Soo 1937: Spătac (5)
38. *Salicornietum europaeae Wendelbg. 1953:* Tiur (5), Odorhei (41)
SCORZONERO - JUNCETALIA GERARDI Vicherek 1973
**Scorzonero - Juncion gerardi** (Wendelbg. 1943) Vicherek 1973
39. *Juncetum gerardi* (Warming 1906) Nordh. 1923: Tiur (5), Spătac (5), Ţapu (!), Odorhei (!)
40. *Caricetum distantis* Rapaics 1927: Copşa Mică (!), Odorhei (!), Cădişeni (!); Coroisânmartin (10), Idrifaia (10)
**MOLINIO - ARRHENATHERETEA** R. Tx. 1937 em. R. Tx. 1970
MOLINIETALIA COERULEAE Koch 1926
**Molinion coeruleae** Koch 1926
41. *Molinietum coeruleae* (Allorge 1922) Koch 1926: ? Blaj (!)
**Calthion** R. Tx. 1937 em. Bal. - Tul. 1978
Calthenion
42. *Angelico-Cirsietum oleracei* R. Tx. 1937: Cursul superior al Târnavei Mari şi Mici (42)
43. *Cirsietum rivularis* Nowinski 1928: Cursul superior al Târnavei Mari (42)
44. *Scirpetum sylvatici* Ralski 1931: Blaj (!), Copşa Mică (!), Odorhei (23, !), Zetea (23), Vârşag (!); Căliăneşti (10), Săngeorgiu de Pădure (10)
405. *Calthaetum laetae* V. Krajina 1933: Mediaş (!), Odorhei (!), Vârşag (!)
46. *Holcetum lanati* Issler 1936 em. Passarge 1964: Mediaş (28,!), Vârşag (!); Bălăuşeri (!), Sovata (!)
**Agrostion stoloniferae** Soo, 1943
47. *Agrostetum stoloniferae* Ujvarosi 1941: Blaj (!), Valea Lungă (!), Micăsasa (!), Ţapu (!), Copşa Mică (!), Mediaş (!), Târnava (!), Bratei (!), Alma (!), Dumbrăveni (!), Sighişoara (!), Albeşti (!), Cristuru Secuiesc (!), Mugeni (!), Odorhei (23, !), Zetea (23, !), Brădeşti (23), Târnoviţa (23), Vârşag (23,!); Sângeorgiu de Pădure (!), Sovata (!)
48. *Agrostio - Deschampsietum caespitosae* (Soo, 1928) Ujvarosi 1947: Şaeş (38); Vârşag (23, !); Ghindari (10), Trei Sate (10)
49. *Alopecuretum pratensis* Regel 1925: Blaj (!), Mediaş (!), Daneş (28), Odorhei (!); Abuş (10)

50. *Festucetum pratensis* Soo 1938: Mediaş (28), Odorhei (!), Zetea (!), Vârşag (!); Bălăuşeri (10)
51. *Ranunculo strigulosi - Equisetetum palustris* Gh. Popescu 1975: Şaeş (38), Odorhei (!), Vârşag (!); Chibed (!), Cerghid (!), Sângeorgiu de Pădure (!)
52. *Poëtum trivialis* Soo 1940: Blaj, (!), Valea Lungă (!), Copşa Mică (!), Odorhei (!), Zetea (!)
POTENTILLO - POLYGONETALIA R. Tx. 1947
**Potentillion anserinae** R. Tx. 1947
Potentillenion anserinae
53. *Potentilletum anserinae* Felfoldy 1942: Blaj (!), Micăsasa (!), Odorhei (!)
54. *Ranunculetum repentis* Knapp ex. Oberd. 1957: Blaj (!), Valea Lungă (!), Micăsasa (!), Țapu (!), Copşa Mică (!), Mediaş (!), Târnava (!), Bratei (!), Dumbrăveni (!), Sighişoara (!), Cristuru Secuiesc (!), Mugeni (!), Odorhei (!), Zetea (!), Brădeşti (23), Vârşag (!)
55. *Myosuretum minimi (D.S. Westh 1940) Tx. 1947:* Petrisat (5)
Juncenion effusi Westhoff et Van Leeuwen ex Hejny et al. 1979
56. *Juncetum effusi* Soo (1931) 1949: Blaj (!), Valea Lungă (!), Micăsasa (!), Țapu (!), Copşa Mică (!), Mediaş (!), Târnava (!), Dumbrăveni (!), Sighişoara (!), Albeşti (!), Cristuru Secuiesc (!), Mugeni (!), Odorhei (23), Vârşag (23); Sovata (10)
57. *Junco inflexi - Menthetum longifoliae* Lohmeyer 1953: Blaj (!), Mediaş (!)
**GALIO - URTICETEA** Passarge ex Kopecky 1969
CALYSTEGIETALIA SEPIUM R. Tx. 1950
**Senecion fluviatilis** R. Tx. 1950
58. *Senecionetum fluviatilis* Th. Muller ex Straka in Mucina 1993: Târnava (!)
59. *Astero - Rubetum caesii* I. Karp. 1962: Mediaş (!), Dumbrăveni (!)
60. *Rudbeckio - Solidaginetum* R. Tx. et Raabe 1950 em. Soo 1961: Sighişoara (42,!), Secuieni (42), Bodogaia (42), Cristuru-Secuiesc (42), Porumbenii Mari (42); Abuş (!), Bălăuşeri (42), Praid (42), Corund (42)
61. *Polygonetum cuspidati* Tx. et Raabe 1950: Secuieni (42), Bodogaia (42), Cristuru-Secuiesc (42), Rugăneşti (42), Beteşti (42), Porumbenii Mari (42), Mugeni (42), Odorhei (42), Subcetate (42), Poiana Târnavei (42); Bălăuşeri (42), Ghindari (42), Sovata (42)
PETASITO - CHAEROPHYLLETALIA Morariu 1967
**Petasition officinalis** Sillinger 1933
62. *Aegopodio - Petasitetum* R. Tx. 1947: Valea Lungă (!)
**BIDENTETEA TRIPARTITI** R. Tx. et al. in R. Tx. 1950
BIDENTETALIA TRIPARTITI Br.-Bl. et R. Tx. ex Klika et Hadac 1944
**Bidention tripartiti** Nordhagen 1940 em. R. Tx. in Poli et J. Tx. 1960
63 *Bidenti - Polygonetum hydropiperis* Lohmeyer in R. Tx. 1950: Blaj (!), Valea Lungă (!), Micăsasa (!), Copşa Mică (!), Mediaş (!), Târnava (!), Alma (!), Dumbrăveni (!), Sighişoara (!), Odorhei (!), Zetea (!)
64. *Rumici - Alopecuretum geniculati* Tx. (1937) 1950: Blaj (!), Valea Lungă (!), Copşa Mică (!)
**SALICETEA PURPUREAE** Moor 1958
SALICETALIA PURPUREAE Moor 1958
**Salicion albae** Soo 1930 em. Th. Muller et Gors 1958
65. *Salicetum albae - fragilis* Issler 1926 em. Soo 1957: Blaj (!), Micăsasa (!), Mediaş (!); Abuş (!)
- *rubosum caesii* (Doniță et al. 1966): Abuş (!)
**Salicion triandrae** Th. Muller et Gors 1958
66. *Salicetum triandrae* Malcuit ex Noirfalise in Lebrun et al. 1955: Copşa Mică (!), Axente Sever (!)
67. *Saponario - Salicetum purpureae* (Br.-Bl. 1930) Tschou 1946: Blaj (!), Micăsasa (!)

**ALNETEA GLUTINOSAE** Br.-Bl. et Tx. ex Westhoff et al. 1946
SALICETALIA AURITAE Doing 1962
**Salicion cinereae** Th. Muller et Gors 1958
68. *Salicetum cinereae* Zolyomi 1931: Şaeş (38)
**QUERCO - FAGETEA** Br.-Bl. et Vlieger in Vlieger 1937
FAGETALIA Pawlowski in Pawlowski et al. 1928
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# A BIODIVERSITY ASSESSMENT OF THE SAXON VILLAGES REGION OF TRANSYLVANIA (ROMANIA)

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**ABSTRACT**

During the twentieth century protection of biodiversity in western and eastern Europe followed rather different routes. For example, in România, with its wealth of intact natural habitats, stress was placed on protection of true wilderness. In contrast, in the United Kingdom management has hugely modified most of the landscape, and British protected areas (*e.g.* National Parks) tend to be semi-natural in character, preserving wildlife values and the artefacts (landscape and cultural) of centuries of human impact. However, as well as the natural forest and montane habitats of the Carpathians, Transylvania also contains valuable habitats shaped by the long history of human presence in România, as for example on the Târnave plateau (the "Saxon Villages region").

The area between Sibiu, Sighişoara and Făgăraş holds a diverse mosaic of woodlands, grasslands and wetlands. In 2000 and 2001, preliminary surveys established the principal communities present, and related them to both phytosociological classification and the *European Nature Information System* (*EUNIS*). This paper summarises the vegetation types (both natural and semi - natural) present in the Saxon Villages area, together with their composition and relationship to described communities. The impact of human management is also discussed with some assessment of the biodiversity value of the area, both in a Romanian and wider European context.

**ZUSAMMENFASSUNG**: Eine Abschätzung der Phytodiversität in der Region der Siebenbürgischen Sachsendörfer.

Im zwanzigsten Jahrhundert entwickelte sich der Naturschutz zur Erhaltung der Biodiversität in West- und Ost-Europa in unterschiedliche Richtungen. In Rumänien zum Beispiel, mit seinem Reichtum an natürlichen Habitaten, stand der Schutz unberührter Landschaftsteile im Vordergrund. Im Gegensatz dazu überwiegen in Großbritannien und Nordirland Kulturlandschaften, und britische Naturschutzflächen (z. B. Nationalparks) sind meist naturnahe Flächen, die sowohl Arten als auch Kulturdenkmäler (sowohl Bauten als auch Landschaften) schützen, die durch jahrhunderte langes menschliches Wirken hervorgebracht wurden. Dennoch gibt es neben den natürlichen Wäldern und montanen Habitaten der Karpaten in Siebenbürgen auch wertvolle Habitate, die durch historische Siedleraktivitäten in Rumänien beeinflusst wurden, z. B. auf dem Târnave-Hochland (ehemaliges Siedlungsgebiet der Siebenbürger Sachsen).

Die Gegend zwischen Sibiu, Sighişoara und Făgăraş besteht aus einem reichhaltigen Mosaik aus Wäldern, Wiesen und Feuchtgebieten. Von 2000 bis 2001 fanden hier vorläufige Erhebungen statt, um die wichtigsten Pflanzengemeinschaften zu kartieren, sie phytosoziologisch zu klassifizieren und in die EUNIS-Klassifikation (*European Nature Information System*) einzuordnen. Dieser Beitrag beschreibt Verbreitung und Artenzusammensetzung der natürlichen und naturnahen Vegetationstypen im Gebiet der Siebenbürger Sachsen, einschließlich ihrer Beziehungen zu bereits beschriebenen Pflanzengesellschaften. Der Einfluss der Landnutzung und die Bedeutung der vorgefundenen Biodiversität werden ebenfalls diskutiert, im rumänischen und europäischen Kontext.

**REZUMAT**: O evaluare a fitodiversităţii regiunii satelor săseşti a Transilvaniei.

În timpul secolului XX protecţia biodiversităţii în vestul şi estul Europei au urmat trasee mai degrabă diferite. De exemplu, în România, cu bogăţia de habitate naturale intacte, accentul s-a pus pe protejarea adevăratei sălbăticii. În contrast în Regatul Unit al Marii Britanii, managementul a modificat drastic majoritatea peisajelor, iar ariile protejate britanice (ex. parcurile naţionale) au tendinţa de a avea un caracter semi-natural, conservând valorile vieţii sălbatice şi artefactele (de peisaj şi culturale) a secole de impact uman. Totuşi, pe lângă habitatele de pădure naturală şi cele montane carpatice, Transilvania mai cuprinde valoroase habitate modelate de lunga istorie a prezenţei umane pe teritoriul României, cum ar fi de exemplu cele din Podişul Târnavelor (regiunea satelor săseşti).

Aria dintre Sibiu, Sighişoara şi Făgăraş conţine un mozaic diversificat de păduri, fâneţe, păşuni şi zone umede. În anii 2000 şi 2001, studii preliminarii au stabilit principalele comunităţi prezente, şi le-au relaţionat atât cu clasificarea fitosociologică cât şi cu *Sistemul Informaţional Natura Europeană* (*EUNIS*). Această lucrare rezumă tipurile de vegetaţie (cele naturale şi cele semi - naturale) prezente în aria satelor săseşti, împreună cu compoziţia şi relaţiile existente pentru comunităţile descrise. Impactul managementului uman este de asemenea discutat, cu unele evaluări ale valorii biodiversităţii ariei, atât în contextul României cât şi într-un context european, mai larg.

## INTRODUCTION and BACKGROUND

From the beginnings of the nature protection movement in the late nineteenth century, rather different philosophies were followed in the western and eastern parts of Europe. In northwest Europe, management for farming, forestry and industry had modified the entire landscape except for fragments, and protected areas (*e.g.* British National Parks) thus tended to be semi - natural in character, preserving wildlife values and the artefacts (landscape and cultural) of centuries of human impact. Such anthropogenic habitats usually required management to maintain them, and nature protection in northwest Europe has often stressed the need to intervene. For example, referring to a protected fen in England, Godwin and Tansley (1929) stated that any rigid attempt to preserve the fen “in its natural state” by excluding all human influence would soon eliminate many species it was desired to conserve. Others took this stance further: "*Until* ... (*ca* 1945) … *nature preservation implied that man must be kept out. Human influence was considered an undesirable disturbance; nature should be left to look after itself. In the western European countries this viewpoint is nowadays considered to be an outdated idea*" (Westhoff 1971).

In România, there remained extensive areas in a (nearly) natural state that had neither been permanently occupied by humans nor subjected to intensive use. This wealth of natural habitats (true wilderness) justified a contrasting approach, with stress on the protection of wilderness (Borza and Pop, 1930). However, as well as the natural forest and montane habitats of the Carpathians, Transylvania also contains very valuable habitats that have been shaped by the long history of human presence in România. Here biodiversity goals might include not only preservation (protection) and conservation (active management to maintain biota) but also "creative conservation" *i.e.* restoration/rehabilitation of habitats that have been degraded by human impact (Sheail et al., 1997). The region around the Saxon Villages is believed to support a mixture of wildlife and cultural values, and is thus being proposed as a Nature or Natural Park. This paper reports some of the work undertaken to assess and document these values.

**Definition of the study area**

The focus of the study is the Târnave plateau, hereafter referred to as the "Saxon Village region", which lies between Sibiu, Sighişoara and Făgăraş in southern Transylvania, România. For administrative goals, the region straddles three judeţe (counties): a) southern Mureş county around Sighişoara; b) north-western Braşov county north of Făgăraş; and c) eastern Sibiu county. Two districts of this region have received detailed botanical study: A) the eastern villages (Akeroyd 2000), including Viscri, Meşendorf, Buneşti, Roadeş, Criţ and Dacia, within the area known to the Saxons as Haferland (*i.e.* Oatland); and B) the western villages (Akeroyd, 2001) of Mălâncrav, Roandola, Noul Sasesc and Floreşti, the Saxon name being Wienland (Vineland).

**Topography, geology, soils, climate and natural vegetation**

The Saxon Villages lie between the highest part of the Southern Carpathians (Munţii Făgăraş) and the upper Mureş basin. The region comprises gently rolling hills rising to an altitude of over 500m, divided by the valleys of three rivers that flow approximately east to west: the Olt in the south, the Hârtibaciu through the centre, and the Târnava Mare along the northern edge. There are no major lakes, nor significant rock exposures, and the general land level falls both from south to north, and from east to west, though there is much local variation.

The rolling countryside of this area is underlain by strata dating from the Middle Tertiary onward, including calcareous clays or marls, with some deposits of fine sand, tufa and narrow limestone beds. Examination of the national soils map (Institutul Geologic, 1970) reflects this underlying geological pattern. Where the parent material is clay, the soil derived is a moderately rich brown earth, but with some localised podsolisation. Such soils predominate in the lower lying parts of the area, including those where agricultural activity is concentrated. More distinctly acid soils develop over the sands. The second main soil type mapped is derived from the thin-bedded limestones, where a base-rich shallow soil develops resembling a rendzina. This soil is most extensive on steeper slopes, though similar soils occur locally on the ridge-tops, or below lime-rich flushes. Even within such a predominately calcareous landscape, the variation in the parent material, from limestone to clays and marls, results in a diversity of soil drainage regimes. The marls and calcareous clays generally give rise to soils that tend to dry out in summer, but locally there is evidence of gleying, and wet, or even waterlogged, conditions.

The Carpathians divide the Transylvanian plateau climatically from the Euxine and sub-Mediterranean zone of Oltenia and Dobrogea. The higher altitude of the Sighişoara-Făgăraş region further affects the climate. Weather patterns are Continental with very cold winters, especially eastward toward the Braşov basin, where mean January temperatures are below $0^{o}C$, and may fall to $-25^{o}C$. During winter, a strong cold wind (the crivăţ) blows from the north, leading to deep snowfalls over much of the region. Through spring and summer the mean temperature is *ca* 20-25°C. The typical annual rainfall is about 700 mm, with peak levels during spring and early summer, when thunderstorms are frequent in and near the mountains.

Recent research has sought to map the potential natural vegetation of Europe *i.e.* the habitats and communities that would have occurred prior to the gross modifications brought about by the human activity of recent millennia (Bohn et al. 2000). The Olt floodplain would originally have been dominated by a Pannonian-pre-Carpathian hardwood alluvial forest of *Fraxinus angustifolia* (species taxonomy here and subsequently, after Ciocârlan 2000) and *Ulmus laevis*, with *Leucojum aestivum* and *Carex remota* prominent in the understorey. Those parts of the floodplain where water lay longer would have supported a forest of *Salix alba* and *Populus* (*P. alba* and *P. nigra*), whilst ridges and freer draining soils would carry a *Quercus-Carpinus* community similar to that on the low hills between the Râul Olt, Agnita and Rupea. The southern study area, from the edge of the Olt floodplain to the Hârtibaciu river, would once have been covered in a mixed forest of *Quercus robur* and *Carpinus betulus*. The hills separating the Hârtibaciu valley from the lower-lying land around Daneş, Mălâncrav and Mediaş areas probably supported a southeast Carpathian *Fagus-Carpinus* forest that was also extensive north of Roadeş. Both *Fagus* and *Quercus* forests were of Transylvanian types characterised by the presence of *Melampyrum bihariense*. The northern and western areas (Târnava Mare valley from Sighişoara to Mediaş, and toward Sibiu), as well as the eastern margin of the region, supported another type of *Quercus-Carpinus* forest, with *Q. petraea* rather than *Q. robur*, and a ground flora where *Lathyrus hallersteinii* was a notable constituent.

## METHODS - ASSESSING THE VEGETATION TYPES

The strong Romanian tradition of descriptive phytosociology has produced many excellent detailed accounts of the vegetation types that occur within Transylvania and the adjacent Carpathians *e.g.* Coldea (1991, 1992). However, such fine scale of detail has sometimes proven unwieldy for describing habitats on an international basis. In particular, the explicit botanical stress of such approaches has not always proved useful in relating the habitats to the animals that occupy them. Recent work from the *European Environment Agency* (2000) has sought to create a unified classification of habitats for use in all strategic planning and legislation on biodiversity protection. In the present paper, we have related our preliminary classification of the vegetation to the *EUNIS* system (Davies and Moss 1999), with some more detailed habitat descriptions derived from the closely-related *PHYSIS* database of Palaearctic habitats (Devillers et al. 1999).

*EUNIS* is the *European Nature Information System* of the *European Environment Agency* (*EEA*), developed and maintained by the European Topic Centre on Nature Protection and Biodiversity. *EUNIS* contains information on selected species, habitat types and sites, based on national data collected through *EIONET* (European Environment Information and Observation Network also co-ordinated by *EEA*) and from international organisations. *EUNIS* information is used to support the *NATURA 2000* process for all *EEA* reports and for international co-ordination *e.g.* the Berne Convention *EMERALD* Network and Helsinki, *OSPAR* and Barcelona conventions. The Romanian component of *EUNIS* was largely prepared by the late Dr. Mircea Oltean (Bucharest Institute of Biology), who was consulted in applying *EUNIS* to national parks in the Romanian Carpathians (Patriquin et al. 2000). Mountford and Akeroyd (2001) provide a complete listing of the *EUNIS* habitat types so far recognised in the Saxon Villages region.

The *PHYSIS* database of the Royal Belgian Institute of Natural Sciences provides a framework to organise the habitats of the Palaearctic realm into an ordered sequence, using the same methodology as that in *EUNIS* (Devillers et al. 1999). The geographical area covered by the *PHYSIS* database encompasses northern Eurasia and North Africa. Within this wide area, coverage for the European Community and Eastern Europe (including România) is thought to be relatively complete. The database includes outlines of each habitat, together with references to any national literature, and these have been used as the basis of the present account.

In addition to the detailed accounts of Romanian vegetation, a broader description of the typical habitats present in the late twentieth century is available in the *Harta Geobotanică* (Institutul Geologic, 1973). This assessment differs from that made of the primeval vegetation (Bohn et al. 2000) in mapping two landscape types: a) lower-lying land with a mosaic of cultivation, *Q. petraea* woods, *Agrostis-Festuca* grassland and "meadow-steppe" (*Festucion valesiacae*); and b) generally wooded hills with a rich forest flora under a canopy of *Q. petraea* or *Fagus*.

The authors visited the Saxon Villages Region during the summers of 2000 and 2001, making inventories of the flora and recording a series of relevés in semi-natural vegetation. Particular attention was paid to the areas around the villages of Mălâncrav and Viscri. Full listings of the species observed during these surveys are given in reports on behalf of the *Mihai Eminescu Trust* (Akeroyd 2000 and 2001; Mountford and Akeroyd 2001). The present paper deals specifically with the semi-natural vegetation - information on the ruderal vegetation and traditional and cultural uses of the flora is given by Akeroyd (2000, 2001).

## RESULTS - COMMUNITY DESCRIPTIONS

The following descriptions provide the name by which the type is known in *PHYSIS*/*EUNIS*, the phytosociological community ("association" or "alliance" level) to which it corresponds and a brief outline of the international distribution and its botanical composition.

### Woodland and scrub communities

Comparison of extant woodland cover with the map of potential vegetation (Bohn et al., 2000) shows that the natural forests of the region (two forms of *Quercus-Carpinus* forest and *Fagus-Carpinus* woodland) are still locally extant, albeit in what are mainly modified forms. Extensive woods covered the higher slopes and valleys, and over much of the region the most abundant tree was *Carpinus betulus*, whose dominance reflects a long history of exploitation by local people. *C. betulus* was accompanied by *Acer pseudoplatanus*, *Quercus* spp. and *Tilia cordata* in a typical Central European forest community. However, especially on steeper slopes with shallow soils, *Fagus* was prominent (locally dominant). Apart from those woods along streams or planted in origin (*Pinus sylvestris* and the American alien *Robinia pseudacacia*), four woodlands and a scrub type were recognised. Most woodland in the region was dense, with poor light penetration, except where the state forestry service (*Romsilva*) had cleared or coppiced the *C. betulus,* allowing a rich ground flora to develop. Some *Fagus* stands had also been coppiced in the past.

Dacian Lathyrus hallersteinii oak-hornbeam forest (PHYSIS/EUNIS) i.e. Lathyro hallersteinii-Carpinetum association (Querco petraeae-Carpinetum transsilvanicum)

This habitat comprises forests of *Q. petraea* and *C. betulus* that occur on the peripheral hills of the Transylvanian plateau (Coldea 1992) *e.g.* the foothills of both the Eastern and Southern Carpathians, the Braşov basin, the eastern foothills of the Apuşeni Mountains, as well as locally on the eastern sub-Pannonic hills of Crişana. The forest developed on more acidic leached brown soils on sheltered slopes, with a ground flora including, typically, *Stellaria holostea*, *Helleborus purpurascens*, *Ranunculus auricomus, Aposeris foetida* and the large tufted *Festuca drymeja*. Locally *Carex pilosa* and *Galium schultesii* were common. In the most typical examples of this forest, *Lathyrus hallersteinii* (Romanian speciality) is frequent.

Dacian *Melampyrum bihariense* oak-hornbeam forest (*PHYSIS/EUNIS*) *i.e. Melampyro bihariensis-Carpinetum* association

This forest tends to replace the latter *Lathyrus hallersteinii* oak-hornbeam type on those more base-rich soils that cover much of the Saxon Villages region and has a very similar distribution within România (Coldea 1992). The higher soil base-status is reflected in the dominance of *Q. robur*, and such woodland is developed on the deep brown soils of depressions and gentle slopes, under a weakly sub-Atlantic climate (*i.e.* relatively less Continental than is typically the case in Transylvania region). The ground-flora has a markedly rich assemblage of herbs, with in addition to *H. purpurascens* and *A. foetida*, several Transylvanian elements: *Aconitum moldavicum*, *Hepatica transsilvanica, Lathyrus transsilvanicus* and *Melampyrum bihariense*.

Dacian hairy sedge beech-hornbeam forest (*PHYSIS/EUNIS*) *i.e. Lathyro-Carpinion* alliance

Forests of *F. sylvatica* (usually with *C. betulus*) are typical of the low-mid slopes of the Carpathian in România, Ukraine and eastern Serbia, and also on the "pre-Carpathian hills" (*e.g.* our study area). This appears to be the main type of *Fagus* forest in the Saxon Villages region, and is relatively common along the ridge tops and especially on the steeper slopes. The *Fagus-Carpinus* canopy, often with *Tilia cordata* and *Prunus avium*, is found in similar conditions to the Dacian *Melampyrum bihariense* oak-hornbeam forest, but is probably most extensive on better-drained and shallower soils. The ground flora is broadly similar to that of the corresponding oak-hornbeam woodland, with *A. foetida*, *Carex pilosa*, *Dactylis glomerata*, *G. schultesii*, *L. hallersteinii*, *M. bihariense*, *R. auricomus* and *S. holostea.*

East Carpathian calciphile beech forest (*PHYSIS/EUNIS*) *i.e. Symphyto-Fagion* and *Epipactido-Fagenion* alliances)

Where limestones predominate, the forest has a much purer dominance of *Fagus*, and the ground flora has many elements that are distinctly calcicole (Boscaiu et al. 1982). Such vegetation is widespread in the eastern and southern Carpathians, as well as the pre-Carpathian hills. The examples observed in the Saxon Villages region are fragmentary, but the ground flora included some characteristic species *e.g. Cephalanthera damasonium*, *Sanicula europaea*, *Symphytum cordatum* and at least two species of *Polygonatum*.

Peri-Pannonic hawthorn-blackthorn scrub (*PHYSIS/EUNIS*) *i.e. Prunetalia* order

The elements in the habitat mosaic were quite well defined, with a fairly abrupt woodland-pasture boundary. However, a circumboscal fringe can be discerned comprising *Crataegus calycina*, *Ligustrum vulgare*, *Prunus spinosa*, *Pyrus pyraster* and *Salix caprea*, together with groves of *Populus tremula*, and climbers like *Rosa canina* and *Clematis vitalba*. *Crataegus, P. spinosa* and introduced *R. pseudacacia* invade pastures, especially where cattle rather than sheep are grazed, and these may in future form extensive scrub should grazing levels continue to decline. Regular burning of *P. spinosa* by farmers achieves some control. Phytosociological analysis of the scrub suggests that various associations of the *Prunetalia* (mainly within the *Prunion spinosae*) occur *e.g. Pruno spinosae-Crataegetum*, *Ligustro-Prunetum*, *Euonymo-Sambucetum nigrae*, *Corno-Ligustretum croaticum*, *Berberido-Rhamnetum fallacis* and *Rosetum rhamnosum*. This diversity of nomenclature reflects a situation where any one of a wide range of shrubs may be dominant. Such deciduous thorny thickets and scrubs are widespread in the Pannonic basin and adjacent regions, including particularly the lower hills of the Banat, the Transylvanian plateau, the Southern Carpathians and the Apuseni mountains (Sanda et al., 1980).

**Drier grassland communities**

Management has created species-rich grasslands over time, and those of the Saxon Villages region are outstandingly rich. Whether managed as meadows (mown or scythed) or pastures (grazed), they probably derive from fragments of ancient grassland on steep slopes, river-banks and other naturally open ground. The communities include not only semi-natural types that may be broadly termed meadow-steppe, but also grasslands with a greater impact of human activity. Romanian botanists have described the characteristic grassland communities of Transylvania (Prodan 1931, 1948; Puscara-Soroceanu 1963, Sanda et al. 1980). Such sources recognise two main divisions, one slightly moister, dominated by *Brachypodium pinnatum*, which is also more tolerant of burning and rather higher nutrient levels. The second is a drier assemblage dominated by brome-grasses, especially *Bromus erectus*. Such vegetation is closer to the meadow-steppes of Central Europe (Cerovsky 1995) than to the true Pannonic steppe dominated by *Stipa* species that occurs in Hungary, the Banat and the Danube corridor. Where soil fertility is especially low, or where grazing is more intensive, short *Festuca* swards (*e.g. F. valesiaca*) can replace *Bromus* and *Brachypodium.* On the driest slopes, often with patches of bare ground, a more truly steppic (with *Stipa pennata*) and sub-Mediterranean flora develops. Such communities are conspicuous due to patches of pale yellow *Linum flavum* and purple *Salvia nutans*.

Survey of the Saxon Villages Region showed a composition intermediate between the classic Central European and Pannonic types. The limits of the described communities were not always clear, since a variety of floristic elements were present and intermingled (Akeroyd 2000). Despite this *caveat*, some hay-meadows with a generally southern aspect could be described as species-rich, xerothermic grassland, and several plants with a highly restricted world distribution occurred in these "Dacio-Pannonic meadow-steppes".

Dacio - Pannonic meadow - steppes (*PHYSIS/EUNIS*) *i.e.* two alliances of *Festucetalia valesiacae* order (Ellenberg 1988): a) *Festucion valesiacae* and b) *Cirsio - Brachypodion* (Popescu and Sanda 1993; Sanda et al. 1980).

This habitat comprised essentially Continental meso-xerophile (*i.e.* fairly dry) grasslands of the Transylvanian basin and the foothills of the Apuseni mountains but which were rich in species with both Mediterranean or Mediterraneo-Atlantic affinities (Tab. 1).

Table 1: Typical species of meadow-steppe in the Saxon Villages Region.

| Anthericum ramosum | Brachypodium pinnatum | Bromus erectus | Bupleurum falcatum |
|---|---|---|---|
| *Carex montana* | *Cirsium pannonicum* | *Dorycnium pentaphyllum* | *Filipendula vulgaris* |
| *Fragaria viridis* | *Gentiana cruciata* | *Hieracium bauhinii* | *Hypochaeris maculata* |
| *Melampyrum arvense* | *Onobrychis viciifolia* | *Origanum vulgare* | *Peucedanum cervaria* |
| *Plantago media* | *Polygala major* | *Prunella grandiflora* | *Ranunculus polyanthemos* |
| *Seseli annuum* | *Thesium linophyllon* | *Trifolium alpestre* | *Trifolium montanum* |

In addition to these widespread grasses and forbs, orchids were especially prominent *e.g. Anacamptis pyramidalis, Herminium monorchis, Himantoglossum hircinum, Ophrys apifera, O. fuciflora, O. sphegodes, Orchis coriophora, O. militaris* and *O. ustulata*. The more arid south-facing slopes supported species representing the xerothermic (classic steppe) element *e.g. Adonis vernalis, Crambe tatarica, Hypericum elegans, Salvia austriaca, S. nutans* and *Seseli pallasii*.

"Grass heath" - *Agrostis-Festuca* grassland

In addition to meadow-steppe, Akeroyd (2000) recognised a less species-rich grassland that was rather heathy in nature, and quite widespread in the study area where the soil is moister and less lime-rich. The sward was more closed, and often associated with recent sheep grazing. The community has strong similarities to several Western European grasslands, and would be placed by *EUNIS* amongst the Non-Mediterranean dry acid and neutral closed grasslands.

**Mesic grasslands**

Other drier grasslands showed an increasing influence of human management, with mesic habitat conditions *i.e.* neither markedly wet nor dry, moderately nutrient-rich (but not excessively fertilised) and with a circumneutral to mildly acidic pH. Where such swards were managed by cutting and some aftermath grazing, communities belonged to the *Molinio-Arrhenatheratalia* and include types categorised by *EUNIS* as a) permanent mesotrophic pastures and aftermath-grazed meadows or b) coarse permanent grassland and tall herbs, usually mown but little grazed. Such communities are very widespread throughout Europe, and have a generally similar composition. Romanian examples contain few species that are not common elsewhere in mown grasslands of the lowland to submontane zones. However, locally in the Saxon Villages Region, there were mown grasslands where the composition included species of the "meadow-steppe" described above, which may be better considered as "meadows of the steppe zone" *i.e.*

Ponto-Pannonic mesophile hay meadows (*PHYSIS/EUNIS*) *i.e.* associations of two alliances: a) *Festucion pratensis* (*e.g. Alopecuretum pratensis* and *Festucetum pratensis*); and b) *Arrhenatherion* (*e.g. Filipendulo vulgaris-Arrhenatheretum*)

This variant of the widespread slightly moist and lightly manured meadow group includes lowland and hill mesophile grasslands from the Pannonic and Transylvanian basins (and their fringing foothills), and the lower Danubian plain (Sanda et al. 1980; Sanda and Popescu 1991).

**Wetland communities: stream-side scrub and woodland, flushes, wet grassland**

Wetland vegetation occurred in two parts of the landscape here. Very localised communities were found where seepage emerged between limestone and clay strata, leading to flushing of lime-rich water. More extensive wetlands lined the streams, with fringing *Salix* scrub and *Carex*-and *Phragmites*-dominated vegetation extending over the floodplain. Floodplain margins were less prone to inundation and showed a greater impact of cutting and grazing, leading to the development of a tall riverine meadow. Especially where stock moved through such wet meadows, ruderals and species of nutrient-rich grasslands (*e.g. Lolium perenne*) were frequent.

**Streamside woodlands and scrub**

Linear communities of *Salix* and *Populus*, often with *Sambucus nigra,* and shrouded in *Humulus lupulus* were common along the streams. Locally *R. pseudacacia* had invaded these wet gallery woodlands, and in many places tall forbs (*e.g. Conium maculatum*) were prominent. In contrast to the drier habitats, correspondence between the Saxon Village relevés and the published accounts was relatively poor, reflecting the degraded nature of the examples of the habitat.

1) Eastern European poplar-willow forest (*PHYSIS/EUNIS*) *i.e*. *Salicion albae* alliance
This woodland typically exists as tree-dominated galleries closely following the watercourse. The usual dominants were tall *Salix alba*, *S. fragilis*, (with *S. x rubens*) and *Populus nigra,* with *P. alba* sometimes important. Such vegetation lines rivers from the lowland to submontane zone in eastern Germany, the Baltic States, Poland, the entire Danube-Carpathian eco-region, the Balkan states, Belarus, Ukraine and Russia, east to Bashkiria.

2) Almond willow-osier scrub (*PHYSIS/EUNIS*) *i.e Salicetum triandro-viminalis*
Within the study area, this much shorter, dense scrub typically comprised *Salix triandra* and *S. purpurea* subsp. *lambertiana*. This type is very widespread throughout the lowlands and hills of Europe from the British Isles and lowland Scandinavia, south to Central Europe, including the Dacian deciduous forest zone, and extending well into European Russia and beyond.

**Flushes**

1) Middle European yellow-sedge fens (*PHYSIS/EUNIS*) *i.e*. *Carici flavae-Eriophoretum latifolii* and *Eriophoretum latifolii* associations (Coldea 1991).

Two broad types of base-rich flush (soligenous fen) were seen in this region, both were vulnerable to invasion by *Phragmites australis* and *Salix*, leading to a less distinctive, species-poor community. This yellow-sedge fen is found throughout the middle latitudes of continental Western and Central Europe, from the Netherlands and France to Poland, Slovakia, România and northern Italy. The Saxon Village examples had prominent *Eriophorum latifolium* and *Carex flava* over a mossy turf of *Campylium stellatum* etc*,* and the typical community also comprises other small *Carex* species (*C. dioica*, *C. lepidocarpa*, *C. panacea*, *C. viridula*) together with *Equisetum* spp. and *Juncus articulatus*. Similar vegetation has been observed along the Carpathian foothills near Braşov and in the Hunedoara area (Mountford, unpublished data).

2) Middle European flat-sedge fens (*PHYSIS/EUNIS*) *i.e.* flushes of the *Carici-Blysmetum compressi* association (Coldea 1991)

Although *Blysmus compressus* itself was not observed in the region during this survey, several of the flush relevés otherwise resembled examples of this association from the Prahova valley and Piatra Craiului national park (Mountford, unpublished data). Short mossy swards occurred in lime-rich water with *Triglochin palustre* and *Myosotis sparsiflora. B. compressus* fens occur in the limestone districts of northern and central Europe, as well as at montane and subalpine levels in the Alps, the Apuseni Mountains and the Southern and Eastern Carpathians.

**Floodplain wet grasslands**

In the region, wet grassland tended to be intermediate in character between the mesic swards of the *Festucion pratensis* and *Carex*-dominated vegetation typical of winter inundation. Some relevés from floodplain margins near Viscri may be related to the following habitat type:

Danubio-Pannonic riverine and humid meadows (*PHYSIS/EUNIS*) *i.e.* associations of two alliances: a) *Deschampsion cespitosae* (*e.g. Deschampsietum cespitosae* and *Agrostio-Poetum trivialis*); and b) *Alopecurion pratensis* (*e.g*. *Carici-Alopecuretum pratensis*).

These meadows were originally described from the floodplains of the great rivers in the Pannonic and Danubian basins, including Transylvania and Oltenia in România. The meadows are subject to repeated flooding in one year, and remain wet or damp with moderately to very nutrient-rich, alluvial or fertilised soils (Sanda et al. 1980; Sanda, Popescu 1991).

**Other herbaceous floodplain and riparian communities**

The taller wetland vegetation along the floodplains of the Saxon Villages region has as yet had only cursory survey. However, it is clear that when defoliation is locally relaxed, *Phragmites australis* and tall *Carex* spp. can rapidly invade, forming communities of the *Phragmition* and *Magnocaricion* alliances (Ellenberg 1988). Some stands with prominent tall forbs amongst the *P. australis* and *Carex* may be transitional in character to a tall-herb fen.

Still less attention has been paid to the macrophyte vegetation of the rivers and streams themselves, and in particular to the gravel, sand and silt banks that are a feature of the Râul Olt. In some reaches, this major river has a fairly natural braided channel and is likely to repay study. Amongst other vegetation, such banks of sediment in rivers draining the Carpathians might also harbour montane plants washed down and surviving under conditions of low competition.

**DISCUSSION - PROVISIONAL BIODIVERSITY ASSESSMENT**

The Saxon Villages Region supports extensive semi-natural vegetation, which is species-rich and closely allied to the natural habitats that occupied the Transylvanian foothills of the Carpathians prior to human impact. The habitats present include several that are localised in distribution and highly characteristic of this part of Central-Eastern Europe, adding greatly to the standing of the region in an international context. The wooded habitats are clearly derived from the original forests, with some natural variation intact and holding species with restricted world distributions. The grasslands too are of great biodiversity importance at a European level, with Dacio-Pannonic and Mediterranean elements, and represent a major area of a valuable habitat that has disappeared from much of north and west Europe through agricultural intensification (Cerovsky 1995). In contrast to farmed landscapes further west in Europe, many of the wetlands (both floodplains and flushes) here remain hydrologically intact, with an almost natural zonation of wetland habitats.

The combination of biodiversity values with the renowned cultural heritage would make the region a good candidate for Nature or Natural Park status *i.e.* Protected Area category V - "protected landscapes" (IUCN 1994). Parks of this type, resembling English National Parks and Environmentally Sensitive Areas, have been successfully instigated in Poland and Czech Republic. Such protected areas function by maintaining and subsidising traditional agriculture, with benefits to both the cultural integrity of the villages and the conservation of wildlife. The survey work and assessment conducted to date is strongly indicative of a region of outstanding biodiversity value. Moreover, high quality habitats appear well-distributed throughout the entire region. The grasslands and woodlands are integral to the remarkable traditional agricultural communities of the Saxon Villages region, already noted for their fortified medieval churches and fine village houses. The establishment of a Natural Park could be linked to the sustainable development of these villages, enabling them to retain their special features and to provide local people with a worthwhile economic future.

Clearly, further work is required to confirm the national and international standing of the region, including comparison with priority habitat criteria for *Natura 2000* (Annex 1 of the European Union's Habitats Directive), and for species in Annexes 2 and 4 of the Habitats Directive and Annex 1 of the Birds Directive (European Union 1979). Priority grassland habitats relevant to the Saxon Villages might include a) Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) and b) Sub-Pannonic steppic grasslands. Within the forests, the following priority types should be examined: a) Medio-European limestone beech forests of the *Cephalanthero-Fagion*; b) Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*; c) *Galio-Carpinetum* oak-hornbeam forests; and d) Pannonic woods with *Quercus petraea* and *Carpinus betulus*. The approach taken here, linking established phytosociology to Europe-wide habitat classifications, makes such assessment practical.

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# PRELIMINARY NOTE ON THE AQUATIC OLIGOCHAETA FROM THE TÂRNAVE RIVERS (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: aquatic oligochaeta, benthic macroinvertebrates, saprobity, Transylvania, Romania.

**ABSTRACT**

In our study we wanted to make an inventory of the aquatic Oligochaeta from the Târnava Mare, Târnava Mică and Târnava, all tributaries of the Mureş River. Along each river we tried to determine the distribution of the Oligochaeta, the modifications of the specific composition at each sampling site due to the water pollution, the hydrologic regime and the type of the substratum. These facts help us to evaluate the quality of the water in the mentioned rivers.

The most polluted river with organic substances is Târnava Mare, where we found high organic contents from the mountainous area. The richest river in aquatic Oligochaeta species is Târnava Mică and the highest degree of saprobity, with polisaprobic areas we found in Târnava River.

**RÉSUMÉ**: Notes preliminares sur Oligochaeta aquatiques des rivières Târnave.

Dans l'étude présent on a proposé à inventarier la faune des oligochètes aquatiques des rivières Târnava Mare, Târnava Mică et Târnava des affluents du Mureş. Le long de chacune rivière on a essayé de surprendre la répartition des oligochètes, les modifications en ce qui concèrne la composition spécifique du niveau de chacune station en fonction du degré de poluation de l'eau, le régime hydrologique et la nature du substrat dans le but de l'évaluation de la qualité d'eau des rivières au-dessus mentionnées.

On a constaté que la plus polluée à des matériaux organiques c'est la rivière de Târnava Mare, la plus riche en espèces c'est Târnava Mică et celle au degré de saprobité la plus élevée avec des portions de l'eau polisaprobe la rivière de Târnava.

**REZUMAT**: Note preliminarii despre Oligochetele acvatice din râurile Târnave.

În acest studiu am intenționat realizarea unui inventar al oligochetelor acvatice din râurile Târnava Mare, Târnava Mică şi Târnava, toate afluente ale râului Mureş. De-a lungul fiecărui râu am încercat determinarea repartiției oligochaetelor, a modificărilor compoziției specifice a fiecărui loc de prelevare a probelor datorată poluării apei, a regimului hidrologic şi a tipului de substrat. Toate acestea ne-au ajutat să evaluăm calitatea apei în râurile menționate.

Cel mai poluat cu substanțe organice este râul Târnava Mare, unde am găsit un conținut organic ridicat din zona montană. Cel mai bogat râu în specii de oligochaete este Târnava Mică şi cel mai ridicat grad de saprobitate, cu arii polisaprobice au fost găsite în râul Târnava.

## INTRODUCTION

The Târnave rivers (Târnava Mare and Târnava Mică) are tributaries of the Mureş River. Their flowing direction is from east to west and they have an almost parallel course till the confluence where they form the Târnava. The two rivers pass through the same kind of relief, but Târnava Mare passes through six towns from which one is very pollutant: Copşa Mică. Târnava Mică passes through three towns, from which only Târnăveni has some functioning factories. After the confluence, the Târnava has a short route and flows into the Mureş River near the Mihalț locality.

In our study, we want to make an inventory of the aquatic Oligochaeta from these rivers and to assess the differences between the three rivers due to the substratum, hydrological regime and the different self cleaning capacity of the rivers.

## MATERIALS AND METHODS

The aquatic Oligochaeta were collected with a bottom Surber sampler, which cover an area of 887cm$^2$, in November 2000, from a number of 12 sampling sites: six from Târnava Mare River, four from Târnava Mică River and two from Târnava River.

The sampled biological material was preserved in the field in 4% formalin, sorted in the laboratory under a 20X magnifying stereomicroscope, transferred in 70% ethyl-alcohol, transparentised in lactic acid and prepared as microscopic slides for determination of the species.

The sampling sites were the following:

Târnava Mare River

$TM_1$ downstream the Zetea dam is situated in the mountainous area of the river, the substratum contains stones, boulders and pebbles and it is covered by a slimy periphyton. The water looked dirty, a high velocity, the banks are low and have arborescent vegetation of *Alnus*.

$TM_2$ is situated downstream Odorheiu Secuiesc locality. The substratum is made of stones, boulders, pebbles and on the river banks sand with organic deposits. The water is polluted with domestic residues, because the Odorhei town has no water cleaning plant.

$TM_3$ upstream Sighişoara has a substratum consisting of stones covered by a periphyton, sand and mud.

$TM_4$ upstream Copşa Mică is situated downstream Mediaş. The substratum is made up from sand and mud, the water flow is calm, the river passes through a relief with a very small slope. The substratum has accumulations of black organic mud.

$TM_5$ downstream Copşa Mică, the substratum is made of from pebbles covered by a black mud and a green periphyton. A part of this mud originates from the dusts emanate from the chemical factory in Copşa Mică. Near the river banks there are sandy accumulations. Near this sampling site, is a sand and pebbles exploitation which make the water to be dirty on a long sector because the raising of the sediments.

$TM_6$ is situated upstream Blaj. The water has a calm course, the substratum is covered by stones and sand, the banks are low.

Târnava Mică River

$Tm_1$ is situated upstream Praid. The river has a typical mountainous course, passes through a mixed forest, the substratum is covered by stones and boulders and the water has a high velocity.

$Tm_2$ downstream Sovata. The substratum consists of stones covered by a slimy periphyton due to the domestic residues from Sovata. Near the banks there are sandy accumulations.

$Tm_3$ upstream Târnăveni. The water has a calm course with bends, the maximum depth is around four meters and the river has a stagnant aspect. The substratum is covered by sand and mud.

$Tm_4$ upstream Blaj. The water has a calm course; it is deep with steep banks. The substratum is covered by sand and mud.

Târnava River

$T_1$ downstream Blaj, after the confluence. The course is calm, the banks are low and the substratum is covered by pebbles, sand and mud.

$T_2$ upstream the confluence with the Mureş. Upstream this sampling site there is an area for the extraction of the river sand and pebbles which make the water to look dirty. The substratum is covered by pebbles, sand and mud.

**RESULTS AND DISCUSSION**

In the 12 sampling sites a number of 27 aquatic Oligochaeta species were found, 16 belonging to Naididae family, 10 to Tubificidae family and one to Enchytraeidae (Tab. 1).

Table 1: Aquatic Oligochaeta found in the Târnave rivers.

| Species | Târnava Mare | Târnava Mică | Târnava |
|---|---|---|---|
| Fam. Naididae | | | |
| *Chaetogaster diastrophus* | - | + | - |
| *Amphichaeta leydigii* | + | - | - |
| *Spercaria josinae* | + | + | + |
| *Uncinais uncinata* | + | - | - |
| *Nais communis* | - | - | + |
| *N. bretscheri* | + | + | + |
| *N. elinguis* | + | + | - |
| *N. barbata* | - | + | - |
| *N. behningi* | + | + | - |
| *N. pardalis* | - | + | + |
| *Piguetiella blanci* | - | + | - |
| *Dero digitata* | - | - | + |
| *Pristina bilobata* | + | + | + |
| *P. aequiseta* | + | - | - |
| *P. longiseta* | - | + | - |
| *Ophidonais serpentina* | - | + | - |
| Total Naididae species | 8 | 11 | 6 |
| Fam. Tubificidae | | | |
| *Tubifex tubifex* | - | - | + |
| *T. newaensis* | + | + | + |
| *Limnodrilus udekemianus* | - | + | - |
| *L. claparedeianus* | + | + | + |
| *L. profundicola* | + | + | - |
| *Potamothrix isochaetus* | - | + | - |
| *P. vejdovskyi* | + | + | + |
| *Peloscolex velutina* | - | + | - |

| | | | |
|---|---|---|---|
| *Peloscolex ferox* | - | + | - |
| *Rhyacodrilus coccineus* | - | + | - |
| Total Tubificidae species | 4 | 9 | 4 |
| Fam. Enchytraeidae | | | |
| *Lumbricillus lineatus* | - | + | - |
| Total Enchytraeidae species | 0 | 1 | 0 |
| Total species | 12 | 21 | 10 |

On the Târnava Mare River we found a total of 12 species, 8 Naididae and 4 Tubificidae (Tab. 2).

At $TM_1$ because of the clean water, the high velocity we found only 4 species: 3 Naididae and one Tubificidae, but this one has a great percentage in the population 64.75%. This Tubificid, *Limnodrilus claparedeianus* is a species which can live in waters with a low organic content. At this sampling site the high velocity of the water and the stony substratum do not create favourable conditions to the development of the Oligochaeta populations.

Table 2: Aquatic Oligochaeta from Târnava Mare River on each sampling site in percentages - relative abundance.

| Species | $TM_1$ | $TM_2$ | $TM_3$ | $TM_4$ | $TM_5$ | $TM_6$ |
|---|---|---|---|---|---|---|
| Fam. Naididae | | | | | | |
| *Amphichaeta leydigii* | 0 | 0 | 1,94 | 20 | 0 | 11,11 |
| *Spercaria josinae* | 0 | 3,85 | 0,65 | 0 | 0 | 0 |
| *Uncinais uncinata* | 0 | 11,54 | 0 | 0 | 0 | 0 |
| *N. bretscheri* | 16,39 | 7,69 | 26,45 | 0 | 0 | 0 |
| *N. elinguis* | 15,57 | 0 | 18,71 | 0 | 7,69 | 0 |
| *N. behningi* | 3,28 | 26,92 | 37,42 | 0 | 0 | 0 |
| *Pristina bilobata* | 0 | 0 | 0 | 0 | 15,38 | 0 |
| *P. aequiseta* | 0 | 0 | 0 | 0 | 7,69 | 0 |
| Total Naididae species | 3 | 4 | 5 | 1 | 3 | 1 |
| Fam. Tubificidae | | | | | | |
| *T. newaensis* | 0 | 0 | 0 | 0 | 0 | 22,22 |
| *Limnodrilus claparedeianus* | 64,75 | 46,11 | 12,9 | 0 | 69,23 | 66,66 |
| *L. profundicola* | 0 | 0 | 0 | 80 | 0 | 0 |
| *Potamothrix vejdovskyi* | 0 | 3,85 | 1,94 | 0 | 0 | 0 |
| Total Tubificidae species | 1 | 2 | 2 | 1 | 1 | 2 |
| Total species | 4 | 6 | 7 | 2 | 4 | 3 |

At $TM_2$ we found six species from which two are Tubificidae. In this habitat, there are species, which can stand high organic load, because the water contains organic residues, which are eliminated in the river from the Odorheiu Secuiesc town.

At $TM_3$ the community is richer and consist of seven species, but from the specific components point of view it is very alike to the community found at $TM_2$, due to the resemblance of the quality of the water with this sampling site.

At $TM_4$ upstream Copşa Mică the community simplifies and it is made up from only two species. This is due to the fact that the river has passed through Mediaş and it had loaded with a high organic content during his passage through this town.

At $TM_5$ upstream Copşa Mică reappear other two species of Oligochaeta found in the previous sampling sites, but the community remains scarce, made up from four species.

At $TM_6$ station, we found here three species of Oligochaeta. For the first time we recorded the *Tubifex newaensis* presence which prefers the more calm waters and with a higher organic load.

On the course of Târnava Mare River, the aquatic Oligochaeta communities are very alike in the first five sampling sites and there are made up from species with a very large tolerance to the environmental factors, but the sixth sampling site have a characteristic community for the high organic loaded waters.

The uniformity of the species along this river is high; the number of species is small, fact which indicates water with a relative uniform quality along its all course and without great substratum modifications.

In Târnava Mică River we found 21 species: 11 from Fam. Naididae, 9 from Fam. Tubificidae and one from Fam. Enchytraeidae (Table 3).

At $Tm_1$ station we found six species. The presence of *Tubifex newaensis* and *Lumbricillus lineatus* indicates a high organic load in the water for this mountainous sector. From the Naididae there are present the species with a great tolerance for the substratum nature and conditions.

At $Tm_2$ the community of aquatic Oligochaeta is made up by a total of 18 species. There are especially abundant the species that tolerate an organic load of the water and we also found a predators Naidid species *Chaetogaster diastrophus*. This rich community indicates a stable substratum, which is not frequently washed away by the floods and do not suffer human interventions, because the settling of such great number of species take a long time. The trophic conditions are also good for the Oligochaeta populations at this sampling site.

Table 3: Aquatic Oligochaeta of Târnava Mică River on each sampling station in percentages - relative abundance.

| Species | $Tm_1$ | $Tm_2$ | $Tm_3$ | $Tm_4$ |
|---|---|---|---|---|
| *Chaetogaster diastrophus* | 0 | 0,55 | 0 | 0 |
| *Spercaria josinae* | 11,69 | 3,32 | 0 | 0 |
| *N. bretscheri* | 0 | 3,88 | 0 | 0 |
| *N. elinguis* | 0 | 8,31 | 0 | 0 |
| *N. barbata* | 0 | 26,04 | 0 | 0 |
| *N. behningi* | 7,79 | 0,83 | 0 | 0 |
| *N. pardalis* | 18,18 | 16,07 | 0 | 0 |
| *Piguetiella blanci* | 0 | 1,39 | 0 | 0 |
| *Pristina bilobata* | 0 | 0,83 | 0 | 0 |
| *P. longiseta* | 0 | 0,55 | 0 | 0 |
| *Ophidonais serpentina* | 0 | 0,55 | 0 | 0 |
| Total Naididae species | 3 | 11 | 0 | 0 |
| Fam. Tubificidae | | | | |
| *T. newaensis* | 55,84 | 0 | 0 | 66,66 |

| | | | | |
|---|---|---|---|---|
| *Limnodrilus udekemianus* | 0 | 0,83 | 0 | 0 |
| *L. claparedeianus* | 0 | 17,73 | 0 | 33,33 |
| *L. profundicola* | 2,6 | 0 | 100 | 0 |
| *Potamothrix isochaetus* | 0 | 8,59 | 0 | 0 |
| *P. vejdovskyi* | 0 | 6,37 | 0 | 0 |
| *Peloscolex velutina* | 0 | 3,05 | 0 | 0 |
| *P. ferox* | 0 | 0,83 | 0 | 0 |
| *Rhyacodrilus coccineus* | 0 | 0,28 | 0 | 0 |
| Total Tubificidae species | 2 | 7 | 1 | 2 |
| Fam. Enchytraeidae | | | | |
| *Lumbricillus lineatus* | 3,9 | 0 | 0 | 0 |
| Total Enchytraeidae species | 1 | 0 | 0 | 0 |
| Total species | 6 | 18 | 1 | 2 |

At $Tm_3$ we found only one species of aquatic Oligochaeta *Limnodrilus profundicola*. At this sample site the water is deep, with a muddy substratum and deficiency of oxygen, fact which explain the presence of a single species.

$Tm_4$ has similar environmental conditions, and we found here two species of Tubificidae, which tolerates very well the high organic load.

Comparing to the Târnava Mare River, the Târnava Mică is richer in species in the upper sector because in this sector the river passes through a non- industrialized area and there are no human interventions along the river.

In the Târnava River we found ten species of aquatic Oligochaeta, six Naididae and four Tubificidae (Table 4).

Table 4: Aquatic Oligochaeta sampled from Târnava River on each sampling site in percentages - relative abundance.

| Species | $T_1$ | $T_2$ |
|---|---|---|
| Fam. Naididae | | |
| *Spercaria josinae* | 0 | 1,2 |
| *Nais communis* | 0 | 1,2 |
| *N. bretscheri* | 0 | 0,6 |
| *N. Pardalis* | 0 | 5,39 |
| *Dero digitata* | 18,18 | 0 |
| *Pristina bilobata* | 72,73 | 0 |
| Total Naididae species | 2 | 4 |
| Fam. Tubificidae | | |
| *Tubifex tubifex* | 0 | 0,6 |
| *T. newaensis* | 0 | 16,77 |
| *L. claparedeianus* | 9,09 | 73,65 |
| *P. vejdovsky* | 0 | 0,6 |
| Total Tubificidae species | 1 | 4 |
| Total species | 3 | 8 |

At $T_1$ sampling station we found three species of aquatic Oligochaeta. The presence of *Dero digitata* indicated an oxygen deficiency in the habitat.

At $T_2$ sampling station we found eight species of aquatic Oligochaeta (four Naididae and four Tubificidae). The Naididae species are tolerant to the organic load of the river substratum (Table 4).

The specific composition of this river is very alike to its two tributaries Târnava Mare River and Târnava Mică River but here we found polisaprobic species *Tubifex tubifex* and *Dero digitata* because the velocity of the water is slower, the transported alluvials can settle and load the substratum with organic substances, and causing the oxygen deficiency.

The aquatic Oligochaeta from the studied rivers are very similar, there are six common species for all the rivers: *Spercaria josinae, Nais bretscheri, Pristina bilobata, Tubifex newaensis, Limnodrilus claparedeianus* and *Potamothrix vejdovsky*.

Considering the water quality, the Târnava Mică River is cleaner than the Târnava Mare River.

**CONCLUSIONS**

In all the studied rivers we identified a number of 27 species of aquatic Oligochaeta, 16 Naididae, 10 Tubificidae and one Enchytraeidae.

The most polluted river is Târnava Mare where from the mountainous sector we found species, which prefer high organic contents in the substratum.

The richest river in species is Târnava Mică where we found 21 species of aquatic Oligochaeta and from the distribution point of view has a normal distribution of the species, with exacting species in the upper sector and a gradually disappearing of these as we go downstream the river.

The poorest river in aquatic Oligochaeta species is Târnava River, which is the shortest and also has the highest organic load. Here we found polisaprobic species.

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# THE FRESHWATER MOLLUSCS FROM THE TÂRNAVA RIVERS BASIN (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: Malacology, pollution ecology, human impact, zoogeography.

**ABSTRACT**

During the last 150 years, several authors have quoted 28 species of molluscs (8 of bivalves and 20 of gastropods) in the Târnava rivers basin. At least two species have probably disappeared, mainly because of pollution and environmental quality debasement, and others were not found during the 1996 - 2001 investigations, carried out by the author, in order to assess the faunistical dynamics which occurred both in time and space, mainly in relation to environmental quality debasement. Most of the 13 present-day living species (among them 7 are quoted for the first time in this basin) belong to tolerant, generalist and resistant groups of Pulmonates and clams, while the Prosobranchs became extinct, and the Unionidae are still living in some short sectors, having a highly patchy distribution.

**ZUSAMMENFASSUNG**: Die Süsswassermollusken aus den Gewässern im Târnava-Tal (Rumänien).

Im Târnava-Tal wurden 28 Süßwassermolluskenarten (8 Muscheln und 20 Schneckenarten) von verschiedenen Autoren in den letzten 150 Jahren nachgewiesen. Wenigstens zwei Arten sind bis heute durch Umweltverschmutzung ausgestorben oder verschollen, und weitere Arten wurden im Untersuchungszeitraum 1996 – 2001 durch den Autor nicht mehr aufgefunden. Die meisten der heutigen 13 Molluskenarten aus den Gewässern im Târnava-Tal (darunter 7 Neunachweise), sind tolerante Generalisten, euryöke Lungenschnecken und Pisidien. Im Gegensatz hierzu sind die Kiemenschnecken ausgestorben oder verschollen, und die Unioniden sind sehr selten und nur in kurzen Flußabschnitten anzutreffen.

**REZUMAT**: Moluştele acvatice din bazinul râurilor Târnave.

În bazinul Târnavelor diferiții autori au identificat în ultimii 150 de ani 28 de specii de moluşte acvatice (8 specii de bivalve şi 20 de gastropode). În urma investigațiilor efectuate de autorul prezentei lucrări în perioada 1996 - 2001 s-a constatat dispariția a cel puțin 2 specii reo-oxifile, fapt explicat prin drasticele modificări ale calității mediului şi deprecierii stării ecologice a habitatelor acvatice din aria menționată. Dintre cele 13 specii care populează actual apele Târnavelor (dintre care 7 sunt nou identificate în apele bazinului), majoritatea aparțin grupelor extrem de tolerante, generaliste şi euriece ale pulmonatelor şi pisidiilor. Prin contrast prosobranchiatele au dispărut, iar puținele unionide au devenit extrem de rare, populând sectoare limitate de râu.

## INTRODUCTION

At the beginning of the 1990's, the flowing point of the Târnava into the Mureş River was considered an inferior limit of the Unionidae and other species' distribution along its course. The reason was the pollution barrier, represented by the heavy metals industrial wastewater discharges, originating mainly from Copşa Mică. Downstream the confluence, in the Mureş River, highest heavy metals contents in the water and high loads in sediments were registered in 1991, and also the disappearance of naiads and some more exacting species from the Mureş course. Due to important industrial pollution reduction, the situation improved significantly during the last years. Many of the aquatic mollusc species are excellent indicators of the environmental quality and ecological state of freshwater systems; therefore it became necessary to trace the fauna dynamics both in time and space in order to highlight the trends. This paper's aim is to evidence the present day distribution of the mollusc fauna along the Târnava rivers, to compare it with that registered in the past by the work of several malacologists and to trace the faunistical changes as response to human impact.

## MATERIALS AND METHODS

The Târnava Mare and Târnava Mică rivers were researched by selecting sampling sectors along their courses, from the spring areas down to the flow into the Mureş River, their positions being selected according to geomorphologic and hydrologic features and to the presence of human impact sources.

The molluscs were sampled directly by hand, by sieves, using bottom Surber or dredges. The systematics is given in accordance to the latest catalogue concerning the freshwater molluscs from the Romanian Inner Carpathians Basin (Glöer and Sîrbu, in press).

Following abbreviations were used in order to present the chorologic catalogue in a brief and synthetic way: **col.** = collection; **leg.** = sampled by; **!** - original data; **Blz.** = Albert E. Bielz; **Km.** = data from the "Mauritius and Richard Winnicki von Kimakowicz collection" kept in the Natural History Museum from Sibiu; **SVNH** = stands for the collections of the "Siebenbürgischer Verein für Naturwissenschaften in Hermannstadt" (Transylvanian Society for Nature Sciences in Sibiu, its collections being kept mainly in the Museum from Sibiu), **NNHA** = collections from the National Natural History Museum "Grigore Antipa" in Bucharest. The other authors are given by surname and year of quotation or sampling.

## RESULTS

The systematic and chorologic catalogue of the freshwater molluscs from the Târnava rivers basin, based on references, collections and original data gathered from several field researches accomplished by the author during the last years, is presented below. The used abbreviations were explained above.

Classis **Gastropoda** CUVIER 1795
Ordo **Neritopsina** COX & KNIGHT 1960
Family **Neritidae** LAMARCK 1809

1. *Theodoxus transversalis* (C. PFEIFFER 1828)

**(Blz., 1867)** - Târnava riverbed at Blaj;

Ordo **Neotaenioglossa** HALLER 1892
Family **Bithyniidae** TROSCHEL 1857

2. *Bithynia tentaculata* (LINNAEUS 1758)

**(col. SVNH)** - Dumbrăveni; **(Blz., 1867)** - Mediaş, Dumbrăveni;

Family **Hydrobiidae** TROSCHEL 1857

3. *Lithoglyphus naticoides* (C. PFEIFFER 1828)

**(Blz., 1867)** - Târnava rivers at Blaj;

Ordo **Pulmonata** CUVIER IN BLAINVILLE 1814

Family **Lymnaeidae** RAFINESQUE 1815

4. *Galba truncatula* (O.F. MÜLLER 1774)

**(col. SVNH - Blz.)**. - Dumbrăveni and Valea Lungă; **(col. Km.)** - Sighişoara (leg. Petri, 1887); **(Blz., 1867)** - Jidvei; **(!)** - brooks and puddles at Vărşag, brook at Şaeş (outflow of a marsh; leg. Ana Benedek, 2003); upstream Mediaş and in Târnava village, the united Târnava at Mihalţ;

5. *Stagnicola palustris* (O.F. MÜLLER 1774)

*Stagnicola palustris* s. lat (agg.) - **(col. SVNH - col. Blz.):** Jidvei, Valea Lungă, Dumbrăveni; **(Blz., 1867)** - Şaeş, Dumbrăveni, Mediaş, Valea Lungă; **(col. Km.)** - Dealu (leg. Traxler, 1890), fishponds at Valea Lungă, sampled in 1866;

*Stagnicola palustris* (O.F. MÜLLER 1774) s. str. (anatomical evidence).

**(!)** - puddles and brooks at Vărşag, in the riverbed downstream Sighişoara;

6. *Stagnicola turricula* (HELD 1836)

**(col. Km.)** - Sighişoara (Blz.);

7. *Stagnicola corvus* (GMELIN 1791)

**(col. Km.)** - Valea Lungă (leg. Barth, 1866; leg. Km., 1906); **(Blz., 1867)** - ponds at Jidvei and Valea Lungă;

8. *Radix auricularia* (LINNAEUS 1758)

**(col. SVNH)** - Mediaş (leg. Barth), Valea Lungă (leg. Blz.); **(col. Km.)** - Mediaş (backwaters of Târnava Mare, leg. 1908), backwaters at Dumbrăveni (leg. 1888); **(Blz, 1867)** - isolated branch at Mediaş, Valea Lungă, Alba Iulia; **(!)** - the riverbed of Târnava Mare between Sighişoara and Târnava Sat, in the vicinity of the banks;

9. *Radix labiata* (ROSSMÄSSLER 1835)

Syn.: *Radix peregra* (O. F. MÜLLER 1774)

**(col. SVNH)** - Valea Lungă, Nicoleşti, Beclean - Odorhei, Sighişoara, Mediaş; **(col. Km.)** - Sighişoara, dead branch of Târnava at Mediaş (leg. Barth, 1908), Valea Lungă (ponds, leg. Barth, 1908); **(Blz., 1867)** - Ocna Sibiului, brook at Mândra; **(!)** - Târnava Mică in the riverbed and flood area, ponds and brooks on the Creanga Mică and Mare, in the riverbed downstream Sovata, in Târnava Mare riverbed, brooks, ponds and springs at Vărşag, and upstream Zetea;

10. *Lymnaea stagnalis* (LINNAEUS 1758)

**(col. SVNH)** - Odorheiu Secuiesc, Jidvei, Blaj; (Blz., 1867) - Sighişoara in the dead branch of Târnava, Şaeş, Richiş, Moşna fishpond, Mediaş - backwater of Târnava, marshes of Jidvei, Valea Lungă, pond at Blaj;

Family **Physidae** FITZINGER 1833

11. *Physella acuta* (DRAPARNAUD 1805)

**(!) -** Târnava Mare between Sighişoara and Târnava Sat, ponds from Mândra (Visa tributary);

12. *Aplexa hypnorum* (LINNAEUS 1758)

**(Blz., 1867)** - Dumbrăveni;

Family **Planorbidae** RAFINESQUE 1815

13. *Planorbarius corneus* (LINNAEUS 1758)

**(col. SVNH and col. Km.)** - Valea Lungă; **(Blz, 1867)** - Jidvei, pond at Blaj, Mediaş in a dead branch, Valea Lungă, Moşna and Mănărade;

14. *Planorbis planorbis* (LINNAEUS 1758)
**(col. SVNH)** - Nicoleşti (near Odorheiu Secuiesc), Şaeş, Sighişoara, Jidvei, Dumbrăveni, Valea Lungă; **(col. Km.)** - Sighişoara, Valea Lungă; **(Blz., 1867)** - Şaeş, pond at Dumbrăveni, Mediaş - Târnava backwater, Jidvei, Valea Lungă; **(!) -** fishponds from Mândra (Visa tributary);

15. *Anisus spirorbis* (LINNAEUS 1758)
**(col. SVNH)** - Beteşti (near Odorheiu Secuiesc); **(col. Blz. in NNHA)** Odorheiu Secuiesc; **(Blz., 1867)** - Ocna Sibiului, ponds at Jidvei; **(!)** - empty shells at Sighişoara;

16. *Anisus leucostoma* (MILLET 1813)
**(!)** - puddles and brooks close to Creanga Mică and Creanga Mare (Târnava Mică River); ponds and brooks at Vărşag (Târnava Mare River);

17. *Anisus calculiformis* (SANDBERGER 1874)
Syn.: *Anisus septemgyratus* (ROSSMAESSLER 1835)
**(col. SVNH and Blz., 1867)** - Valea Lungă;

18. *Segmentina nitida* (O.F. MÜLLER 1774)
**(col. SVNH)** - Valea Lungă; **(Blz., 1867)** - Ocna Sibiului;

Family **Ferrissiidae** WALKER 1917

19. *Ferrissia wautieri* (MIROLLI 1960)
**(!)** - in the Târnava Mare, on leaves of *Potamogeton natans* downstream Sighişoara;

Family **Ancylidae** RAFINESQUE 1815

20. *Ancylus fluviatilis* O.F. MÜLLER 1774
**(!)** - Târnava Mică from the Creanga Mică and Mare rivers, downwards to Sovata, and in the Târnava Mare from upstream Vărşag, down to Zetea;

Classis **Bivalvia** LINNAEUS 1758
Ordo **Unionoida** STOLICZKA 1871
Family **Unionidae** RAFINESQUE 1820

21. *Unio crassus* PHILIPSSON 1788
**(col. SVNH)** - Târnava Mare at Odorhei Secuiesc; **(Blz., 1867)** - Târnava Mare at Sighişoara and Dumbrăveni, Târnava Mare and Mică at Blaj, Târnava Mică at Chendu Mic; **(Sárkány-Kiss, 1983)** - Târnava Mică from downstream Sovata, once continuously spread between Ghindari and Târnăveni; **(!)** - Târnava Mică - one individual sampled by D. Bănăduc in 2001 from Sângeorgiu de Pădure; scattered groups upstream of Târnăveni. In Târnava Mare, only shells along its course.

22. *Anodonta cygnaea* (LINNAEUS 1758)
**(Blz., 1867)** - backwaters at Blaj;

23. *Anodonta anatina* (LINNAEUS 1758)
**(col. SVNH)** - Visa River at Veşeud (leg. Look Thomas, 1975); **(Sárkány-Kiss, 1983)** - scattered individuals in the Târnava Mică;

Ordo **Veneroida** H. & A. ADAMS 1856
Family **Sphaeriidae** DESHAYES 1855 (1820)

24. *Musculium lacustre* (O.F. MÜLLER 1774)
**(col. SVNH)** - Valea Lungă; **(col. Km.)** - Sighişoara, Valea Lungă (leg. Barth, 1906); **(Blz., 1867)** - Şaeş near Sighişoara;

25. *Pisidium casertanum* (POLI 1791)
**(!)** - brooks and puddles near Creanga Mică and Creanga Mare, upstream of Praid (Târnava Mică); ponds and rivulets at Vărşag and in Târnava Mare at Zetea;

26. *Pisidium personatum* MALM 1855
**(!)** - ponds and brooks near Creanga Mică and Mare (upstream Praid), Vărşag, outflow of the Şaeş marsh (leg. Ana Benedek, 2003);
27. *Pisidium obtusale* (LAMARCK 1818)
**(Blz., 1867)** - Şaeş;
28. *Pisidium subtruncatum* MALM 1855
**(!)** - Târnava Mică riverbed upstream Târnăveni, puddles at Vărşag (Târnava Mare basin).

**DISCUSSION**

The oldest records of some freshwater molluscs species from the Târnava rivers date back to the XIX[th] Century, especially regarding riverbeds' sectors in the vicinity of the main localities, such as Blaj, Mediaş, Sighişoara, Odorheiu Secuiesc and others. Some prosobranchs, like *Theodoxus transversalis* and *Lithoglyphus naticoides*, once largely spread, were not found again during the last decades, being presumably extinct in these rivers. A. Sárkány-Kiss (1989) stated that Târnava Mică, downstream Sovata, was populated with *Unio crassus* down to its confluence, and scattered individuals of *Anodonta anatina* could also be found. In the Târnava Mare River, he quoted *Unio crassus* downstream Odorheiu Secuiesc.

Târnava Mare was thoroughly checked out in 1996 (with Monica Sîrbu), and in the years 2000 - 2001, but no living Unionidae were found again in the whole course of this river. However, lots of empty shells belonging to *U. crassus*, prove its former continuous distribution and the effect of the past wastewater discharges. Investigations of some areas along the Târnava Mică River, together with A. Sárkány-Kiss, during 1996 - 97, remained also without result in the attempt to find naiads, and we assumed that all Unionidae, have also disappeared from this river (Sárkány-Kiss and Sîrbu, 1998). But in 2000 the author has found scattered but abundant groups of individuals belonging to the former mentioned species upstream Târnăveni, and D. Bănăduc sampled in 2001 one individual from Sângeorgiu de Pădure. It became clear that the species has not disappeared from the whole Târnava Mică course, but it became rare, having a highly patchy distribution, in a shorter sector bordered downwards by the Târnăveni locality.

During the investigations carried out in the years 2000 and 2001, 13 present-day living species have been found, among them 7 are quoted for the first time in the area of reference. By contrast, no prosobranchs and no other Unionidae (excepting the former mentioned case regarding *Unio crassus*) have been found again. One of the exacting rheo-oxyphillous Pulmonates, indicating a certain quality of the aquatic environment, *Ancylus fluviatilis*, is in present restricted on both rivers to some short sectors in the upper reaches.

In the Târnava Mică upper basin, the river is formed by the confluence of two mountain shaped rivulets named Creanga Mică and Creanga Mare. Upstream their confluence, 5 species were found; among them *Ancylus fluviatilis* inhabits the riverbeds, while *Radix labiata* is confined to some shallow sectors, puddles, pools and brooks from their valleys. In small waters from this area, large populations of *Pisidium casertanum, Pisidium personatum* and *Anisus leucostoma* have been found, the last two being premier identifications in this area. *A. fluviatilis* can still be found upstream Praid and some scattered individuals close and downstream Sovata, but not further. The rest of the river's course is very poor in species, and some sectors were proved to shelter no mollusca species at all, for instance near the localities of Coroisânmartin and Suplac. Downwards, although the single living naiad, *Unio crassus*, became very scarce and patchy distributed, the presence of both reproductive adults and juveniles, at the level of Târnăveni, signifies a certain guarantee of the species' maintenance in the future. In the riverbed near this locality, the euribiont *Pisidium subtruncatum* was first time found in the Târnava basin.

Along the Târnava Mare the mollusc fauna is even poorer than it was formerly presented. There can be distinguished only two groups of species: those sheltered in the area delimited between the springs and downstream the dam placed above Zetea locality, and that formed by a very few euribionts species, pollution resistant Pulmonates, from the whole rest of the river.

Table 1: Distribution of the freshwater molluscs species, found by the author between 1996 and 2001 in the Târnava rivers basin.

| No. | Species / Sampling station | Târnava Mică | | | | | | Târnava Mare | | | | | | | | | | UT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 1. | *Galba truncatula* | | | | | | | b | | | b | X | | X | X | | | X |
| 2. | *Stagnicola palustris* | | | | | | | p<br>b | | | | X | | | | | | |
| 3. | *Radix auricularia* | | | | | | | | | | | X | X | X | X | | | |
| 4. | *Radix labiata* | X<br>b<br>p | X<br>b<br>p | | X | | | X<br>b<br>p<br>s | p | | | | | | | | | |
| 5. | *Physella acuta* | | | | | | | | | | | X | X | X | X | | L | |
| 6. | *Planorbis planorbis* | | | | | | | | | | | | | | | | L | |
| 7. | *Anisus leucostoma* | p | p | | | | | p<br>b | | | | | | | | | | |
| 8. | *Ferrissia wautieri* | | | | | | | | | | | X | | | | | | |
| 9. | *Ancylus fluviatilis* | X | X | X | X | | | X<br>b | X | | | | | | | | | |
| 10. | *Unio crassus* | | | | | X | X | | | + | | | + | | + | + | | |
| 11. | *Pisidium casertanum* | p | p | X | | | | p<br>b | X | | | | | | | | | |
| 12. | *Pisidium personatum* | p | p | | | | | p<br>b | | | b | | | | | | | |
| 13. | *P. subtruncatum* | | | | | | X | p | | | | | | | | | | |

The codes and symbols used in Tab. 1: UT - the river formed by the confluence of Târnava Mare and Târnava Mică, 1 - Creanga Mică rivulet upstream the confluence with 2. - Creanga Mare river, both forming the Târnava Mică, 3. - upstream Praid, 4. - downstream Sovata, 5. - Sângeorgiu de Pădure, 6 - upstream Târnăveni; (sampling stations on Târnava Mare) 7. - upstream Vărşag, 8. - upstream Zetea, 9. - downstream Odorheiu Secuiesc, 10. - Şaeş, 11. - downstream Sighişoara, 12. - Lunca-Hoghilag, 13. - upstream Mediaş, 14. - Târnava Village, 15. - downstream Copşa Mică, 16. - fishponds at Mândra - Visa tributary, 17. - Mihalț. In the cells: p - pools or puddles, b - brooks or rivulets, s - springs, L - lakes or ponds, X - Târnava riverbed, + - only empty shells were found in the rivers' sediments.

From upstream Vărşag down to Zetea, *Ancylus fluviatilis* is frequently encountered in the riverbed and brooks, sometimes being associated with *Radix labiata*, the last being sampled also from lots of small-sized flowing or stagnant waters. In brooks and puddles from the mountain valleys *Pisidium personatum,* sometimes joined by *Galba truncatula*, can be found. In the marshy bed of a former trout fishpond, a very interesting and abundant community was registered, the populations being ascribed to *Stagnicola palustris, Radix labiata, Anisus leucostoma, Pisidium casertanum, P. personatum* and *P. subtruncatum.* Downstream Odorheiu Secuiesc the riverbed is very poor in species, but sometimes rich in individuals. The characteristic community for organic overloaded waters is best shown downstream Sighişoara, down to Târnava locality, formed by abundant populations belonging to *Galba truncatula,* *Radix auricularia* and *Physella acuta*, rarely joined by *Stagnicola palustris.* Most are capable to survive and develop on thick muddy layers placed close to the riverbanks, or above the water level (*G. truncatula* or *P. acuta*), being less dependent on dissolved oxygen, or even adapted to semi-amphibious life. The premier encounter of *Ferrissia wautieri* on leaves of *Potamogeton natans*, downstream Sighişoara, is an exception explained by chance, this habitat resembling no specific required conditions (usually stagnant waterbodies, rich in vegetation). Most probably, both plant and mollusca have been washed from the flood area or some pools in the vicinity. Downstream, at Copşa Mică and further to Blaj, no living mollusc has been found in the riverbed. The distribution of the present-day species along the Târnava rivers is given in Tab. 1.

Some rarely encountered species can still be sampled from tributaries, like the Visa River or the outflow of the Şaeş marsh. Downstream the confluence of the Târnava Mică and Târnava Mare, only *Galba truncatula* was found alive.

Analysing the present day structure and distribution of the mollusc fauna along the Târnave rivers suggests the effects of human impact, expressed mainly by pollution and hydrotechnical works. But in this case, the improvement of the ecological state is hard to be evidenced by molluscs, because the rivers lack the flood areas and the repopulating sources, responsible for the fauna recovery.

Table 2: Mean density (D = no. of individuals/m$^2$) and relative abundance (A%) of the benthic macroinvertebrates groups in the Mureş River, at Gura Arieş and Sântimbru (upstream and downstream the Târnava rivers flow) in 1999 - 2000 (based on 12 samples taken in all seasons).

| Sampling station / Systematic group | Gura Arieş | | Sântimbru | |
|---|---|---|---|---|
| | D | A% | D | A% |
| Hydroidea | 4.35 | .095 | 1.74 | .015 |
| Nemathelminthes | 4.35 | .095 | 16.54 | .145 |
| Oligochaeta | 2033.20 | 44.257 | 7382.22 | 64.555 |
| Hirudinea | .87 | .019 | .00 | .000 |
| Mollusca | 17.42 | .379 | 101.88 | .891 |
| Amphipoda | .00 | .000 | 3.48 | .030 |
| Hydracarina | 5.22 | .114 | 1.74 | .015 |
| Collembola | 4.35 | .095 | 3.48 | .030 |
| Ephemeroptra | 274.29 | 5.970 | 653.93 | 5.718 |
| Odonata | 1.74 | .038 | 1.74 | .015 |
| Plecoptera | .00 | .000 | .87 | .008 |
| Trichoptera | 134.10 | 2.919 | 64.44 | .563 |
| Coleoptera | .00 | .000 | .87 | .008 |
| Chironomidae | 2080.22 | 45.280 | 3161.69 | 27.649 |
| Other Diptera | 33.96 | .739 | 40.93 | .358 |
| Total: | 4594.07 | 100 | 11435.55 | 100 |

The environmental changes can be better traced by comparing the past and present day effect of the Târnave discharge in the Mureş River and its benthic communities' dynamics (I. Sîrbu and A. Sárkány-Kiss, 2002; I. Sîrbu, A. Sárkány-Kiss and M. Sîrbu, 2002). Until the 8$^{th}$ decade of the last Century, the Unionidae populated the whole middle course of the Mureş River, being represented by 5 species. During the expedition in 1991, A. Sárkány-Kiss has not found a single living individual downstream the discharge of the Târnava River, because of the heavy metals pollution originating from Copşa Mică. Downstream the confluence, high concentrations in the water were registered by Waijandt (published in 1995) for Cu (25 mg/l), Zn (147 mg/l), Cr (75 mg/l), Hg (9 mg/l), Cd (2 mg/l) and Pb (30 mg/l) and also high contents in sediments. The discharging point was also the threshold for some other species' distribution along the river. During 1999 - 2000 the Unionidae were found again downstream the confluence; at least two species (*Unio pictorum* and *Anodonta anatina*) were once again capable to repopulate the Mureş riverbed. Scattered individuals are found in present, in the vicinity of riverbanks, from this point downstream to Alba Iulia and further to Vinţu de Jos. Later, in the lower sector (western lowland) of the Mureş River, there were also noticed *Anodonta cygnaea* (individual sampled by D. Bănăduc near the town of Arad) and *Sinanodonta woodiana* (Sárkány-Kiss, in. verbis). In 2000 the team lead by A. Sárkány-Kiss recorded a decrease in heavy metal pollution of the water (concentrations were 4 times lower in case of Pb, and more than 2 times lower in case of Cu and Cd), and also of sediments, compared with the situation registered in 1991. All these are linked to the important reduction of industrial pollution during the past decade. But there are some certain clues that household and farms' organic wastewater discharges are not decreasing at all, but in contrary, as it was proved by both chemical analysis and macrozoobenthos studies (A. Szitó, 1995, 2002, I. Sîrbu et al., 2002).

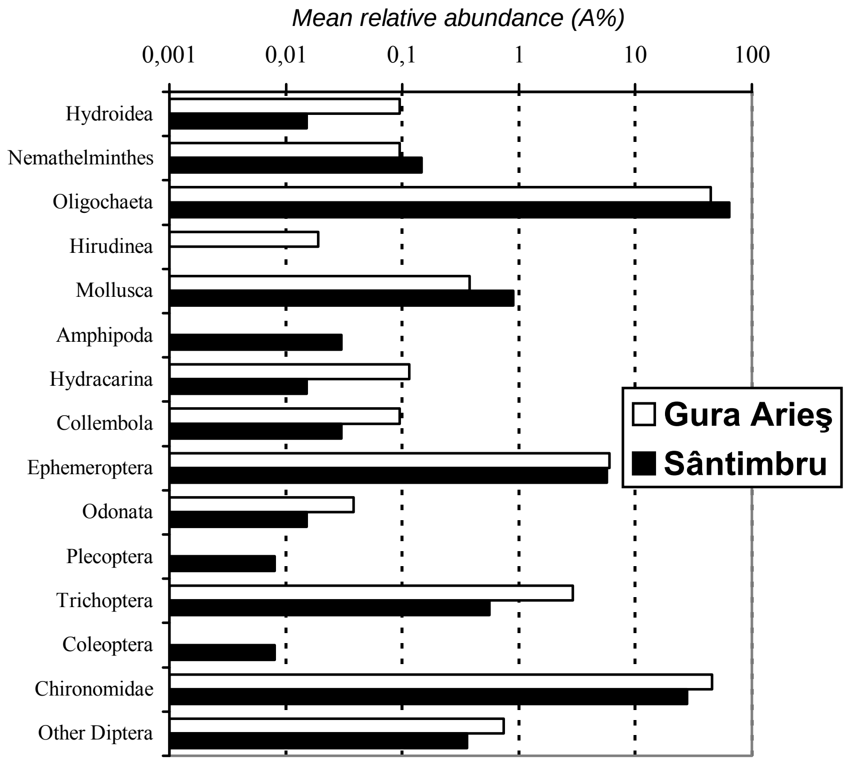


Fig. 1: Benthic macroinvertebrates communities' structure from the Mureş River, at Gura Arieş (downstream the Arieş tributary flow and upstream the Târnava discharge) and from Sântimbru (downstream the flow of the Târnava River) in terms of relative abundance (A%), based on 12 samples taken in 1999 - 2000 (on logarithmic scale).

In Tab. 2 the benthic macroinvertebrates communities' structure from the Mureş River, at Gura Arieş (downstream the Arieş River tributary flow) and from Sântimbru (downstream the Târnava River flow) is presented. The values of mean density (D = no. of individuals / $m^2$) and mean relative abundance (A%) are based on 12 benthic samples taken between 1999 and 2000, all seasons being represented. Because the two stations are placed upstream and downstream the Târnava flow, the environmental conditions changes can be highlighted. In 1991 A. Szitó found at Gura Arieş some few species belonging to 4 benthic groups. In 2000 we found a much more diverse benthic community, 12 systematic groups being represented. Analysing the present structures from the two stations, it is obvious that downstream the Târnava flow, among the 14 systematic groups, Amphipoda, Plecoptera and Coleoptera representatives are once again appearing in the riverbed. The actual benthic total density is raising downstream (from 4594.97 individuals/$m^2$ at Gura Arieş to 11435.55 individuals /$m^2$ at Sântimbru). The thick muddy layers placed downstream along the banks, prove a higher organic pollution, the Târnava River being an important responsible for this state. But, as chemical analysis also suggests, the heavy metal discharge is much higher at the Arieş tributary flow. Comparing the benthic macroinvertebrates structure (in terms of relative abundance; Fig. 1) it is evidenced that at Gura Arieş the Oligochaeta and Chironomidae larvae are codominant, while at Sântimbru the Oligochaeta became the prevailing group.

## CONCLUSIONS

In the Târnave rivers basin, a total of 28 species of freshwater molluscs (8 of bivalves and 20 gastropods) belonging to 10 families were quoted until the present. During the 1996 - 2001 period, the author has found 13 species, among them 7 are identified for the first time in this area. Another species, *Anisus spirorbis* was found only by empty shells. Among the species that were not recovered, at least two (*Theodoxus transversalis* and *Lithoglyphus naticoides*) are probably extinct. No prosobranchs have been found again, and the Unionidae have either totally disappeared from the whole course (as it happened in Târnava Mare), or have restrained their distribution to some sectors and patches (as it happened with *Unio crassus* along the Târnava Mică). There can be roughly distinguished two groups of species and two sectors of environmental quality: the source areas, were the species *Ancylus fluviatilis* is restricted in present, indicating also the border between the two categories, and the rest of the flowing waters, where a few euribiont, highly resistant or opportunistic Pulmonates populate a narrow sector close to the riverbanks. Although the recovery of Unionidae distribution and of other benthic groups, downstream the Târnave flow in the Mureş River, prove a certain improvement of environmental quality the mollusc fauna of the Târnave riverbeds is still very poor. This is explained by hydrotechnical works (draining of wetlands, debasement of flood area, damming, etc.) that destroyed the potential repopulating sources of lots of species, and the prevailing effect of organic household wastewater discharges, despite the fact that industrial pollution (and especially the heavy metals discharges) has drastically decreased during the last years.

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# PRELIMINARY NOTE CONCERNING THE TERRESTRIAL MOLLUSK FAUNA OF THE TÂRNAVA RIVER HYDROGRAPHIC BASIN (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: specific diversity, terrestrial gastropods, human impact, Transylvania, Romania.

**ABSTRACT**

This paper presents the qualitative results on the terrestrial mollusk fauna of the Târnava hydrological basin.

In the 16 sampling stations there have been identified 43 taxa. The number of taxa per station is generally low. The highest diversity was recorded in the mountainous stations relatively close by the rivers sources on Târnava Mare, uphill Vârşag ($TM_1$), (16 species) and on Târnava Mică, on sampling stations $Tm_1$ - Craca Mică, and $Tm_2$ - Craca Mare (10 species). The rest of the stations present a very low number of species (3 to 7). The low diversity of terrestrial mollusk fauna of the investigated area exist most probably due to the changes occurred in specific habitats by anthropogenic activities, and especially due to the vegetation degradation, which is known as determinative for the terrestrial mollusks communities.

**RÉSUMÉ**: Notes préliminaires sur les gastropodes terrèstres du basin hydrographic Târnava.

Ce travail présent des résultates préliminaires qualitatives sur la malacofaune terrèstre du basin hydrographique Târnava. Dans le 16 points de prélèvement, ont été identifiées 43 éspèces de gastropodes terèstres. La diversité spécifique la plus élevé a été trouvé dans les habitats situées a la proximité de la source, sur Târnava Mare ($TM_1$), (16 éspèces); Târnava Mică, $Tm_1$ - Craca Mică, et $Tm_2$ - Craca Mare (10 espèces). Dans le rest des points de prélèvement la diversité spécifique est très réduite (3 a 7 especes). Ce résultat est probablement determiné par les changements survenues dans les habitats spécifiques, et specialement dans la vegetation grâce à l'activité anthropique, étant connu le fait que cette-ci est définitiore pour les communautées des gastropods terrèstres.

**REZUMAT**: Note preliminare privind fauna de moluşte terestre din bazinul hidrografic Târnava.

Lucrarea prezintă date calitative privind fauna de moluşte terestre din 16 stații localizate în zona văilor râurilor Târnava Mare, Târnava Mică, Târnava, precum şi Mureş în apropierea confluenței cu Târnava. Au fost identificate un număr de 43 de specii de gastropode terestre. Cea mai mare diversitate specifică a fost înregistrată în stațiile situate amonte, în apropierea izvoarelor, pe Târnava Mare ($TM_1$), (16 specii) şi Târnava Mică, $Tm_1$ - Craca Mică, şi $Tm_2$ - Craca Mare (10 specii). În restul stațiilor diversitatea este foarte scăzută (între 3 şi 7 specii per stație). Diversitatea scăzută înregistrată este cel mai probabil datorată deteriorării habitatelor specifice şi în special a vegetației, fiind cunoscut faptul că aceasta din urmă este definitorie pentru edificarea comunităților de gastropode terestre.

## INTRODUCTION

In the terrestrial ecosystems, gastropods represent one of the most important invertebrate group, with a central place in the terrestrial food chains. Their presence in certain habitats is determined by the environmental factors, among which the most important for the group seems to be the humidity, temperature and vegetation type.

References concerning the terrestrial molluskfauna of the studied area, Târnava hydrographic basin, are pour, and only punctual (Bielz M, 1843; Bielz A.E., 1867; Kimakowicz M.v., 1883 - 1884; Grossu Al., 1955, 1956, 1981, 1983, 1987, 1993). This paper presents preliminary qualitative results on the terrestrial gastropods of the Târnava hydrological basin.

## MATERIAL AND METHODS

Qualitative samples including soil samples, were collected in 2000 and 2001, and gastropods were identified.

Six sites were selected on the Târnava Mică River, uphill Praid, Craca Mică ($Tm_1$) and Craca Mare ($Tm_2$), downhill Sovata ($Tm_3$), Coroisânmartin ($Tm_4$), uphill Târnăveni ($Tm_5$), and uphill Blaj ($Tm_6$), and 7 on the Târnava Mare River, uphill Vârşag ($TM_1$) and ($TM_2$), and downhill Zetea ($TM_3$), downhill Odorhei ($TM_4$) and downhill Sighişoara ($TM_5$) uphill Mediaş ($TM_6$), and downhill Copşa Mică ($TM_7$). Samples were also taken on Târnava River at Mihalț (T), and on Mureş uphill ($M_1$) and downhill ($M_2$) the confluence with Târnava [see Fig. no. 1].

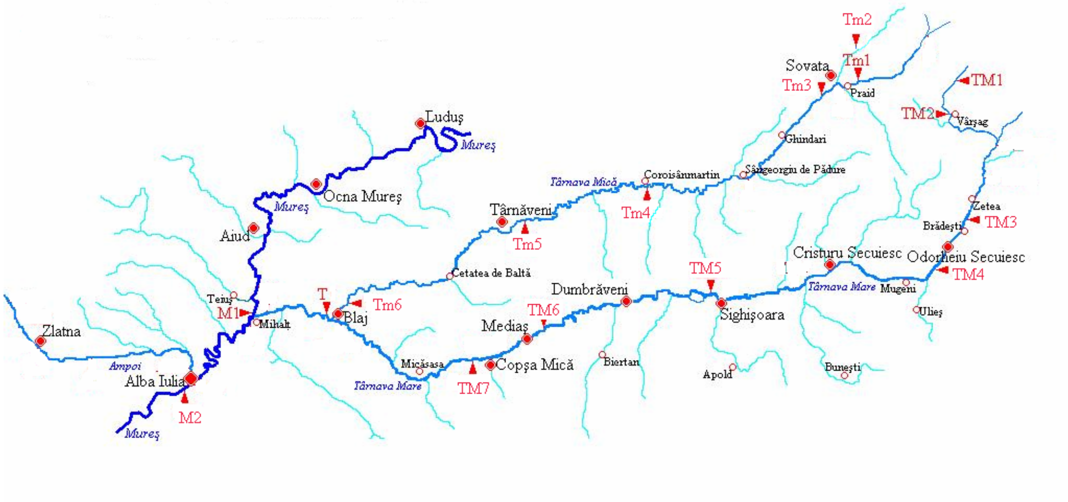


Fig. 1: Sampling stations on Târnava Mare (TM), Târnava Mică (Tm), Târnava (T) and Mureş (M).

## RESULTS AND DISCUSSION

In the 16 sampling stations there have been identified 43 taxa (Tab. 1). The number of taxa per station is generally low. The highest diversity was recorded at the stations near the source on Târnava Mare, uphill Vârşag ($TM_1$), (16 species) and on Târnava Mică, on sampling stations $Tm_1$ - Craca Mică, and $Tm_2$ - Craca Mare (10 species). The rest of the sampling stations present a very low number of species (3 to 7).

Concerning the composition of terrestrial molluskfauna, the three sampling stations located uphill, near the source are located in similar biotops - deciduous forest, and here were found species of Cochlicopidae, Valoniidae, Vertiginidae, Enidae, Clausilidae, Patulidae and Oxichilidae families, but also species of Bradibenidae, Hygromiidae and Helicidae.

Table 1: The terrestrial gastropods identified in the 16 stations. (Ts = the presence of taxa in all 16 stations; Ref = indications in references concerning the presence of some species in the area, Bielz, Kimakowicz, Grossu).

| | TM1 | TM2 | TM3 | TM4 | TM5 | TM6 | TM7 | Tm1 | Tm2 | Tm3 | Tm4 | Tm5 | Tm6 | T | M1 | M2 | Ts | Ref |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Succineidae | | | | | | | | | | | | | | | | | | |
| *Succinea putris*<br>Linnaeus | | | | | + | + | | | | | | | | | | | + | + |
| *Succinea oblonga*<br>Drap. | | | | | | | | | | | | | | | | | | + |
| Cochlicopidae | | | | | | | | | | | | | | | | | | |
| *Cochlicopa lubrica*<br>Müll. | | | + | | | | | + | | | | | | | | | + | + |
| Orculidae | | | | | | | | | | | | | | | | | | |
| *Agarna bielzi*<br>Rossm | + | | | | | | | | | | | | | | | | + | |
| Valloniidae | | | | | | | | | | | | | | | | | | |
| *Vallonia pulchella*<br>Müll. | | | + | | | | | | | | | | | | | | + | + |
| *Vallonia costata*<br>Müll. | | | | | | | | + | | | | | | | | | + | |
| *Vallonia excentrica*<br>Sterki | | | | | | | | | | | | | | | | | | + |
| *Acanthinula aculeata*<br>Mull. | | | | | | | | | + | | | | | | | | + | + |
| Vertiginidae | | | | | | | | | | | | | | | | | | |
| *Vertigo pygmaea*<br>Drap | | | | | | | | | | | | | | | | | | + |
| *Vertigo alpestris*<br>Alder | + | | | | | | | | | | | | | | | | + | |
| *Vertigo antivertigo*<br>West | | | | | | | | | | | | | | | | | | + |
| *Vertigo angustior*<br>Jeffreys | | | | | | | | | | | | | | | | | | + |
| *Columella edentula*<br>Drap. | | | | | | | | | | | | | | | | | | + |
| *Truncatellina cylindrica*<br>*Fér.* | | | | | | | | | | | | | | | | | | + |
| Enidae | | | | | | | | | | | | | | | | | | |
| *Ena montana*<br>*Drap.* | | | | | | | | + | | | | | | | | | + | |
| *Merdigera obscura*<br>Mull. | + | | | | | | | | | | | | | | | | + | |
| *Chondtrula tridens*<br>Rossm. | | | | | | | | | | | | | + | | | | + | + |
| *Granaria frumentum*<br>Drap. | | | | | | | | | | | | | | | | | | + |
| Clausiliidae | | | | | | | | | | | | | | | | | | |
| *Cochlodina laminata*<br>Mont | + | | | | | | | | | | | | | | | | + | |
| *Cochlodina orthostoma*<br>Menke | | | | | | | | + | | | | | | | | | + | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Macrogastra plicatula* Drap | | | | | | | | | | | | | | | | | | + |
| *Laciniaria plicata* Drap. | + | | | | | | | | | | | | | | | | + | |
| *Rithenica filograna* Rossm. | + | | | | | | | | | | | | | | | | + | |
| *Clausilia dubia* Drap. | | | + | | | | | | + | | | | | | | | + | + |
| *Laciniaria plicata* Drap. | | + | | | | | | | | | | | | | | | + | |
| *Vestia elata* Rössm. | | | | | | | | | + | | | | | | | | + | |
| *Vestia gulo* *Bielz* | | | | | | | | + | + | | | | | | | | + | + |
| *Pseudalinda falax* Rössm. | | | | | | | | | | | | | | | | | | + |
| *Bulgarica vetusta* Rossm. | + | | | | | | | + | | | | | | | | | + | |
| Punctidae | | | | | | | | | | | | | | | | | | |
| *Punctum pygmaeum* Drap. | | | | | | | | | | | | | | | | | | + |
| Patulidae | | | | | | | | | | | | | | | | | | |
| *Discus ruderatus* Ferr. | + | | | | | | | | | | | | | | | | + | |
| *Discus perspectivus* Mühlf. | + | | | | | | | | + | | | | | | | | + | |
| Pristilomatidae | | | | | | | | | | | | | | | | | | |
| *Phenacolimax bielzi* Kimak. | | | | | | | | | | | | | | | | | | + |
| Euconulidae | | | | | | | | | | | | | | | | | | |
| *Euconulus fulvus* Müll. | | | | | | | | | | | | | | | | | | + |
| Gastrodontidae | | | | | | | | | | | | | | | | | | |
| *Zonitoides nitidus* Müll. | | | | | | | | | | | | | | | | | | + |
| Oxychilidae | | | | | | | | | | | | | | | | | | |
| *Vitraea transsylvanica* Cless | + | | | | | | | | | | | | | | | | + | |
| *Vitraea diaphana* Studer | + | | | | | | | | | | | | | | | | + | |
| *Vitraea crystalina* Bourg. | | | | | | | | | | | | | | | | | | + |
| *Oxychillus depressus* Sterki | | | | | | | | + | | | | | | | | | + | + |
| *Aegopinella mino* Stabile | | | | | | | | + | | | | | | | | | + | |
| *Aegopinella pura* Adler | | | | | | | | | + | | | | | | | | + | + |
| Limacidae | | | | | | | | | | | | | | | | | | |
| Limax cinereoniger *Wolf* | + | | | | | | | | | | | | | | | | + | + |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arionidae | | | | | | | | | | | | | | | | | | |
| Arion subfuscus *Drap.* | | | | | | | | + | | | | | | | | | + | |
| Bradybaenidae | | | | | | | | | | | | | | | | | | |
| *Fruticicola fruticum* Müll. | + | + | + | + | | + | + | | | + | | + | | + | + | | + | |
| Hygromiidae | | | | | | | | | | | | | | | | | | |
| *Helicella obvia* Menke | | | | | + | | | | | | | | | | | | + | + |
| *Helicopsis cereoflava* Bielz | | | | | | | | | | | | | + | | | | + | + |
| *Helicopsis instabilis* Rossm | | | | | | | | | | | | | | | | + | + | + |
| Euomphalia strigella *Drap* | | + | | | | | | | | + | + | + | | + | | | + | + |
| *Pseudotrichia rubiginosa* Schm | | | | + | | + | | | | | | | | | | | + | + |
| *Trichia edentula* Drap. | + | | | | | | | | | | | | | | | | + | |
| *Monacha cartusiana* Mull. | | | + | | + | + | | | | | | | | | | + | + | + |
| *Monachoides vicinus* Ross | | | | | | | | | + | | | | | | | | + | + |
| *Monachoides incarnatus* Mull. | + | | | | | | | | | | | | | | | | | + |
| *Perforatella bidentata* Gmelin | | | | | | | | | | | | | | | | | | + |
| *Perforatella dibotryon* Kimakowicz | + | | | | | | | | + | | | | | | | | + | + |
| Helicidae | | | | | | | | | | | | | | | | | | |
| Drobacia banatica *Rossm.* | | | | | | | | | | | | | | | | | | + |
| *Faustina faustina* Rossm. | | | | | | | | | | | | | | | | | | + |
| *Isognomostoma isognomostomos* Gmelin | | | | | | | | | | | | | | | | | | + |
| *Arianta arbustorum* Pfeiffer | | | | | | | | | + | | | | | | | | + | |
| *Cepaea vindobonensis* Ferr. | | + | | + | + | + | + | | | + | | + | | + | + | | + | + |
| *Helix pomatia* Linnaeus | | + | + | + | | + | + | + | + | + | + | + | | | + | | + | + |
| *Helix lutescens* Rossm. | | | | + | + | + | | | | | + | + | + | + | + | + | + | + |
| Total | 16 | 5 | 6 | 5 | 4 | 7 | 3 | 10 | 10 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 43 | 41 |

In the rest of the stations, there are present almost only species of Bradybenidae, Hygromiidae and Helicide, namely *Fruticicola fruticum, Cepaea vindobonensis*, *Helix pomatia Helix lutescens* and *Euomphalia strigella.* Three of these sampling stations are disposed on sunny slopes ($TM_5$, $Tm_6$ and $M_2$), with xerophylous vegetation where inhabit xerophylous gastropods like *Helicella obvia, Helicopsis instabilis, Helicopsis cereoflava, Chondrula tridens, Cepaea vindobonensis.*

The comparative analysis of this list of taxa and of the references on the molluskfauna of this area show that 20 of the 43 species founded in 2000 - 2001 are not signaled for the region, but also 20 of the 41 signaled before (Bielz, Kimakowicz, Grossu) were not founded. This situation is probably due to the fact that it is a large and heterogeneous area, not entirely studied before and there are only few punctual references concerning terrestrial gastropods. Our study is also only an preliminary one, and the sampling stations were located exclusive near the river flow some habitats may be poorly or not present anymore here.

The low diversity of terrestrial mollusk fauna of the investigated area exist most probably due to the changes occurred in specific habitats by anthropogenic activities, and especially to the vegetation degradation, which is known as determinative for the terrestrial mollusks communities. The Târnava hydrographic basin is characterized by the absence of riverside thickets. This is the fact that a series of families usually presents in the valleys of most rivers, are absent here. This is the case for Cochlicopidae, Valoniidae, Patulidae, Oxichilidae gastropods, which are numerically dominant in other valleys (Gheoca and Popovici, 1999) and absent here, except the tree stations uphill.

Further investigations are necessary for the completion of this list of taxa.

## CONCLUSIONS

The presence of terrestrial gastropods on riversides is not conditioned directly by the river itself, or his estate, but by the humidity characteristic for river valleys. This is the cause that hygrophilous and mezohygrophilous species are numerically dominant in most valleys.

On the other hand, important for terrestrial mollusks populations is the type of the vegetation, and its degradation has as subsequent result, changes in terrestrial mollusks communities. The absence of the riverside thickets and of the dead branches in Târnava hydrographic basin, cause a decrease in mollusks communities diversity, comparing with other riversides. A quantitative analysis will be able to bring more information on the mollusk comunities situation and their future trends.

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# THE ACCUMULATION OF THE HEAVY METALS IN THE TISSUES OF *HELIX POMATIA* LINNAEUS, 1758 FROM LOCATIONS WITH INDUSTRIAL AND URBAN POLLUTION

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**KEYWORDS**: human impact, bioaccumulation, Transylvania, Romania.

**ABSTRACT**

This paper, presents the results of the analysis on the presence of the heavy metals in the tissues and shells of the *Helix pomatia* individuals. In this purpose, were analyzed individuals from an area with intense car traffic in Sibiu locality, from an area with industrial pollution - Copşa Mică - Mediaş localities area and, as a control sample, were used individuals collected from a mountain area, namely the Lotrioara Valley. The toxicological analysis of *Helix pomatia* individuals, have proved that this species accumulates Cd and Cu in their tissues, but not Pb and Zn. None of the tested metals were accumulated in the shell. Among the tissues, the highest content of metals was found in the digestive gland - the core of the metabolic processes. Cd has the highest accumulation rate in the digestive gland. Cu shows similar accumulations in the digestive gland, leg and mantle. Due to the central position in the terrestrial food chains, the heavy metals accumulation capacity determines that terrestrial snails can became a potential danger for the upper trophic levels, being a threat for the snails' predators.

**RÉSUMÉ**: L'accumulation des métaux lourd dans les tissues de *Helix pomatia* Linnaeus provenant des locations avec polution industriale et urbaine.
La contamination des écosystèmes terrestres avec métaux lourds détermine l'augmentation de l'absorbation de ceux-ci par les invertébrés, avec implications sur la faune terrestre et même sur le fonctionnement des écosystèmes terrestres.

On a déterminé le degré d'accumulation des métaux lourd dans les divers tissues de l'espèce *Helix pomatia*, dans le cas d'une pollution industrielle - Copşa Mică, Mediaş - et urbaine - Sibiu. Le Pb, Zn, Cu et Cd ont été déterminé par SAA, dans le sol, les feuilles d'*Urtica dioica* et dans les tissues de *Helix pomatia* - masse viscérale, pied, manteau, glande digestive. Parmi les quatre métaux investiguer, le Cd et le Cu s'accumulent dans les tissue de l'escargot, mais pas le Pb et Zn. Parmis les tissues, la concentration la plus importante a été trouvé, pour toutes les métaux analysées, dans la glande digestive - le siège centrale des proceses méthaboliques. Pour le cadmium on a trouvé la plus élevé taux d'accumulation dans la glande digestive, tandis que le cuivre a des taux d'accumulation comparable dans la glande digestive, et la musculature du pied.

La capacité des gastropodes terrestre d'accumulation des métaux lourd, comme et le cas du Cu et Cd, augmente le risque de la contamination des niveaux trophique supérieures, à cause de la position centrale de ces animaux dans les réseaux trophiques.

**REZUMAT**: Acumularea de metale grele în țesuturile indivizilor de *Helix pomatia* Linnaeus din locații cu poluare industrială şi urbană.

Contaminarea ecosistemelor terestre cu metale grele, determină o creştere a absorbției acestora de către nevertebratele din sol, cu implicații asupra faunei terestre sau chiar a funcționării ecosistemelor terestre în ansamblu.

Această lucrare cuprinde rezultatele analizei prezenței metalelor grele în țesuturile indivizilor speciei *Helix pomatia.* Au fost analizați indivizi provenind dintr-o zonă cu trafic intens a oraşului Sibiu, precum şi indivizi provenind dintr-o zonă poluată industrial, Copşa Mică - Mediaş analizând totodată ca martor, indivizi dintr-o zonă montană - Valea Lotrioarei. Analizele toxicologice au demonstrat faptul că *Helix pomatia* acumulează Cd şi Cu, în țesuturi, şi nu acumulează Pb şi Zn. Nici unul dintre metalele investigate nu se acumulează la nivelul cochiliei. Dintre țesuturi, concentrația cea mai mare de metale a fost găsită la nivelul glandei digestive - sediul central al proceselor metabolice - aceasta crescând odată cu scăderea concentrației metalului în mediu. Cadmiul are cea mai crescută rată de acumulare la nivelul glandei digestive, cuprul prezintă rate de acumulare comparabile la nivelul glandei digestive, a piciorului şi a mantalei.

Dată fiind poziția centrală a gastropodelor în lanțurile trofice terestre, capacitatea de acumulare a metalelor grele fac din acestea o potențială sursă de contaminare a nivelurilor trofice superioare, determinând efecte adverse în populațiile de prădători, efecte datorate toxicității acestor metale.

## INTRODUCTION

In the city ecosystems outside the industrial areas, the most important pollution source is the car traffic, which generates an important amount of pollutants, on the soil along the roads and in the atmosphere. The fuel combustion, the main source of pollution that eliminates in the atmosphere important amounts of $CO_2$, CO and gassy hydrocarbons, as well as solid particles, is not the only pollution source related to the car traffic. Other elements, proceeding from the wearing of the vehicles but also of the roads, play an important role concerning the heavy metal pollution.

This paper, presents the results of the analysis on the presence of the heavy metals in the tissues and shells of the individuals belonging to *Helix pomatia.* In this purpose, were analyzed individuals from an area with an intense car traffic in Sibiu locality, from an area with industrial pollution - Copşa Mică - Mediaş localities area and, as a control sample, were used individuals collected from a mountain area, namely Lotrioara Valley.

The source of the heavy metal pollution in the Copşa Mică - Mediaş area is represented by S.C. SOMETRA S.A. - Copşa Mică. This metallurgic industrial unit, built in 1939 - 1940, increased its output (non - ferrous and chemical products as: zinc, lead, cadmium, bismuth, sodium antimony, sulfuric acid, zinc sulphates and oxides etc.) along the years. The unit's activity causes spreading in the atmosphere of some gassy pollutants rich in $SO_2$, carbon and nitrogen oxides, as well as solid particles that contain heavy metals (especially lead, cadmium, zinc).

The effects of this pollution started to be better monitored after 1990, in the same time with the implementation of the legislation regarding the functioning of the Environmental Protection Agency (APM) from Sibiu.

## MATERIALS AND METHODS

During this research, the Pb, Cd, Zn and Cu content from the soil, vegetation, shell, and visceral mass (foot, digestive gland) of *Helix pomatia* individuals has been measured. The snails have been collected from four stations, two with industrial pollution - Copşa Mică and Mediaş, one with pollution caused by the car traffic, in Sibiu, and one control sample from Lotrioara Valley, far from any pollution source. The analysis of the heavy metal content from the soil, vegetal and animal tissues was done by spectrophotometry with atomic absorption (SAA).

## RESULTS AND DISCUSSIONS

The results of the toxicological analysis are presented in Tab. 1.

Table 1: The concentration of the heavy metals (µg/g) in the four investigated sampling stations, in the soil, vegetation (*Urtica dioica*), and in the shell and tissues of *Helix pomatia* individuals, and the accumulation rates (R.A.) in comparison with the heavy metal concentration in the vegetation.

| Station | Analysed tissue | Pb | | Cd | | Zn | | Cu | |
|---|---|---|---|---|---|---|---|---|---|
| | | Conc. | RA | Conc. | RA | Conc. | RA | Conc. | RA |
| Copşa Mică | Soil | 1841 | - | 57.5 | - | 1294.5 | - | 187.91 | - |
| | Vegetation | 457.5 | - | 22.25 | - | 1168 | - | 26.50 | - |
| | Shell | 42.59 | 0.09 | 5.99 | 0.26 | 46.98 | 0.04 | 8.74 | 0.329 |
| | Visceral mass | 241.5 | 0.52 | 74.28 | 3.33 | 886.05 | 0.758 | 80.18 | 3.03 |
| | Leg | 41.27 | 0.09 | 9.4 | 0.42 | 67.87 | 0.05 | 78.77 | 2.97 |
| | Mantle | 34.47 | 0.07 | 10.48 | 0.47 | 104.3 | 0.08 | 57.10 | 2.15 |
| | Digestive gland | 773.3 | 1.69 | 207.3 | 9.31 | 237.4 | 0.20 | 64.45 | 2.43 |
| M e d i a ş | Soil | 255.00 | - | 4.37 | - | 258.06 | - | 29.50 | - |
| | Vegetation | 97.75 | - | 4.75 | - | 330.50 | - | 18.75 | - |
| | Shell | 28.81 | 0.29 | 3.72 | 0.78 | 14.1 | 0.042 | 7.41 | 0.395 |
| | Visceral mass | 30.99 | 0.31 | 34.32 | 7.22 | 147.30 | 0.445 | 113.95 | 6.07 |
| | Leg | 19.56 | 0.20 | 4.95 | 1.04 | 58.07 | 0.175 | 93.06 | 4.963 |
| | Mantle | 32.29 | 0.33 | 6.40 | 1.34 | 37.43 | 0.113 | 80.80 | 4.309 |
| | Digestive gl. | 51.31 | 0.52 | 91.66 | 19.29 | 139.4 | 0.421 | 142.7 | 7.610 |
| S i b i u | Soil | 67.5 | - | 1.00 | - | 125.00 | - | 42.75 | - |
| | Vegetation | 10.00 | - | 0.25 | - | 50.00 | - | 19.00 | - |
| | Shell | 1.97 | 0.19 | 0.70 | 2.8 | 9.75 | 0.195 | 7.22 | 0.38 |
| | Visceral mass | 10.99 | 1.09 | 11.75 | 47 | 360.50 | 7.21 | 125.50 | 6.605 |
| | Leg | 1.56 | 0.15 | 1.49 | 5.96 | 38.7 | 0.774 | 125.7 | 6.615 |
| | Mantle | 4.17 | 0.42 | 2.11 | 8.44 | 33 | 0.66 | 86 | 4.52 |
| | Digestive gl. | 62.48 | 6.24 | 34.11 | 136.44 | 802 | 16.04 | 95.9 | 5.04 |
| Lotrioara Valey | Soil | 5.00 | - | 0.10 | - | 90.0 | - | 24.00 | - |
| | Vegetation | 0.1 | - | 0.08 | - | 17.00 | - | 5.50 | - |
| | Shell | 0 | 0 | 0 | 0 | 9.75 | 0.573 | 4.95 | 0.9 |
| | Visceral mass | 2.64 | 26.40 | 3.76 | 47.00 | 182 | 10.70 | 74.30 | 13.509 |
| | Leg | 0.97 | 9.7 | 0.71 | 8.85 | 38.70 | 2.26 | 52.20 | 9.49 |
| | Mantle | 2.05 | 20.5 | 0.75 | 9.37 | 33.00 | 1.94 | 49.80 | 9.054 |
| | Digestive gl. | 16.69 | 166.9 | 22.97 | 287.12 | 227.8 | 13.4 | 227.8 | 41.418 |

All the four investigated heavy metals had the highest concentration at Copşa Mică, followed by Mediaş, Sibiu and Lotrioara Valley. The Pb concentration in the soil had at Copşa Mică locality values 7,2 times higher than at Mediaş locality, 27 times higher than in Sibiu locality and 368 times higher than in Lotrioara Valley, exceeding the intervention limit (Tab. 2). The normal values are surpassed at Copşa Mică, Mediaş, and Sibiu, where as in Mediaş the alert limit is exceeded.

Table 2: Reference values for chemical elements in soil. Source *O.M. 756/97*.

| Element | Normal values | Alert concentrations | | Intervention concentrations | |
|---|---|---|---|---|---|
| | | Sensibles | Less sensibles | Sensibles | Less sensibles |
| Pb | 20 | 50 | 250 | 100 | 1000 |
| Cd | 1 | 3 | 5 | 5 | 10 |
| Zn | 100 | 300 | 700 | 600 | 1500 |
| Cu | 20 | 100 | 250 | 200 | 500 |

The differences between the three stations concerning the Pb concentration in the soil are found also in the visceral mass. The ratios between the concentrations in the visceral mass in the four stations are almost equal to those from the soil. The lowest concentration was recorded in the shell. In none of the station a Pb accumulation neither in the shell, nor in the visceral mass was recorded.

The Cd concentration in the soil surpasses the intervention limit at Copşa Mică locality, the alert limit in Mediaş locality and registers normal values in the other two stations. The Cd accumulation rates in the visceral masses are higher when the metals concentration in the soil is low. Thus, the Cd concentration in the soil is 57.5 times lower in Sibiu locality than at Copşa Mică locality and on Lotrioara Valley this value reaches 575, but the ratio between the Cd concentrations in the visceral mass of the individuals from Copşa Mică, on one side, and Sibiu and Lotrioara Valley on the other side, are 6.32 and 19.86. In the last stations the accumulation rates of Cd are 47 (the Cd concentration in the visceral mass was compared with that from the vegetal tissue).

The Zn concentration surpasses the normal value in Sibiu, the alert limit in Mediaş and the intervention limit at Copşa Mică. Accumulation rates higher than 1 in the visceral mass, were recorded at Sibiu and Lotrioara Valley.

Cu exceeds the normal values even on Lotrioara Valley, but remains below the alert limit in all the stations. There is an accumulation in the visceral mass and its rates range between 3.03 at Copşa Mică and 13.509 at Lotrioara. The highest Cu concentration in the visceral mass was found at Sibiu (125.7 µg/g). The copper does not accumulate in the shell. The values of the heavy metal concentration in different tissues of the gastropod *Helix pomatia* are illustrated in Fig. 1 - 4.

In spite the fact that there is no Pb accumulation in the visceral mass, the concentration of this metal in the digestive gland reaches at Copşa Mică, Sibiu and Lotrioara, higher values than those in the vegetation. The other organs do not accumulate Pb.

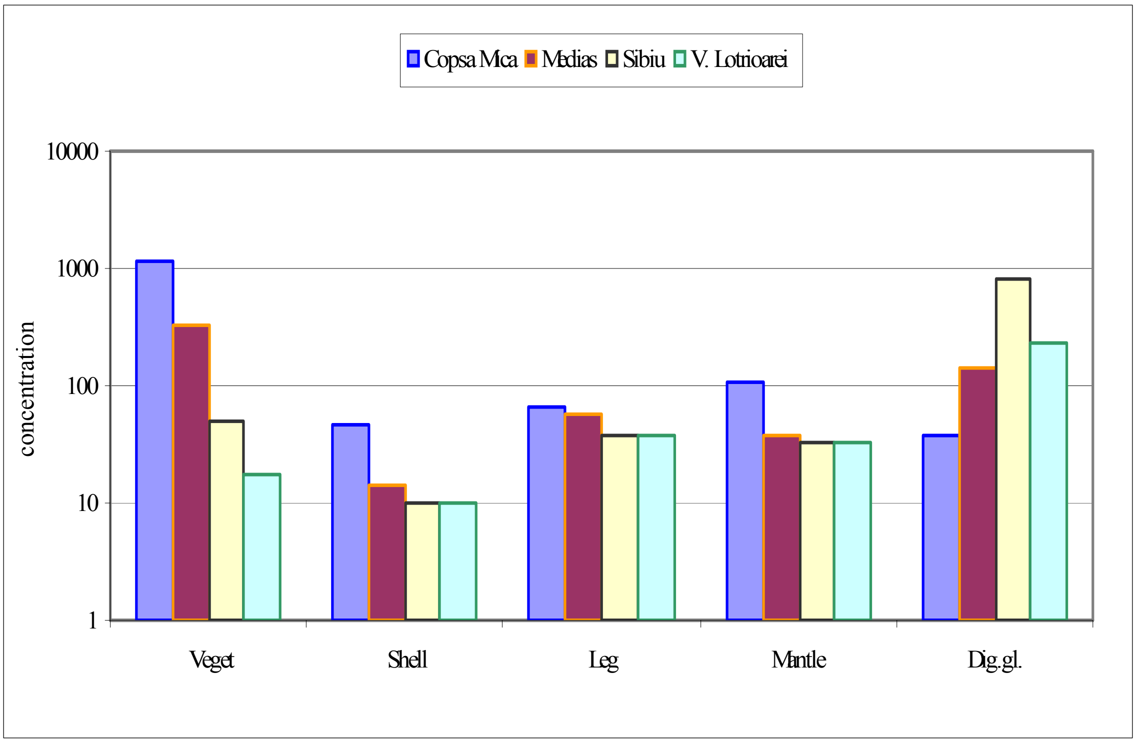


Fig. 1: The Pb concentration in the tissues of *Helix pomatia* (µg/g - logarithmic scale).

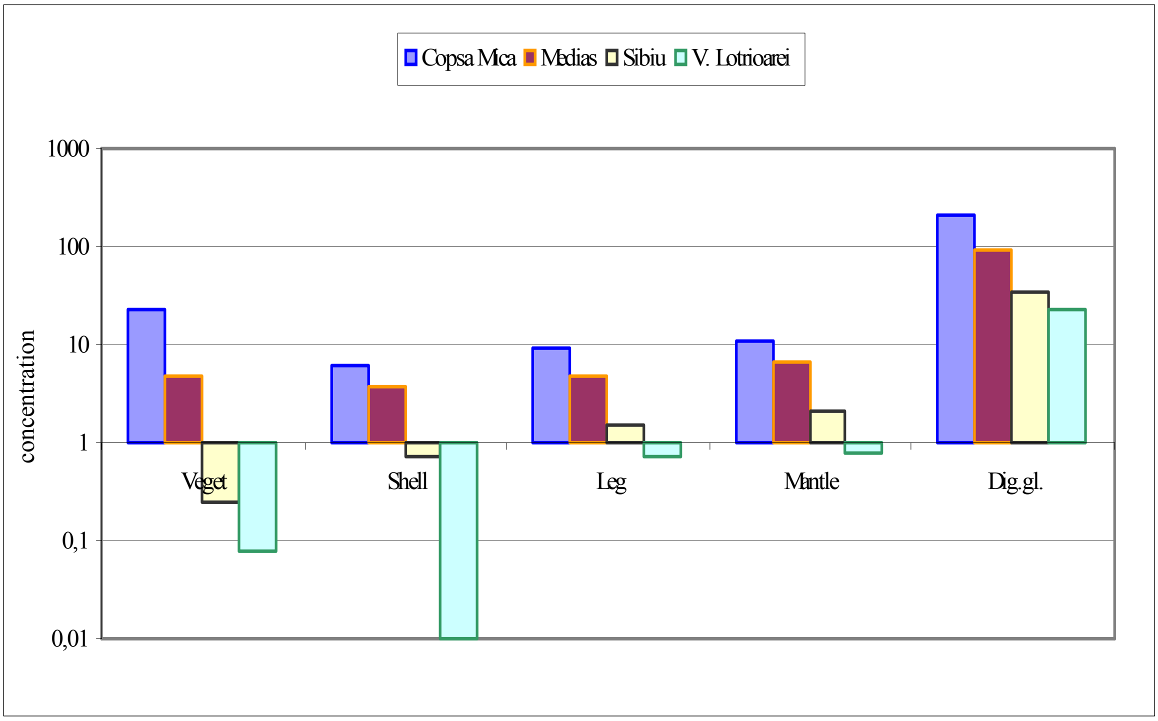


Fig. 2: The Zn concentration in the tissues of *Helix pomatia* (µg/g - logarithmic scale).

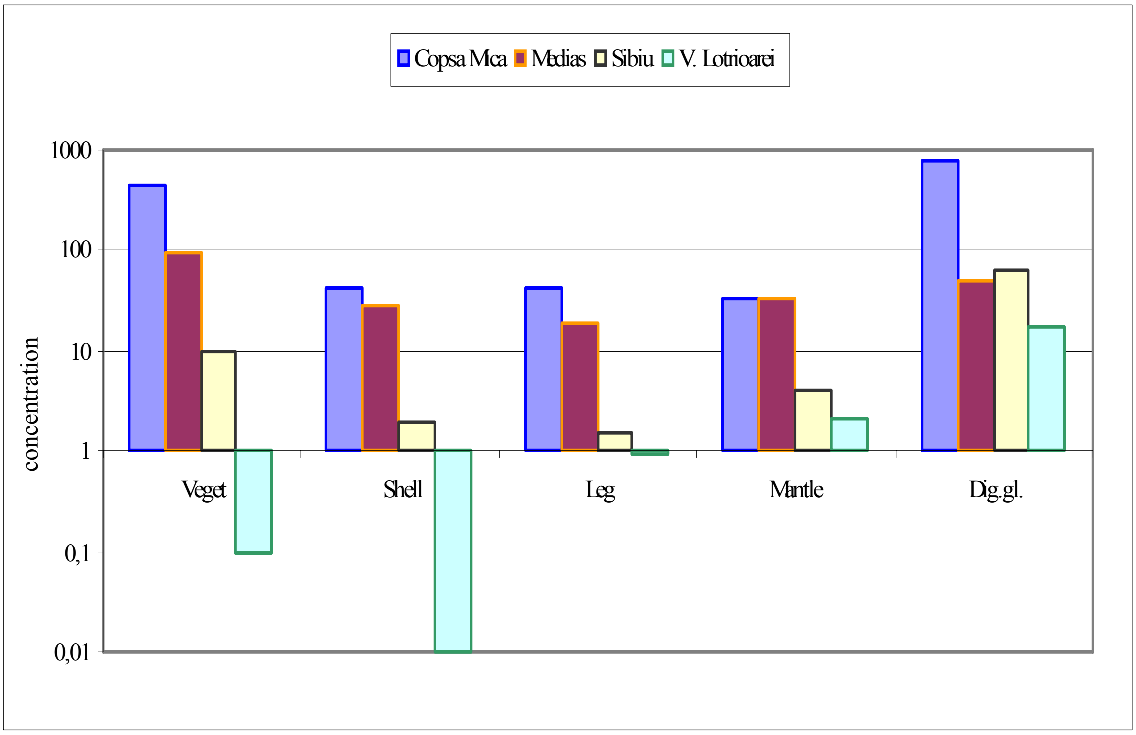


Fig. 3: The Cd concentration in the tissues of *Helix pomatia* (µg/g - logarithmic scale).

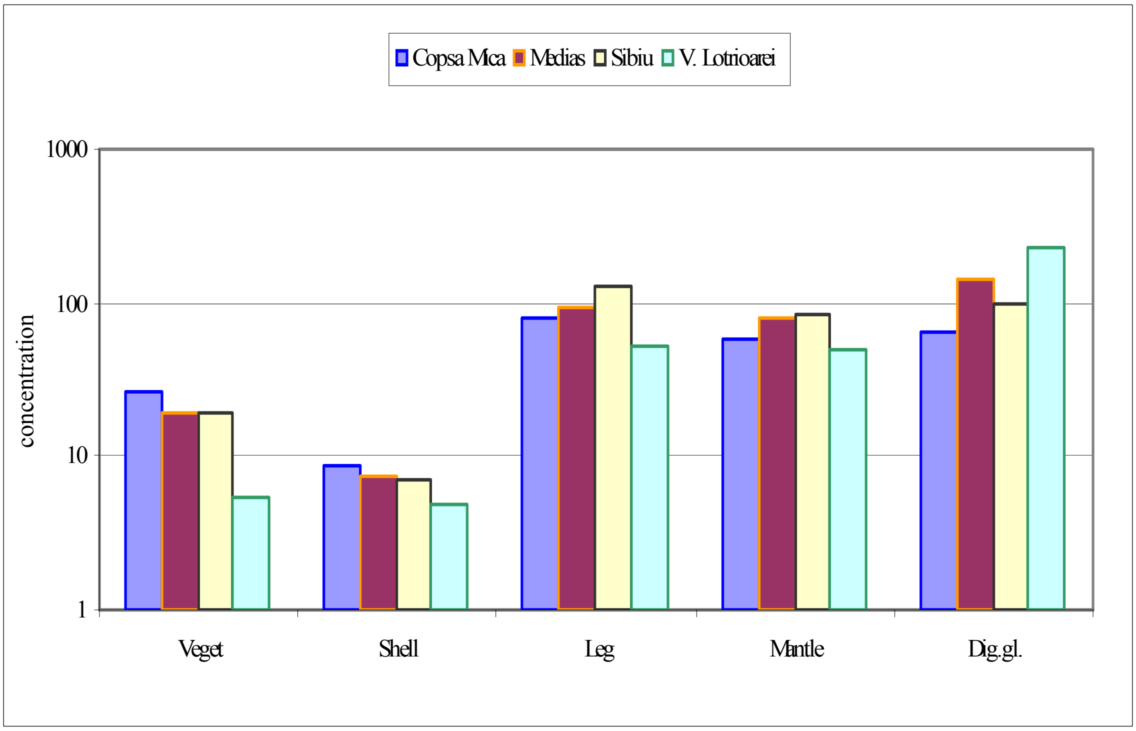


Fig. 4: The Cu concentration in the tissues of *Helix pomatia* (µg/g - logarithmic scale).

All the tissues present Cd accumulation rates higher than 1, except for the individuals collected from the most polluted habitat, from Copşa Mică, which accumulate Cd only in the digestive gland.

The Zn accumulates in the individuals from less polluted habitats, namely in those from Sibiu, in the digestive gland, and from Lotrioara Valley, in all the organs except the shell.

The Cu accumulation rates are almost equal in leg, mantle, and digestive gland, except for the individuals from Lotrioara Valley, that present a much higher rate in the digestive gland.

The highest value of the accumulation rate in the digestive gland confirms the theory that most of the microelements are accumulated especially in this organ. The digestive gland can be considered the metabolic center of the gastropods, used for the enzymes' synthesis, the absorption and decomposition of the nutrients, in storing and detoxifying the metals.

Using the classifying system elaborated by Berger and Dallinger (1993), based on the concentration values registered by the three metals in the visceral mass, we can frame the Lotrioara Valley station in the 1$^{st}$ class, the station from Sibiu in the 2$^{nd}$ class and those from Copşa Mică and Mediaş in the 3$^{rd}$ class.

Despite the fact that the quantitative bioindicators concept (Dallinger, 1994) is successfully applied in terrestrial invertebrates as isopods (Hopkin et al., 1986), this linear relationship cannot be applied for terrestrial gastropods without biases, because of the varied alimentary regime of this group. Another reason is the fact that the concentration of metals in different invertebrates depend on their seize (Greville and Morgan, 1990; Dallinger and Berger, 1992), the species particularities, seasons (Greville and Morgan, 1990), and temperature (Meinke and Schaller, 1974). There are studies, which affirm that this concept is not applicable at all for some metals as Cu (Berger and Dallinger, 1993).

A series of recent studies prove that the food is not the only input way of the metals in the gastropods' body, and the heavy metals could be more accessible for these organisms than it was considered. This fact increases the amount of heavy metals that enters in the food chains.

In this context we can raise the question if the terrestrial gastropods contribute to the metals' biomagnification along the food chains, as is the case of earthworms (Gheoca, 1995; 1996). However, it was proved that in the terrestrial ecosystems no heavy metal biomagnification process takes place (Laskovski, 1991, ap. Dallinger et al., 2001). On the other hand, even low transfer rates between the different trophic levels can cause negative effects to the predator populations, due to the metals' toxicity (Dallinger, 1993).

## CONCLUSIONS

The toxicological analyse of *Helix pomatia* individuals have proved that this species accumulates Cd and Cu in the tissues, but not Pb and Zn. None of the tested metals was accumulated in the shell.

Among the tissues, the highest content of metals was found in the digestive gland - the core of the metabolic processes - negatively correlated with the concentration in the environment.

Cd has the highest accumulation rate in the digestive gland - 136.44 in the individuals from Sibiu and 287.12 in the individuals from Lotrioara Valley.

The Cu shows similar accumulations in the digestive gland, leg and mantle, facts linked to the copper - specific metal - tioneyne from these tissues.

Due to the central position in the terrestrial food chains, the heavy metals accumulation capacity determines that terrestrial snails can became a potential danger for the upper trophic levels, being a threat for the snails' predators. The human contamination hazard through snails' ingestion is low, because their digestive gland is removed in the technological process.

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# STUDY REGARDING TÂRNAVA MARE AND TÂRNAVA MICĂ RIVERS (TRANSYLVANIA, ROMANIA) STONEFLY (INSECTA. PLECOPTERA) LARVAE COMMUNITIES

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**KEYWORDS**: Plecoptera larvae communities, interspecific association, benthic macroinvertebrates communities.

**ABSTRACT**

This paper presents a description of the plecopterans larvae communities of Târnava Mare and Târnava Mică rivers. A total of twelve species belonging to nine genera and six families were identified. Among these, seven species are common for the both rivers, one species was sampled only in the Târnava Mare River Basin, and four species were sampled only in the Târnava Mică River Basin.

In the Târnava Mare River, the plecopterans larvae present the highest specific diversity (six species) in the river sector situated one kilometer upstream the Zetea Dam Lake. In the Târnava Mică Rive, the plecopterans highest specific diversity (six species) was found in the river sector situated upstream Praid, at almost seventeen kilometers downstream the springs. In this areas the human impact on the river is not significant, and the biotope characteristics favoured the plecopterans. The plecopterans disappear from the Târnava Mare River benthic macroinvertebrates communities downstream Odorheiul Secuiesc locality, due to the water pollution with organic substances. Also, on Târnava Mică River, the plecopterans were no more found downstream Praid.

**ZUSAMMENFASSUNG**: Aspekte bezüglich der Steinfliegenlarven-Vergesellschaftungen (Insecta, Plecoptera) in den Flüssen Târnava Mare and Târnava Mică (Transsilvanien, Rumänien).

Dieser Aufsatz beschreibt die Vergesellschaftungen der Steinfliegenlarven in den Flüssen Târnava Mare und Târnava Mică. Insgesamt konnten zwölf Arten, die zu neun Gattungen und sechs Familien gehörten, identifiziert werden. Darunter waren sieben Arten in beiden Flüssen allgemein verbreitet, eine Art konnte nur im Târnava Mare Tal und vier Arten nur im Tal der Târnava Mică aufgefunden werden.

Im Fluss Târnava Mare zeigte sich im Flußabschnitt 1 km aufwärts vom Zetea Dam See die höchste Artendichte der Steinfliegenlarven (sechs Arten). Im Fluss Târnava Mică betrug die höchste Artendichte (sechs Arten) im Abschnitt der flußaufwärts bei Praid und fast 17 km flussabwärts der Quellen liegt. In diesem Gebiet sind die Einflüsse durch den Menschen nicht signifikant und die vorhandenen Biotope sind ideal für Steinfliegenlarven. Die Steinfliegenlarven verschwinden aus den Lebensgemeinschaften der Makroinvertebraten des Flusses Târnava Mare flussabwärts von Odorheiul Secuiesc, aufgrund der organischen Wasserbelastung. Ebenso wurden die Steinfliegenlarven in Fluß Târnava Mică flussabwärts von Praid nicht mehr aufgefunden.

**REZUMAT**: Aspecte privind comunitățile larvelor de plecoptere (Insecta. Plecoptera) din râurile Târnava Mare şi Târnava Mică.

Lucrarea prezintă o descriere a structurii comunităților larvelor de plecoptere din râurile Târnava Mare şi Târnava Mică. Au fost identificate în total douăsprezece specii aparținând la nouă genuri şi şase familii. Dintre acestea, şapte specii sunt comune pentru cele două râuri, o specie a fost colectată numai în bazinul râului Târnava Mare, iar patru specii au fost colectate numai în bazinul râului Târnava Mică.

În cazul Târnavei Mari, plecopterele prezintă diversitatea specifică cea mai mare (şase specii) în sectorul situat la un kilometru amonte de lacul de acumulare Zetea. În cazul Târnavei Mici, cea mai mare diversitate specifică a plecopterelor (şase specii) se înregistrează în sectorul situat amonte de Praid, la aproximativ şaptesprezece kilometri aval de izvoare. În aceste zone impactul antropic asupra râului este nesemnificativ, iar caracteristicile biotopului favorizează dezvoltarea plecopterelor. Plecopterele dispar din structura comunităților bentonice ale Târnavei Mari aval de Odorheiul Secuiesc, datorită poluării apei cu substanțe organice. De asemenea, pe Târnava Mică nu au mai fost găsite pelcoptere aval de localitatea Praid.

**INTRODUCTION**

This study presents a description of the plecopterans larvae communities of Târnava Mare and Târnava Mică rivers.

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 Târnave Plateau.

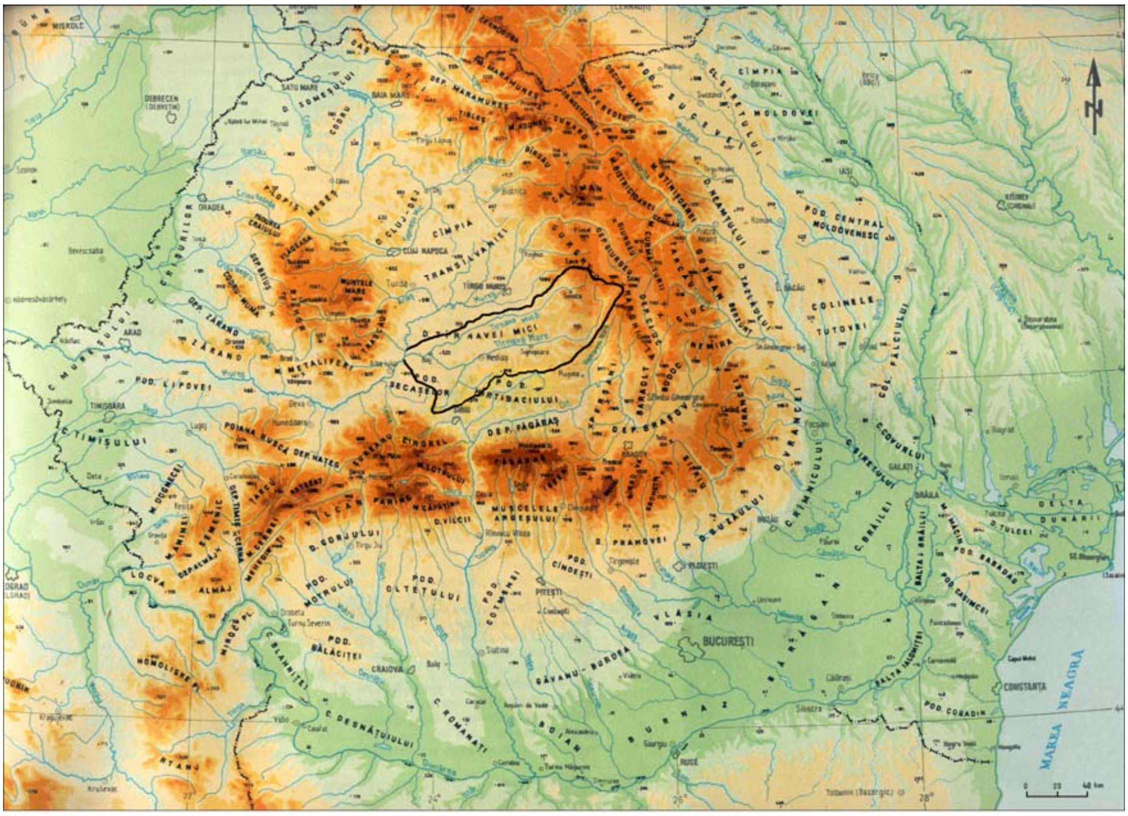


Fig. 1: The Târnava River Watershed study unit location (L. Badea et al., 1983 - modified).

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. (A. Roşu, 1980; L. Badea et al. 1983; G. Posea et al. 1982; A. Curtean - Bănăduc et al. 2001).

## MATERIAL AND METHODS

The data are based on quantitative benthic macroinvertebrates samples and plecopterans qualitative samples, sampled in 2000 - 2003 period, in seven field sampling campaigns, every one of it with 18 sampling stations, eleven of them placed along Târnava Mare River and seven placed along Târnava Mică River (Fig. 2, Tab. 1).

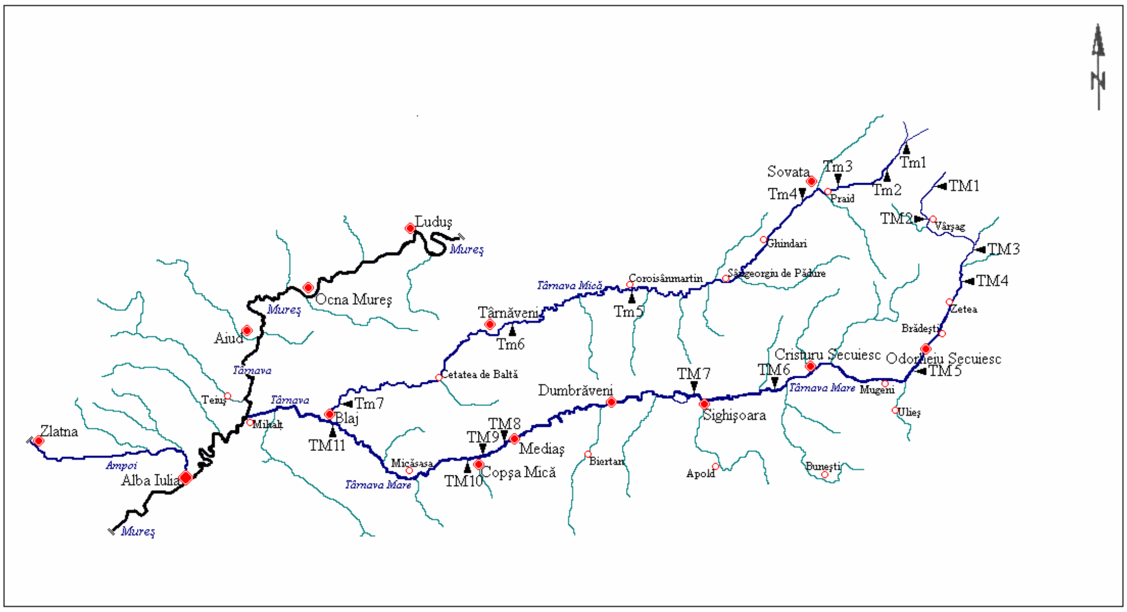


Fig. 2: The sampling stations localization on the Târnava Mare River ($TM_1$ - $TM_{11}$) and on the Târnava Mică River ($Tm_1$ - $Tm_7$).

The sampling stations were chooses according to the valley morphology, the type of the river substratum, the confluence with the main tributaries, the human impact types and degrees on the river sectors so that to can be highlighted the plecopterans specific diversity, and also the benthic macroinvertebrates communities dynamics. In each sampling station many samplings were sampled so that to can be highlighted the specific habitats diversity. During the study period were sampled and analyzed 242 qualitative benthic samples.

The benthic macroinvertebrates quantitative samples were taken with an 887 $cm^2$ surface bottom Surber Sampler, with a 250 μ mesh net. The sampled biological material was fixed in 4% formaldehyde solution at which $NaHCO_3$ was added.

Table 1: The sampling stations' positions and some of their physico-geographic characteristics, along the Târnava Mare River and Târnava Mică River.

| Sampling stations | River length (km) | Average altitude (m) | Average slope (°/oo) | Multi annual average water discharge ($m^3$/s) (1974 - 2000) |
|---|---|---|---|---|
| Târnava Mare River | | | | |
| $TM_1$ (5 km upstream Vârşag) | 5 | 766 | 13 | 1.20 |
| $TM_2$ (0,5 km upstream Vârşag) | 9 | 691 | 10 | 1.60 |
| $TM_3$ (1 km upstream Zetea Dam Lake) | 33 | 582 | 8 | 3.25 |
| $TM_4$ (1km downstream Zetea Dam) | 39 | 571 | 6 | 4.3 |
| $TM_5$ (4 km downstream Odorhei) | 52 | 458 | 2.5 | 5.10 |
| $TM_6$ (5 km upstream Sighişoara) | 105 | 365 | 1.5 | 8.5 |
| $TM_7$ (1 km downstream Sighişoara) | 110 | 358 | 1.3 | 11.0 |
| $TM_8$ (4 km downstream Mediaş) | 165 | 299 | 1.2 | 12.0 |
| $TM_9$ (4 km upstream Copşa Mică) | 182 | 291 | 1.1 | 12.5 |
| $TM_{10}$ (3 km downstream Copşa Mică) | 187 | 288 | 1.1 | 13.0 |
| $TM_{11}$ (2 km upstream Blaj) | 215 | 250 | 1.0 | 15.0 |
| Târnava Mică River | | | | |
| $Tm_1$ (8 km downstream the springs) | 8 | 760 | 16.1 | - |
| $Tm_2$ (11 km downstream the springs) | 11 | 650 | 14.2 | - |
| $Tm_3$ (0.5 km upstream Praid) | 17 | 470 | 20 | 6.29 |
| $Tm_4$ (1 km downstream Sovata) | 35 | 420 | 7 | 9.25 |
| $Tm_5$ (in Coroisânmartin locality) | 85 | 320 | 1.7 | - |
| $Tm_6$ (1 km upstream Târnăveni) | 125 | 293 | 0.8 | 19.16 |
| $Tm_7$ (2 km upstream Blaj) | 180 | 250 | 0.7 | - |

After the biological material was sorted and analyzed in the laboratory, the sampled organisms were preserved in alcohol 70% and included in the "Lucian Blaga" University of Sibiu, Department of Ecology and Environment Protection, Hydrobiology Laboratory collection.

For the quantitative structure description of the plecopterans larvae communities we have used the following ecological indexes: relative abundance (A%), frequency (F%) and ecological significance Dzuba index (W = (A x F) / 100). Depending on the ecological significance index values, the species were classified as follow: eudominants W > 10, dominants W€ [5.1, 10], subdominants W€ [1.1, 5], recedents W€ [0.1, 1] and subrecedents W < 0,1 (C. Krebs, 1989; M. T. Gomoiu and M. Skolka, 2001).

To analyze and quantify the association degree among species the average square contingency coefficient (CCM) values and the Cole interspecific association coefficient were determined; to test which of the species are statistically significantly associated the $\chi^2$ test was used for the probability level of 5% ($\chi^2 > 3,89$) (I. Sîrbu, A. Benedek, 2004).

## RESULTS AND DISSCUSSIONS

In Târnava Mare River eight plecopterans species were identified, belonging to five genera and five families (Tab. 2).

In Târnava Mică River ten plecopterans species were identified belonging to eight genera and five families (Tab. 2).

The analyzed biological material included 467 plecopterans larvae in their last larvae stages.

In the case of Târnava Mare River, the plecopterans present the highest specific diversity (six species) in the river sector situated at 1 km upstream the Zetea Dam Lake ($TM_4$) (Fig. 3). In Târnava Mică River case, the highest specific diversity of the plecopterans (six species) was noted in the river sector situated upstream the Praid locality, at approximately 17 km downstream the springs (Fig. 4). In these sectors the anthropogenic impact on the river is not significant (A. Curtean - Bănăduc et al., 2001), and the biotope characteristics are favorable for the plecopterans.

The plecopterans disappear from the Târnava Mare River benthic communities structure downstream Odorhei locality due to the water pollution with organic matter. Also on Târnava Mică the plecopterans were no more found downstream Sovata locality. In the first half of the past century, in the lower courses of these rivers the plecopterans were present - in the Sibiu Natural History Museum are kept *Nemoura cinerea* individuals sampled at Târnava locality in_the Târnava Mare River ($TM_9$), in 1922 by A. Müller and *Bracyptera braueri* individuals sampled at Târnăveni locality in the Târnava Mică River (B. Kis, 1971), in 1922 by Czekelius (B. Kis, 1971).

Table 2: The sampled Plecoptera species along the Târnava Mare and Târnava Mică rivers.

| Species | Sampling stations | | | | | | |
|---|---|---|---|---|---|---|---|
| | $TM_1$ | $TM_2$ | $TM_3$ | $TM_4$ | $Tm_1$ | $Tm_2$ | $Tm_3$ |
| Fam. Leuctridae | | | | | | | |
| *Leucra nigra* (Olivier, 1811) | | | x | | | x | |
| *Leuctra fusca* (Linnaeus, 1758) | x | x | x | x | | | x |
| *Leuctra inermis* Kempny, 1899 | | x | x | x | | | x |
| Fam. Capniidae | | | | | | | |
| *Capnia bifrons* (Newman, 1839) | | | | x | | | |
| Fam. Nemouridae | | | | | | | |
| *Amphinemura sulcicollis* (Stephens, 1835) | | | | | x | x | |
| *Nemoura cambrica* Stephens, 1835 | | | | x | | | x |
| *Protonemura intricata* (Ris, 1902) | | | | | | | x |
| Fam. Perlidae | | | | | | | |
| *Perla pallida* Guérin, 1838 | x | x | x | | x | x | x |
| *Perla marginata* Panzer, 1799 | x | x | x | | | | |
| Fam. Perlodidae | | | | | | | |
| *Perlodes microcephala* (Pictet, 1833) | | | x | | | x | x |
| Fam. Chloroperlidae | | | | | | | |
| *Chloroperla tripunctata* (Scopoli, 1763) | | | | | x | x | |
| *Siphonoperla neglecta* (Rostock, 1881) | | | | | x | | |

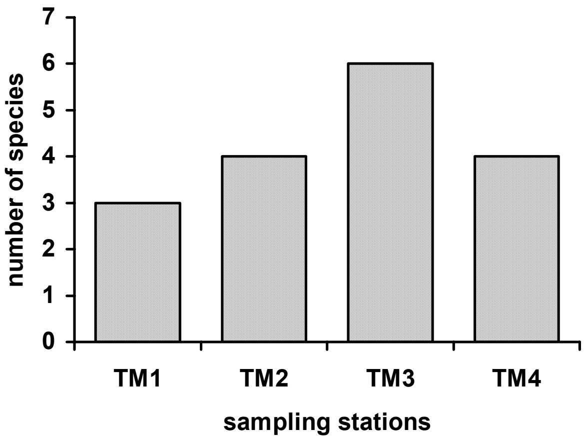


Fig. 3. The plecopterans species number variation along Târnava Mare River.

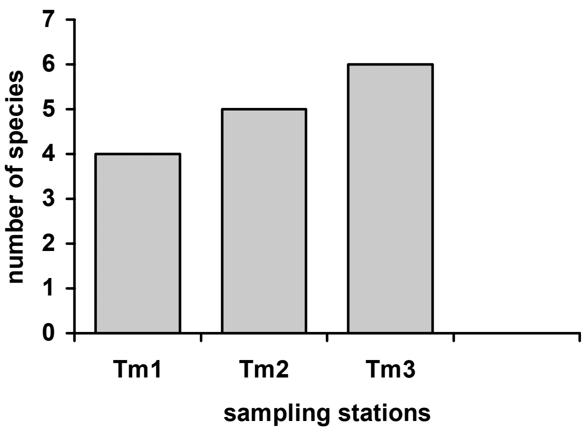


Fig. 4. The plecopterans species number variation along Târnava Mică River.

The plecopterans species with the widest distribution along the upper Târnava Mare River course are: *Leucra fusca* - present in all four analyzed river sectors, in which the plecopterans are present, *Leuctra inermis*, *Perla pallida* and *Perla marginata* - present in three sectors. The species with restricted distribution are *Leuctra nigra* and *Perlodes microcephala* sampled only in the river sector situated 1 km upstream of Zetea Dam Lake, and *Capnia bifrons* and *Nemoura cambrica* sampled exclusively in the river sector situated 1 km upstream the same lake (Tab. 2).

In the upper course of Târnava Mică River, the species with the largest distribution are: *Perla pallida* - which is present in all three analyzed river sectors in which the plecopterans are present, *Amphinemura sulcicollis*, *Perlodes microcephala* and *Chloroperla tripunctata* - which are present in two of these river sectors (Tab. 2).

**The Târnava Mare River plecopterans larvae communities description.**

In $TM_1$ sector, situated 5 km downstream the springs, the plecopterans have a relative abundance of 3.37% of the total number of the benthic macroinvertebrates. The plecopterans larvae community is formed here by three species, with the higher relative abundance in the case of *Perla marginata*, near which appear with a much lower relative abundance *Perla pallida* and *Leuctra fusca* (Tab. 3). In relation with the ecologic significance index values (Tab. 3) *Perla marginata* is eudominant, and *Perla pallida* and *Leuctra fusca* are dominant.

The plecopterans larvae community which is present in the river sector situated at 9 km downstream the springs ($TM_2$) is formed by four species. The numerical weights of the (four) species had an balanced distribution, the relative abundances values vary between 36.64% - *Leuctra fusca* and 14.29% - *Leuctra inermis* (Tab. 3). In relation with the ecologic significance index values (Tab. 3), *Leuctra fusca* and *Perla marginata* are eudominants, *Leuctra inermis* is dominant, and *Perla pallida* is subdominant. In $TM_2$ sector the plecopterans represent 2.22% of the total number of the benthic macroinvertebrates.

The plecopterans larvae community of the river sector situated at 31 km downstream the springs ($TM_3$) is formed by six species. The species with the highest relative abundance is *Leuctra fusca*, this has also the highest frequency and is eudominant. *Perla marginata* and *Leuctra inermis* are dominant, and *Perla pallida*, *Perlodes micorcephala* and *Leuctra nigra* are subdominants (Tab. 3). Here the plecopterans represent 1.58% of the total of the benthic macroinvertebrates.

In $TM_4$ river sector, situated 1 km downstream the Zetea Dam Lake, the plecopterans represent 1.65% of the total number of benthic macroinvertebrates. The plecopterans larvae community of this sector is formed by four species, two eudominant (*Leuctra fusca* and *Leuctra inermis*) and two subdominant (*Capnia bifrons* and *Nemoura cambrica*) (Tab. 3).

**The Târnava Mică River plecopterans larvae communities description.**

In the river sector situated at 8 km downstream the springs ($Tm_1$) the plecopterans numerical weight is 22.79% of the total of the benthic macroinvertebrates. The plecopterans larvae community present in this river sector is formed by four species, which in relation with the ecological significance index values (Tab. 3) are classified as following: *Siphonoperla neglecta*, *Perla pallida* and *Chloroperla tripunctata* are eudominants, and *Amphinemura sulcicolis* is dominant. This structure reveal the high stability of this community.

The plecopterans larvae community present in the river sector situated at 11 km downstream the river springs ($Tm_2$) is formed by five species: *Chloroperla tripunctata* and *Amphinemura sulcicolis* - eudominants, *Leuctra nigra* - dominant, *Perlodes microcephala* - subdominant, *Perla pallida* - recedent (Tab. 3). In this river sector, the plecopterans had a 17.82% numerical weight of the total of the benthic macroinvertebrates.

The plecopterans larvae community of the river sector situated at 17 km downstream the springs ($Tm_3$) is formed by six species. The species with the highest relative abundances are *Leuctra fusca* and *Leuctra inermis*, these species are characterized also by the highest frequencies in samples, being eudominants (Tab. 3). Near these species in the samples are also present the species *Protonemura intricata* - dominant, *Nemoura cambrica* - subdominant, *Perlodes microcephala* - subdominant and *Perla pallida* - recedent (Tab. 3). The plecopterans numerical weight in this river sector is 18.06% of the total benthic macroinvertebrates.

Analyzing the plecopterans larvae communities similarity, based on species ecological significance index values (Tab. 3), it was revealed the existence of a high degree of similarity among the Târnava Mare and Târnava Mică larvae plecopterans communities, situated at similar altitudes, which indicate an altitudinal zonation of the plecopterans larvae communities (Fig. 5).

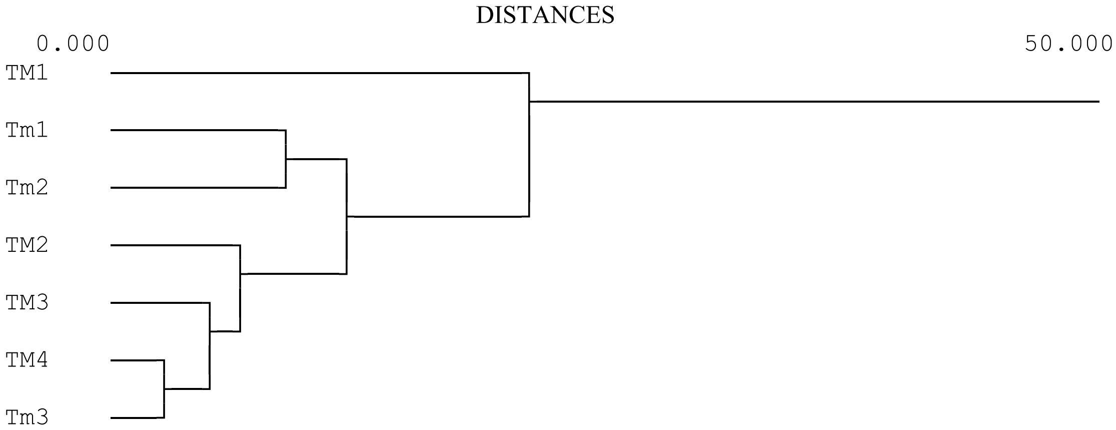


Fig. 5: Tree diagram - based on the plecopterans species ecologic index values in seven river sectors of Târnava Mare River (TM) and Târnava Mică River (Tm), (average linkage method; the distance metric is euclidian distance).

The analyze of the contingency tables in the cases of the 12 plecopterans species identified in the Târnave rivers basin, toked as pairs, based on the Cole interspecific association coefficient (C) and of the average square contingency coefficient (CCM), indicate significant positive associations, for a significance level of 5%, among the species: *Leuctra nigra* and *Perlodes microcephala* ($\chi^2$ = 5.168, CCM = 0.401, C = 0.625 ± 0.192), *Leuctra fusca* and *Leuctra inermis* ($\chi^2$ = 4.877, CCM = 0.391, C = 0.625 ± 0.241), *Perla pallida* and *Perlodes microcephala* ($\chi^2$ = 4.359, CCM = 0.373, C = 0.755 ± 0.303). Based on the association degree, it was revealed the fact that significant positive associations exist among the species with similar ecologic preferences.

Table 3: Ecological indexes for Plecoptera larvae species sampled in Târnava Mare River and Târnava Mică River (A - relative abundance, F - frequency, W - Dzuba ecological signification indexes).

| Species | Ecological indexes | Sampling stations | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $TM_1$ | $TM_2$ | $TM_3$ | $TM_4$ | $Tm_1$ | $Tm_2$ | $Tm_3$ |
| *Leucra nigra* | A% | 0 | 0 | 6.60 | 0 | 0 | 17.19 | 0 |
| | F% | 0 | 0 | 19.04 | 0 | 0 | 33.33 | 0 |
| | W | 0 | 0 | 1.26 | 0 | 0 | 5.73 | 0 |
| *Leuctra fusca* | A% | 8.30 | 36.64 | 48.31 | 40.00 | 0 | 0 | 47.61 |
| | F% | 71.43 | 52.38 | 76.19 | 66.66 | 0 | 0 | 100 |
| | W | 5.93 | 19.19 | 36.81 | 26.66 | 0 | 0 | 47.61 |
| *Leuctra inermis* | A% | 0 | 14.29 | 13.51 | 46.66 | 0 | 0 | 31.33 |
| | F% | 0 | 42.89 | 57.14 | 33.33 | 0 | 0 | 66.66 |
| | W | 0 | 6.13 | 7.72 | 15.55 | 0 | 0 | 20.88 |

| Species | Ecol. index. | $TM_1$ | $TM_2$ | $TM_3$ | $TM_4$ | $Tm_1$ | $Tm_2$ | $Tm_3$ |
|---|---|---|---|---|---|---|---|---|
| *Capnia bifrons* | A% | 0 | 0 | 0 | 6.66 | 0 | 0 | 0 |
| | F% | 0 | 0 | 0 | 33.33 | 0 | 0 | 0 |
| | W | 0 | 0 | 0 | 2.22 | 0 | 0 | 0 |
| *Amphinemura sulcicollis* | A% | 0 | 0 | 0 | 0 | 15.88 | 30.20 | 0 |
| | F% | 0 | 0 | 0 | 0 | 47.61 | 61.90 | 0 |
| | W | 0 | 0 | 0 | 0 | 7.56 | 18.69 | 0 |
| *Nemoura cambrica* | A% | 0 | 0 | 0 | 6.66 | 0 | 0 | 4.76 |
| | F% | 0 | 0 | 0 | 33.33 | 0 | 0 | 52.38 |
| | W | 0 | 0 | 0 | 2.22 | 0 | 0 | 2.49 |
| *Protonemura intricata* | A% | 0 | 0 | 0 | 0 | 0 | 0 | 10.08 |
| | F% | 0 | 0 | 0 | 0 | 0 | 0 | 57.14 |
| | W | 0 | 0 | 0 | 0 | 0 | 0 | 5.76 |
| *Perla pallida* | A% | 11.50 | 20.50 | 6.99 | 0 | 28.82 | 2.31 | 2.02 |
| | F% | 57.14 | 23.81 | 33.33 | 0 | 42.89 | 28.57 | 19.04 |
| | W | 6.57 | 4.88 | 2.33 | 0 | 12.36 | 0.66 | 0.38 |
| *Perla marginata* | A% | 80.20 | 28.57 | 17.21 | 0 | 0 | 0 | 0 |
| | F% | 90.40 | 57.14 | 52.38 | 0 | 0 | 0 | 0 |
| | W | 72.50 | 16.32 | 9.01 | 0 | 0 | 0 | 0 |
| *Perlodes microcephala* | A% | 0 | 0 | 7.38 | 0 | 0 | 10.00 | 4.20 |
| | F% | 0 | 0 | 19.05 | 0 | 0 | 33.33 | 33.33 |
| | W | 0 | 0 | 1.40 | 0 | 0 | 3.33 | 1.40 |
| *Chloroperla tripunctata* | A% | 0 | 0 | 0 | 0 | 20.10 | 40.30 | 0 |
| | F% | 0 | 0 | 0 | 0 | 52.38 | 57.14 | 0 |
| | W | 0 | 0 | 0 | 0 | 10.53 | 0 | 0 |
| *Siphonoperla neglecta* | A% | 0 | 0 | 0 | 0 | 35.20 | 0 | 0 |
| | F% | 0 | 0 | 0 | 0 | 66.66 | 0 | 0 |
| | W | 0 | 0 | 0 | 0 | 23.46 | 0 | 0 |

**CONCLUSIONS**

In the studied area a total of twelve plecopterans larvae species belonging to nine genera and to six families were identified.

Among all these twelve plecopterans species, seven are considered common for both studied rivers (*Leuctra nigra*, *Leuctra fusca*, *Leuctra inermis*, *Nemoura cambrica*, *Perla pallida* and *Perlodes microcephala*), one species (*Capnia bifrons*) was sampled only in Târnava Mare River, and four species (*Amphinemura sulcicollis*, *Protonemura intricata*, *Chloroperla tripunctata* and *Siphonoperla neglecta*) were sampled only in Târnava Mică.

In the Târnava Mare River, the plecopterans larvae present the highest specific diversity (six species) in the river sector situated at 1 km upstream the Zetea Dam Lake. In the Târnava Mică case, the highest specific diversity of the plecopterans (also six species) was noted in the river sector situated upstream the Praid locality, at a distance of approximately 17 km downstream the river's springs. In all these sectors the anthropogenic impact on the river is not significant, and the biotope characteristics are favorable for the plecopterans.

In both studied rivers the plecopterans are present only in the upstream course, in the mountainous zone, where the anthropogenic impact on the river is low. The plecopterans are no more present in the Târnava Mare River benthic communities structure downstream Odorheiul Secuiesc, and in the Târnava Mică River benthic communities structure downstream Sovata. This fact is induced by the water pollution, with unfiltered or insufficient filtered industrial, zootechnical and urban wastewater discharges.

The plecopterans larvae numerical weight in the benthic macroinvertebrates communities, vary between 22.79% ($Tm_1$ sampling station) and 17.82% ($Tm_2$ sampling station) in the Târnava Mică River and between 3.37% ($TM_1$ sampling station) and 1.58% ($TM_3$ sampling station) in the Târnava Mare Rive. The plecopterans larvae communities structure and the numerical weight of this group in the local benthic macroinvertebrates communities, of the studied rivers reveal the fact that Târnava Mare River is under an accentuated anthropogenic impact pressure in comparison with Târnava Mică River. This situation is characteristic starting even in these two rivers mountainous zones.

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# CONTRIBUTIONS TO THE STUDY OF AQUATIC AND SEMIAQUATIC HETEROPTERA (INSECTA) FROM THE HYDROGRAPHIC BASIN OF TÂRNAVE RIVERS (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: Heteroptera, Nepomorpha, Gerromorpha, *Velia rivulorum, Velia* (*Plesiovelia*) *capra*, Transylvania, Romania.

**ABSTRACT**

In this paper, species of aquatic and semi aquatic Heteroptera collected from the Târnave rivers hydrographic basin in September 2001 are presented.

A number of three species of aquatic Heteroptera (Nepomorpha) and four species of semiaquatic Heteroptera (Gerromorpha) were identified.

The species *Velia rivulorum* and *Velia (Plesiovelia) caprai* (Gerromorpha), represents a special interest from the faunistic perspective, for Romanian territory, being less recorded until the present.

**ZUSAMMENFASSUNG**: Beiträge zur Studie über aquatische und semiaquatische Heteroptera (Insecta, Heteroptera) aus dem hydrographischen Einzugsgebiet des Flusses Tarnave.

In diesem Aufsatz werden Arten von aquatischen und semiaquatischen Heteropteren vorgestellt, die im September 2001 aus dem hydrographischen Becken der Tarnave gesammelt wurden.

Es wurden drei Arten von aquatischen Heteropteren (Nepomorpha) und vier Arten von semiaquatischen Heteropteren (Gerromorpha) identifiziert.

Unter diesen stellen *Velia rivulorum* und *Velia (Plesiovelia) caprai* (Gerromorpha) besondere Nachweise für Rumänien dar, weil es bislang in der Fachliteratur nur wenige Angaben hierzu gibt.

**REZUMAT**: Contribuții la studiul heteropterelor acvatice şi semiacvatice din bazinul hidrografic al râurilor Târnave.

În această lucrare sunt prezentate specii de heteroptere acvatice şi semiacvatice colectate din Bazinul hidrografic al Târnavelor în septembrie 2001.

Au fost identificate trei specii de heteroptere acvatice (Nepomorpha) şi patru specii de heteroptere semiacvatice (Gerromorpha).

Speciile *Velia rivulorum* şi *Velia (Plesiovelia) caprai* (Gerromorpha) prezintă un interes faunistic deosebit pentru teritoriul României, existând foarte puține semnalări până în momentul de față.

## INTRODUCTION

The data presented in this work are the results of the researches done within the ecologic assessment Program "A clean Mureş River through clean tributaries". There had been some sporadic researches in the Mureş River basin and in the surrounding areas for the studied group of insects, but they are quite out of date (Horváth, 1878, 1918; Szilády, 1908 and Benedek, 1970).

## MATERIAL AND METHODS

The biological material was collected from several sampling stations (Fig. 1, Tab. 1) on Târnava Mare ($TM_2$, $TM_5$, $TM_6$, $TM_9$) and Târnava Mică ($Tm_1$), and also from an affluent of Târnava Mare, near $TM_9$, as well as from a swamped field near Târnava Mare, downstream Vârşag locality (near $TM_2$). Samples were taken in September 2001, using an aquatic net of 30 cm diameter with loops of one mm. The captured insects were preserved in 70° alcohol; their identification was done using references like: Davideanu, 2000; Poisson, 1957; Tamanini, 1979.

Table 1: The species of aquatic and semiaquatic Heteroptera collected between 08. September and 10. September 2001.

| Crt. no. | Species | Sampling station | Individuals number |
|---|---|---|---|
| Infraorder Gerromorpha, Popov 1971 | | | |
| Fam. Gerridae, Leach 1815 | | | |
| 1 | *Aquarius paludum*, Fabr. 1794 | $TM_6$ | 6 (3♀, 3♂) |
| 2 | *Gerris lacustris*, L. 1758 | $TM_2$ | 7 (4♀, 3♂) |
| | | $TM_5$ | 5 (1♀, 4♂) |
| | | $TM_9$ | 21 (10♀, 11♂) |
| | | $Tm_1$ | 2 (1♀, 1♂) |
| Fam. Veliidae, Amyot & Serville 1843 - Dohrn 1859 | | | |
| 3 | *Velia rivulorum*, Fabr. 1775 | $Tm_1$ | 2 (2♂) |
| 4 | *Velia (Plesiovelia) caprai*, Tam. 1947 | $Tm_1$ | 6 (6♀) |
| Infraorder Nepomorpha, Popov 1971 | | | |
| Fam. Nepidae, Latreille 1812 | | | |
| 5 | *Nepa cinerea*, L. 1758 | $TM_2$ | 2 (1♀, 1♂) |
| | | $TM_9$ | 28 (20♀, 8♂) |
| Fam. Notonectidae, Leach 1815 | | | |
| 6 | *Notonecta glauca*, L. 1758 | $TM_2$ | 2 (2♂) |
| 7 | *Notonecta viridis*, Delc. 1909 | $TM_2$ | 2 (2♀) |

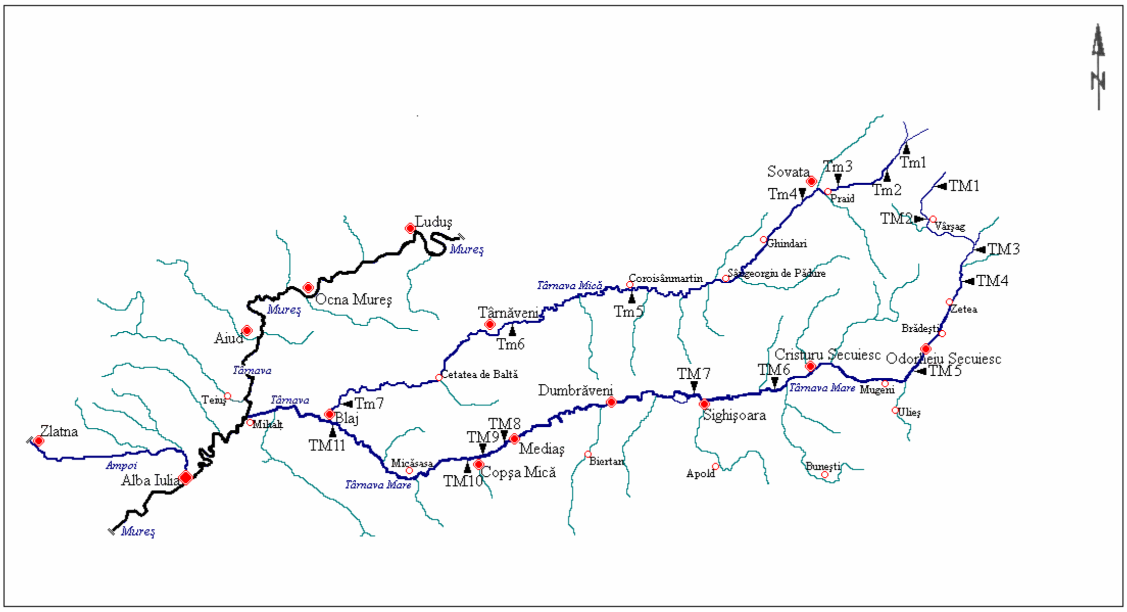


Fig. 1: The sampling stations localization on the Târnava Mare River ($TM_1$ - $TM_{11}$) and on the Târnava Mică River ($Tm_1$ - $Tm_7$).

## RESULTS AND DISCUSSION

A total of 83 adult individuals were sampled, belonging to seven species, from four families (Table 1).

Four species: *Aquarius paludum*, *Gerris lacustris, Velia rivulorum* and *Velia (Plesiovelia) caprai* are semiaquatic Heteroptera (Gerromorpha) being represented in samples by 49 adult individuals.

The aquatic Heteroptera (Nepomorpha) are represented by three species: *Nepa cinerea, Notonecta glauca, Notonecta viridis*, through 34 adult individuals.

Most species have a wide range in Palearctica and are common on the territory of Romania.

The species *Velia rivulorum* and *Velia (Plesiovelia) caprai* represent a special faunistic interest, for being very rare in Romania. We have sampled them on Târnava Mică, upstream of Praid ($Tm_1$).

*Velia rivulorum* is considered a Mediterranean species (living in France, Italy, Algeria and Tunisia). In Romania it was reported by G. Horváth in 1873 in Caraş - Severin County and quoted by I. Sienkiewicz in 1964, in Tulcea County (from Montandon's collection). Our reports about the presence of this species in the Târnava basin certifies their presence on the territory of Romania and shows that the spreading of these species is larger that it is shown in the specialized literature.

*Velia (Plesiovelia) caprai* was reported almost on the entire surface of Europe. In Romania it was reported only in Zarand Mountains (in 1968), Cluj County (in 1976 and 1978) and in Iaşi County (in 1997) by B. Kis and Ana Davideanu.

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# ASPECTS CONCERNING TÂRNAVA MARE AND TÂRNAVA MICĂ RIVERS (TRANSYLVANIA, ROMANIA) CADYS FLY (INSECTA. TRICHOPTERA) LARVAE COMMUNITIES

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**KEYWORDS**: benthic macroinvertebrates, Trichoptera larvae communities.

**ABSTRACT**

This paper presents a description of the trichopterans larvae communities of Târnava Mare and Târnava Mică rivers. A total of fifteen species belonging to nine genera and nine families were identified. Among these, seven species are common for the both rivers, six species were sampled only in the Târnava Mare River Basin, and two species were sampled only in the Târnava Mică River Basin.

In the Târnava Mare Rive, the trichopterans larvae presents the highest specific diversity (nine species) in the river sector situated one kilometer downstream the Zetea Dam Lake. In the Târnava Mică River, the trichopterans highest specific diversity (nine species) was found in the river sector situated 0.5 km upstream Praid, at almost seventeen kilometers downstream the river springs. In these areas the human impact on the river is not significant, and the biotope characteristics favored the existence of many trichopterans species.

Analyzing the longitudinal dynamics of the trichopterans larvae communities structure for the studied rivers, can be note the fact that in their upper courses these communities presents a high specific diversity, and the species with the highest relative abundance of these communities are lithophilous, rheophilous and oxyphilous species; the trichopterans larvae communities of the middle and lower courses are characterized by a lower specific diversity, the numerical dominant species being eurivalent.

**ZUSAMMENFASSUNG**: Aspekte bezüglich der Vergesellschaftung von Köcherfliegenlarven (Insecta, Trichoptera) in den Flüssen Târnava Mare und Târnava Mică (Transsilvanien, Rumänien).

Die Arbeit beschreibt die Vergesellschaftungen der Trichoptera-Larven in den Flüssen Târnava Mare and Târnava Mică. Insgesamt wurden 15 Arten aus 9 Gattungen und neun Familien nachgewiesen. Sieben von diesen waren in beiden Flüssen allgemein verbreitet, sechs Arten wurden nur im Târnava Mare Flusstal gefunden und zwei Arten lebten nur im Flusstal der Târnava Mică.

Im Fluß Târnava Mare besaßen die Trichoptera-Larven die höchste Artendichte (11 Arten) im Flußabschnitt 1 km abwärts des Zetea Dam Sees. Im Flußabschnitt des Târnava Mică lag die höchste Artendichte (9 Arten) 0.5 km oberhalb Praid bis siebzehn km unterhald der Quellen des Flusses. In diesen Gebieten sind die menschlichen Einflüsse auf den Fluß unbedeutend und die Biotopmerkmale begünstigen das Vorkommen vieler Arten von Köcherfliegenlarven.

**REZUMAT**: Aspecte privind comunităţile larvelor de trichoptere (Insecta. Trichoptera) din râurile Târnava Mare şi Târnava Mică.

Lucrarea prezintă o descriere a structurii comunităţilor larvelor de trichoptere din râurile Târnava Mare şi Târnava Mică. În zona de referinţă au fost identificate cincisprezece specii aparţinând la nouă genuri şi nouă familii. Dintre acestea, şapte specii sunt comune pentru cele două râuri, şase specii au fost colectate numai în bazinul râului Târnava Mare, iar două specii au fost colectate numai în bazinul râului Târnava Mică.

În cazul Târnavei Mari, trichopterele prezintă diversitatea specifică cea mai mare (nouă specii) în sectorul situat la un kilometru aval de lacul de acumulare Zetea. În cazul Târnavei Mici, cea mai mare diversitate specifică a trichopterelor (nouă specii) se înregistrează în sectorul situat la 0.5 km amonte de localitatea Praid, la aproximativ şaptesprezece kilometri aval de izvoare. În aceste zone impactul antropic asupra râului este nesemnificativ, iar caracteristicile biotopului favorizează dezvoltarea mai multor specii de trichoptere.

Analizând dinamica longitudinală a structurii comunităţilor larvelor de trichoptere în cazul celor două râuri studiate, se constată că în cursurile superioare aceste comunităţi prezintă diversitate specifică mare, iar speciile edificatoare ale acestor comunităţi sunt lito-reo-oxifile. Comunităţile larvelor de trichoptere din cursurile mijlocii şi inferioare se caracterizează prin diversitate specifică mică, speciile dominante numeric fiind cele eurivalente.

**INTRODUCTION**

This study presents a description of the trichopterans larvae communities of Târnava Mare and Târnava Mică rivers.

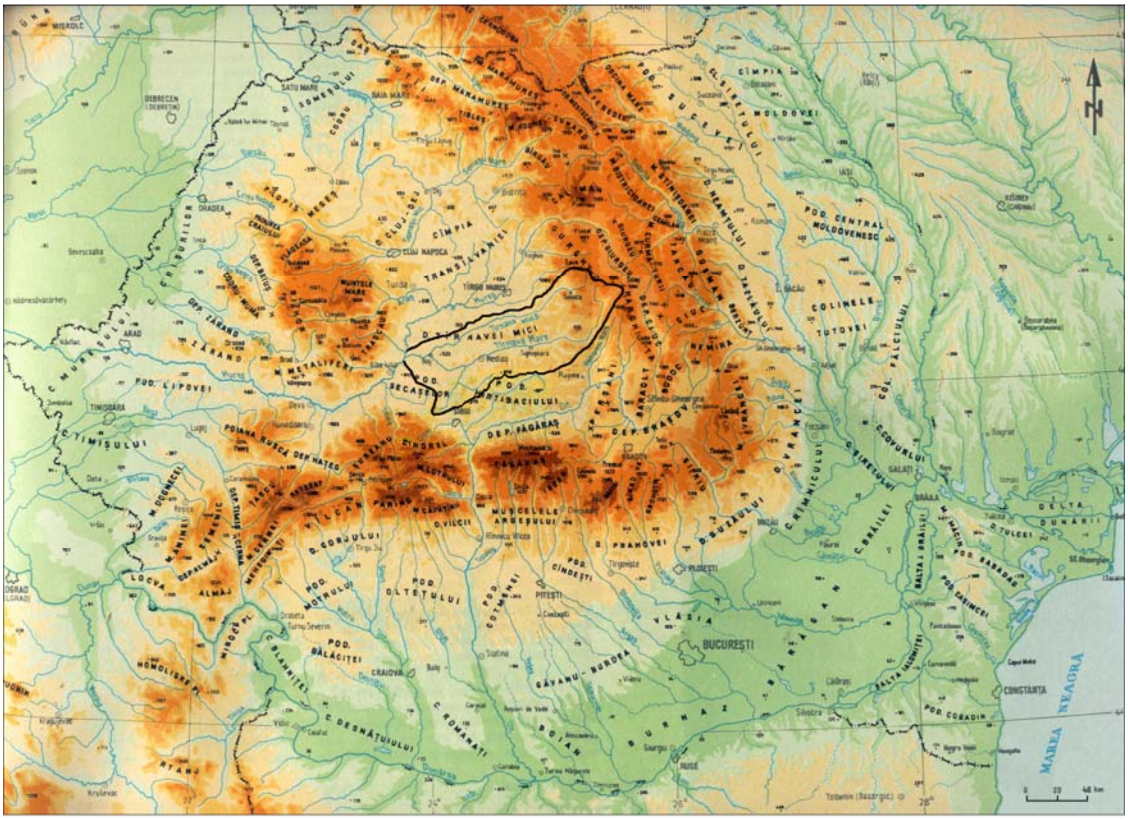


Fig. 1: The Târnava River Watershed study unit location (L. Badea et al., 1983 - modified).

Târnava River Watershed (Fig. 1) is placed in the inner part of the Romanian Carpathians arch, draining the Transylvania Depression, respectively its southern division the Târnave Plateau.

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. (Roşu, 1980; Badea et al. 1983; Posea et al. 1982; Curtean - Bănăduc et al. 2001).

## MATERIALS AND METHODS

The data are based on quantitative benthic macroinvertebrates samples and trichopterans qualitative samples, sampled in 2000 - 2003 period, in seven field sampling campaigns, every one of it with 13 sampling stations, eight of them placed along Târnava Mare River and five placed along Târnava Mică River (Fig. 2, Tab. 1).

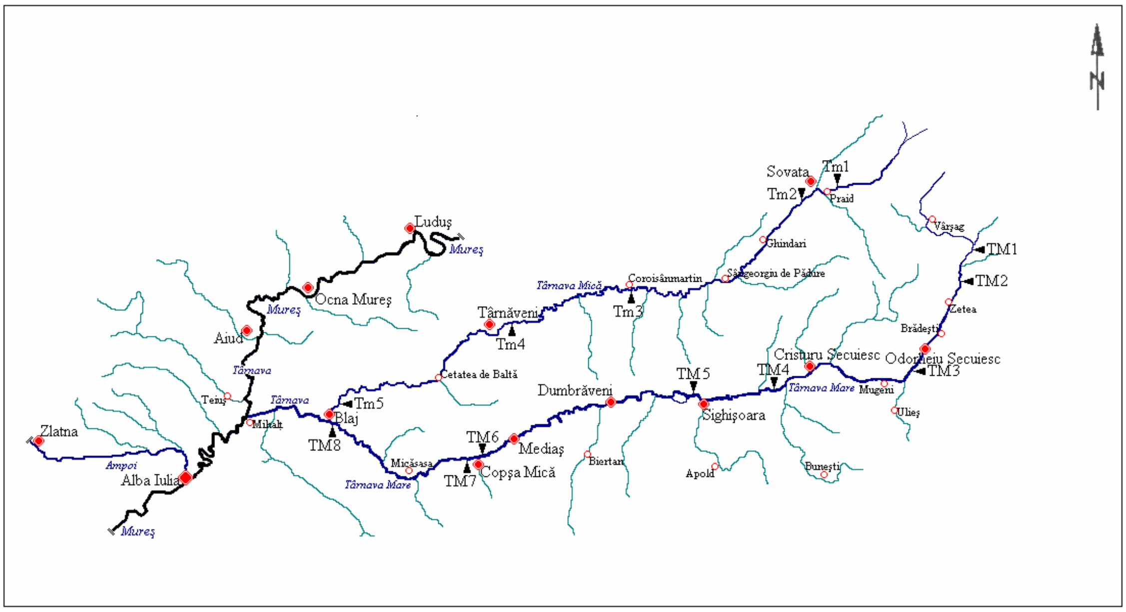


Fig. 2: The sampling stations localization on the Târnava Mare River ($TM_1$ - $TM_8$) and on the Târnava Mică River ($Tm_1$ - $Tm_5$).

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 and degrees on the river sectors, in order to highlight the trichopterans specific diversity, and also the benthic macroinvertebrates community's variation.

In each sampling station many samples were taken, in order to highlight the specific habitats' diversity. In the study period 432 qualitative benthic samples were sampled and analyzed. The benthic macroinvertebrates quantitative samples were realized with an 887 cm$^2$ surface Surber Sampler, with a 250 µ mesh net. The sampled biological material was fixed in 4% formaldehyde solution at which $NaHCO_3$ was added.

Table 1: The sampling stations positions and some of their physico-geographic characteristics, along the Târnava Mare River and Târnava Mică River.

| Sampling stations | River length (km) | Average altitude (m) | Average slope (°/oo) | Multi annual average water discharge ($m^3/s$) |
|---|---|---|---|---|
| Târnava Mare River | | | | |
| $TM_1$ (1 km upstream Zetea Dam Lake) | 33 | 582 | 8 | 3.25 |
| $TM_2$ (1km downstream Zetea Dam) | 39 | 571 | 6 | 4.30 |
| $TM_3$ (4 km downstream Odorhei) | 52 | 458 | 2.5 | 5.10 |
| $TM_4$ (5 km upstream Sighişoara) | 105 | 365 | 1.5 | 8.50 |
| $TM_5$ (1 km downstream Sighişoara) | 110 | 358 | 1.3 | 11.0 |
| $TM_6$ (4 km upstream Copşa Mică) | 182 | 291 | 1.1 | 12.5 |
| $TM_7$ (3 km downstream Copşa Mică) | 187 | 288 | 1.1 | 13.0 |
| $TM_8$ (2 km upstream Blaj) | 215 | 250 | 1.0 | 15.0 |
| Târnava Mică River | | | | |
| $Tm_1$ (0.5 km upstream Praid) | 17 | 470 | 20 | 6.29 |
| $Tm_2$ (1 km downstream Sovata) | 35 | 420 | 7.0 | 9.25 |
| $Tm_3$ (in Coroisânmartin locality) | 85 | 320 | 1.7 | - |
| $Tm_4$ (1 km upstream Târnăveni) | 125 | 293 | 0.8 | 19.16 |
| $Tm_5$ (2 km upstream Blaj) Petrisat | 180 | 250 | 0.7 | - |

After the biological material was sorted and analyzed in the laboratory, the sampled organisms were preserved in alcohol 70% and included in the "Lucian Blaga" University of Sibiu, Department of Ecology and Environment Protection, Hydrobiology Laboratory collection.

The analyzed biological material included 3449 trichopterans larvae (1784 individuals from Târnava Mare River and 1665 from Târnava Mică River) in their last larvae stages.

For the quantitative structure description of the trichopterans larvae communities we have used the relative abundance (A%).

**RESULTS AND DISCUSSIONS**

In Târnava Mare River 13 trichopterans species were identified, belonging to 9 genera and 9 families. The identified trichopterans species list of Târnava Mare River, with the specification of the sampling site ($TM_1$ - $TM_8$ - sampling stations, Tab. 1):

Fam. Rhyacophilidae
*Rhyacophila aurata* Braure, 1857 ($TM_1$, $TM_2$)
*Rhyacophila tristis* Pictet, 1834 ($TM_1$, $TM_2$)
Fam. Glossosomatidae
*Glossosoma intermedium* Klapalek, 1892 ($TM_1$, $TM_2$, $TM_3$, $TM_4$)
Fam. Hydroptilidae
*Orthotrichia costalis* (Curtis, 1834) ($TM_1$)
Fam. Philopotamidae
*Philopotamus montanus* (Donovan, 1813) ($TM_1$)
Fam. Psychomyidae
*Psychomyia pusilla* (Fabricus, 1781) ($TM_3$, $TM_4$)
Fam Polycentropodidae
*Neureclipsis bimaculata* (Linnaeus, 1758) ($TM_2$)
Fam. Hydropsychidae
*Hydropsyche angustipennis* (Curtis, 1834) ($TM_2$, $TM_3$, $TM_4$, $TM_5$, $TM_6$, $TM_8$)
*Hydropsyche contubernalis* McLaclan, 1865 ($TM_4$, $TM_5$, $TM_6$, $TM_7$, $TM_8$)
*Hydropsyche modesta* Navas, 1925 ($TM_2$, $TM_3$, $TM_4$)
*Hydropsyche pellucidula* (Curtis, 1843) ($TM_2$, $TM_3$)
Fam. Limnephilidae
*Ecclisopteryx dalecarlica* Kolenati, 1848 ($TM_2$)
Fam. Sericostomatidae
*Sericostoma schneideri* Kolenati, 1848 ($TM_1$, $TM_2$)

In Târnava Mare, the trichopterans had the highest specific diversity (nine species) at 1 km downstream the Zetea Dam Lake ($TM_2$) (Fig. 3). Here, the human impact is not significant, and the hydrological conditions and the water chemical characteristics are favorable for the existence of many trichopterans species (A. Curtean - Bănăduc, 2005).

In the mountainous river sector ($TM_1$, $TM_2$), between the springs to Odorheiul Secuiesc locality, the trichopterans larvae communities present a structure which is characteristic for the well oxygenated water, with low organic matter and with lithological substrata. The reophilic and oxyphilic species and those which prefer the water with low organic content are dominant (Tab. 2).

Downstream Odorheiul Secuiesc ($TM_3$) the clean water species weight decrease significantly, dominants from the numerical point of view are now the Hydropsychidae family species, eurivalent species, which live in water with rich organic content (Tab. 2). This situation can be found downstream on the whole Târnava Mare River course.

The trichopterans present the lowest specific diversity and the lowest density at 3 km downstream Copşa Mică ($TM_7$) (Fig. 3). This fact is induced by the river pollution and the sediments with heavy metals (A. Curtean - Bănăduc, 2005), pollution generated by the non ferrous metallurgy of the Copşa Mică industrial platform.

The trichopterans species with the widest distribution along the Târnava Mare River course is: *Hydropsyche angustipennis* - present in six of the total of eight studied river sectors. The species with restricted distribution are *Orthotrichia costalis*, *Philopotamus montanus* - sampled only in the river sector situated 1 km upstream of Zetea Dam Lake, and *Neureclipsis bimaculata* sampled exclusively in the river sector situated 1 km downstream the same lake.

Table 2: The trichopterans larvae communities present in the (eight) studied river sectors of Târnava Mare and the numerical weight of this systematical group in the benthic macroinvertebrates communities (P - trichopterans numerical weight in the benthic macroinvertebrates communities structure, Ds - average density, A% - relative abundance of each species).

| Sampling station | P (%) | The specific structure of the trichopterans larvae community | Ds (Number of individuals/ $m^2$) | A (%) |
|---|---|---|---|---|
| $TM_1$ | 6.33 | *Rhyacophila aurata* | 55.18 | 18.15 |
| | | *Rhyacophila tristis* | 56.76 | 18.67 |
| | | *Glossosoma intermedium* | 67.55 | 22.22 |
| | | *Orthotrichia costalis* | 49.04 | 16.13 |
| | | *Philopotamus montanus* | 46.54 | 15.31 |
| | | *Sericostoma schneideri* | 28.94 | 9.52 |
| $TM_2$ | 1.71 | *Rhyacophila aurata* | 83.25 | 18.50 |
| | | *Rhyacophila tristis* | 60.75 | 13.50 |
| | | *Glossosoma intermedium* | 71.24 | 15.83 |
| | | *Neureclipsis bimaculata* | 36.68 | 8.15 |
| | | *Hydropsyche angustipennis* | 11.25 | 2.50 |
| | | *Hydropsyche modesta* | 23.85 | 5.30 |
| | | *Hydropsyche pellucidula* | 45.00 | 10.00 |
| | | *Ecclisopteryx dalecarlica* | 56.25 | 12.50 |
| | | *Sericostoma schneideri* | 61.74 | 13.72 |
| $TM_3$ | 1.18 | *Glossosoma intermediu* | 14.88 | 7.33 |
| | | *Psychomyia pusilla* | 27.08 | 13.34 |
| | | *Hydropsyche angustipennis* | 65.41 | 32.22 |
| | | *Hydropsyche modesta* | 56.39 | 27.78 |
| | | *Hydropsyche pellucidula* | 39.24 | 19.33 |
| $TM_4$ | 7.96 | *Glossosoma intermedium* | 34.01 | 7.73 |
| | | *Psychomyia pusilla* | 203.01 | 46.14 |
| | | *Hydropsyche angustipennis* | 78.98 | 17.95 |
| | | *Hydropsyche contubernalis* | 67.98 | 15.45 |
| | | *Hydropsyche modesta* | 56.01 | 12.73 |
| $TM_5$ | 1.31 | *Hydropsyche angustipennis* | 115.06 | 56.96 |
| | | *Hydropsyche contubernalis* | 86.94 | 43.04 |
| $TM_6$ | 1.07 | *Hydropsyche angustipennis* | 64.26 | 33.82 |
| | | *Hydropsyche contubernalis* | 125.47 | 66.18 |
| $TM_7$ | 3.56 | *Hydropsyche contubernalis* | 65 | 100 |
| $TM_8$ | 3.10 | *Hydropsyche angustipennis* | 90.00 | 56.96 |
| | | *Hydropsyche contubernalis* | 68.00 | 43.04 |

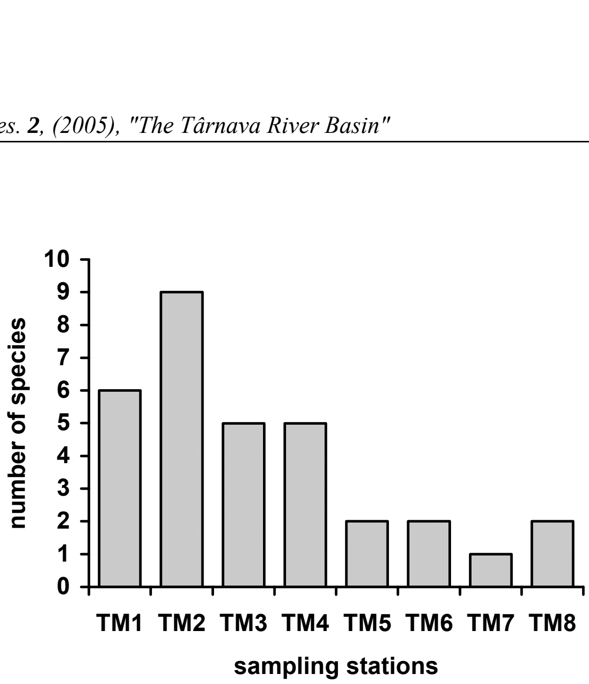


Fig. 3. The trichopterans species number variation along Târnava Mare River.

In Târnava Mică River 10 species were identified belonging to 7 genera and 7 families. The identified trichopterans species list of Târnava Mică Rver, with the specification of the sampling site ($Tm_1$ - $Tm_5$ - sampling stations, Tab. 1):

Fam. Rhyacophilidae

*Rhyacophila obliterata* McLaclan, 1863 ($Tm_1$)

*Rhyacophila tristis* Pictet, 1834 ($Tm_1$, $Tm_2$)

Fam. Glossosomatidae

*Glossosoma intermedium* Klapalek, 1892 ($Tm_1$)

Fam. Hydroptilidae

*Orthotrichia costalis* (Curtis, 1834) ($Tm_1$)

Fam. Philopotamidae

*Philopotamus montanus* (Donovan, 1813) ($Tm_1$)

Fam. Hydropsychidae

*Hydropsyche angustipennis* (Curtis, 1834) ($Tm_1$, $Tm_2$, $Tm_3$, $Tm_4$, $Tm_5$)

*Hydropsyche bulbifera* McLaclan, 1878 ($Tm_1$)

*Hydropsyche modesta* Navas, 1925 ($Tm_2$, $Tm_3$, $Tm_4$, $Tm_5$)

Fam. Brachycentridae

*Micrasema minimum* McLaclan, 1876 ($Tm_1$)

Fam. Sericostomatidae

*Sericostoma schneideri* Kolenati, 1848 ($Tm_1$, $Tm_2$)

Also, upstream Praid in the qualitative samples, individuals belonging to the Limnephilidae family were found.

In Târnava Mică, the highest specific diversity of the trichopterans (nine species) was noted in the river sector situated upstream the Praid locality ($Tm_1$), at approximately 17 km downstream the springs (Fig. 4). In this river sector numerically dominants are the oxyphilic, rheophilic and litophilic species, characteristic for mountainous river courses (Tab. 3).

Downstream Sovata, the specific trichopterans diversity decrease accentuated. In $Tm_2$ three species are present, here the highest numerical weight exist for the eurivalent species *Hydropsyche angustipennis* (Tab. 3). Starting with the Coroisânmartin area to the confluence with the Târnava Mare River, only two eurivalent trichopterans species had occurred - *Hydropsyche angustipennis* and *Hydropsyche modesta*, which appear in different proportions (Tab. 3).

In the Târnava Mică River course, the species with the largest distribution are *Hydropsyche angustipennis* which is present in all five analyzed river sectors. The species with restricted distribution are *Rhyacophila obliterata*, *Orthotrichia costalis*, *Glossosoma intermedium*, *Philopotamus montanus, Hydropsyche bulbifera* and *Micrasema minimum* - sampled only in the river sector situated 0.5 km upstream of Praid locality.

Table 3: The trichopterans larvae communities present in the (five) Târnava Mică studied sectors and the numerical weight of this systematical group in the benthic macroinvertebrates communities (P - trichopterans numerical weight in the benthic macroinvertebrates communities structure, Ds - average density, A% - relative abundance of each species).

| Sampling station | P (%) | Specific structure of the trichopterans larvae communities | Ds (number of individuals/m$^2$) | A (%) |
|---|---|---|---|---|
| $Tm_1$ | 19.98 | *Rhyacophila obliterata* | 75.09 | 8.23 |
| | | *Rhyacophila tristis* | 150.19 | 16.64 |
| | | *Glossosoma intermedium* | 125.28 | 13.85 |
| | | *Ortotrichia costalis* | 49.09 | 5.43 |
| | | *Philopotamus montanus* | 67.64 | 7.48 |
| | | *Hydropsyche angustipennis* | 96.10 | 10.62 |
| | | *Hydropsyche bulbifera* | 92.73 | 10.25 |
| | | *Micrasema minimum* | 192.43 | 21.27 |
| | | *Sericostoma schneideri* | 56.36 | 6.23 |
| $Tm_2$ | 1.70 | *Rhyacophila tristis* | 92.73 | 32.61 |
| | | *Hydropsyche angustipennis* | 146.56 | 51.54 |
| | | *Sericostoma schneideri* | 45.09 | 15.85 |
| $Tm_3$ | 3.38 | *Hydropsyche angustipennis* | 101.46 | 37.50 |
| | | *Hydropsyche modesta* | 169.10 | 62.50 |
| $Tm_4$ | 2.04 | *Hydropsyche angustipennis* | 90.19 | 42.11 |
| | | *Hydropsyche modesta* | 124.01 | 57.80 |
| $Tm_5$ | 1.19 | *Hydropsyche angustipennis* | 67.64 | 33.33 |
| | | *Hydropsyche modesta* | 135.28 | 66.67 |

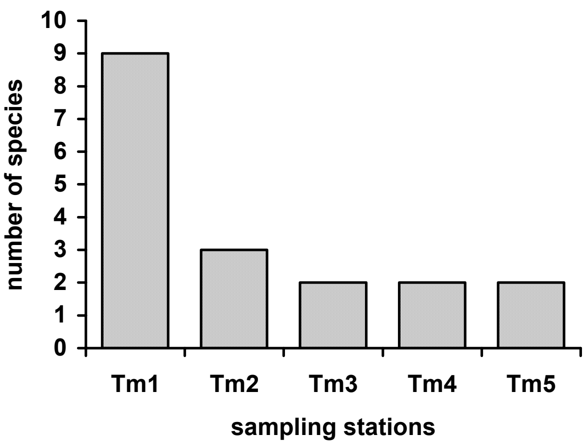


Fig. 4. The trichopterans species number variation along Târnava Mică River.

**CONCLUSIONS**

In the studied area a total of fifteen trichopterans larvae species belonging to nine genera and to nine families were identified.

Among all these fifteen trichopterans species, seven of them are considered as common for both studied rivers (*Rhyacophila tristis*, *Glossosoma intermedium*, *Orthotrichia costalis*, *Philopotamus montanus*, *Hydropsyche angustipennis*, *Hydropsyche modesta*, *Sericostoma schneideri*), six species (*Rhyacophila aurata*, *Psychomyia pusilla*, *Neureclipsis bimaculata*, *Hydropsyche contubernalis*, *Hydropsyche modesta*, *Ecclisopteryx dalecarlica*) were sampled only in Târnava Mare River, and tow species (*Rhyacophila obliterata*, *Hydropsyche bulbifera*) were sampled only in Târnava Mică River.

In Târnava Mare River, the trichopterans presents the highest specific diversity (a total of nine species) in the river sector situated at 1 km downstream the Zetea Dam Lake. In the Târnava Mică Rive, the highest specific diversity of the trichopterans (a total of nine species) was noted in the river sector situated upstream the Praid locality, at a distance of approximately 17 km downstream the river's springs. In all these sectors the anthropogenic impact on the river is not significant, and the biotope characteristics are favorable for the existence of many trichopterans larvae species.

The trichopterans larvae numerical weight in the benthic macroinvertebrates communities vary between 19.98% ($Tm_1$ sampling station) and 1.19% ($Tm_5$ sampling station) in the Târnava Mică River, and between 7.96% ($TM_4$ sampling station) and 1.07% ($TM_6$ sampling station) in the Târnava Mare River.

Analyzing the longitudinal dynamics of the trichopterans larvae communities structure for the studied rivers, can be note the fact that in their upper courses these communities presents a high specific diversity, and the species with the highest relative abundance of these communities are lithophilous, rheophilous and oxyphilous species; the trichopterans larvae communities of the middle and lower courses are characterized by a lower specific diversity, the numerical dominant species being eurivalent. This longitudinal structural dynamics highlight the natural habitat degradation in the middle and lower Târnava Mare and Târnava Mică rivers courses.

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# AN ECOLOGICAL SURVEY OF THE CERAMBYCIDAE (COLEOPTERA) IN THE GEOGRAPHIC BASIN OF THE TÂRNAVA MICĂ VALLEY (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: cerambycids-vegetation relations, Transylvania, Romania.

**ABSTRACT**

We have investigated the *Cerambycidae* within five areas of the Târnave Rivers Plateau and the Gurghiu Mountains.

A connection has been emphasized between the calendar periods of adult emergence and the spaced out blooming of various ligneous (woody) plants. Various floral merocenoses are presented which include the participation of the anthophilous/palynophagous *Cerambycidae*. The negative impact of man on the ecosystems (particularly on the forest ecosystem) is stressed, which results in a decrease in the number of Longhorned Beetle/Cerambyx species. The Târnava Mică River basin is still a geographical area rich in coleopterological (beetle) fauna, yet with patchy distribution. For four years we have collected here specimens belonging to 63 *Cerambycidae* species and we have managed to determine 60 of them.

**RÉSUMÉ**: Étude écologique concernant les Cerambycidae du basin géographique de la rivière Târnava Mică.

Renseignements concernant la répartition des *Cerambycidae* dans cinq zones du Plateau des (rivières de) Târnava et des Montagnes de Gurghiu, étudiées par nous.

On a mis en évidence une liaison entre les saisons d'émergence des adultes et la floraison échelonnée des diverses plantes ligneuses. On présente plusieurs mérocénoses florales qui impliquent la participation des *Cerambycidae* anthophiles/palynophages. On souligne l'impacte négatif que l'homme produit sur les écosystèmes, surtout sur l'écosystème forestier, qui conduit à une diminution du nombre d'espèces de capricorne/cérambyx. Le bassin de la rivière Târnava Mică représente encore une région géographique avec une faune qui abonde en coléoptères, mais qui sont dispersés de manière inégale - dont on a collecté, pendant 4 ans, des spécimens (exemplaires) appartenant à 63 espèces de *Cerambycidae* et dont on a déterminé 60 espèces.

**REZUMAT**: Studiu ecologic asupra cerambicidaelor în bazinul geografic a râului Târnava Mică.

Au fost studiate *Cerambycidaele* din cinci arii ale Platoului Târnava şi Munților Gurghiu.

A fost reliefată o conexiune între perioadele calendaristice a emergenței adulților şi înflorirea a variate plante lignofile. Variate merocenoze florale sunt prezentate care includ participarea Cerambycidaelor. Impactul negativ al omului asupra ecosistemelor (în mod particular în ecosistemele forestiere) este accentuat, fapt care induce descreşterea numărului de specii de Cerambicidae. Bazinul râului Târnava Mică este încă, o arie geografică bogată în faună coleopterologică, deşi cu o distribuție neuniformă. Pentru o perioadă de patru ani am colectat aici indivizi aparținând la 63 de specii de *Cerambycidae* şi am reuşit determinarea a 60 dintre ele.

**INTRODUCTION**

A description of the geographical region of the Târnava Mică Valley.

The Târnava Mică Valley has resulted from the river and its tributaries eroding the marl, clay and also the sandstone layers of the Târnava Plateau. The bells, which are typical with the relief here look like overhanging bridges running along the right side of the river and its affluents. The hill slopes look more or less steep. The topoclimates determined by the irregular relief favour such grassy vegetation, that one can find nowhere else in the country an equally diverse range of species. The highly eroded, steep, southern slopes shelter various xerophytic species, such as *Adonis vernalis, Pulsatilla montana, Stipa sp., Iris pumilla, Iris aphylla, Iris variegata, Crambe tatarica, Festuca sp., Dictamnus albus, Carex humilis* - particularly in the lower area, where the topoclimatic conditions are similar to those in the Transylvanian Plain and the Secaş Plateau.

The terraces on the left side of the Târnava Mică River are cultivated, but many lands there are also lie fallow. The tops of the local hills and the northern slopes are patchily covered with woods, which consist, towards the west of the studied river, mainly of *Quercus robur, Quercus petraea* and *Carpinus betulus*, associated with some thermophilic species. These patchy forests are quite sparse and clear, the soil is covered with thick grass and many underbrush species grow inside and on the edge of the forest. Larger forests spread out eastward and they even cover some of the southern hill slopes. Beech forests can be found in the Sovata region, whereas pine spruce and fir-trees are present in the mountains areas, along the Târnava Mică River tributaries.

The anthropic changes of the ecosystems, particularly those undergone by the forests fundamentally altered their structures, lime and hornbeam trees replace the compact oak-tree clumps, which are sparse here. Old trees showing signs of drying up have been constantly felled and the alluvial plain forests have been cut down, so that most of the forests in the west part of the Târnava Plateau are of secondary types and mainly consist of young shrubs and bushes of the same age, a fact which obviously explain the scarce presence of the *Coleoptera* species in this area.

The state of current research on *Cerambycidae* in Romania

The *Cerambycidae*, or the wood beetles, belong to the *Coleoptera*, rich in species (about 20000 all over the world), most of them spread in the Neotropical and Oriental regions. We can also find here the largest-sized insects belonging to the *Titanus* genus - more than 150 mm large, as well as glaring, light-coloured species.

About 240 species have been found in Romania.

An important contribution in studying the Coleoptera on the Romanian territory have been done: Bielz (1850, 1852, 1853, 1887), Siedlitz (1891), Petri (1912), Csiki (1895), Worel (1951) - concerning the Cerambycidae group in Transylvania. Researchers like Hormuzachi (1902, 1904), Montandon (1906), Ieniştea (1932), Panin (1941), Săvulescu (1969, 1972), Serafim (1985, 1997, 1998), Ruicănescu (1992, 1997) have collected a rich material in Romania, establishing extensive fauna lists, which include the *Cerambycidae* species, too.

The biological material concerning the *Cerambycidae* group species is found in the collections of the Natural History Museum in Sibiu, the Agronomy Faculty in Timişoara, the Forestry Institute in Braşov, the „Grigore Antipa" National Natural History Museum in Bucharest, the Museum of Natural Science in Târgu - Mureş, as well as in other museums and private collections.

The *Cerambycidae* fauna in Romania is relatively well known due to these collections and to the fauna lists that have been published. Although relatively old, "Coleoptera - Cerambycidae" in the Fauna of the People's Republic of Romania, 10-5 (1961) is still the most complex study published in Romania so far.

No Romanian researcher has ever thoroughly studied the *Cerambycidae*, although these can cause great damage to the woods by ruining the trees (all the *Cerambycidae* species are phytophagous and their larvae feed on the cellulose of the host plant, boring galleries into the tree wood).

Fortunately, the *Cerambycidae* species nowadays attack the trees sporadically, mostly in the vast mountain woods; the other forests covering smaller areas can be easily kept under control within the forestry systems. Furthermore, insecticides which are regularly sprayed over from the planes destroy the worms, the Ipidae etc., which usually cause the trees to grow weaker, thus favouring the attack and the development of the *Cerambycidae* in the forests. Basically, over the last 60 - 70 years there has been a gradual decrease in the number of *Cerambycidae* species in Romania - which were formerly considered harmful, are pretty scarce nowadays in most of the regions.

## MATERIALS AND METHODS

The *Cerambycidae* were collected manually or by shaking the studied trees or underbrush flowers on the edge of the forests, into entomological umbrellas, in the period of time between 1988 and 2002. An entomological net was used when mowing the grass in the forest glades, or the blooming herbs in the meadows or on the edge of the forests - given the fact that the larvae of these insects are xylophagous and their adults usually live near the forests, too. The steppe *Cerambycidae* species, such as the ones in the *Dorcadion* and *Neodorcadion* genus, were collected from the glades and meadows, from the edge of the forests, or from the local country roads - in spring and also in early summer. Many *Cerambycidae* feeding on the tree leakage, or which do not leave the tree trunks they emerged from, while breeding, were collected after attentively examining the age-old oak-trees which showed signs of attack, i.e. galleries for insect emergence, sap leakage, brownish spots, dry twigs and branches. The branches and the trunks of the trees fallen on the edge of the forest were examined, as well as the dry poplars, the dry faggots lying along the forest roads and the wood piles left after clearing certain sectors of the forest. Several species that live in the trees bark have been collected from the trunks of live trees which were growing inside the forest. The areas around the electric bulbs in the isolated countryside railway stations were also investigated and some of the *Cerambycidae* species were collected after the identification and inspection of the host herbs, such as *Matricaria sp*., and *Artemisia sp*.

The best results were obtained in the case of the diurnal *Cerambycidae* species after 10 o'clock in the morning as the sun raises higher. The nocturnal and the sunset species were examined after 18.00 hours and the best results were obtained in the case of *Cerambyx cerdo* species around 21.00 - 22.00 hours. Special attention was given to isolated areas, less influenced by man, such as the old-age brushes and the sunny forest edges, given the fact that all the species are thermophilic and mesophilic and get warmed up in the sun in the daytime. These areas include the age-old oak-trees in Boian and Cetatea-de-Baltă, which shelter an old fauna, with many rare species.

Regular outings were taken as of the end of the month of April, when the first species emerge, till the end of August and the routes were precisely established so as to visit a wide range of ecosystems every week. The inflorescences were thus successively studied, for *Viburnum lantana, Cerasius avium, Prunus spinosa, Viburnum opulus, Acer pseudoplatanus, Sambucus nigra, Ligustrum vulgara, Chrysanthemum corymbosum, Sambucus ebulus* and *Daucus carota,* as they bloomed.

Notes were regularly tooked regarding the local floral merocenoses, which are that groups of animals which visit the same flower, more *Coleoptera* species were collected and the samples were killed in ethyl ether or alcohol and also preserved in these liquids. The *Coleoptera* species profusely covered with hairs and the ones that presented a certain elytra (tegument) pattern were carefully collected and kept alive. The material collected was pinned and kept in cases belonging to the author's collection or to the Natural Science Museum in Târgu Mureş, which took over a part of this material. The collection includes a total of more than 700 *Coleoptera* specimens.

**RESULTS AND DISCUSSION**

A good knowledge of the seasonal succession of plant blooming and blossoming (woody plants, trees and underbrush) proved to be very important. The blooming/blossoming succession we have noted in the Târnava Plateau:

- *Malus sylvestris, Pyrus pyraster, Cerasus avium* - 15th - 25th April; these species blossom too early and little importance is attached to them for collecting *Cerambycidae* species;
- *Viburnum lantana* - 20th - 25th April; this species is in full bloom by the end of the month of May; the first species emerge on the inflorescence of this shrub (bush); when they become adult individuals, they feed on pollen, nectar and stamina; floral merocenoses of special interest comprising palinophagous *Cerambycidae*, *Cetoniinae, Hoplinae* and *Trichinae*, as well as nocturnal *Lepidoptera, Diptera* and *Hymenoptera* can be found on the edge of Corneşti Forest, towards the local natural meadow where xerophytic and also mesoxerophytic plant species are growing;
- *Acer pseudoplatanus* - early in May; identified in the blooming period (May 3, 2002) in Bazna Forest, at 550 m altitude, in a newly cut clearing; the very special floral merocenoses included palinophagous *Cerambycidae* (*Cerambyx scopoli, Stenostola ferrea, Leptura sp.*), alongside C*etoniinae, Hoplinae, Trichinae, Carabidae - Calosoma inquisidor*; the greatest concentration of Coleoptera species and specimens in the Târnava Plateau was noticed here;
- *Crataegus monogyna, Acer tataricum* - in the first decade of May; shrubs that occur frequently, which are visited by palinophagous Cerambycidae species, but the insects can be watched and collected difficult, given the height of the trees;
- *Cornus sanuguinea, Viburum opulus, Rosa canina* blossom after the 15th May; a great concentration of C*erambycidae coleoptera* can be found on the inflorescence of *Cornus sanguinea* - mostly in Bazna and Corneşti forests;
- *Lingustrum vulgare* - blossoms after *Cornea sanguinea* species, towards the end of the month of May; the highest concentration of Cerambycidae can be found in the Bazna Forest;

- *Sambacus nigra* and *Tilia cordata* - blossom in the month of June; few species of *Cerambycidae* can be found on these species flowers; many palinophagous species are found in this period of time on the inflorescence of the herbs that blossom now, for example: *Chrysanthemum leucanthenum, Sambucus ebulus, Daucus carota, Carum sp.* and other species related to them;
- In July, the palinophagous *Cerambycidae* are present on the herbs with umbelliform inflorescence and their number decreases by the end of August, when practically no adult specimens can be found; this applies in the case of the species that feed on tree bark and leakage;
- In the area of Sovata, particularly in the mountains, the presence of Cerambycidae was noted throughout the May - September vegetation period and most of them were present in June, the widest range of specimens being identified with the species that feed on floral elements.

Most of the biological material was observed and collected from five areas of the Târnava Mică River basin (Fig. 1) - four of them being located in the Târnava Plateau, Târnaveni, Cetatea de Baltă, Bazna - Boian, Vaidacuța - Cerghid. The last area, Sovata, is a mountainous one. Exist a similitude between the first four areas. Some of them, such as Târnaveni, Cetatea de Baltă and Vaidacuța - Cerghid are situated in the oak climatic complex, characterized by the aridity index 30 - 35, whereas the Bazna - Boian area is located in the beech climatic complex, with the aridity index 35 - 40 and the passage to the oak-trees takes place in Boian. According to the local climatic complex, the vegetation features determine the presence of certain Cerambycidae. Most of the biological material was observed and collected in the areas of Târnăveni and Cetatea de Baltă.

Târnaveni locality area, is characterized by a strong industrial activity and the anthropical alteration of the environment (ecosystems) - particularly in the "Oak" Forest, nearby the town. That is the reason why specimens belonging to a smaller number of species could be sampled here. However, more observations were made here, as the town was a propitious point of departure.

Cerambycidae were collected from the hills neighbouring the town of Târnăveni, particularly from the southern slopes rich in xerophytic vegetation, from Soroşpata Pit, the village of Dâmbău, Păucişoara hill and from the glades and meadows in Coroana forest. *Dorcadion pedestre* and *Dorcadion scopoli* emerge early/late in March/April. The latter species is rather present in the steppe. *Dorcadion fulvum,* which is a large-size Cerambycidae species, was present starting from mid-April. The larvae of these species bore (gnaw at) the roots of spontaneous graminae (grasses), while the adults crawl through the grass (on the ground). Sporadically, *Agapanthiola leucaspis* could be found in the xerophitic meadows in Coroana forest. The forests in the villages of Dâmbau, Târnăveni and Păucişoara cover comparatively small areas and farming lands mostly surround them. As trees were often felled and the underbrush was often cut down in all these forests, they have grown poor in Coleoptera species - a phenomenon which is obvious in the forest of the town of Târnaveni. More *Cerambycidae* are present in Dâmbău forest, where *Quercus robur* species grows mostly on the top of the hill, where shrubs and brushes are more frequent and the passage towards the xerophytic pasture includes several meadows, where rare plants grow, such as *Dictamnus albus* and *Stipa lessingiana.*

In the clearing and on the edge of all these forests, depending on the calendar time of our investigation, antenophilous and palinophagous Cerambycidae species were collected, such as: *Leptura sexgutatta* on the *Rosa canina* flowers, *Crataegus monogyna, Sambucus nigra; Gaurotes collaris, Strangalia aethiops, Strangalia nigra* on the inflorescence of *Ligustrum vulgare, Cornus sanguinea; Vadonia livida* on the inflorescence of *Daucus carota, Judolia erratica* on *Umbelliferae* in June - July, *Strangalia melanura* on *Chrysanthemum sp., Chlorophorus figuratus* on *Sambucus nigra* and *Viburnum lantana, Sambucus ebulus* - rarely; *Anaglyptus mysticus* on *Ligustrum vulgare, Cornus sanguinea, Stenostola ferrea* on the leaves of *Acer campetre.* On the tree trunks and branches*, Stenocorus meridianus* was present in the month of May and *Stenocorus quercus* - less frequently; *Rhagium sycophanta* on *Quercus robur* - in the month of May. A decrease in this species has been noted in the recent years. *Liopus nebulosus* and *Mesosa curculionides* could be found but seldom - on freshly cut oak twigs and branches both of them in June, in the forest of Tarnaveni. In July, *Prionus coriarius sp.* is present on *Quercus sp.*, *Acer campestre*, in the evening. A reduction in this species has been noted in the recent years, as the rotten (decayed) tree stumps where the larvae grow have been cut away. Many specimens of *Agapanthia villosoviridescens* were collected from *Carduus sp.* and *Urtica sp.* in June and *Phytoecia nigripes* - in the damp areas, in the meadows with mesophitic vegetations in Târnăveni forest.

As the propitious conditions provided by old trees and rotten tree stumps have been disappeared, many xylophagous *Cerambicydae* species and also other large-size Coleoptera species disappeared too, for example the most of the *Cetoniinae* species*.* A decrease in the species of *Carabidae* genus has been observed, which in Târnaveni forest is represented almost exclusively by *C. glabratus* species; the specimens of *Lucanus cervus* have also become less frequent.

Few Cerambycidae species are present in the Târnava Mică River valley. In the damp areas of Târnăveni the ponds were dried out in the 1970s and in the 1980s and most of the woody vegetation was thus ruined. The forests that used to grow on the alluvial land have practically disappeared - the last one in the vicinity of Şeuca village, the Commune of Găneşti was cut off in the mid-80s. That is why few species could be collected which grow in a typical woody and grassy vegetation, e.g.: *Strangalia quadrifasciata* on the inflorescence of *Daucus carota*, in June*, Strangalia attenuata, Armia moschata*, on the leaves of *Phragmytes sp.,* in the month of June and a species of *Phytoecia cilindrica* was found more recently on *Euphorbia sp.* A population of *Xylotrechus rusticus* was revealed in 2002, which develops on dry poplars, in a xeromesophilic meadow.

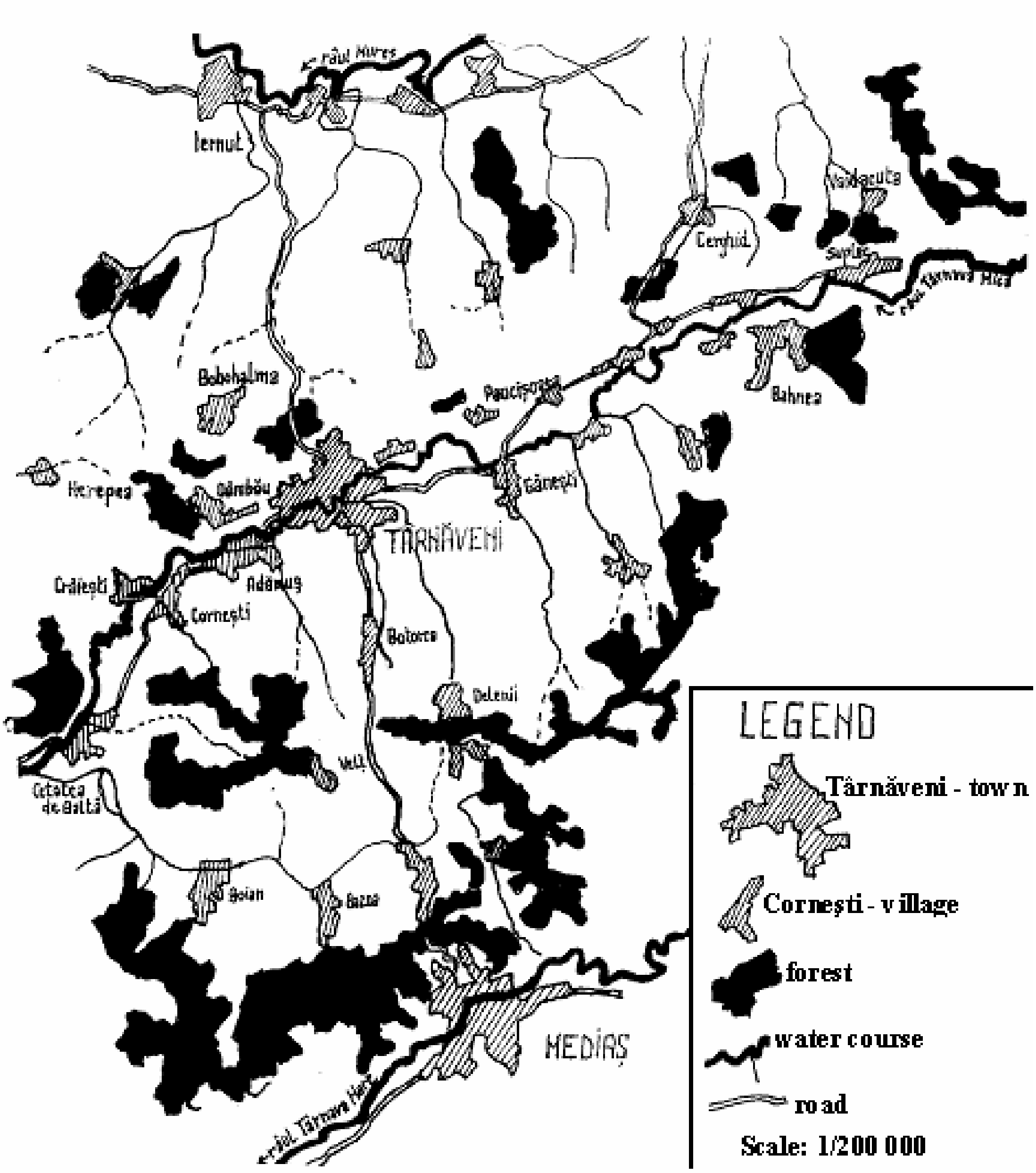


Fig. 1: The map of the researched area
in the Târnave rivers watershed.

Cetatea-de-Baltă area. As this area it is located quite far from Târnăveni locality and it borders the counties of Mureş, Sibiu and Alba, it has undergone little anthropical influences. The forests cover an extensive area here and they have suffered from an insignificant influence of humans. Age-old specimens of *Quercus robur,* up to 1.6 m in diameter, are well preserved, mostly towards the riverside and in the vicinity of Cetatea-de-Balta castle. Xerophytic vegetation of rare plants exists in the neighbourhood of Corneşti and Cetatea-de-Baltă localities and halophytic vegetation is present near Groapa Sărăturii ("The Salt Pit") in Cetatea-de-Baltă. This area, abound in microlocations of diverse well-preserved vegetation includes rare Cerambycidae species alongside remarkable Coleoptera. Among the cerambycids species, special mention deserves *Cerambyx cerdo* in the forest and the park of the nearby castle; it lives on the age-old oak trees, where *Mesosa nebulosa* and *Mesosa curculionides* are also present. *Cerambyx cerdo* species were also collected in June - July, from the trunks of old oak-trees growing on the pastures of the village of Boian, where they grow in quite large numbers. *Agapanthia dahli* was found in Corneşti forest. Of great interest are the *viburnum lantana* floral merocenoses on the steppe-type vegetation growing on the southern hill slopes in Corneşti, where they are present alongside such Cerambycidae and Cetoniinae like *Potosia fieberi* and *Potosia cuprae metallica, Poplia farinose*, being associated with various Buprestidae. Besides *Cerambycidae,* coprophagous scarabs are represented by various species, such as *Trox scabulosus, Trox hispidus, Ontophagus lemur* - rarely. We found *Cetonischema aeruginosa* on the ancient oak-trees in Cetatea-de-Baltă.

Bazna - Boian area. This area includes the forests nearby the villages of Româneşti, Bazna and Boian, which cover vast and continuous areas. Pure beechwood grows on the northern slopes, whereas *Quercus petrea* are present on the southwestern hillsides, sometimes in compact tree clumps. Most of the samples were collected in the cut-wood clearings and on the edge of the forest. The forests border pastures where mesophytic and mesoxerophytic plants grow, where the plough lands cover a small area, as the slopes are very steep. Many species were collected and those characteristics to the area of Târnăveni could all be found here. Species typical for the beech forests are also present, e.g. *Judolia cerambyciformis* - on the Umbelliferae in the meadows of Bazna forest, *Plagionotus arcuatus* and *Xylotrechus antiope* - on oak branches, in the forest of Româneşti, *Rhopalopus clavipes*, also in Româneşti - on the dry branches of *Prunus domestica.* In the cut-wood clearings of Bazna forest we found: *Oberea linearis*, which is a rare species in the fauna of Romania living on the wild graminae (grass) stalks, *Phytoecia virgula*, which was captured in flight - by means of an entomological net; *Teropium castaneum* - a nocturnal species was discovered in the Cetatea-de-Baltă railway-station and *Stenostola ferrea* was found on *Acer pseudoplatanus* leaves in the forest of Bazna. We have pointed out the abundance in Coleoptera in the forest of Bazna, where 150 - 200 years old *Quercus robur* and *Quercus petrea* can often be found, by collecting a lot of specimens belonging to *Hoplis* genus - who live on *Acer pseudoplatanus* flower's occuring in a remarkable range of varieties.

Cerghid - Vaidacuța area. This area greatly resembles the Târnăveni locality area. As compared to the latter, human's interference and pressure upon the local ecosystems is less significant; the forests are generally better preserved and also they are spreading on larger areas. *Fagus sylvatica* species also occurs sporadically, from Sovata locality eastward. There are more plough lands here and less pastures with xerophytic plants and the pasture vegetation is generally more abundant in mesophytic plants - which is a stronger characteristic of the eastern Târnava Plateau.

We have paid particular attention to the case of the Cerghid Forest, a *Quercus robur* forest with trees with 120 to 150 years old, which shows signs of drying up. The forest abounds in Cerambycidae in the months of May and June and we have collected interesting species, such as: *Mesosa curculionides, Ploagionotus arcuatus, Xylotrechus antilopae* - on the branches and the trunks of the oak-trees on the edge of the forest, associated with various Buprestidae. *Mesosa nebulosa* was collected from the branches of *Carpinus betulus* on the edge of the forest; *Rhopalupus clavipes* was picked up from the dry branches in the forest and a specimen of *Clytus tropicus* was found on a grassy plant on the edge of the forest, in May 2002. Besides these, we have captured a flying specimen of *Phytoecia pustulata,* on the edge of the forest. Besides Cerambycidae, the forest also shelters various Carabidae, such as: *Carabus ullrichi, Carabus hampei, Carabus rothi* - rarely; all of them feature multicoloured, metallic types. Some rare species - *Barber* and *Cetonischema neruginosa* were also trapped. The pastures of xerophytic plants on the edge of the forest favour the thriving of *Dorcadion pedestre, Scopoli* and *Fulvum* species, of which we have collected many samples. A rare, steppe-living species, *Neodorcadion bilineatum,* which usually emerges later than the other three *Dorcadion* species, was found in the month of June.

Of a special interest in Vaidacuța is the oak meadow in the forest of Biia, where we collected *Xylotrechus antiope* and *Plagionotus arcuatus* species, from the branches that had been broken by the wind. The anthophilous flower species are the ones we have already met and described in the forest of Târnăveni. Additionally, we have noted here and in Cerghid the *Strangalia septempunctata* species, which is present on the *Compositae* inflorescences, in the month of June.

Sovata area. We have less investigated this last region, which lies at the foot of the Gurghiu Mountains featuring hills covered with beech forests. *Quercus petrea* forests can also be met in the depression of Sovata, towards Săcădat and along the valleys. Fir-trees and pine spruces grow in the mountains. In the month of August 1999 we made investigations in the Sebeş River valley. We found there the following species: *Prionus coriarius* (one evening, while walking on the road), *Pachyta quadrimaculata, Judolia cerambyciformis, Strangalia qudrifascuata, Stranglalia maculata* and *Aromia moschata* - on high *Umbelliferae*. A mention must be made of the fact that along the Jirca River valley (a tributary of the Sebeş River which flows into the Mureş River), close to the Lunca Bradului village, in the Gurghiu Mountains, we have collected Cerambycidae species that grow on pine spruce, such as *Monochamus sartor* and *Monochamus galloprovincialis* species or on beech logs, e.g. *Rosalia alpina.* The presence of these and of other species we have found in the Jirca Valley, in the upper basin of the Târnava Mică River, is quite likely.

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# TÂRNAVA MARE RIVER (ROMANIA) ECOLOGICAL ASSESSMENT, BASED ON THE BENTHIC MACROINVERTEBRATES COMMUNITIES

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**KEYWORDS**: Belgian Biotic Index, Hilsenhoff Biotic Index, biotope, Târnava River.

**ABSTRACT**

This paper presents the Târnava Mare and Târnava rivers ecological status, based on the benthic macroinvertebrates communities in correlation with the biotope conditions.

The river sector between Odorhei and the confluence with the Mureş River (197 km), is the most affected by the human impact. Along this sector successive and diverse pollutions were noted, the most quantitatively significant pollution is that of organic type, due to the urban and rural waste water, zootechnical water, food and light industries. The most accentuated organic pollution exist upstream Mediaş ($TM_8$). The sector between km 182 and 187 (4 km upstream and 3 km downstream Copşa Mică) is seriously influenced by the pollution with heavy metals.

**ZUSAMMENFASSUNG**: Ökologische Beurteilung des Flusses Târnava Mare auf der Basis benthischer Lebensgemeinschaften der Makroinvertebraten.

Diese Arbeit stellt den ökologischen Zustand der Flüsse Târnava Mare und Târnava dar auf der Grundlage der benthischen Lebensgemeinschaften der Makroinvertebraten in Korrelation zu den Habitateigenschaften.

Diese Studie zeigt, dass der Flussabschnitt zwischen Odorhei und dem Zusammenfluss mit dem Mureş (197 km), durch menschliche Einflüsse am meisten betroffenen ist. Entlang diesem Abschnitt wurden aufeinanderfolgende und vielfältige Verschmutzungen beobachtet, wobei die quantitativ signifikantesten Verschmutzungen aus städtischen und landwirtschaftlichen organischen Abwässern besteht, sowie aus Viehzucht Anlagen, Nahrungsmittel- und der Leichtindustrie. Die stärkste organische Belastung wurde flussaufwärts Mediaş ($TM_8$) festgestellt. Der Flussabschnitt zwischen Fluss-km 182 und 187 (4 km stromaufwärts und 3 km stromabwärts von Copşa Mică) ist stark beeinflußt durch eine Verunreinigung mit Schwermetallen, die mögliche Ursache für die niedrige Artendichte der benthischen Makroinvertebraten des ganzen Flusses.

**REZUMAT**: Evaluarea stării ecologice a râului Târnava Mare pe baza comunităților de macronevertebrate bentonice.

Lucrarea analizează starea ecologică a râurilor Târnava Mare şi Târnava, pe baza structurii comunităților de macronevertebrate bentonice în corelație cu condițiile de biotop.

Sectorul de râu cuprins între Odorhei şi confluența cu Mureşul (197 km), este cel mai afectat de impactul antropic. De-a lungul acestui sector se înregistrează poluări succesive şi diverse, poluarea cantitativă cea mai semnificativă este cea de natură organică, datorată aportului de ape reziduale menajere, provenite din zootehnie, industria alimentară şi uşoară. Poluarea organică cea mai accentuată există amonte de Mediaş ($TM_8$). Sectorul cuprins între km 182 şi 187 (4 km amonte şi 3 km aval Copşa Mică) este grav afectat de poluarea cu metale grele.

## INTRODUCTION

This study's aim is Târnava Mare and Târnava (downstream the confluence of the rivers Târnava Mare and Târnava Mică) rivers ecological assessment, based on the quantitative and qualitative structure of the benthic macroinvertebrates communities and on the biotopes characteristics (substratum type, water velocity and water's physico-chemical characteristics).

The Târnava Mare Watershed (Fig. 1) is located inside the Romanian Charpathians, drain the Transylvania Depression, respective its southern division the Târnave Plateau. The Târnava Mare River has its sources in the Oriental Carpathians, on the western slopes of the volcanic mountain mass Harghita Şumuleului at 1441 altitude. After 221 km, Târnava Mare had its confluence with Târnava Mică, forming Târnava Mare River which has a 6157 km$^2$ total watershed surface, as one of the main tributary of the middle Mureş River sector. (A. Roşu, 1980; L. Badea et al. 1983; G. Posea et al. 1982; A. Curtean - Bănăduc et al. 2001).

At least due to the biotope characteristics variation and to a variety of human impact types presence, this river is an interesting one concerning the ecological research.

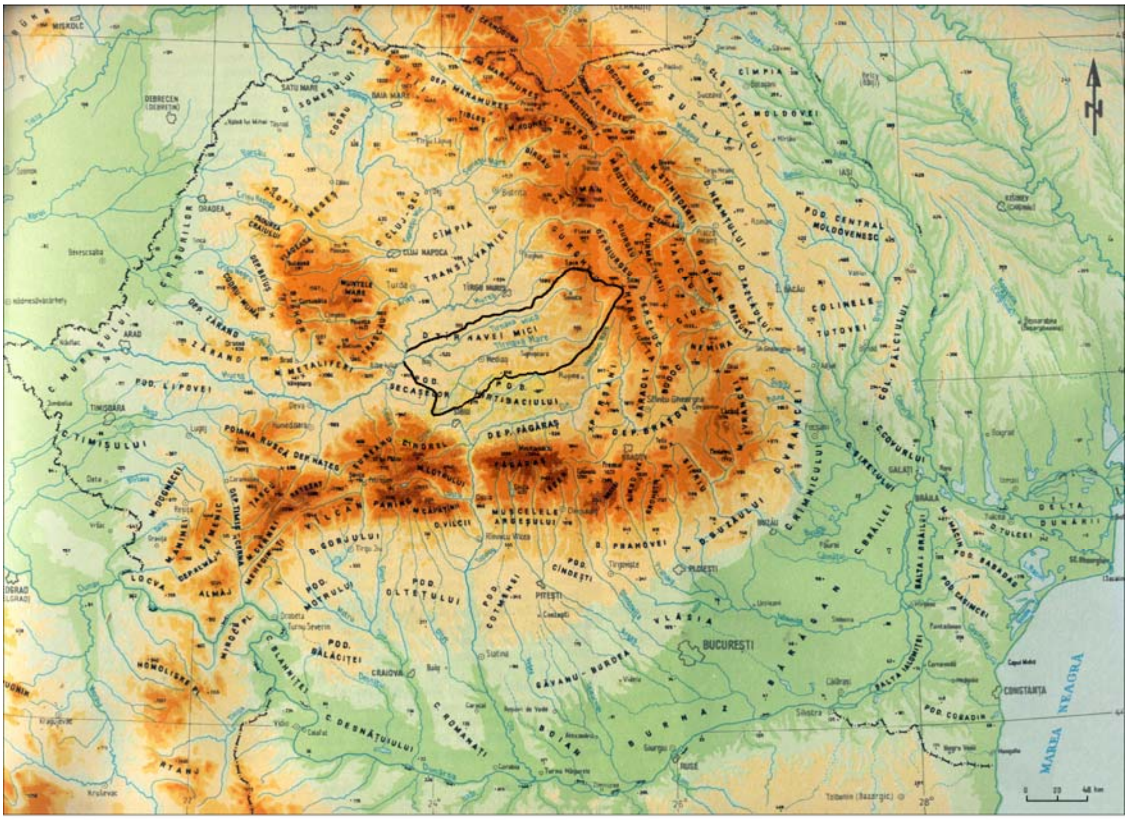

Fig. 1: The Târnava River Watershed study unit location (L. Badea et al, 1983 - modified).

## MATERIALS AND METHODS

The Târnava Mare River was researched (2000 - 2003) along its entire course. 11 sampling stations ($TM_1$ - $TM_{11}$) starting at 5 km downstream the springs to the confluence with Târnava Mică, and two sampling stations ($T_1$ and $T_2$) on the Târnava River (Fig. 2, Tab. 1) were chosen according to the valley morphology, the type of the river substratum, the confluence with the main tributaries and the human impact types and degrees (hydro technical works, pollution sources, riverbed mineral resources over exploitation and riverine lands exploitation) on the river.

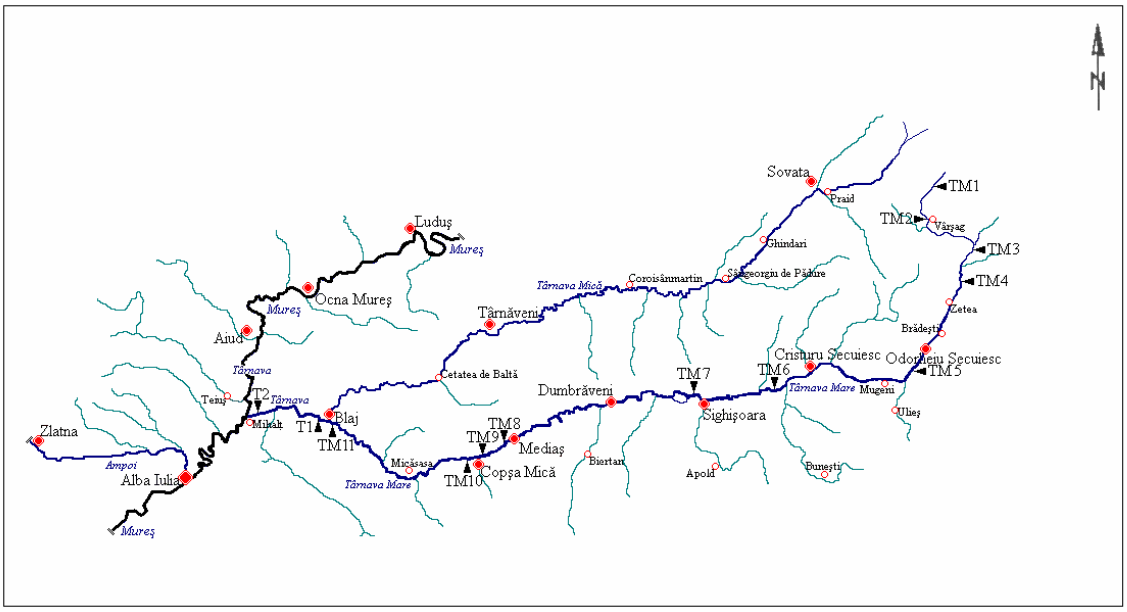


Fig. 2: The location of the sampling stations on the Târnava Mare River ($TM_1$ - $TM_{11}$) and on the Târnava River ($T_1$ - $T_2$).

Table 1: The location of the sampling stations and some physico-geographic characteristics, along the Târnava Mare River and Târnava River.

| Sampling stations | River length (km) | Average altitude (m) | Average slope ($^o/_{oo}$) | Multi annual average water discharge ($m^3/s$) |
|---|---|---|---|---|
| $TM_1$ (5 km upstream Vârşag locality) | 5 | 766 | 13 | 1.20 |
| $TM_2$ (0,5 km upstream Vârşag locality) | 9 | 691 | 10 | 1.60 |
| $TM_3$ (1 km upstream the Zetea Lake) | 33 | 582 | 8 | 3.25 |
| $TM_4$ (1 km downstream the Zetea Dam) | 39 | 571 | 6 | 4.30 |
| $TM_5$ (4 km downstream Odorhei locality) | 52 | 458 | 2.5 | 5.10 |
| $TM_6$ (5 km upstream Sighişoara locality) | 105 | 365 | 1.5 | 8.50 |
| $TM_7$ (1 km downstream Sighişoara locality) | 110 | 358 | 1.3 | 11.0 |
| $TM_8$ (4 km downstream Mediaş locality) | 165 | 299 | 1.2 | 12.0 |
| $TM_9$ (4 km upstream Copşa Mică locality) | 182 | 291 | 1.1 | 12.5 |
| $TM_{10}$ (3 km downstream Copşa Mică) | 187 | 288 | 1.1 | 13.0 |
| $TM_{11}$ (2 km upstream Blaj locality) | 215 | 250 | 1.0 | 15.0 |
| $T_1$ (1 km downstream the confluence with Târnava Mică River) | 222 | 238 | 1.0 | 26.5 |
| $T_2$ (3 km upstream the confluence with the Mureş River) | 247 | 227 | 0.8 | 27.6 |

The benthic macroinvertebrates quantitative samples were monthly sampled, in March - November 2001 - 2003 period, in each sampling station, numerous samples, in different points were done to cover the habitats diversity. The number of the quantitative samples in a sampling station varies between three and seven, related with the biotope heterogeneity, but is constant for each sampling station in each sampling campaign. This number was established before, based on a preliminary study, to allow a correct organism's diversity assessment in each studied riverbed section.

To find the species with a low abundance (rare species) in the studied river sectors, qualitative samples were also taken.

A total number of 514 quantitative macroinvertebrates samples were analyzed.

The benthic macroinvertebrates quantitative samples were realized with an 887 $cm^2$ surface bottom Surber Sampler with 250 μ mesh net. The sampled biological material was fixed in a 4% formaldehyde solution at which $NaHCO_3$ was added. The organisms and sediments separation was realized through washing on screens in the laboratory. The biological material was sort out, the macroinvertebrates individuals belonging to each systematic group were counted, preserved in alcohol 70%, and included in the collections of the Aquatic Biology Laboratory, Department of Ecology and Environmental Protection, "Lucian Blaga" University of Sibiu.

For the biotope conditions description were analyzed the following physical and chemical characteristics of the river water: temperature, pH, total hardness (TH), dissolved oxygen (DO), biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD-Mn), $Cl^-$, $SO_4^{2-}$, $NO^-_3$, $PO_4^{3-}$, total N, total P, Pb, Zn, Cu, Cd and Mn. Also we considered the type of substratum, water discharge and water velocity. The water for the physico-chemical analyze was sampled in the same stations and with the same frequency of the benthic macroinvertebrates quantitative samples. Water temperature, pH and the dissolved oxygen were determined at the sampling station with a portable MultiLine pH-oxi device. The rest of the analysis, were realized in the Sibiu Regional Environmental Protection Agency laboratories, through actual standardized (STAS) methods.

For the quantitative structure description of the present benthic macroinvertebrates communities we have used the following ecological indexes: relative abundance (A%) and frequency (F%).

As synthetic indexes used for the river ecological state assessment the Belgian Biotic Index (BBI) (N. de Pauw at all., 1992) and Hilsenhoff Biotic Index (HBI) (D. M. Rosenberg, V. H. Resh, 1993) were determined for all the 13 considered river sectors.

The Belgian Biotic Index (BBI) values can be grouped in five classes corresponding to the water quality classes (Tab. 2).

Table 2: The water quality classes in relation with the Belgian Biotic Index values.

| Class | Belgian Biotic Index value | Quality category |
|---|---|---|
| I | 10 - 9 | Unpolluted water |
| II | 8 - 7 | Low polluted water |
| III | 6 - 5 | Polluted water, critical situation |
| IV | 4 - 3 | Very polluted water |
| V | 2 - 1 | Excesive pollution |

In relation with the Hilsenhoff Biotic Index (HBI) values, seven water quality classes can be distinguished (Tab. 3).

Table 3: The water quality classes in relation with the Hilsenhoff Index values.

| HBI | Water quality | Organic pollution degree |
|---|---|---|
| < 3,75 | excelent | no organic pollution |
| 3,76 - 4,25 | very good | very low organic pollution |
| 4,26 - 5,0 | good | low organic pollution |
| 5,01 - 5,75 | acceptable | moderate organic pollution |
| 5,76 - 6,50 | unsatisfying | substantial organic pollution |
| 6,51 - 7,25 | low | critical organic pollution |
| 7,26 - 10,0 | very low | severe organic pollution |

The utilized methods for the river ecological assessment and the indicator values of the determined species were took from the papers of the following authors: W. M. Beck (1977); S. Marcoci (1984); J. M. Hellawell (1986); D. Chapman (1992); D. M. Rosenberg, V. H. Resh (1993); N. De Pauw, H. A. Hawkes (1992); J. Seager and colab. (1992), R. A. E. Knoben et al. (1995), V. Resh et al. (1996).

**RESULTS AND DISCUSSION**

The **$TM_1$** sampling station is situated 5 km downstream the river springs and approximately at 5 km downstream the Vârşag locality. In this sector, the river has a mountainous aspect, the maximum width of the riverbed is 5 m and the multiannual (1950 - 2000) average water discharge is 1.20 $m^3/s$. The river substrate is formed of rocks, boulders and pebbles, and near the banks exist narrow coarse sand stripes. The water had a high velocity due to the 13‰ riverbed average slope.

The physico-chemical analysis reveal that the water is well oxygenated - the average value of the oxygen saturation was 98,79%, with a low level of organic matter (COD-Mn = 5.12 mg/l, $BOD_5$ = 1,5 mg/l - average values for the study period), low levels of salts: $NO^-_3$= 1.98 mg/l, $PO_4^{3-}$ = 0.0 mg/l, TH = 3.08 German degrees; the values of total N is small (0.48 mg/l).

Rheophilic species form the benthic macroinvertebrates community. The insects larvae are numerically dominant: chironomids - 45.96%, ephemeropterans - 19.29, trichopterans - 14.67%, plecopterans - 3.37%, simulids - 1.97%, coleopterans - 1.32, near which are present too the copepods - 4.98%, oligochetes - 4.36%, hydracarians - 2.67%, gastropods (*Ancylus fluviatilis*) - 1.39% and collembols - 0.04%.

Oxyphilic and rheophilic species which characterize natural mountain rivers are present: *Perla marginata*, *Perla pallida*, *Leuctra fusca* (Plecoptera), *Leptophlebia marginata*, *Habroleptoides modesta*, *Caenis macrura* (Ephemeroptera), *Rhyacophila aurata*, *Rhyacophila tristis*, *Ortotrichia costalis* (Trichoptera). These species, form in this river sector, stable populations (appear in samples with frequencies of over 70%). Among the chironomids, numerically dominant are that species which belong to the genera which prefer clean water: *Diamesa*, *Pseudodiamesa* and *Heptagenia*.

The Belgian Biotic Index value (7) and that of the Hilsenhoff Biotic Index (1.56) reveal a good ecological status of this river sector.

The **$TM_2$** sampling station is situated 0.5 km upstream the Vârşag locality. In this river sector the riverbed maximum width is 6 m, the multiannual average water discharge is 1.60 $m^3/s$, and the riverbed average slope is 10‰. The substratum is formed of boulders, boulders covered with periphyton, pebbles and coarse sand near the banks. The water is characterized by a high velocity, well oxygenation (the average value for the study period of the saturation in oxygen is 99%), a low contents of organic substances (COD-Mn = 5.25 mg/l, $BOD_5$ = 1.65 mg/l - average values for the study period).

The benthic macroinvertebrates communities structure, in terms of relative abundance, is the following: chironomids - 69.62%, trichopterans - 11.53%, ephemeropterans - 4.93%, oligochetes - 3.88%, plecopterans - 2.22%, blepharocerids - 1.73%, hydracarians- 1.99%, simulids - 1.88%, gastropods - 1.33% (*Ancylus fluviatilis*), coleopterans - 0.89%.

The insects larvae are numerically dominant, rheophilic and oxyphilic species are present. Thus, among the ephemeropterans, stable populations are present in the cases of *Bäetis alpinus* and *Ecdyonurus venosus* species, together with *Ephemera danica* species, and among the trichopterans the species *Rhyacophila aurata*, *Rhyacophila tristis*, *Orthotrichia costalis* and *Philopotamus montanus*. The plecopterans group which appear with a 100% frequency in the $TM_2$ sampling station samples, are represented by the species: *Perla marginata, Perla pallida, Leucra fusca* and *Leuctra inermis.*

The Belgian Biotic Index value (7) and that of the Hilsenhoff Biotic Index (4.61) reveal a good ecological status of this river sector.

The **$TM_3$** sampling station is situated one km upstream the Zetea Dam Lake, downstream the confluence with the Desag River. In this sector the riverbed average slope is

8‰, its maximum width is 5 m, the multiannual average discharge is 3.25 $m^3/s$, and its substrate is formed of medium sized boulders, pebbles and coarse sand.

The water is well oxygenated, the average oxygen saturation is 98.33%, the contents of organic substances is low - the average values of the chemical oxygen demand (COD-Mn) is 5.33 mg/l, and that of the biochemical oxygen demand ($BOD_5$) is 1.78 mg/l, the water is also poor in salts ($NO_3^-$ = 1.75 mg/l, $PO_4^{3-}$ = 0.0028 mg/l, $Cl^-$ = 33.72 mg/l, $SO_4^{2-}$ = 8.87 mg/l, TH = 4.03 German degrees, Ca = 9.4 mg/l, Mg = 12.52 mg/l), the average values for the study period of total N and total P indicators are 0.317 mg/l, respective 0.009 mg/l.

The quantitative structure of the benthic macroinvertebrates communities in this river sector is: chironomids - 68.48%, ephemeropterans - 6.61%, hydracarians - 6.56%, trichopterans - 6.33%, oligochetes - 3.72%, gastropods (*Ancylus fluviatilis*) - 2.7%, plecopterans - 1.58%, blepharocerids - 1.35%, coleopterans - 1.32%, amphypods - 0.98%, cladocerans - 0.37%.

In this river sector the rheophilic and oxyphilic species are also present: *Perla marginata*, *Perla pallida*, *Leuctra nigra*, *Leuctra fusca*, *Leuctra inermis*, *Perlodes microcephala* (Plecoptera), *Bäetis alpinus*, *Bäetis sinaicus, Bäetis lutheri*, *Caenis macrura* (Ephemeroptera), *Rhyacophila aurata*, *Rhyacophila tristis*, *Ortotrichia costalis*, *Philopotamus montanus* (Trichoptera). The present chironomids belong to the genera *Diamesa*, *Pseudodiamesa* and *Heptagenia*, which are characteristic for clean water.

The Belgian Biotic Index value (7) and that of the Hilsenhoff Biotic Index (4.71) reveal a good ecological status of this river sector.

Although the benthic community structure is characteristic for the mountainous rivers and reveal a good ecological status, the water physico-chemical analysis reveal the existence of an organic substances supplementary input in comparison with the upstream river sectors, the sources of this input being considered the riverine wastewaters of the Vârşag locality houses.

The sampling station **$TM_4$** is situated one km downstream the Zetea Dam Lake, upstream of the confluence with Brădeşti River. In this river sector the riverbed average slope is 6‰, the maximum riverbed width is 7 m and the multiannual average water discharge is 4.3 $m^3/s$. The riverbed substratum is formed of medium sized boulders covered with periphyton.

The water physico-chemical analysis reveal the fact that the water is well oxygenated (average oxygen saturation value for the study period is 97.8%), with a relative low contents of organic substances (the average value of the COD-Mn indicator is 6.9 mg/l, and of the $BOD_5$ indicator is 3.1 mg/l), but higher then in upstream sectors. The average water total hardness is low (4.03 German degrees). The salts concentration ($Cl^-$ = 7.1 mg/l, $SO_4^{2-}$ = 5.71 mg/l, $NO^-_3$= 1.2 mg/l, $PO_4^{3-}$ = 0.0030 mg/l) is not significant different in comparison with the upstream sectors.

The benthic macroinvertebrates communities of this river sector present the following structure (in terms of relative abundance): celenterates - 63.02%, chironomids - 17.95 %, oligochetes - 7.41%, ephemeropterans - 3.74%, gastropods (*Ancylus fluviatilis*) - 1.96%, trichopterans - 1.71%, plecopterans - 1.65%, hydracarians - 1.35%, blepharocerids - 0.80%, amfipods - 0.36%, nematods - 0.048%, odonates - 0.048%, heteropterans - 0.048%.

High number of planktonic organisms (Cladocera, Copepoda and Ostracoda) were also frequent identified, organisms which probably drifted from the upstream dam lake.

The following oxyphilic species are constantly present (with a frequency higher than 50%): *Leuctra fusca*, *Leuctra inermis*, *Capnia bifrons*, *Nemoura cambica* (Plecoptera), *Caenis moesta* (Ephemeroptera), *Rhyacophila aurata*, *Rhyacophila tristis*, *Sericostoma schneideri* (Tirchoptera). Also, the oxyphilic *Ancylus fluviatilis* is characterized here by a stable population (the frequency with which it appear in samples is 100%), with high number of individuals.

Near these stenovalent clean water species appear eurivalent species, thus, among the ephemeropterans the species with the highest number of individuals is *Ephemerella ignita*, a species characteristic for the „stressed" rivers sectors. Also, in lower proportions and with lower than 33% frequency the trichopterans *Hydropsyche modesta*, *Hydropsyche pellucida* and *Hydropsyche angustipennis* are present, which are eurivalent species but prefer water richer in organic substances.

The Belgian Biotic Index value (7) and that of the Hilsenhoff Biotic Index (5.12) reveal an „acceptable" ecological status of this river sector. The values variation of these indexes in comparison with the upstream determined values reveal the impact of the wastewater discharges in river and the impact of the hydro technical constructions on the river natural equilibrium.

The **$TM_5$** sampling station is situated 4 km downstream the Odorhei locality, at a 458 m altitude. In this river sector the riverbed average slope is 2.5‰, the maximum width is 7 m and the multiannual average water discharge is 5.10 $m^3$/s. The riverbed substratum is predominantly formed of pebbles and medium sized boulders covered with mud, these zones alternating with surfaces covered with sand.

The average values for the study period of the main physico-chemical indicators of the water are: DO = 78.03%, $BOD_5$ = 3.6 mg/l, COD-Mn = 7.56 mg/l, $Cl^-$ = 41.41 mg/l, $SO_4^{2-}$ = 21.97 mg/l, $NO^-_3$= 11.56 mg/l, $PO_4^{3-}$ = 0.167 mg/l, total N = 3.26 mg/l, total P = 0.054 mg/l, TH = 7.0 German degrees.

It was noticed an increasing of the organic substances quantities and of the salts concentration (especial of the nitrates) in water in comparison with the upstream sector, fact which reveal a constant water pollution.

The benthic macroinvertebrates communities, present the following structure (in therms of relative abundance): chironomids - 51.2%, oligochetes - 44.83%, ephemeropterans - 1.11%, trichopterans - 1.18%, hydracarians - 0.73%, hirudineans - 0.66%, nematods - 0.11, heteropterans - 0.10%, tipulids - 0.08%.

In this sector appear with high abundances and with frequencies above 50%, species which prefer water richer in organic substances, as *Hydropsyche angustipennis*, *Hydropsyche modesta* (Trichoptera) and species of the genus *Chironomus* (Chironomidae).

The Belgian Biotic Index value (6) and that of the Hilsenhoff Biotic Index (6.43) reveal the water pollution with organic substances. The source of this water pollution is the Odorhei locality, its wastewater is not properly filtered and exist many illegal wastes deposits on the riverbanks, and also the pollution from riverine farms is present.

The sampling station **$TM_6$** is situated 5 km upstream the Sighişoara locality, at the 105 km of the river springs, at 365 m average altitude. In this river sector the average riverbed slope is 1.5‰, and the river meadow is well structured. The maximum width of the riverbed is 7 m; its substrate is formed of pebbles, coarse sand and medium sized boulders covered with mud and periphyton. The multiannual water discharge is 8.5 $m^3$/s.

The average values for the study period of the main physico-chemical indicators are: DO = 79.05%, $BOD_5$ = 4.13 mg/l, COD-Mn = 10.24 mg/l, $Cl^-$ = 128.16 mg/l, $SO_4^{2-}$ = 69.68 mg/l, $NO^-_3$= 52.75 mg/l, $PO_4^{3-}$ = 0.028 mg/l, total N = 1.077 mg/l, total P = 0.009 mg/l, TH = 4.36 German degrees.

Comparing with the upstream sector, the organic matter quantity in water increase, also increase the chlorides, sulphates and nitrogenous concentrations.

The benthic macroinvertebrates community of this river sector has the following structure: oligochetes - 49.64%, chironomids - 39.76%, trichopterans - 7.96%, ephemeropterans - 1.49%, hirudineans - 0.51%, tipulids - 0.45%, hydracarians - 0.19%.

In this river sector indicator species for organic pollution are present: *Hydropsyche angustipennis*, *Hydropsyche contubernalis*, *Hydropsyche modesta* (Trichoptera), among chironomids numerically dominant are those belonging to *Chironomus* genus, near which appear that belonging to *Cricotopus* genus.

The Belgian Biotic Index value (6) and that of the Hilsenhoff Biotic Index (6.48) reveal the accentuated water pollution with organic substances, due to the constant alochtonous inputs from localities and farms wastewater.

The **$TM_7$** sampling station is situated 1 km downstream Sighişoara locality, at an average altitude of 358 m. In this river sector the riverbed average slope is 1.3‰, the water average discharge is 11 $m^3/s$, and the maximum width of the riverbed is 8 m. The river substratum is formed of pebbles, coarse sand and medium sized boulders covered with periphyton or mud. In the riverbed building materials remains (concrete and asphalt) are present. Also in this area, domestic wastes are deposited on the riverbanks.

The average values for the study period of the main water physico-chemical indicators are: DO = 78.7%, $BOD_5$ = 13.66 mg/l, COD-Mn = 31.04 mg/l, $Cl^-$ = 17.75 mg/l, $SO_4^{2-}$ = 15.3 mg/l, $NO_3^-$ = 4.62 mg/l, $PO_4^{3-}$ = 0.028 mg/l, total N = 1.054 mg/l, total P = 0.009 mg/l, TH = 5.12 German degrees.

The water had a high content of organic matter, but is well enough oxygenated and the nitrogenous, sulphates and chlorides concentrations decrease in comparison with the upstream sector.

The benthic macroinvertebrates community of this river sector is numerically dominated by the oligochetes (81.38%). Here are also present the chironomids (15.51%) and with a much lower number of individuals the trichopterans (1.31%), turbelarians (1.06%), ephemeropterans (0.65%), hydracarians (0.05%) and odonates (0.03%). The trichopterans are represented only by two species (*Hydropsyche angustipennis* and *Hydropsyche contubernalis*), which are characteristic for organic rich water, and the present chironomids belong to the genera *Chironomus* and *Cryptochironomus*, which prefer organic rich water.

The Belgian Biotic Index value (5) and that of the Hilsenhoff Biotic Index (7.45) reveal the fact that in this river sector the water pollution with organic substances is severe and constant.

The **$TM_8$** sampling station is located 4 km upstream the Mediaş locality, at an average altitude of 299 m. In this sector the river course is meandered and its average slope is reduced at 1.2‰. The maximum width of the minor riverbed is 15 m and the multiannual average water discharge is 12 $m^3/s$. The river substrate is formed of coarse sand and pebbles covered with mud and periphyton, in the center of the riverbed, and near the riverbanks sandy and clay zones are present.

The average values for the study period of the main water physico-chemical indicators are: DO = 80.09%, $BOD_5$ = 6.2 mg/l, COD-Mn = 10.81 mg/l, $Cl^-$ = 59.16 mg/l, $SO_4^{2-}$ = 172.71 mg/l, $NO_3^-$ = 10.23 mg/l, $PO_4^{3-}$ = 0.104 mg/l, total N = 2.75 mg/l, total P = 0.033 mg/l, TH = 17.73 German degrees.

The quantity of organic substances in water decrease in comparison with the upstream river sector, but the concentrations of sulphates, nitrates, phosphates and chlorates increase, also the total water hardness significantly increase.

The benthic macroinvertebrates community of this river sector present the following structure (in therms of relative abundance): oligochetes (59.76%), chironomids (33.91%), trichopterans (5.59%), tipulids (0.75%), ephemeropterans (0.11%), celenterates (0.055) and collemboles (0.05%).

The benthic macroinvertebrates community structure is characteristic for the river sectors polluted with domestic wastewater. With a high number of individuals and with a high frequency in samples (F = 100%) appear the oligochetes of the Tubificidae family, the chironomids belonging to *Chironomus* genus, and two species of trichopterans: *Hydropsyche angustipennis* and *Hydropsyche contubernalis*, which are characteristic for water rich in organic substances, which although have small relative abundances, appear with high frequency in samples (100% and respectively 66.66%).

We mention that in the benthic samples of this station appeared frequently planktonic organisms (copepods and cladocerans), which probably came from the anthropogenic lake Nemşa situated on the Moşne tributary, which met Târnava Mare River upstream $TM_8$.

The Belgian Biotic Index value (5) and that of the Hilsenhoff Biotic Index (7.89) reveal the accentuated organic pollution on the river.

The $\mathbf{TM_9}$ sampling station is located 4 km upstream the Copşa Mică locality, at an average altitude of 291 m. In this river sector the average riverbed slope is 1.1‰, the multiannual average water discharge is 12.5 $m^3/s$, and the maximum riverbed width is 10 m. The riverbed substrate is formed of pebbles and sand, covered with a 10 - 15 cm layer of black organic mud near the banks. In the riverbed building materials remains are present and also in this area, domestic wastes are illegally deposited on the riverbanks.

The average values for the study period of the main water physico-chemical indicators are: DO = 68.3%, $BOD_5$ = 6.3 mg/l, COD-Mn = 15.8 mg/l, $Cl^-$ = 62.71 mg/l, $SO_4^{2-}$ = 191.88 mg/l, $NO_3^-$ = 11.32 mg/l, $PO_4^{3-}$ = 0.147 mg/l, total N = 3.28 mg/l, total P = 0.047 mg/l, TH = 17.94 German degrees, Pb = 0.01 mg/l, Zn = 0.059 mg/l, Cu = 0.02 mg/l, Cd = 0.006 mg/l.

In comparison with the upstream river sectors, here the organic substances quantity increase and also increase the sulphates, chlorates, nitrates and fosphates concentration. Remarkable is the presence of the heavy metals (Cu, Cd and Pb) in the water, all these coming from the sedimentary powders emitted in atmosphere by the Copşa Mică nonferrous metallurgy, and also in the insufficient filtered wastewater of Mediaş locality industries.

The benthic macroinvertebrates community is formed of oligochetes (51.96%), chironomids (39.00%), ephemeropterans (7.66%), trichopterans (1.07%), hydracarians (0.11%), heteropterans (0.09%), tipulids (0.06%) and gastropods (0.04%).

The oligochetes (Tubificidae) and the chironomids (*Chironomus*) are present, with a high relative abundance and a frequency of 100%. The trichopterans are represented by two species - *Hydrposyche angustipennis* and *Hydropsyche contubernalis*, and the ephemeropterans by one species *Bätis rhodani*, which is resistant to organic pollution. This benthic macroinvertebrates structure reveals the fact that the river is under a constant human impact, especially due to the domestic and industrial wastewater discharges which are not properly filtered.

The Belgian Biotic Index value (5) and that of the Hilsenhoff Biotic Index (6.48) reveal the accentuated organic pollution in this river sector, and the heavy metals and some salts high concentrations presence in water reveal also the industrial pollution.

The $\mathbf{TM_{10}}$ sampling station is situated at 3 km downstream the Copşa Mică locality, upstream the confluence with the Visa River, at an average altitude of 288 m. In this sector the river is meandered and communicates with pools in the major riverbed, the average slope is low (1.1‰). The riverbed substrate is formed of pebbles and sand covered with black mud and periphyton, the maximum riverbed width is 15 m, the multiannual average flow is 13.0 $m^3/s$.

The average values for the study period of the main water physico-chemical indicators are: DO = 61.9%, $BOD_5$ = 8.4 mg/l, COD-Mn = 25.0 mg/l, $Cl^-$ = 98.2 mg/l, $SO_4^{2-}$ = 291.12 mg/l, $NO_3^-$ = 13.02 mg/l, $PO_4^{3-}$ = 0.156 mg/l, total N = 3.26 mg/l, total P = 0.0576 mg/l, TH = 20.94 German degrees, Pb = 0.196 mg/l, Zn = 0.31 mg/l, Cu = 0.023 mg/l, Cd = 0.025 mg/l, Mn = 0.34 mg/l.

In comparison with the upstream river sector the organic substances quantities in water increased, also the chlorates, nitrates, sulphates and phosphates concentrations, and the total hardness increased.

In this sector the water present the highest concentrations of heavy metals for the entire river course.

The benthic macroinvertebrates community is structured as follow: chironomids - 79.41%, oligochetes -11.45%, trichopterans - 3.56%, ephemeropterans - 2.14%, heteropterans - 1.34%, tipulids - 1.22%, hydracarians - 0.88%. The density of benthic macroinvertebrates is low in comparison with the upstream and downstream river sectors, a fact which can be associated with the heavy metals presence in water and in the sediments.

The constantly present in samples are the chironomids (*Chironomus*), the oligochetes and trichopterans (*Hydropsyche contubernalis*), organisms resistant to the organic pollution; ephemeropterans, heteropterans and tipulids appear in samples with low frequencies (› 25%).

The Belgian Biotic Index value (5) and that of the Hilsenhoff biotic index (5.87) reveal the accentuated organic pollution in this river sector, pollution induced by the Copşa Mică unfiltered wastewater discharged in the river. High heavy metals concentrations in water are induced by the nonferrous metallurgy of Copşa Mică.

The sampling station $\mathbf{TM_{11}}$ is situated at 2 km upstream Blaj locality, at an average altitude of 250 m. In this sector the Târnava Mare River course has large meanders, the average slope is low (1‰), the maximum riverbed width is 25 m, and the water average multiannual flow is 15.0 $m^3$/s. The riverbed substratum is formed of pebbles alternating with coarse sand, in the banks zones the pebbles are covered with a thin layer of mud.

The average values for the study period of the main water physico-chemical indicators are: DO = 77.9%, $BOD_5$ = 7.4 mg/l, COD-Mn = 21.6 mg/l, $Cl^-$ = 133.71 mg/l, $SO_4^{2-}$ = 184.75 mg/l, $NO_3^-$ = 7.25 mg/l, $PO_4^{3-}$ = 0.043 mg/l, total N = 2.00 mg/l, total P = 0.014 mg/l, TH = 12.41 German degrees, Pb = 0.002 mg/l, Zn = 0.041 mg/l, Cu = 0.04 mg/l, Cd = 0.014 mg/l.

A significant decrease of the heavy metals in water was noted, in comparison with the upstream sector, the organic matter quantities in water are decreased, and also the sulphates, nitrates and phosphates concentrations and total hardness are decreased.

The benthic macroinvertebrates community of this sector presents the following structure (relative abundance): chironomids (72.9%), oligochetes (15.82%), trichopterans (3.1%), coleopterans (2.28%), ephemeropterans (2.1%), tipulids (1.74%), amphipods (1.05%), collemboles (1.05%), heteropterans (1.01%). In comparison with the upstream sector, here increase the benthic macroinvertebrates density, and the specific diversity also increased.

Characteristic species for the polluted river sectors with residual domestic wastewater are present: chironomids of Chironomus genus (F = 100%), oligochetes of Tubificidae family (F = 100%), trichopterans *Hydropsyche angustipennis* (F = 88.88%) and *Hydropsyche contubernalis* (F = 100%) (the single present trichopterans species). Beside those appear euryvalent organisms: chironomids of the genera *Microtendipes* (F = 50%) and Cryptochironomus (F = 88.88%), ephemeropterans belonging to *Bătis rhodani* species (F = 33.33%).

The benthic macroinvertebrates community structure and the water physico-chemical analysis reveal a significant increasing in the river ecological status/quality in comparison with the upstream sector.

The Belgian Biotic Index value (6) and that of the Hilsenhoff Biotic Index (5.47) reveal for this river sector the presence of a moderate organic pollution.

The $T_1$ sampling station is situated downstream of Blaj locality, at one km downstream the confluence of Târnava Mare River with Târnava Mică River. In this river sector the major riverbed is large, the minor riverbed reach 50 m, the average riverbed slope is 1‰ and the multiannual water discharge is 26.5 $m^3/s$. The river presents a net of secondary branches and backwaters which in periods with floods communicate with the minor riverbed. The river substrate is formed of pebbles and coarse sand in the center, and near the banks exist surfaces with fine sand and clay covered with mud.

The average values for the study period of the main water physico-chemical indicators are: DO = 75.9%, $BOD_5$ = 6.9 mg/l, COD-Mn = 18.2 mg/l, $Cl^-$ = 319.2 mg/l, $SO_4^{2-}$ = 195.30 mg/l, $NO^-_3$= 3.30 mg/l, $PO_4^{3-}$ = 0.0 mg/l, total N = 1.001 mg/l, total P = 0.0 mg/l, TH = 15.68 German degrees.

Comparatively with the upstream sector, significantly decrease the organic matter substances quantities and increase chlorates concentration, also increase the total hardness.

The benthic macroinvertebrates community of this sector presents the following structure (in terms of relative abundance): chironomids (79.23%), oligochetes (13.26%), trichopterans (3.42%), coleopterans (0.40%), ephemeropterans (0.78%) and turbelariates (2.73%).

The constant presence of the chironomids of *Chironomus* genus (F = 100%) and of the *Hydropsyche modesta* (F = 88.88%, the single trichopterans species identified in this river sector), reveal a constant organic pollution of this river sector. This aspect is revealed also by the Belgian Biotic Index value (5) and that of the Hilsenhoff Biotic Index (6.30).

The $T_2$ sampling station is situated at 2 km upstream of Târnava River and Mureş River confluence. In this river sector the average riverbed slope is 0.08‰, the minor riverbed is large (maximum width of 40 m), the water flow is of a linear type, the average water discharge is 27.6 $m^3/s$, the riverbed substrate is formed of pebbles and sand covered near the banks with mud.

The average values for the study period of the main water physico-chemical indicators are: DO = 55.6%, $BOD_5$ = 5.9 mg/l, COD-Mn = 15.2 mg/l, $Cl^-$ = 93.2 mg/l, $SO_4^{2-}$ = 178.30 mg/l, $NO_3^-$ = 2.95 mg/l, $PO_4^{3-}$ = 0.02 mg/l, N total = 1.02 mg/l, P total = 0.01 mg/l, TH = 13.20 German degrees.

The benthic macroinvertebrates community of this river sector is formed (in terms of relative abundance) of: chironomids (88.965%), oligochetes (7.54%), trichopterans (1.99%), coleopterans (0.17%) and ephemeropterans (1.34%).

The specific diversity increase in comparison with the upstream river sector, also increase the benthic macroinvertebrates density. Although the ephemeropterans present a low relative abundance, them appear with a high frequency in samples (F = 100%), representing a constant component of the communities. This group is represented by the species *Bäetis vernus* (F = 50%), *Caenis moesta* and *Ephemerella ignita* (F = 33.33%). In the case of the trichopterans, the species *Hydropsyche modesta* (F = 66.66%), *Hydropsyche angustipennis* (F = 66.66%) and *Hydropsyche contubernalis* (F = 50%) form stable populations in this river sector, all of them are eurivalent species. The present chironomids species belong to *Chironomus*, *Cryptochironomus* and *Microtendipes* genera.

The benthic macroinvertebrates community structure, based on the Belgian Biotic Index value (6) and that of the Hilsenhoff Biotic Index value (5.75), reveal the fact that the river quality is significantly increased in comparison with the upstream river sector.

This increasing of the river ecological quality can be explained by the absence of the significant pollution sources and to the presence of the natural water self cleaning processes which are favored by the hydrological regime and by the relatively clean water of the tributaries (Secaş River).

**CONCLUSIONS**

The benthic macroinvertebrates community's structure, like an expression of the biotope selection and of the interspecific and intraspecific relations, reveal the existence of four ecological zones along Târnava Mare/Târnava River.

I. The mountainous sector of Târnava Mare River is stretching for 32 km between the river springs and Zetea Dam Lake ($TM_3$). This sector is characterized by clean water, with low organic matter and mineral salts content, well oxygenated, with high speed velocity (the average riverbed slope is 11‰) and the predominance of lithological substrate.

The benthic macroinvertebrates communities present a relatively high specific diversity, the typical reophilic and oxyphilic species are present, species characteristic for mountainous rivers courses. Insect's larvae are numerically dominant.

In this area the anthropogenic impact upon the river is not significant, this sector can be considered as a reference sector for the downstream degraded under the human impact river sectors assessment.

II. The Zetea Dam Lake is stretching on 3 km. The lotic environment was replaced with a lenitic environment, facts which induced profound changes in the biocoenosis structure.

The biologic and physico-chemical river characteristics downstream the dam lake are influenced by the dam presence, which induce an interruption in the river hydro biogeochemical continuum, influencing the river bioeconomy.

III. The river sector downstream the dam and upstream Odorhei locality, which is stretching on a distance of almost 10 km, is characterized by a good ecological state, relatively similar with the natural one, here the pollution being insignificant.

Downstream the lake ($TM_4$) the benthic macroinvertebrates community structure is significantly different comparing with the upstream sector ($TM_3$). This community is characterized by the numerically dominance of Coelenterata (*Hydra vulgaris*) and the relative abundance decreasing of chironomids, efemeropterans, plecopterans and trichopterans.

In this river sector the relation among the habitats diversity, the water trophicity and the anthropogenic impacts is favourable for the existence of many insect species. Thus, in comparison with the upstream dam river sector, the specific diversity is increasing, for trichopterans from six to nine and for ephemeropterans from four to five.

IV. The sector downstream Odorhei - the confluence with the Mureş River, which is stretching on a distance of almost 197 km, is the most affected by the anthropogenic impact.

Along this sector, successive and diverse pollutions were noted; the significantly quantitative pollution is the organic pollution due to the domestic, zootechnique, food industry and light industry wastewater. It is remarkable that the majority of the riverine localities have no sewerage systems and filtering stations for wastewater, or them are below the proper dimensions. The most accentuated organic pollution was noted upstream Mediaş ($TM_8$).

The river sector between km 182 and km 187 (four km upstream and three km downstream Copşa Mică) was seriously affected by the pollution with heavy metals, a reason for which the specific diversity and the benthic macroinvertebrates is low.

Upstream Blaj locality ($TM_{11}$), an improvement in the river state was noted, due to the fact that along the Copşa Mică - upstream Blaj sector, no significant pollution sources are present, and the hydrological conditions are favorable for the water self cleaning processes.

Downstream Blaj the river ecological state is worse in comparison with the upstream sector, due to the incorrect filtered inputs of domestic and of food industry wastewater.

As far as the confluence with Mureş, the Târnava River state is improoving significantly.

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

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**KEYWORDS**: fish associations, fish zonation, biotope, human impact, river ecological status, Târnava Mare River, Târnava Mică River, Târnava River .

**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**: Relaţia asociaţii de peşti - calitatea habitatelor, în evaluarea ecologică a râurilor Târnave.

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

Prezenţa şi structura asociaţiilor de peşti au fost analizate în raport cu influenţele antropice (urbane, industriale, hidrotehnice, utilizarea terenurilor) pentru a oferi imaginea calităţii habitatelor ihtiofaunei Târnavelor. Urmărirea componentei ihtiologice ca element al continuumului lotic a permis reliefarea unor concluzii referitoare la variaţia structurii asociaţiilor de peşti în ultimii zeci de ani şi identificarea relaţiilor cauză - efect, ca element informaţional important în construcţia 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.

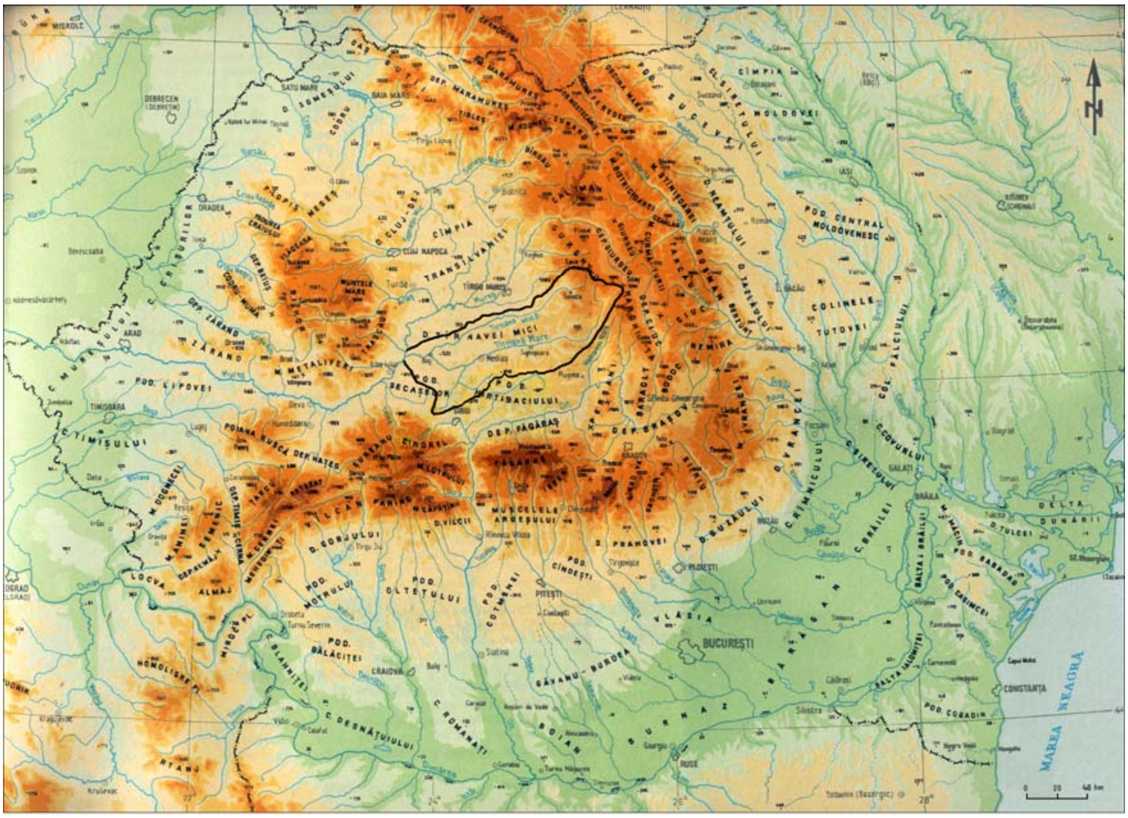


Fig. 1: The Târnava River Watershed study unit location (Badea et al., 1983 - modified).

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 Mihalț 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).

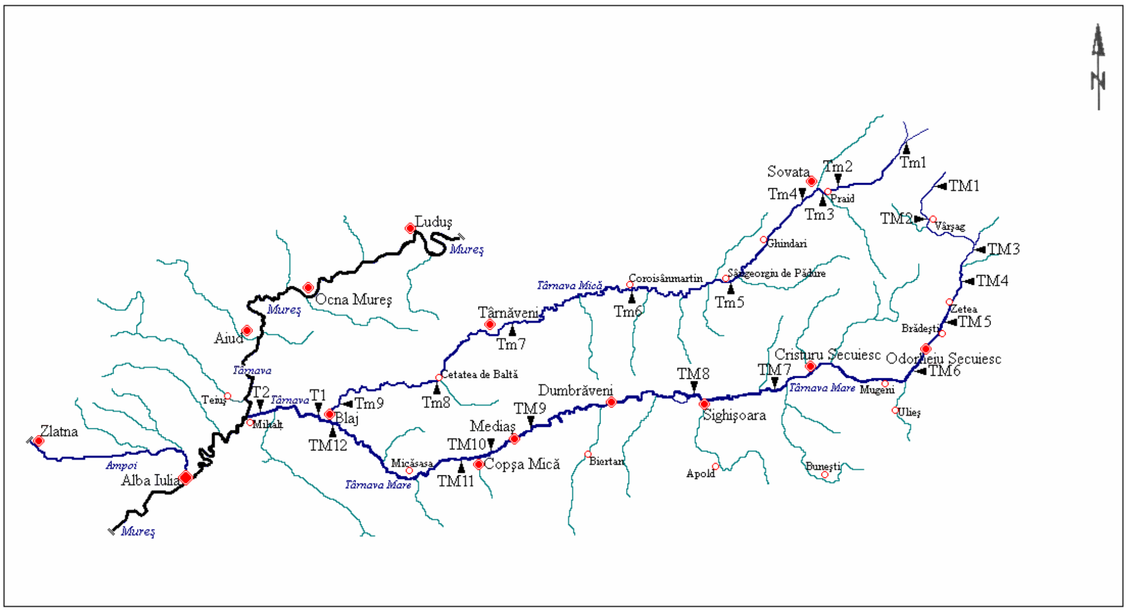


Fig. 2: the quantitative sampling stations on Târnava Mare River (◄ TM),
Târnava Mică River (◄ Tm) and Târnava River (◄ T).

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% |
|---|---|---|---|
| **Tm₁** (confluence with Craca Mică) | *Salmo fario* | 3 | 100 |
| **Tm₂** (1 km upstream Praid) | *Salmo fario* | 9 | 100 |
| **Tm₃** (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 |
| **Tm₄** (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 |
| **Tm₅** (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 |
| **Tm₆** (1 km upstream Coroisânmartin) | *Barbus petenyi* | 4 | 13.79 |
| | *Gobio kessleri* | 14 | 48.29 |
| | *Alburnoides bipunctatus* | 10 | 34.48 |
| | *Orthrias barbatulus* | 1 | 3.44 |
| **Tm₇** (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 |
| **Tm₈** (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% |
|---|---|---|---|
| **TM8** (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 |
| **TM9** (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 |
| **TM10** (1 km downstream Mediaş) | *Barbus petenyi* | 5 | 62.50 |
| | *Gobio gobio* | 1 | 12.50 |
| | *Squalius cephalus* | 2 | 25.00 |
| **TM11** (2 km downstream Copşa Mică) | *Barbus petenyi* | 2 | 100 |
| **TM12** (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 |
| **T1** 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 |
| **T2** 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 **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 **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 **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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# ICHTHYOLOGICAL INVESTIGATIONS IN THE DRAINAGE AREA OF THE MUREŞ RIVER, 1948 - 1997 (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: systematics, zoogeography, Mureş River, Târnava Mare River, Târnava River, Transylvania, Romania.

**ABSTRACT**

The present paper deals the ichthyological results of half a century field investigations on the River Mureş and its tributaries, the most important of which are Târnava Mare and Arieş. A total number of 29 species have been collected, most of which belong to Cyprinidae. These are listed, the rivers, localities and year (or years) of collecting being mentioned. This list will be useful to future researchers, since several species may become extinct. Special remarks deal with the systematic and zoogeographic status of *Barbus petenyi* and on the species of *Gobio, Cobitis* and *Sabanejewia*.

**RÉSUMÉ**: Des Investigations ichtyologiques dans le secteur du drainage de la rivière Mureş, 1948 - 1997.

L'auteur a collecté, pendant un demi-siècle, des poissons d'eau courante, de la rivière Mureş et de ses tributaires, de la parmis eaux la Târnava Mare et l'Arieş, 29 espèces, la majorité étant des Cyprinidés. On en donne la liste, en ajoutant pour chacune les rivières et localités, de même que l'année ou les années quand on l'a trouvé. On fait des mentions concernant la taxonomie et la zoogéographie de *Barbus petenyi* et des espèces de *Gobio, Cobitis* et *Sabanejewia*.

**REZUMAT**: Investigaţii ihtiologice în aria de drenaj a râului Mureş, în perioada 1948 - 1997.

Timp de jumătate de secol am făcut numeroase colectări de peşti din Râul Mureş şi afluenţii săi, între care Târnava Mare şi Arieşul; s-au colectat un număr total de 29 de specii, majoritatea dintre acestea fiind Cyprinidae. În lucrare este prezentată lista speciilor, menţionându-se toate localităţile şi anul sau anii în care speciile au fost găsite. Se fac observaţii privind sistematica şi zoogeografia speciilor *Barbus petenyi* şi a speciilor genurilor *Gobio, Cobitis* şi *Sabanejewia*

## INTRODUCTION

The author worked between 1946 and 1950 at the University from Cluj and, starting with 1948 he collected fishes from the river Mureş and its tributaries Târnava Mare, Arieş, Sebeş, Cugir, Beriu, Strei and Cerna (Hunedoara County). After having moved from Cluj he continued his investigations in the drainage area of the Mureş, extending them to the upper and lower sectors of the river, from Toplița to the Hungarian border and to the tributaries Ampoi, Pian, Dobra, Râul Mare and Răstolnița. One species of lamprey and 28 of bony fishes have been found. Much attention has been paid to the species of the critical genera *Gobio* and *Sabanejewia*.

## MATERIAL AND METHODS

This study is based on the field investigations carried on during almost a half a century. The families are listed in systematic order, genera and species in alphabetical one. Discussions are limited to the species not recorded priorly from the Mureş basin or which raise taxonomic problems. Few data concerning extinctions, numerical decline or, on the contrary survival or range extension of some species are also mentioned. Exclusive standing water inhabitants - *Carassius carassius*, *Leucaspius delineatus*, *Tinca tinca*, *Misgurnus fossilis* are not mentioned.

## RESULTS

One species of lampreys and 28 of bony fishes have been found.

Petromyzonidae

*Eudontomyzon danfordi* Regan, 1911. Found in a tributary of the Strei at Sarmizegetusa in 1948, in the Mureş River at Deda in 1971 and in the river Strei upstream of Baru - Mare in 1989.

Salmonidae

*Salmo trutta* Linnaeus, 1758 (form *fario*). Collected in Mureş River at Răstolița in 1991 and at Deda in 1971, in the Râul Mare at Gura Zlata in 1974 and in the Cugir at Cugir in 1997. The species is widely distributed in the upper sector of the Mureş and of most of its tributaries.

*Thymallus thymallus* (Linnaeus, 1758). Collected only from the river Mureş at Deda in 1971 but more widely distributed.

Cyprinidae

*Alburnoides bipunctatus* (Bloch, 1782). Collected in Mureş River between Stânceni and Reghin in 1957 to 1991; middle Mureş at Târgu - Mureş in 1981 - 1983; between Iernut and Luduş, in 1974 and 1975, Teiuş in 1948; lower Mureş between Păuliş and Nădlac from 1961 to 1997; tributary Niraj at its confluence in 1973; Arieş River from upstream of Câmpeni in 1989 and 1997, from Buru in 1957, Turda in 1948 and 1949, at the confluence with the Mureş in 1949 and 1973; the species became extinct from Câmpeni to the confluence; river Târnava Mare at Odorhei in 1948 and 1958, at Sighişoara in 1949, at Blaj from 1948 to 1971, at the confluence in 1949; confluence with the Mureş of the tributaries Cugir in 1949, Beriu (same year), Pian (in 1997); from the river Strei between Călan and confluence, at Simeria (1949, 1960) and Dobra from upstreams of the village Dobra to its confluence in 1960 and 1993.

*Alburnus alburnus* (Linnaeus, 1758). Collected from the river Mureş in its upper reach at Deda in 1963, in the middle sector, between Cuci and Luduşin 1974 - 1975, from its tributary Târnava Mare at Blaj and its confluence in 1949 and 1960 and from three other tributaries at their confluence: Niraj in 1973, Sebeş in 1949, 1960 and 1971, Strei in 1949.

*Aspius aspius* (Linnaeus, 1758). Collected in the middle stretch of the Mureş at Iernut, Cuci and Luduş in 1974 and 1975.

*Barbus barbus* (Linnaeus, 1758). Collected in the river Mureş between Reghin and Târgu - Mureş between 1956 and 1981, between Iernut and Luduş in 1974 and 1975 and in the lower sector between 1961 and 1997 in the Târnava Mare between Odorhei and the confluence in 1948 to 1971 and from the confluence in the Mureş of the tributaries Niraj in 1973, Arieş in 1957 and 1973 and Sebeş, Beriu and Strei in 1949.

*Barbus peloponnesius petenyi* Heckel, 1947. Collected from the upper reach of the Mureş (Deda to Reghin) between 1958 and 1991, at Iernut in 1974; from the Arieş in the upper reach (upwards of Câmpeni) in 1989 and 1997; at Buru in 1957, at Turda in 1948 - 1949 and at the confluence with the Mureş in 1949 and 1957; from the Târnava Mare between Odorhei and Blaj between 1948 and 1960, from the river Ampoi at Alba - Iulia in 1960, from Strei at Pui in 1948 and at Călan in 1960, from the river Dobra upstreams of the village Dobra in 1962, from the confluence of four tributaries in Transylvania - Sebeş, Cugir and Beriu in 1949, Pian in 1997 (in the last tributary also upstreams, at Pianul de Sus) and finally from the small tributary in the Arad County, western Romania: Valea Ungurului between Slatina de Mureş and Vărădia in 1943, from the Cerna (Hunedoara County) between Sântandruş and Simeria in 1949.

*Chondrostoma nasus* (Linnaeus, 1758). Collected from the upper Mureş at Stânceni and Deda in 1951 and 1961, from the middle Mureş between Iernut and Luduş in 1974 and 1975 from Târnava Mare between Blaj and the confluence in 1948 and 1949, from the Arieş at Turda in 1949 and its confluence in 1949 and 1973 and from Sebeş River at its confluence in 1973.

*Gobio albipinnatus vladykovi* Fang, 1943. The species has not been recorded priorly from the Mureş River basin and from elsewhere in Transylvania, being found for the first time by the author in the river Târnava Mare at Blaj in 1948, later in 1958; also found in the middle sector of the Mureş between Iernut and Luduş in 1974 and 1975 at the confluence of the Arieş and Sebeş with the Mureş in 1973 - here a recent intruder, since it was not present in 1948, 1949 and 1960; and in the lower sector between Păuliş and Nădlac from 1961 to 1997.

*Gobio gobio* (Linnaeus, 1758). There are many old records of this species from the drainage area of the river Mureş. Jaszfalusi (1951) described the population from the upper Mureş River as a distinct subspecies, *Gobio gobio muresia* because it differs from the population inhabiting the river Someşul Mic at Cluj (considered as *Gobio gobio carpathicus* Vladykov) in having a slender body, longer caudal peduncle, pectoral fin and barbels etc. Actually, the characters of *muresia* occur in many other populations inhabiting more rapidly flowing water, like that from the river Someşul Mare, while the populations from more slowly flowing sectors of rivers have the same morphometric characters as the population from the Someşul Mic (typical *carpathicus* sensu Jaszfalusi); other populations are intermediate. There are hence not distinct geographical subspecies, but forms or ecomorphs.

It was once believed that two subspecies are present in the Danube basin: *obtusirostris* in the upper, *carpathicus* in the middle and lower sectors. Both proved later to be synonym and it is presently accepted that one can no more recognize a subspecies in the Danube basin (*obtusirostris*) taxonomically distinct from the western European nominal form.

The species was collected from the upper Mureş between Stânceni and Reghin in 1951 - 1967; from the middle Mureş at Târgu - Mureş, Ungheni and Iernut between 1973 and 1981, from the lower Mureş in 1961 and 1997, from the Arieş between Câmpeni (1999), and its confluence in 1949 (may be extinct downstream Câmpeni) and from tributary Hăşdate (1949); from the Târnava Mare between Odorhei and its confluence (1948 - 1960), from the Pian at Pianu de Sus and its confluence (1997), from Strei at Călan (1960) and at Simeria (1949) and from the confluence of the rivers Beriu, Cugir and Sebeş (1949), Dobra (1993) and Valea Ungurului (1943).

*Gobio kessleri* Dybowski, 1962. This species was found for the first time in the Mureş basin (and in general in Transylvania) by Bănărescu in 1948 in the river Târnava Mare at Blaj; it was collected subsequently from the upper sector of the same river immediately downstream of Odorhei in 1956 and in the lower one near the confluence, having hence a continuous distribution between Odorhei and the confluence. It underwent later a numerical decline, may have become extinct downstream Blaj, but survives upstreams (D. Bănăduc, in verbis). It has been collected in the upper sector of the Mureş between Deda and Reghin in 1957 - 1973, in the middle sector at Ungheni in 1973, between Iernut and Luduş in 1974 and 1975 and in the lower sector at Păuliş in 1961, at Periam in 1959 and at Nădlac in 1997. In the river Arieş it was collected at Buru in 1957 and at the confluence in 1949 and 1957; presently it became extinct from this river. It was also collected from the river Strei at Călan in 1960 and at its confluence (near Simeria) in 1949. Finally it was found at the confluence of the tributaries Niraj in 1973, Beriu in 1949, Sebeş in 1949 and 1960.

*Gobio uranoscopus* (Agassiz, 1828). This species was recorded by Karoli (1877) from the river Strei; it is however possible that this record was based on mis-identified specimens of *Gobio kessleri*. The first sure record of the species from the Mureş basin and in general from Transylvania is that of Bănărescu (1953) who found, in October 1948, numerous specimens in the river Arieş at Turda and also established its habitat: stretches of rivers with stony ground and rapidly running water; in 1949 the species was collected from the same river at its confluence with the Mureş and in 1989 from the upper sector at Câmpeni; the species had then an uninterrupted distribution from Câmpeni to the confluence (119 km), the Arieş being then, alongside the Lăpuş, Timiş, Cerna, Bistriţa Moldovenească and possibly Moldoviţa, one the rivers in Romania in which the species was abundant *Gobio uranoscopus* is now extinct from the Arieş downstream of Câmpeni because of the pollution of the water; it may survive, in small quantities upstream of Câmpeni.

The species was also collected in the upper Mureş, between Deda and Reghin in 1956, in the upper Târnava Mare and Odorhei in 1956, in the upper Târnava Mare at Odorhei in 1956 and in the river Beriu at its confluence; it probably inhabits several other tributaries of the Mureş.

The specimens from the Mureş River basin, like those from whole Romania, belong to the subspecies *Gobio uranoscopus friči* Vladykov, 1925.

The species of the genus *Gobio* are good indicators for ecological zones in the rivers; three successive zones having been identified in rivers e.g. in the Timiş and Someş. (Bănărescu 1964 and 2001); these are characterized by *Gobio uranoscopus*, *Gobio kessleri* and *Gobio albipinnatus*, the fourth species, *Gobio gobio* being present, usually in small number in all three zones, slightly more numerous in the first one; a distinct *Gobio gobio* zone is sometimes present in slowly running, usually muddy sectors of the rivers.

The sector of the Mureş River upstreams of Topliţa, which has no mountainous character, represents the *Gobio gobio* zone; the *Gobio uranoscopus* zone belong the sector Topliţa - downstream of Reghin; it is followed by the *Gobio kessleri* zone while the *Gobio albipinnatus* - zone begins between Deva and Zam but has the tendency to extend upstreams. The upper sector of the river Târnava Mare belongs to the *Gobio uranoscopus* - zone, that extends some distance downstream of Odorhei: to the *Gobio kessleri* zone belongs the longest sector of the river, downstrem to the confluence; *Gobio albipinnatus* is present at Blaj and farther downstream, but in small number. The river Arieş belongs - or belonged before having been polluted - on most of its length to the *Gobio uranoscopus* - zone, only its short lowermost sector could be ascribed to the *G. kessleri* zone.

*Leuciscus leuciscus* (Linnaeus, 1758). A single specimen was collected from the Mureş River at Deda in1962; the species probably became extinct from the Mureş River drainage.

*Phoxinus phoxinus* (Linnaeus, 1758). Collected from the upper sector of the Mureş at Stânceni and Deda in 1951 and 1980; the river Arieş at Câmpeni in 1989 and 1997; the river Sebeş at Lancrăm, near its confluence in 1960; the river Pian at Pianul de Sus and at its confluence in 1997; the river Strei at Pui and Subcetate in 1949 and finally from the brook Valea Ungurului, tributary of the lower Mureş (Arad County) in 1943. The species is widely distributed in the upper sectors of most or even all tributaries and subtributaries of the Mureş.

*Rhodeus sericeus* (Bloch, 1782). Collected in the upper Mureş (Stânceni, Deda Aluniş between 1957 and 1999, at Târgu Mureş during 70's, in the sector Iernut - Luduş in 1974 - 1975, at the confluence with Arieş in 1992 and Târnava Mare at Blaj between 1948 and 1962.

*Rutilus rutilus carpathorossicus* Vladykov, 1930. Collected only from the upper sector of the Mureş at Stânceni and Deda between 1951 and 1991; the species actually is more widely distributed throughout the drainage area of the river.

*Squalius cephalus* (Linnaeus, 1758). Repeatedly collected in the upper Mureş River (sector Topliţa - Stânceni - Deda - Brâncoveneşti - between 1951 and 1991), at Reghin, Târgu - Mureş, Ungheni in 1956 - 1973, between Iernut and Luduş in 1974 and 1975, at Teiuş in 1948 and in the lower sector of the river, between Păuliş and Nădlag during the years 1961 and 1997. It was collected also in the tributary Niraj near its confluence in 1973, in the upper reach of the Arieş at Câmpeni and upwards in 1989 and 1997 and in the lower reach, at Turda in 1948 and 1949, at the confluence with the Mureş in 1949 and 1971. This river being strongly polluted, the species seems to have become extinct from Câmpeni dowstream, almost to its confluence. It was also collected in the tributaries Ampoi at Alba Iulia in 1960 and in Târnava Mare between Odorhei and the confluence between 1948 and 1973. The species was finally collected in the lower stretches of the seven south - western tributaries of the Mureş, Sebeş, Pian, Cugir, Beriu, Strei, Cerna (Hunedoara County) and Dobra, in the years 1949 and 1992, in the Strei also far upstream from the confluence in 1949 and 1960.

*Vimba vimba* (Linnaeus, 1758). Is a rather recent intruder in the Mureş area and in other rivers of Transylvania and of eastern and southern Romania; it has not been recorded in the three classical monographs of the fish fauna of Transylvania (Bielz, 1853, 1856, 1888); Vutskits (1913) records it from the Tisa River but not from its eastern tributaries (Someş, Mureş, etc) while Antipa (1909) asserts that it is present in the lower Danube in southern and eastern Romania without ascending the tributary rivers. The species is distributed in present in the eastern tributaries of Tisa (Someş, Mureş, Criş) and in several tributaries of the Danube in southern and especially in eastern Romania. In the Mureş river it has been found for the first time by Nalbant at Târgu - Mureş in 1950 (personal information) the author collected it at Reghin in 1960, at Târgu - Mureş in 1981 and 1982, between Iernut and Luduş in 1974 and 1975 and in the tributary Sebeş at its confluence in 1975 (but not in 1949 when he collected fishes in the same locality).

Nemacheilidae

*Orthrias barbatulus* (Linnaeus, 1758)

Collected in the upper Mureş between Stânceni and Deda during 1951 to 1991 and at Reghin in 1956; from the tributary Arieş at Câmpeni in 1889 and 1997 and at Turda in 1948, from the Târnava Mare at Odorhei in 1948, 1956, 1961; from the south - western tributaries Sebeş, Beriu, Cugir at their confluence in 1949; Pian and Pianul de Sus and at its confluence in 1997; the Strei, at Pui, Călan and at its confluence in 1949 and 1960 and finally the westernmost southern tributary the river Dobra upstreams of the village Dobra in 1960 and 1993.

Cobitidae

*Cobitis vardarensis danubialis* Băcescu, in Nalbant, 1993. The common spiny loach from the Danube river basin and from the neighboring rivers, listed until recently as Cobitis taenia proved to be distinct from the western European *C. taenia*. Its valid name is controversial: either *C. elongatoides* Băcescu and Maier, 1969 according to Kottelat (1997) or *C. danubialis* Băcescu according to Nalbant (1993). Because its strong similarity with *C. vardarensis* from Vardar River, I consider it a subspecies of the later. It has been collected only from few localities in the Mureş basin: the river Mureş at Târgu - Mureş in 1981, the Târnava at its confluence with the Mureş - near the village Mihalț and the Arieş at its confluence with the Mureş - downstream the village Grigoreşti, in 1949 and 1973.

*Sabanejewia aurata* (Filippi, 1863) The *S. aurata* populations from the upper Mureş have been ascribed by Jaszfalusi (1951) to a distinct taxon, „*Cobitis aurata balcanica* natio *radnensis*. This „natio" was raised by Bănărescu et al. (1980) to subspecific rank, while the populations from the upper part of the lower Mureş are ascribed by most authors to the subspecies *S. aurata balcanica* being almost but not fully identical to the balcanica populations from the other tributaries of the Tisa (Someş, Criş) and from the upper part of the middle Mureş are, considered intergrades between *radnensis* and *balcanica* (Bănărescu et al. 1972).

There are differences between the presumed balcanica populations from the middle and lower Mureş sectors and the true balcanica ones from the other western Romanian rivers: in the lower sectors of the latter rivers a gradual intergradation between the subspecies balcanica and bulgarica takes place, the specimens from the Someş River at the Romanian - Hungarian border and thous from Timiş River at the Romanian - Yugoslavian border are almost pure *S. aurata bulgarica*. No such intergradation occurs in Mureş River all populations from the middle and lower sectors of this rivers up to its confluence with the Tisa River, are identical with no traces of intergradation, with *S. a. bulgarica*. Specimens of *bulgarica* ascend from the Tisa in the lowermost sector of the Mureş River, occurring sympatrically with the presumed balcanica species, without any hybridization or intergradation. This means the population from the middle and lower Mureş are, genetically closer to *radnensis* than to *balcanica*.

Typical *Sabanejewia aurata radnensis* have been collected from the upper sector of the Mureş River at Stânceni, Răstolnița, Gălăoaia, Deda, Brâncoveneşti and Reghin between 1956 and 1991; intermediate specimens (morphologically closer to *balcanica*, genetically to *radnensis*) at Târgu Mureş in 1981, at Ungheni, Iernut and Luduş in 1973 - 1975 at Teiuş in 1948, at Deva in 1957 and in the lower sector of the Mureş at Păuliş in 1979, at Periam in 1953 and 1961, at Nădlac in 1997; T. Nalbant collected them also at Makó in Hungary in 1991.

Intermediate specimens were also collected from the following tributaries of the Mureş River. Arieş River: upstreams from Câmpeni, 1989 and 1997; from Turda, 1949; confluence with the Mureş, 1949 and 1973. Târnava Mare River: Odorhei, 1956, 1961; Blaj, 1948, 1958 - specimens from this locality are characterized by very small lateral spots; confluence with the Mureş, 1949. The rivers Sebeş, Beriu, Cugir at their confluence with the Mureş, in 1949; in the Sebeş also in 1960. The river Strei at Călan, 1960, at its confluence, 1949. The river Cerna (Hunedoara County) upstreams of the town Hunedoara, 1949. The river Pian at its confluence, 1997. The river Dobra, a short distance from the village Dobra, 1993.

*Sabanejewia romanica* (Băcescu, 1943). This species was initially described, as *Cobitis caspia romanica* from rivers flowing southwards into the Danube: tributaries of the Jiu, Olt, (also in Transylvania) and Argeş. In 1945 it was collected also from the Strei, a tributary of the Mureş (Băcescu, 1947). Since the species was absent from other tributaries (Arieş, Târnava), the author of this contribution made in August 1949, a collecting trip on five south western tributaries of the Mureş and found the species in all five rivers: in Sebeş, Cugir and Beriu near their confluence, in Strei also further upstream, at Pui and in the Cerna (Hunedoara County) a short distance upstream the town of Hunedoara.

In 1993 samplings were made also in another southwestern tributary, the Dobra, about seven km upstreams its confluence, while in 1997 it was establish that this is absent from the seventh south - western tributary of the Mureş: the Pian River. Hence this species inhabits six of the seven south - western tributaries of the Mureş. In two of them it is restricted to the lowermost sector (Cugir and Beriu; in the latter river it survives, having also been found by T. Nalbant in 1999; in the Cugir it became extinct). In the Strei, quite probably also in the Sebeş, Cerna (Hunedoara County) and Dobra it occurs also far upstreams, in the trout zone. In five of these rivers it is present as far downstream as their confluence; in the Dobra it is absent from the lowermost sector.

Siluridae

*Silurus glanis* Linnaeus, 1758. Collected only in the river Târnava at its confluence with the Mureş in 1949.

Gadidae

*Lota lota* (Linnaeus, 1758). Collected in the river Mureş at Stânceni in 1971. The Mureş is alongside the Olt (upper sector), the Bega and the Dorna one of the few Romanian rivers in which this species is not very rare.

Cottidae

*Cottus gobio* (Linnaeus, 1758). Collected in the upper Mureş, at Stânceni, Răstolniţa, Gălăoaia, Deda, Aluniş and Brâncoveneşti between 1957 and 1991, in the brooks Tihu, Mijlocu and Secu, tributaries of the river Răstolniţa. The species was found also in the river Arieş upstreams of Câmpeni in 1989 and 1999 in the Târnava Mare upstream Odorhei in 1957, 1958, 1961 and in Râul Mare, tributary of the Strei at Gura Zlata, in 1974 and at Greben in 1992.

Percidae

*Zingel streber* (Siebold, 1863). A rather great number of specimens have been collected in the river Mureş at Reghin, in 1956 and 1960, one in Arieş at its confluence with the Mureş in 1949 and one in the Târnava Mare at Blaj in 1960; the latter specimen was probably an occasional intruder from the Mureş.

*Zingel zingel* (Linnaeus, 1758)

Collected from the lower sector of the river Mureş at Periam in 1949 and from the river Târnava Mare at Blaj in 1962 (in this locality a single juvenile specimen, probably a occasional intruder from the Mureş). The species has a wide distribution in the middle and lower sectors of the river Mureş, but is everywhere rare.

Additional remark. Bielz (1888) mentions the occurrence of *Abramis ballerus* in the Transylvanian sector of the Mureş River. More recent authors have not recorded the species from that river; it was therefore suggested (Bănărescu, 1964) that it became extinct from the Transylvanian sector of the river. However, Nalbant (in verbis) found it in 1991 River at Deva in the Mureş River.

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# THE BREEDING MIGRATION AND POPULATION CARACTERISTICS OF A COMMON TOAD (*BUFO BUFO*, LINNAEUS 1758) POPULATION VISITING A SEMINATURAL POND IN SIGHIŞOARA

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**KEYWORDS**: *Bufo bufo*, breeding migration, sex ratio, sexual selection, Târnava Mare River Watershed, Romania.

**ABSTRACT**

We studied the breeding migration of a common toad population in Târnava Valley near Sighişoara in 2001 and 2002. The duration and intensity of the migration is highly influenced by air temperature and precipitation. No terrestrial movement was observed under 5 °C. The sex ratio is male biased in both years, but in 2002 the relative number of migrating females tends to be larger in daylight. The pairs were formed randomly, we found no correlation between the SVL of amplectant males and females. There is no significant difference between the average SVL of paired and unpaired males. There is no significant correlation between the SVL of males and the distance from the pond from which they migrate.

**ZUSSAMEFASSUNG**: Frühlingsmigration und die Merkmale einer Erdkrötenbevölkerung die sich in einem halbnatürlichen Teich in Schassburg reproduziert.

Zwischen den Jahren 2001 und 2002 haben wir die Frühlingswanderung der Erdkröte bei Schassburg (Kokeltal) studiert. Die Dauer und die Intensität der Migration waren von der Temperatur und den Niederschlägen signifikant beeinflusst. Wir haben keine Wanderungen unterhalb 5 °C beobachtet. Der Anteil der wandernden Männchen war während des Tages in beiden Jahren größer, aber 2002 schien der Anteil der wandernden Weibchen tagsüber zuzunehmen. Es gibt keine Korrelation im Amplex zwischen dem Anteil der Männchen und dem der Weibchen. Der Mittelwert (SVL) der Männchen im Amplex unterscheidet sich nicht bemerkenswert von dem der einsamen Männchen. Es gibt keine signifikante Korrelation zwischen dem Anteil der Männchen und der Distanz zwischen Migrationsort und Reproduktionsort.

**REZUMAT**: Migrația de primăvară şi caracteristicile populaționale ale unei populații de broască râioasă brună (*Bufo bufo*) care se reproduce într-o baltă seminaturală în Sighişoara.

În 2001 şi 2002 am studiat migrația de primăvară a broaştei râioase brune lângă Sighişoara, Valea Târnavei Mari. Durata şi intensitatea migrării a fost influențată semnificativ de variațiile de temperatură şi precipitații. Nu am observat mişcare terestră sub 5 ºC. Rata pe sexe este balansată în favoarea masculilor, dar numărul femelelor relativ la acela al masculilor este mai mare ziua (2001). Nu există corelație între dimensiunea masculilor şi acea a femelelor în amplex. Dimensiunea medie (SVL) a masculilor în amplex nu diferă semnificativ de aceea a masculilor solitari. Nu există corelație semnificativă între dimensiunea masculilor şi distanța de la care migrează spre locul de reproducere.

## INTRODUCTION

For the majority of the temperate amphibians, the important habitat resources are separated in space and time. The annual activity of adults is characterized by periodical migrations from one habitat to another (Sinsch, 1988). During the breeding migration, the amphibians left the hibernation places and then migrated towards the breeding pond. Considering the intensity of the breeding period and the behaviour of the reproductive males and females during the breeding Wells (1977) distinguished two breeding systems in anurans: explosive breeding and prolonged breeding. In Europe, the explosive breeding system is represented tipically by the common toad (*Bufo bufo*). The start and duration of the breeding migration is influenced by several environmental factors, like winter temperature (Reading, 1998) or the climatic conditions during the breeding migration (Wisniewsky et al., 1980). During the breeding migration, the amphibians use a variety of cues (e.g. acoustic, magnetic, mechanical, olfactory and visual) for orientation (for a review see Sinsch, 1991). In most amphibian species the sex ratio between the breeding males and females is male-biased. This results in an intense competition between males for females (Halliday, 1998).

In this study we present the breeding migration of a population of common toad (*B.bufo*), in the Târnava Mare Valley. The aims of this study are: (i) to gather informations about the beginning and intensity of the breeding migration and its influencing climatic factors, and (ii) to find if there is a sexual selection, by comparing the sizes (SVL) of the amplectant adults with those that are not in amplex.

## MATERIAL AND METHODS

This study was conducted near Sighişoara (46º13’47.8’’N; 24º46’47.6’’E; 349 m elevation), Târnava Mare Valley. The study area has approximately 5 ha, and the pond has a 2.23 ha surface area. The study site is situated on the right side of the Târnava Mare river at approximately 100 m distance from this (Fig. 1). In the vicinity of the pond (on right side) at a distance of about 400 - 600 m there is a deciduous forest (Fig. 1).

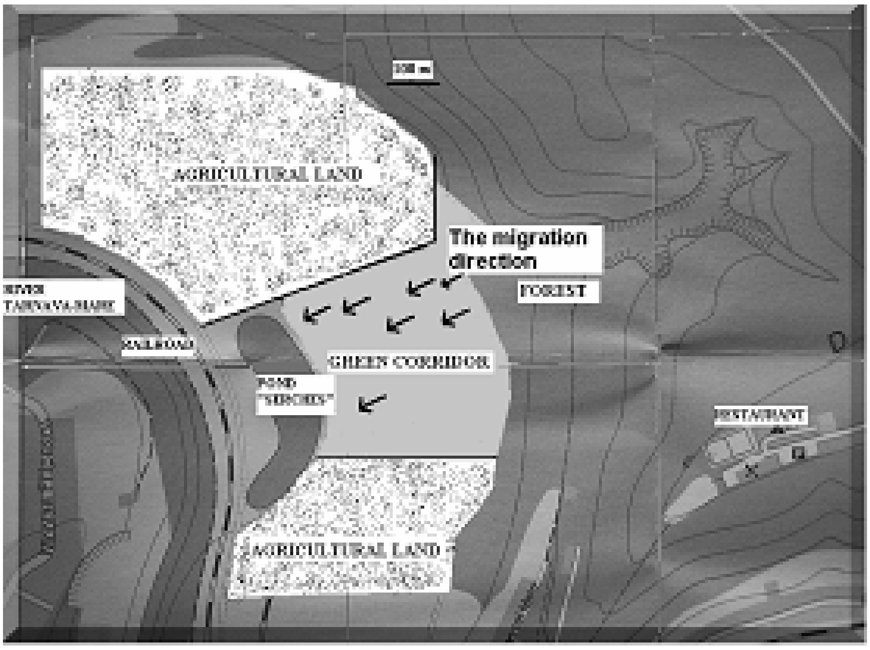


Fig. 1: The map of the study area.

In 2001 the toads were counted in the night hours, over 19 days in eight plots between the pond and the forest. The surface of each plot was 300 m² (three m width and 100 m long).

In 2002, the migrating toads were counted both by day (between 16-18 hours, a 20 day interval) and at night (32 day interval), each day for one or two hours in both periods in a standardized route. All these observations were made by two persons at each time.

We measured the snout - vent length (SVL) of individuals with a precission of 0.1 mm. The sampled toads were weighed to the nearest 0.05 g. The air temperature at ground level was measured, and the presence or absence of wind (blowing from NW) and precipitation was recorded.

The effect of temperature on the intensity of breeding migration, the size relationships of the amplectant pairs and the correlation between the terrestrial activity of the two sexes was studied using Pearson product-moment correlation. The average size (SVL) of the males and females was compared using t test (after the normal distribution of the data was tested using Kolmogorov-Smirnov test). The significance level is 0.05.

**RESULTS**

**The effect of environmental conditions on the breeding migration**

In 2001 the breeding migration lasted for 19 days (Fig. 2). The average air temperature during the migration in 2001 was 8.6ºC (range 1ºC to 16ºC). It has been raining three times (Fig. 2). In 2002 the migration was prolonged relative to 2001: the migration lasted 36 days (Fig. 3 and 4). In the night hours, the temperatures varied between -2ºC and 19ºC (Fig. 3) with an average of 8.17ºC. In the afternoon hours the average value of the air temperature was 10.81ºC (range 2.5 ºC to 19ºC, Fig. 4). Precipitation (rain, snow) fell seven times.

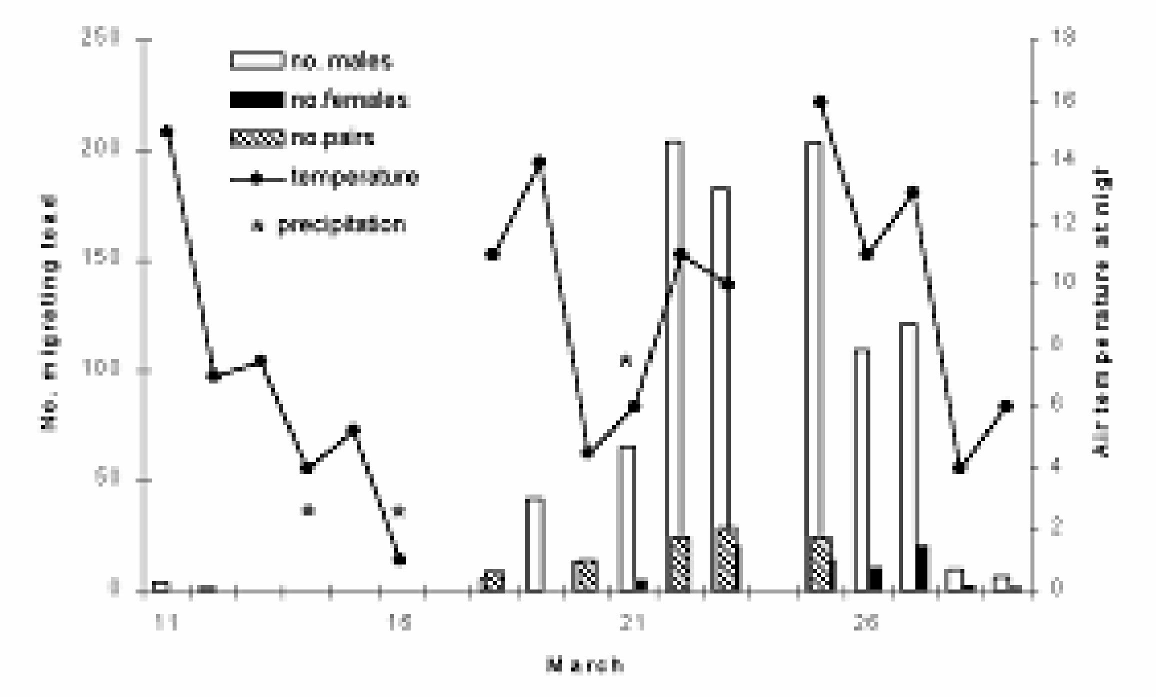


Fig. 2: The duration and intensity of the breeding migration in 2001, night hours.

In 2001 we found toad activity in 14 days (= 73.6%), the low temperature impeded the toad movement in other days (Fig. 2). The males migrated in 13 nights (= 68.4%) and the females in 12 days (= 63.1%). The males outnumbered females during the breeding migration. The average sex ratio was 13 males to one female. A large number of females emigrated from pond towards the forest (data not shown). This indicates that the females stay only for a short period in the water, and leave immediately after the egg deposition. These females were single, and almost no attempt of males to clasp them was observed. Pairs were found in five days (Fig. 2).

In 2002 the toads migration was studied both in the afternoon and in the night hours (Fig. 3 and 4). In the night hours the toads were active in 19 days (=52.7%). The males were active 100% of the days in which we registered toad activity (Fig. 3). By daylight we found toad activity in nine days (= 45%). The sex ratio was male-biased both in the afternoon hours and in the night hours, but by daylight the sex ratio was smaller because of the smaller number of males. The sex ratio by daylight was 2.6:1 and in the night hours 14.7:1. There is a significant positive correlation between the terrestrial activity of males and females in both years (Pearson r, p<0.02).

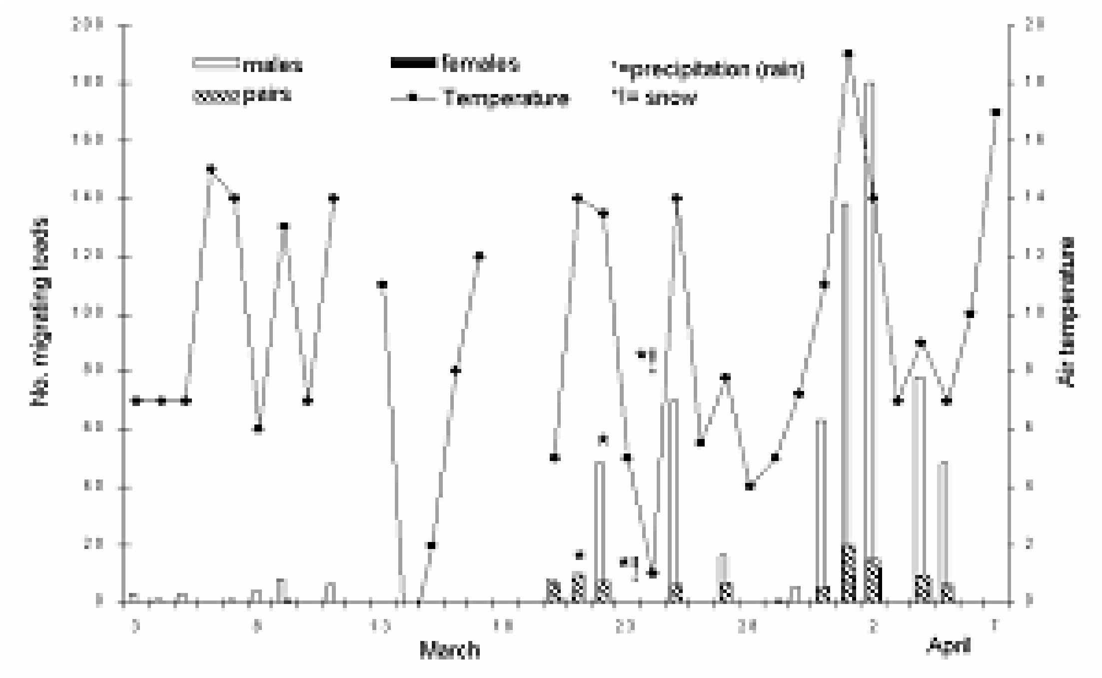


Fig. 3: The intensity and duration of the breeding migration in 2002, night hours.

There is a significant positive correlation between the number of active adults (males and females) and the air temperature (Pearson r, p<0.05 for both 2001 and 2002). There are clear differences between the day and night activity of males, the major peak of their activity being at night. In the case of females the differences are not obvious (Fig. 3 and 4). The average number of migrating males in 2002 is higher in the night than in the afternoon (23.2 *vs* 14.5). The females tend to migrate in a larger number in the afternoon hours than in the night hours (average 5.9 *vs* 3.8). In both years the majority of toads were active at higher air temperatures: in 2001 between 21 - 27 March and in 2002 between 31 March and 5 April. The number of nights with substantial toad movement is constant in both years: five days in 2001, (Fig. 2) and five days in 2002 (Fig. 3). The minimum air temperature at which we recorded toad activity at dusk was 5.5 ºC in 2001 and 6.6 ºC in 2002 for males and 4.8 ºC in 2001 and 9.33 ºC in 2002 for females. The average air temperature in which the males were active was 9.87 ºC in 2001 and 10.45 ºC in 2002. For females the recorded average air temperature was 9.56 ºC in 2001 and 11.02 ºC in 2002 during the night.

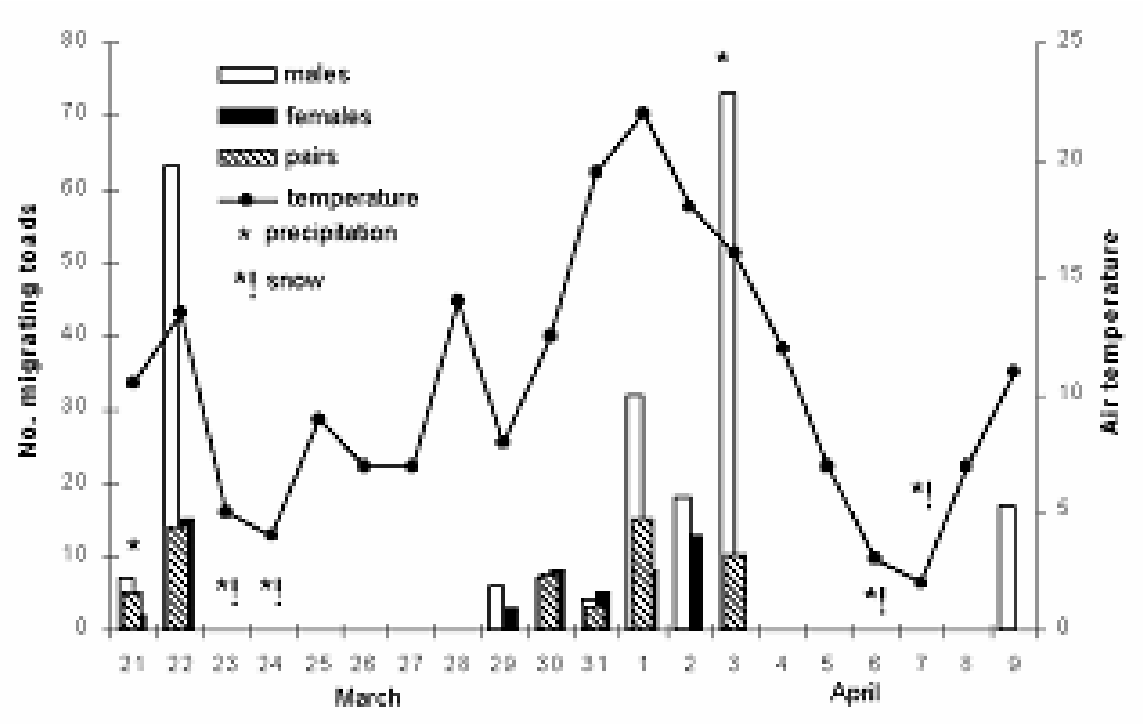


Fig. 4: The breeding migration
by daylight, 2002.

No active toads were found when the air temperature was under 5 ºC temperature in 2002. The males number in 2002 was higher in windy weather than in calm weather, although the temperatures were lower. At night, because of the cold wind, with an average of 7 ºC, most of the males were inactive. This temperature value is close to the minimal threshold temperature which hampers the male toad`s activity. The wind blowing from the pond, increased toad activity (Sinsch, 1987). The females average number decreased when the wind was associated with low temperature. The average air temperature was higher when toad movement occurred than in other days.

Most of the migrating individuals were found in a 150 ms distance from the pond (Fig. 5), in 2001 and 2002. We found some individuals in distances up to 450 ms, in the near forest. In these distances the females migrated single, pairs were formed at about 150 ms or closer to the pond where the number of males is higher. However all the females entering the pond were paired. We identified some hibernating places at about 80 - 150 ms from the studied pond. This fact may be a reason why a large number of toads individuals migrated from this distance.

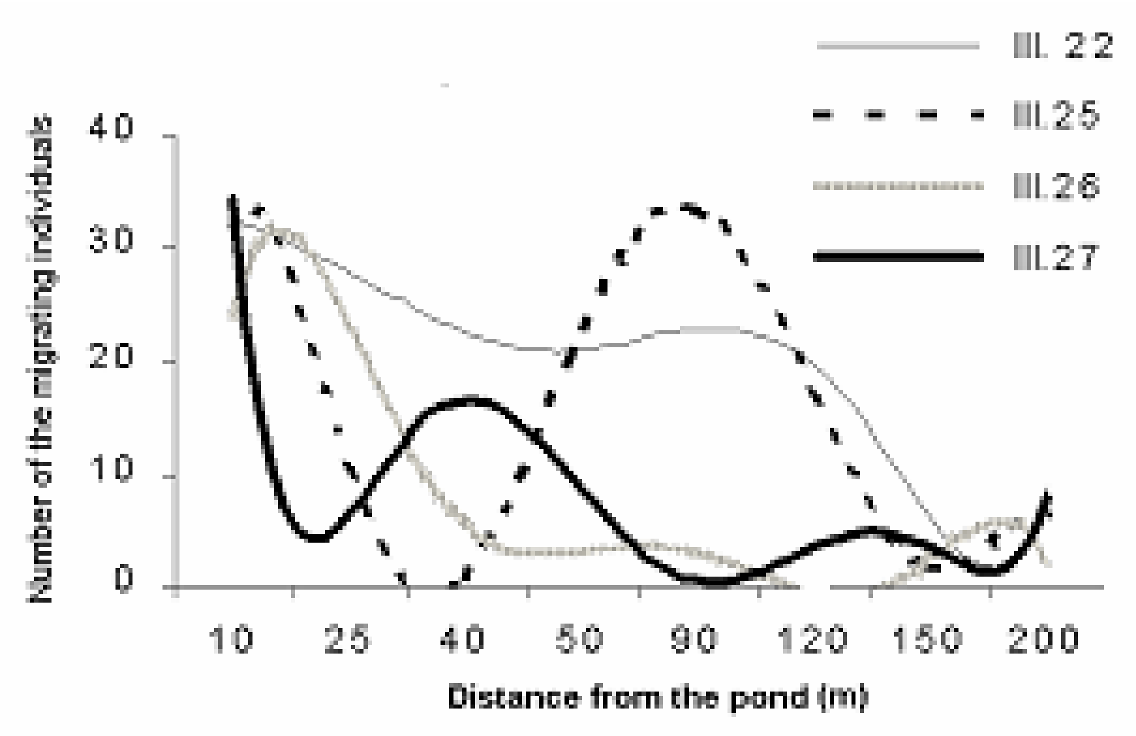


Fig. 5: The intensity of the toads migration at different distances and days, 2001.

The pasture between the pond and the forest is the main migration route for toads. The average number of migrating adults was larger in the pasture than in the arable areas (Fig. 6).

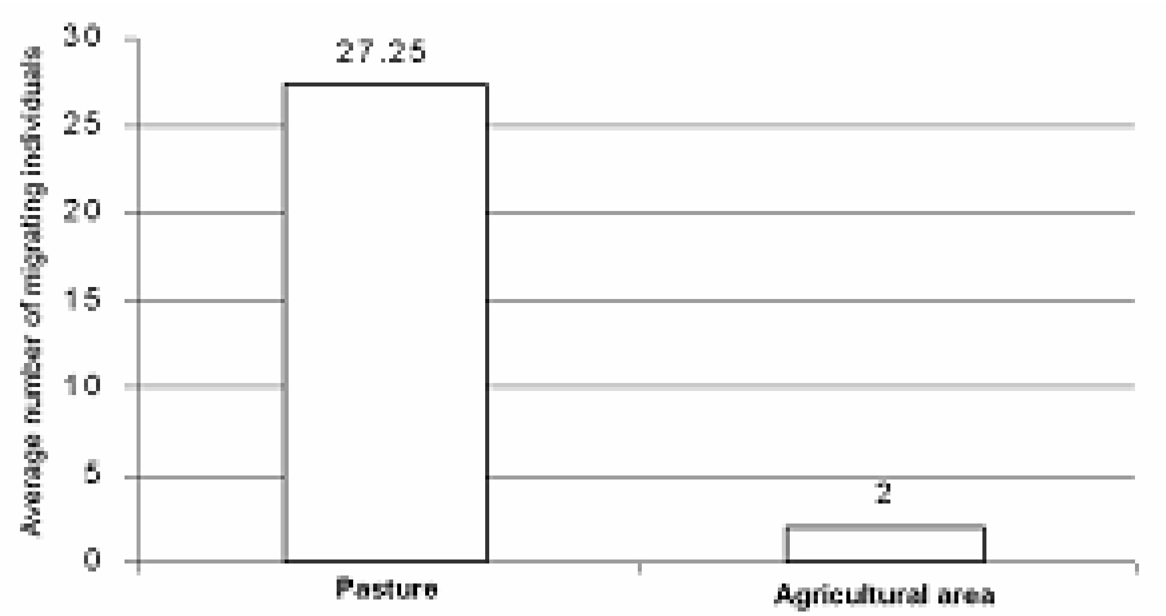


Fig. 6: The average number of migrating toads found in the pasture between the forest and the pond, and the arable area between 10-25 m distances from the pond (2001).

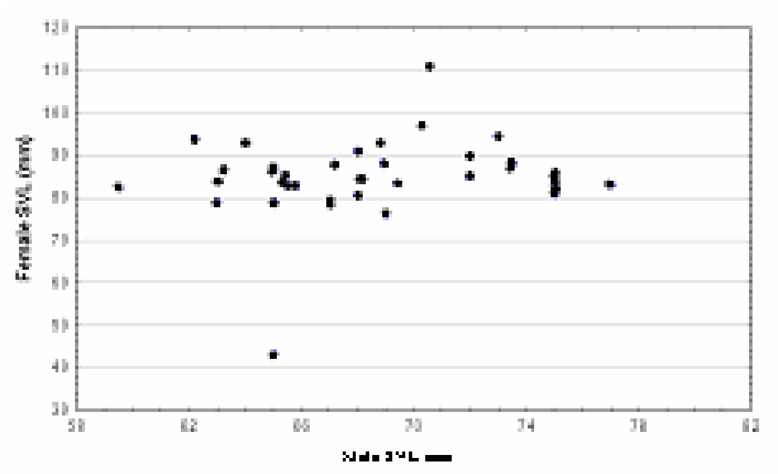


Fig. 7: The relationship between the body length
of the amplectant toads.

In the days with intense toads activity, their density on land was on average 0.16 toads/m² in 10 m distance from the pond. In the more distant points the average number of breeding toads was lower: 0.055 toads/m² (in 150 m distance from the pond). We never found significant toad migration from the Târnava River (only 3 males in 2001). The temporary ponds of the deciduous forest near the pond have never been used for reproduction (Hartel, *unpublished data*).

**The body length and weight of males and females individuals in the breeding population**

The mean SVL of male toads was 68.65 mm (n = 164, range 53.8 - 82.) in 2001 and 68.05 (n = 134, range 55.6 - 84.2 mm) in 2002. The mean body weight of males in 2002 is 31.8 g (n = 25). The mean SVL of females has an average value of 94.57 mm (n = 71, range 70.12 - 114.8 mm) in 2001 and 86.10 mm (n = 54, range 70.10 - 113.4 mm) in 2002. The mean female body weight before breeding in 2002 was 88.53g (n = 30). We didn't find differences between SVL of males in 2001 and 2002 (t = 0.42, df = 296, p = 0.64). The females were shorter in 2002 than in 2001 (t = 2.92, df = 123, p = 0.04). The SVL of paired and unpaired males did not differ in two years (t = 0.31, df = 72, p = 0.7 in 2001 and t = 0.84, df = 124, p = 0.38 in 2002). We found no correlation between the body length of males and that of the females found in amplexus (r = 0.14, p>0.05, n = 35, Fig. 7). There was found no correlation between the body length of toads males and the distance from the pond during the breeding migration in 2002 (22$^{nd}$ of March: r = -0.16, n = 13, p>0.05; 1$^{st}$ of April: r = -0.38, n = 12, p>0.05; 3$^{rd}$ of April: r = 0.14, n = 39, p>0.05).

## DISCUSSION

### The breeding migration, sex ratio and environmental conditions

The activity of most amphibians is highly correlated with the environmental conditions (ex. the temperature, Kusano and Fukuyama, 1989). Air temperature has a strong influence on the starting (Reading, 1998) and intensity (Kusano and Fukuyama, 1989) of the toads breeding migration. Amphibians are more sensitive to temperature in the prespawning period than in the postspawning period (Wisniewsky et al., 1980). The toads males are active in lower temperature conditions than females in more amphibian species (Douglas, 1979; Wisniewsky et al., 1980).

The activity pattern of anurans is reported to be generally crepuscular or nocturnal (Pechmann and Semlitsch, 1985, Duellmann and Trueb, 1986). The main selective forces favoring amphibian nocturnal activity may be the avoidance of desiccation and predators (Pechmann and Semlitsch, 1985). This behaviour pattern may be modified periodically for a while by the alterations of climatic conditions (Sinsch, 1988). This study presents evidences that females are more active during daylight than at night hours, whereas the majority of the males are active at night. Two reasons can cause such a difference: the more favorable climatic conditions during the day and the avoidance of the high density of males (see below).

The minimal threshold air temperature in which the number of active toads on land is low, seems to be specific for populations and species. In the case of *Bufo bufo* species, the minimal threshold air temperature may be 0 ºC (Sinsch, 1988), 1ºC (Puky et al., 1990), 3,3 ºC (Wisniewsky et al., 1980), 4ºC (Gittins et al., 1980), 6 ºC (Reading, 1998) in different populations. In our study we found no aquatic or terrestrial movement when the temperature was below 5 ºC.

We found little toad activity in cold wind. The wind associated with higher air temperature and humidity (Dem and Hartel, 1999) offers favorable conditions for migrating toads. The locomotory activity can be influenced by a variety of environmental conditions, e.g. temperature, rainfall, air humidity, atmospheric pressure and moon phases, but as Sinsch (1988) and Fukuyama and Kusano (1992) suggested, these factors should be studied over several years, and multiple regression analysis can be helpful in elucidating the relationship between weather conditions and migratory and breeding activity (Semlitsch et al., 1996).

The pairs were formed in the close vicinity of the breeding pond (<150 m) where the number and density of males is high. In a previous study Dem and Hartel (1999) find that a great number of females can migrate unpaired because of low density of individuals.

In our studied population, the males outnumbered females at the breeding site similar to other *Bufo bufo* populations (Davies and Halliday, 1979; Gittins et al., 1980). Reading (1991) assumed that the sex ratio after metamorphosis is equal, and it may be distorted by environmental factors such as temperature. The sex ratio may be male-biased for few reasons: (i) Males breed yearly but the females do not, because the eggs are energetically more costly to produce than sperm (Reading, 1988). (ii) The males reach maturity in 2 - 3 years but the females in 4. The males and females may have a minimal body length in which they reach sexual maturity, and the males reach maturity in shorter body size than females (Reading, 1991). However the body size which sexual maturity is reached is not fixed and could vary between populations (Reading, 1988). (iii) The males reach earlier and spend more time in the breeding pond than females (Davies and Halliday, 1979; Gittins et al., 1980; Loman and Madsen, 1986). The reproductive females number in the breeding site decreased in time, since the females left the pond after breeding (in 1 - 3 hours, Hartel, *personal observations*.). It was observed that one male can fertilize more females (Hartel, *personal observations*.). (iv) The smaller number of females can be caused by winter mortality (Kuhn, 1994).

The result of the male-biased sex ratio is an intense male - male competition for females (Davies and Halliday, 1979; Halliday, 1994; 1998). The pairs are permanently attacked by single males. Davies and Halliday (1979) found that the largest males are stronger and this can result that these males have best opportunity to obtain females by takeovers. In our study the SVL of paired and unpaired males did not differ significantly. We found no significant correlation between the body length of paired males and females. We conclude that in this population the pairs were formed randomly. Similar result, were found by Loman and Madsen (1986) in a Sweedish *Bufo bufo* population. The correlation between amplectant adults SVL was positive and significant in English populations (Gittins et al. 1980; Reading and Clarke 1983). This difference is explained by that the females stay a short period in the water in the Sweedish population, and for a longer period in the populations from England (Loman and Madsen 1986). It is not known, whether the density of the males influences or not the behaviour of females. It is known that in explosive breeders (*sensu* Wells 1977) such as the common toad the males actively search for mates. The active searching is usually accompanied by intense competition among males for the possession of females. If several males clasp a single female in order to dislodge the male most securely fixed at female`s back, the female could be seriously injured and even killed. This behaviour of males negatively affects the number of the deposited eggs (Halliday, 1998). Considering this it would be interesting to study the behaviour of the females in different densities of males.

Due to strong instinct to clasp females, the male common toads could pair with females, which belong to other species. We found in 2001 males common toads pairing with specimens belonging to *Rana ridibunda* complex. We never found interspecific spawning between *Bufo bufo* and *Rana temporaria*, as Reading (1984) found.

The toads in this population are larger than in Wales (England) (Gittins et al. 1980) but the male body length is close to the values found by Passenheim et al. (2001) in Braken (Germany). The female body length in our population is larger than the female body length in Braken.

More toads males migrate in the relatively undisturbed pasture than in the arable land. The terrestrial areas around the pond (Fig. 1) are used for agriculture. The pasture is only occasionally used, but in the arable areas the land use is intensive, chemical fertilizers being used, that have negative effects on amphibians (Oldham et al. 1997; Oldham 1999). The spatial distribution (i.e. numerous toads in the pasture *vs* less number in the arable area) could be explained by the land use patterns. A study of the egg mass distribution of *Rana dalmatina* in a pond shows a constant spatial distribution that could be understood by the terrestrial habitat quality around the breeding pond (Hartel *unpublished data*). Considering these, it is important to identify and protect those terrestrial habitats that serve as migration culoars for amphibians, to protect this group of vertebrates. Our observations show that the pasture between the pond and the forest represent a migration culoar for amphibians, and it should be protected from changes (conversion on arable land, buildings, etc.).

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# DISTRIBUTION, POPULATION SIZE AND DYNAMICS OF THE WHITE STORK (*CICONIA CICONIA* LINNAEUS, 1758) IN THE TÂRNAVA RIVERS BASIN (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: white stork, Târnave rivers basin, distribution, population size, breeding success, nest site selection, population trends.

**ABSTRACT**

Based on the results of the censuses carried out in 2003 and 2004, the total White stork population of the Târnave Rivers Basin is 105 HPa distributed in 94 localities. The total population of the region can be estimated to approx. 130 HPa. The mean population density (StD) for the whole area was only 1.68 HPa/100 km$^2$. Most common nest sites are electric pylons (60.16 %), chimneys (20.33 %) and churches (8.47 %). The mean JZa and JZm values for the region were above 2.0 and 2.5, values which are higher than the estimated Jza and JZm values needed to keep the population stable. In comparison to the last survey in 1974, the 2003-2004 surveys shows a 58.83 % HPa decrease in the Târnave River Basin.

**ZUSAMMENFASSUNG**: Verbreitung, Populationsgröße und Populationsdynamik des Weißstorches (*Ciconia ciconia* L.) im Flusstal der Târnava (Rumänien).

Basierend auf Vogelzählungen, die in den Jahren 2003 und 2004 durchgeführt wurden, lag der Bestand an Weißstörchen im Flusstal der Târnava bei 105 HPa an 94 Fundorten. Die Gesamtpopulation der Region kann auf 130 HPa geschätzt werden. Die mittlere Dichte (StD) für das gesamte Gebiet betrug nur 1,68 HPa/100 km$^2$. Die bevorzugten Nistplätze waren Strommasten (60,16 %), Schornsteine (20,33 %) und Kirchen (8,47 %). Die Durchschnittswerte von JZa and JZm lagen in dieser Region über 2,0 und 2,5, Werte die höher sind als die geschätzten Werte JZa und JZm, die für den Erhalt einer stabilen Population notwendig sind. Im Vergleich zu Beobachtungen aus dem Jahr 1974 zeigen die Daten aus 2003-2004 eine Abnahme von 58,83 % HPa im Flussgebiet der Târnave.

**REZUMAT**: Distribuţia, mărimea populaţiei şi dinamica berzei albe în bazinul râurilor Târnave.

În urma recensămintelor din 2003 şi 2004 am identificat 105 perechi de berze albe în 94 de localităţi din bazinul Târnavelor. Populaţia totală a teritoriului poate fi estimată la aproximativ 130 de perechi de berze albe. Densitatea medie a perechilor (StD) a fost de numai 1,68 HPa/100 km$^2$. Valoriile medii ai parametrilor JZa şi JZm au fost mai mari decât 2,0 şi 2,5 (valori minime considerate ca necesare pentru menţinerea unei populaţii stabile). Între 1974-2004, în bazinul Târnavelor, numărul perechilor clocitoare a scăzut cu 58.83 %.

## INTRODUCTION

With the exception of high mountainous regions and the forested areas, the white stork is distributed over the entire territory of Romania, and the total number of breeding pairs was estimated by the last national census (realized in 1999) to ~ 4500 breeding pairs (Kósa, 2001).

The first regional white stork census in the Târnave rivers geographical area, was conducted in 1974 by Mr. Peter Weber (Klemm, 1975). Some scattered data on the numbers of the white stork in the Târnave rivers basin were published by the following authors: Klemm (1983), Klemm and Salmen (1988), Pap (1995), Pap and Szabó (1996), Philippi (2001), Philippi and Popa (1990), Salmen (1980), Sárkány-Kiss (1991), Szabó and Pap (1996) and Weber and Antal (1978).

In 2004, the white stork population from the Târnave River Basin was censused again after 30 years. The main goal of this study was to evaluate the population size, breeding parameters and population dynamics of the white stork in the Târnave rivers basin. The second aim was to locate and characterize the nest sites used by White storks in this region.

### Definition of the study area

The Târnave rivers basin occupies the middle part of Romania and is situated within four counties (Alba, Harghita, Mureş and Sibiu), along about 200 river kilometers. The total size of the Târnave rivers basin is 6245.85 $km^2$ (Ujvári, 1972). The geographical range of the area is from 23˚40'E to 25˚36'E and from 45˚51'N to 46˚42'N.

## METHODS

Between June 11th and July 10th 2004, 175 villages from the Târnave rivers basin were surveyed for white stork nests by the members of the "Milvus Group" - Association for Bird and Nature Protection.

The data from another 19 localities were obtained in 2003.

The population size and breeding success were established by standard methods used during the International Census of white stork (Schulz, 1999 a, b). The following parameters were registered and calculated:

HPa - number of pairs occupying a nest, nesting pairs (Hpa = HPm + Hpo + HPx);

HPm - number of pairs with fledglings;

HPo - number of pairs occupying a nest but without fledgling;

HPx - number of pairs with unknown breeding success;

JZG - total number of fledglings in a defined area per year;

JZa - breeding success, avearage number of fledged young per pair related to all HPa of a defined area (JZG/HPa);

JZm - breeding success, average number of fledged young per pair related to all HPm of a defined area (JZG/HPm);

Std - "Stork density": number of pairs (HPa) per 100 sq km of a defined area.

Brood sizes were estimated from the ground and the number of successful nests used in the analyses was strictly the number of nests with young about to fledge. It was not always clear whether young from these nests did actually fledge.

The nests were photographied with a Canon PowerShot A60 and the geographical location of the stork nests were determined with a Garmin 12CX.

Data analysis was made with the FileMaker Pro software and the distribution map was produced with the fGIS software.

## RESULTS AND DISCUSSION

### Distribution, population size and density

The distribution of the 118 white stork identified nests in the study area is presented in Fig. 1. The species was identified in 102 localities (Tab. 1). The distribution of the white stork throughout the area is uneven, nesting birds are confined mainly to the upper Târnava Mare River and the lower Târnava rivers basins. About 47.4 % of the surveyed villages had no storks. No white stork nests were identified in the following 92 localities (Fig. 1): Abuş, Aluniş, Andreeni, Apold, Aţel, Atid, Avrămeşti, Bălăuşeri, Bălcaciu, Bazna, Benţid, Bernadea, Biertan, Biserican, Boiu, Brateiu, Bulgăreni, Cădaciu Mare, Cădaciu Mic, Călimăneşti, Căpâlna de Jos, Ceheţel, Chibed, Cireşeni, Cistei, Cobăteşti, Copşa Mare, Crăciunel, Crişeni, Cund, Curciu, Deaj, Dejuţiu, Dobeni, Dupuş, Ernea, Făget, Feisa, Filitelnic, Forţeni, Găneşti, Glogoveţ, Goagiu, Gogan, Hoghia, Iclod, Idiciu, Inlăceni, Izvoarele, Jidvei, Laslău Mare, Lepindea, Lodroman, Lunca, Lunca Târnavei, Lupeni, Lupu, Medişoru, Mihai Viteazu, Morăreni, Mureni, Nadeş, Ocna de Jos, Ocnişoara, Odrihei, Ormeniş, Păltiniş, Petrisat, Poloniţa, Presaca, Săcel, Sântămărie, Şaroş pe Târnave, Satu Mare, Satu Mic, Senereuş, Şmig, Şoimuşu Mic, Şona, Spătac, Tăietura, Tărceşti, Târnoviţa, Tăuni, Ungurei, Valchid, Valea Lungă, Văleni (HR),Velţ, Veza, Viişoara, and Zagăr.

Based on the results of the censuses carried out in 2003 and 2004, the total population of the Târnave Rivers Basin is 105 HPa (Tab. 1.). As about ~20 % of the region was not covered by the censuses (mainly the small settlements from the mountainous area), the total population is estimated to approx. 130 breeding pairs.

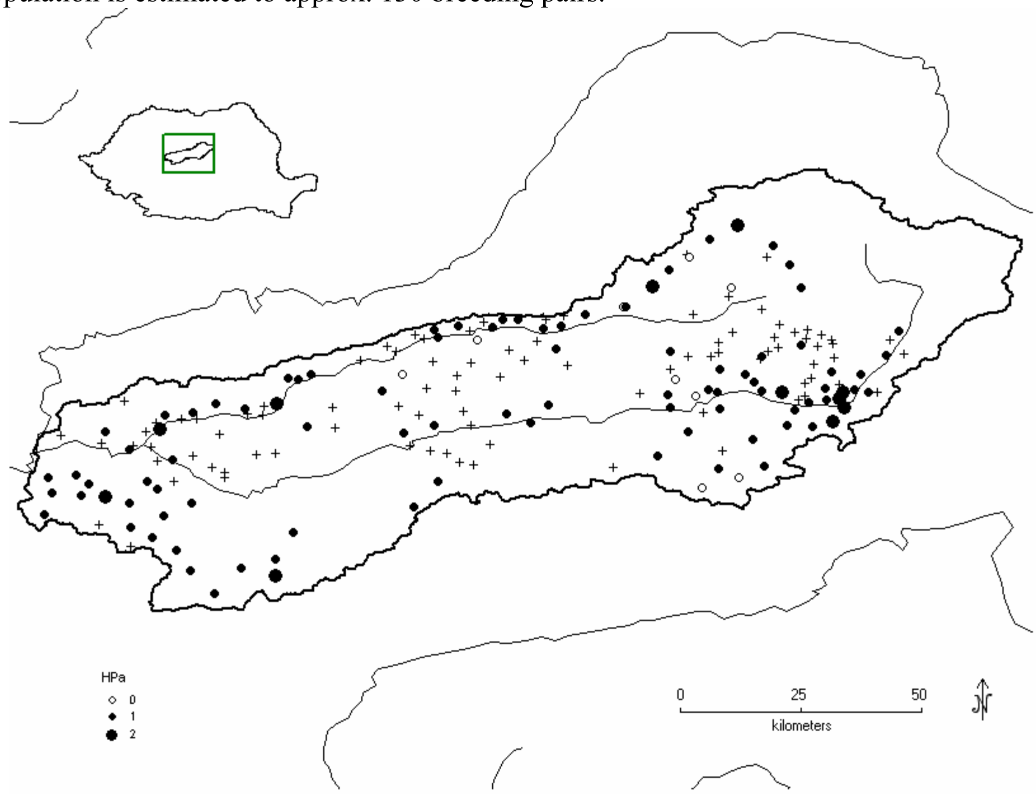


Fig. 1: Distribution and number of white stork breeding pairs (HPa) in the Târnave basin (Upper left corner: position of the study area in Romania; + surveyed localities without white stork nests).

In the Târnave Basin no white stork colonies were recorded. The mean number of nests/ localities is 1.03 and the maximal number of nest/localities doesn't exceed 2 nests/locality.

About 4.28 % of the Transylvanian population, and about 2.18 % of Romanian population breeds in the study area.

The mean population density (StD) for the whole area was 1.68 HPa/100 km$^2$. It is much lower than the average value for Romania (4.18 HPa/100 km$^2$ in 2004 - Kósa, unpublished data). In the neighbouring region (Olt River basin), we calculated an even higher average value of 5.47 HPa/100 km$^2$ (Kósa et al. 2002).

Table 1: List of localities with white stork nests in the Târnava Rivers Basin in 2003-2004 (Abbreviations: counties: AB - Alba, HR - Harghita, MS - Mureş, SB - Sibiu; Nest support: E - electric pylon, ES - electric pylon with nest support, C - chimney, R - roof, B - barn, T - tree, CR - church or ruin; Latitude and longitude are expressed in decimal degrees).

| Locality | County | Latitude | Longitude | H | HPa | HPm | HPo | HPx | HE | uH | JZG | Nest support | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adămuş | MS | 46.3040 | 24.2359 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | B | 2004 |
| Agrişteu | MS | 46.3922 | 24.6833 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2004 |
| Alămor | SB | 45.9275 | 24.0027 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | E | 2004 |
| Alma | SB | 46.2066 | 24.4714 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | E | 2004 |
| Alma Vii | SB | 46.0500 | 24.4333 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | C | 2004 |
| Archita | MS | 46.1801 | 25.0841 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | R | 2004 |
| Armeni | SB | 45.9660 | 23.9766 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2004 |
| Arvăţeni | HR | 46.2702 | 25.3065 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2003 |
| Băgaciu | MS | 46.2706 | 24.3724 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | C | 2004 |
| Bahnea | MS | 46.3737 | 24.4791 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 4 | 2E | 2004 |
| Berghin | AB | 46.0772 | 23.7361 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | E | 2004 |
| Beta | HR | 46.2771 | 25.2240 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | R | 2003 |
| Beteşti | HR | 46.2888 | 25.0867 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 3 | 2E | 2003 |
| Biia | AB | 46.2314 | 24.0089 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Boarţa | SB | 46.0000 | 24.2000 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | C | 2004 |
| Bodo-gaia | HR | 46.2746 | 24.9986 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | C | 2003 |
| Bogatu Român | SB | 45.9907 | 23.9308 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Boian | SB | 46.2036 | 24.2281 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | C | 2004 |
| Brădeşti | HR | 46.3404 | 25.3419 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | E | 2003 |
| Broşteni | SB | 46.0318 | 23.9525 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | E | 2004 |
| Bucerdea Grânoasa | AB | 46.1927 | 23.8387 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | T | 2004 |
| Buneşti | BV | 46.1069 | 25.0589 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | CR | 2004 |
| Căpâlna de Jos | AB | 46.2382 | 24.1076 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2004 |
| Cecheşti | HR | 46.3143 | 25.0206 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | CR | 2003 |

| Locality | County | Latitude | Longitude | H | HPa | HPm | HPo | HPx | HE | uH | JZG | Nest support | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cenade | AB | 46.0574 | 24.0055 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | E | 2004 |
| Cergău Mare | AB | 46.0987 | 23.9212 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 4 | 2E | 2004 |
| Cergău Mic | AB | 46.0826 | 23.9398 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | E | 2004 |
| Cetatea de Baltă | AB | 46.2472 | 24.1705 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 9 | 2E | 2004 |
| Chendu | MS | 46.3952 | 24.7175 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | C | 2004 |
| Chibed | MS | 46.5292 | 24.9632 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | ES | 2003 |
| Colibi | AB | 46.1112 | 23.7840 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Corneşti | MS | 46.2937 | 24.2117 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | ES | 2004 |
| Coroi | MS | 46.4088 | 24.6342 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | E, ES | 2004 |
| Coroi-sânmartin | MS | 46.4076 | 24.6047 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | ES | 2004 |
| Corund | HR | 46.4690 | 25.1782 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2004 |
| Crăieşti | MS | 46.2964 | 24.1915 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | B | 2004 |
| Criț | BV | 46.1230 | 25.0180 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | CR | 2004 |
| Cuşmed | HR | 46.4702 | 25.0432 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | E | 2003 |
| Daia | MS | 46.1464 | 24.9024 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | C | 2004 |
| Dârjiu | HR | 46.2024 | 25.1990 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | CR | 2004 |
| Dârlos | SB | 46.1903 | 24.4129 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | CR | 2004 |
| Eliseni | HR | 46.2938 | 24.9357 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | ES | 2003 |
| Fântânele | MS | 46.4193 | 24.7626 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | C | 2004 |
| Feleag | MS | 46.2379 | 25.0204 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2004 |
| Feliceni | HR | 46.2746 | 25.2794 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | C | 2003 |
| Filiaş | HR | 46.2696 | 25.0168 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | CR | 2004 |
| Forțeni | HR | 46.3082 | 25.2361 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | C | 2004 |
| Ghindari | MS | 46.5045 | 24.9229 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | ES | 2004 |
| Ghirbom | AB | 46.0342 | 23.7218 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Haranglab | MS | 46.3045 | 24.4116 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | E | 2004 |
| Henig | AB | 46.1055 | 23.7288 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | E | 2004 |
| Hoghilag | SB | 46.2289 | 24.6106 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | C | 2004 |
| Idrifaia | MS | 46.3888 | 24.4719 | 2 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | E,B | 2004 |
| Laslău Mic | MS | 46.3685 | 24.5560 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | E | 2004 |
| Laslea | SB | 46.2099 | 24.6569 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | CR | 2004 |
| Loamneş | SB | 45.9333 | 24.1000 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2004 |
| Lutița | HR | 46.2502 | 25.1917 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | CR | 2004 |

| Locality | County | Latitude | Longitude | H | HPa | HPm | HPo | HPx | HE | uH | JZG | Nest support | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mănărade | AB | 46.1411 | 23.9679 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Mătişeni | HR | 46.2352 | 25.1664 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Meşendorf | BV | 46.0867 | 24.9884 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | E | 2004 |
| Mihăileni | HR | 46.3604 | 25.1773 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Mugeni | HR | 46.2555 | 25.2271 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | CR | 2004 |
| Mujna | HR | 46.2061 | 25.1506 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Nicoleşti | HR | 46.2412 | 25.2599 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 6 | 2E | 2004 |
| Ocna de Sus | HR | 46.5142 | 25.1566 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2003 |
| Ocna Sibiului | SB | 45.8833 | 24.0500 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | C | 2004 |
| Odorheiu Secuiesc | HR | 46.3034 | 25.2937 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | C | 2003 |
| Ohaba | AB | 46.0710 | 23.7937 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | R | 2004 |
| Oțeni | HR | 46.2578 | 25.2522 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 6 | E, ES | 2004 |
| Pănade | AB | 46.2245 | 23.9548 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Păuca | SB | 46.0097 | 23.8882 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | B | 2004 |
| Porumbenii Mari | HR | 46.2701 | 25.1414 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 3 | E,C | 2003 |
| Porumbenii Mici | HR | 46.2730 | 25.1030 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | CR | 2004 |
| Praid | HR | 46.5512 | 25.1253 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | C | 2003 |
| Richiş | SB | 46.0991 | 24.4790 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | C | 2004 |
| Roadeş | BV | 46.1283 | 25.1076 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | C | 2004 |
| Roşia de Secaş | AB | 46.0568 | 23.8872 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Rugănești | HR | 46.3045 | 25.0712 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | ES | 2003 |
| Ruşi | SB | 45.9500 | 24.1667 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | C | 2004 |
| Sâncel | AB | 46.1998 | 23.9442 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 5 | 2E | 2004 |
| Sângeorgiu de Pădure | MS | 46.4325 | 24.8406 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | C | 2004 |
| Sânmiclăuş | AB | 46.2473 | 24.0529 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | B | 2004 |
| Sărățeni | MS | 46.5632 | 25.0031 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Saschiz | MS | 46.1943 | 24.9602 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | R | 2004 |
| Secăşel | AB | 46.0947 | 23.8079 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | E | 2004 |
| Secuieni | HR | 46.2621 | 24.9747 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | C | 2003 |

| Locality | County | Latitude | Longitude | H | HPa | HPm | HPo | HPx | HE | uH | JZG | Nest support | Census year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seleuş | MS | 46.2455 | 24.6920 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | C | 2004 |
| Simoneşti | HR | 46.3385 | 25.1016 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | ES | 2003 |
| Slimnic | SB | 45.9167 | 24.1667 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 8 | 2E | 2004 |
| Şoard | MS | 46.2640 | 24.9223 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | C | 2004 |
| Şoimuş | MS | 46.3946 | 24.5846 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | E | 2004 |
| Şoimuşu Mare | HR | 46.3481 | 24.9261 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | C | 2003 |
| Sovata | MS | 46.5881 | 25.0566 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | ES, R | 2004 |
| Suplac | MS | 46.3969 | 24.5195 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | ES | 2004 |
| Tău | AB | 46.0701 | 23.8407 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 7 | E,B | 2004 |
| Tăureni | HR | 46.2693 | 25.2595 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 8 | 2E | 2004 |
| Ţigmandru | MS | 46.3525 | 24.7077 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | C | 2004 |
| Tiur | AB | 46.1596 | 23.8869 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | T | 2004 |
| Trei Sate | MS | 46.4711 | 24.8922 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 7 | ES, ES | 2004 |
| Ulieş | HR | 46.2134 | 25.2399 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 7 | 2E | 2004 |
| Vânători | MS | 46.2396 | 24.9274 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | E | 2004 |
| Zetea | HR | 46.3874 | 25.3660 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | E | 2003 |
| Total | | | | 118 | 105 | 91 | 6 | 8 | 4 | 9 | 325 | | |

**Breeding success**

The JZa and JZm values, which characterize the breeding success, were calculated only for the second census year (2004). In this year 89 HPa (78 HPm + 6 HPx + 5 HPo) and 284 JZG were recorded, distributed in 83 localities. The mean JZa and JZm values for the Târnava Rivers Basin were 3.19 and 3.64. Thus the mean JZa and JZm values for the region were above 2.0 and 2.5, values which are higher than the estimated JZa and JZm values needed to keep the population stable (Burnhauser 1983, Lakeberg 1995).

The frequency distribution of brood size for the study area in 2004 was the following (Fig. 2): the percentage of nests with 1 young (HPm1) was 2.56 %, HPm2 - 7.69 %, HPm3 - 28.2 %, HPm4 - 46.15 %, HPm5 - 15.38 % (n = 78 HPm).

In 2004 the percentage of breeding failure (% HPo) was low, only 5.61 %.

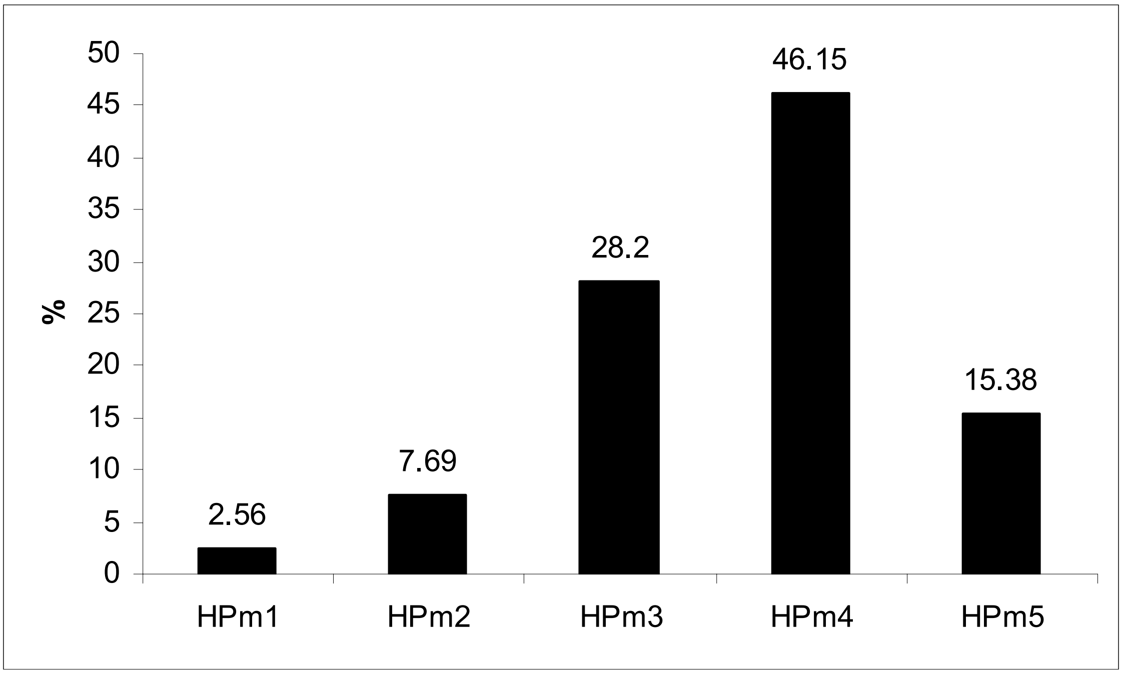


Fig. 2: The frequency distribution of brood size in the Târnava Rivers Basin in 2004 (n = 78 HPm).

**Nest site selection**

The most common nest sites in the Târnave rivers basin are electric pylons (60.16 %), chimneys (20.33 %) and churches, ruins (8.47 %) (Tab. 1 and Fig. 3). The frequency distribution of nest sites for Romania (2004) is the following: 83.5 % of nests are constructed on electric pylons and only 12.57 % on buildings (chimneys + barns + roofs) (Kósa 2005, *unpublished data*). Thus the study area remains behind other regions in Romania, as far as the proportion of nests constructed on electric pylons is concerned.

There are regional differences in nest site preferences. The proportion of nests constructed on churches is the highest in the Odorheiu Secuiesc Basins and chimneys are preferred as nesting sites in the lower section of the Târnava Mare River valley.

During the last decades massive changes have been observed in Romania in nest site preferences, birds were moving from buildings to electricity pylons (Kósa 2001, Kósa et al. 2002, Weber 1999). This process differed significantly in various parts of the country (Kósa et al. 2002). Unfortunately, due to the lack of data we don't know when and where this process started in the Târnava Rivers Basin.

In the middle of the 1990s, in cooperation with the national electricity company, the installation of artificial nest platforms on electricity poles begun in Romania and until 2004 about 1100 poles were equipped with such platforms. Unfortunately only 13 platforms were installed in the Târnava Rivers Basin. Consequently, there are still 58 nests in direct contact with electric wires.

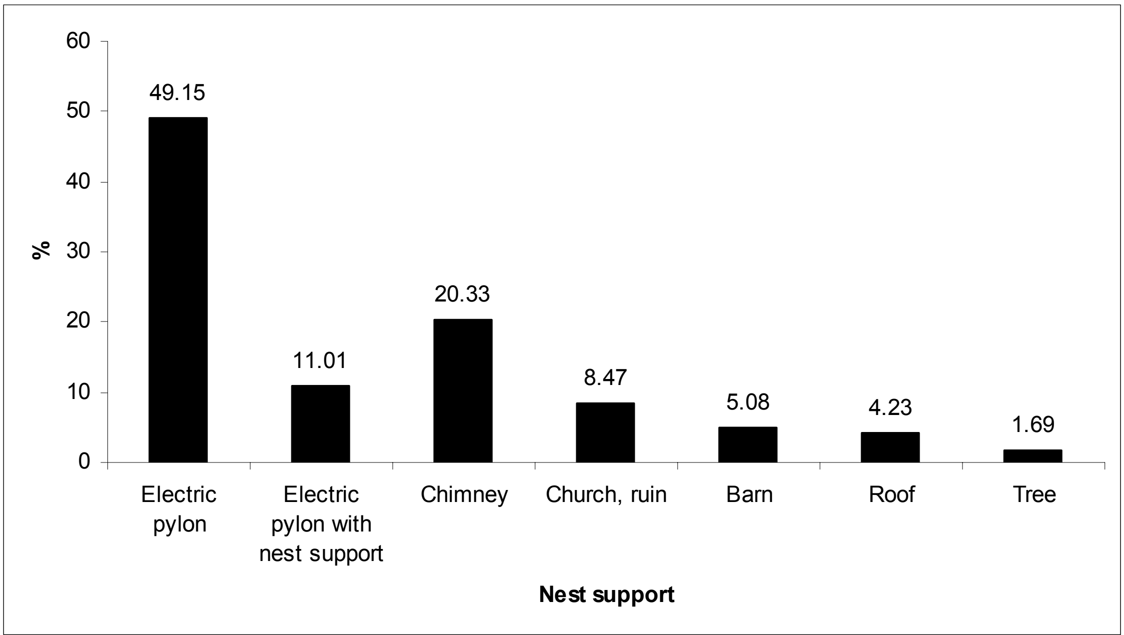


Fig. 3: The frequency distribution of different nest sites of the white stork in the Târnava Rivers Basin (n = 118).

**Population trends**

The Târnava rivers basin, considering the available amount of white stork population data, is one of the less studied area in Romania. The only census covering the whole area was organised thirty years ago, in 1974 (Klemm, 1975). For the 1974-2002 period we have only scattered data from some localities.

As we can see in Tab. 2, in comparison to the last survey in 1974, the 2003-2004 surveys shows a 58.83 % HPa decrease in the Târnave Rivers Basin. The white stork disappeared from 40 % of the compared localities. Today, nesting birds became increasingly confined to the main river valleys (Târnava Mare, Târnava Mică, Secaş).

The Romanian breeding white stork population underwent a large decline between 1958 and 1978 (Klemm 1983). In the 1973/1974-1988/1989 period the decline of Stork populations continued also in the neighbouring region (Olt River basin) (Kósa et al., 2002). Among the causes of the decline Klemm (1983) listed the disappearance of wetlands due to drainage and river regulation following a systematic government plan and structural changes of the human settlements and attitudes with transition to urban building and behaviour.

Although in the period 1990-2002 the species experienced moderate increase in many regions, the population has recovered to the level preceded its decline in only some regions (Kósa et al., 2002). Unfortunately white stork breeding data are lacking between 1990 and 2003, so we do not know in what manner the breeding population in the Târnave Rivers Basin was affected in the last 13 years, when increases were registered for some of the neighbouring regions (Sibiu Basin, Ciuc Basin).

Table 2: Population changes of the white stork in the Târnave rivers' basin from 1974 to 2004 (HPa values from 1974 are based on data published by Klemm (1975) and Weber and Antal (1978)). (Data marked with * were obtained in 2003).

| Locality | HPa 1974 | HPa 2004 |
|---|---|---|
| Adămuş | 3 | 1 |
| Alma Vii | 1 | 1 |
| Atid | 1 | 0* |
| Bahnea | 3 | 1 |
| Bălăuşeri | 1 | 0 |
| Biertan | 1 | 0 |
| Blăjel | 1 | 0 |
| Boian | 2 | 1 |
| Boiu | 3 | 0 |
| Călimăneşti | 1 | 0 |
| Căpâlna de Jos | 2 | 1 |
| Cetatea de Baltă | 2 | 2 |
| Chendu | 5 | 1 |
| Copşa Mare | 1 | 0 |
| Corneşti | 1 | 1 |
| Corund | 1 | 1 |
| Daneş | 1 | 0 |
| Fântânele | 1 | 1 |
| Găneşti | 1 | 0 |
| Ghindari | 2 | 1 |
| Hoghilag | 1 | 1 |
| Idrifaia | 1 | 1 |
| Jidvei | 2 | 0 |
| Laslea | 1 | 1 |
| Moşna | 1 | 0* |
| Porumbenii Mari | 1 | 2* |
| Praid | 4 | 1* |
| Săcel | 1 | 0* |
| Sâncel | 5 | 2 |
| Sângeorgiu de Pădure | 2 | 1 |
| Sărăţeni | 1 | 1 |
| Saschiz | 2 | 1 |
| Şoard | 1 | 1 |
| Şoimuşu Mare | 1 | 1* |
| Şona | 2 | 0 |
| Trei Sate | 2 | 2 |
| Vânători | 1 | 1 |
| Velţ | 3 | 0 |
| Viforoasa | 1 | 0* |
| Zagăr | 1 | 0 |
| Total | 68 | 28 |

**CONCLUSIONS**

Based on the results of the censuses carried out in 2003 and in 2004, the total white stork population of the Târnave Rivers Basin is 105 HPa distributed in a total of 94 localities. The total population of the region can be estimated to approx. 130 HPa. The mean population density (StD) for the whole area was only 1.68 HPa/100 $km^2$. Most common nest sites are electric pylons (60.16 %), chimneys (20.33 %) and churches (8.47 %). The mean JZa and JZm values for the studied region were above 2.0 and 2.5, values which are higher than the estimated JZa and JZm values needed to keep the population stable. In comparison to the last survey in 1974, the 2003 - 2004 survey shows a 58.83 % HPa decrease in the Târnave River Basin.

From a conservational point of view it is necessary to continue the monitoring of the white stork populations in key sites. As the foreseeable introduction of the EU agricultural policy in Romania will damage the white stork feeding habitats, increasing efforts are needed to protect these regions. The installation of nestplatforms on electric poles must be continued in the Târnava Rivers Basin

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# DATA ON THE BAT FAUNA OF THE UPPER PART OF THE TÂRNAVA RIVERS BASIN (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: chiroptera, distribution, species.

**ABSTRACT**

The paper presents the results of chiropterological researches carried out since 1999 in the upper part of the Târnava Rivers Basin. During the study nine bat species were identified. Check-up of village churches, detectoring and determination of dead specimens were used as methods. Bats were present in more than half of the checked churches. This fact suggests the importance of old buildings as roosts for bats, and their considerable role in bat protection.

**ZUSSAMEFASSUNG**: Daten zur Fledermausfauna des oberen Teils des Târnava-Flusstals (Transsilvanien, Rumänien).

Der Aufsatz stellt die im Jahre 1999 gesammelten Daten über die Fledermausfauna von dem oberen Teil des Flussbeckens der Târnava vor. Während der Datenerhebung haben wir neun Fledermausarten festgestellt. Dabei gingen wir nach folgender Methode vor: Untersuchung von Gebäuden (hauptsächlich der Kirchen), Beobachtungen mit Detektor, Untersuchung der gestorbenen Exemplare. In mehr als der Hälfte der Kirchen haben wir Fledermäuse gefunden. Diese Daten beweisen die Wichtigkeit und die Bedeutung der Kirchen beim Schutz der Fledermäuse.

**REZUMAT**: Date referitoare la fauna de lilieci din bazinele superioare ale râurilor Târnave (Transilvania, România).

Lucrarea prezintă datele colectate începând din anul 1999, despre fauna de lilieci din zona superioară a Bazinului Târnavelor. În cursul studiului nouă specii de lilieci au fost identificate, prin aplicarea următoarelor metode: controlarea bisericilor, utilizarea detectoarelor de ultrasunete, determinarea exemplarelor moarte. Liliecii erau prezenţi în mai mult de jumătate a bisericilor controlate, fapt ce arată importanţa acestora ca adăpost pentru lilieci, lucru care nu trebuie neglijat în protecţia acestor animale.

## INTRODUCTION

The nature degradation due to human activity was increased in the last decades. Bats are endangered in every respect, many species have their roosts in buildings, or in other places expose to human disturbation (e.g. forests, caves). For this reason the direction of natural processes in bat populations become more and more determinated by the human interference.

In Romania the knowledge about bats distribution and ecology is extremely poor. Papers published in the past decades are focused mainly in cave-dwelling bats, very few publications are about hose-dwelling bats (Barbu and Sorescu, 1968; Valenciuc and Ion, 1969; Valenciuc, 1989; Răduleț, 1997). Studies started in the last few years are focused on bats distribution and some ecological aspects, which can provide important data for protection measures.

For the territory of Harghita County we can find some chiropterological data in the literature (Méhely, 1900; Paszlawszky, 1918; Dumitrescu et al., 1962 - 1963), but none from the study area. In 1999 - 2000 was made a study on house - dwelling bats in this county (Jére and Dóczy, 2001), and some data collected during the study are from the Târnava Rivers Basin.

## MATERIALS AND METHODS

The study area situated in the western hilly part of Harghita County, in the vicinity of the western slopes of the Eastern Carpathians. The boundaries of this territory are on the east of the Harghita Mountains, and on the north of the Gurghiului Mountains. This territory represent the upper part of the Târnave rivers basin, the most important watercourses are the Târnava Mică and Târnava Mare rivers, and streams like Brădeşti, Fernic and Corund which flow into them. The relief altitude is here between 400 and 700 m above the sea level, the medium annual temperature is about 8°C.

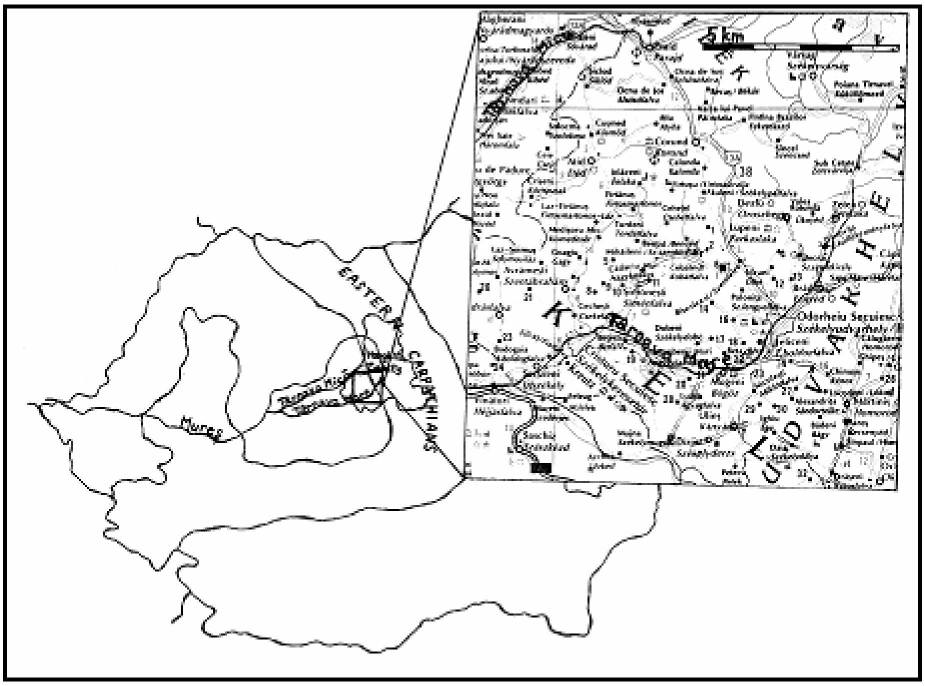


Fig. 1: Location of the study area.

The study basis was the survey of 32 village churches in July 1999 and 2000. The species were determinated by visual observations, we didn't capture specimens in their roosts, to avoid unnecessary disturbation. Number of specimens was counted or if it wasn't possible estimated. Besides this survey work visual observations, detectorings carried out sporadically in different parts of the study area and determination of dead specimens provide some faunistical data.

**RESULTS AND DISCUSSION**

During a survey of house-dwelling bat colonies in July 1999 and 2000, we checked 32 churches in villages in the study area. In 18 buildings were found bats, in one of them two bat species were present, but in different parts of the building. Thus, bats populated 56,25% of the checked buildings. In seven churches, we found more than 10 specimens. It means that 21,87% of the churches roosts colonies need attention from the point of view of protection.

In summer females form nursery colonies in favourable roosts (buildings, hollows, caves), where they give birth and grow up youngsters. These colonies often consist by hundreds or thousands of individuals, a big colony assures a more favourable energy budget for bats. Males meanwhile aren't present in colonies they wander using several roosts (Zahn and Dippel, 1997).

The following species were found in buildings: *Myotis myotis/Myotis blythii*, *Eptesicus serotinus, Plecotus austriacus, Rhinolophus hipposideros.*

Greater and lesser mouse - eared bat (*Myotis myotis* and *Myotis blythii*)

These two species are discussed together because they are similar, and often form mixed colonies. *Myotis blythii* is somewhat lesser and has a white spotted between ears (Arlettaz et al., 1991), but these species are hard to separate even when are kept in hand. Certain separation can be realized by osteological measurements (Topál, 1969; Kowalski and Ruprecht, 1981; Görner and Hackethal, 1987; Valenciuc, 2002). During mistnettings made in the vicinity of the study area (in the Vârghiş Gorge) both species were captured, but *Myotis myotis* seems to be more frequent. In consequence, we can suppose that both two species occur in the study area.

These two species are the most frequent in the buildings of the area. We found them in nine churches in 1999 and 2000, in five buildings lived large colonies, consisting of 60-700 specimens. Later, in October 2002 a solitary exemplar was found in the church of Dealu Village. Probably this specimen roosted here for a shorter period of time during autumn migration or searching for a suitable hibernating place.

Serotine bat (*Eptesicus serotinus*)

This species is a frequent house-dwelling bat, in summer occurs almost exclusively in buildings. In the Hungary is the most frequent house - dwelling bat (Dobrosi, 1997), the number of individuals in colonies shows an increasing tendency in the past years (Bihari, 1990, 1996a; Boldogh and Gombkötő, 1996; Papp, 1996). Studies carried in Western Europe suggest that the serotine is one of those bat species which shows a good adaptation to human environment (Catto et al., 1995, 1996; Robinson and Stebbings, 1997; Gaisler et al., 1998).

The serotine bat is the second frequent species in the buildings of the area, it was recorded in seven churches. The maximum number of individuals was 10, in the other cases only few (one-six) individuals were found.

Grey long - eared bat (*Plecotus austriacus*)

In Hungary is the second frequent among house-dwelling bat species (Dobrosi, 1997), but seems to be rare in the study area. Three individuals were found in a building. This species doesn't show a serious demand for the size of the entrance holes in buildings, probably the geographical and climatic conditions aren't suitable in the study area.

In December 2002, a dead specimen was found in the cellar of an old building in Dealu Village. It was an adult female, with 40,6 mm forearm length and 5,5 mm long thumb.

Lesser horseshoe bat (*Rhinolophus hipposideros*)

Rhinolophus species need large holes to enter in buildings, and this fact reduces the number of roosts which are suitable for them.

We could find it in two churches, two respectively ten individuals, in the first case probably a female and its offspring.

Table 1: House - dwelling bats in the study area.

| Species | Nr. of individuals | Locality | Date |
|---|---|---|---|
| *M. myotis/M. blythii* | 1 | Brădeşti | 26.07.1999 |
| *M. myotis/M. blythii* | 2 | Târnoviţa | 26.07.1999 |
| *M. myotis/M. blythii* | 1 | Sâncrai | 26.07.1999 |
| *M. myotis/M. blythii* | 120 | Tăureni | 27.07.1999 |
| *M. myotis/M. blythii* | 100 | Mujna | 27.07.1999 |
| *M. myotis/M. blythii* | 60 | Văleni | 28.07.1999 |
| *M. myotis/M. blythii* | 700 | Mihăileni | 29.07.1999 |
| *M. myotis/M. blythii* | 1 | Inlăceni | 19.07.2000 |
| *M. myotis/M. blythii* | 120 | Atid | 19.07.2000 |
| *E. serotinus* | 3 | Mugeni | 27.07.1999 |
| *E. serotinus* | 10 | Cobăteşti | 29.07.1999 |
| *E. serotinus* | 2 | Beteşti | 29.07.1999 |
| *E. serotinus* | 3 | Porumbenii Mari | 29.07.1999 |
| *E. serotinus* | 1 | Satu Mare | 30.07.1999 |
| *E. serotinus* | 2 | Atid | 19.07.2000 |
| *E. serotinus* | 6 | Ocna de Jos | 20.07.2000 |
| *P. austriacus* | 3 | Ulieş | 27.07.1999 |
| *Rh. hipposideros* | 10 | Inlăceni | 19.07.2000 |
| *Rh. hipposideros* | 2 | Firtuşu | 19.07.2000 |

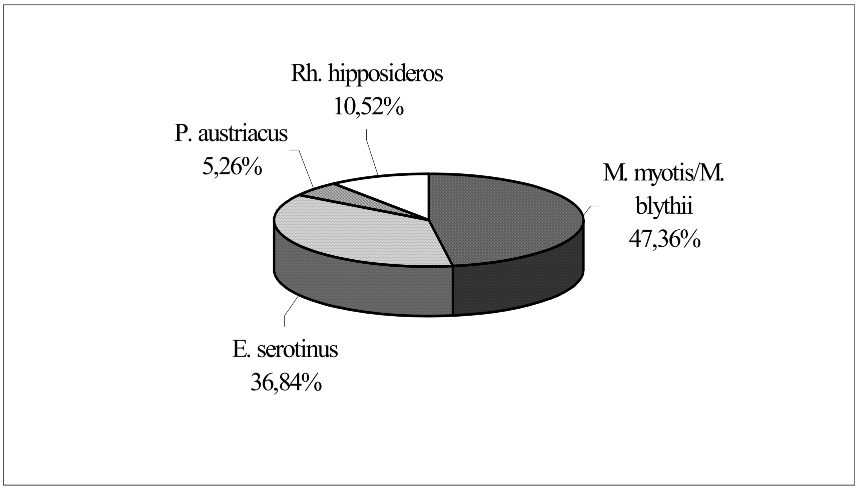


Fig. 2: The division of buildings inhabited by certain species.

Noctule bat (*Nyctalus noctula*)

It's one of those few bat species which are well adapted to human environment (Gaisler et al., 1998). It is present even in large cities. Primarily a tree - dwelling bat but nowadays specimens often use crevices in buildings, even in block of flats for roosting.

It was recorded many times using bat detector, seems to be one of the most frequent species in the study area and probably in the whole country.

Localities: Odorheiu Secuiesc, Băile Szejke, Dealu, Ulcani, Sâncrai, Subcetate Artificial Lake, Vârşag.

Pipistrelle bat (*Pipistrellus pipistrellus*)

It is the smallest bat in Europe, often can be found in settlements. As a consequence of its size can use a variety of roosts, seems to be frequent. It was recorded with ultrasound detector in different habitats mainly in town Odorheiu Secuiesc.

Localities: Odorheiu Secuiesc, Subcetate Artificial Lake

Daubenton's bat (*Myotis daubentonii*)

The species is strongly attached with habitats characterized by water all over Europe. It was recorded with bat detector in a few cases over or in vicinity of rivers or lakes. It can be found roosting also in settlements.

Localities: Odorheiu Secuiesc, Subcetate Artificial Lake

Barbastelle bat (*Barbastella barbastellus*)

It is a tree-dwelling bat, during hibernation, in winter can be recorded in caves, but usually in small number. It is rare all over Europe (Bihari, 1996b), and also in Romania (Murariu, 1995; Valenciuc, 2002).

An adult female was found in a pile of board in Băile Szejke, near Odorheiu Secuiesc town.

Localities: Băile Szejke

Data gained have mainly faunistical importance, more detailed and longer period studies are needed to observe changes which happens in bat populations. Earlier than 1999 we couldn't find chiropterological data from the study area in the literature. Data presented in the paper contribute to the knowledge of bat distribution in the area, during next years probably presence of other bat species will be proved.

**ACKNOWLEDGEMENTS**

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# REMARKS ON THE HABITAT OF THE *MUSCARDINUS AVELLANARIUS*, LINNAEUS 1758 IN THE TÂRNAVA PLATEAU (TRANSYLVANIA, ROMANIA)

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**KEYWORDS**: hazel dormouse, mammology, habitat preferences.

**ABSTRACT**

*Muscardinus avellanarius* (Linné, 1758) or the Hazel Dormouse is the smallest species in the Gliridae family (Thomas, 1897) and the most widely spread species in Romania. It is the most frequent dormouse in the Transylvanian plateau. The occurrence is examined of the populations of this kind of dormice, which live near the edge of the oak forests and in the wood clearings, where it breeds exceedingly in the propitious years, as well as in the shrubs and bushes spread around the broad-leaved/deciduous tree forests. A connection is demonstrated between the habitat of this kind of dormice, which build their spherical nests of moss and leaves among the undergrowth twigs and in the underbrush covered with voluble, hygrophilous plants - and the superficial ground water on the edge of the forest.

**RÉSUMÉ**: Observation sur l'habitat de *Muscardinius avellanarius* dans Târnava Plateau.

*Muscardinus avellanarius* (Linné, 1758) ou le loir de noisetier, représente l'espèce la plus petite de la famille de *Gliridae* (Thomas, 1897) et il est le plus répandu en Roumanie. Parmi les loirs, c'est lui qu'on trouve le plus souvent sur le Plateau de la Transylvanie.

On analyse les situations dans lesquelles se présentent les populations de ce type de loir, qui vit à la lisière des forêts de chêne, dans les clairières d'arbres coupés, où il prolifère pendant les années favorables, et parmi les cépées et les broussailles répandues autour de la forêt d'arbres feuillus/à feuilles caduques.

On démontre une liaison entre l'habitat de ces loirs, qui font leurs nids sphériques en mousse et en feuilles, parmi les branches des buissons et des demi-buissons recouverts d'herbes volubiles et hygrophiles - et la nappe phréatiques superficielle des bords de la forêt.

**REZUMAT**: Observații asupra habitatului lui *Muscardinius avellanarius* în Platoul Târnava.

***Muscardinus*** *avellanarius* (Linné, 1758) sau pârşul de alun este specia de cea mai mică talie din familia Gliridae (Thomas, 1897) şi cea mai răspândită în România. Este cel mai frecvent pârş din podişul Târnavelor. Este analizată ocurența populațiilor care trăiesc la marginea pădurilor de stejar şi în poieni, unde se reproduce cu succes în anii favorabili, precum şi în tufărişurile din jurul pădurilor de foioase. Este demonstrată o corelație între cuiburile sferice construite din muşchi şi frunze, acoperite cu plante higrofile, de la baza tufărişurilor, şi stratul superficial de apă freatică de la marginea arboretelor.

## INTRODUCTION

*Muscardinus avellanarius* or the hazel-tree dormouse is the smallest species in the *Gliridae* family living in Romania, where the existence was demonstrated of the subspecies listed under the name of *Muscardinus avellanarius avellanarius.* Thus, Simionescu (1971) measured 52 specimens he had collected all over the country and he listed the species found in our region in the subspecies spread all over Central and West Europe. Other subspecies present in Europe are *M. avellanarius pulcher* (Hamilton, 1898), which lives in Sicily and the Italian Peninsula and *M. avellanarius zeus* (Ondrias, 1966), which lives in Greece and mainly differs from the former in the size of some of the skull bones.

*Muscardinus avellanarius* can be met in Romania in the woody areas, starting from the sylvo-steppe and well beyond the higher level of the coniferous forests (the alpine area), that is 1800 – 2000 m and this dormouse is the one most frequently found over the widest area. It was observed in all the geographic areas of the country (Simionescu, 1971), including the Danube Delta. Unlike the other dormice, *Muscardinus avellanarius* seems to be equally present both in the plain forests and in the hill and mountain forests. In reference to the 26 specimens we have collected over the period 1981 - 1999, this species stands for 7.90 % of all the mammals caught in the ecosystem of the broad-leaved tree forests we have investigated. Sporadically, this species is less frequent.

*M. avellanarius* was first mentioned in Romania by Bielz (1888), in Sighişoara and Braşov. Xanton (1896) found it in Alba Iulia and Miller (1912), in Haţeg. Subsequently, it appears in some fauna treatises by Călinescu (1931), Vasiliu (1937), Hellwing (1963), Simionescu (1965, 1966, 1968, 1969), Sutova (1971). Andreescu and Murariu (1981) mentioned the presence of this dormouse in the sylvo-steppe area of the counties of Teleorman and Ilfov. Ghizelea (1969) found it in the forest of Grădinari, near Bucharest. Petrache (1987) found it in the forests of the hydrologically improved area of Sadova - Corabia and Nania (1875 - 1985) noticed it in the area of Trivale - Piteşti.

Ene and Almăşan (1964) also found it in the higher, hilly regions. Borcea and Băcăuanu (1980) noted it as one of the most characteristic rodent species in the Bârlad and Suceava plateaus. Popescu and Yusuf (1980) located it in the mixed forests in the Bucegi Mountains. Munteanu (1973) traced it in the Massif Ceahlău and Simionescu (1977) drew up a map of the range covered by this dormouse in Romania showing this species is spread unevenly.

## MATERIALS AND METHODS

*Muscardinus avellanarius* lives in widespread bushes/shrubs (field brushes) and in the forest bushes (bushy forests), according to Pucek (1981). These dormice stick very closely to the territory they get used to. The females usually confine themselves within an area with a radius of up to 100 m. The males dare to move a little further. It was proved that the greatest distance they moved away during one season was 1600 m. The dormice search their food mostly in the brushes, as noted by Reichholf (1983).

*Muscardinus avellanarius* could be found in the area we have investigated over a range starting from 300 m up to the highest hills of 560 - 580 m.

We have investigated and caught small mammals in the geographical region of the Târnava Mică Hills, which is a central subunit of the Transylvanian Plateau. The relief is characterized by the presence here of hill-bells. The energy of the relief ranges from 150 - 250 m. The relief, unevenly divided by a large hydrographic network, is made up of a succession of interfluves, which are usually asymmetrical and not too large, divided by well-shaped valleys. The main water stream that crosses the region is the Târnava Mică River (Fig. 1).

The land is covered with agricultural cultures, 60 % of which are carefully parceled out, yet a lot of it lies fallow. Most of the forests are closed up and their grassy cover is usually poorly developed due to their exposure to the north. They belong to the oak and beech subarea, whereas the bushy forests rich in grassy vegetation are the ones exposed to the south and southwest. Both the cases often occur within the same forest, due to their diverse exposure to the sunlight. Frequent among the woody species are *Quercus robur, Quercus petraea, Carpinus betulus,* as well as *Quercus pubescens* on the sunny slopes, and *Populus tremula* and *Tilia cordata.* Specimens of *Fagus sylvatica*, growing in almost exclusive beech woods can be found sparsely on the northern slopes, in the region of Bazna.

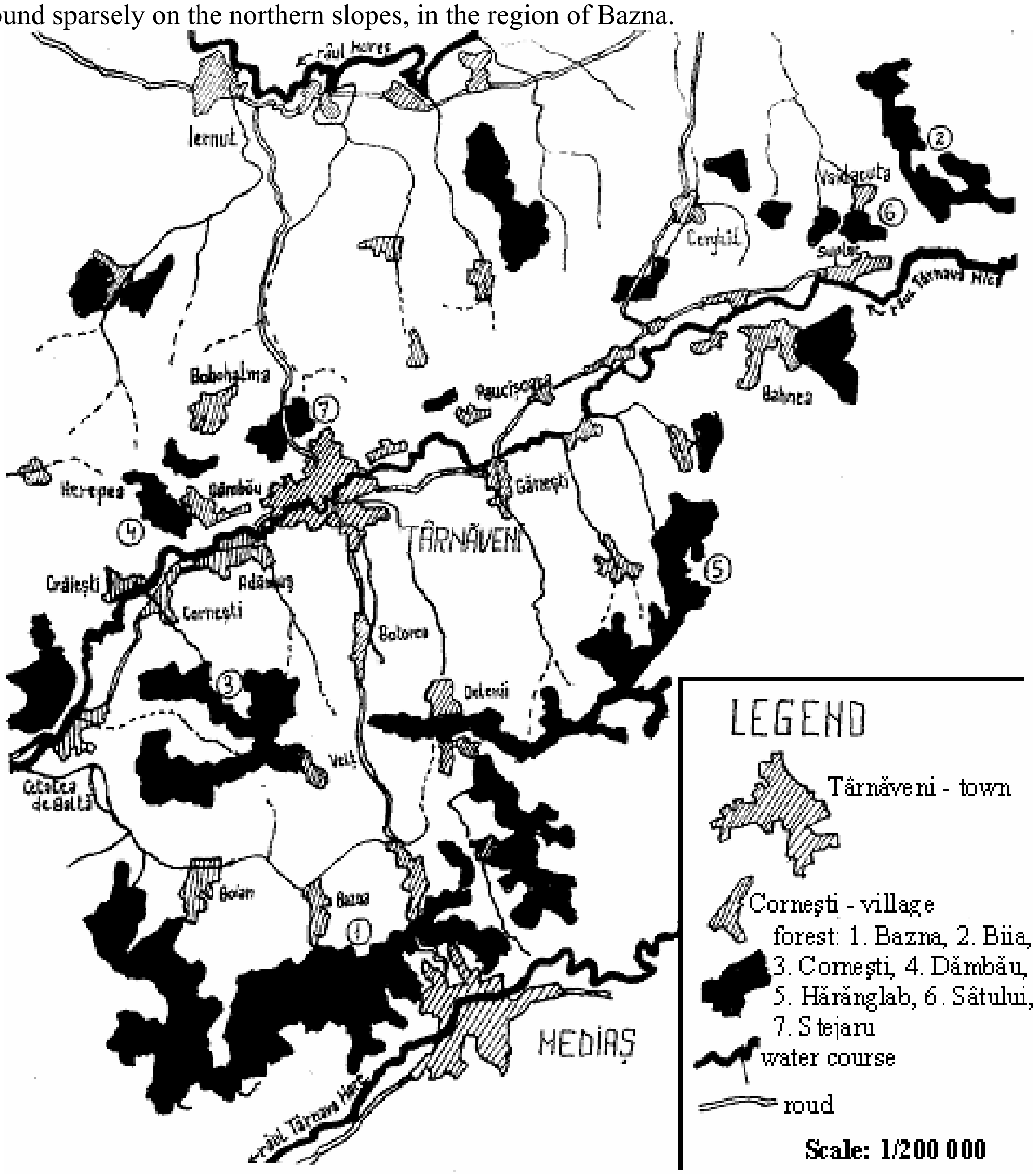



Fig. 1: A map of the Târnava Plateau, showing some of the locations/sites, water streams and forests (adapted after N. Josan, 1979).

Table 1: The locations/sites where and the date when we caught the specimens of *Muscadinus avellanarius* (original).

| Location | Year | Habitat |
|---|---|---|
| **Târnăveni** | 1981-1997 | |
| Stejaru Forest | 1981-1983 | - recently cut wood clearing (four years old) made up of *Corylus avellana*; *Quercus robur*; *Carpinus betulus* - as brushes 3 - 4 m high, covered with *Clematis vitalba*. Among these, high composite and grassy plants are growing |
| Stejaru Forest | 1992-1997 | - a 6 - 10 year old clearing consisting of brushes and trees belonging to the species *Quercus robur*, *Fraxinus excelsior*, *Carpinus betulus*, of variable heights (2-6-12 meters), on the edge of the old *Quercus robur* forest |
| Stejaru Forest | 1997 | the edge of the forest consisting of various brushes, such as *Prunus spinosa*, *Urtica dioica*, *Rosa canina*, covered with *Clematis vitalba* and *Rubus caesius*. |
| Stejaru Forest | 1997 | - Inside the sparse forest of *Quercus robur*, *Acer pseudoplatanoides*, *Cerasus avium*, in the 1.5 m high *Sambucus nigra* bushes |
| Stejaru Forest | 1990-1997 | - The tree-hollows of *Carpinus betulus* and *Salix* sp., shrubs of *Prunus spinosa* and *Crataegus monogyna* invaded by *Rubus caesius* |
| **Vaidacuta** | | |
| The Village Forest | 1981-1984 | - recently cut wood clearing, consisting of shrubs and brushes of *Corylus avellana*, *Tilia cordata*, *Quercus robur*, *Rubus idaeus* and *Rubus caesius* |
| Biia Forest | 1992-1996 | - recent clearing neighbouring an older clearing, made up of *Corylus avellana*, *Quercus robur*, *Carpinus betulus*, *Pinus sylvestris* (planted), *Rubus idaeus* (invasive), *Robinia pseudacacia* (sparse brushes and trees), various shrubs of *Rubus caesius*. |
| **Dâmbău**<br>Dâmbău Forest | 1990-1993 | - Young clearing made up of brushes of *Corylus avellana*, *Quercus robur*, *Rubus caesius*, *Clematis vitalba* |
| **Hărănglab**<br>Hărănglab Forest | 1998 | - The edge of a young forest of *Quercus robus*, in the brushes of *Corylus avellana*, *Prunus spinosa* |
| **Bazna**<br>The Large Forest | 1999-2002 | - Open oak-wood; in the *Rubur idaeus* bushes |
| **Corneşti**<br>Corneşti Forest | 1999-2002 | Young clearing; in the brushes of planted *Quercus robur*, Acer sp.; *Rubus idaeus* bushes - in dark, wet/damp places/sites |

*Muscardinus avellanarius* prefer the wood clearings where hazel-trees 4 - 8 years old grow alongside oak shrubs invaded by *Clematis vitalba*, *Humulus lupus*, *Vitis sylvestris* and other brushes and tall grassy plants. These dormice breed very well here during the propitious years and these wood clearings are real genetic pools for this species. We have often found this animal on the edge of the forests, or inside the sparse, bushy woods. It thrives in the most favourable biotope - the recently cut clearings, as the second generation of young dormice is growing - and their spherical nests can be found more easily now. Tab. 1 shows the variety of situations in which we have found this kind of dormouse.

*Muscardinus avellanarius* build their spherical shelters, generally called nests, among the shrub twigs/branches and they do not depend on the tree-hollows, as other dormouse species do. That is the reason why they breed easily and can live in great numbers, in the same place, over many years. Thus, in 1982, we noticed a good thriving of this population in the Stejaru Forest, near Târnăveni, where we found about 30 nests over an area of 10,000 square meters. The next year, the number of nests decreased and the nests were even fewer in 1984. The dormice breed best when the clearings offer optimal conditions. Later on, as the biocenosis changes due to the growth of the plants, the dormice migrate towards the edge of the forest. We noted this phenomenon in the clearing of the Vaidacuta Forest, as well as in the cut tree clearings of the forests of Dâmbău and Biia, where, as the plants grew up, the number of nests lessened every year, and the only ones left could be found on the border between the old forest and the newly cut clearing or in some of the glades. A great number of nest - about 15 - were found in late September 1966, in the newly cut clearing of the Stejaru Forest.

The next year, in 1997, as the young trees were cut off to protect the *Acer sp.* saplings that had been planted, no more nests could be found, nor did we trap any dormice anymore.

The literature includes a few remarks on the habitat of *Muscardinus avellanarius.* Laar (1979) examined the location of the tree nests in a large-leaved/deciduous-tree forest in France and he noted that several structure factors of the vegetation, such as height, as well as the physical-geographical factors play a key role in *Muscardinus avellanarius* selecting their habitat. This has also been noticed by Ardwidson (1926), Bauer (1960), Laar (1971), Schultze (1973), Sidorowicz (1959), Wachttendorf (1951). According to Laar, the dormice he found live in the area of mesophilic vegetation, which is structurally a transition from the forest to the pastures, and they build their tree nests on the limit of the Rhamno-Prunetea association level and on the limit of the Trifolio-Geranietea sanguinei associations or where such associations are connected through a level consisting of *Convolvuletalia sepium* saplings. An essential factor for the dormice living in this area is the superficial ground water, which sporadically springs from the ground and favours the development of the transition vegetation between the thick forest and the rich pastures around it. This kind of vegetation needs a wet/damp soil. Comparing the situation already described to what we found in the Stejar Forest, Târnăveni; the Village Forest, Vaidacuta and the Hărănglab Forest, we notice many similarities. The situation we found on the edge of the Stejaru Forest, on August 24, 1997 is shown in Fig. 2. When examining the drawing, we notice the presence of a *Muscardinus avellanarius* nest 0.75 up from the ground. The nest is located 3.5 meters away from the sparse forest. The nest could be easily built due to the presence of a small clearing resulting from the cutting off of a *Cerasus avium* tree (proved by the branches spread on the ground) and, probably, the felling of other brushes/shrubs, too. *Rubus caesius* shrubs invaded the whole area. The plant supporting the nest is a sapling, that is *Rhamus frangula* - buckthorn/waythorn.

Another situation is the one we met on the edge of the Stejaru Forest, on August 25, 1997. In a nest we found a female and 5 naked young, 0.30 m up from the ground, in a small cluster of *Rosa canina*, covered with *Cletatis vitalba* and surrounded by various specimens of *Urtica dioica, Mentha sp.* The woody vegetation of *Acer pseudoplatanoides* makes up a curtain against the road winding up along the edge of the old forest, Fig. 3. The area is very damp, with the ground water oozing up and it is the spring of a small tributary of the Mureş River.

Several levels of vegetation have been noted in the Hărănglab Forest. The lower level, where the vegetation is the highest, is a young forest, with the trees 20 meter high, made up of species such as *Quercus petraea, Carpinus betulus*, under which sparse shrubs of *Corylus avellana* are growing. The second level, the external level, is the edge of the forest, 4 - 6 meters high, consisting of shrubs and bushes of *Corylus avellana, Ulmus sp., Crataegus monogyna.* Sporadically*, Quercus robur* can be found here, too. The third level of vegetation is on the edge of a low forest, 2.5 meter high, and it is made up of *Corylus avellana, Prunus spinosa, Alnus glutinosa, Cornus sanguinea.* It is worth mentioning that a desert road, 1.5 - 2 meter broad, crosses/separates level II and level III, where grow *Achillea millefolium, Festuca pratensis, Poa pratensis, Cichorium inthybus* and tall *Umbellifera.*

The level IV, consists of tall grasses, such as *Angelica sylvestris*, *Eupatorium cannabium* (forest/wild hemp), with heights ranging from 1.40 to 1.75 meters, *Filipendula ulmaria* (goat's beard), *Lythrum salicaria, Carex sp., Solanum dulcamara* (nightshade) and *Mentha sp.* and *Potentillia anserine. Rubus fruticosus* saplings, 2 - 3 meter long, can be met sporadically in the meadow and towards the forest. *Potentillia erecta* (cinquefoil), *Galium verum* (yellow bedstraw) were found on the pastures and *Stachys verum, Urtica dioica, Paris quadrifolia* -– in the sunniest areas. The vegetation is affected by the cattle, which graze the grass and stamp the ground. *Talpa europaea* hillocks and hoof stamps can be seen all around. The *Muscardinus avellanarius* nests were found in the level II transition area (shrubs/bushes and pasture), especially in the areas where tall grassy plants grow which are well exposed to the sunlight. The branches of the thorn trees we have already mentioned provided the support to the nests. An analysis of the vegetation growing in the area of the forests of Hărănglab and Dâmbău and the comparison to the existing literature strengthen the idea that the nests are not built within a mixture of forest and field species, but rather in an environment made up of a vegetation with specific composition and structure. These nests are present at a height varying between 0.30 and 1.60 meters. The literature states that this type of habitat is due to the influence of humans, who repeatedly cut off the trees and wipe off the vegetation and it is also due to the grazing - all resulting in the appearance of meadows and hedges on the edge of the forest. Communities of *Muscardinus avellanarius* build their summer nests and live here almost permanently. Where the forest matures without man interfering repeatedly by cutting the trees on the edge and where crops are cultivated and the grass is frequently mown in the meadows, *Muscardinus avellanarius* disappears, after a while.

Unlike the situations already described and compared to the existing literature, in the area we have investigated we have met a typical situation in the recently cut clearings with woody vegetation, 4, 6 or 8 years old, at most, when catching dormouse specimens in the forests neighbouring Târnăveni, Vaidacuta, Dâmbău and Odrihei, yet we tend to believe that all the clearings that provide the conditions we have described previously shelter *Muscardinus avellanarius* populations. Following the analysis of a few tens of tree nests, we have reached the conclusion that they are all built on the side of the clearing bordering the forest (Fig. 4).

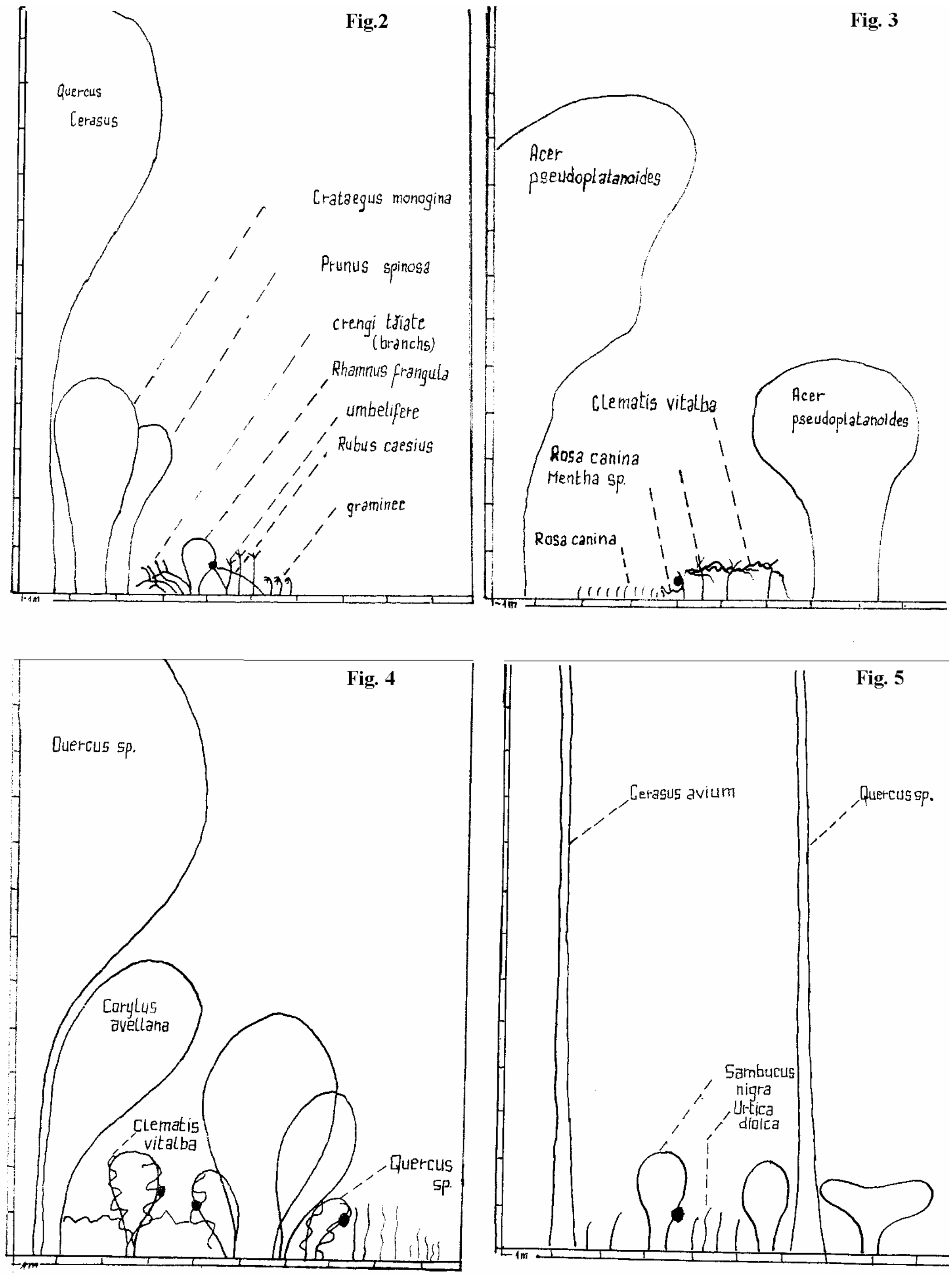
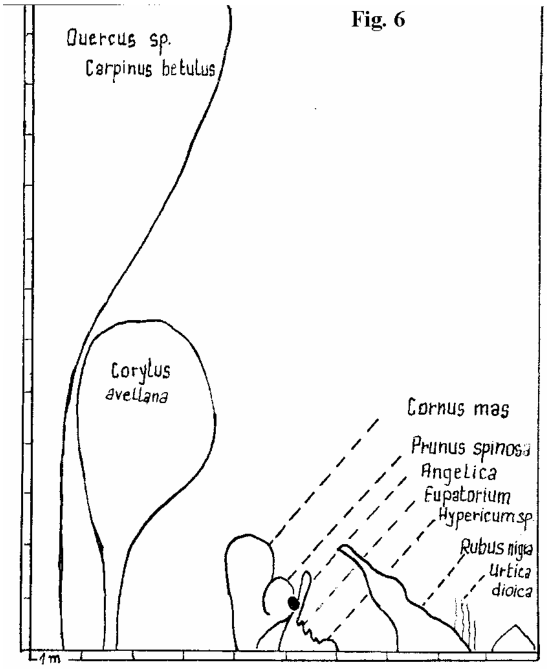
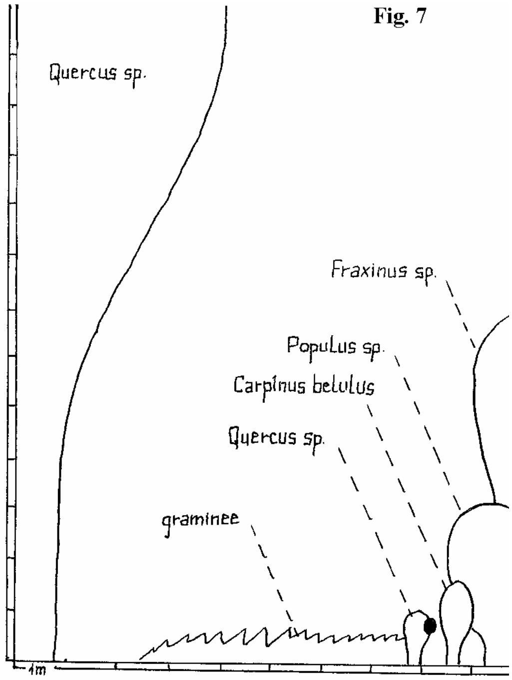



Fig. 2, 3, 4, 5: (2) A nest of Muscardinus *avellanarius* located in a clearing resulting from the cutting off of a specimen of *Cerasus avium* (original); (3) A nest of *Muscardinus avellanarius* on the edge of the Stejaru Forest (original); (4) *Muscardinus avellanarius* nests in an old clearing of the Stejaru Forest (1977), located in a damp clearing neighbouring the forest (original); (5) A *Muscardinus avellanarius* nest in a shrub of *Sambucus nigra*, inside the Stejaru Forest (original).



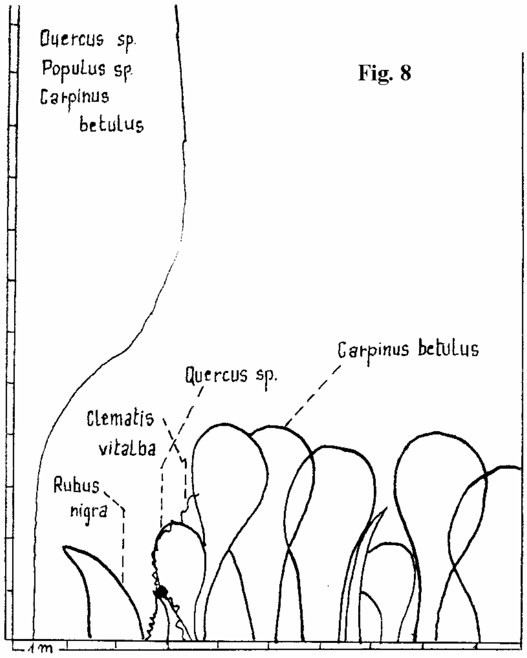




Fig. 6, 7, 8: (6) A *Muscardinus avellanarius* nest on the edge of the Hărănglab Forest (original); (7) A *Muscardinus avellanarius* nest on the border between the old clearing of the Stejaru Forest and the sparse forest, in September 1997 (original); (8) A *Muscardinus avellanarius* nest in the Biia Forest, found on the border between the clearing consisting of intermingling brushes and the sparse forest (original).

The clearings' middle is less damp than the forest and that is why it is usually avoided. The greatest number of nests can be found early in September and they are massively deserted by the end of the month, except for those inhabited by females with belated young (Stejaru and Biia forests, where 2 out of 6 nests were still inhabited on September 29, 1966).

The clearings appear after the trees are cut off for firewood or for other purposes. The tree felling is resumed every several years, in order to protect the saplings planted by man. Only the strong specimens are preserved in the old forest. Within a year of the cutting off, a vegetation starts growing consisting of shrubs of *Corylus avellana, Crataegus monogyna, Carpinus betulus* - all very vigorous - alongside other species of trees and brushes. The grassy vegetation is abundant, too, particularly in the first year and it is made up of *Urtica sp., Mentha sp., Agrostis vitalba, Hypericum perforatum*, as clusters, *Thymus sp., Clematis vitalba*, which soon grow among shrubs and bushes, *Medicago sativa* and other legumes.

The same day we also found here a female and 6 young, the nest being located on the branch of a *Cicuta sp.* We discovered a rare case on August 22, 1997 (Fig. 5), that is a tree nest located inside a sparse forest, in a *Sambucus nigra* bush. It sheltered 7 naked very young dormice. The female was not there when we found the nest. The nest was set 1.2 meters from the ground and it was badly hidden.

The situation in Hărănglab is probably the closest to the case described by Vincent van Laar (1979), as the young forest neighbours a fat pasture, often grazed by cattle. The dormice were caught here by means of metal traps, right at the bottom of the valley, which was damp - and the source of many springs - among which the stream of Bede, a tributary of the Târnava Mică River.

In all the cases the vegetation consisted of plant species that require damp soils (Fig. 6). The nests are located up to 30 meters away from the edge of the wood, but the average distance is 5 - 15 meters. The location of the nests at more than 3 meters from each other (ranging from 8 to 12 meters) is considered to be territorialism. Not all the nests are occupied. As the sprigs/branches grow, the phenomenon appears of shrub intermingling (Fig. 7), which is more apparent when the clearings are invaded by *Rubus fructicosus.* This results in the disappearance of the biotope convenient to *Muscardinus avellanarius.* As a consequence, the tree nests can also be found on the border between the forest and the clearings, where the branches of the trees in the clearing, growing towards the forest, are used as a support. We noticed this situation in an 8 - 10 year old clearing in the Biia Forest, in August 1996. The following examples also prove that the occurrence of *Muscardinus avellanarius* is, however, quite frequent (Fig. 8 and 9).

We have found dormice in tree-hollows, up to 200 meters away from the edge of the forest. M. Ene and H. Almăşan (1964) mentioned their presence in the nests set up for the birds. In 1981, they were noted to have made their nest in the hay placed in a deer manger in the Hărănglab Forest. They can sometimes be found under the logs in the forest and even inside the food-cans.

By examining these situations we can but note their variety, which explains the abundance in this kind of dormice, as compared to the other representatives of the family.

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