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Ecology of River Valleys

Edited by

László Gallé and **László Körmöczi**

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Introduction

Similarly to other sciences, the history of ecology consists of different periods. These periods could be characterized by scientific fashions, such as the so-called „ecosystem approach" in the era of International Biological Program, or the evolutionary and behavioural ecology in the turn of '80s and '90s, last century. These preferred topics, however, are not only scientific fashions, but they are brought about by theoretical or practical necessities, too. The alternation of population and community level approaches is very apparent example of the periodical changes in topics as a consequence of theoretical requirements. In the great periods of the community ecology, in the 1910s, 1950s and 1980s, when the composition and structure of many communities were described with more and more sophisticated methods, it turned out that too little was known about the mechanisms behind the community patterns. That is why these periods were followed by mechanistic, usually population level approaches, which, already equipped with deeper knowledge of the mechanisms, catalyzed the further development of community studies, and so on.

Another couple of alternating approaches is that of the equilibrium and non-equilibrium paradigms. In this case, since the scientists prefer to see „rules" in the nature, the equilibrium concepts have been more widespread, and show organic development from the classical Clementsian and Lotka-Volterra approaches to the recent population, community level studies and system models. Although the non-equilibrium theories are not at all new, their history is more disjunct. Recently, they have a renaissance, because it has been clear that a considerable part of dynamic community processes, which are important mechanisms of both degradation and recovery, therefore they are of utmost significance for nature conservation and environmental protection, cannot be understood on the basis of so-called equilibrium concepts. In this case, the practical issues are at least as important as the theoretical ones.

The third cluster of conceptual questions is the appropriate selection of the spatio-temporal scales of the ecological researches. The ecological scenario of the last half century has clearly demonstrated that the mechanistic and the causal backgrounds of the biotic phenomena cannot be explained exclusively on the basis of traditional short-term studies at habitat spatial scales. The studies moved into both directions, toward finer and larger spatio-temporal scales. The microcosm studies and the information theoretical analysis of vegetation-level patterns via micro quadrates provide examples for finer scale approaches, whereas the enlarged scale is well demonstrated by the recent development of the long-term programs, the island ecology, the metapopulation biology, the metacommunity researches and the landscape ecology. The large-scale, landscape or regional level ecological approach (sometimes referred to as macroecology) has a lot of possibilities in conservation applications (e.g. ecological corridors, econets, river corridors and other programs). This has been well recognized by a lot of authorities, and the Eu-region programs provide suitable basis for regional, cross-border cooperation in ecology and nature conservation.

The ecological researches in river valleys are concerned by all of the above issues, as seen in the chapters of the present volume, based on the presentations of the symposium "Ecological research in river valleys (Eu-region conference)". The majority of papers performs syncentric and/or biotic (faunistic and floristic) approaches, with the exception of the paper by Báldi *et al.* (Ch. 1.1.) on the distribution of four bird species in Szigetköz flood plain affected by the water regime changes. Though we expect a non-equilibrium dynamics in the majority of river aquatic communities (e.g. different plankton assemblages), very few papers are dealing with non-equilibrium dynamics (e.g. Sárkány-Kiss, Ch. 1.6.) although some of them are concerned by human or natural disturbances (e.g. Kisbenedek, Ch 1.9., Bába, Ch 1.10.). An apparent example of the man-made habitat destruction by water management is the hydroelectric power station on River Danube, which caused a reduction of the water supply in the Szigetköz region to 10 p.c. of its original value (Báldi *et al.*, Ch 1.1., Kisbenedek, Ch 1.9., Szabó and Molnár, Ch 1.4.). The high number of the papers on water quality is not surprising, because it is one of the most problematic issues in river ecology. The water qualification from different (biological, chemical et.) aspects is a theoretically problematic issue itself and Gôri *et al.* (Ch 2.1.) give a good example on the complex ecological classification. Other contribution in this topic are mainly dealing with the quality of water in particular areas (Brankovic and Budakov, Ch 3.10., Djukic *et al.*, Ch 3.6., Lakatos *et al.*, Ch 2.2., Matavuly *et al.*, Ch 3.8., Ötvös *et al.* Ch 3.9., T. Nagy *et al.*, Ch 3.1., Teodorovic *et al.*, Ch 3.7.).

The current environmental catastrophe caused by the cyanide pollution of river Tisza highlighted the role of oxbow lakes as potential sources of recolonization of different species populations. This is an additional importance of the oxbow lakes besides their other, well known conservation values. Therefore, the studies on these water bodies are of great significance (Braun *et al.*, Ch 3.5., Lakatos *et al.*, Ch 2.2., Szilágy *et al.*, Ch 3.2.). The establishment of Tisza dam and the reservoir at Kisköre was disputed by a lot of hydrobiologists and ecologists. The reservoir, however, having similar conditions to the state of the river before regulation, was not so vulnerable to cyanide pollution than the other part of the river. This fact does not provide enough basis to support the establishment of newer and newer hydroelectric power stations and reservoirs, but it underlines the necessities of the hydrobiological research of the reservoir, which is given by Kiss *et al.* (Ch 3.3.) and Zsuga *et al.* (Ch 3.4.). We think that the scientific experiences on the ecology of oxbow lakes, channels and the reservoir contribute to the theoretical foundations of the reconstruction of Tisza valley into such state, which improves the resistance of the systems against pollution and high floods, and which is similar to the river before it had been regulated.

River valleys are landscape-level complexes of zonations along the rivers. The habitat strips which are the components of this complex, form interactive systems, therefore the natural history of river valleys cannot be understood without studies on the terrestrial and wetland habitats of the flood plains (Bába, Ch. 1.10., Báldi *et al.*, Ch 1.1., Gallé *et al.*, Ch 1.3., Horváth and Wagner, Ch 1.7., Kisbenedek, Ch 1.9., Majer, Ch 1.5., Margóczi *et al.*, Ch 1.2., Szabó and Molnár, Ch 1.4.). We also emphasize the significance of landscape-level researches for the same reason (Gallé *et al.*, Ch 1.3., Horváth and Wagner, Ch 1.7., Margóczi *et al.*, Ch 1.2., Szabó and Molnár, Ch 1.4.), which could be developed into regional level projects (e.g. Gallé *et al.*, Ch 1.3. and Margóczi *et al.*, Ch 1.2. are the first publications of such a project).

Although it was thought some decades ago that the biological researches in river valleys have been over their descriptive periods in the region, current results show that there are a lot to do in this field, too. These descriptive studies, which are represented by the papers of Bába (Ch1.10.), Margóczi *et al.* (Ch 1.2.), Pekli and Zsuga (Ch 4.4.), Popovic *et al.* (Ch 4.3.), Szabó (Ch 1.11.), Szitó (Ch 4.2.) and Tóth *et al.* (Ch 1.8.), contribute to the knowledge of the flora, fauna and ecological communities of the river valleys and provide foundations for the further, detailed analysis and for the nature conservation.

We hope that this volume, besides documenting the current results of the regional ecological researches, will stimulate further cooperation of the ecologists interested in the fascinating world of the ecology, natural history, conservation and hydrobiology of river valleys.

Szeged, March 2000

László Gallé and László Körmöczi

Chapter 1

Community and population ecology

1.1. RELATIONSHIP BETWEEN THE DISTRIBUTION OF FOUR BIRD SPECIES AND THE WATER REGIME CHANGES IN THE SZIGETKÖZ FLOODPLAIN AREA OF RIVER DANUBE

Báldi, A., Moskát, Cs. and Zágon, A.

1.1.1. INTRODUCTION

Riparian areas are among the most productive and richest terrestrial habitats (Báldi *et al.* 1995). However, 77% of river systems in the northern third of the world are significantly affected by human activities (Dynesius and Nilsson 1994). Thus, riparian landscapes are probably among the most threatened landscapes in the world (Décamp 1993).

River Danube at the Slovakian - Hungarian border suffers from a regional scale human disturbance, namely a large hydroelectric power-station was built. The implemented plan of the reservoir and hydroelectric power-station included the construction of a 35 km long artificial bypass canal (including the reservoir), parallel with the Danube. The original river has been received approximately 10% of its natural water regime, thus the upper parts of the Szigetköz suffered from serious water deficiency (Báldi *et al.* 1998).

Monitoring of changes of biodiversity in the Szigetköz is a key task of several Hungarian and Slovakian institutions. The monitoring work of birds in Hungary included community approach in different habitats and using different methods (Báldi 1995, Moskát *et al.* 1999), and a faunal mapping approach (Báldi *et al.* 1998). In this paper we evaluate the results of the faunal mapping technique to document the frequency of occurrence of bird species in the affected areas. In the present short paper we intend to demonstrate the changes of the avifauna, using four indicator species.

1.1.2. STUDY AREA AND METHODS

The Szigetköz is the floodplain on the right side of the River Danube in NW Hungary ($48^{o}00'$-$47^{o}40'$N, $17^{o}15'$-$17^{o}45'$E), consisting of many small islands, side- and dead-branches. The area is managed by the forestry, more than two-third of the area was planted with poplar (*Populus* sp.) plantations (Simon 1992). The River was diverted in late 1992, and a water replenishment system was built in 1995 to artificially provide water for the Upper Szigetköz. An extensive inventory of bird species nesting in the Szigetköz area was conducted by one of us (A. Z.) during the breeding season of 1994, 1996 and 1998. All bird presences were recorded in 62 quadrates of 1x1 km each. The quadrates formed three clusters: 22 in the desiccating Upper Szigetköz near Dunasziget; 22 in the transition zone, Middle Szigetköz, at Ásványráró; and 18 in the Lower Szigetköz, over Vámosszabadi, where the bypass canal already rejoins the river (cf. Báldi *et al.* 1998). See more details in Moskát and Fuisz (1995), Waliczky (1992).

The distribution of four species was analysed: the Common Sandpiper (*Actitis hypoleucos*), which prefers river banks, gravel shores; the Sedge Warbler (*Acrocephalus schoenobaenus*), a characteristic species of reedbeds and marshlands; the Great Reed Warbler (*A. arundinaceus*), which prefers reed/water edges; and the Coot (*Fulica atra*), a common species of open water, but avoids running waters. Considering the different habitat requirements of these four wetland species (Haraszthy 1998), we assume that they together may indicate most water regime changes.

1.1.3. Results and discussion

The faunal mapping method proved to be a sensitive technique for monitoring at the regional scale, and in heterogeneous landscapes (Báldi *et al.* 1999, Moskát *et al.* in press). The distribution of the four selected species showed characteristic patterns. The Common Sandpiper was frequent in the Upper and Middle Szigetköz after the diversion of the main flow, probably due to the large extent of drying gravel river beds (Báldi *et al.* 1998), but after the water replenishment system was built, and the water level increased in many of the canals and branches, its frequency declined (Fig. 1). The frequency of the Common Sandpiper in the Lower Szigetköz was low, and did not show any changes from 1994 to 1998.

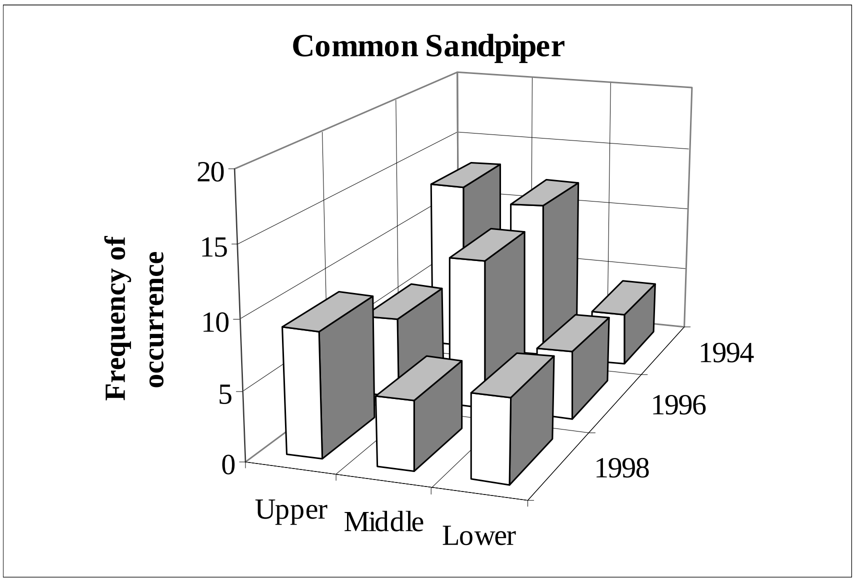

Fig. 1. The frequency of occurrence of the Common Sandpiper (*Actitis hypoleucos*) in the three study years in three study areas in the Szigetköz region.

The frequency of Sedge Warbler was low in the Upper Szigetköz in 1994, when most of the suitable habitats dried out (Fig. 2). In the Middle and Lower Szigetköz, however, it still performed well. Immediately after the water replenishment system started to work, its distribution was homogenous across the Szigetköz, but in 1998, its frequency pattern was the opposite to that observed in 1994: low frequency in the Lower Szigetköz, and large frequency in the Middle and Upper Szigetköz. This was probably the consequence of the very high water level due to the water replenishment system, and the lot of precipitation, which changed the structure of reedbeds and landscape to a non-optimal habitat for the Sedge Warbler.

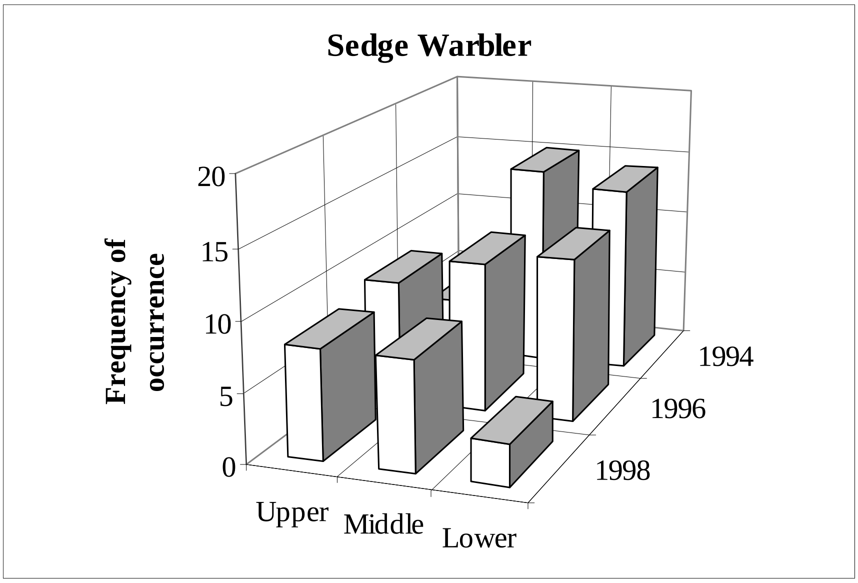

Fig. 2. The frequency of occurrence of the Sedge Warbler (*Acrocephalus schoenobaenus*) in the three study years in three study areas in the Szigetköz region.

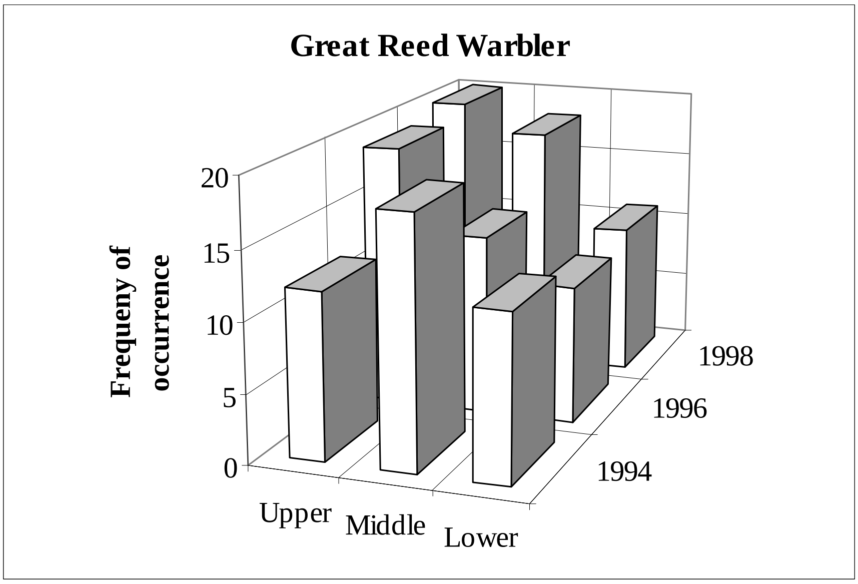

Fig. 3. The frequency of occurrence of the Great Reed Warbler (*Acrocephalus arundinaceus*) in the three study years in three study areas in the Szigetköz region.

The occurrence pattern of the Great Reed Warbler did not show any trend in 1994, but it preferred the Upper Szigetköz both in 1996 and 1998 (Fig. 3). This result is in accordance with the observation of the Sedge Warbler, a closely related species, and connected with the disappearance of reed and marshland habitats from the Lower Szigetköz. In the Upper Szigetköz, the water replenishment system turned the floodplain to a near optimal Great Reed Warbler habitat, with a general dry landscape, with many deep water canals and water courses with narrow elongated reedbeds.

The Coot, a nationally common and abundant species was regionally rare in 1994, when most water courses were totally, or partially dried out (Fig. 4). It was absent from the Lower Szigetköz in the two surveys in 1996 and 1998, probably as the consequence of high and rapidly flowing waters, caused by the new water replenishment system. In the Middle and Upper Szigetköz, however, its frequency largely increased after the water replenishment and precipitation filled up the canal and branch systems.

We demonstrated that changes of the water regime modified the distribution pattern of four wetland species in a species-specific way. Thus, any human disturbance is a potential threat to wildlife. Because river valleys are important habitats and movement corridors for many valuable species (Gallé *et al.* 1995), canalisation, dam construction and other disturbances should be avoided.

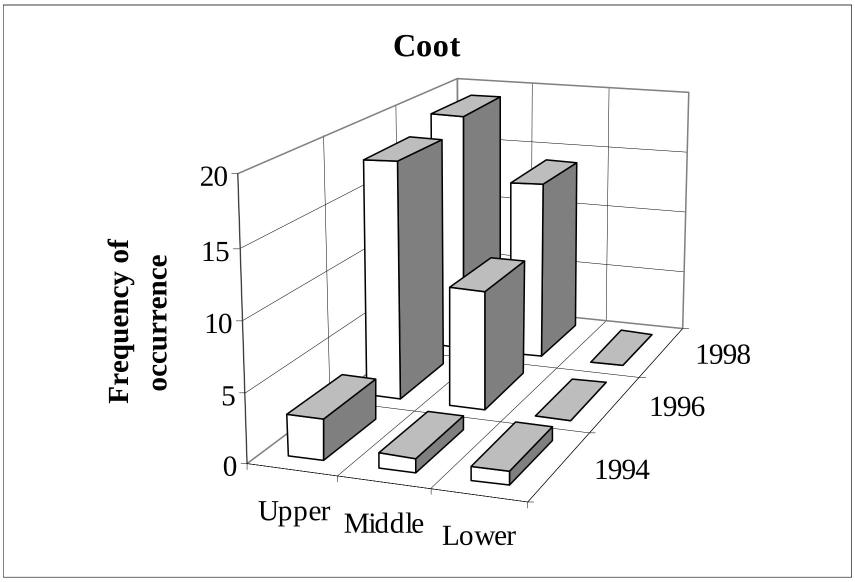

Fig. 4. The frequency of occurrence of the Coot (*Fulica atra*) in the three study years in three study areas in the Szigetköz region.

1.1.4. SUMMARY

We investigated the changes of occurrence frequency of four wetland bird species in the Upper, Middle and Lower Szigetköz areas, where the water regime differed due to the construction of a bypass canal for a hydroelectric power-station. The four species showed habitat selection-specific responses to the environmental changes.

1.1.5. ACKNOWLEDGEMENTS

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1.2. VEGETATION DESCRIPTION OF REPRESENTATIVE HABITAT COMPLEXES ALONG THE MAROS (MURES) RIVER I. THE UPPER SECTION (VASLÁB/VOSLOBENI)

Margóczi, K, Dragulescu, C. and Macalik, K.

1.2.1. Introduction

East and Central European rivers and related habitats play an important role in maintaining the biological diversity of the biogeographical regions, not only because of their corridor function, but being rich core areas of ecological networks (Gallé *et al*. 1995, IUCN 1995). European policy toward flood control is being revised, and provides major opportunities toward nature development or restoration (PEBLDS, 1996). Detailed identification and description of still existing natural or semi natural habitat complexes is necessary to planning conservation strategies, or restoration programs of deteriorated riverine habitats.

The Maros River with its 768 km length is the most important tributary of the Tisza River. It csosses several relief features with varying lithological structures and its valley include several various habitat complexes with rich flora, fauna and diverse vegetation. This study is the first piece of a series dealing with the most important natural habitat complexes representing the whole river valley.

Since 1991 Hungarian and Rumanian non-governmental organizations has started interdisciplinary research to assess the common river's environmental condition (Hamar and Sárkány-Kiss, 1995). On the base of this pilot research representative, and highly natural areas has been selected for more detailed scientific investigations. This paper describes the riverine vegetation of the Giurgeu (Gyergyói) basin related to the upper segment of Maros River.

Dragulescu (1995) presents an enumeration of the flora and vegetation of Mures river valley. He refers 1846 taxa of plants, 174 plant associations, and points out, that the Maros valley is now moderately degraded by human activity. The rate of degradation increases from the springs to the river mouth. The peat bogs and swamps on the upper river section (in the Giurgeu (Gyergyói) basin) must be protected and preserved by all means for their floristic,-phytocoenologic and landscape values.

1.2.2. Geographical features of the study area

The spring of the river is at 856 m above sea level, than the river steps in a large, poorly drained quaternary subsidence zone, surrounded by a mountain area built of silicate metamorphic rocks on the right valley slope, and volcanic, andesitic rocks on the left slope (Jakab, 1995). A considerable part of the active flood plain is covered by a thick organic matter layer, partly transformed into peat or peaty soil. Their existence is due to a permanent water supply from several left side mountain stream affluents, that maintain a high groundwater level (Jakab, 1995).

1.2.3. Materials and Methods

The study area is situated south from Vasláb (Voslobeni) village. The Maros is narrow and shallow here, at 12 km from its spring. Some other small streams flows through an (about 6 km^2) highly natural area, with two peat bog patches, swamps, mown meadows and pastures. The lower edge of the mountain spruce forest is the border of the riverine habitat.

Cenological relevés were made in representative stands of the seven main habitat types. The percent cover of each plant species were recorded in 5x5 m quadrates, altogether 31 such relevés were evaluated and analysed by principal component analysis (SynTax program package by Podani, 1993). The nomenclature and identification of plant associations are according to Borhidi and Sánta (1999) and Sanda *et al.* (1980).

The spatial pattern of habitats were sampled by two transects, 3 km long each, running from the river bank to the foot of the mountain. Along this transect the border of different plant associations were recorded.

Table 1. Spatial arrangement of plant associations along the first transect running from the Maros to the foot of the mountain.

Zone	Plant associations	width (m)	Distance from the Maros (m)
	Maros River		0
Wetland	*Salicetum albae - fragilis*	5	5
Wetland	*Carici flavae - Eriophoretum*	100	105
Meadow	*Agrostio-Deschampsietum caespitosae*	120	225
Wetland	*Scirpetum sylvatici*	20	245
Wetland	*Caricetum rostratae*	100	345
Wetland	*Molinietum (Trollius europaeus facies)*	60	405
Wetland	*Salicetum cinereae - Sphagnaetum*	90	495
Wetland	*Carici rostratae - Sphagnaetum (Picea excelsa)*	30	525
Wetland	*Piceaetum x Betuletum x Phragmiteteum*	90	615
Wetland	*Caricetum paniculatae (Picea excelsa)*	60	675
Wetland	*Molinietum (Picea excelsa)*	100	775
Wetland	*Betulo pubescenti - Sphagnetum*	40	815
Wetland	*Alnetum incanae*	20	835
Wetland	*Filipendulo-Geranietum palustris*	30	865
Meadow	*Succiso - Molinietum*	440	1305
Meadow	*Alnetum incanae -spiraeaetosum salicifoliae*	3	1308
Meadow	*Molinietum coeruleae deschampsietosum*	680	1988
Meadow	*Agrostio - Deschampsietum festucetosum rubrae*	350	2338
Meadow	*Juncetum conglomerati - effusii*	300	2638
Meadow	*Juncetum X Eriophoretum*	60	2698
Transitional	*Nardo - Festucetum rubrae*	40	2738
Transitional	*Juncetum conglomerati - effusii*	60	2798
Transitional	*Nardo - Festucetum rubrae*	30	2828
Transitional	*Juncetum conglomerati - effusii*	50	2878
Transitional	*Nardo - Festucetum rubrae*	70	2948
Dry pasture	*Agrostio - Deschampsietum festucetosum rubrae*	50	2998
Dry pasture	*Agrostio-Festucetum rubrae*	300	3298
Forest	*Vaccinio - Piceaetum*	~	

1.2.4. Results

1.2.4.1. Characterisation of main habitat types

1.2.4.1.1. Peat bog (Carici stellulatae (echinatae)-Sphagnetum, Carici rostratae - Sphagnetum, and Carici flavae-Eriophoretum)

There are two, about 60 m diameter peat bog patches on the area. In the central part of the bog the peat moss layer is thick under the sparse spruce tree stand. The percent cover of the peat moss *(Sphagnum recurvum, Sph. teres, Sph. platyphyllum)* is 70-80%. The habitat is very patchy, the recorded three plant associations form a rather small scale mosaic. In *Carici stellulatae (echinatae)-Sphagnetum,* and *Carici rostratae - Sphagnetum* association the dominant species is the *Carex rostrata.* Other typical species with 5-10% cover are *Betula pendula, Betula pubescens, Ligularia sibirica, Drosera rotundifolia, Selinum carvifolia, Valeriana simplicifolia.* Here occures the rare *Pedicularis sceptrum-carolinum.* The central sparse spruce stand is surrounded by *Salix cinerea* and *Alnus incana* shrub. The *Carici flavae-Eriophoretum* association has similar species composition, but the dominant species is *Eriophorum latifolium.*

1.2.4.1.2. Sedge meadow (Caricetum rostratae)

The stand is dominated by *Carex* species. Occurrence of trees and shrubs (*Betula pubescens, Salix cinerea, Salix pentandra)* is typical, sometimes only on the grass layer. The following *Molinion* and *Caricion* species belongs to this habitat: *Ligularia sibirica, Polygonum bistorta, Trollius europaeus, Parnassia palustris, Eriophorum latifolium, Cirsium rivulare.* The moss layer is rich, *Sphagnum* species occurs as well. *Polemonium coeruleum population* is a particular natural value of the habitat. *Filipendula ulmaria,* and *Geranium palustre* are common with the next habitat.

1.2.4.1.3. Flowery mire (Filipendulo-Geranietum palustris)

Not very species rich (17-20 species on 5x5 m), but very nice colourful association with colourful (yellow. red, white) flowers. The typical name giving species are *Filipendula ulmaria,* and *Geranium palustre, Carex elata* forms big tussocks. Other characteristic species: *Senecio palludosus, Lysimachia vulgaris, Lythrum salicaria, Selinum carvifolia.* Particular value is *Spirea salicifolia*

1.2.4.1.4. Rush meadow (Caricetum flavae juncosum subnodulosi)

Juncus subnodulosus is the dominant species. Several sedge species are characteristic and codominant as well (*Carex flava, C. leporina, C. buxbaumii, C. panicea, C. stellulata (=echinata)).* This stand is rich in *Molinion* element, such as *Trollius europaeus, Veratrum album, Geum rivale, Filipendula ulmaria, Achillea ptarmica, Gladiolus imbricatus, Valeriana dioica, Serratula tinctoria, Succisa pratensis, Selinum carvifolium.*

1.2.4.1.5. Moor meadows (Molinietum coeruleae)

This grassland has a great extent in the studied area, their stands are diverse and species rich. *Molinia coerulea* is the dominant grass species, *Succisa pratensis, Carex hartmanii, C. stellulata, C. panicea, C. flava, Juncus conglomeratus, Salix rosmarinifolia, Potentilla erecta, Genista tinctoria* are the most frequent and characteristic species. Owing to higher grazing pressure *Agrostis stolonifera*, *Deschampsia caespitosa*, and *Nardus stricta* may overgrow *Molinia coerulea.* Several *Molinion* element occures: *Achillea ptarmica, Serratula tinctoria, Iris sibirica, Gladiolus imbricatus, Dianthus superbus, Dactyloriza majalis, Gentiana pneumonanthe, Trollius europaeus, Veratrum album.*

1.2.4.1.6. Wet pasture (Agrostio - Deschampsietum caespitosae)

Perhaps grazing played important role in developing this grassland. The name giving species are dominant, also abundant species are *Potentilla erecta, Genista tinctoria, Ranunculus acris.* several *Molinion* species survive the grazing pressure: *Carex flava, Achillea ptarmica, Salix cinerea, S. pentandra, S. rosmarinifolia, Serratula tinctoria.* The species of dryer mountain meadows occurs frequently: *Betonica officinalis, Alchemilla vulgaris, Briza media, Festuca rubra, Nardus stricta.* There are different transitional stands to the direction of *Agrostio - Festucetum rubrae* .

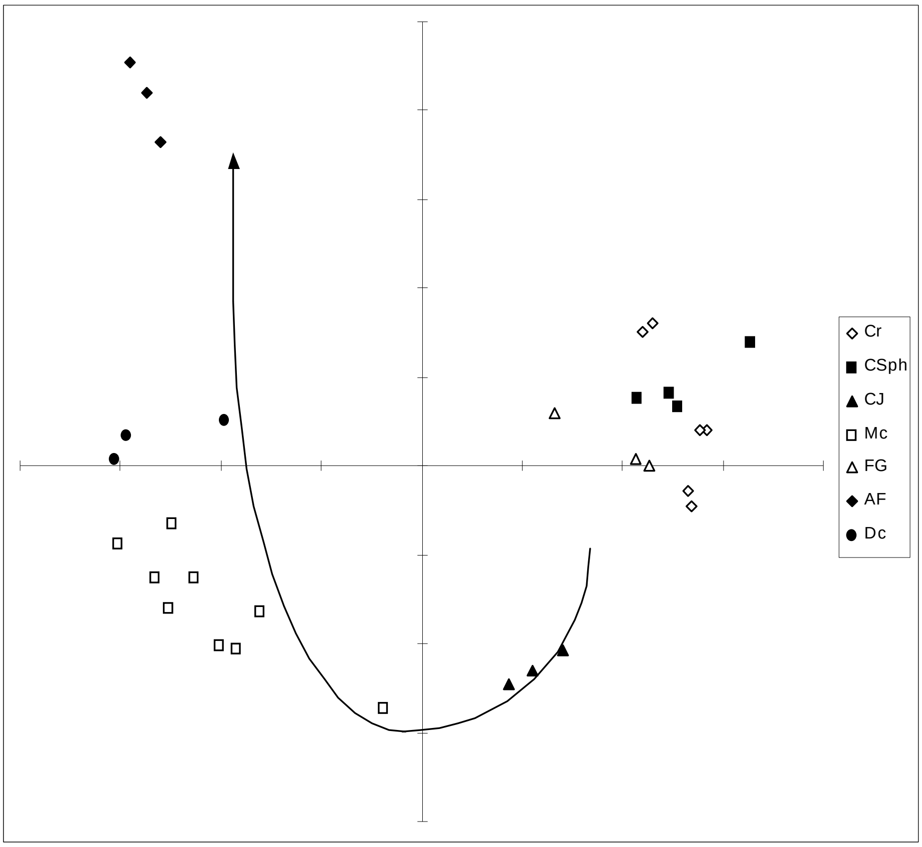

Fig. 1. Principal coordinate analysis of the relevés according to the floristic composition (using Jaccard index). The groups of points, representing the same associations are settled along a line running from wet areas to the dryer places (see the arrow). Abbreviations: *Carici stellulatae and rostratae-Sphagnetum* (Csph), *Caricetum rostratae* (Cr), *Filipendulo-Geranietum palustris* (FG), *Caricetum flavae juncosum subnodulosi* (CJ), *Molinietum coeruleae* (Mc), *Agrostio - Deschampsietum caespitosae* (Dc), *Agrostio - Festucetum rubrae* (AF).

1.2.4.1.7. Dry pasture (Agrostio - Festucetum rubrae)

This is the most species rich habitat type, 35-37 species are within 5x5 m. Very nice mountain meadow with full of flowers. I occurs at the foot of mountains, under spars spruce stands and on hills, emerging from the moor meadow zone. *Agrostis tenuis* and *Festuca rubra* are dominants, *Achillea millefolium, Briza media, Centaurea phrygia, C. scabiosa, Rhynanthus minor, Phleum pratense, Leontodon autumnalis* are also frequent and abundant. Such species of the mesophyllous mountain meadows as *Anthoxanthum odoratum, Cynosurus cristatus, Knautia arvensis, Pimpinella saxifraga, Gentianella lutescens, Campanula patula, Helianthemum nummularium, Thymus pulegoides, Anthyllis vulneraria, Trifolium spp.* belong to this habitat type.

1.2.4.2. Similarity analysis of habitat categories (Fig.1.)

The relevés are settled along a line from wetlands to dryer habitats. Three main groups are formed: (1) wetlands, characterised mainly by Carex species. *Carici stellulatae and rostratae-Sphagnetum* (Csph), *Caricetum rostratae* (Cr), and *Filipendulo-Geranietum palustris* (FG) relevés belongs to this group, (2) meadows, dominating by purple moor-grass *Molinietum coeruleae* (Mc), and (3) dry pasture *Agrostio - Festucetum rubrae* (AF). *Caricetum flavae juncosum subnodulosi* (CJ) association has in transitional position between the wetland and meadow groups. *Agrostio - Deschampsietum caespitosae* (Dc) relevés are transitional as well between the meadow and dry pasture groups.

1.2.4.3. Spatial pattern of habitat categories

The distance of the centre of the two peat bog patches from the Maros river are 600 and 1000 m. The diameter of the wetland area is about 600 m. Inside this area the vegetation is very diverse, the identificated 11 associations form a mosaic like pattern with an average of 50 to 100 m patch diameter. In the meadow zone the patches are larger, cover about 200 to 300 m sections along the transect. Only the *Nardo-Festucetum rubrae* and *Juncetum conglomerati-effusi* patches alternate by 30 to 50 m within this zone. The meadow zone is the widest, 2200 and 1400 m along the first and second transect respectively. It is situated between the wetland patches and the foot of the mountains.

1.2.5. Discussion

The studied habitat complex is a special riverine area. The Maros river is not unambiguously the axis of the walley, but together with the other streams a fan shape network develops. The streams provide a permanent water supply for developing of peat bogs and related wetlands. The words bog, fen, moor, swamp, mire indicates different types of special wetlands and meadows, but the scientific classification and public name does not meet unambiguosly. Classification of such wetlands is possible according to their origin, morphology, structure, hidrology, nutrient content and vegetation. Lájer (1996) suggested a classification, regarding all of the above considerations. His 1.1.3. topogen, flood plain fen category fits rather good to the studied habitats, where the water dinamic of the river drive the development of the vegetation. Such type of wetlands are very rare in Hungary, for most of them have been drained, and converted into agricultural fields. This study shows what kind of natural values have been lost because of drainage and river regulation.

The selected seven habitats represents well the whole habitat complex ranging from the peat bog to the dry pasture. The spatial pattern investigation and the multivariate analysis of relevés correlates rather well. The three habitat groups separated by principal component analysis have different spatial locations as well. The most possible background factor of habitat group differences is the water content of the soil, which mainly depends on the micro or meso relief differences.

The vegetation of studied area is very rich and divers. Most of the plant species are natural, very few weeds and disturbance indicator species occures in this area. The structure and pattern of plant associations seems to be undisturbed as well. The present human use of the grasslands, that is moderate grazing and mowing, do not endanger considerably the natural values.

1.2.6. Summary

Habitat complexes along the river valleys are important elements of ecological networks. Preservation of remained riverine natural habitats deserves special attention. The aim of this study is identification and description of representative habitat complexes along the most important tributary of the Tisza River. The first selected area is in the Giurgeu (Gyergyói) basin. This paper gives cenological description of seven representative habitats of this area, and reveal their spatial pattern by transect method. The several different vegetation types can be grouped into three groups according to their floristic composition and spatial arrangement as well: wetland area (mainly *Carici stellulatae and rostratae-Sphagnetum*, *Caricetum rostratae*, *Caricetum flavae juncosum subnodulosi*, and *Filipendulo-Geranietum palustris*), meadow zone (*Molinietum coeruleae* and *Agrostio - Deschampsietum caespitosae*), and dry pasture *Agrostio - Festucetum rubrae.*

The vegetation of studied area is very rich and divers. The composition and pattern of plant associations seems to be rather undisturbed. The present human use of the grasslands, that is moderate grazing and mowing, do not endanger considerably the natural values.

1.2.7. Acknowledgement

This study was supported by the grant (No. 1-0379/98) of the Hungarian Nature Conservation Office (Ministry of Environment).We would like to thank to Professor László Gallé, the leader of the whole program and Dr. Endre Sárkány-Kiss from the Babes-Bólyai University, who organized the field work. We are grateful to local people who let us have their cottage for use and gave us manifold help during the field work.

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1.3. HABITAT CORRELATES OF GROUND INVERTEBRATE ASSEMBLAGES IN A FLOOD PLAIN LANDSCAPE COMPLEX

Gallé, L., Gallé, R., Markó, B., Mikó, I. and Sárkány-Kiss, A.

1.3.1. Introduction

The wide recognition of the significance and the threat of biodiversity has drawn the attention to the study of ecological communities on both habitat and landscape level (cf. Tilman 1999). River valleys are regarded as agents in the maintenance of biodiversity both as core areas and stripe-like habitat complexes („ecological corridors”), which promote the migration and distribution of floral and faunal elements (Gallé et al 1995) and therefore they are important elements of so called ecological networks or econets (Nowicki et al 1996). Instead of slogans and general description of the landscape types by the rivers, however, detailed studies are necessary to reveal real ecological structure and processes of river valleys.

This paper presents a part of a complex regional project on river Maros/Mures. The aim of this research is to reveal the patterns of animal and plant communities from very small, within habitat scale (e.g. vegetation of ant mounds, distribution of ant individuals as a function of the distance from the top competitor's nest) to a regional level (e.g. distribution of different species and/or assemblage types along the whole river valley). Here we present our first results on the ground invertebrates (ants, ground and Staphilinid beetles and spiders) at the middle, i.e. between habitat scale within one landscape (for the first botanical results see Margóczi et al, this volume). The following questions are addressed: (1) What is the composition of ground invertebrate macrofauna in different habitat types at Upper-Maros valley? (2) How do different invertebrate assemblages indicate the diversity of habitat types within a landscape? (3) Which habitat attributes are correlated with the composition of ground invertebrate assemblages?

1.3.2. Materials and methods

Field studies were carried out in the Gyergyói medence at upper Maros/Mures region. A detailed sampling program was conducted in seven habitats: (1) peat-bog (*Carici stellulatae (echinatae) — Sphagnetum, Carici rostratae — Sphagnetum and Carici fluvae — Eriophoretum*); (2) wet meadow (*Molinietum coeruleae*); (3) a drier peat-bog (*Caricetum rostratae*); (4) wet bog-meadow (*Caricetum rostratae*); (5) wet pasture (*Agrosti — Deschampsietum caespitosae*); (6) mooreland bushy forest and (7) drier meadow (*Agrosti — Festucetum rubrae*).

We employed pitfall traps to sample ground surface animals. Traps were plastic jars with 6 cm diameter, with ethylene glycol preservative. Fifteen traps were used at each site, which were arranged in a grid with at least 5 m distance between the neighboring ones. The sampling period lasted for nine days in July. As an additional method, we carried out hand sampling, too, but in the present paper we restrict our evaluation to the data of pitfall samples.

For the characterization of the habitats, we used 177 scores grouped in three groups (Table 1): habitat architecture (19 scores), vegetation composition (155 scores) and soil (3 scores).

Table 1. Habitat attributes for characterization of study plots

Group	Attributes	No of categories
1. Habitat architecture (19 scores)	1.1. moisture degree	1
	1.2. total cover of higher plants, mosses and debris	3
	1.3. moss and debris thickness	1
	1.4. vegetation cover at 0-5, 5-15, 15-30 ..... 100-300, >300 cm	8
	1.5. maximum heights of plants	1
	1.6. no of stones	1
	1.7. no and condition of twigs on the ground	2
	1.8. heighth and cover of moss mounds	2
2. Vegetation composition	2.1. coverage of higher plant species	155
3. Soil	3.1. different soil parameters (pH, hardness, water content)	3

The community-level indication of habitat differences by the ground invertebrate assemblages was assessed with principal coordinate analysis (PCoA) and Bray-Curtis distance function (sometimes referred to as Czekanowski distance, Podani 1997, Tóthmérész 1993) between habitats computed on the basis of different assemblages. The external correlates of the studied assemblages were established with Spearman rank correlation of the between-habitat Bray-Curtis similarity matrices of the invertebrate assemblages and the habitat score groups. To avoid the consequences of the cross-correlation of the composed statistical tables, we employed Bonferroni corrections of the significance levels.

1.3.3. Results

1.3.3.1. Generalists and specialists

No absolute generalist ant was found, which occurred in all habitats. *Myrmica scabrinodis* Nyl. and *Lasius platythorax* Seifert were present in six out of seven habitats, whereas several ants occurred exclusively at site 7: *Formica rufibarbis* F., *Lasius paralienus* Seifert and *Myrmica schencki* Em., however these species cannot be regarded as specialist elsewhere, in this case rather the range of the surveyed sites was special. From the spiders, *Pardosa pullata* (Clerck) was found at every site but one, while Pardosa palustris (L.) and *Trochosa spinipalpis* (Pickard Cambridge F.) lived at sites 7 and 1, respectively. The latter one is typical bog-specialist. The absolute generalist beetle was *Drusilla canaliculata* (F.) occurring at every site. Although *Harpalus affinis* (Bach.) and *Pterostichus niger* Schall. were of more restricted distribution, in one and two habitats, respectively, they cannot be regarded specialists either.

1.3.3.2. Indication of habitat differences

On the basis of the community-level distances, the vegetation is the most sensitive indicator of the site differences (Table 2). Ground beetles have high distance values, too. Wolf spiders perform the lowest distance average, but the great coefficient of variation indicates a clustering tendency in habitat differentiation. All values are higher than those of the habitat attributes, but do not differ markedly from the values of random references.

Table 2. Average distance and their coefficient of variation between habitats on the basis of habitat attributes, vegetation and different ground invertebrates

	Habitat attributes	Random reference	Vegetation	Ants	Wolf spiders	Ground beetles
Mean distance	0.60	0.75	0.88	0.76	0.68	0.86
S.D./mean distance	0.36	0.21	0.24	0.25	0.47	0.18

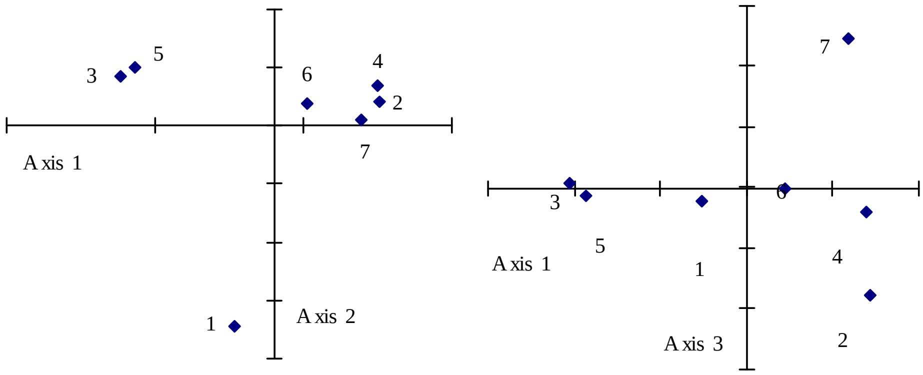

Fig. 1. PCoA scattergram of ground beetle assemblages of seven studied habitats. See text for habitat numbers

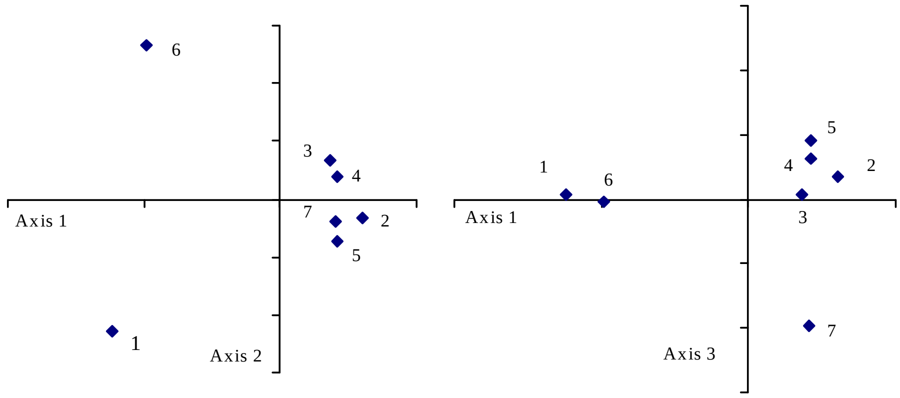

Fig. 2. PCoA scattergram of wolf spider assemblages of seven studied habitats

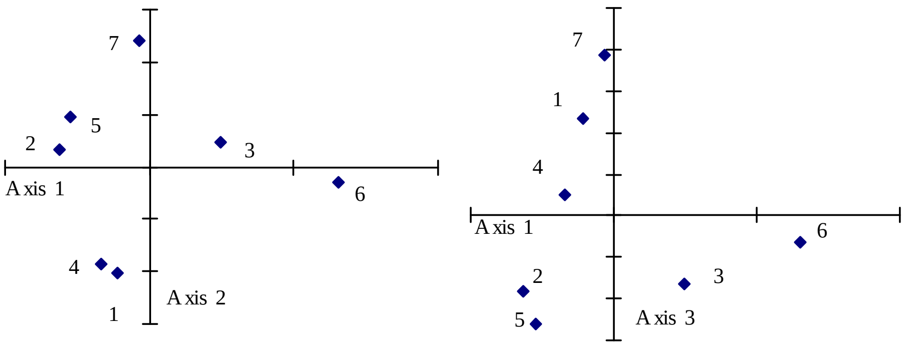

Fig. 3. PCoA scattergram of ant assemblages of seven studied habitats

In the PCoA scattergrams of the beetles and the spiders (Fig. 1 and 2) , sites 1, 6 and 7 are well separated from the others. The spider assemblages of sites 3 and 5 are very similar. In the case of ants, the assemblages of the drier peat-bog and the moore bushforest are the most similar (Fig. 3).

1.3.3.3. External correlates

On the level of habitat score groups and assemblages, ants and wolf spiders show significant correlation with habitat architecture, whereas the matrix of ground beetles is well correlated with the species composition of vegetation (Table 3). Interestingly, only the vegetation composition is correlated with the group of soil properties. The significant rank correlation between spiders and ants indicates that the assemblages of these two groups are similar in differentiating of habitats. Although the direct product-moment and rank correlation analyses between the soil properties and the number of individuals of the studied groups gave no significant coefficients, each coefficient was positive between pH and the density of the groups (ranked from 0.30 to 0.52) and negative between the water content and density (ranked from -0.42 to -0.50).

1.3.4. Discussion

In addition to the difficulties of the „habitat and non-habitat” distinction (Bevers and Flather 1999, Thomas and Kunin 1999), since the range of the habitats was rather extreme in this study, the specialist-generalist character of the studied species could not be established on the basis of their occurrence in the different habitats. The only species, which can be regarded as bog specialist is the wolf spider *Trochosa spinipalpis.* One could expect that the generalists i.e. the species , which are present in the majority of the studied sites, are locally abundant, too (Hanski 1982, Gaston 1999, Hartley 1998). Here we found several species having very high density but restricted to one or two habitats. The explanation could be the very different character of the habitat within this complex landscape, therefore the typical metapopulation and metacommunity processes (cf. Hanski 1999) do not work. If the conditions are extreme, we can expect close correlation between the habitat properties and the composition of the animal assemblages (cf. Gallé 1999). In this case the presumably most critical habitat properties, i.e. the pH and the water content of the soil were not significantly correlated with the studied properties of the assemblages neither as whole group of soil characteristics nor as individual scores. There are, however, several published data on the effect of water regimes and flooding on epigeic invertebrates, including spiders, ants and beetles (e.g. Gallé et al 1983, Holopainen et al 1995, Krumpalova 1999, Schlaghamersky 1999) and the wolf spiders are not so sensitive for some other, e.g. microclimatic conditions (Bayram and Luff 1993).

It is always a dilemma for arthropod community ecologists, whether animal assemblages should be classified on the basis of plant communities of their habitats, or an attempt of independent classification should be made. This study shows, that although there was good correlation between ground beetles and the composition of vegetation, the assemblages of the other two groups are more correlated with structural habitat properties then plants. Successional studies showed uncoordinated steps between plant and insect community dynamics (Gallé et al 1998), different community structures and patterns (Markó 1998) and different sensitivity in the indication of habitat heteromorphy (Gallé *et a*l

1989) and the different types of community variability makes this picture even more complicated (cf. Micheli *et al* 1999). This latter study demonstrated that the vegetation is the most „coarse grained” community type in within-habitat indication of spatial heteromorphy. These conclusions are in concordance with the findings of the present paper at higher, landscape level.

1.3.5. Summary

In a set of seven habitats ranging from peat bogs to dry grassland by the upper stream of river Mures/Maros, the vegetation of the habitats was more different than the assemblages of three studied invertebrate groups. Among invertebrates, ground beetles are the most sensitive indicators of habitat differences, the average between-habitat distance of wolf spiders' assemblages is the smallest, but the great variation coefficients indicate a clustering tendency in their habitat differentiation. Ants perform a middle rank between-habitat differences. Ants and wolf spiders are well correlated with habitat architecture, beetles show a significant correlation with species composition of vegetation. There was a positive community level relation between ants and wolf spiders.

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1.4. LANDSCAPE CHANGES IN THE SZIGETKÖZ REGION, NW HUNGARY (PRELIMINARY RESULTS)

Szabó, M. and Molnár, E.

1.4.1. Introduction

Covering almost 36.500 ha, the Szigetköz is the largest semi-natural flood area in the entire Danube Valley today. Its unique status explains the outstanding importance of its wetland habitats. Due to the region's particular geological, geomorphologic, climatic, and hydrological and soil properties, great habitat diversity has developed, which in turn supports a high biodiversity. This is reflected equally in the large variety of landscape mosaics, the plant communities, the high species diversity of communities and the unique species composition. The community spectrum reflects the almost natural state of the region, showing that it preserved its ecological potential until the 1990s (Kárpáti-Kárpáti, 1991; Simon et al., 1993). In addition to its important role in preserving biodiversity at several organisational levels, as a wetland biotope the Szigetköz has also the potential of buffering antropogenous loads, mostly that of nitrogen, phosphorous and toxic heavy metals.

The Szigetköz area has an exceptionally high ecological and landscape value even in European scale. Together with the Slovak Zitny Ostrov (Csallóköz), it has been a functioning, active floodplain containing a large area of islands, side arms, natural and planted forests, meadows and swamps, redbuds and arable land. In spite of previous human activities, all these landscape mosaics (and habitats) were still governed by the dominating dynamics arising from periodic and episodic floods with associated fluctuating levels of surface and groundwater. In particular, the active floodplain kept its dynamic character (Yon-Tendron, 1981).

Law protects sites of highest natural value since 1987 as a part of the Szigetköz Landscape Protection Area. The idea of establishing a joint Austrian-Hungarian-Slovakian National Park in the region has also turned up already.

1.4.2. The main goal of the study

The alluvial territories have become as targets of scientific studies because of the following reasons:

changes in soil moisture regime could cause strong influences in landscape development and landscape maintenance

any modification in natural water regime would force the agricultural and forestry practice and the nutrient balance of the soil

wetlands are very sensitive for changing water regime of soils, as one of the most important ecological factor

As the major part of the Danube's water was diverted into the service canal in October 1992, the river's water level and the depth of ground water table in its environs dropped remarkably thereafter. Consequently, the Danube bed became exposed over large areas, while its tributaries and oxbow lakes dried up partly or completely. Changes of these environmental factors for the temporal and spatial transformation of natural vegetation types started to study in 1993. Because of the short term monitoring, our result can be seem as preliminary ones.

1.4.3. Results

1.4.3.1. Natural site conditions and their changes

1.4.3.1.1. Soils

Soils are a key element of the natural environment and are of fundamental importance to natural ecosystems and agriculture. The nature and fertility of the soil is dependent on many factors, but in the Szigetköz, the water regime of the surface layers is perhaps the most fundamental. The groundwater level plays an important role in this regime. Changes in groundwater level or character will impact on the soil and on all those elements dependent on it. The groundwater of the Szigetköz has a direct connection with the Danube. The Danube flows are the predominant source of groundwater recharge and control groundwater levels throughout the region.

The soils of the Szigetköz have developed from alluvial material under the influence of climate, vegetation and groundwater conditions (Várallyay, 1992). Groundwater levels thus determine long-term soil formation and also make an important contribution to the soil moisture regime and hence to the water balance of the area. This contribution depends critically on the depth of the water table with respect to the interface between fine-grained topsoil and the underlying gravel alluvium. Where the water, table is located within the topsoil, capillary effects supply the root zone from the groundwater for plant use. This subsurface input is essential to support current agricultural production and natural vegetation and also plays a key role in reducing vulnerability to drought. The seasonal responses of the Danube result in high flows (and hence high water table conditions) during the late spring and summer, when plant water requirements are the greatest. If the water table falls below this interface, this subsurface water supply is effectively lost. The nature and fertility of the soil is dependent on many factors, but in the Szigetköz, the water regime of the surface layers is perhaps the most fundamental. The groundwater level plays an important role in this regime. Changes in groundwater level or character will impact on the soil and on all those elements dependent on it. The groundwater of the Szigetköz has a direct connection with the Danube. The Danube flows are the predominant source of groundwater recharge and control groundwater levels throughout the region.

Apart from direct effects on soil water, the water table location is also critically important for soil chemistry, and thus to soil structure and fertility. The soils have a high natural calcium carbonate content, due to their alluvial origin. This is mobilised by plant activity and gradually leached to the base of the root zone: groundwater are also high in carbonates, and hence carbonate-rich water is drawn up by capillary action, as discussed above.

For the various impacts on the soil depending on their location in the Szigetköz will disturb the natural profile chemical equilibrium. A lowered water table will induce additional leaching; a higher water table, additional upwards transport. Increased evaporation (of pure water) from a near-surface water table will concentrate salts and carbonates in the upper part of the soil structure, with adverse effects on plant growth and soil structure.

Carbonate accumulation is of particular concern in those areas where the frequent fluctuation of water table levels would be expected due to peak power operation. If the water table lies close to the top-soil alluvium interface, the frequent upwards movement of carbonate-rich groundwater into the topsoil would be expected to cause carbonate precipitation to form an impervious hard pan.

1.4.3.1.2. Agriculture

Intensive agricultural production is carried out in the Szigetköz region. The crop yield of wheat, corn, sunflower, and alfalfa, major crops for Hungary is normally about 15-20% higher in the Kisalföld, including Szigetköz, than nationally, and often of higher quality. In the areas near the reservoir, where the groundwater level would have been extremely high, shallow rooting crops were to be grown because only the top layer of the soil would have been suitable. In the areas where the groundwater level would have decreased substantially, replacement, deeper rooting crops were to be grown. These would either have been extremely dependent on precipitation, in which case the security of yield would have significantly decreased on irrigation. Only 8-13% of the farmland in the Szigetköz is currently irrigated. Irrigation not only would be costly, but it has a range of potential disadvantages including adverse effects on soil structure.

1.4.3.1.3. Natural landscape and vegetation

From the beginning of this century the area of **forest stands** has continuously decreased on sites protected from floods, while those in the active floodplain have partly survived. In the 1960's, forests covered 9.000 ha in the Szigetköz. Within this, the proportion of poplar plantations has gradually increased and in the 1990's reached approximately 80% of the forested area. The remaining 20% occupied by semi-natural forests - *willow thickets, willow woods* and *poplar woods* are particularly attractive and species-rich. At some places (e.g. in the environs of the Middle-Szigetköz) stands have a definite pristine character with original forest biota and represent the highest natural value of the region and probably of the entire Danube Valley. Although weed species dominate in poplar plantations, some remnants of the original flora still occur. The bird and insect faunas are also rich in these plantations. The immense fall in the groundwater table can destroy these vegetation type and landscape within a few years.

Formerly *hardwood forests* (oak-ash-elm gallery forests) played important role on higher-lying flood areas. Only few fragments of these remained on the active floodplain, but several stands can be found in an almost natural state on the protected side of the Danube and along the Mosoni Danube. The species composition of these hardwood forests showed only 10% degradation since 1930.

On higher terrains *oak woods* and on several sand ridges *forest-steppe oak woods* grow as relicts of former warm climatic periods and contain several thermophilic drought-resistant species. The expansion of these forests is expected in the future as a consequence of the groundwater table fall.

The mostly aquatic habitats of the Szigetköz support a diverse **wetland vegetation** and landscape. Numerous protected and relict species lived in these communities. *Aquatic pondweed communities, wet meadows and hayfields* are very various in this area. Traditional management practised throughout the past decades saved these wet meadows. The process of the habitat desiccation, the disappearance of the most susceptible relict or protected species, and the invasion of weeds have already started.

Only small fragments of the natural sand **dry grasslands** have survived the agriculture occupation in the Szigetköz. Thermophilic steppe species inhabiting these grasslands contribute to the high floristic diversity of this area.

The natural landscape types (characterized by their dominant vegetation types) were aggregated into six groups according to similarities in their ecological characteristics. The groups are as follows:

Distribution of natural habitats in the Szigetköz

Habitat and vegetation type	**Size of territory (ha)** (before 1992)
1.Flooded forests and aquatic-marsh herbaceous vegetation in the active floodplain	6.500
2. Oak-ash-elm gallery forests (hardwoods) in the active floodplain	200
3. Oak-ash-elm gallery forests (hardwoods) in the old floodplain	1.500
4. Aquatic habitats and wetlands in the active and old floodplain	2.800
5. Wet meadows and hayfields	2.600
6. Dry forests and grasslands	1.100
Summa	**14.700**

*Active floodplain – the section of the original inundated area. Floods, corresponding groundwater-table fluctuations are responsible for the existence of wetlands.

** Old floodplains (protected side of the floodplain) – it originate from natural floodplain but luck the determining factor. The influence of a fluctuating groundwater-table, which corresponds to the water level of the river, although reduced, is the only one remaining.

Beside the above-mentioned landscape elements, agricultural areas and settlements are characteristics as landscape units.

Szigetköz, till the 1990s was unique with respect to all ecological and nature conservation features. As a consequence of the diversion, the river water level as well as the ground water decreased, resulting the drying-out of the riverbanks side arms and oxbow lakes. Due to the past dramatic human impact, the replacement of floodplain vegetation and landscape mosaics by vegetation and landscape adapted to drier soils was an acceptable consequence of significantly lower water discharges in the Danube.

The expansion of weed communities due to the decreasing ground-water table still indicates the degradation of the natural value of the Szigetköz. An extensive weed invasion occurred in the exposed Danube bed, bans and oxbow lake bottoms (Simon-Szabó, 1995).

The substantial drop in the groundwater level will inevitably result in the death of these communities and the floodplain landscape. Most of wet meadows and hayfields have dried out or are currently drying out. Their transformation into arid, weedy grasslands has already started and their economic and biological value is negligible.

The colonization of the newly created biotopes started right after the river diversion. Rapidly invading weeds and seedlings of poplar and willow species were the first plants to become established here. Our studies in the area showed that secondary succession has started very quickly and soon has advanced to the stage of typical willow thickets, where various willow species dominate.

1.4.3.1.4. Cultivated forest stands

The forest plays an important role in the ecosystem. In the Szigetköz, the alluvial forests, primarily poplars, are of great direct economic value, as compared with other indigenous species such as ash, elm, and oak. This area constitutes one of the most important raw material resources for cellulose production. Changes in the groundwater table and water regime negatively influence the growth and yield of these forests. Specifically, these changes would have threatened the softwood riparian forests of poplar and willow present in those areas. Although species requiring less water could have been planted, their biomass production and annual yields would have been much less than that of poplars. It has been suggested that new, slowly growing forests would not have been able to be harvested for 60-120 years.

1.4.4. Summary

The Szigetköz and its environs comprise the youngest, still developing part of the Danube’s vast alluvial fan, where alluvial deposits are the exclusive sources of soil formation. In addition to the highly diverse geomorphology and soil properties, the regular yearly inundation is the most important ecological factor responsible for the development and long-term survival of the region’s natural vegetation. Along with the frequency of floods and the depth of ground water table, other soil properties also play an important role.

In Hungary, the Szigetköz region is one of the most valuable territories from the point of view of landscape, nature conservation, as well as agriculture. Soils have a unique role in preserving the natural and semi-natural state of the landscape and they are very important determining factors of crop production. In this area, the particular groundwater conditions and associated soil moisture regimes have been a determining influence on soil and hence landscape development. In addition, the natural water regime, which provided a natural sub-irrigation for much of the area, was an essential factor in maintaining the natural ecosystems, as well as in enhancing agricultural productivity and reducing susceptibility to drought.

The rapid and substantial drop in the groundwater level was accompanied by a significant loss in soil moisture. The influence of it was very various from the natural landscape mosaics and the natural vegetation types point of view. Aquatic habitats, wetlands, wet meadows, hayfields and softwood forests in the lower floodplain has already started to drying out and as a consequence of it the degree of degradation of these vegetation types are rather high. The transformation of these valuable natural landscape mosaics into arid, weedy grasslands, forest stands or weed communities seem to be an irreversible process.

At the same time the expansion of dry forests and grasslands are expected in the near future as a consequence of the groundwater table fall.

1.4.5. References

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1.5. DIVERSITY PATTERN AND HABITAT CHARACTERISTICS OF FEMALE TABANID FLIES IN A WETLAND AREA OF DRÁVA RIVER

Majer, J. M.

1.5.1. Introduction.

Female Tabanidae are known as important pests of livestock and humans, and vectors of several diseases of man and the animals. Studies of their biology have focused on the host seeking and blood feeding behaviours and the physiological ages of females populations. The effect on the distribution of Tabanids investigated some European and American specialists (i.e. Auroi and Graf, 1982, Auroi, 1986, Pollet, 1991, Roberts, 1971, Strickman and haga, 1986). Species of the family Tabanidae often are frequent member of semiaquatic and wetland environments.

The purpose of this study was to derive a generalised relationship between the basic characteristics of deer fly habitats and the spatial patterns of species diversity, richness, and evenness in the assessment of riverine wetlands. A linear relationship found between some environment characteristics and the pattern of diversity, richness and evenness in deer fly (Diptera: Tabanidae) communities. The results of investigations show that diversity was highest in moisture substrates and in better balanced physical conditions. Richness was highest in moisture substrates, better balanced physical conditions and frequency of inundation. The best evenness was found in moisture substrates and in better balanced physical conditions (physical stability) abundance of vegetation and presence of standing water.

Among the chosen 12 habitat characteristics 4-5 (some of them closely related) could be the primary causes of the presence and pattern of Tabanids in a wetland habitat of Dráva river. Some effect of these environment factors on Tabanids have already bee n investigated separately but not all to gather. This indicates that these community parameters are important and they could be primary causes of the patterns found in this work.

1.5.2. Material and methods.

Tabanidae were captured with red coloured Malaise traps. Trap operation generally corresponded to photoperiod. Collecting operations started about sunrise and ended at sunset. The daily trapping period was about 14 hours per day until late July were operated for a 14 h period each day,. 2435 specimen of collected deer flies were stored and determined. 31 species were captured in 21 collection days. From the study of literature and our observations, we postulate that there are 12 basic characteristic of most tabanid's habitats and that these characteristics are important in regulating species diversity and abundance patterns. Lack of the quantitative data all variables were scored in qualitative manner. We postulated that there are 12 basic characteristics of all tabanid habitats and these characteristics are important in regulating species diversity and abundance patterns.

The variation in species diversity (H') was primarily accounted for by frequency of inundation (31,60%), physical stability (includes dependent variables of climatic measured factors) (11,40%), and the presence of sand (7,10%). the variation in species richness was primarily accounted for by the type of vegetation (35,00%), the abundance of vegetation (32,16%), the presence of running water (4,00%), substrate moisture (41,84%), lotic habitat (5,4%), presence of a shore (18,0%), presence of standing water (9,8%) abundance of vegetation (7,2%), and frequency of inundation (6,7%).

The 12 characteristics of tabanid habitats used in this study and the method of scoring are:

- inundation (1 = few during year, 2 = numerous during year);
- physical stability, persistence (1 = unstable, 2 = moderately unstable, 3 = stable);
- and the presence of sand (0 = no, 1 = yes);
- the variation in species richness was primarily accounted for by the type of vegetation . vegetation type (0 = none, 1 = floating, 2 = emergent and floating, 3 = emergent, 4 = emergent and terrestrial, 5 = terrestrial);
- the abundance of vegetation, (0 = no vegetation, 1 = sparse, 2 = abundant in late summer, 3 = abundant in all summer);
- the presence of running water (0 = no, 1 = yes);
- substrate moisture (0 = shallow water, 1 = wet substrate to shallow water, 2 = wet substrate; 3 = moist to wet substrate, 4 = moist substrate)
- lotic habitat (0 = no, 1 = yes);
- presence of a shore (0 = no, 1 = yes);
- presence of standing water (0 = no, 1 = yes);
- abundance of vegetation (0 = no vegetation, 1 = sparse, 2 = abundant in late summer, 3 = abundant in all summer);
- and frequency of inundation inundation (1 = few during year, 2 = numerous during year); and 12 = physical stability or persistence (1 = unstable, 2 = moderately unstable, 3 = stable);

Tabanidae were trapped with 6 Malaise traps similar to the design of Townes (1962), except they were red coloured, the original traps were white. The study wetland areas situated along the Dráva river and at the Boros Dráva oxbow ($18^o15'05'$ East and $45^o48'34'$ North). Trap operation generally corresponded to photoperiod. Trapping operations started about sunrise and ended at sunset. The daily trapping period was about 14 hours per day until late July were operated for a 14 h period each day. During the trapping period, collecting cages were removed at 1 – hour intervals and replaced with empty cages. 2435 specimen of collected flies were stored and determined. 31 species were captured in 21 collection days. The Shannon – Wiener diversity index (H') and evenness (J') was calculated. The rationale and permissibility of using these indices in this type of study have been discussed by Scheiring (1974) and Scheiring and Deonier (1979). The linear multiple regression model (Harris, 1975) is a useful technique for determining the effect and importance of several independent variables on a single dependent variable. A step – wise multiple regression adds one independent variable at a time, choosing to include that independent variable which has the highest partial correlation with the dependent variable at that point in the analysis. This model is described by the equation:

$$Y = b_o + b_1X_1 + b_2X_2 +. . . + + b_nX_n$$

(Y = dependent variable, b = intercept, X = independent variable, b_1 = intercept of X_1

(X_1 = first independent variable)).

The NuCoSA (Tóthmérész, 1995), and own made PC programs were run using diversity, richness, and evenness as the dependent variables and the 12 habitats characteristics as the independent variables. Each analysis was run until all independent variables had been included, only those included up to the point where the standard error (S. E.) of the estimated Y was minimum were considered to be significant.

1.5.3. Results and discussion

1.5.3.1. Diversity Patterns

The result of the step – wise multiple regression using diversity (H') as the dependent variable and the 12 habitat characteristics as the independent variables are give in Table 1. The substrate moisture seems to be the most important factor affecting diversity in this study and accounts for 41,84% of the observed variation of H'. The other more important factors in this research area vegetation type and physical stability. These variables together take the 88,24 % variation in H'.

Substrate moisture, vegetation type and physical stability are positively related to diversity. We do not have facilities to measuring of wind velocity yet. Probably it is negatively related to H'. The substrate moisture and the vegetation allows presence highest species diversity of deer flies.

Both substrate moisture and physical stability are significantly correlated (r = 0,696, p< 0,01; r = 0,486, p< 0,05) with deer fly abundance.

Table 1. result of multiple regression using diversity (H') as the dependent variable and 12 habitat characteristics as independent variables.

Independent variable	% variation of H'*	R^a	R^2
Significant variables			
+ Substrate moisture	41,84	0,853	0,792
+ Vegetation type	35,00	0,593	0,321
+ Physical stability	11,40	0,884	0,654
Non significant variables	11,76	0,998	0,999

R^a = multiple correlation coefficient; R^2 = variation of H' accounted for by all independent variables entered at this point.

1.5.3.2. Richness Patterns

The result of the step – wise multiple regression using species richness (s) as the dependent variable and the 12 habitat characteristics as the independent variables are give in Table 2. The substrate moisture seems to be the most important factor affecting diversity in this study and accounts for 41,84% of the observed variation of s. The other more important factors in this research area physical stability and frequency of inundation. These variables together take the 84,84 % variation in s.

Substrate moisture, physical stability and frequency of inundation are positively related to species richness. We do not have facilities to measuring of wind velocity yet. Probably it is negatively related to s. The substrate moisture and the physical stability allow more species of deer flies.

Both substrate moisture and physical stability are significantly correlated (r = 0,673, p< 0,01; r = 0,557, p< 0,05) with deer fly abundance.

Table 2. result of multiple regression using species richness (s) as the dependent variable and 12 habitat characteristics as independent variables.

Independent variable	% variation of H'*	R^a	R^2
Significant variables			
+ Substrate moisture	41,84	0,571	0,528
+ Physical stability	11,40	0,813	0,511
+ Frequency of inundation	31,60	0,901	0,716
Non significant variables	15,16	0,998	0,998

R^a = multiple correlation coefficient; R^2 = variation of s accounted for by all independent variables entered at this point.

1.5.3.3. Evenness Patterns

The result of the step – wise multiple regression using diversity (J') as the dependent variable and the 12 habitat characteristics as the independent variables are give in Table 3. The substrate moisture seems to be the most important factor affecting diversity in this study and accounts for 41,84% of the observed variation of J'. The other more important factors in this research area abundance of vegetation, physical stability and presence of standing water. These variables together take the 70,04 % variation in J' only.

Substrate moisture, abundance of vegetation, physical stability and presence of standing water are positively related to diversity. The substrate moisture and the vegetation type allows presence highest species diversity of deer flies.

Table 3. result of multiple regression using diversity (J) as the dependent variable and 12 habitat characteristics as independent variables.

Independent variable	% variation of H'*	R^a	R^2
Significant variables			
Substrate moisture	41,84	0,701	0,792
Abundance of vegetation	7,00	0,619	0,321
Physical stability	11,40	0,864	0,676
Presence of standing water	9,80	0,892	0,824
Non significant variables	29,96	0,999	0,998

R^a = multiple correlation coefficient; R^2 = variation of J accounted for by all independent variables entered at this point.

1.5.3.4. Habitat Characteristics an Community Patterns

The results of this work verify that a linear relationship exists between some environment characteristics and the pattern of diversity, richness and evenness in deer fly (Diptera: Tabanidae) communities. The results of investigations show that diversity was highest in moisture substrates and in better balanced physical conditions. Richness was highest in moisture substrates, better balanced physical conditions and frequency of inundation. The best evenness was found in moisture substrates and in better balanced physical conditions (physical stability) abundance of vegetation and presence of standing water.

Among the chosen 12 habitat characteristics 4-5 (some of them closely related) could be the primary causes of the presence and pattern of Tabanids in a wetland habitat of Drava river. Some effect of these environment factors on Tabanids have already bee n investigated separately but not all to gather. This indicates that these community parameters are important and the could be primary causes of the patterns found in this work.

1.5.4. Summary

The composition of deer fly (Diptera: Tabanidae) communities is reported from wetland habitats of Drava river in Baranya County. Tabanidae were captured with red coloured Malaise traps. 2435 female specimen of collected deer flies were determined. 31 species were captured in 21 collection days. A generalised relationship between the basic characteristics of deer fly habitats and the spatial patterns of the habitat's species diversity (H'), species richness (s) and evenness (J) was derived using linear step-wise multiple regression. We postulated that there are 12 basic characteristics of all tabanid habitats and these characteristics are important in regulating species diversity and abundance patterns.

The results of this investigation of indicate that not at all evolutionary responses of deer flies to the environment need to be fine tuned but can at times be rather generalised.

1.5.5. Acknowledgements

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1.5.6. References

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1.6. CHANGES OF THE MOLLUSCS COMMUNITY IN FLOOD AREA DURING SUCCESSION

Sárkány-Kiss, A.

1.6.1. Introduction

The aquatic habitats of the inundation areas of rivers go through different developmental stages during their evolution in time, due to mineral and biological colmatation. These stages are: lateral branches (flow waters), dead branches, inundable pools, marshy lands and wetlands with semistatic waters. Spring and autumn floods play an essential role in the formation of these types of habitat. Freshets in the superior and middle sectors of rivers may give rise to anyone of the first three habitats mentioned above, and their future evolution will follow the enumerated steps. This succession of types of habitats is followed by a succession of aquatic mollusc communities (Sárkány 1977, 1983). These findings were made in the river meadow of the Mureº at the time when this was still in a nearly natural state. In order to demonstrate the importance of the inundable meadow in the preservation of biodiversity and of the river as an ecological system, we set forth the above mentioned idea, supporting it by new data that emerged from a series of research experiments performed on the Someº, Criº, Olt, Bodrog rivers and on their affluents.

1.6.2. Material and method

From the investigated habitats of the inundable areas of the Mureş, Olt, Bodrog, Latorca and Laborec rivers 85 natural habitats were selected and classified as follows (codifications correspond to those in Table 1):

I. Lateral branches with flow waters
- A. lateral branches with stony bottom and without vegetation
- B. lateral branches with silty bottom and with aquatic vegetation

II. Dead branches
- A. dead branches without aquatic vegetation, with gravel or with rough sand on the bottom
- B. dead branches with aquatic vegetation and with sitly bottom

III. Inundable pools
- A. inundable pools without aquatic vegetation, with gravel or rough sand on the bottom
- B. inundable pools with aquatic vegetation and with silty bottom

IV. Wetlands with semistatic waters
- A. without a specific aquatic vegetation
- B. with aquatic vegetation

The c% values in Table 1. indicate in what extent (expressed in percentage) the species is characteristic for the respective type of habitat. Bellow the mark "c%" the number of investigated habitats belonging to the corresponding subtype was taken down.

1.6.3. Results and discussion

Examining the results shown in Table 1. one can find that the most euritope species is *Radix auricularia*, which occupies very quickly the newly formed aquatic habitats, being in most of the cases the pioneer species, and persisting until the evolution of these habitats to an advanced degree of eutrophication. The species *Radix peregra* is very similar, but it disappears from the strongly eutrophicated habitats. Even in these highly euriece species an optimal preference can be noticed, according to the "c" values. The presence of species in the different subtypes of habitats, with or without aquatic vegetation (marked with "A" and "B" in the table), indicates their preference towards the character of the habitat. Accordingly, the species Viviparus contectus, V. acerosus, Bithynia leachi, B. tentaculata, Acroloxus *lacustris*, *Lymnaea stagnalis* and many other live only in habitats that have a rich vegetation.

Table 1. The mollusc communities of the different habitat types

Habitat typs	I. Lateral branches		II. Dead branches		III. Inundable pools		IV. semistatic waters	
Habitat subtype	A	B	A	B	A	B	A	B
Number of studied h. subtyps	(7)	(14)	(3)	(18)	(11)	(18)	(7)	(7)
	c%	c%	c%	c%	c%	c%	c%	c%
Species								
Viviparus contectus				16				
Viviparus acerosus				16				
Lithoglyphus naticoides				5				
Bithynia leachi				5				
Bithinia tentaculata				11				
Acroloxus lacustris				38		11		
Physa fontinalis				5		5		
Physa acuta				5		17		
Aplexa hypnorum						11	14	28
Lymnaea stagnalis				50		17		14
Stagnicola palustris				22	9	41	57	42
Radix auricularia	57	50	66	38	27	29	14	14
Radix peregra	28	14	33	16	45	17		
Galba truncatula	14	50		33	27	23	28	
Planorbarius corneus		7		72		52	14	42
Planorbis planorbis				27		47	14	57
Gyraulus albus				27	9	11		14
Anisus spirorbis			33	11			14	28
Anisus vorticulus				5				
Bathyomphalus contortus				5		5		
Armiger crista						5		
Hippeutis complanatus				16		5		
Ancylus fluviatilis	14			5				
Ferrissia wautieri				5				
Unio pictorum	14	7		38				
Unio tumidus	14			22				
Unio crassus	14		33					
Anodonta cygnaea		14		50		29		
Anodonta anatina	14							
Anodonta woodiana		7		5				
Sphaerium corneum				5				
Spphaerium lacustris				11		11		

The sequence used by us in the enumeration of the types of habitat corresponds to the natural one, i.e. to their succession in time. In this order, one can observe an increase of the number of species to the dead branches with vetgetation, but afterwards their number decreases towards the inundable pools and semistatic waters. The dead branches still conserve some species that usually live in the river bed, but they also host a series of species which prefers still waters. This supports the fact that the succession of habitats is followed by an adequat succession of the mollusc populations. This succession can be revealed even better if we examine separately the habitats of the "B" subtype.

The reason why the "A" subtypes are mentioned in all types of habitats is the fact that the freshets may create new aquatic milieus in the inundable meadows, which will firstly have a gravely bottom and will be populated by aquatic vegetation after a certain period of time. The habitats that pass from "A" to "B" category will develop further on the way of the "B" subtypes. The freshets may render the habitats "younger" by sweeping the mud and the detritus deposited on their bottom, they may transform the dead branches into lateral river beds, or may open the flooded lakes towards the river bed, converting them in dead branches. Consequently, the inundable meadows are characterized by a permanent dynamics. On its whole the inundable meadow can be conceived as a dynamics of the patches brought about by a sustainable disturbance (Margóczi, 1998; Gallé, 1998), caused mainly by periodic freshets. These communities exhibit a strong reziliance so that they return quickly after the action of the disturbing factors.

Succession of the communities implies, of course, more delicate intermediate aspects, fact that will be exemplified by the sequence in time of the eutrophication of an inundable pool. In a small flooded pool, generated after the inundation in 1970 in the vicinity of the locality Lunca Mureşului during the autumn of that year, the species *Radix auricularia* was collected. In 1971 we identified the species *R. auricularia* (dominant), *Stagnicola palustris* (characteristic) and *Galba truncatula* (accessory). In 1972 the species *Planorbis planorbis* appears and becomes dominant, being followed by *S. palustris* and *R. auricularia*. In 1973, when the providing channel was embanked with a bank of sand, eutrophication became enhanced, *R. auricularia* disappeared, while *Pl. planorbis* and *S. palustris* reduced significantly the number of individuals until the autumn. In the same year, the species *Hippeustis complanatus* and *Aplexa hypnorum* made their appearance, the former one registering a very intense multiplicaton until the end of this year. In 1974 *A. hypnorum* becomes dominant, and a new species appears: *Gyraulus albus*, its natality overtaking the one of *Pl. planorbis*. The low water level causes the desiccation of this pool in the autumn of 1974, while the freshets of the spring of 1975 lead to the leveling by colmatation of the basin.

The example described above shows that in such environments with small surfaces the succession performs with a considerable speed. In the same time, one can conclude that each subtype of habitat examined by us represents only one of the multitude of intermediary phases of the succession. The qualitative and quantitative composition of the aquatic mollusc communities is determined by the configuration of the limiting abiotic factors, but it is also regulated by the interspecific retations of the populations (Padisák, 1998).

In the present state, the malacological biodiversity on the rivers of the Carpathian Basin depends mainly on the degree of anthropic modifications. Among the rivers from Transylvania, the Olt which is seriously polluted, bears a series of reservoir lakes and lacks many bends that had been cut off, still maintains a number of 41 species. But most of the species survived in the old bends, isolated from the river, bends that are able to maintain this abundance of species only until their complete colmatation, considering that they are rarely flooded. The fauna of this river, reconstituted on the base of bibliographical data, consists of 50 species (Sîrbu et al., 1999). In this respect, Olt is followed by the rivers Mureş (31), Cirşul Negru (25), Someş (23), Crişul Repede (21), Crişul Alb (20) and Tur (17). In the basin of Bodrog a much more abundant fauna was found, but at the present we possess only a few data on it because only certain stations were investigated.

1.6.4. Summary

Freshwater molluscs communities were studied in different habitat types.

The dynamics of the habitats in flood areas is followed by a corresponding succession of the aquatic mollusc communities. On the whole of a natural river they function on the principle of the dynamics of patches, maintaining a high value of biodiversity.Examination of the fauna based on the types and subtypes of habitats reveals the preferences of species, fact that could be used in the typology of aquatic environments.

1.6.5. Conclusions

Biodiverstiy of the malacofauna in rivers is tightly dependent on the natural state of the inundable meadows.

The dynamics of the habitats in flood areas is followed by a corresponding succession of the aquatic mollusc communities. On the whole of a natural river they function on the principle of the dynamics of patches, maintaining a high value of biodiversity.

Examination of the fauna based on the types and subtypes of habitats reveals the preferences of species, fact that could be used in the typology of aquatic environments

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1.7. DENSITY ESTIMATION OF TWO RODENT POPULATIONS USING A TRAPPING WEB AND DISTANCE SAMPLING METHOD ON THE DRÁVA LOWLANDS

Horváth, Gy. and Wagner, Z.

1.7.1. Inrtoduction

The estimation of population size (*N*) using capture-recapture (CR) data is usually conceived as a capture-recapture problem (White *et al.* 1982). When using CR-method for data collection, traps are positioned at intersections of a rectangular grid. In the boundary lines, however, animals in the surrounding areas are attracted by the smell of baited traps and therefore they are also subject to being captured. Accordingly, the effective sampling area becomes larger than the grid and density cannot be estimated as simple as N / A_g, where A_g is the area covered by the trapping grid, because it leads to the overestimation of the real density on the observed habitat (Buckland 1993). The problem of edge effect has been known for a long time in CR literature (Dice 1938, Stickel 1954, Tanaka 1972) and for a solution the area of the trapping grid was to be extended by a boundary strip. Dice (1938), in assuming that animals have circular home ranges, suggested that the area of the boundary strip (*W*) should be equal to one-half the average home range of the individuals trapped. Home range estimates though proved to vary as a function of trap spacing, which has an effect on the number of recaptures, too (Stickel 1954, Tanaka 1972). As studies progressed, Otis et al (1978) interpreted the traps on the grid as concentric cycles of equal width. Starting from the centre the population size is overestimated on the subgrids, but as grid size increases the edge effect decreases, and the estimated density decreases as well (Demeter és Kovács 1991). The expected value of density (*D*) and the area of the boundary strip *A*(*W*) are best estimated by the weighted nonlinear least square procedure using a minimum number of four subgrids (Otis *et al.* 1978). The method to estimate density using distance sampling theory and the trapping web was first proposed by Anderson *et al.* (1983). Here density is estimated directly instead of calculating population size and the effective trapping area separately. This study introduced the new method on small mammals particularly. A detailed review of the theory of models using distance sampling for density estimation can be found in Buckland (1987), Wilson and Anderson (1985) and Buckland *et al.* (1993).

Small mammal live trappings have been performed in different forests and open habitats since 1994 at the Department of Ecology and Zoogeography, Janus Pannonius University. Our sample small mammal assemblage was chosen around Lake Matty along the River Dráva, where a long-term monitoring is carried out on the fauna and population dynamics. This choice was also reasonable since the lake and the Hótedra are objects of the chemical water monitoring project run by the Department and its distance from the city allows inexpensive and frequent sampling. The trapping web was laid out in a damp grassy association next to the lake. Its practical application could be with great help in designing the national monitoring project. The results of sampling with this method in 1997 are reported in Horváth (1998) according to which paper the most frequent species in the area were *Apodemus agrarius* (Pallas, 1771) and *Microtus arvalis* (Pallas,1779). The present study focuses on the density estimation of these two species with the method of distance sampling.

1.7.2. Material and Methods

Our study area near Lake Matty used to be a pasture grassland, but presently it is not cultivated, reaped or used for grazing cows. The lack of disturbance allowing a higher undergrowth provided better conditions for small mammal trapping. The area is partly a damp, meadow with weeds taking over and with different tall grass species like *Alopecurus pratensis*, *Poa pratensis*, *Dactylis glomerata*, and those indicating and enduring disturbance like *Daucus carota*, *Cichorium intybus*, *Rumex crispus* The herb layer comprises *Trifolium repens*, *Lolium perenne*, *Cruciata ciliata*, *Taraxacum officinale*, *Galium verum.* The south-west part of the study area is damper, here *Typha latifolia*, *Juncus effusus* and sedge (*Carex vulpina*, *Carex hirta*, *Carex acutiformis*) are also present, in company with *Mentha longifolia*, *Mentha arvensis*, *Rorippa austriaca*, *Crisium vulgare* and *Rannunculus repens.* Aggressive, non-indigenous weeds had established themselves in great amounts in the northern, north-western part of the area covered by the trapping grid, such as *Solidago gigantea* and *Sambucus ebulus*, which created a thick, high coverage.

Plastic and wooden box-type live traps were used, the applicability of which is discussed in Horváth *et al.* (1996). The trapping web was laid out according to Anderson *et al.* (1983) and Buckland *et al.* (1993), with 16 line-transects radiating from the cetrum of the circular grid, so that traps form concentric rings. The trap-lines were situated at 22.5 angles to each other, having T traps (T=20) in a distance of 3 metres (θ), which left us with a cycle of 120 meters in diameter. Thus, 320 live-traps were placed in the grid altogether. The radial distance of the rings is a_i which is expressed according to the equation by Wilson and Anderson (1985): $a_i = (i\text{-}1)\theta + (\theta / 2)$, for $i = 1, 2,\ldots, T$. The sampling grid covered an area of 1.13 hectare.

Traps were baited with bacon and whole cereals. Sampling was performed in two 6-night periods. Traps were operating from July 28th to August 1st (1st period) and from August 30th to September 5th (2nd period) 1997, yielding a total of 3480 trap nights. Traps were checked twice daily (8^{00} CET and 19^{00} CET). After the morning checking traps were left open due to the hot summer conditions and they were set again only between 17^{00}-18^{00} before the night checking. For individual identification of the captured animals, the removal of the first knuckle of certain toes was applied, and the following data were recorded: species, sex (gravidity or lactation in females), body weight. The present estimation includes captures during the nights only, i.e. we analysed data collected in the mornings.

The basic data for the estimation is given by the number of individuals captured in a certain ring, with recapture data ignored. Density was estimated for each period separately in both species. The estimation was performed using the program DISTANCE 3.5 (Thomas *et al.* 1998), which was developed for data of distance sampling methods. The program allows to run several models. Being the most basic one, the uniform model uses the Fourier series without any parameters (Burnham *et al.* 1980) and it estimates detection probability of individuals in point transect methods. The half-normal model has one unknown parameter to be estimated from the distance data and the hazard-rate model, which is a derived one, uses two estimated parameters in the analyses. Model selection was carried out by calculating AIC (Akaike's Information Criterion) values (Anderson *et al.* 1994).

Just like in the square-shaped grid, the outer rings of the trapping web attract animals from around the area of the trapping grid, which can bias the estimation, therefore Anderson *et al.* (1983) left out the data collected in the 19th and 20th rings in their density estimation in an American mice (*Peromyscus sp.*) population. After the model selection procedure using AIC-values had been developed, Buckland *et al.* (1993) performed an estimation with the same input data without the two outer rings, thus creating 18 distance groups. From our two observed species *A. agrarius* showed the same problem, therefore the outer rings with high numbers of captures were left out from the estimations.

1.7.3. Results

During the two sampling periods 12 small mammal species were captured. The order of insectivores (*Insectivora*) was represented by 5 species belonging to the shrew family (*Soricidae*), whereas 7 species comprised the order of rodents (*Rodentia*) in the trapped area. A thorough investigation of the fauna can be found in Horváth (1998). The two most frequent species were *A. agrarius* and *M. arvalis*: their populations were analysed with the density estimators of distance sampling method. *A. agrarius* was captured in a greater area on the trapping grid, which is showed in the graph of the radial lines (Fig. 1). The graph also indicates that the population used the north-western part of the grid and its expansion was not concentric. The area where *M. arvalis* was encountered in the traps was much smaller (Fig. 2) and in the outer rings there were even less captures, sometimes even none at all. Its distribution was concentrated around the centre, on the north-west to south-east line. Its presence was minimal in the lines perpendicular to this expansion.

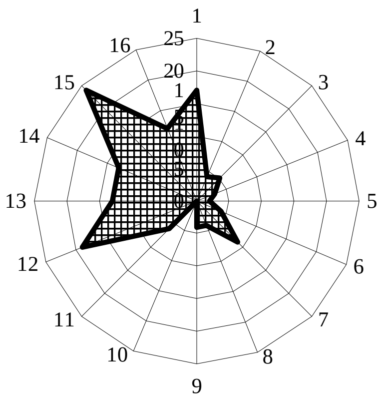

Fig. 1. Number of captures of *A.agrarius* in the radial lines of the trapping web

The total number of first-captured and marked individuals and the measured value of radial distances used in the estimation, with both sampling periods considered, appear in Table 1.

The detailed data of concentric trap circles indicate the high number of *A. agrarius* in the outer rings. The 19th and 20th rings had to be ignored in the first period, while in the second the three outer rings (18th, 19th, 20th) had to be left out from the estimations. In the case of *M. arvalis,* data from all 20 rings were used in both periods; no animal was captured in the 20th ring during the first six days.

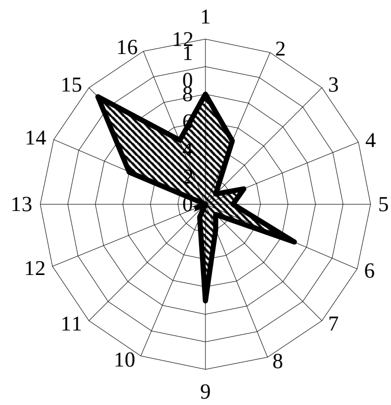

Fig. 2. Number of captures of *M. arvalis* in the radial lines of the trapping web

Table 1. The total number of first-captured individuals and the measured value of radial distances

		Total number of marked individuals			
	Distance	*Apodemus agrarius*		*Microtus arvalis*	
i	a_i	*First period*	*Second period*	*First period*	*Second period*
1	1.5	2	-	-	-
2	4.5	-	2	-	1
3	7.5	1	-	-	3
4	10.5	-	-	-	
5	13.5	1	1	4	2
6	16.5	4	1	-	1
7	19.5	3	1	4	5
8	22.5	5	1	2	6
9	25.5	1	-	2	4
10	28.5	2	3	4	8
11	31.5	4	-	4	2
12	34.5	6	5	-	4
13	37.5	6	6	6	1
14	40.5	2	2	3	2
15	43.5	6	3	7	5
16	46.5	6	2	3	2
17	49.5	4	5	5	5
18	52.5	2	10	3	2
19	55.5	8	9	3	2
20	58.5	10	5	-	5
Total		73	56	50	62

i = ring number, a_i = the distance of each ring from the centre

All three models were run by DISTANCE. The result of model selection showed that our data best fitted the uniform model applying the Fourier series. This model had the smallest AIC value and its coefficients of variation were also valid (Table 2). The value of the latter was below 20% in all cases, which range is accepted in estimations of short-term CR data.

Table 2. The results of model selection

	Apodemus agrarius		*Microtus arvalis*	
MODEL/Parameters	*First period*	*Second period*	*First period*	*Second period*
UNIFORM MODEL				
Number of parameters	0	0	0	1
AIC value	**426.22**	**308.16**	**381.13**	**428.09**
Coefficient of variation (cv [%])	**13.48**	**15.43**	**14.14**	**19.39**
HALF-NORMAL MODEL				
Number of parameters	1	1	1	1
AIC value	427.17	310.16	382.99	429.57
Coefficient of variation(cv [%])	25.65	27.63	28.17	21.42
HAZARD-RATE MODEL				
Number of parameters	2	2	2	2
AIC value	429.18	312.16	384.88	429.95
Coefficient of variation (cv [%])	21.05	15.43	21.29	32.84

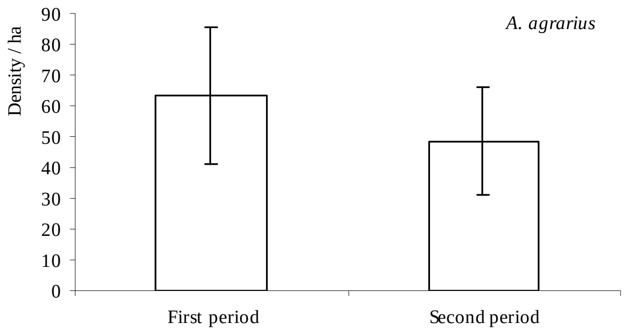

Fig. 3. Density estimates of *A.agrarius* with 95% confidence intervals

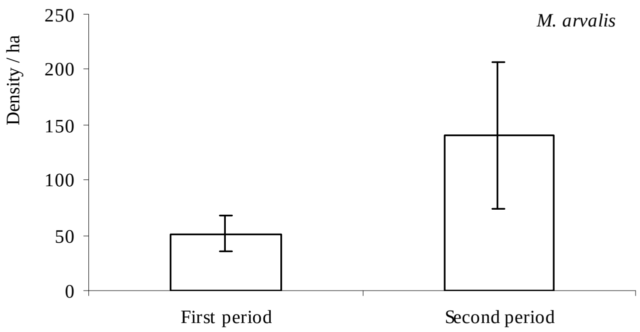

Fig. 4. Density estimates of *M. arvalis* with 95% confidence intervals

The estimated density of *A. agrarius* was higher around the end of July in the first sampling period, and it decreased by the second period (Fig. 3). The 95% confidence intervals of all the estimations were plotted. In the case of *A. agrarius* the two confidence intervals overlap, thus the decrease of density in September is statistically unacceptable. *M. arvalis* had a low estimated density in the first period, but it became higher in September (Fig. 4). Despite the large confidence interval in the second estimation, the two confidence intervals for the two estimated densities do not overlap, which proves a statistically significant increase in the density of *M. arvalis*.

1.7.4. Discussion

The trapping web proved to be an appropriate method for estimating the density of our two observed small mammal populations that had enough data available in the different trapping rings. Anderson *et al.* (1983) and Buckland *et al.* (1993) recommend this method because density can be estimated directly with the edge effect being taken into consideration. *A. agrarius* had a higher number of captures in the outer rings, so truncation was necessary. A possible explanation for the decreased number of individuals could be the species' ability for great expansion. It also covers much larger distances in its movements than *M. arvalis*, which has already been established in several earlier studies (Liro and Szacki 1987, Skacki and Liro 1991). The high number of individuals caught in the outer rings points to the high attracting capacity of the bait and the smell of traps that lure the animals from the surrounding area, causing significant bias in the estimated density in the effective study area. *M. arvalis* did not have such a large-scale movement at all, which was shown by the low number of individuals captured in the outer rings and by the distribution of capture numbers in the radial lines. The best model fitting our data proved to be the uniform model applying the Fourier series, the one that had been used by Anderson *et al.* (1983).

The density of *M. arvalis* had increased by September, which phenomenon was expected to be characteristic of *A. agrarius* particularly, because earlier studies had proved a sudden autumn peak in its population size. The explanation for this contradiction could be that *A. agrarius* changes its habitat for autumn, which could be investigated by other trapping methods.

1.7.5. Summary

Two 6-night trapping periods were carried out using a trapping web near Lake Matty on the Drava Lowlands in 1997. Based on CR-data (capture-recapture), densities of *Apodemus agrarius* and *Microtus arvalis* were estimated applying the distance sampling method in the two periods. In the case of *A. agrarius* truncation was necessary to correct bias in density estimation caused by edge effect, which resulted 17 and 18 rings instead of 20 to be included in our study. Density values per hectare were different in both species. The density of *A. agrarius* decreased by the second period, while it increased in the case of *M. arvalis*. Significant difference between density estimates could only be proved statistically, considering the 95% confidence intervals, only in the case of *M. arvalis*.

1.7.6. Acknowledgements

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1.8. Silver Crucian Carp (Carassius auratus gibelio Bloch, XXX) in the Danube river basin

Tóth, B., Varadi, L., Várkonyi, E. and Hidas, A.

1.8.1. Introdution

The silver crucian carp can be originated from East-Asia. It is not really clear, that this species are indigenous or not in the Danube river basin. Natural migration could be done after the ice-age, when melting ice filled areas, that could make a connection between the Danube and the Volga river basin. Taking into the consideration the really simple environmental demands of the s.c.c., it is possible, that some individuals was able to survive in astatic waters. It is a fact, that the s.c.c. was introduced to Hungary at 1954 by fish culturists. The main target of the settlement was to fill the ecological niche beside the carp (Cyprinus carpio). It was also videly regarded, that s.c.c. are has a dropsy resistance. From the Danube river J. Tóth detected this species for the first time in 1975. According to Holcík (1980) in the Fig. 1 the s.c.c. distribution can be seen between 1970 and 1980.

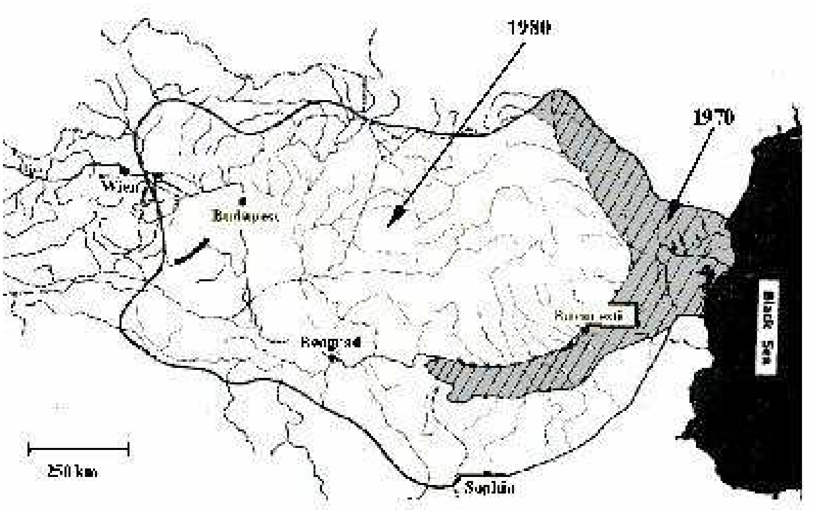

Fig. 1. Distribution of the Silver crucian carp in 1970 and 1980 (Holcík 1980)

This is not known if the settlement influenced this spreading process or not, but anyway we have realized, it was not a good business. The s.c.c. has a wide adaptability, and a very successful reproductive mechanism called gynogenesis. In the other hand there were changes in water habitats, – because of the water management – that mostly turned the stream, and river habitats into a lake habitat, which meant favourable conditions for the s.c.c. populations. Nowadays the s.c.c. are widely spreaded fish pushing out other valuable rare species as tench (Tinca tinca), and crucian carp (Carassius carassius). 10-15 years ago triploid unisex (female) populations were recorded only, but few years ago male individuals – which were not studied genetically – were also detected in natural waters, (Pénzes et al.) and those were spreaded quickly in our waters. To summarise the written above nowadays there are two forms of the s.c.c. in Hungary:

Type of triploid unisex populations with chromosome number of 150 and a diploid type containing male and female members too, that has 100 chromosomes and reproduce traditionally.

The triploid females reproduce by gynogenesis. Development of the gynogenetic eggs are induced by sperm of other fish species (carp or other cyprinids), but the genetic staff of the sperm does not play role in the development of the offsprings. As the literature on the subject showes, in this process the duplication of the chromosomes can be observed, but the first meiotic division doesn't occur. During the second meiotic division the second polar body eliminates, which reslust triploid eggs. (Horváth and Orbán, 1995).

In our study we try to find the genetic background of the special adaptability of s.c.c. We want to examine the relations between the two genetic types from the wiew of reproduction and genetics too. We also would like to get closer to find a method, wich can help us to make a ballance in fish populations. For the first step we separated diploid and triploid individuals. Morpho-meristic estimations, erythrocyte nucleus diameters, and chromosome number had been examined.

1.8.2. Materials and methods

After fishes were taken from the Isaszegi-pound, they were transfered into the laboratory in 10 litre tanks. In the laboratory the individuals were kept in 50 litre tanks at 28 C for 1 month. Morpho-meristic data were detected using a simple calliper and weight was measured by scale.

The erythrocyte nucleus diameters were detected by using Burker-chamber. The result was appraised according to Katsutoshi et al. (1990)

Chromosome preparations were made from fin fibroblast cultures. Fish-fins were clipped with sterile scissors and washed with ethanol (70%). They were put into Petri-dishes with trypsin-PBS solution (0.025%) and cut into small pieces, about 2x2 mm. The pieces of fins were soaked in trypsin for 10 minutes, and then transferred to sterile tissue culture flasks without any solution and allowed to stick for 1 or 2 h. After this procedure, the flask was filled up with sterile TC-199 medium containing 15% FCS (fetal calf serum, Sigma F 7524). After four weeks when the fibroblast monolayer was almost confluent in the flasks, one drop of 0.05% colchicine (Sigma C 9754) was added. After two hours the medium was removed from the flask into a centrifuge-tube, replaced with 0.5 - 1 ml trypsin (0.025%) and the fibroblasts incubated for 7-10 min. at 28°C. The cell suspension was added to the culture medium and after 7 min centrifugation (1500g) the supernatant was removed and the cells resuspended in 0.35% KCl. Hypotonic treatment took 10 minutes at room temperature and was followed by 3 changes of methanol/acetic acid (3:1) fixative. The cell suspension was spread on slides, dried at room temperature, and stained with 5% fresh Giemsa (in phosphate buffer pH 7.0) for 7-8 min. Five slides from each individual were prepared.and at least 20 metaphase spreads per individual examined.

1.8.3. Results

Comparing the different sexes we have found that the body weights of females are higher than male's. The differences of relative size of head (body lenght/head lenght) between females and males shows that females are probably more successful in competition, living in unfavourable conditions. The triploid and the diploid form cannot be separated by morphologically, even we have found some diploid individuals with morphological default, that was detected only in goldfish till this time.

The amount of the genetic staff was found to be different between females and males. The average erythrocyte nucleus diameter of males 6.28 mm, and females 7.69 mm. (Fig. 2). Those studies was verified with determination of chromosome number. Almost all of the males are diploid, but we have found some male individuals showig chromosome mosaicity with a chromosome number of 100, 125, 134, 156, 174 and 186, usually between 100 and 190.

As it known the s.c.c. females produce triploid eggs, that induced by males of other species. We have done an artificial fertilisation using different males and both triploid and diploid females.

In case of artificial spawning we have found the next results:

	Triploid female
male	hatching ratio
S. crucian carp (Carassius auratus gibelio)	98%
Goldfish (Carassius auratus auratus)	95%
C. carp (Cyprinus carpio)	95%
Roach (Rutilus rulitus)	90%
Rosybarb (Barbus conchonius)	75%
Pearch (PercaJluviatilis)	0%
Ruffe (Gymnocephalus cernuus)	0%
Diploid female	
Silver crucian carp (Carassius auratus gibelio)	95%
Goldfish (Carassius auratus auratus)	90%
Rosybarb (Barbus conchonius)	3%

1.8.4. Discussion

It is clear, that Silver crucian carp has an ability to survive extraordinary ecological conditions. We have been trying to find the reasons for the wide tolerance interval of this species, and we also would like to find a method, for regulating the growth of their population. We have done a study, that showed the diploid and triploid populations of s.c.c. live together the same natural water area. Some of the diploid individuals have morphological default, but the two forms can not be separated simply by measuring morphological parameters. Genetic measurements showed that there are differences between the amount of genetic staff in the males. We have found a phenomenon of mosaicity. Mosaicity was found in related species Carassius carassius by Lingenfelser et al. (1997) in Ukraine near Chernobil.

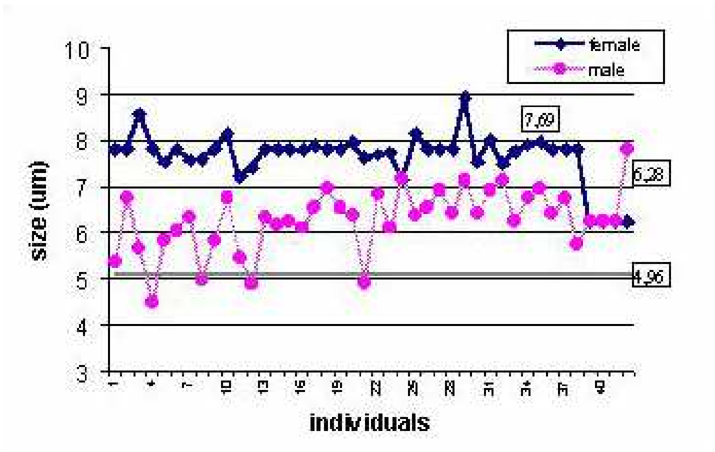

Fig. 2. Erithrocyte nucleus diameter of female and male silver crucian carps

This study raised some questions. Where the diploid form and the mosaic males came from? Our hypothesis is that mosaic males can be offsprings from the situation, when the two fomrs spawn together. This idea suppose, that the diploid males spawn with the triploid females, and the genetic staff of the sperm stays in the eggs after inducing the development of the offsprings. Later some of these "strange chromosomes" eliminate. A related study was done by Taniguchi and Dong (1997), that proved, that the heat shock during the fertilization of gengoroubuna (Carassius auratus cuvieri) eggs - treated with common carp sperm - led to the apperance of the carp's fragments in the offsprings genome.

Further studies have to be carried out to find if there is any difference between the two form's ecological demands. The females are more successful on competition in bad ecological circumstances. We have to examine if there is a connection between the ploidy level and ecological demands.

As it is known there was a spontaneous polyploidisation in the cyprinids about 1 million years ago, so some of the cyprinids including the Carassius genus has nearly 100 chromosomes instead of 50. Furthermore the silver crucian carp had gone through a process called triploidization, so the chromosome number increased to 150. This way the s.c.c. is hexaploid behaving triploid gynogenetic unisex populations. Our hyphotesis is the following: The hexaploidy may provide a lot of possibilities to produce different kind of proteins depending the ecological circumstances. To point out, are there any reality of the hypothesis RAPD analysis and protein polymorphism analysis were carried out, but before any conclusion it has to be completed with allelspecific examinations.

1.8.5. Summary

The number of the silver crucian carp has been increasing in the last 10-15 years in the hungarian section of the Danube river basin. This process leads to the loss of biodiversity in natural waters, and causes damages in fish farms. This huge population growth can be explained by several reasons as the changes of the water habitats, and the special characteristic of this species includig a very successful reproductive mechanism, and the ecological simplicity. In our study we try to find the reasons of it's wide adaptability and

also try to get closer to find a method, which can help us to make a ballance between the populations of s.c.c. and other species. We tried to separate diploid and triploid individuals. Morpho-meristic estimations, erythrocyte nucleus diameters, and chromosome number had been examined. In this study we also wanted to point out some of the causes of the huge flexibility of the s.c.c. using RAPD analysis and protein polymorphism.

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1.9. Effects of regional perturbation on Orthopteran communities

Kisbenedek, T.

1.9.1. Introduction

The natural communities in the riverine wetland ecosystems are exposed to disturbances of both human activities (e.g. mowing, grazing) and physical forces (regural flood), all of them can be regarded as natural conditions, however the structure of the communities of the wetland sites have evolved in the presence of these disturbances. Nevertheless a regional perturbation interrupts the ecological processes developed under the influnece of so called natural conditions. The regional perturbation is ususally considered as a process that occurs on large geographical scale and cut across more than one ecosystem component (Bernstein *et al.* 1997). Two regional perturbations occured in the Szigetköz area during the last decade. One of them was the construction of a resevoir in the upper parts of the Szigetköz, which transformed significantly the natural landscape and the other one was the diversion of 90% of the original water regime of the river Danube into an artificial bypass channel on the Slovakian territory by the Slovakian government. The immediate conseqence of the later operation was a serious decrease in the water table in the upper pats of the Szigetköz. The Hungarian government to retrieve the water deficiency in Szigetköz area put down a small dam into bed of the main branch of the river in 1996.

The aim of this study to test the influence of landscape transforming, the decrease of the water table and water supplying on the ecological status of the Szigetköz area using monitoring investigation of the orthopteran communities on permanent sampling points in the flood plains and the protected areas along the river Danube. It has been demonstrated that the orthopteran communities have correlations with their habitats (Joern and Lawlor 1981, Gallé *et al.* 1985, Kemp et al 1990, Miller and Onsager 1991, Quinn *et al.* 1991, Fielding and Brusven 1995, Schell and Lockwood 1997, Varga 1997), and they might be good indicators of the environmental changes (Parmenther et al 1991, Kemp 1992, Fielding and Brusven 1993, Báldi and Kisbenedek 1997, Rácz 1998 a).

Only a few data about the presence of the orthopteran species in the Szigetköz area were previously the diversion of Danube river available for us, but they were not intensive (Aradi 1955). So we had to start the monitoring of the orthopteran communities lack of data suitable to comparison between the previous and later states of the diversion of the river Danube and we had to locate our control sites the they were based on our assuming and results of other investigations. These control sites were chosen on the sites of the low part of the Szigetköz area between villages of Ásványró and Nagybajcs, where water table did not change.

1.9.2. Materials and methods

The monitoring studies of the orthopteran communities were conducted in the Szigetköz region. The region is an elongated irregular-shaped geographical unit, which is located between the river Mosoni-Danube and the river Old-Danube in the North-western part of Hungary (48°00'-47°40' N, 17°15'-17°45') with 375 km^2 extension. This unique landscape type of Hungary is composed of small islands, side-branches and meanders of the Danube. The botanical and fauna reviews of the area show that this region has special biological features, too (see e.g. Simon 1992, Báldi *et al.* 1995). The region can be divided into two main parts according to its heights above the see level, one part is the so called Upper Part (Fels ő-Szigetköz) with about 125-115 metres average height and the other is the Lower Part (Alsó-Szigetköz) with 115-110 metres height (Göcsei 1979).

The sampling sites were located partly on the flood plain and partly outside of the embankment on the so called protected side.

(In the below enumeration the villages are named near to which the sampling sites can be found, furthermore the grassland types and its management is given, too.) The following sampling sites were located on the flood plain: (1) Rajka, mown meadow. This site is found on the area of the planned artificial water-basin, so it was exposed to the highest superficial transforming human activity, namely the vegetation cover was totally removed at the beginning of the building of the water-plant. After the stoppage of the operations the vegetation recognised to the area and some part of it was regularly mown. (2) Dunakiliti, wet meadow. (3) Dunasziget, (Dunaköz), mown meadow. On the protected area: Dunaremete, mown wet meadow. The locations of the above mentioned sampling sites were unchanged during the whole length of time of the monitoring study. The locations of the sampling sites near to village Ásványráró and Nagybajcs needed to be changed from the flood plain to the protected site after 1996 because these sites had been frequently inundated. The frequent inundation were consequences of the laying down of a small dam into the bed of the river Old-Danube by the Hungarian Government in 1996. So the new sampling sites were the next: Ásványráró (Zsejkepuszta), mown wet meadow. Nagybajcs, grazed wet meadow.

The sampling of the orthopteran communities were carried out by sweepnetting in 10x10 metres quadrates during a standardised sampling time (15 minutes per quadrates) and the number of sweeps were standardised (300 sweeps per quadrates), too. At each sampling sites four quadrates were located in order to take samples of spatial variability of the habitat. The results of singling samplings of orthopterans by hand and hearing their calling sounds showed that locating four quadrates per sampling sites proved to be enough because the studied grasslands showed rather homogeneity than heterogeneity and few new orthopteran species come up by the singling sampling method. The samplings were carried out three times in each year in July, August and September.

To the calculation of the diversity profiles was used the Divord 1.0 program (Tóthmérész 1993).

1.9.3. Results

Altogether 17570 orthopteran individuals were caught during the 6 years of the monitoring study which belonged to 29 species (Table 1). The identification of the orthopteran nymphs is not possible therefore they were omitted from the analyses.

The changes of Rényi diversity values of the orthopteran communities among the years of the monitoring ranged from 0.1 to 2.7 at the sampling sites excluding the orthopteran community of Rajka, where the magnitude of the changes in the diversity values ranged from 1.2 to 2.5. The curves of the diversity profiles intersected each other at the sampling sites of Rajka, Dunasziget, Dunaremete and Ásványráró what suggested that there had been no changes in the structure of orthopteran communities at these sites during the period of the monitoring studies. The diversity profiles separated into two groups at Dunakiliti, the first group composed of the diversity curves of the first half of the monitoring period (1994-1996) while the second group comprised the diversity curves of the second half of the monitoring period (1997-1999). There were no comparable differences among the diversities inside the groups but the diversity value of the second group was lower in than first group. The curves of the diversity profiles were segregated into three groups at Nagybajcs. The diversity was the highest in 1997-1998 years and the lowest in 1995, by 1999 the diversity values decreased to the level of years 1994 and 1996. The diversity-ordering methods gives the possibility of making comparisons separately between the diversity of the rare species and dominant species of two communities when

Table 1. The caught orthopteran species with theri ecological type in the Szigetköz area during the period of the monitoring.

species	ecological type
Tetrigidae	
Tetrix (Tetratetrix) bipunctata	hygrophilous
Tetrix (T.) subulata	hygrophilous
Tetrix nutans	hygrophilous
Terix undulata	hygrophilous
Acrididae	
Aiolopus thalassinus	hygrophilous
Calliptamus italicus	xerophilous
Chortippus albomarginatus	mesophilous-hygrophilous
Chortippus dorsatus	mesophilous-hygrophilous
Chortippus parallelus	mezofil
Chrysochraon dispar	hygrophilous
Euchortippus declivus	xerophilous
Euthystira brachyptera	mesophilous-hygrophilous
Chortippus (Glyptobothrus) apricarius	xeroterm
Chortippus (Gl.) biguttulus	xerophilous
Chorippus (Gl.) brunneus	xerophilous
Chortippus (Gl.) mollis	xerophilous-mesophilous
Mecosthetus grossus	hygrophilous
Oedipoda caerulescens	xerophilous
Parapleurus alliaceus	hygrophilous
Phaneropteridae	
Leptophyes albovittata	steppe
Phaneroptera falcata	xerophilous
Conocephalidae	
Conocephalus (Xiphidion) dorsalis	hygrophilous
Conocephalus (Xiphidion) discolor	hygrophilous
Tettigoniidae	
Pholidoptera fallax	forested steppe
Metrioptera (Bicolorana) bicolor	xerophilous
Metrioptera (Roeseliana) roeselii	hygrophilous
Tettigonia viridissima	forested steppe
Gryllidae	
Oecanthus pellucesn	steppe

the curves of diversity profiles are intersected and otherwise there is no significant differences between the diversity of two communities (Tóthmérész 1997). Considered this above mentioned eventuality and continued the analysis of the results of Dunasziget sampling on this way, a high decreasing in the diversity of the dominant orthopteran species could be found in this sampling after 1996 (Fig. 1).

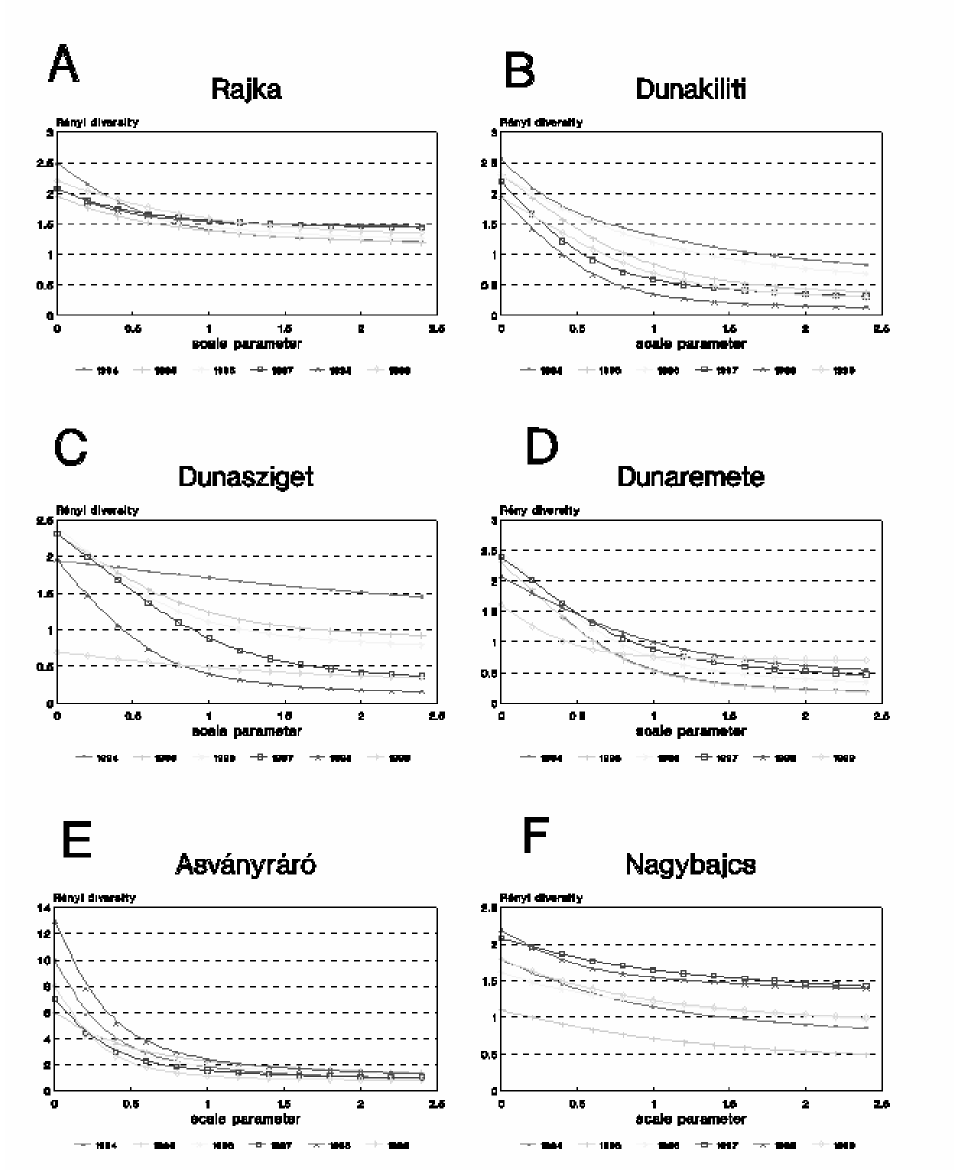

Fig. 1. a-f. Diversity profiles of the orthopteran communities at the different sampling sites.

Table 2. The presence and absence of the hygrophilous species in the Szigetköz area.

	1995	1997	1999
Aiolopus thalassinus	+	-	-
Chrysocraon dispar	+	+	-
Mecosthetus grossus	+	-	-
Parapleurus alliaceus	+	+	+
Conocephalus discolor	+	+	+
Conocephalus dorsalis	+	+	+
Metrioptera roeselii	+	+	+

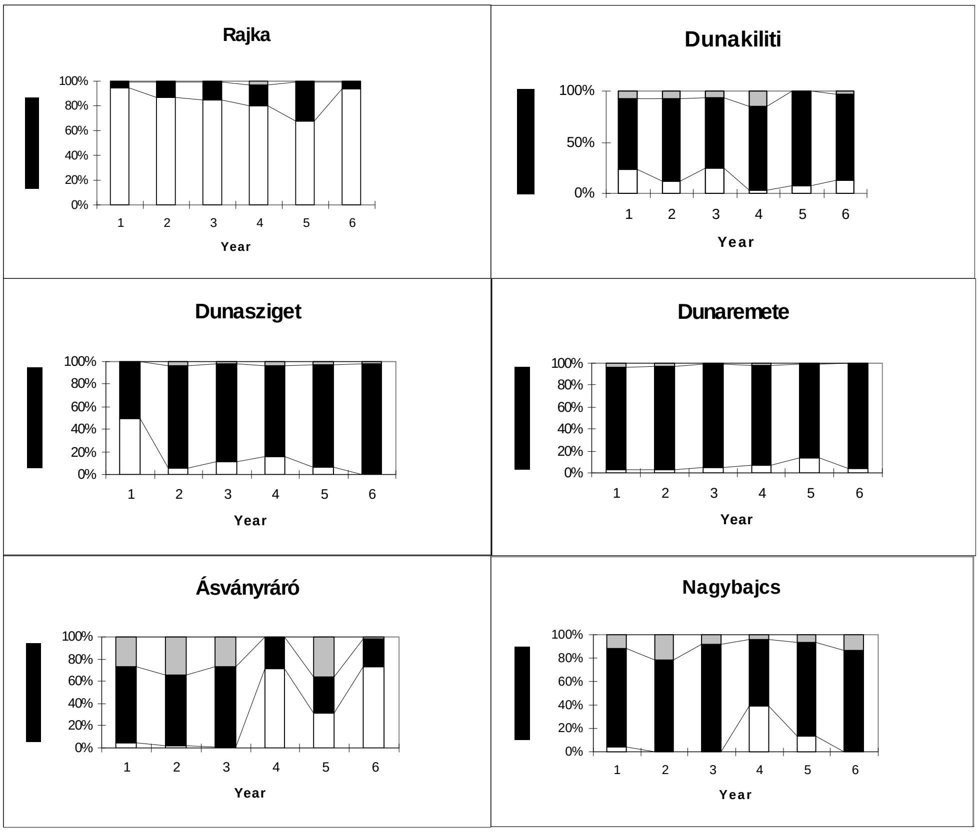

Fig. 2. a-f. Percent proportion of dominance values at the different sampling sites. The white coluor: xerophilous species, black colour: mseophilous species, grey colour: hygrophilous species.

The caught orthopteran species, according to their ecological types, can be ranked into three groups (see Table 2). The individual groups contain (a) xerophilous, (b) mesophilous or (c) hygrophilous species. Fig. 2 (a-f) presents the changes of the percentage proportion of the dominance values of the ecological groups in the different orthopteran communities. While in the habitats of Rajka and Ásványráró (after the fourth year of the monitoring) the xerophilus species till then in the other ones the mesophilous species were dominant. The average dominance values of the hygrophilous species were higher than 5% only in the habitats of Ásványráró and Nagybajcs during the length of time of our monitoring study. A slight changes were observable in the proportion of the groups in all sampling sites. While the proportion of the mesophilous group increased as long as the proportion of the hygrophilous group decreased. The dominance structures of the orthopteran community of the new study site, which had been chosen in 1997, and the former study site at Ásványráró was entirely different from each other.

The decreasing in the percentage proportion of the hygrophilous group went with disappearance of *Aiolopus thalassinus*, *Chrysocraon dispar* and *Mecosthetus grossus* from entire region of the Szigetköz by 1999 (Table 2).

1.9.4. Discussion

The main traits of the orthopteran communities of the wet grasslands can be given in the next points: (1) they occurrence with relatively low species number (Table 3 and 2) relatively high abundance (Table 4 and 3) one or two dominant species, these are usually the *Chortippus parallelus* and *Chortippus albomarginatus* species, are present with 50-90% dominance values in a given community, (4) besides the dominant mesophilous species the characteristic hygrophilous species (e.g. *Aiolopus thalassinus*, *Conocephalus discolor*, etc.) are stable part of this communities.

Table 3. The species number of the individual orthopteran communities in the Szigetköz during the monitoring period.

Sampling years/ Sampling sites	1994	1995	1996	1997	1998	1999
Rajka	11	7	9	8	8	9
Dunasziget	7	9	11	9	11	4
Dunakiliti	7	10	11	9	7	6
Dunaremete	10	10	12	11	8	3
Ásványráró	12	7	8	9	12	8
Nagybajcs	6	3	4	7	14	6

Table 4. The abundance values of the individual orthopteran communities in the Szigetköz during the monitoring period.

Sampling years/ Sampling sites	1994	1995	1996	1997	1998	1999
Rajka	844	346	386	465	1272	535
Dunasziget	42	106	249	108	730	356
Dunakiliti	1228	410	1087	689	693	239
Dunaremete	729	619	698	350	495	324
Ásványráró	910	88	219	339	368	413
Nagybajcs	248	89	218	452	1079	147

Under the influence of the perturbations the above mentioned structure of the orthopteran communities of the wet grasslands changed. The orthopteran communities in the Szigetköz region can be divided into four groups. The first group contains the community of the considerably damaged site (Rajka) in the Upper Part inside the flood plain, the second comprises the communities of the flood plain in the Upper Part (Dunakiliti, Dunasziget), the third group contains community of the lower wetland on the protected side of the Upper Part (Dunaremete), and the fourth group contains the communities of the Low Part (Ásványráró, Nagybajcs). The divison into groups of the orthopterans properly follows the configurations of the terrain of the area. 10-20 cm difference between the heights above the sea levels is enough to that the water table drops off and in consequence of that different vegetation associations can be found a few metres distance from each other.

The effect of the landscape transforming got on limited and increased the proportion of the xerophilous orthopteran species in the community. The effect of the decrease of the water table got on in the entire Szigetköz area and caused decrease dominance of the hygrophilous species and while the mesophilous species had become dominant. The water supplying had no effect on the orthopteran communities in the middle and upper part of the Szigetköz.

The retreat of the hygrophilous species and the pushing forward of the mesophilous species, under influence of decrease of water table, consistent with results of Lisicky *et al.* (1997), Báldi *et al.* (1998) and Rácz (1998b) who found that with decreasing humidity and changes of the vegetation structure the characteristic hygrophilous species disappear and the mesophilous species become more dominant stated in his study of the succession of the wet grasslands.

Monitoring studies of orthoperan communities (Orthoptera) was conducted for six years (1994-1999) in Szigetköz region. During our investigation the changes of structure parameters of orthopteran communities, such as number of species, dominance, diversity and abundance, and the proportion of hygrophylous, mesophilous and xerophylous orthopteran species were monitored on fixed sampling points. According to our expectations from the results of these monitoring methods conclusions might be draw in relation to ecological state of the Szigetköz area.

Our results showed that the orthopteran communities can be divided into two main parts which was corresponding to the differences in the elevations above the sea level between the upper part (125-115 m) and lower part (115-105 m) of the Szigetköz and we could separated the orthopteran communities of the flood plains and the protected side. The beginning of our monitoring investigations the more humid wet grasslands could be characterised by the presence of some hygrophilous orthopteran species from which three species (*Ailopus thalassinus, Mecosthetus grossus* and *Chrysocraon dispar*) disappeared from the study sites by 1999. We found significant effect of the landscape transforming and the decreasing of the water table on the structure of the orthopteran communities but the water supplying had no demostrable effect.

1.9.5. Summary

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1.9.6. Acknowledgement

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1.10. STRUCTURAL AND ECOLOGICAL STUDY ON THE MOLLUSC FAUNA OF THE HARDWOOD GALLERY FORESTS (FRAXINO PANNONICAE ULMETUM SOÓ 1960) IN THE GREAT HUNGARIAN PLAIN

Bába, K.

1.10.1. Introduction

Gallery forests used tobe the most extent type of forests in the Great Hungarian Plain (Soó 1968). Previous studies showed that these forests were inhabited by 26 (54%) of 48 stenotolerant mountain species, due to the faunatransport of the rivers.

1.10.2. Material and Methods

Our researches were completed in the Great Hungarian Plain‘s 79 gallery forest plots. In every study site data were collected in ten 25 × 25 cm quadrats. Microclimate measurements were carried out by Andó and Bába (1962). The fauna of the climate regions of the Great Hungarian Plain was compared with Pócs-Ramsey chi^2-test (Bába 1992). The author studied the role of stream deposit fauna, soil reaction and pollution of rivers on the settlement of mollusc species (Bába 1970, 1973, 1977, 1982), the effects of mineralogenic succession (Bába 1980, 1985, 1986) and forest management (Bába 1992a, 1994). Following from Lozek’s (1964) classification of mollusc species into ecological groups I made a division regarding species’ habitat types: HF - forest dwellers (hygrofil), B - bush forest dwellers (light demanding), RU - riparian ubiquiest and St - steppe dwellers. A further classification was done considering species’ feeding habits on the grounds of Frömming (1954): O - omnivorous, H - herbivore, Sp - saprophagous. The species composition of gallery forests was arranged by reason of the level of constancy with the indication of the dominance (Table 1 and 2).

1.10.3. Ecological factors affecting the occurence of mollusc species in the Great Hungarian Plain

Csiki (1906) reported 56 mollusc species from the Great Hungarian Plain. Later studies (Soós, Czogler, Rotarides, Richnovszky, Kovács) added five more species to this list. Since 1956, when Tisza Project (long term study project) started, I found 104 mollusc species in nearly 800 Hungarian and foreign study sites from the Great Plain. In the Great Hungarian Plain 97 species were present from the above mentioned 104 species. The number of species in study sites were 66, accounting for 68.04 per cent of the total number of species. Besides the gallery forests data were also collected from 27 managed forests and plantations (Table 2), where 22 species (33 per cent) were indicated. As a consequence of forest management (eg. thinning of 40-60 year-old forests) and plantations Shannon-Wiener diversity values of the gallery forests’ mollusc fauna considerably decreased.

Table 1. Mollusc species of gallery forests (*Fraxino pannonicae-Ulmetum*) arranged considering their feeding habits and constancy-dominancy level

No	Eg	Fh	K%	D%	Species
1	HF	O	54,02	6,50	*Bradybanea fruticum* (O. F. Müller 1774)
2	B	H	50,70	1,58	*Cepaea vindobonensis* (Ferussac 1821)
3	HF	O	47,88	12,70	*Perforatella vicina* (Rossmässler 1842)
4	RU	O	45,07	4,47	*Succinea oblonga* Draparnaud 1801
5	B	O	43,66	8,45	*Aegopinella minor* (Stabile 1864)
6	B	H	32,8	1,49	*Helix pomatia* Linné 1758
7	HF	O	33,8	0,80	*Arion subfuscus* (Draparnaud 1805)
8	B	O	30,9	2,73	*Cochlicopa lubrica* (O. F. Müller 1774)
9	B	O	29,5	3,12	*Vitrina pellucida* (O. F. Müller 1774)
10	B	O	29,5	2,19	*Nesovitrea hammonis* (Ström 1765)
11	RU	H	22,5	4,39	*Perforatella rubiginosa* (A. Schmidt 1853)
12	St	Sz	22,5	3,05	*Vallonia pulchella* (O. F. Müller 1774)
13	HF	Sz	22,5	4,88	*Vitrea crystallina* (O. F. Müller 1774)
14	HF	Sz	21,1	1,24	*Cochlodina laminata* (Montagu 1803)
15	B	H	19,7	1,27	*Euomphalia strigella* (Draparnaud 1801)
16	RU	Sz	18,3	3,69	*Carychium tridontatum* (Risso 1826)
17	RU	O	16,9	1,27	*Carychium minimum* O. F. Müller 1774
18	B	Sz	16,9	0,65	*Punctum pygmaeum* (Draparnaud 1801)
19	RU	O	15,4	3,17	*Zonitoides nitidus* (O. F. Müller 1774)
20	HF	O	14,8	0,81	*Arion subfuscus* (Draparnaud 1805)
21	HF	O	14,2	0,61	*Arion sylvaticus* Lohmander 1937
22	HF	O	14,1	0,58	*Arion cirkumscriptus* Johnston 1868
23	RU	O	14,1	1,02	*Deroceras agreste* (Linné 1758)
24	RU	O	14,0	0,99	*Deroceras reticulatum* (O. F. Müller 1774)
25	RU	H	12,6	4,20	*Columella edeutula* (Draparnaud 1805)
26	HF	O	12,6	0,41	*Limax cinereoniger* Wolf 1803
27	B	H	12,2	0,53	*Helix lutescens* Rossmässler 1837
28	HF	H	12,6	1,78	*Chilostoma banaticum* (Rossmässler 1838)
29	HF	H	10,4	1,85	*Hygromia kovácsi* Varga et Pintér 1972
30	B	O	9,8	1,07	*Aegopinella pura* (Alder 1830)
31	HF	O	8,4	4,66	*Oxychilus glaber* (Rossmässler 1835)
32	HF	Sz	8,4	0,05	*Clausilia pumila* C. Pfeiffer 1828
33	St	O	8,4	0,41	*Vallonia costata* (O. F. Müller 1774)
34	RU	O	7,0	7,49	*Oxyloma elegans* (Risso 1826)
35	St	Sz	7,0	0,19	*Chondrula tridens* (O. F. Müller 1774)
36	HF	Sz	7,0	0,17	*Acanthinula acuhata* (O. F. Müller 1774)
37	B	Sz	5,6	0,65	*Pomatias rivulare* (Eichwald 1829)
38	HF	H	5,6	0,85	*Perforatella incarnata* (O. F. Müller 1774)
39	HF	O	5,6	0,12	*Deroceras laeve* (O. F. Müller 1774)
40	St	H	5,6	0,21	*Monacha carthusiana* (O. F. Müller 1774)
41	HF	O	4,2	0,83	*Perforatella bidentata* (Gmelin 1788)
42	HF	H	4,2	0,31	*Arianta arbustorum* (Linné 1758)
43	HF	O	4,2	0,14	*Lehmania nyctelia* (Bourguinat 1861)
44	St	O	4,2	0,31	*Cochlicopa lubricella* (Porro 1838)
45	St	Sz	4,2	0,21	*Truncatellina cylindrica* (Ferussac 1807)
46	B	O	4,2	0,14	*Arion hortensis* Ferussac 1819
47	RU	Sz	4,2	0,14	*Vertigo angustior* Jeffreys 1830
48	B	O	4,2	0,12	*Euconulus fulvus* (O. F. Müller 1774)
49	B	H	4,2	0,29	*Trichia hispida* (Linné 1758)
50	RU	O	2,8	0,09	*Succinea putris* (Linné 1758)

Table 1. (continued)

51	HF	Sz	2,8	0,09	*Vertigo pusilla* O. F. Müller 1774
52	St	H	2,8	0,05	*Granaria frumentum* (Draparnaud 1801)
53	St	Sz	2,8	0,02	*Cecilioides acicula* (O. F. Müller 1774)
54	B	H	2,8	0,05	*Cepaea hortensis* (O. F. Müller 1774)
55	B	O	2,8	0,05	*Aegopinella ressmanni* (Westerlund 1883)
56	B	Sz	1,4	0,39	*Balea biplicata* (Montagu 1803)
57	HF	Sz	1,4	0,04	*Hygromia transsylvanica* (Westerlund 1876)
58	HF	Sz	1,4	0,04	*Daudebardia rufa* (Draparnaud 1805)
59	HF	O	1,4	0,02	*Malacolimax tenellus* O. F. Müller 1774
60	B	Sz	1,4	0,02	*Vitrea contracta* (Westerlund 1871)
61	HF	H	1,4	0,02	*Trichia unidentata* (Draparnaud 1805)
62	HF	Sz	1,4	0,02	*Ruthenica filograna* (Rossmässler 1836)
63	B	Sz	1,4	0,02	*Discus rotundatus* (O. F. Müller 1774)
64	RU	O	1,4	0,02	*Vertigo moulinsiana* (Dupuy 1849)
65	B	O	1,2	0,02	*Truncatellina claustralis* (Gredler 1856)
66	HF	Sz	1,2	0,02	*Acicula polita* (Hartmann 1840)

Table 2. Mollusc fauna of managed forests planted after clearig of gallery forests arranged by constancy values

No	Fd	Fh	K%	D%	Species
1	St	Sz	100	8,11	*Vallonia pulchella* (O. F. Müller 1774)
2	B	O	55,5	29,05	*Cochlicopa lubrica* (O. F. Müller 1774)
3	RU	O	44,4	14,31	*Deroceras agreste* (Linné 1758)
4	B	H	44,4	2,99	*Helix pomatia* Linné 1758
5	B	H	44,4	1,49	*Cepaea vindobonensis* (Ferussac 1821)
6	RU	O	33,3	6,19	*Succinea oblonga* Draparnaud 1801
7	BE	O	33,3	5,12	*Aegopinella minor* (Stabile 1864)
8	RU	O	22,2	8,76	*Zonitoides nitidus* (O. F. Müller 1774)
9	B	O	22,2	8,76	*Vitrina pellucida* (O. F. Müller 1774)
10	B	O	22,2	6,49	*Oxychilus draparnaudi* (Beck 1837)
11	St	O	22,2	1,49	*Vallonia costata* (O. F. Müller 1774)
12	St	O	22,2	0,42	*Cochlicopa lubricella* (Porro 1838)
13	St	H	11,1	1,70	*Pupilla muscorum* (Linéé 1758)
14	B	O	11,1	1,28	*Limax maximus* Linné 1758
15	B	Sz	11,1	1,06	*Acanthinula aculeata* (O. F. Müller 1774)
16	St	Sz	11,1	0,85	*Truncatellina cylindrica* (Ferussac 1807)
17	B	O	11,1	0,42	*Arion hortensis* Ferussac 1819
18	St	Sz	11,1	0,42	*Chondrula tridens* (O. F. Müller 1774)
19	B	O	11,1	0,42	*Euconulus fulvus* (O. F. Müller 1774)
20	HF	O	11,1	0,21	*Perforatella vicina* (Rossmässler 1842)
21	HF	O	11,1	0,21	*Arion subfuscus* (Draparnaud 1805)
22	B	Sz	11,1	0,21	*Punctum pygmaeum* (Draparnaud 1801)

Gallery forests grow on pH=6-7 alluvial brown forest soil in the relatively higher parts of the flood plains between the dams. Their fauna is much affected by the faunatransport of the rivers, which in addition depends on the river‘s water output (Bába 1998). Polluted rivers, like the Sebes Körös, lack faunatransport. In the neutral parts of the riverbanks there are better conditions for the settlement of the species (Andó and Bába 1962).

Due to forest management, deforestation, river regulations and clearing in the surroundings of the river sources (Romania, Ukraine) the climate of the gallery forest altogether with that of the Great Hungarian Plain turned drier and the number of gallery forests decreased (Bába 1978). At the same time the number of constant- and dominant species decreased while the number of accessoric species increased. From the climateregions defined by Kakas (1960) the A1-A2 (Crisicum, Praematricum) and B1, B4, A4 (Colocense, Titelicum, Samicum, Nyírségense) typessignificantly differed from the warm and dry A1-2 regions using chi²-test. Warm and dry climate disables the faunatransport and the settlement of species (Bába 1996).

1.10.4. The species composition and levels of constancy of molluscs in the gallery forests

The list of species arranged considering the constancy levels in gallery forest and managed forests is indicated in Tables 1-2. Percentage frequencies of constant, subconstant and accessoric species are shown in Fig. 1. There are different constant species in plantations and managed forests, their ratio is different, too. The number of species decrease due to human effects, although the ratios of the three cathegories are similar. In north-eastern part of the Great Hungarian Plain among the constant species are *Chilostoma, Nesovitrea*, in the region of the river Körös and Érmellék *Hygromia kovácsi, Vitrea crystallina* and in the Körös-Maros interfluve area *Hygromia kovácsi* and *Cochlicopa lubrica*.

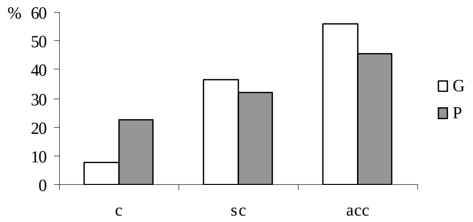

Fig. 1. Distribution of constant, subconstant and accessoric species of gallery forests and managed forests. G: gallery forest; P: plantation; c: constant; sc: subconstant; acc: accessoric

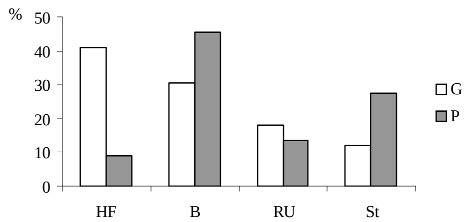

Fig. 2. Distribution of species on the basis of habitat types in gallery forests and managed forests. G: gallery forest; P: plantation; HF: forest dweller; B: bush forest dweller; RU: riparion ubiquist; St: stepp dweller

1.10.5. Distribution of species on the basis of habitat type and feeding habits

While forest dweller (HF) species were dominant in gallery forests, bush forest dwellers (B) and steppe dwellers (St) dominated in plantations and managed forests (Fig. 2). The distribution of species' feeding habits well indicated the human effects and it was different in gallery forest and managed habitats (Fig. 3). In the latter case the percentage frequency of omnivorous species increased while that of herbivorous and saprophagous species decreased.

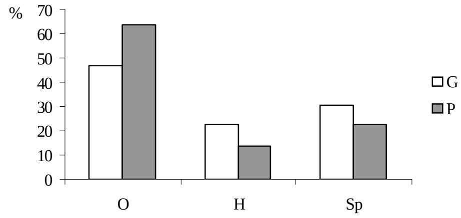

Fig. 3. Distribution of mollusc species on the basis of feeding habits in gallery forests and managed forests and plantations. G: gallery forest; P: plantation; O: omnivore; H: herbivore; Sp: saprofagous.

1.10.6. Summary

The authors investigations in 79 gallery forest study sites 66 mollusc species were recorded respresenting 68.04 per cent of the total number of the molluscs in the Great Hungarian Plain, which stressed the importance of gallery forests as ecological corridors. Constant species in certain regions may differ from the summerized list of species shown in Table 1. The distribution of species on the basis of the habitat types and feeding habits differs considerably between plantations and managed forests and unmanaged gallery forests indicating human influence. 54.16 per cent of the river transported mountain fauna was present in seminatural stands.

1.10.7. References

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1.11. THE HISTORY OF A LITTLE RIVER OF THE UPPER-KISKUNSÁG (HUNGARY) FROM THE ICE-AGE TO NOWADAYS

Szabó, S.

1.11.1. Introduction

Malacology, the science which studies the life of the mollusks, is particularly suitable to study the changes of the environment. The snail, which is a well-fossilizing organism, is an excellent bioindicator even after it's death. Upper-Kiskunság is a historical region of the Danube-Tisza Interfluve. The center of it is Kunszentmiklós.

The history of the river Bakér is inseparable from that of Kunszentmiklós, the "capital" of the Upper - Kiskunság. Our ancestors from the Bronze and Sarmata ages settled down at its bank, and so did the Hungarians from Árpád's age, and founded the old settlement which became the town of our time. Until the 1950s the river had a considerable size. The middle of the river-bed was dredged regularly. The big drought of the 1970s caused the decrease of the water-output. The river-bed was not looked after any more. In 1985 most of the river flowing through the town was covered, at a point even totally embanked. The water became swampy, muddy, and grown over by plants. At the lower part of the river the inflowing organic materials from the farmers' houses cause an extremely high burden (pollution) (Szabó, 1998).

1.11.2. Material and methods

This paper contains results of malacological examinations of 25 years. The fossil examinations were done in 1978, at the upper part of the river Bakér, in the walls of a former sand - mine. I sifted ten liters of material from each "snail - layer". For the classification I asked for Dr. Endre Krolopp's help, who is one of the best experts of this science.

For the recent - examinations I used the quadrate - methods. When treating the data, to make the comparison easier I used the dominance-degrees of the species as basic data. For the comparing analyses I used mathematical-statistic methods, such as cluster analysis with Czekanowski index, Shannon-Wiener’s diversity and the basic works of Lozek and Frömming (Szabó, 1994a-b).

1.11.3. Results and discussion

At the fossil examinations 36 mollusk species turned up. Among the data I include the *Vallonia* and *Vertigo* species, living near the bank and demanding constant wet; and the *Chondrula*, which endures drought, and was carried in by flood. Out of the five layers the two lower ones show the features of the early Pleistocene, the upper ones show the features of the late Pleistocene. The different species appearing from the different layers show the variety of the climate: those from the lower streaks show that in the beginning the climate was much warmer than nowadays; the middle streaks show much cooler climate as compared to the upper layers which, again, show warmer climate. Quite interestingly *Chorbicula fluminalis* also came to light. This species is the leader fossil of the second phase of the Würm. According to our present-day knowledge this streak was the highest where it came to light. The presence of the *Theodoxus danubialis, Theodoxus transversalis* and *Lithogliphus naticoides* species is also interesting, which refers to the assumption that Bakér was a rapidly flowing river that time. The *Gyraulus riparius*, which appeared in the higher streaks, is a typical standing water and marsh-living species.

Fossil and recent malacological examinations at the upper part of the river Bakér (% degrees of dominance)

	species	I	II	III	f 1	f 2	f 3	f 4	f 5	1975	1985	1998
1	Acroloxus lacustris	S	S	T						2,6		
2	Anisus spirorbis	O	Pp	T	5,21	6,52	3,73	11,6	6,87	25,7	38,4	78,4
3	Anisus vortex	O	SP	E					0,62			
4	Anisus vorticulus	H	S	O		0,43						
5	Bathyomphalus contortus	H	SP	O			0,46					
6	Bithinia leachii	O	P	O	9,21	9,13	10,74	13,25	6,25			
7	Bithinia tentaculata	O	FS	O	6,26	20,43	14,01	18,28	5,62	8,79	4,58	
8	Chondrula tridens	H	X	T					1,25			
9	Cobicula fluminalis	S	F	O		0,43						
10	Fagotia acicularis	O	F	O	0,54	0,43	0,93		0,62			
11	Gyraulus /Armiger/ crista	H	S	O	8,67	3,91	3,27	4,41	7,5	0,54		
12	Gyraulus albus	O	S	E	8,44	5,65	4,67	7,18	2,5	3,25	1,25	
13	Gyraulus laevis	O	S	E	6,11	10,43	10,28	8,28	1,25			
14	Gyraulus riparius	P	FS	O	0,27		0,46	1,1	1,25			
15	Hippeutis complanatus	S	S	O				0,55		0,54		
16	Lithoglyphus naticoides	O	F	O			1,4	1,65				
17	Lymnaea /Galba/ truncatula	H	SPPp	E					1,25	0,54		
18	Lymnaea /Radix/ peregra	O	FS	T		0,86	0,46	0,55	0,62	17,9	25,8	18,6
19	Lymnaea /Stagnicola/ palustris	H	P	E	8,97	2,6	3,73	4,97	1,87	2,34	0,45	
20	Lymnaea stagnalis	O	S	E	10,84	2,17	1,4		0,62	5,78	0,45	
21	Pisidium amnicum	S	FS	O			0,87	0,55	1,25			
22	Pisidium sp.	S	S	O	0,81	1,13	2,33	8,81	30,62			
23	Planorbarius corneus	O	S	E		0,43				1,25	0,45	
24	Planorbis planorbis	H	P	O	8,67	13,47	24,29		4,37	14,3	6,4	
25	Segmentina nitida	O	P	O				0,55	1,25	2,5	4,4	
26	Succinea /Oxyloma/ elegans	H	P	T				1,1				
27	Succinea oblonga	H	H	E	1,35	3,47	1,86	0,55	8,75	12,3	17,9	3
28	Theodoxus danubialis	H	F	O		0,86						
29	Theodoxus transversalis	H	F	O			0,46					
30	Vallonia enniensis	S	H	E	0,54	0,43	0,64	0,55	1,25			
31	Vallonia pulchella	S	H	E	1,35	0,43		2,2	1,87			
32	Valvata cristata	S	P	E	3,79	2,17	2,33	2,2	2,5	1,52		
33	Valvata piscinalis	S	FS	O	8,13	8,69	8,41	7,18				
34	Valvata pulchella	S	SP	E	10,56	5,65	3,27	4,41	6,87			
35	Vertigo antivertigo	S	H	E					1,25			
36	Vertigo pygmea	S	H	E					1,87			

I = nourishment type , II = ecological group, III = temperature demand

During the recent examinations one more species turned up, the *Acroloxus lacustris.* It might have lived here formerly, but it is very difficult to find. The recent mollusk species turned up from Bakér are almost the 50 % of the mollusk fauna of the Upper - Kiskunság.

(Szabó, 1980) Most of the species turned up from the upper Pleistocene layer (25), least of them turned up at the collection in the year of 1998. (3)

I examined the diversity of living places of different ages with the Shannon - Wiener diversity (Orbán, 1995).

	Fossil layers					Recent collections		
	1	2	3	4	5	1975	1985	1998
H_S	0,86	0,89	0,91	0,88	0,87	1,05	1,30	1,73
J	0,43	0,43	0,44	0,43	0,43	0,51	0,62	0,82

(H_S = degree of diversity, J = evenness of Shannon diversity)

The examination of nourishment habits shows it balanced in the three lower layers of Pleistocene. The increase in the rate of the *saprovor* species shows the process of marshiness. There were *saprovors* only in 1975 in the recent material, then, because of the increasing accumulation of mud, which is not suitable for these snails, they disappeared. (Frömming, 1956)

	fossil layers					recent collections		
	1	2	3	4	5	1975	1985	1998
H	27,66	24,74	34,07	11,03	24,99	30,00	24,80	3,00
O	46,88	56,05	48,08	62,44	27,47	65,10	75,30	97,00
S	25,18	18,93	18,85	26,45	47,48	4,66		

(H = plant-eating /*herbivor*/, O = all-eating /*omnivor*/, S = detritus-eating /*saprovor/;* In % degrees)

Examining the temperature demand of the species turned up we can see that there are *oligotherm* (cool water liking) species in bigger rate in the Pleistocene layers. At the recent materials the dominance of *thermophile* species increasing, in proportion to the decrease of water depth. (Frömming, 1956)

	fossil layers					recent collections		
	1	2	3	4	5	1975	1985	1998
T	5,21	7,38	4,19	13,25	8,74	46,2	64,2	97,00
E	51,95	33,43	28,18	30,34	32,47	27,00	20,50	3,00
O	42,56	58,90	67,63	56,33	58,73	26,60	15,40	

(T = thermophyl, E = eurytherm, O = oligotherm; In % degrees)

I examined the basic data according to the ecological classification of Lozek. (In %)

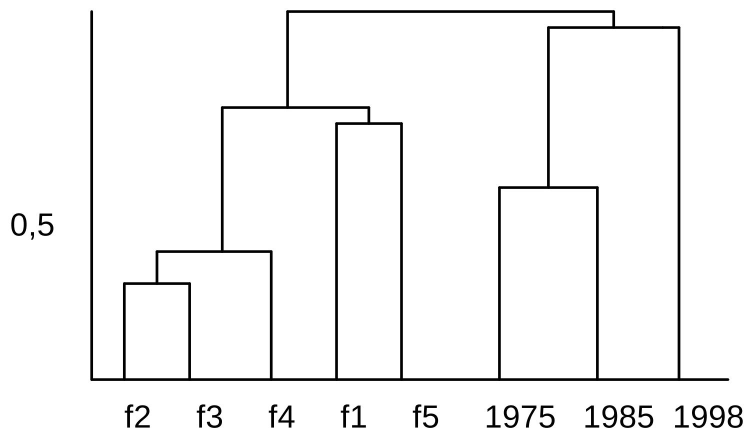
	fossil layers					recent collections		
	1	2	3	4	5	1975	1985	1998
F	0,54	1,72	2,79	1,65	0,62			
FS	14,66	29,98	24,21	27,66	8,47	26,7	30,4	18,6
S	34,87	24,15	21,95	29,23	42,49	14,00	2,15	
SP	10,56	5,65	3,73	4,41	7,49			
P	30,64	27,37	41,09	22,07	16,24	20,60	11,3	
Pp	5,21	6,52	3,73	11,60	6,87	25,7	38,4	78,4
SPPp					1,25	0,54		
H	3,24	4,33	2,50	3,30	14,99	12,30	17,90	3,00
X					1,25			

(F = flowing-water, FS = flowing - standing water, S = standing water, SP = standing water - marsh, P = marsh. Pp = marsh - puddle living, SPPp = puddle - living, H = wet demanding, X = drought suffering; In % degrees)

In the Pleistocene layers, although in low degrees, the flowing water species are present. It refers to moving water. The presence of several standing water and marsh living species, however, refers to the riverside reeds and seaweeds of the bending river. In their rations layers No. 2-3 and No. 4 are similar, as well as layers No. 1 and No. 5.

Flowing-water species are not included in the material of the recent collections and gradual increase can be seen in the dominance of the most common snails (*Linnaea peregra, Anisus spirorbis* . Now the total reign of the puddle-living *Anisus spirorbis* is typical (Lozek, 1965).

Comparing examinations of the collected materials were done with the correlative method (Index of Czekanowski), then, using these data, I did Cluster - analysis. (Szabó 1994b). Analyzing the dendogram of the Cluster - analysis it is seen that the Pleistocene and recent material is isolated. More closely connected are layers No 2. and No. 3. To this layer No. 4 is closely connected. Then, at a low level come layers No.1 and No.5. In recent materials there is a loose connection between the materials from the year 1975 and 1985. To this is connected, at a very low level, the material from the 1998 collection.



1.11.4. Conclusion

The history of the river Bakér ended with the XXth century. But, with good will, it could be living water again . I believe that, with appropriate division of water from the canal XXX, the problem of water-supply, by derging the problem of open-water could be solved. This will be the task of the XXIst century.

1.11.5. Summary

This paper presents the history of a river of the Upper - Kiskunság (HUNGARY) from the Ice - Age to nowadays. Fossil examinations show the paleoecological state of the River Bakér. The turning up of *Corbicula fluminalis* is a special value of the fossil malaco-fauna. Recent examinations follow the total decline of this little river in the last three decades of the XXth century. Now, in the bed of the former river only wide - suffering, puddle -living species live.

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Chapter 2

Conservation biology

2.1. PRINCIPLES AND METHODOLOGY OF INTEGRATED CATEGORISATION OF WATER BODIES AND WETLANDS DEMONSTRATED ON BACKWATERS

G őri, Sz., Aradi, Cs., Dévai, Gy. and Nagy, S.

2.1.1. Introduction

From all natural systems perhaps water bodies and wetlands have been lost or degraded to the most serious extent due to human impacts. River regulations, drainage of marshes, fens and bogs caused not only extinction of number of plant and animal species, but also resulted in major transformation of landscape structure and feature on vast areas. Therefore particular attention has to be paid to those wetlands have been escaped from destruction, with special regard to backwaters being of outstanding natural, landscape and economical values.

In spite of differing according to their transformation and use, backwaters bear joint features of their genesis and ecological relationship. Their vulnerability is dependent on the status of their natural systems, preservation of which determines the possibility of their maintenance. Through undertaking an inventory they may be ranked from backwaters representing highest nature conservation value (so called sanctuary-like backwaters) to those backwaters, of which wildlife has almost completely destroyed (economical use or wastewater recipient). Difficulty and complexity of their preservation and maintenance may be ranked in the same sequence.

Due to different genesis (e.g. different age, shape, length, depth of bed), backwaters exhibit different stages of ecological succession resulting in filling up, or even there may exist different successional stages within a single wetland area. Ranging from backwaters with deep and open water to backwaters staying in later stages of succession (wet meadow, marshy meadow, fen or gallery woodland like backwaters), all types may be of appropriate quality in compliance with the given successional stage and thus valuable. Effective state estimation of backwaters using traditional water chemical and biotic indices is very difficult, sometimes even impossible. Backwaters having completely different character on synbiological grounds, may be qualified as equally valuable. Attributes, like a backwater is characterised by alkaline water or eutrophic status (and many more besides could be taken as an example) does not mean inevitably one being of higher value than other.

2.1.2. Methods and Results

2.1.2.1. Survey

Survey of a biotope, and so of a backwater, is practically done by the expert, who has appropriate field experience, while observing the site (almost automatically, based on physiognomy) and without conducting any special sampling or sample analysis. Such a simple survey is usually founded on species diversity of a studied taxa, with special regard to presence or absence of characteristic and unique species. Often, knowledge of a given taxa is not even used in the first phase of survey. In this case, decision is taken considering the general scenery, feature of the area. Contrary to evident appearance, decision is not at all subjective. In the course of conducting a survey on the area, expert considers completeness of natural spatial connections and landscape features of the object, characteristics of natural communities (e.g. mosaic structure, zonation), completeness of littoral communities (as ecotons, natural buffer zones). Opinion formed of the values of the area may be influenced by presence of protected or strictly protected plant and animal species, which are easy to observe and possibly even landscape atmosphere aspects.

As the overview in the preceding suggests, it is not so easy to measure or quantify those attributes referred to above. Nature conservation and ecology have tried to determine nature conservation value and degree of being endangered for species of flora and fauna of a region (continent, country, region). Categories of supraindividual organisation, especially biocoenosis and holoceonosis have received more and more attention from nature conservation in recent years, regarded as values which should be protected. Among their components, from synbiological point of view, these are mainly the characteristic physiognomy of plant communities and their mosaic complexes which determine the feature of our natural landscapes. Visual survey outlined above focuses practically on these supraindividual systems. Survey and estimation of them require profound and broad knowledge and excellent field experience as well. We are convinced, that state (species richness, diversity, naturalness, degree of degradation) of these supraindividual units will increasingly became one of the most important factors of state estimation in the future.

In the next phase of visual survey, threatening factors are taken into consideration, like size and isolation of the area, possibilities of water supply, ratio of different use and utilisation forms, distance from intensive agriculture lands. It is easy to evaluate morphological feature, shape (loop, crescent), location (within or outside embankments) of the backwater to be surveyed. These information in most cases serve precise separation within the different categories, and sometimes they are not used at all.

<table>
<tr><td colspan="2">Utilisation categories</td></tr>
<tr><td rowspan="2">I. Nature conservation priority</td><td>protected (on international level, on country level, on local level)</td></tr>
<tr><td>not protected, but has to be protected on some level</td></tr>
<tr><td colspan="2">If the backwater does not meet criteria of category I., procedure has to be continued with category II. (wise use).</td></tr>
<tr><td rowspan="2">II. Wise use</td><td>nature area (enjoys some protection by law)</td></tr>
<tr><td>sound use (traditional fisheries, reed and reedmace harvesting)</td></tr>
<tr><td colspan="2">If the backwater does not meet criteria of category II., procedure has to be continued with category III. (economical utilisation).</td></tr>
<tr><td rowspan="7">III. Economical utilisation</td><td>water storage (emergency reservoir, water reservoir)</td></tr>
<tr><td>water take-off for agriculture (irrigation)</td></tr>
<tr><td>industry (cooling water)</td></tr>
<tr><td>recreation (tourism, water sports, intensive angling)</td></tr>
<tr><td>intensive fishery, fish production</td></tr>
<tr><td>poultry farming (duck, goose)</td></tr>
<tr><td>wastewater storage</td></tr>
</table>

Visual survey is one of the most simple state estimation form, thus requires appropriate knowledge of natural communities connected to backwaters and native community species. Most important community types to be investigated are hydrophytes, reeds and long-stand dicotyledones dominated associations, meadows and woodlands fringing backwaters (soft and hardwooded woodlands). Besides knowledge of communities and species, orientation of communities, their spatial pattern (zonation, mosaic structure) and ratio between different habitats (open water, hydrophytes and marsh vegetation) are important. Visual survey, as the first phase of state estimation, is appropriate tool for separating the main use categories. Advantage and essential feature of the method is, that the first phase focuses on the wildlife, the most vulnerable element of the system to be qualified. Separation of main categories (I. nature conservation priority, II. wise use, III. economical use) is based on dominancy and determinant importance of use forms. This first, rough separation may be refined by obtaining some simple additional data.

The following phase of survey is continued on the field, serving for more precise separation, differentiation. The necessary macroscopic data collection (e.g. for the sake of estimating species diversity, state of buffer zones, landuse forms, distance from agriculture, industry and residental areas and how they affect the object), may be completed with the registration of some typical baseline data (e.g. water depth, extension, volume). These information are usually available from registers at municipalities, land offices, water management offices, environmental authorities and nature conservation authorities.

From the point of view of the procedure of survey, it is always the natural status which has to receive high-priority. The role of the real utilisation forms should be taken into consideration depending on state of nature. For example in the case of a so called "sanctuary-like backwater", which is also used for angling, the more vulnerable value, the natural richness should receive priority. While the run-off water or wastewater storage or fish-pond function of a backwater is relatively easy to restore, comprehensive rehabilitation of its natural systems is almost impossible.

Practical implementation of survey

1, If the backwater is protected by any of the national legislative protection categories (protected by law on national or on local level or is under designation of being protected), or if stays under protection of international conventions (e.g. Ramsar Convention), it has to be classified without any further investigation into category I.

2, If the backwater meets at least three of the following criteria (independently from one another), it has to be regarded as an object of nature conservation priority (category I.).
Main attributes of category I. (nature conservation):

- holds valuable (endemic, relic) species and communities,
- home to species and/or communities/associations threatened with extinction,
- holds natural or near-natural species assemblage and associations,
- the object is considered free from degradation,
- at least on 50 % of the full length of the bed the three dominant zones (open water, hydrophytes, reeds/long-stand dicotyledones dominated plant associations) occur in original development,
- littoral zone is fringed at full length with natural or near-natural plant communities/associations,
- can be regarded as fundamental part of a green corridor (e.g. river valley, floodplain).

(Recently in the Hungarian practice a special group of backwaters of outstanding natural and landscape values has been formulated, so called "sanctuary-like backwaters". The "sanctuary-like backwaters" may be regarded as a special case of category I. A given backwater may be included in this category, if it meets the majority of the above mentioned criteria and besides represents highest value of biological diversity and landscape feature of the ecological type it belongs to.)

Having the necessary skill, given backwater simply can be ranked into category I., based on visual evaluation and without conducting any particular survey on plant associations or on fauna. (More precise classification within this category is provided by adopting the assessment procedure outlined hereinafter.)

3, If, on the basis of the visual survey the backwater meets only one or two from criteria listed above, it may be required to undertake at least three investigations on flora, on plant associations and on fauna during growing season. Suggested timing: early May, mid-June, early August.

4, If, on the basis of the visual survey the backwater does not meet the criteria of point 2. and biotic investigations carried out as set in point 3. also do not suggest to rank it into category I., the survey has to be continued at category II. This rigorous process of survey has to be followed, even if it is obvious already at the first look on the area, that the backwater belongs to category III.

5, As the next step, it has to be examined that the backwater meets or does not the criteria of being ranked into category II.
Main attributes of category II. (wise use):

- natural zonation is incomplete, but it has survived on at least 50 % of the area,
- the object is characterised by common, but native species and/or communities/associations,
- the area is degraded only in small part and in a small degree,
- landscape values of the object demand some protection (e.g. stage for ecotourism),
- the area is influenced by human activity to some extent, but it is characterised by traditional use forms (e.g. reed and/or reedmace harvesting, traditional fishing),
- littoral edge is partly built in or used for agriculture, but edge communities occupy 50% of the littoral edge,
- maximum 50 % of the object is used for recreation and recreation activities and maintenance of natural values are harmonised.

6, If the backwater meets at least three of the criteria stated above, it has to be ranked into category II. In this case it is very likely, that irreversible degradation processes did not take place yet, and after implementing adequate rehabilitation actions the backwater may be ranked even into category II. (More precise classification within this category is provided by adopting the assessment procedure outlined hereinafter.)

7, If it does not meet at least three criteria from those set for category II., the object should be ranked into category III. These objects are degraded, their natural systems are for the most part destroyed, they may be characterised by predominance of human impact.

Damages in most cases are irreversible under natural conditions, which means that their restoration requires full reconstruction, that is a slow process with uncertain result, in addition requires lot of expend (mainly money and care).

2.1.2.2. Assessment

The second phase of integrated categorisation is assessment. This phase of the procedure requires particular field investigations, moreover, for some factors appropriate sampling and laboratory processing. It has emerged through our broad preliminary studies, that this task would not be practical to be performed universally, basically for reasonable restriction of range of investigations. It would be yet more advisable, to handle together water body types or those water body groups related in certain respect (e.g. genesis, use). Proposal for backwaters is completed already (Dévai *et al.* 1999). This allows assessment according to 44 attributes. Attributes were selected with the aim at allowing a comprehensive representation of the state of the backwater and the terrestrial surroundings affecting it, from both biotic and abiotic sides, even considering major positive and negative human influences.

2.1.2.3. Qualification

As the third phase of integrated categorisation, we think it essential to carry out a qualification procedure which is objective, therefore independent of human judgement. This procedure has to be conducted mainly on those objects, which later may be used as basis for comparison (etalon) in some important respects (e.g. water body type, management or use form type). Theoretical grounds of ecological qualification was previously elaborated (Dévai 1994) and also a comprehensive qualification procedure for backwaters was conducted and interpreted (Dévai *et al.* 1999). Qualification procedure always starts with the classification of water bodies, as all those attributes refer to the wetland type, which will be used later as indicative indices suitable for comprehensive qualification. Two main groups of these indices are distinguished. One of them is the group of so called static attributes, which characterise the object and the wildlife it holds for a longer period of time or at least for one growing season. Dynamic attributes, the other main group of attributes, are varying to some extent in time, sometimes significantly. The qualification system operates with basic data, state-characteristics and indicative indices. Actual values (observed or measured) are handled as basic data. It requires the first level of abstraction to determine state-characteristics, which mean a conversion into a quality category according to a code list established relying upon the whole range of potential concrete values. Requiring next level of abstraction, based on the indicative indices and with regard to state attributes the global environmental quality state over at least one growing season can be estimated, with the help of a comprehensive code list consisting of all alternatives.

2.1.3. Discussion

In the course of considering theoretical and practical issues of integrated categorisation, we became more and more aware of the essential importance of analysing two main aspects concerning any matter related to the extremely divergent and complicatedly interlinked issues of preservation and conservation and use and utilisation. These aspects are area dependence and target dependence. Failing a properly detailed preliminary assessment of them, nor finding the appropriate solutions, nor the harmonisation of interest can be expected.

Area dependence is in most cases clear and definite. Target dependence is basically a question of conception, which has to be determined according to general aspects in the beginning. Within an area of significant size and diverse geomorphology a range of use and utilisation forms may exist, with strongly varying character and intensity of impacts on it. It is impossible and at the same time senseless to assesst them beforehand and to be prepared for all possibilities. The only effective solution in the course of careful designing of preparatory works is to elaborate a program, that could be used as basis for rapid designing of further investigations adopted to actual objectives, which could be successfully implemented and their comparative analysis can also be executed successfully. Necessary consequence of all these, that the preliminary proposal should meet the criteria of being comprehensive enough (but not inexecutably) and appropriately (practically) detailed, in order to provide suitable information for the varied, sometimes basically differing later approaches.

Related to target dependence, both generally and concretely, it has basic importance from ecological aspect to analyse those functions, which may be raised in connection with use and utilisation of the area. Concerning this issue, relationship of different utilisation forms has inevitably to be discussed in ecological approach, if only because prevention.

From the point of view of ecologists, principle of complex utilisation is very much open to criticism and according to experiences gained of late decades, it is even perfectly unacceptable. Adopting this principle is mainly cloaks irresponsibility and is the father of uninhibitedness. That is to say, complex utilisation is mostly mentioned, if explicit priority order is not set, because it is not wanted to be established or it is impossible to establish. If such an order does not exist, all user may well feel so, he is entitled to enforce his rights to the highest degree. And this usually results the object will not be suitable for performing any function after a while, because it has been drastically and irreversibly deteriorated. We have to avoid this approach in the future and the practice based on it by all means, particularly in the case of sites and objects of outstanding natural values.

In this respect ecologists think, that before selecting among the main utilisation forms (e.g. nature conservation, water management, power generation, shipping, irrigation, public welfare), careful consideration and comprehensive function analysis have to be carried out, and for each site only one function has to receive absolute high-priority. Though multy function utilisation according to the main functions is not excluded in this case, but absolutely clear and explicit priority order of rank always has to be set up and strict and consistent observance of them has to be ensured. Theoretically and also practically it is possible to perform simultaneously various partial functions within the main use categories (e.g. ecotourism within public welfare, water sports within recreation). But if so, the often completely different interests should be prioritised and harmonised. For the sake of the success of this aspects, it is advisable to term this utilisation form integrated (harmonised) utilisation and not complex (combined) utilisation.

We publish our proposal in the hope of constructive dialogue of representatives of various professions, founded on scientific arguments, will result in providing suitable conditions for starting a new chapter in water management, particularly in the case of the river valleys playing key role in many respects, in which also wetlands will obtain the place and role their significance deserves.

2.1.4. Summary

Effective state estimation of backwaters using traditional water chemical and biotic indices is very difficult, sometimes even impossible. Three phase of integrated categorisation of backwaters will be discussed in this paper, more detailed about survey. As the first phase of integrated categorisation, visual survey is appropriate tool for separating the main use categories. Visual survey focuses on supraindividual systems. Advantage and essential feature of the method is that the first phase focuses on the wildlife, the most vulnerable element of the system to be estimated. Separation of main categories (I. nature conservation priority, II. wise use, III. economical use) is based on dominance and determinant importance of use forms. The second phase of integrated categorisation is assessment. This phase of the procedure requires particular field investigations, moreover, for some factors appropriate sampling and laboratory processing. As the third phase of integrated categorisation, an ecological qualification procedure has to be carried out, which is objective, therefore independent of human judgement.

Finally we will discuss some aspects of preservation and utilisation of backwaters. Before selecting among the main utilisation forms of a backwater, careful consideration and comprehensive function analysis have to be carried out, and for each site only one function has to receive absolute high-priority. The often completely different interests should be prioritised and harmonised. It is advisable to term this utilisation form integrated (harmonised) utilisation and not complex (combined) utilisation.

2.1.5. References

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2.2. THE ECOLOGICAL, HYDROBIOLOGICAL AND NATURE CONSERVATIONAL STATE OF THE EUSTATIC DEAD-ARMS AROUND THE VILLAGE OF TARPA (NE-HUNGARY)

Lakatos, Gy., Kovács, B., Kiss, M. K. and Keresztúri, P.

2.2.1. Introduction

Wetlands can be generally characterized by the littoral phytal being always larger than the part of the littoral zone that is dominated by planktonic life forms. Items of specifications and classifications cannot always be arranged hierarchically, but one assumption is completely accepted, wetlands can be either natural wetlands, or constructed wetlands connected to human activities (Lakatos, 1997), such as rice-lands and mine ponds. Naturally, it is also agreed that the individual wetlands differ from each other in their degrees of water circulation, and can represent eustatic, semistatic or astatic water bodies (Dévai, 1994).

Regarding the localisation of the Hungarian wetlands, they can be classified as palustrine (marsh and bog), lacustrine (connected to lakes) or riverine (in river valleys) types, according to the IUCN's recommendation (Dugan, 1990). Dead beds of river are found in the river valleys and flood plains, with this latter case being especially common after the process of the Hungarian river regulations. On the basis of their connection to the main-arm, the actual water flow, these beds can be divided into ox-bow lakes, where the high water level of the river provides flushing in particular periods of the year, and short-cut dead-arms, which either have lost all their connections to the river or can be found in the discharged side (Lakatos, 1998).

Wetlands are often evaluated as theatres of biodiversity. Large-scale morphometric differences and the biochemical variety of the present processes yield a diverse flora that, in turn, gives shelter to a rich kind of fauna, coupled with an abundance of micro-organisms that is less spectacular, but plays an essential role in the life of wetlands (Mitsch, 1996).

During 1998, in the framework of the „Tarpa region environmental state assessment" supported by the Programme Financing Application, examinations have been initiated in order to gain an overall survey on the ecological and hydrobiological ground state, as well as on the local fish fauna of the dead-arms situated in the area of Tarpa. The research work covered the dead-arm of River Tisza at Helmecszeg (H), Vargaszeg (V) and the so-called Kiss Jánosné's dead-arm (K).

2.2.2. Materials and Methods

All the three dead-arms are situated within the right-sided flood plain of River Tisza, and evolved in the time of the river regulations there by cutting off the bends of the flowing river. Their regular water supply is not ensured, and the dead-arms receive fresh water only in periods when the water level of the river is high, reaches up to 290 cm at the watermark post of Rahó.

The northernmost of the three dead-arms is the dead-arm of River Tisza at

Helmecszeg that has a relatively steady run-down. Among the examined wetlands, this dead-arm lies in the largest area (12 ha), but has the smallest depth (its deepest point is about 2 m). Today, water can only be found in the upper branch, even when completely filled, while in water deficiency exclusively the deepest site of the upper branch (upper end) contains water. The inlet for the settled communal wastewater of Tarpa is situated in the lower third part of the dead-arm (water sampling site 1). In the upper end (water sampling site 3) there was a small open water spot observed. All along the right bank, except for the section including water sampling site 2, a belt of *Typha angustifolia* runs.

When heading for south one faces the dead-arm at Vargaszeg with its area of 6 ha. This is the deepest one of the three investigated wetlands, therefore has the most balanced hydrobiological character. Its deepest point reaches down to about 6 m. Due to its depth and the introduction of grass carp, its flora is scattered. In the lower end being intermittently dried up (water sampling site 1) there are patches of *Polygonum amphibium* detected. In the middle part of the dead-arm (water sampling site 2), in the inner part of the former bend, *Phragmites australis* appears in patches, as a bordering plant. In the upper end (water sampling site 3) with shallow regions some spears of *Stratiotes alloides* can be found.

Kiss Jánosné's dead-arm lies further to the south. According to the land registry, it has an area of 8 hectares, yet the water surfaces and the depth (4 m) is measured to be smaller than those of the dead-arm at Vargaszeg. Similarly to this latter dead-arm, the flora is scanty, and in the shallow parts at the two ends of the dead-arm, spears of *Potamogeton lucens* grow, while in the lower end (water sampling site 1) it is complemented by stands of *Trapa natans* and *Sagittaria sagittifolia*. In the inner side of the bend some stems of *Nymphaea alba* shoots up, and close to the shore there are patches of *Polygonum amphibium*. Within the section of water sampling site 3, in the right bank, stands of *Schoenoplectus lacustris* can be detected, while in the left bank and the upper end of the dead-arm, *Glyceria maxima* are found.

Water, plankton and plant samples were taken on four occasions – 16/04, 09/06, 21-23/07 and 11-12/09 – during the year of 1998, whereas fish individuals were collected three times with accumulator-generated electric fishing machine. The water samples were processed according to the methods published in Felföldy's handbook (1987). On the basis of the obtained results, the water types, as well as the phyto- and zooplanktonic compositions were established. The species list and nature conservational evaluation of tangles are also detailed (Simon, 1988; Borhidi, 1993).

2.2.3. Results

The particular characters of the wetlands are primarily determined by hydrological factors, the water coverage, water circulation (flooding, drying), water depth and changes in the water level, and at the same time these are the elements that ensure the most essential conditions to aquatic organisms. In this way, the amount of water supply has fundamental importance, however, it is specially the reaction of the organisms through which the significance of water quality is revealed. The physical and chemical properties of water, as well as the factors being responsible for them, do not exercise their effects separately, but through a rather complex system of action mechanisms, and considering the principle of tolerance, the aquatic organisms – with certain limitations – flexibly adopts itself to this system on the level of populations.

All the three dead-arms have relatively low conductivity, and can be grouped to the beta-oligohalobic and beta-alpha-oligohalobic halobity category (Felföldy, 1987), while they – with the exception of the spring water sample collected near the wastewater inlet of the dead-arm at Helmecszeg that is characterized by the Na-HCO_3 ion type – belong to the Ca-HCO_3 ion type, identically with the wetlands of the Tisza valley (Lakatos, 1990).

Small figures for the values of oxygen saturation remaining under 10 % were measured only at water sampling site 1 of the dead-arm at Helmecszeg (near the wastewater inlet, in a flood-free period). The oxygen saturation value generally exceeded 50 %, and accordingly, aerobic conditions prevailed. Furthermore, in areas thickly grown with aquatic plants, saturation values over 100 % were frequently experienced. It can be claimed that the oxygen supply proves to be favourable for the occurrence of natural purification, as well as for the lives of zoo-organisms including fish species.

Regarding the results of measurements on the concentrations of nitrogen and phosphorus forms, the trophity of the dead-arms, that is the nutrient supply, was found to be poor, even in the case of wetlands for fishing, since they reached a mesotrophic state only on two occasions. It is the oligo-mesothrophic type that generally dominates the aquatic sites, and the phosphorus supply is extremely low. The dilute effect of the floods was indicated by the measurements, in these periods the trophity of the investigated dead-arms reduced to an oligotrophic state.

Values for saprobity were detected to be more unfavourable than those of trophity, because – due to the inflowing wastewater – water sampling site 1 of the dead-arm at Helmecszeg showed an alpha-mesosaprobic state that as a consequence of dilution was decreased by two units into beta-mesosaprobity. As compared to this latter state, more favourable water quality conditions were observed only at water sampling site 3. In the case of the dead-arm at Vargaszeg, it ranged between oligo-beta-saprobity and oligosaprobity, therefore the dead-arm could be considered as having fine water quality. The water saprobity of Kiss Jánosné's dead-arm brought values between the data for the two above dead-arms.

The results of phytoplankton analyses correspond to the water chemical data, they can be characterized by relatively small species, as well as individual numbers (30 000 ind/L), the biomass does not reach 0.1 mg/L, and turned out to be remarkably low in the cases of the two dead-arms used for fishing. The most frequent species belong to the *Bacillariaphyceae*, and the most important are *Aulacoseria granulata var. angustissima*, *Nitzschia palea*, *Synedra acus* and *Synedra ulna*. The presence of the *Dinophyta* species, *Peridinium palatinum* at water sampling site 1 of the dead-arm at Helmecszeg being heavily loaded with organic pollutants is worth to be mentioned separately. On the other hand, the infrequency of green algae (*Chlorophyta*) in all the three dead-arms is quite a surprising observation.

The results of zooplanktonic analyses reflect what has been established on the basis of biological-ecological water quality indices about trophity and constructivity, because the entire year brought about small taxon and individual numbers. Favourable conditions were only examined in the September samples from the dead-arm at Vargaszeg, in which the individual number came close to the 30 000 ind/10 L value. In the case of the other dead-arm utilised as fishing water, the individual number remained below 20 000, and about one-third of this amount could be found in the samples of the dead-arm at Helmecszeg. Among zooplankton species, the following rotifers (*Rotatoria*) were detected in larger masses: *Anuraeopsis fissa, Brachionus diversicornis*, *Keratella cochlearis* and *Polyarthra dolichoptera*.

In the life of wetlands, plants, respectively their various life forms and connections to the water (their obligate or amphibian nature) have important roles, yet these factors naturally originate from long-term evolutionary processes. The potential vegetation and its structure are primarily defined by the water supply and water quality of the given wetland. Abiotic and biotic parameters work through a series of interrelations that may change dynamically, and thus can develop into more complex interdependencies. Revealing these interdependencies must involve the examination and determination of the sub-processes.

From the three dead-arms, 20 aquatic plant species were identified, and the species list is given in Table 1.

Table 1. Species identified

	H	V	K
Alisma plantago-aquatica	+		
Glyceria maxima	+	+	+
Iris pseudacorus	+		
Lemna minor	+	+	+
Lycopus europaeus	+		
Lysimachia vulgaris	+		
Nymphaea alba	+		
Phragmites australis	+	+	+
Polygonum amphibium	+	+	+
Potamogeton lucens	+		+
Rorippa amphibia	+	+	+
Sagittaria sagittifolia	+		+
Schoenoplectus lacustris	+	+	+
Solanum dulcamara	+		+
Spirodela polyrrhiza	+	+	+
Stratiotes aloides		+	
Trapa natans	+		+
Typha angustifolia	+	+	+
Utricularis vulgaris	+	+	+
Zannichellia palustris	+		
total species number	19	10	13

From the 20 species, 19 were found in the dead-arm at Helmecszeg, and only one, the stratiotes (*Stratiotes aloides*) did not show up. Small stands of the latter species were observed in the dead-arm at Vargaszeg, yet in this site just 10 species could be identified, three species less than in the third dead-arm.

Regarding the distribution of plant species into nature conservation value categories according to Simon (1988), it is the dominance of associative and accompanying species that is characteristic (90 %), while there was one species authorised as protected (*Iris pseudacorus*) and one disturbance tolerant species (*Solanum dulcamara*) also occurred, which indicates degradation. Based on the naturality valuation figures for the Hungarian flora (Borhidi, 1993), the natural competitor species have a determinant role among the social conduct types of natural habitats (45 %), and besides, the generalists or accompanying species, and the natural pioneer plants must be mentioned here. Specialist have only one species, the arrow-head (*Sagittaria sagittifolia*) detected in the area, while on the other hand disturbance tolerant species, which generally belong to interfered habitats, are represented by four species (*Lycopus europaeus*, *Lysimachia vulgaris*, *Polygonum amphibium* and *Solanum dulcamara*).

Apart from the macro-ions, microelements were also subjected to analyses, and particular attention was given to the analysis of heavy metals from the water samples and the fractions of the collected fish species. Quite interestingly, the water analysis carried out with ICP AES could not detect iron in any of the dead-arms, and the manganese concentration remained below 0.1 ppm. It is certainly the aerobic and oxidised conditions that resulted in the deposition of dissolved iron ions and the reduction of the manganese content, though the low level of loading may also contribute to it. Similarly to iron, the concentration of copper did not enter the zone of detectability, because no sample contained this particular element in an observable form. The highest concentration was measured in the case of zinc, the two extreme values were 0.05 and 0.5 ppm. This significant concentration of zinc originates from external loading, still remains well under the value of about 100 ppm obtained from River Túr (Kocsis & Lakatos, 1999). Among heavy metals, every sample bore chromium, and some of the samples had lead and cadmium.

H1	Zn > Cd > Pb > Mn > Cr > Cu
V1	Zn > Pb > Mn > Cr > Cd = Cu
K1	Zn > Pb > Cd > Mn > Cr > Cu

The examination results on fish-biological and faunistic conditions, as well as fish stock structure of the investigated dead-arms near Tarpa have been published in Kovács and Lakatos's survey (1999). Analyses on heavy metals were also performed from the musculature, liver and scales of the fish individuals that belong to the species collected in larger masses in the dead-arm at Vargaszeg. The musculature of the fish individuals did not reveal the presence of cadmium or lead, while the manganese and copper contents were measurable for all the three, examined fish species, though the concentrations remained below 10 ppm. The zinc concentration was detected to be the highest in the roach, the chromium content showed maximal values in the samples from the bream musculature, yet none of the analyses experienced such a limit value that would brought about problems of pernocisiosity (Dévai et al, 1992). In the liver and scale samples of the fish, high zinc and manganese concentrations were measured, while – similarly to the samples from the musculature – no cadmium and lead could be detected.

2.2.4. Discussion

By today, it has been definitely demonstrated that the preservation and protection of the present conditions in nature conservation areas can only be achieved by productive activities of care-taking, supported by thorough and well-founded research work. The preservation of natural values being visible to the naked eye (such as plants and birds) can be virtually achieved by the assistance of thorough and versatile preparatory works that represent essential requirements especially in the case of protecting vulnerable wetlands with small remnants of highly valuable areas.

An important part of the research woks on these wetlands was constituted by investigating the ground ecological state and examining the local water supply and water quality in order to provide adequate information to active nature conservation. Among the examined dead-arms, it is the upper part of the dead-arm at Helmecszeg that is qualified as having a nature conservation value on the basis of its preserved natural state and diversity of the aquatic flora. This particular area represents a remarkable feeding site for the protected black stork (*Ciconia nigra*), and provides shelter for a variety of herons (Ardeidae) and ducks (Anatidae). Due to the hard floods of 1998, the diversity of phyto- and zooplankton could not be verified.

The other two dead-arms primarily serve as fishing water, but since they are presently short of nutrients (oligo-mesotrophic state) and free of organic pollutants (oligo-beta mesosaprobity), they can be considered as approaching the natural state in spite of the local water farming activities. The significance of all three dead-arms are connected to recreation, and the upper part of the Tisza dead-arm at Helmecszeg is utilised as a zone of ecotourism.

The local effects of the mechanically treated wastewater on the receptive dead-arm could be clearly observed and measured, but in a distance from this site, the more favourable, natural purification processes were already functioning, thus the present loading caused by the wastewater could not be particularised, neither modified. When explaining this phenomena, the fact should be considered that in arid periods even the treated or purified water with substandard quality may perform more favourably for the living organisms of wetlands than any dry conditions that ultimately may lead to the destruction of most aquatic organisms.

In the almost one-year period of the application, the research works – in accordance with the preliminary plans – were primarily confined to the dead-arms near Tarpa, in the Szatmár-Bereg Plain, as they contained the selected sampling sites, though the results and experiences are referential to the whole of nature conservation in the Szatmár-Bereg Plain. Consequently, the studies aiming to reveal the basic ecological state of wetlands and the potentialities of nature conservation treatments have not been completed, these first results call for the extended continuation of the examinations.

2.2.5. Summary

An essential task of nature conservation is to reveal the structural and functional state of the remaining natural wetlands. By today, it has been definitely demonstrated that the preservation and conservation of the present conditions in nature restoration areas can only be achieved by productive activities of care-taking, supported by thorough and well-founded research work.

In the framework of the „Tarpa region state assessment” examinations have been initiated in order to gain an overall survey on the ecological and hydrobiological ground state, as well as the local fish fauna of the dead-arms situated in the area of Tarpa. The research work covered the dead-arms of River Tisza at Helmecszeg and Vargaszeg, and the so-called Kiss Jánosné’s dead-arm.

In the case of these wetlands, constituent parts of the research work included the observation of the ground ecological state, and the examination of the water supply and water quality so as to provide adequate information for active nature conservation. From the investigated dead-arms, it is the upper area in the dead-arm of Tisza at Helmecszeg that can be classified as having nature conservational value on the basis of its preserved natural conditions, as well as its diversity in the aquatic flora.

The other two dead-arms offer fine fishing water, yet due to their current state of lacking nutrients (oligo-mesotrophy) and being free of organic pollutants (oligo-beta sabrobity), and in spite of the local water farming are considered to be even more of natural state. The significance of all three dead-arms are connected to recreation, and the upper part of the Tisza dead-arm at Helmecszeg serves the ends of ecotourism.

2.2.6. Acknowledgement

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Chapter 3

Water quality

3.1. WATER QUALITY RELATIONS BY FLOOD OF RIVER TISZA

T. Nagy, M., Csépes, E., Bancsi, I., Végvári, P.,
Kovács, P. and K. Szilágyi, E.

3.1.1. Introduction

We followed the phases of different water-quality components during a year at two water-sampling points of the river Tisza. During our work we set the target to show the relations between the studied water quality indexes and the water-level of the river and to analyse their nature with special interest in the features of the great floods of the latest years. By choosing between the water-sampling points it played a great role to have up-dated information about the waterquality of the river Tisza leaving the area of the Kisköre reservoir, as the water supply of the river Tisza is the sole drinking water basis of the city Szolnok.

3.1.2. Material and method

We followed the runs of different water-quality components (electrical conductivity, flowing-material content, hydrogen-carbonate ion, number of thalluses of saprophytes at 22 ^{o}C, number of coliforms, number of planktonic bacteria) from 1st July 1998. untill 30th June 1999. The water-chemical analyses were carried out daily at Pusztataskony, twice a week at Szolnok, the water-bacteriological analyses in every second week at Pusztataskony, and weekly at Szolnok. The determination of chemical and biological components were carried out on the basis of analytical standards listed in the qualificatory standard MSZ 12749:1993 (Surface water water-quality, quality characteristics and qualification).

3.1.3. Results

The annual measuring results of some water-quality components are indicated on case-historical graphs. The essence of it is, that the values of the water-quality indexes measured at the two water-sampling points are showed using the phases of water-level of the river Tisza as the background of the events. This type of data representation provides a picturesque and well understandable information about the periodical changes of the river. The graph of the changes of the values of conductivity and water-level (Fig. 1) shows the close correlation between the electrical conductivity and the water-level.

It can be seen on Fig. 1, that that the electrical conductivity of the water is decreasing in the case of rising in the water-level while increasing in the case of low-water. The concentration of the hydrogen-carbonate ions of the water changes the similar way. Futher on we defined the determinatory coefficient (R^2=0.9021) between the two variants, which characterized the closeness of the joint. It means, that the change of one of the parameters explains by 90% the variation of the other.

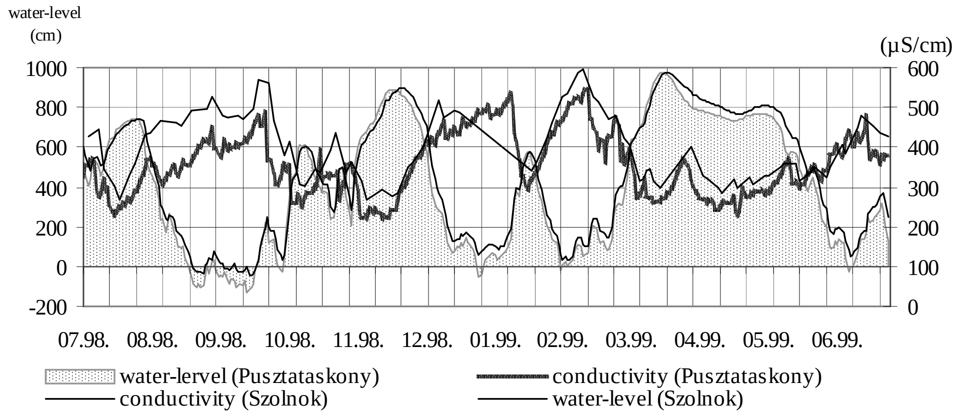

Fig. 1. The relation betveen the values of conductivity and the water-level measured at two sampling-points of the river Tisza

We can observe a similar periodicity on Fig. 2 too showing the phases of floating-material content and water-level.

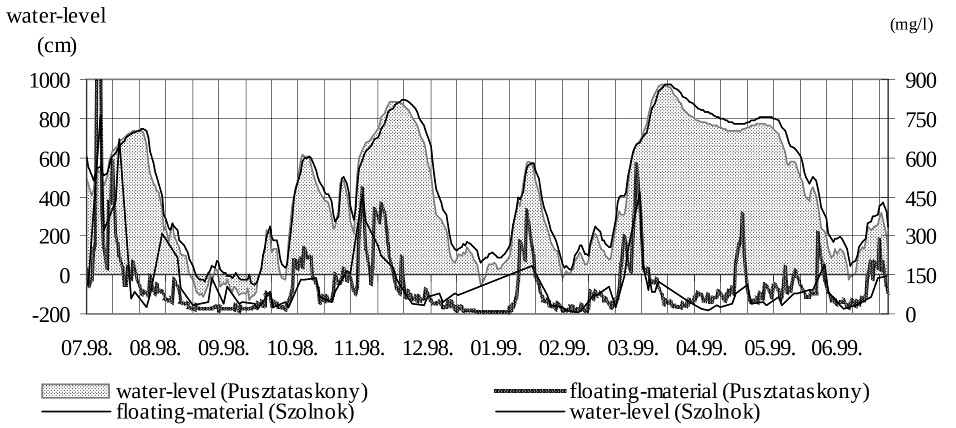

Fig.2. The relation between the floating-material content and the water level at two sampling-points of the river Tisza

The maximum values of the concentration of floating-materials can be observed at the starting phases of each flood, which is then followed by a sudden drop. As the quantity of the floated siltage is affected mainly by the quantity of the rainfall fell onto the cathment-area and the siltage wased into the water by it, by the speed of the waterflow and the sedimentation of the floating-materials (so called hydrological factors) (Bogárdi, 1971) so it is understandable that the floating-material content shows a saltatory increase at the starting phase of the floods. The floating-materials washed-in by the rainfall fallen onto the cathment-area contains a great amount of organic materials, which is well demonstrated by the close correlation of the COD_{pa} and the floating-material content. It can be seen from the results of the regression- and correlation-analyses carried out by a similar way, that in a certain case there is a closer relation (R^2=0.9024) between the two observed components, for ex. HCO_3 and the conductivity, than between the measured values of COD_{pa} and the floating-material content (R^2=0.8772). The relations of the functions similar to these can be adaptable for predictious aims too, and can be played important roles in the controll of the results of the measurements.

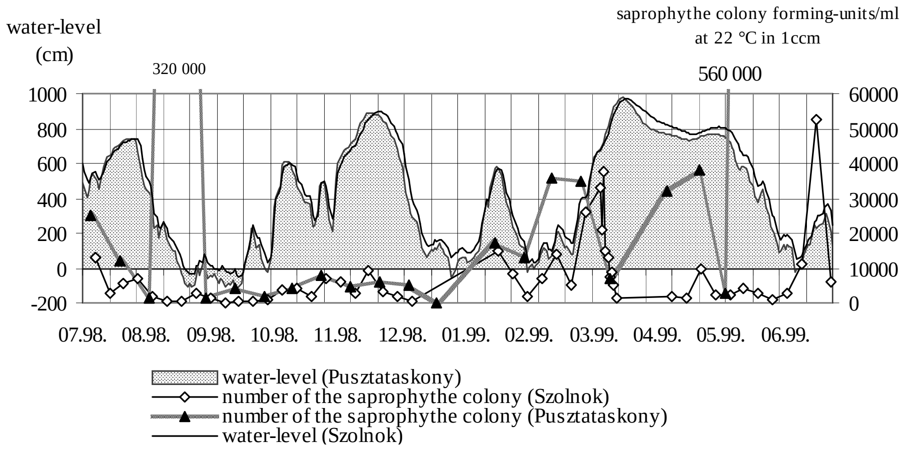

Fig. 3. The relation between the values of number of the saprophythe colony forming-units and the water-level measured at two sampling-points of river Tisza

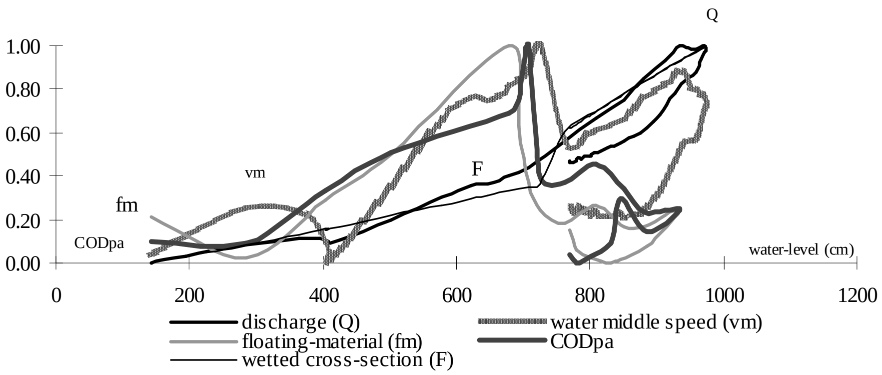

Fig. 4. Charasteristic curves of river regime of some hydrological indicators at the river Tisza (Szolnok) between 24.04.-26.02. 1999.

By analysing the case-historical graphs we noticed, that a periodical changes of the observed water-quality components can be monitored in the case of an individual flood.

So we concluded to analyse the action of a flood more thoroughly. The water-level historical loop-curves (Dvihally, 1963) proved to be the best for this purposes. Let's see for ex. the actions of the flood between 26th February and 24th April 1999 through the example of the floating-material content and the COD_{pa}.

The phases of the values of five observed parameters measured at Szolnok standardized by expansion (by Podani, 1997) can be followed during a run of a flood on Fig. 4. It can be seen, that the culmination of the values of each parameters follows each-other in a determined chronological order. By the rising of the water-level the first is the concentration of the floating-materials reaching its maximum value, which is then followed by the COD_{pa} and the mean-speed (v_m) of the water-flow. We can observed at last the culminations of the discharge (Q) and the water-level. The graph can be devided into two well separated parts: the ascending an the descending line. In the optimal case – when the starting and the final water-level of the flood is equal – two values of floating-material content (etc.) belong to each water-level value, and these values meet at just one point. On account of this the graph traces a loop.

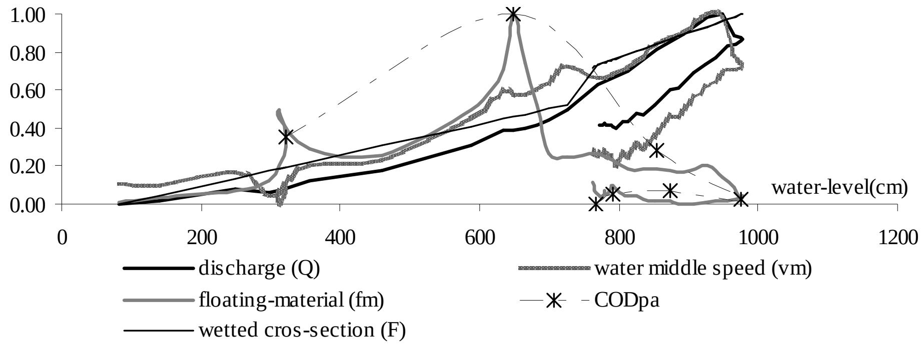

Fig. 5. Charasteristic curves of river regime of some hydrological indicators at the river Tisza (Pusztataskony) between 24.04.-26.02. 1999.

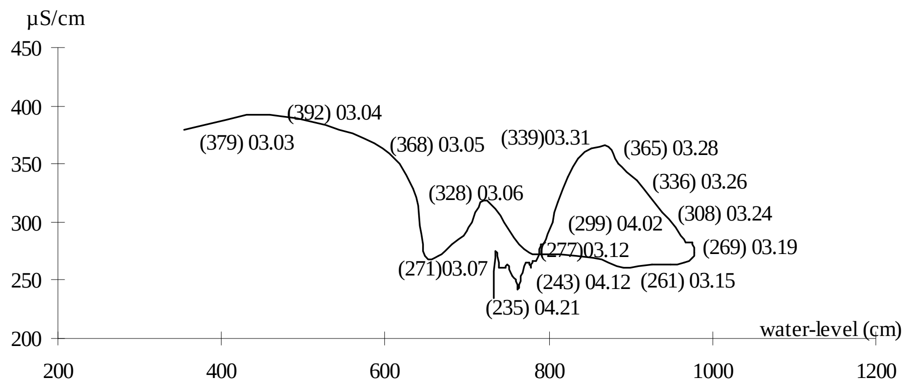

Fig. 6. Charasteristic curves of river regime of conductivity at the river Tisza (Szolnok) between 04.21.-03.03. 1999.

In the nature there can not be observed such a regular flood of course, as during a flood there are usually more floods piling up together, so the starting and the ending points of the graphs do not meet at the same water-level. The phases of the five measured parameters of this same flood at Pusztataskony can be seen on the Fig. 5. By comparing to the previous figure we can observe that the events described above followed each other in similar order. The measurements of COD_{pa} at Pusztataskony were carried out only once a week, so we do not have daily data about the phases of this parameter. Because of this we joined the stars marking the results of COD_{pa} measurements with unconnected line on Fig. 5 so it is just an additional information.

The number of the saprophyte colony forming units shows the size of the bacterium-flora depending on the presence of the quickly demolishable organic materials and which demolish it. To propagate these bacteria at 22°C the saprophyte-bacterium stand of the water can be traced. The number of the psychrophyl bacteria is significantly increasing in the ascending phase of the flood (Fig. 3), as the saprophyte-bacteria can be multiplied on the organic particles stuck to the surface of the floated siltage. In this case a great number of of psychrophyl bacteria joins to the high values of COD_{pa}. A great increase in the abundancy of the bacteria was observed in the descending phase of the flood (at Pusztataskony). During this period with outstanding internal-water quantity the number of bacteria can significantly be affected partly by the disadvantageous quality of the internal-water pumped into the river, and partly because the river washes in a great amount of organic materials during recedeing from the flood-plain, and if the water-temperature is favourable the bacteria could be multiplied in great quantities (Fig. 3).

The number of saprophytes which can be measured in the water is decreasing because of the little washing-in, and because of the sedimentation of the bacteria together with the floating-materials during low-level. In the work of B. Tóth (1997), K. Szilágyi (1995), and Hegedűs (1980) the relation between the planktonic number of bacterium, the discharge and the floating-material content is well studiable. It can be observed during low-level, that when the floating-material is subsiding (and the greater part of the bacteria forming units at 22°C), the number of planktonic bacteria defined by the AODC method is increasing. It is interesting, because this later method – although the number of saprophytes at 22°C can be advised as an alternative of the AODC method, according to the literary data - is far more precise, as not only the heterotrophes with active metabolism can be included, but those bacteria as well which are living, but do not show active metabolism.

The number of planktonic bacteria of the river Tisza is varied between 0.38-2.1 million cell/ml during the observed flood period. During flood the number of planktonic bacteria is increasing, and the bacterial biomass is quite high (B. Tóth, 1978). The dominants are the small coccuses, while during a long-lasting low-water level the rod- and filiform forms are also appearing in greater number. The coliform bacterium is a rod-shaped facultative fecal indicator bacterium. They can revive nitrate into nitrite, dissociate lactose during formation of acid and gas, and multiply well at 37°C. The coliform bacteria indicate the organic-material loading getting into the water from outside, so their number is increasing together with the quantity of the organic-materials getting into the river Tisza on the occasion of a flood. The highest number of coliform bacteria was observed in the descending phase of the floods, as the quantity of the organic-materials originating from the flood-plain and from the internal waters is significant.

3.1.4. Discussion

The case-historical graphs prooved cleanly, that the actual value of the water-quality indicators are greatly depending on the hydrological state of the river (Tisza). The water-level, the discharge, the flow-speed, the quantity and the distribution of rainfall fell onto the cathment etc. are all determinative factors of the waterquality indicators. That's why it is important, that the results of the water-quality analyses will be always defined in the mirror of the hydrological state of the observed river.The close correlation between the values of the conductivity and the concentration of HCO_3 ions may seem to be surprising by the first approach, as the hydrogencarbonate ion does not belong to the mobile ions by its size. As the electrical conductivity is the sum of the conductivities of all ions being present in the solution, it seems to be certain, that cations getting into the water by the dissolution of carbonated rocks generate the rise of the conductivity.

When we analyse the phases of the electrical conductivity during a run of a flood (Fig. 6), we can see, that at the beginning of the flood we measured relatively high values, later on a significant thinning was observed, what characterized the river untill the culmination of the flood. The receding of the river was happened beside a new increase in the values of the conductivity on account of the concentration of the water. The salt-concentration of the water of the river Tisza and its phases are depending on the quantitative relations of the springs supplying the river and being rich in soluted mineral salts, together with the "thinning-waters" originating from thaw and rainfall (Juhász, 1976).

At thaw, or at the time of a heavy rain the rainfall agushing from the catchment is nearly pushing the more thick salt-contented water in front of it in the river-bed. It is followed by the spring-water gained higher discharge in the meantime mixing with the rain-water arriving continuously (Bancsi *et al*., 1977). So at the starting phase of the flood we meet a thick water, then later on - untill the culmination - a thiner rain-water, and at the descending phase a mixture of the higher discharged spring-water and the rain-water.

The explanation of the phases of the floating-material content (Fig. 2) is a very complicated task. At first we have to clarify two abstractions: the siltage-carrying ability of the water is the upper limit of the quantity of the siltage carryable by the waterway, which are determined by the hydromechanical factors. The quantity of the siltage carried actually is much less, so the waterways are always carrying less siltage, than as much as they could (Bogárdi, 1971.). It can be seen well on Fig. 4., that the mean flow-speed of the water (v_m) and the quantity of the floated siltage (floated-material f_m) only at the starting phase of the flood increases together. The curve of $f_m$reaches its maximum value earlier, than the v_m which can be explained by the decrease in the quantity of the wased-in siltage. The sudden fall back of the v_m can be explained by the specialities of the bed-profile of the observed segment of the river. As the *F* curve shows, at the water-level of 750 cm the river steps out of its main bed and expands on the flood-plain, which leads to the sudden decrase of v_m, while the discharge *(Q)* is continuously increasing. Passing through this breaking-point the v_m is increasing again by the rise in the discharge, but in a less slow measure, than in the main riverbed. In the descending phase both the *Q* and the v_m is continuously decreasing.

The different between the values of the two parameters measured in the ascending and in the descending phases is originating from the different in the water-level fall of the surging and the retreating river. The number of the planktonic saprophyte and the number of coliform bacteria are dominantly increasing in the ascending phase of the flood, but we observed the the saltatory increase of the abundancy of the bacteria in the descending phase of the flood at every group of bacteria analysed by us (August 1998., May 1999. at Pusztataskony) The cause of this is probably that, that after the flood the river retreating back from the flood-plain and the over-lifted sewages are washing a great amount of organic materials, fecalic and other contaminants into the water, what the psychrophyl saprophytes, the coliform and Clostridium-type bacteria can utilize in a different way in the case of favourable conditions.

3.1.5. Summary

The analysis of the case-historical graphs produced on the basis of yearly data flashes light onto the necessarily frequent changes in the water-level of the river and in the examined parameters. It can be seen, that the electrical conductivity of the water is decreasing in the case of rising in the water-level while increasing in the case of low-water. The concentration of the hydrogen-carbonate ions changes the similar way. The maximum concentration of the floating-materials can be observed at the starting phases of a certain flood. The curves of the graphs of the yearly changes of COD_{pa} and floating-materials are similar, which indicates the close correlation between the two components. The number of the psychrophyl bacteria and the number of coliforms are significantly increasing in the ascending phase of the flood, but the maximum values of the abundancy of the bacteria was measured in the descending phase. During this period with outstanding internal-water quantity the number of thalluses of saprophytes are significantly affected partly by the disadvantageous quality of the internal-water pumped into the river, and partly because the river washes in a great amount of organic materials during recedeing from the flood-plain, and if the water-temperature is favourable the bacteria could be multiplying in great quantities.

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3.2. PREVIOUS SURVEY OF THE ECOLOGICAL STATE OF MIDDLE-TISZA BACKWATERS

Szilágyi, E. K., Zsuga, K. and T. Nagy, M.

3.2.1. Introduction

The protection and reconstruction of backwaters is an urgent and current task of nowadays as backwaters are in a senile state, the water supply is often uncertain and incidental. The existing backwaters, as wetlands were upgraded. However, their manifold usage accelerates their destruction. The wetlands belong to the most endangered ecological systems in the world (Gopal and Sah, 1995). They represent a significant natural value, so their survey, the knowledge of their water quality and the protection of their biodiversity is very important.

During the investigations of the „Tasks concerning the protection of water quality of backwaters", coordinated by the Environmental Ministry in 1998 we carried out the survey and ecological qualification of three Middle Tisza backwaters (Tiszaugi Holt-Tisza, Cibakházi Holt-Tisza, Alpári Holt-Tisza).

3.2.2. Material and methods

The examined backwaters and sampling areas were the following: Tiszaugi Holt-Tisza: the area under the village, 1300 m segment, Cibakházi Holt-Tisza: Dóra-farm, Alpári Holt-Tisza: beach area, 6200 m segment.

The evaluation was based on the previous data and result of a tour of the backwaters by boat. Besides this we examined the macrovegetation, we sampled water and sediment for the purpose of chemical, biological and sediment investigation. We characterised the dead arms generally and we valued the sediment investigations. At last, we prepared the reference ecological qualification of the three backwaters based on the Dévai *et al.* (1992) works.

The samples of sediment were taken with an Eijkelkamp-Beeker-type sampling instrument. We made the separation according to the MSZ 12739/4-78.

The metal investigations were held on a VARIAN 20 BQ-type atomabsorption spectrophotometer. The determination of Cu, Cd, Cr, Ni, Zn, and Pb were carried out with the vaporisation of air-acetylene into flame, the determination of Hg was carried out by VGA-76 hydride system. During the physical and chemical investigation of the sediment we determined the dry content by torrefaction on 105 oC. We determined the collfaction loss by heating on 600 oC from dried, homogenised sample. The preparation of the determination of N and P-content of the sediment was carried out according to the MSZ 12739/2-78. Destruction and the processing of the destructed sample was carried out according to the MSZ 448/27-85. For the determination of the phosphorus content of the sample we used the MSZ 318/19-81. For the COD determination we used prepared sediment sample. We diluted 0,1 g of sample with 10 ml distilled water and we measured according to the MSZ 260/16-82 used at the sewage investigation.

3.2.3. Results

3.2.3.1. Tiszaugi Holt-Tisza

The backwater can be found on the left bank of the River Tisza. It is not divided by culvert. Its length is 3,4 km, its area is 50 ha. The region isn't under environmental protection. The backwater receives precipitation and inland water primarily, furthermore, it is used as irrigation water. Moreover, it is utilised for fish raising. On a short part it serves as holiday resort and bathing area. The outskirts of Tiszaug touches the shore of the backwater here. The right shore of the horseshoe-shape is less visited and built. The reed and the avenue are boundary to an agricultural area.

From the point of view of backwaters the small water depths are quite unfavourable. By the end of summer the water depth doesn't reach 1 m in the midline and there's hardly any area deeper than 2 m. The two ends of the backwater with their depth of 0,3-0,5 m are critical parts of the riverbed.

A huge open-water area and a macrovegetation with small species and individual are characteristic of the backwater. Two discovered, protected plant species of the water are the Nymphaea alba and the Trapa natans. The Nymphaea alba association is extensive on the Lower-end. During the summer, at dawn the huge biomass can result in the water being backing in oxygen or having a low oxygen content.

By the distillery seeds of grape and plum and remainders of peel cover the silt in a thick layer. The dark colour of the water suggests eutroph state, sometimes it bubbles (anaerobe gas production). The accumulated huge amount of organic matter provides a favourable nutriment supply to the alga vegetation.

On the former left shore the reed zone unfortunately became disconnected at many places, it is incomplete at the plots, at the angling zones and at the beaches. In a few places the reed (Phragmites australis) is replaced by pavement.

At the Lower-end a less extensive reed association can be observed, whereas at the Upper-end the reed is connected and widespread, with some signs of swamping. The attendant plant of the reed in some spots is the Typha angustifolia and the Typha latifolia. Next to the reed the Utricularia vulgaris occurs in some spots. In the open water the floating reed-grass association is negligible. The rooting reed-grass species are the Myriophyllum spicatum, the Potamogeton crispus and the Potamogeton lucens that submerge into the water.

During the irrigation season the water pumping without water compensation can damage the biological life of the backwater. The signs of natural growing old can be observed in the backwater, its bed contains silt in large amounts.

Aesthetically the backwater provides a beautiful spectacle although it doesn't possess significant ideal values. Botanically the backwater is less valuable, besides the Nymphaea alba occurring in large numbers we cannot find significant plant associations.

The thickness of the sediment of the Tiszaugi Holt-Tisza is 66 cm. From above downwards: the upper 35,5 cm is a loose, black, fine-grained silt with a high water content, then between 39-95 cm the sample is graphite grey. Compared to the sediment of other backwaters there are quite high amounts of $COD_{K2Cr2O7}$, COD_{KMnO4}, total N and total P found during the investigations (Fig. 1.). The measured amounts suggest a quite high level of organic matter content (e.g. total N 7000 mg/kg dry content). This indicates an eutroph water. Among the examined backwaters the values are the most extreme here, which suggests the most unfavourable states. The ratio of inorganic and organic matters is also the worst here, the heating loss from the three backwaters is the lowest here.

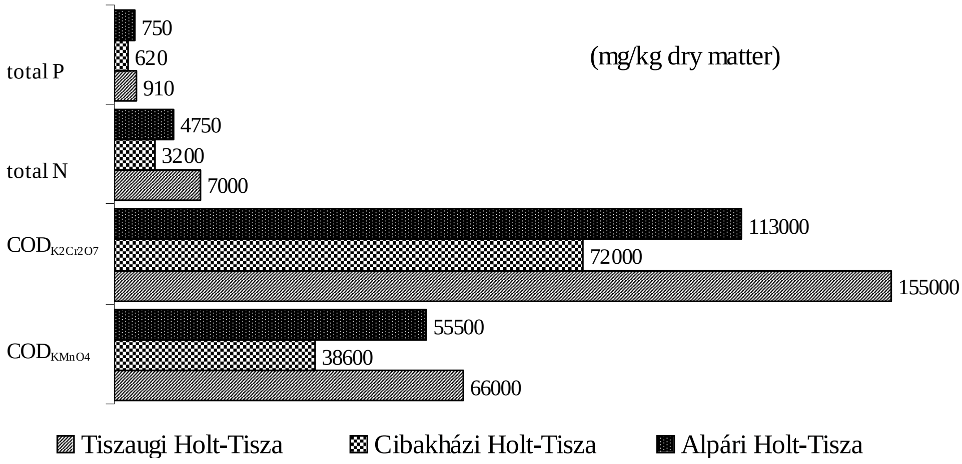

Fig. 1. Examinations in the sediment of dead arms

3.2.3.2. Cibakházi Holt-Tisza

It was formed during the regulation of the River Tisza in 1856. It is located on the left bank of the River Tisza. On the evidence of the air photos the dead arm has an area of 272 ha. From that the open water area is 194 ha (71,3%) and the plant surface is 78 ha (28,7%). Its length is 16,9 km. The two dams are separated by a culvert not precluding the water flow.

On its upper (next to the dam-keeper house) end there extends a long swamp zone, hardly any open-water surface can be found there. The species forming the swamp, in order of the extent of the area they cover, are the following: Phragmites australis, Typha angustifolia, Schoenoplectus lacustris, Carex sp., Glyceria maxima.

From the village of Cibakháza the backwater can be divided into two different water areas, habitually and botanically. From the beach of Cibakháza until the Dóra-farm the reed stands occur in knots in front of the connected reed association. For the other end of the dead arm a smaller plant individual number and increasing rate of building is characteristic. As for the amount of pondweed, the most significant is the submerging pondweed, this mainly consists of Ceratophyllum demersum. Along the shore the Myriophyllum spicatum occurs in large amounts. The Utricularia vulgaris and Potamogeton natans occur in spots. Potamogeton lucens and Potamogeton crispus can be found in smaller amounts. The floating pondweed is represented by the so-called Lemnetum associations that consist of the following species: Salvinia natans, Lemna minor, Spirodela polyrrhiza, Butomus umbellatus, Iris pseudacorus, Lythrum salicaria, Polygonum amphibium, Alisma plantago-aquatica.

The thickness of the sediment of the Cibakházi Holt-Tisza is 90 cm. From beginning to end it is greyish black, a bit smelly. The sediment has a high water content, it is quite soft and has a loose structure. At the pig farm in Dóra-farm the high N, P, COD values suggest an accumulated organic matter amount (Fig. 1). The available N and P content can maintain plankton organisms in a great mass.

3.2.3.3. Alpári Holt-Tisza

It is located on the right bank of the River Tisza in a flood area protected by a summer dam, it is divided by one culvert. Its length is 9,9 km, its area is 147 ha. From the Upper-end until the culvert the water depth is 1,2-1,5 m, the water is in eutroph state. The species occurring here: Hydrocharis morsus-ranae, Wolffia arrhiza, Lemna minor, Lemna trisulca, Salvinia natans, Nuphar lutea, Stratiotes aloides.

On the right bank of the former flow direction there is no reed, the water is flanked by trees. On this bank the primarily occurring species is the Nuphar lutea, on the opposite bank the Nymphaea alba lives. Until the section of the beach the water is similar in appearance and the water depth is 1,6-2 m. The nearly 2 m deep water is almost totally grown in by the Ceratophyllum demersum. This huge biomass results in a nearly 200% oxygen saturation. The water is dark brown, bubbling, with a huge biomass. For decades it was burdened by the organic impurities of the nearby pig farm. At the section of the beach both banks are flanked by trees, there is no closed reed association. From the beach until the lower end on the right bank of the former flow direction - usually in shady areas - flourished the Nuphar lutea fields. In dead arms of the Middle Tisza such Nuphar lutea fields can rarely be found. On the opposite, sunny bank the Nymphaea alba lived. Towards the Flower-end at the island only the left branch can be visited by boat. During the summer, at maximal biomass, the „traffic" is impossible in both branches, the area can only be approached in September. In this water area the main species are Ceratophyllum demersum and Nymphaea alba. The other branch is covered with Stratiotes aloides in 100% so it so impassable.

The species found in the Alpári Holt-Tisza: Lemna trisulca, L. minor, Spirodela polyrrhiza, Salvinia natans, Hydrocharis morsus-ranae, Potamogeton pectinatus, P. crispus, Ranunculus sp., Utricularia vulgaris, U. australis, Myriophyllum spicatum, M. verticillatum, Ceratophyllum demersum, Stratiotes aloides, Trapa natans, Nymphaea alba, Nuphar lutea, Nymphoides peltata, Polygonum amphibium, Wolffia arrhiza.

The thickness of the sediment of the Alpári Holt-Tisza is 65 cm. From up downwards: the upper 13-15 cm is black, loose silt containing plant remainders. Under that: dark grey, clayey silt, consistent, soft. The part between 60-65 cm is grey, harder, clayey silt. The quite high $COD_{K2Cr2O7}$ suggests high amount of organic matter.

Although they are not chemical components, we discuss the results of the toxic tests done from the sediment here. The result of the Daphnia-test and Seedling plant test was negative on all three backwaters, so the sediment is non-toxic.

3.2.4. Summary

For the Tiszaugi Holt-Tisza a huge open water area and less plant association is characteristic. The macrovegetation is poor in species and individual number. We found two protected plant species the Nymphaea alba in huge biomass and the Trapa natans occurring one by one. The investigations prove that the Tiszaugi Holt-Tisza needs fresh water supply and sweeping from time to time because after a few dry years there can be a serious danger for the backwater and its associations.

For the Cibakházi Holt-Tisza 70% open water area and 30% plant area is characteristic. It can be divided into two parts, habitually and botanically. The reed is perishing. The welfare utilising and the building have important role.

The Alpári Holt-Tisza is rich in natural and landscape values, botanically valuable backwater. The found protected plant species: Nymphaea alba, Trapa natans, Salvinia natans.

The eaxmined backwaters are not protected at present but they deserve to be protected.

3.2.5. References

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MSZ 318/19-81: Szennyvíz-iszap vizsgálata - Összes foszfor meghatározása (Sewage sludge test - Determination of total phosphate).

MSZ 260/16-82: Szennyvizek vizsgálata - Kémiai oxigénigény meghatározása (Wastewaters analysis - Determination of demand for chemical oxygen /KOI/).

MSZ 448/27-85: Ivóvízvizsgálat - A szerves és az összes nitrogén meghatározása (Drinking water analysis - Determination of organic and total nitrogen).

APPENDIX

<u>Preliminary qualification of Tiszaugi Holt-Tisza</u>

<u>Type of water body</u>

The Tiszaugi Holt-Tisza is standing water by the comprehensive type of water bodies (code=1), and it is „kopolya" type dead arm by the concrete type of water body (code=22)

<u>The group of the static attributes</u>

Characters of the bed morphology

-Typology by the water depth

The dead arm is a tempered shallow water (average water depth is between 0,5-2,5 m) (code=2)

<u>The group of the dynamic attributes</u>

The group determined by the lifeless nature

-Reity-typology (by the flowing circumstance):

Water body without considerable horizontal and vertical flow (code=1)

-Loticity-typology (by the fluctuation and whirling circumstance):

Slowly fluctuating water surface (code=2)

-Thermity-typology (by the temperature circumstance):

Water temperature: 18,9 ^{o}C (code=5)

-Halobity-typology (by the salt content and salt composition):

Specific conductivity: 355 $\mu S/cm$ (code=2)

Dominant cation: Ca-Mg-ion (code=6)

Dominant anion: HCO_3-ion (code=1)

pH: 8,75 (code=4)

The group determined by the life and the lifeless nature

-Lucidity-typology (by the light circumstance): *Secchi-transparency: 20 cm (code=6)*

-Aerobity-typology (by the oxygen circumstance): *Dissolved oxygen: 9,7 mg/l (code=6)*

Oxygen saturation: 105 % (code=7)

-Trofity-typology (by the inorganic nutrient): *Dissolved o. PO_4: 0,02 mg/l (code=2)*

Inorganic N: 0,13 mg/l (code=2)

-Saprobity-typology (by the organic nutrient):

Chemical oxygen (KOI_{sMn}): 21 mg/l (code=6)

-Toxicity-typology (by the toxicant): By Seedling plant test: *Non-toxic (code=1)*

The group determined by the life nature

-Constructivity-typology: *Chlorophyll-a: 151 $\mu g/l$ (code=5)*

-Destructivity-typology: *Number of the planktonic bacteria: $1{,}31 \times 10^6$ ind/ml (code=2)*

Biomass of the planktonic bacteria: 0,085 mg/l (code=3)

Biomass of the zoolpankton: 7,9054 g/m^3 (code=6)

<u>Preliminary qualification of Cibakházi Holt-Tisza</u>

<u>Type of water body</u>

The Tiszaugi Holt-Tisza is standing water by the comprehensive type of water bodies (code=1), and it is „kopolya" type dead arm by the concrete type of water body (code=22)

<u>The group of the static attributes</u>

Characters of the bed morphology

-Typology by the water depth

The dead arm is a tempered shallow water (average water depth is between 0,5-2,5 m) (code=2)

<u>The group of the dynamic attributes</u>

The group determined by the lifeless nature

-Reity-typology (by the flowing circumstance):

Water body without considerable horizontal and vertical flow (code=1)

-Loticity-typology (by the fluctuation and whirling circumstance):

Slowly fluctuating water surface (code=2)

-Thermity-typology (by the temperature circumstance):

Water temperature: 18,8 ^oC (code=5)

-Halobity-typology (by the salt content and salt composition):

Specific conductivity: 1210 $\mu S/cm$ (code=4)

Dominant cation: Na-Mg-ion (code=5)

Dominant anion: HCO_3-ion (code=1)

pH: 8,55 (code=4)

The group determined by the life and the lifeless nature

-Lucidity-typology (by the light circumstance): *Secchi-transparency: 80 cm (code=3)*

-Aerobity-typology (by the oxygen circumstance): *Dissolved oxygen: 8,1 mg/l (code=6)*

Oxygen saturation: 88 % (code=6)

-Trofity-typology (by the inorganic nutrient): *Dissolved o. PO_4: 0,01 mg/l (code=2)*

Inorganic N: 0,02 mg/l (code=1)

-Saprobity-typology (by the organic nutrient):

Chemical oxygen (KOI_{sMn}): 14,8 mg/l (code=5)

-Toxicity-typology (by the toxicant): By Seedling plant test: *Non-toxic (code=1)*

The group determined by the life nature

-Constructivity-typology: *Chlorophyll-a: 68 $\mu g/l$ (code=4)*

-Destructivity-typology: *Number of the planktonic bacteria: $8,19x10^6$ ind/ml (code=3)*

Biomass of the planktonic bacteria: 0,398 mg/l (code=5)

Biomass of the zoolpankton: 0,574 g/m^3 (code=1)

Preliminary qualification of Alpári Holt-Tisza

Type of water body

The Alpári Holt-Tisza is standing water by the comprehensive type of water bodies (code=1), and it is „kopolya” type dead arm by the concrete type of water body (code=22)

The group of the static attributes

Characters of the bed morphology

-Typology by the water depth

The dead arm is a tempered shallow water (average water depth is between 0,5-2,5 m) (code=2)

The group of the dynamic attributes

The group determined by the lifeless nature

-Reity-typology (by the flowing circumstance):

Water body without considerable horizontal and vertical flow (code=1)

-Loticity-typology (by the fluctuation and whirling circumstance):

Smooth or dimple surface of the water respectively stagnant state (code=2)

-Thermity-typology (by the temperature circumstance):

Water temperature: 20,6 ^{o}C (code=5)

-Halobity-typology (by the salt content and salt composition):

Specific conductivity: 620 μS/cm (code=3)
Dominant cation: Ca-Mg-ion (code=6)
Dominant anion: HCO_3-ion (code=1)
pH: 8,55 (code=4)

The group determined by the life and the lifeless nature

-Lucidity-typology (by the light circumstance): *Secchi-transparency: 80 cm (code=3)*

-Aerobity-typology (by the oxygen circumstance): *Dissolved oxygen: 10,4 mg/l (code=6)*
Oxygen saturation: 117 % (code=8)

-Trofity-typology (by the inorganic nutrient): *Dissolved o. PO_4: 0,005 mg/l (code=1)*
Inorganic N: 0,13 mg/l (code=2)

-Saprobity-typology (by the organic nutrient):
Chemical oxygen (KOI_{sMn}): 15,6 mg/l (code=5)

-Toxicity-typology (by the toxicant): By Seedling plant test: *Non-toxic (code=1)*

The group determined by the life nature

-Constructivity-typology: *Chlorophyll-a: 29 μg/l (code=3)*

-Destructivity-typology: *Number of the planktonic bacteria: 5,6x10^6 ind/ml (code=3)*
Biomass of the planktonic bacteria: 0,289 mg/l (code=5)
Biomass of the zoolpankton: 4,2911 g/m^3 (code=6)

3.3. INVESTIGATION OF MACROPHYTE – PERIPHYTON COMPLEX IN TISZA RESERVOIR

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Borics, G. and Szilágyi, E. K.

3.3.1. Introduction

Communities of aquatic plants play decisively important roles the life of shallow waters directly or indirectly through their effects on the development of aquatic habitats, as well as on the material circulation and energy flow. The functioning of macrophytes as agents in the changes and regulation of water quality is largely enhanced by the periphyton forming on the submerged parts of macrophytes.

Kisköre Reservoir is a shallow water reservoir that can be characterized by the determinant influence of the littoral zone, the area of which covered by aquatic vegetation (littoral phytal) gradually increases to the cost of the open water area (littoral pelagial). Consequently, the contribution of periphyton gains ever larger significance. The periphyton examinations performed in Kisköre Reservoir have focused on investigating the role of the aquatic macrophyte-periphyton (epiphyton) complex (Lakatos *et al.*, 1998) in transforming and indicating water quality, as well as on revealing the relationship between the host plant and the periphyton. The obtained results can add to the professional basis for the future water managing and biomanipulating intervention on the life of the reservoir.

3.3.2. Materials and Methods

In the summer of 1999, water, plant and periphyton samples were taken from the stands of the dominant aquatic plants at several sites of the basins, primarily the middle basins (Poroszlói and Sarudi basins), of Kisköre Reservoir, whereas local measurements (water depth, transparency, temperature, conductivity, pH, oxygen concentration and saturation) were also carried out. Where the proper depth of water allowed it, samples collected near the surface, in mid-depth and deep submergence were distinguished during processing the samples in order to survey the influence of their vertical stratification on the results. Horizontal differences were detected through taking samples both from the middle part of the plant stands and their edges.

The wet and dry mass of the periphyton samples were measured, and the organic matter, chlorophyll-a, nitrogen and phosphorus contents were established. The ash content of the samples was determined, while the identification of cations was made with the ICP-AES technique after wet exploration. The algal species composition of epiphyton samples was also revealed.

3.3.3. Results

In 1999 the results of the water chemical examinations support the view on the middle basins of the reservoir having different water qualities, as well as justify the role of the macrophyte-periphyton complex in the formation of local impacts, such as oxygen supersaturation, oxygen shortage or the evolution of ‘peat’ characteristics. A large part of the plant mass reproducing year by year is utilized in the detritus food-chain, while the algae and zoo-organisms of the periphyton constitute an important nutrient base for the fish (Simonian *et al.*, 1995).

A significant amount of periphyton was found on the surface of *Potamogeton lucens* leaves, with its bulk being ash from the silicon skeleton of diatoms. Similarly, large quantities were observed in the middle of the *Trapa* stand and the edge of the *Nymphoides* vegetation. According to the classification system based on the mass of the periphyton, the majority of the samples could be grouped as small-mass periphyton (Lakatos, 1983), and their ash contents showed considerable differences.

The results from the examinations performed on the mass and ash content of the periphyton proved that the macrophyte-periphyton complex actually determined the water currents, and indirectly the water quality, as well. The mass of the periphyton on the various plant species was found to be different in the middle basins of the lake. The periphyton of the saligot (*Trapa natans*) and cattail (*Typha angustifolia*) showed increases in the Poroszlói Basin, the amount on the bulrush (*Schoenoplectus lacustris*) decreased, while the saligot collected in the Sarudi Basin also had larger quantities of periphyton (22 g/m^2 dm). Data obtained on the ash contents of the periphyton partly reflected the differing suspended matter contents in the water of the various basins in Kisköre Reservoir, with the local effects being in work. Samples collected from the Poroszlói Basin, near the dead-arm at Óhalászi and at the end of the dead-arm at Csapó could be described by an inorganic periphyton group. Even when observing the very same sampling site, the periphyton of *Schoenoplectus* belongs to the organic periphyton group, whereas that of *Glyceria* could be classified as inorganic due to a significant amount of suspended solids deposition.

It is the marsh plant species and *Potamogeton lucens* that generally have large quantities of periphyton, while the dense stand of saligot can be characterized by a relatively small amount. Regarding the chlorophyll-a content, the periphyton types of larger masses brought about smaller values, which may be explained by the higher ash contents, that is more considerable presence of the inorganic fraction and indirectly the filtering and settling functions of the periphyton. The highest chlorophyll-a concentration (0.797 %) was observed in the periphyton taken from the saligot, while a decisively lower value (0.005 %) was measured in the case of *Potamogeton perfoliatus*.

The largest amount biomass of periphyton can be found in the middle part of stems of emergent macrophytes (*Typha, Phragmites*). This is valid for the organic matter and chlorophyll-a content too. It’s necessary to know that the samples were taken from the edge of macrophyte stand, so the effect of waves is not negligible.

The N % content of the periphyton turned out to be the lowest in the case of the *Potamogeton lucens* sample (0.6 %), which can be due to the large ash content and the decisive role of the inorganic fraction, while for the bulrush, this value was much higher (3.6 %). The phosphorus concentration just partly responded to the values of the nitrogen content, and was the highest for the flowering rush (*Butomus umbellatus*), while in the case of pondweed (*Potamogeton*) species, low concentrations were obtained. The macrophyte-periphyton complex has an essential tendency for retaining and absorbing nutrients (Smoot *et al.*; 1998, Havens *et al.*, 1999). As compared to the host, substrate pondweed (*Potamogeton*), the nitrogen and phosphorus contents of the periphyton can be up to three times larger, but at least show coherently higher values. The amount of plant nutrients retained and stabilized by the macrophyte-periphyton complex can be established and estimated for the whole of Kisköre Reservoir through attaining appropriate information on the submerged fraction of the emergent vegetation and the biomass of the pondweeds. The importance of periphyton in retaining nutrients had also been verified by the results of the former examinations on shallow lakes and wetlands (Lakatos and Bíró, 1991; Lakatos *et al.*, 1998).

On the basis of measurement of heavy metals in periphyton there is no essential difference among macrophytes but the periphyton of emergent plants contains more iron manganese and the extreme values of other heavy metals are also characteristic of these plants.

The accumulation of heavy metals by periphyton is an important fact in the development of water quality and establishes the effect of the biofiltration.

On the basis of analyses of algae the submerged and floating leaves macrophytes' periphyton characterized by large number of algae. The largest individual number but the lowest species number were determined in the periphyton of *Nymphoides peltata*. The most number of algae species was found in periphyton of *Hydrocharis morsus-ranae* and *Potamogeton natans*.

Periphyton of *Typha angustifolia* had a largest of algae compared with other emergent plants but its species richness was far below of reed-periphyton. The characteristic species of periphyton belong to the group of diatoms and green algae (46 and 38 % of total species number). The ratio of species number of cyanobacteria and euglenids is only 10 and 5%. The fitoplankton and algae in periphyton are bioindicators and useful for determine water quality.

42 macroscopic invertebrates taxa were identified in zootecton. The periphyton forming on submerged and floating leaves plants usually have more invertebrate animal taxa than the emergent. macrophytes' zootecton. Lots of insect larvae (mainly *Chironomidae*) were found in zootecton. The importance of invertebrates appears in material circulation and fish feeding.

3.3.4. Conclusion

Studying the basins of Kisköre Reservoir, which were partly formed by natural processes after the creation of the reservoir, as separate water regions is recommendable, since ensuring the various requirements of water utilization (irrigation, nature conservation, fishing, recreation, water sports, ecotourism, energy production, shipping, etc.) seems to be achievable exclusively in this way. The aquatic vegetation-periphyton complex has a decisive role in providing the proper water quality for these activities and fulfilling the varied demands of water utilization, and this role has to be taken into account when interfering in the life of the reservoir.

3.3.5. Summary

Investigation of periphyton of different macrophytes was carried out in summer 1999 in Kisköre Reservoir. The wet and dry mass, organic matter, chlorophyll-a, nitrogen and phosphorus contents of periphyton were measured. The ash and cation content were also established. The algal and macroinvertebrate species composition of periphyton samples were also revealed. The emergent plant species and the submerged *Potamogeton lucens*

have the largest biomass of periphyton. The larger mass of periphyton contains less chlorophyll-a because of the the higher inorganic fraction. The nitrogen and phosphorus content in periphyton are different and there is no significant correlation between them.

On the basis of our results there is no essential difference among the heavy metal content of periphyton. Most of the identified 151 alga species belong to the group of diatoms and green algae. The characteristic taxon in the biotecton are insects' larvae (mainly chironomids) and the total invertebrate taxon number is 42.

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3.4. HYDROECOLOGICAL INVESTIGATION IN THE KISKÖRE-RESERVOIR

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3.4.1. Introduction

The Kisköre-reservoir with its area of 127 km^2 is the second largest lake of Hungary. Besides its primary water management functions its welfare utility and its role in tourism has a stressed significance. It also has considerable nature protection values.

In the present-day ecological state of the reservoir a big problem is the filling and, in connection with that, the spread of the macrovegetation. During our investigation, we took more points of view into consideration: We held it important to make a water-and material balance for the whole reservoir. This primarily determines the water quality standards.The phytocenological surveys can give us information about the changes in the quantitative and qualitative composition of the macrovegetation also inform us about the intensity of the growth of certain associations, about the conditions influencing the spread of the plants.

To follow the seasonal changes, we pointed out a biomonitoring area in the Poroszló-basin, in which we wish to registrate the changes of the different physical, chemical and biological parameters. Our purpose is that the results of the investigation of the biomonitoring area would be useable to recognise and value the changes occurring in different associations.

This project is the first phase of a more-year program, on the basis of which we can describe the ecological circumstances of the Kisköre-reservoir.

3.4.2. Material and methods

The sampling was held in the plant-covered *(Trapa natans, Nymphoides peltata,* Typha angustifolia, Phargmites australis, Nymphaea alba) and open-water areas in the region of the Poroszló-basin, at 14 investigation points. The water depth was between 0.6-1.8 m.

The material balance calculations included the investigation of the yearly output of the total floating material, the total dissolved material, the dissolved orto-phosphate-phosphorus, the formed phosphorus, the inorganic and organic nitrogen. We investigated the yearly and seasonal formation of the above mentioned components as well as their changes in case of flood and low-water periods.

During the investigation of the water-and swamp vegetation of the Kisköre-reservoir an air-photo series and a vegetation map were made, besides the phytocenological survey and ranging over the spot. We value the air photos of 1987, 1993 and 1997, and the experience of the ranging over summarised.

In the 14 sampling points of the Poroszló-basin we held field measurements once per month from may to September with the GRANT ISY 3800 type water quality data collecting system. The parameters were the following. Water depth, water temperature, pH, conductivity, oxygen saturation, dissolved oxygen, turbidity, redox potential, sunshine intensity.

The components of the laboratory water-chemical and biological investigations: the chemical oxygen demand (COD_{KMnO4}) of the original sample, ammonium-N (NH_4-N), nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), total-nitrogen, dissolved orto-phosphate-phosphorus, total phosphorus, and a-chlorophyll content. We held the investigations according to the Hungarian standards. For determining the bacteria number and its biomass we applied the fluorescent microscopic technology after biological dying.

To investigate the biodiversity, algological, zooplankton dragonfly fauna and periphyton examinations were held.

Sediment sampling and investigation was held twice. We took the samples with Eijkelkamp sampler. During the analysis total organic carbon (TOC), total nitrogen and total phosphorus were determined.

3.4.3. Results

The turnover of substances in the Kisköre-reservoir is mainly determined by the qualitative and quantitative circumstances of the incoming and leaving waters. Among the incoming waters we distinguish waters that nourish the reservoir and waters burden the reservoir. Nourishing water is the River Tisza. Burdening waters are the Eger- and Laskó creeks and the trench drains. The turnover of water in the reservoir is partly determined by natural factors (evaporation, river regime), mainly determined by artificially directed factors (filling, emptying, water outtake). On the basis of the water balance data the incoming waters consist of Tisza-water (98.7 %), water the Laskó-and Eger creeks (1.1 %), and water from the trench drains (only 0.2 %). From the leaving water annual 97.1% leaves the reservoir through the River Tisza, 2.4 % goes to irrigation, the evaporation loss is 0.5 %. The variations of the salt content and the floating material is similar to the above mentioned. As for the phosphorus and nitrogen content, the burden coming from the Laskó- and Eger creeks is significant, it is much more than the plant nutriment coming from the River Tisza and from the trench drains. The main part of the 116 tons of phosphorus and 1518 tons of nitrogen remaining in the reservoir goes to the organisms in the water. From that 45.4 tons of phosphorus and 417 tons of nitrogen leaves the system infiltrated into the phytoplankton. The remainder accumulates in the macrovegetation and stays in the system for a long time (Bancsi and Végvári 1998).

In area of the Kisköre-reservoir the spreading of the water and swamp vegetation were significant in the past few years. The spreading macrovegetation hinders the utility of the water surface (fishery, ecotourism, traffic, etc.). This will probably increase in the future, supposing a similar rate of spreading. According to the macrovegetation surveys the presence of 87 plant species is proved. This is 29 more than the result of the survey of 1993-94.

53.9 % of the area of the reservoir (i.e. 68.44 km^2) is covered with macrovegetation, from that 22.03 km^2 is the pondweed association. This is 4.29 km^2 larger compared to the survey of 1994 – this shows an 1.07 km^2 growth per year. The growth in area is striking on the side if the Kis-Tisza at the Sarud-basin and Poroszló-basin, mainly in the protected bays. The main species is the Trapa natans. The swamp vegetation has an area of 22.4 km2. This value did not change significantly compared to the amount of 1994 (Pomogyi and Szalma 1998).

During the field measurements it became proved that the dissolved oxygen content in the areas covered with vegetation is very low during the summer, near to the bed it is close to zero. In the case of the other parameters there was not a significant difference in depth or between different sampling areas.

According to the laboratory measurements the water of the River Tisza is I-II. category in quality according to the limits of the MSZ 12749:1993. Compared to each other the higher concentration values can be found next to the exit at the Kis-Tisza. This suggests that the area is more burdened (waters coming from the Kis-Tisza and from the Eger-creek). On the basis of the concentration values of the nitrogen forms (NH_4-N, NO_2-N, NO_3-N) the sampled area of the Poroszló-basin is also favourable, I-II. category in water quality. In case of both the a-chlorophyll and the bacteria number and biomass the area of the *Trapa natans* association proved to be the most unfavourable in water quality. These are relatively shallow, quickly warming up, stagnant water areas.

According to the results of the algological investigations, considering the water quality the most important question is the optimality of the size of the *Trapa natans* association as well as the providing of the optimal water quality for the open water areas. The worst water quality is characteristic to the middle of the *Trapa natans* association while the most favourable water quality forms in the *Typha angustifolia,* and *Phragmites australis* associations (Grigorszky 1998).

According to the zooplankton surveys the highest fluctuation is characteristic to the *Trapa natans* associations. The most stable community was formed in the *Typha angustifolia* and *Nymphoides peltata* associations. The diversity rate was the highest in the areas adjacent to open-water areas. The maintenance of these regions would be favourable in the future for ensuring the biological variety.

The dragonfly-investigations (Odonata-fauna) prove that the extended open-water areas and the connected, homogenous *Trapa natans* associations do not favour the biodiversity (Dévai, Jakab and Müller 1998).

On the basis of the coating-investigations the macrophyta-periphyton complex has an important nutriment sting feature. From the point of view of biomonitoring the vegetation adjacent to open-water areas can be appropriate (Lakatos et al. 1998).

According to the measurement the spatial changes of total nitrogen content of the sediment is similar to the change in the TOC values. The highest values were measured usually in the upper, the lowest values were measured in the lower regions. On the basis of the *total phosphorus* investigations it can be stated that in May the differences between the three layers of sediment are higher than in the autumn. From the measurements it can be seen that the values of the investigated parameters decrease from the “upper” layer (5 cm) to the “lower” layer (15 cm). This change can be regarded as tendency, it does not occur consistently in every sampling area, sometimes the change is vice versa, e.g. in the *Trapa natans - Potamogeton nodosus* mixed association.

3.4.4. Summary

The Kisköre-reservoir is an artificially established and operated water system. The water turnover is periodical, it repeats yearly. During the winter the largest part of the bed becomes dry after emptying, after spring filling and the formation of macrophyte stands the open-water and the vegetation covered surface areas are formed.

The result prove that the fulfilled investigations bring lots of new information but the biggest part of these are single results. It multitude of questions and hypothesis require further surveys that we would like to continue. Both the chemical and biological investigations prove that the selected area is appropriate for biomonitoring, where the long-term changes can be well observed.

The last year, rich in precipitation proves that for gaining overall knowledge we need more years as the investigation of one vegetation period is in sufficient for getting information about tendencies and regularities.

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3.5. ENVIRONMENTAL HISTORY OF OXBOW PONDS: A SEDIMENT GEOCHEMICAL STUDY OF MARÓT-ZUGI-HOLT-TISZA, NE-HUNGARY

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3.5.1. Introduction

Until the mid-19th century the landscape of the Hungarian lowland "Alföld" was characterised by vast areas of backwaters, oxbows, marshland, wet meadows and riparian forests associated with floodplains of major watercourses. Since then the number and extent of these have decreased greatly and the floodplains have become restricted to narrow belts along the main stream channel between dykes (IUCN, 1995). In the flood control operations through the second half of 19th century most of the bends (meanders) of river Tisza were cut off the main channel which lead to the formation of oxbow ponds both on the reclaimed side and on the remaining (active) floodplain. These two basic types are characterised by highly contrasting hydrologies, the former being completely or largely independent of flood regimes and fed by groundwater whereas the latter being exposed to flood disturbance. In such systems deposition of allogenic particles, erosion, and accumulation of authigenic material seem to dominate different periods and occur with different intensity (Brunet and Astin, 1999). The rate and character of sediment accumulation in oxbows are a key factor in determining the future (e.g. terrestrialization, eutrophication) of these water bodies.

Despite their artificial origin oxbows have become important features of the landscape (Ward *et al.*, 1999). The original wildlife has largely been preserved by oxbow ponds, a type of shallow, less disturbed water bodies with a general abundance of aquatic vegetation (Abernethy and Willby, 1999, Müller *et al.*, 1999, Amoros *et al.*, 2000). According to a recent survey, the number of oxbows with a surface area over 5 ha is around 70 along the river Tisza (Pálfai, 1995). Owing to diverse plant and animal communities many of them have been regarded as wildlife sanctuaries (IUCN, 1995).

Because of their critical role in flood control, nutrient cycling and the maintenance of biodiversity, floodplain wetlands either provide or influence many landscape functions that are valued by society. Hence we studied the environmental history of a reference oxbow pond, Marót-zugi-Holt-Tisza, to demonstrate the usefulness of palaeolimnological methods, and particularly sediment geochemical analysis, in reconstructing past aquatic environments.

3.5.2. Methods

Marót-zugi-Holt-Tisza is a smallish oxbow pond (length 1.8 km; width 60 m; area 10 ha, position 48°10'28''N, 21°37'09''E) near the village Gávavencsell ő in NE Hungary. Owing to the richness of the biota it has been registered as a nature reserve and wildlife sanctuary, and selected as part of the pilot project area for the PHARE-sponsored

Hungarian National Biodiversity Monitoring Programme (Dévai *et al.*, 1998). The basin of the oxbow was created in 1860 when a large bend of river Tisza was cut through in the frame of the water regulation.

A sediment sequence was taken by using a rod operated piston sampler (Walker, 1964) which provides 100 cm long undisturbed core samples even from shallow water. Sampling was carried out from ice at the deepest point around the centre of the curved basin, on March 8 1997. Water depth was 190 cm and the corer stopped in the bottom fluvial sand at 590 cm relative to the surface ice. The cores were wrapped first in polyethylene (PE) then in aluminium foil. To avoid sample contamination volumetric subsamples (0.785 cm^3) were taken from the centre of the cores at 5 cm intervals using a small sampler tube and then processed individually. Sediments were described and labelled following Troels-Smith (1955). Organic dry matter (ODM) was determined as loss on ignition at 500 °C (Engstrom and Wright, 1984).

Subsamples were dried at 105°C for 24h, weighed and digested with a mixture of 20 cm^3 65% (m/m) HNO_3 and 2 cm^3 30% (m/m) H_2O_2. The samples were heated on hot plate at 100°C until dryness and then diluted to 10 cm^3. Before analysis sample solutions were filtered and stored in plastic reagent tubes. Concentrations of Al, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, P, Pb, S, Sr and Zn were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) using a Spectroflame instrument (Spectro GmbH, Cleve, Germany). Photosynthetic pigments were extracted with acetone, pigment concentration were determined spectrophotometrically and expressed as sedimentary pigment degradation units (SPDU) following the simple method of Wetzel and Likens (1991).

Against-depth plots of sediment composition data were produced by using Psimpoll 3.0 (Bennett, 1997).

3.5.3. Results and Discussion

The entire length of the sediment sequence was 400 cm which represented about a 130 yr time span (Fig. 1). The average rate of deposition therefore was estimated at 2-3 cm/yr. Radiometric dating of this sediment core has been in progress and expected to provide a more detailed and accurate estimation (e.g. Owens *et al.*, 1999).

The lower third section (590-450 cm relative to ice) of the obtained core was characterised by alternating layers of coarse sand and clayey silt (Fig. 1) which indicates that the basin was incompletely isolated from the main river channel. The sediment section between 450-350 cm was found to have high clay content which suggests slow current velocity but still a fairly continuous water supply. Through this period the organic content of sediments remained very low (c. 4%).

A remarkable change in the history of the oxbow took place at 350 cm where clearly recognisable remains of submersed macrophytes, mostly the hornwort *Ceratophyllum demersum* appeared (Fig. 1). This indicates a shift toward a permanent, less disturbed pond stage. From 350 cm upwards the lacustrine system continued which was shown by a two-fold increase in the organic content. Concentrations of sulphur and phosphorus showed a similar pattern against depth (Fig. 1). However, fossil pigment concentration increased earlier (at 400 cm) than the appearance of macrophyte remains, together with peaks of phosphorus and sulphur. This is likely to imply that in the first stage the dominant process was planktonic eutrophication which was followed by a burst of aquatic macrophytes and probably periphyton, i.e. benthonic eutrophication (Lakatos and Kiss, 1983). From 350 cm upwards to the topmost 190 cm, *Ceratophyllum* was found to appear as 7 distinct peaks. Moreover, SPDU values in the topmost 20-30 cm still increased twofold.

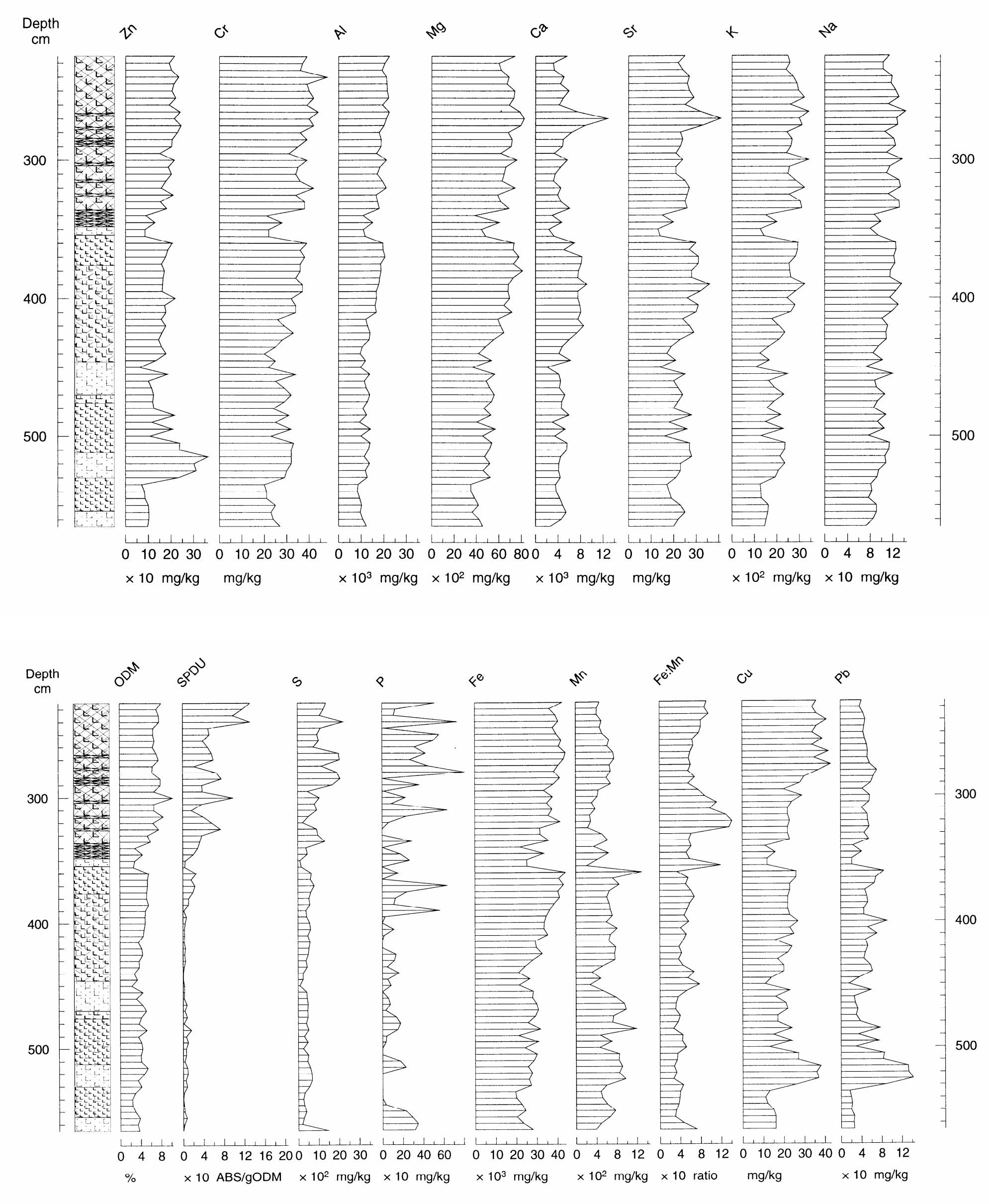

Fig. 1. Sediment description and geochemical data plotted against depth for the oxbow pond Marót-zugi-Holt-Tisza, NE-Hungary; depth measured relative to surface ice.

On the very top of the whole sequence a 1-2 cm thick yellow clayey layer was detected which marked the unusual yet significant winter flood of Tisza a few month before the time of coring (early March, 1997). We suggest that similar events may have resulted in the repeated dieback and burial of aquaphytes detected in the upper section of the sediment.

On the basis of sediment chemistry, 14 recurrent floods were identified in the whole sequence which is in agreement with our earlier results for the oxbow Tiszadobi-Holt-Tisza (15 floods) and also historical records on major, often catastrophic, floods of Tisza (Braun *et al.*, 1996).

In river water, iron and manganese are known to be present as oxides and hydroxides bound to suspended matter (Hoyer *et al.*, 1982, Tóth *et al.*, 1998). Consequently, concentrations of both iron (20-40 g/kg) and manganese (0.4-0.8 g/kg) were found to be fairly high in the sediment. These elements are regarded as subtle indicators of palaeoredox conditions (Mackereth, 1966) as well. The large peak of the Fe:Mn ratio at 330-300 cm was due to a decrease of manganese relative to a constant level of iron. This reflects a relatively oxygen-deficient environment in the water column of the oxbow which occurred closely after the dieback and burial of aquaphytes.

Concentrations of Al, Mg, Cr, Na, K, Ca, Sr along the sequence showed a dull, similar pattern (Fig. 1.) which is primarily determined by the input of allochtonous riverine matter. However, peaks of Cu, Pb and Zn between 540-500 cm reflect increased heavy metal loads probably associated with intense ore mining in the second half of the 19^{th} century. In the upper 50 cm of sediment, representing the last 20-25 yr, concentration of copper was again found to be significant (30-40 mg/kg) whereas levels of Pb and Zn did not differ from the normal values. This suggests that either the source of pollution or the mining technology changed.

3.5.4. Conclusion

The chemical composition of sediment sequences from oxbow ponds are valuable records of floods, trophic state, redox conditions and pollution history. Perspectives of future palaeolimnological investigations on oxbows and other floodplain wetlands should include the radiometric dating techniques (^{137}Cs and ^{210}Pb) of sediment cores, refinement of palaeoenvironmental reconstruction by considering pollen, diatoms, molluscs other aspects of the fossil biota, as well as the ecological comparison of oxbows on the active floodplain and the reclaimed land, including managed and unmanaged ones.

3.5.5. Summary

We studied the usefulness of sediment geochemical analysis as a tool for reconstructing the environmental history of oxbow ponds. >From the deepest point around the centre of Marót-zugi-Holt-Tisza, a smallish oxbow near the village Gávavencsell ő (NE Hungary), an undisturbed sediment core of 400 cm length was taken, representing a 130 yr period. Sediment chemical data revealed a crucial change in the history of the oxbow at 350 cm (around the 1920's?) where recognisable remains of submersed macrophytes, mostly *Ceratophyllum demersum* appeared. This indicates a shift toward a permanent, less disturbed pond stage. It seems likely that planktonic eutrophication was followed by a burst of aquatic macrophytes and probably periphyton (benthonic eutrophication). Through the

entire sediment sequence, evidence for 14 major floods were found, in agreement with our earlier results and historic records. Concentration peaks of Cu, Pb and Zn between 540-500 cm suggested enlarged heavy metal loads, probably associated with intense ore mining in the second half of the 19th century. In the upper 50 cm of sediment (the last 20-25 yr), concentration of copper was again significant (30-40 mg/kg) whereas levels of Pb and Zn did not differ from the normal values which implies that either the source of pollution or the mining technology changed. Perspectives of future palaeolimnological investigations on oxbows are discussed.

3.5.6. Acknowledgements

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3.6. EUTROPHICATION PROCESSES IN THE DANUBE RIVER BANK REGION NEARBY NOVI SAD

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3.6.1. Introduction

Environmental monitoring and water quality assessment programs of the Danube River are being systematically undertaken for three decades. (Djukic *et al.* 1996, 1998). Measurement of chemical and physical aspects of the environment indisputably has its role, but it is the ecosystem health that is to be the primary concern, and the emphasis on biological measurements in the program reflect this awareness. (Loeb and Spacie, 1994). Quantitative estimation of the status and trends in the indicators of ecological conditions requires using standardised procedures for monitoring in the region and using comparable methods across ecological resources. Quantitative estimates of resource condition are critical in determining the relative risk to our ecological resources and they are also critical for the decision-makers in order to implement effective regulatory and management decisions. Therefore, complex surveillance of the Danube River bank region in period 1998/1999, including hydrological, physico-chemical and biological monitoring was undertaken in the section around Novi Sad. The objective of this study was to asses direct and indirect impact of untreated municipal discharges on water quality, species composition and functional organisation of the bank region ecosystems and to estimate eutrophication rate in the investigated section of the Danube River.

3.6.2. Material and methods

In period 1998-1999 samples (water - ASTM, 1995; plankton - plankton net N°22; and bank region bottom samples - Peterson dredge with catchment area 400 cm^2) have been taken seasonally on 12 sampling sites: Begec 1 (Danube), Begec 2 (Danube), Begecka Jama (the Danube River wetland), Kamenjar (Danube - 1262 km), Sremska Kamenica (Danube - 1259 km), Ribnjak (Danube - 1257 km), Danubius (Danube 1257 km), Petrovaradin (Danube - 1255 km), railway bridge - municpipal wasterwater discharge (Danube 1254 km), the confluence of the Canal System Danube - Tisza - Danube into the Danube River (1253,5 km), public beach (Danube 1253 km) and Sremski Karlovci (Danube 1245 km). Saprobic Index (Pantle and Buck, 1955) has been calculated according to indicator values and number of recorded taxon. Ichthyological investigation have been undertaken in two sections: upstream (1262-1269 km) and downstream (1250) Novi Sad. The samples have been collected using nets (various mesh size) and electric fishing. Chemical analysis have been done by standard methods (APHA, 1995).

3.6.3. Results and discussion

3.6.3.1. Chemical analysis

The samples for basic physico-chemical analysis were taken in 1999, seasonally , at 5 sampling sites (Begecka Jama wetlands, Kamenjar, Sremska Kamenica, mouth of the canal DTD ionto te Danube River and Sremski Karlovci) . The results are shown in Table 1.

In the River Danube section near Novi Sad, COD-MnO_4 ranged from 4.2 - 13.2 mg L^{-1} and O_2 content and saturation varied with the season, while the lowest values were recorded in winter period, due to lack of photosynthetic activity of algae. An exception to this was observed at Begeèka jama locality, where O_2 content decreased during summer period probably because of the high water temperature. BOD_5, as an indicator for organic matter pollution showed moderate values for the most of the localities. Maximum load was observed in summer period at sampling site Begecka jama wetland. Higher values for both

Table 1. Basic physico-chemical parameters -seasonal mean values 1999. Winter (I), spring (II), summer (III) and autumn (IV)

Parameter:	Sampling sites 1 (Begecka jama)	2 (Kamenjar)	3 (Sremska Kamenica)	4 (mouth of the canal DTD)	5 (Sremski Karlovci)
1.COD-MnO_4 (mg O_2 L^{-1})	I – 11.6 II – 11.1 III – 9.6 IV – 13.2	I – 5.5 II – 7.5 III – 5.9 IV – 6.2	I – 4.9 II – 6.8 III – 6.2 IV – 5.7	I – 4.2 II – 6.8 III – 9.1 IV – 11.2	I – 5.8 II – 6.9 III – 6.8 IV – 9.0
2. BOD_5 (mg O_2 L^{-1})	I – 7.02 II – 8.20 III – 11.48 IV – 8.57	I – 3.65 II – 5.10 III – 5.47 IV – 4.20	I – 4.90 II – 4.98 III – 5.76 IV – 3.45	I – 4.26 II – 6.55 III – 8.66 IV – 4.52	I – 5.34 II – 6.44 III – 5.28 IV – 7.55
3. NH_4^+-N (mg L^{-1})	I – 0.33 II – 0.07 III – 0.51 IV – 0.38	I – 0.34 II – 0.21 III – 0.08 IV – 0.75	I – 0.38 II – 0.19 III – 0.26 IV – 0.39	I – 1.20 II – 1.10 III – 2.00 IV – 1.62	I – 0.41 II – 0.35 III – 0.64 IV – 0.29
4. NO_3^--N (mg L^{-1})	I – 2.87 II – 0.03 III – 0.35 IV – 2.62	I – 11.60 II – 3.52 III – 4.58 IV – 8.55	I – 12.40 II – 3.00 III – 4.08 IV – 8.34	I – 9.46 II – 2.05 III – 1.51 IV – 6.84	I – 11.20 II – 2.55 III – 3.54 IV – 8.52
5. NO_2^--N (mg L^{-1})	I – 0.05 II – 0.03 III – 0.007 IV – 1.09	I – 0.10 II – 0.07 III – 0.05 IV – 0.11	I – 0.13 II – 0.06 III – 0.06 IV – 0.12	I – 0.06 II – 0.11 III – 0.10 IV – 0.13	I – 0.08 II – 0.08 III – 0.08 IV – 0.12
6. PO_4^{3-}-P (mg L^{-1})	I – 0.06 II – 0.08 III – 0.02 IV – 0.03	I – 0.08 II - ∅ III – 0.06 IV – 0.08	I – 0.11 II – 0.02 III – 0.07 IV – 0.09	I – 0.27 II – 0.22 III – 0.54 IV – 0.17	I – 0.08 II – 0.04 III – 0.01 IV – 0.10
7. EC (dS m^{-1})	I - 670 II - 420 III - 380 IV - 1060	I – 410 II – 330 III – 320 IV – 410	I – 460 II – 330 III – 330 IV – 440	I – 690 II – 490 III – 520 IV – 600	I – 410 II – 360 III – 320 IV – 460
8. pH	I – 7.5 II – 8.3 III – 8.4 IV – 8.5	I – 8.1 II – 8.3 III – 8.3 IV – 8.3	I – 8.2 II – 8.1 III – 8.1 IV – 8.2	I – 8.0 II – 8.2 III – 8.0 IV – 8.1	I – 8.3 II – 7.8 III – 8.2 IV – 8.2

COD and BOD_5 were also recorded downstream of Novi Sad municipal wastewater discharge input. Most of the total organic load were biodegradable organic compounds.

In the spring and summer period biochemical processes are more intensive so the nutrient content is low, remaining within maximal allowed concentrations for class I-II water. The content of ionic forms of nitrogen (NO_2^-, NO_3^-, NH_4^+) and phosphorus (PO_4^{3-}) have not exceeded limits recorded in previous years. (Anon, 1995,1996,1997). In autumn, and especially in winter period, primary production is much lower and the nutrient level increases. Maximum concentrations of nutrients and soluble salts is recorded at the mouth of the canal DTD into the River Danube just downstream Novi Sad. caused by the untreated and partly treated wastewater discharge of mineral fertilizer factory and food processing facilities located on the bank of the canal.

According to the results of physico-chemical analysis, a certain trend of nutrient and organic enrichment along the Danube River bank region around Novi Sad is observed. Moreover, the section of the river downstream municipal wastewater discharge could be regarded as europhic.

3.6.3.2. Macrophytes

Table 2. Aquatic macrophytes as water quality indicators of the Danube River near Novi Sad

	sampling stations				ecological indices			
	Begecka Jama	Sremska Kamenica	Petrovaradin	Sremski Karlovci	R	N	H	D
Submersed macrophytes								
Ceratophyllum demersum L.	*	*	*	*	4	5	3	5
Myriophyllum spiccatum L.	*				4	2	4	5
Potamogeton pectinatus L.	*				4	4	3	4
Potamogeton lucens L.	*			*	4	4	4	5
Potamogeton acutifolius Link	*				4	3	3	5
Vallisneria spiralis L.				*	2	2	3	5
Elodea canadiensis Rich.				*	4	4	3	4
Floating macrophytes								
Nymphaea alba L.	*				3	3	4	5
Potamogeton fluitans Roth.			*		3	3	3	3
Trapa natans L (agg.)	*				3	3	4	5
Hydrocharis morsus-ranae L.	*				3	4	3	5
Polygonum amphibium L.	*				3	4	3	5
Salvinia natans L.	*	*		*	2	3		
Lemna minor L.	*	*	*	*	3	3		
Spirodela polyrrhiza (L.) Scheild.	*	*	*	*	3	3	3	4
Emergent macrophytes								
Veronica anagallis-aquatica L.			*		3	4	4	5
Phragmites communis Trin.	*			*	3	3	3	4

ecological indices - based environmental evaluation (R,H,N and D percent values)	R3 50% H3 > 50% N3 >50% D5 > 70%	R3 >70% H3 100% N3 70% D5 50%	R3 80% H3 >70% N3 60% D5 50%	R3,R4 40% H3>80% N3 50% D4,D5 50%

R - pH indicator; N- nitrogen and N-compounds content indicator H - indicator of organomineral compounds content; D index of transparency

According to indicator values - ecological indices (Landolt, 1977) of the most abundant macrophytes, the difference between the Danube River water quality upstream and downstream of Novi Sad has been observed. (Table 2) Sampling site Begecka Jama wetland is characterised by the presence of *Nymphaea alba*, *Myriophyllum spiccatum* and *Phragmites communis* - indicators of mesotrophic environment.

However, the appearance of a few *Potamogeton* species as well as *Hydrocharis morsus-ranae* indicate occasional nutrient enrichment (mainly runoff from the surrounding agricultural soil). In the "inner city" river section (sampling sites Sremska Kamenica and Petrovaradin) the presence of small-sized floating macrophytes (*Lemna minor*, *Spirodela polyrrhiza* and *Salvinia natans*) indicate mezzo - eutrophic environment. (Donk *et al.* 1993). Yet,, downstream Novi Sad (sampling site Sremski Karlovci) the high abundance of the duckweed, as well as occurrence of *Elodea canadiensis* imply the significant increase of nutrient input and eutrophic environment. (Lewis, 1995). The values of ecological index R suggest neutral to slightly alkaline pH of the Danube River, while high values index D point out impaired transparency along the section.

3.6.3.3. Phytoplankton

Qualitative analysis of phytoplankton reveals the presence of 100 taxon, with the absolute dominance of *Bacillariophyta* (62 taxon). Besides, 10 taxon of *Euglenophyta* and *Chlorophyta*, 6 taxon of *Cyanobacteria* and 1 from *Pyrrophyta*, *Xanthophyta* and *Crysophyta* were recorded. *Asterionella formosa* (*Bacillariophyta)* with saprobic index value 1.4, indicator of oligo towards β-mezzosaprobic waters, appears as subdominant species at all sampling sites, except Begecka jama wetland. However, *Nitzschia acicularis*, the typical indicator of α-mezzosaprobic waters has been recorded also at all sampling site, except Begecka jama wetlands. Species richness and saprobic Index at 11 sampling sites along the Danube River section Begec - Sremski Karlovci are shown in Fig. 1. The highest

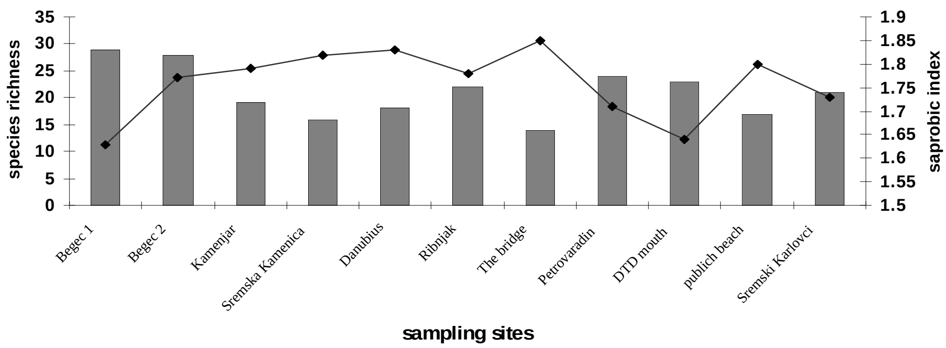

Fig. 1. Phytoplankton species richness and saprobic indices in the Danube River section near Novi Sad

number of recorded species (>25) and the lowest saprobic index values (1.63) were recorded at sampling site upstream Begec. Sampling site The Bridge (municipal wastewater discharge point) is characterised by decrease in species richness (<15) and high recorded saprobic index value (1.85). Therefore, according to phytoplankton analysis, an impairment of the Danube River water quality downstream Novi Sad is obvious. Yet, the highest saprobic index value (1.98) and the biggest species richness (37) were recorded at Bagecka jama wetland, which was expected, since this wetland represent a specific ecosystem, with rather poor connection with the main flow of the Danube River.

3.6.3.4. Zooplankton

As sample was taken only in winter 1998/1999 , only four groups - *Protozoa, Rotatoria, Cladocera* and *Copepoda* with total number of 11 species were recorded. (Table 3). Such low biodiversity within the zooplankton is typical for cold period of the year.

Table 3. Relative abundance of zooplankton in the Danube River section Kamenjar-Sremski Karlovci (winter 1998)

	Sampling stations								
	Kamenjar	Sremska Kamenica	Ribnjak	The bridge	public beach	Petro-varadin	Danu-be	DTD mouth	Sremski Karlovci
PROTOZOA									
Epistylis plicatilis		1	1						
Paramecium aurelia	1	1	1	1	1	1	1	1	1
Votricella microstoma	1	1	1	3	1	1	1	1	1
ROTATORIA									
Asplanchna priodonta	1								1
Brachionus angularis	1	1			1		1	1	1
B. calyciflorus	1	1	1	1	1	1	1	1	1
Keratella quadrata	1		1				1	1	1
Polyarthra dolichoptera	1			1					1
Rotaria rotatoria	1	1	1	1	1	1	1	1	1
CLADOCERA									
Bosmina longirostris			1			1			
COPEPODA									
Acanthocyclops vernalis								1	

3.6.3.5. Macrozoobenthos

Qualitative analysis of the bank region benthos in the Danube River section Begec - Sremski Karlovci - revealed the presence of 3 groups: *Oligochaeta, Gastropoda* and , *Diptera (Chironomidae).* The dominant gro In winter 1998/1999. 16 taxon - 8 genera and 2 families - *Naididae* and *Tubificidae* : *Aulophorus furcatus, Amphichaeta rostrifera, Dero digitata, N. barbata, Nais bretscheri, N christinae, N. communis, N. elinguis, N. stolci, Ophydonais serpentina, L. claparedeanus, Limnodrilus hoffmeisteri, L. udekemianus, Potamothrix hammoniensis, P. isochaetus* and *Tubifex tubifex* were recorded.

Total number of Oligochaeta in the Danube River bank region along the section Begec - Sremski Karlovci (Fig. 2) ranged from 1666 at sampling site Ribnjak to 15453 ind/m^2 at sampling site Sremski Karlovci, in mixing zone downstream Novi Sad municipal wastewater discharge point. The number of Oligochaetes in samples from Begecka jama wetlands, was, as expected, much higher than in the Danube River, and reached 26058 ind/m^2.

According to these results, which are in agreement with the previous research (Djukic *et al.* 1997), the Danube River bank region nearby Novi Sad can be regarded as eutrophic, while particularly enhanced eutrophication process have been observed in the section Kamenjar - Sremski Karlovci. Nevertheless, the situation in future could easily worsen. During the recent events in Yugoslavia, three bridges across the Danube River in Novi Sad section have been destroyed and ruins remained in the river ever since. Besides, the pontoon across the Danube River, just downstream sampling site Ribnjak, has been built as the only connection between left and right bank. Consequently, the Danube River flow drastically slowed down. As a result, the total number of Oligochaetes in the section Sremska Kamenica - Ribnjak increased from 1666 to almost 30000 ind/m^2, the number typical for almost stagnant waters. (Djukic *et al.* 1998).

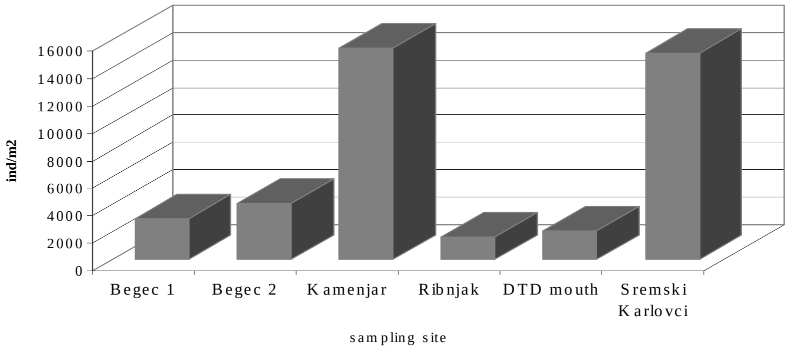

Fig. 2. Total number of Oligochaeta in the Danube River bank region (section Begec - Sremski Karlovci)

Moreover, qualitative analysis of the sample taken even before the pontoon construction, in spring 1999, in high-water level period, at sampling site Sremska Kamenica, suggested the total dominance of *Limnodrilus hoffmeisteri* (Miljanovic, unpublished) - the typical indicator of stagnant, highly eutrophic waters. (Lang, 1985). Yet, if the ruins remain, even worse situation can be expected in forthcoming period of low water levels and high temperatures in summer, while the impact of slowing flow might spread upstream

3.6.3.6. Fish communities

Qualitative analysis of the Danube River bank region using electric fishing showed the presence of 15 species from 5 families. The highest species richness was recorded within *Cyprinidae* family (10 species). Family *Percidae* was represented by 2, while the other 3 families were represented by a single species. Quantitative analysis reveals the dominance of *Blicca bjoerkna* (50%) and sub-dominance of *Alburnus alburnus* (17%). According to mass percentage, B. bjoerkna is also found as a dominant species (50%), while Leuciscus idus was sub-dominant (14% out of the total catch).

Fish community of Bagecka jama wetland is represented by 16 species from 6 families. Again, the highest species richness was recorded within *Cyprinidae* family (11 species), while all the other families were represented by a single species. According to quantitative analysis, *Carassius auratus* can be regarded as totally dominant species (71%), while *B. bjoerkna was sub-dominant* (15%). However, *Silurus glanis* made 54 mass % out of total catch, while *C. auratus* made 25% and *B. bjoerkna* only 11mass % of total catch.

Structure and composition, particularly regarding nutrition types, indicate complexity and stability of the fish community in investigated regions, which mainly applies to the Danube River and to a smaller extent to the wetlands. Consequently, a better interconnection of the Danube River and the wetlands must be provided.

3.6.4. Conclusion

The results of the integrated surveillance of the Danube River bank region in period 1998/1999, indicate that bank region of the Danube River section around Novi Sad must be evaluated as eutrophic environment. The highest rates of the eutrophication process were recorded at sampling sites Kamenjar (upstream) and at the sampling site Sremski Karlovci - downstream Novi Sad's municipal wastewater discharges, within the mixing zone. The problem of depleted velocity of the Danube River flow along the investigated section, caused by the remaining ruins of the three destroyed bridges and the recently built pontoon, could, in future, even worsen the situation by weakening self-purification capacity of the Danube River, which, eventually, leads to acceleration of already enhanced eutrophication process in the section around Novi Sad.

3.6.5. Summary

Complex surveillance of the Danube River bank region in period 1998/1999, including hydrological, physico-chemical and biological monitoring was undertaken with an aim to estimate eutrophication level in the river section around Novi Sad. During the whole investigated period, The Danube River water levels were unexpectedly extremely high. Even in winter, in high water level periods, with low rate biochemical processes, the nutrients (N, P) concentrations were, at several sampling sites elevated up to III-IV class level. Nevertheless, biological monitoring (phyto and zooplankton dynamics, bottom fauna and ichtyofauna) indicate high primary and secondary production as a result of the organic load. Therefore, the bank region of the Danube River section around Novi Sad must be regarded as eutrophic, while the highest rates of the eutrophication process were recorded at sampling sites Kamenjar (upstream) and at the sampling site Sremski Karlovci - downstream Novi Sad municipal wastewater discharges, within the mixing zone.

3.6.6. References

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3.7. METAL POLLUTION INDEX-BASED WATER QUALITY ASSESMENT OF THE DANUBE RIVER BASIN IN YUGOSLAVIA

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3.7.1. Introduction

Although fish do not fulfil all requirements for indicator organism, OECD and ICES agreed upon using trace metal concentrations in stationary fish as possible indicators in areas affected by human activities. (Jorgensen and Pedersen, 1994). Also, bioaccumulation studies of persistent substances in aquatic biota (including fish) are required for NPDES permit in United States (US EPA, 1991a). Fish tissue metal content has been, so far, successfully used in estimations of trace metal input into large European and American rivers. (Pujin *et al*., 1990, Wachs, 1991, 1992/3, Allen-Gil and Martynov, 1995; Chevreuil *et al*., 1995; Saiki *et al*., 1995; Carru *et al*., 1996, Maletin *et al*., 1996) and lakes (Salanki, 1982, Balogh, 1985, Strip *et al*., 1990, Spry and Wiener, 1991, Scharenberg, 1994, Kock *et al*., 1996).

The Danube River Basin is constantly subjected not only to trace metal and other toxic substances input, but to different legislative, enforcement measures and monitoring programmes along its flow. Therefore, it is becoming inevitable to establish internationally standardised methods for water quality monitoring, which seems not to be a problem when considering physico-chemical analysis of sediments, waters and wastewater. However, biological monitoring and, to a certain extent, ecotoxicological studies are highly dependent on biodiversity and species richness within the region. In spite of the fact that the fish tissue preparation methods, and analytical methods for metal determinations as well, have been standardised so far, (APHA, 1989; U.S. EPA, 1991), the question of choosing the most appropriate fish group, species and tissue for these kind of monitoring studies is still to be answered. Therefore, the objective of this paper is to contribute to ecotoxicological studies of the Danube River by offering applicable method for standardised monitoring of metal pollution in the Basin. Recently introduced Metal Pollution Index (Teodorovic *et al*., 1998b, Teodorovic *et al*., 1999, Teodorovic, 1999) has been calculated for selected ecosystems within the lower Danube River Basin with an aim to produce some useably data for comparative, as well as monitoring purposes, at least within the region.

3.7.2. Material and Methods

3.7.2.1. Sampling and chemical analysis

The fish for this study was caught in spring and summer 1997 from the River Danube (1 sampling site), from The Danube wetlands (2), Canal System Danube - Tisza - Danube (5) , the River Jegricka (1), Backwater Tisza (1) , Zasavica (Backwater Sava) (1) and 3 reservoirs within the Basin (Fig 1).

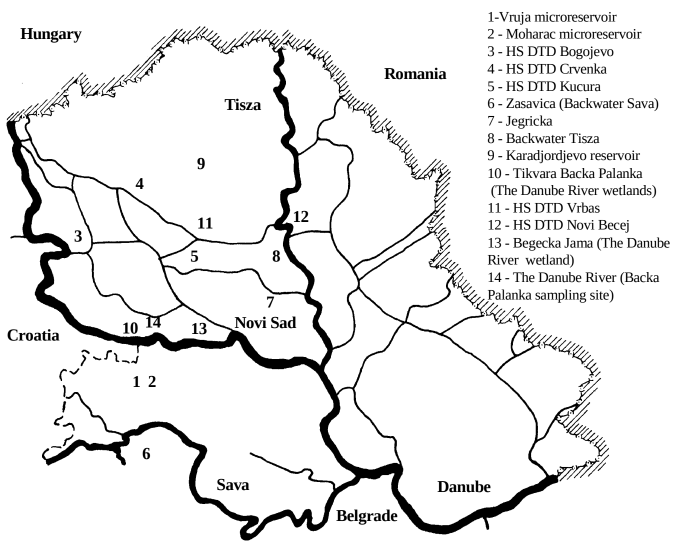

Fig. 1 Sampling stations

All samples consisted of 10 specimens of *Carassius auratus gibelio*, except the samples from Zasavica (backwater Sava) where *Carassius carassius* was taken. Tissue (fish liver) digestion and sample preparation was done according to standard procedure (U.S. EPA, 1991) and Perkin Elmer AAS (flame and graphite furnace with background correction) was used for Cd, Zn, Cu, Pb and Al determinations. (APHA, 1989). All results are presented on a wet weight basis, as mg/kg, but recalculation by the factor 2.6 from wet to dry weight basis for liver enables comparison.

3.7.2.2. Metal Pollution Index (MPI)

MPI has been calculated to enable presentation of all results from 5 metal concentrations (Cd, Cu, Zn, Pb and Al) as one value if possible, yet overcoming the difficulties with both application and understanding of demanding statistical analysis. According to Jorgensen and Pedersen (1994), this implies that the five metal concentrations must be normalised to make it possible to sum up and average the different metal concentrations into one value and, what is more important, to diminish the more than thousand-fold difference between the least and the most abundant elements. Without such transformation, the least abundant elements would be without influence on the results. (Julshamn and Grahl-Nielsen, 1996). We have chosen the average values of fish liver metal burden (Cu, Zn, Pb, Al and Cd) from the reference sites. (Vruja and Moharac microreservoir) Such normalizer is used to account for the biological variation in a non-polluted area. Moreover, as seasonal variations in metal content have been observed (Balogh *et al*., 1985; Kock *et al*., 1996), sampling was undertaken within the same season (spring/summer), at precisely defined sampling stations (Fig 1).

Since no significant difference has been found between liver metal content in goldfish from two microreservoirs (one way ANOVA, $p \leq 0.05$) (Teodorovic, 1999) the sample has been pooled so the reference values represent the means± SD of 20 specimens. (Table 1).

Table 1 Concentrations (mg/kg wet wt) of Cd, Pb, Zn, Cu and Al in goldfish liver from Vruja and Moharac microreservoirs and proposed referent values (normalizers) * below detection limit (0.015 ppm)

	Cd	Pb	Zn	Cu	Al
pooled sample Vruja & Moharac	*	0.19± 0.42	19.58± 0.7	1.91±0.42	13.62 ±4.01
proposed normalizers	0.015	0.2	20	2	15

MPI has been calculated as:

$$MPI = \log \sum_{i=1}^{n=5} \frac{[\bar{x}]}{ref_i} \qquad (1)$$

where ref_i represents a normalizer, or a reference value for each of five chosen metals (Cd, Cu, Pb, Zn and Al) in liver, while x represents mean value (n≥10, SD up to 30%) of metal concentration in the same tissues from the chosen sampling site). Furthermore, logarithmic transformation enables normalisation of MPI values. If calculated as proposed, MPI distinguishes: non polluted if MPI< 1, polluted: 1<MPI<1.5, and very polluted ecosystem: if this combined index is above 1.5. In other words, ecosystems are being classified into three categories: "non-polluted" - if the sum of the normalised metal concentrations is up to twice the reference value, "polluted" - if from 2 to 6 time higher and "very polluted" - if the sum of normalised metal concentration is more than 6 time higher than the reference value.

3.7.3. Results and Discussion

Trace metal accumulation patterns in aquatic biota (Strip *et al.*, 1990, Pujin *et al.*, 1990, Wachs, 1992/3, Allen, 1995, Kraal *et al.*, 1995), along with bioconcentration (Salanki *et al.*, 1982, Wachs 1990, Kock *et al.*, 1995 Djukic *et al.*, 1998a,b) and biomagnification processes (Jorgensen and Pedersen, 1994, Saiki *et al*., 1995, Carru *et al.*, 1996, Teodorovic *et al.*, 1998a,b) have been excessively studied. The general conclusions regarding the named processes are that muscle is the tissue of the lowest, while liver, kidney and gills represent the target tissues for trace metal accumulation in fish. To minimise expenses and, on the other hand, to standardise procedure, fish liver was chosen as the monitoring tissue in this study. Further on, researchers mainly agree upon the fact that Hg is the only metal which is subjected to biomagnification via aquatic food chain. Nevertheless, bentivore fish proved to accumulate Cd and Pb to higher extent than the piscivore, which is to be expected considering biology and feeding habits of the group. To avoid possible species-specific differences, *Carassius auratus gibelio*, which, according to recently published data (Jankovic, 1994; Maletin *et al*., 1997) makes up to 50% out of total catch in Yugoslav part of the Danube Basin, has been taken as sentinel species.

Besides, to diminish possible age/size influence on trace metal content, only specimens belonging to same age group (1+) have been used in this study.

Table 2 shows Zn, Cu, Cd, Pb and Al concentrations (mg/kg wet wt) in goldfish (*Carassius auratus gibelio*) liver from 12 representative study sites within the Yugoslav part of the Danube River Basin. The content of all analysed metals was the lowest in fish liver from Vruja and Moharac microreservoirs. (table 1). Such results were expected as these microreservoirs do not receive any direct wastewater (sewage nor industrial) input and are quite remote from urban areas and major roads. Moreover, when compared with the results of previous research of trace metal load in bentivore fish (Pujin *et al*., 1992, Maletin *et al*., 1992, Maletin *et al*., 1996, Djukic *et al*., 1998a,b) these concentrations are significantly the lowest ever recorded in Yugoslav part of the Danube Basin. (Teodorovic, 1999). Therefore, as explained in Material and Methods section, these values have been chosen as normalizers (reference values).

Table 2 Metal concentrations (mg/kg wet wt) in goldfish (*Carassius auratus gibelio*) liver (mean n=10 ±SD) from representative study sites within the Yugoslav part of the Danube River Basin

ecosystem/ sampling site	Zn	Cu	Cd	Pb	Al
HS DTD Bogojevo	20.46 ±2.3	2.24± 0.42	*	0.2 ±0.02	15.34 ±1.67
HS DTD Crvenka	31.58± 0.47	2.21± 0.1	0.01	0.39± 0.1	16.09 ±0.16
HS DTD Kucura	30.41± 3.67	3.34± 1.09	0.02	0.44 ±0.09	15.11 2.37
Zasavica	21.22±1.96	5.59±0.32	*	0.9±0.28	17.98±7.85
Jegricka - Zabalj	46.87± 26.18	2.1± 0.34	0.01	0.79± 0.38	84.9 ±12.4
Backwater Tisza - Curug	34.9±7.69	10.07±2.85	0.11±0.05	1.8±0.41	21.08±5.64
Karadjordjevo reservoir	75.03±20.1	2.7±0.2	0.13±0.07	1.96±0.21	35.23±4.12
Tikvara Backa Palanka (The Danube wetland)	57.46± 3.69	9.22± 2.55	0.19± 0.08	0.95± 0.21	17.87± 7.13
HS DTD Vrbas	30.79 ±0.19	16.75 ±1.41	0.13± 0.01	0.59 ±0.12	107 ±29
HS DTD Becej	34± 9	13.7± 2.5	0.2± 0.05	3± 0.6	64 ± 3
Begecka Jama (The Danube wetlands)	225± 90	9.07± 5.7	0.23± 0.11	1.96± 0.03	45.84± 7.27
The Danube River (Backa Palanka)	123± 20	8.71 ±3.2	0.26± 0.07	5.18 ±0.5	15.81± 8.4

The Metal Pollution Index for selected sites in Yugoslav part of the Danube River Basin has been calculated according to equation (1). The results are presented in Fig. 2, where MPI based classification into 3 categories has also been shown. The lowest values of MPI are recorded at three study sites Bogojevo, Crvenka and Kucura along the Danube - Tisza- Danube Canal System, 0.72, 0.83 and 0.89, respectively. According to MPI-based classification, these sites could be regarded as non-polluted, considering trace metals. The highest values (1.61, 1.64 and 1.73) are recorded at Becej dam, in the Danube wetland Begecka Jama (upstream Novi Sad) and in the Danube River (sampling site Backa Palanka), respectively. These are the sites that, according to MPI value, must be considered as very polluted. Between these two extremes, there are 6 ecosystems: Zasavica (Backwater Sava), the Jegricka River (sampling site Zabalj), Backwater Tisza (sampling site Curug), Reservoir Karadjordjevo, Tikvara - Backa Palanka (The Danube wetland upstream Novi Sad) and Vrbas (Canal System Danube-Tisza-Danube) with MPI values ranging from 1.02 to 1.46, and consequently classified as polluted.

The sampling sites with the highest MPI : Backa Palanka (The Danube -1.73 and the wetlands 1.42) and Begecka Jama wetland (1.64) are located on The Danube River section between Vukovar (Croatia) and Novi Sad. This area is urbanised and industrialised, so the Danube River receives huge amounts of untreated and partly treated municipal and industrial effluents, particularly from metal processing, leather and textile industry. The results of Yugoslav national monitoring programme (chemical analysis of water and sediments) from this section of the Danube River in period 1995-1997 (Anon, 1995, 1996,

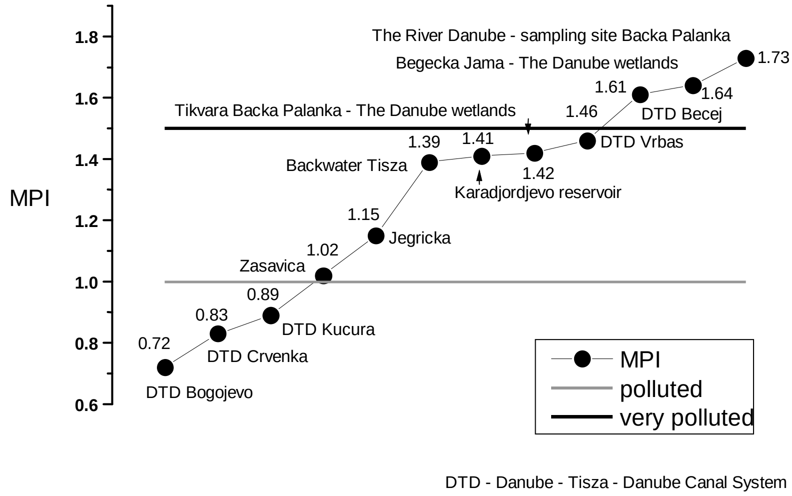

Fig 2. MPI-based evaluation of the selected ecosystems within the Yugoslav part of the Danube River Basin

1997) reveal highly changeable concentrations of Zn (0-30 μg/l), Pb (0-36μg/l) and Cu (0-12μg/l) in water, while most of the time Cd was below the detection limit. On the other hand, sediment concentrations of Zn and Cu ranged from 30 - 200 mg/kg, while Cd and Pb were constantly below the detection limit. Yet, Cd and Pb are the main components of such high MPI values since their average concentrations in goldfish liver from these sites are 12-15 and 5-26 time higher than reference values, respectively. The similar situation is found in Canal section Vrbas - Bezdan on sampling site Vrbas (MPI 1.46) located downstream effluent discharges of industrial zone Kula - Vrbas (food, metal processing, leather and textile industry). Trace metal concentrations in Canal water show even higher variability than in the Danube. (Zn 10-180000 μg/l; Cd 0-5, Pb 0-26, Cu 0-3 μg/l), (Anon, 1995, 1996, 1997), while Cd and Cu contents represent the main components of the MPI, being 8 times higher than the reference values. These results prove the existing opinion that accumulated trace metal content in aquatic biota has smaller variability and thus could serve as more reliable indicator of the metal pollution than chemical analysis of water and sediments. (Salanki *et al*., 1982, Sharenberg *et al*., 1994).

The “non-polluted” sites along the Canal system (Bogojevo, Crvenka and Kucura), as well as “polluted” Backwater Tisza (Zabalj) and Zasavica are located in predominantly rural areas, so that trace metal occurrence in aquatic environment is due only to patchy inputs, mainly runoff from agricultural land.

However, the results of this study must be taken with the utmost care. The reason for such statement is the fact that due to economic and political situation in Yugoslavia, industrial facilities in the whole region have not been working with full capacity for almost 10 years and the river transport, due to the latest events, is insignificant compared to the period before 1990. Therefore, toxic substances (including trace metals) inputs to the Danube River Basin from the Yugoslav and Croation territories is impared. Yet, MPI-based evaluation indicates metal pollution as an already serious environmental issue. Thus, it could be expected that in future, after the normalisation of the situation in the region, the problem of toxic substances input emerges as one of the hot spots in the lower part of the River Danube. Our opinion is, therefore, that MPI could serve in future for trend analysis and comparative purposes as an easy, relatively prompt and inexpensive monitoring method.

3.7.4. Summary

MPI - Metal Pollution Index is being introduced with an aim of improving the freshwater pollution control, monitoring and classification based on fish metal body burden. This simple mathematical model enables presentation of Cd, Pb, Cu, Zn and Al fish liver concentration as a single unit-less value and, therefore, evaluation, classification and time trend analysis within the region. Metal burden in liver of *Carassius auratus gibelio* has been used for calculations, while normal distribution and biological variation estimation have been achieved by using normalizers (liver concentrations of selected elements in fish from reference sites). MPI - based water quality assessment and classification of the selected sites within the Yugoslav part of the Danube River Basin have been undertaken. The results of this study indicate that metal pollution of the Danube River could be regarded as a rather serious environmental issue.

3.7.5. Acknowledgements

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3.8. THE RIVER DANUBE WATER QUALITY NEARBY NOVI SAD AS AFFECTED BY CHANGES IN RIVER WATER FLOWS

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Radnovicy, D. and Simeunovicy, Y.

3.8.1. Introduction

Continual investigations of the river Danube water quality in the Institute of Biology (Faculty of Science in Novi Sad) last already 25 years. Our published results (Gayin *et al.,* 1982, 1984, 1987, Matavuly *et al.*, 1988) point to the various quality of the Danube water at the Novi Sad sector, with the tendency of decrease of water quality after 1979 and the slight increase of water quality after 1989 (Gayin *et al.*, 1990, 1995). Supported by Novi Sad City Authorities for the environmental protection and conservation, investigations with 11 sampling sites at the Novi Sad sector have been organized in the course of 1998-1999. Since the river Danube waterbed has been used as the main source of Novi Sad potable water, and in the same time the river water has been serving as the main recipient of municipal sewage water, results of current sapromicrobiological investigations should point to the effect of main city polluters on the river water quality, as well as to the effect of destruction of all three bridges over the river Danube in Novi Sad.

Fig. 1. Novi Sad City map with sampling sites

3.8.2. Material and methods

Samplings of the river Danube water in the Novi Sad region were done seasonally during 1998 (prewar period) and during 1999 (postwar period). Sampling sites are shown at fig. 1. 11 localities (left river bank: 1 Kamenyar, 2 Shtrand, 3 Railway bridge, 4 Pover plant; main river current: 5 Freedom bridge, 6 between Petrovaradin and Railway bridges, 7 Sremski Karlovci; right river bank: 8 Sremska Kamenica, 9 Ribnyak, 10 Petrovaradin, 11 Oficirska plazha) have been chosen with aim to illustrate the influence of the main Novi Sad City polluters on the river Danube water quality from the sapromicrobiological and enzymological point of view.

The mesophilic saprophytic bacteria were enumerated at the nutrient agar. The number of facultative oligotrophs has been determined at 10 times diluted nutrient agar. The number of colony forming units was used for the river Danube water categorization into classes of quality according to Kohl (1975).

The relationship between heterotrophs, originating from eutrophic environments, and facultative oligotrophs, originating from oligotrophic environments, defined as H/FO ratio was used for determination of the water selfpurification ability (Gayin *et al.,* 1990). Enzyme, phosphatase activity of nontreated water sample has been determined using p-Nitrophenylphosphate as a substrate and Phosphatase activity index (PAI) was calculated as a mean value of acid, neutral and alkaline phosphatase activity of water, and used for categorization of water into classes according to Matavuly (1986).

3.8.3. Results and discussion

The results obtained by enumeration of organotrophic bacterioplankton point to the various water quality depending on the locality, as well as to the seasonal fluctuating in the quality of water considering its organic load. As a rule, the lowest number of heterotrophs, as well as facultative oligotrophs, was recorded in the spring season and the highest during the summer-autumn seasons in the course of 1998, what was in agreement with our previous reports. The lowest number of heterotrophs at the most sampling sites in summer or autumn season during 1999, except at the locality No 3 (downstream of destroyed railway bridge), disagreed with our previous findings of bacterial seasonal fluctuations in the river Danube water (Gayin *et al.*, 1995), probably due to changed conditions considering organic load caused by changed flow of sewage water.

The ratio between the number of facultative oligotrophic and heterotrophic bacterioplankton (FO/H index, Gayin *et al.,* 1990, 1993) point to the preserved selfpurification ability and high rate of degradation of pollution downstream of Novi Sad sewage effluent, especially during warm seasons. The exception of this rule was localities downstream of sewage effluent during 1998 (Fig. 2, localities 3 and 4).

Huge amount of building material that has plunged into the riverbed due to Novi Sad bridges destruction by NATO bombardment has drastically changed the course of main current of the river Danube, as well as the bank water currents. Consequently, the course of municipal wastewater has been changed, what caused the changes in the river Danube water quality considering the river water horizontal profiles. These changes are the most noticeable downstream of the destroyed railway (Zhezhely's) bridge (sampling site No 3, Fig. 1). In the course of prewar period (1998) the highest water pollution according to sapromicrobiological and enzymological indicators has been recorded at this locality, caused by the nearby effluent of Novi Sad municipal water (Fig. 2, Fig. 3). According to the same parameters, the river Danube water quality at the same locality, after the fall of railway bridge has substantially changed, because the municipal water stream has been shifted from the bank current to the main river stream. The same effect has been recorded at the sampling site No 4, downstream of Novi Sad oil refinery. In the course of prewar period this locality was the second, considering the organic pollutants load (Fig. 2, Fig. 6). After turning the municipal water into the main river stream due to destruction of all three bridges, the water quality at this locality shifted from III to II-III class according to Kohl (1975), (Fig. 4, Fig. 7). Such a findings were confirmed by the Phosphatase activity index. According to this parameter, the water downstream of main sewage effluent in 1998 belonged to IIIA class in the spring and summer seasons (significantly polluted water

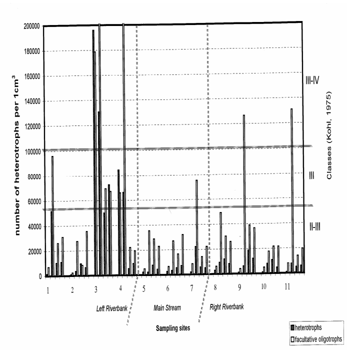

Figure 2 The River Danube water quality nearby Novi Sad during 1998 according to the number of organotrophs (spring, summer, autumn and winter)

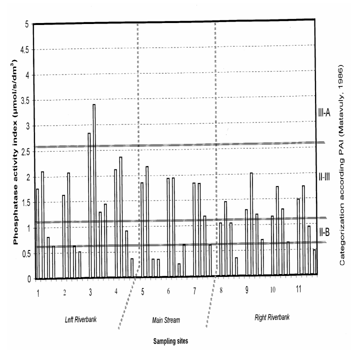

Figure 3 The River Danube water quality nearby Novi Sad during 1998 according to the phosphathase activity index (PAI) (spring, summer, autumn and winter)

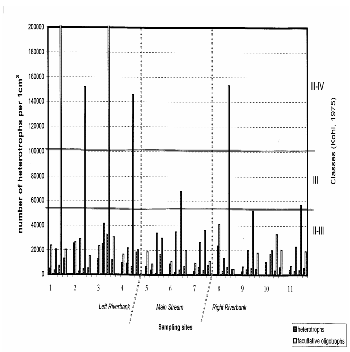

Figure 4 The River Danube water quality nerby Novi Sad during 1999 according to the number of organotrophs (spring, summer, autumn and winter)

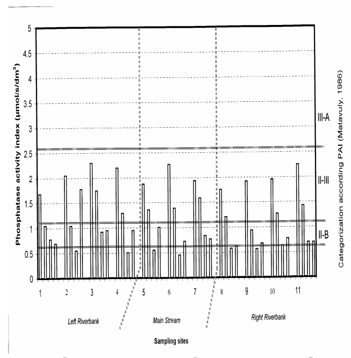

Figure 5 The River Danube water quality nearby Novi Sad during 1999 according to the phosphathase activity index (PAI) (spring, summer, autumn and winter)

according to Matavuly, 1986) (Fig 3). In 1999 the water sampled at the same locality increased in quality one class higher (Fig 5) due to turning the sewage water from coastal into main Danube stream. Even though the lowest water quality was found downstream of Novi Sad sewage effluent (site 3) during both one year prewar as well as postwar period, it is noticeable that at the same site after forming a dam made of destroyed concrete railway bridge the coastal stream of the river flows about 100 m in opposite direction than the main river stream flows.

According to sapromicrobiological and enzymological indicators, the water of the river Danube at the most localities nearby Novi Sad belonged to II class (Kohl, 1975) and to II-III class - moderately polluted (Matavuly, 1986) respectively. Expectedly, the lowest water quality downstream of the main sewage effluent was recorded during both, 1998 and 1999 years of investigation. Destruction of all of three Novi Sad bridges over the river Danube by NATO bombardment, and formation of dam of huge amount of building material that has fallen down into the riverbed caused changes of the river coastal streams as well as mainstream. Consequently, the stream of sewage effluent changed its direction from coastal current to the main river stream, what caused changes in the river water quality downstream of new formed dam in Novi Sad.

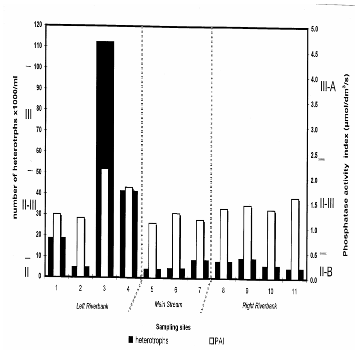

Figure 6 The River Danube water qualities nearby Novi Sad during 1998 (mean values)

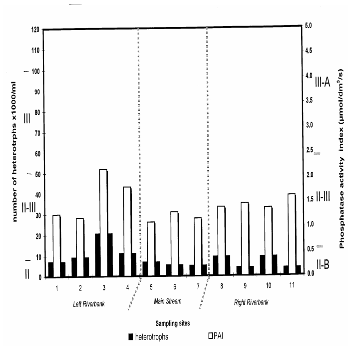

Figure 7 The River Danube water qualities nearby Novi Sad during 1999
(mean values)

3.8.4. Summary

Continual investigations of the river Danube water quality in the Institute of Biology (Faculty of Science in Novi Sad) last already 25 years. Since the river Danube waterbed has been used as the main source of Novi Sad potable water, and in the same time the river water has been serving as the main recipient of municipal sewage water, results of current sapromicrobiological investigations should point to the effect of main city polluters on the river water quality, as well as to the effect of destroying of all three bridges over the river Danube in Novi Sad. Obtained results point to the preserved selfpurification ability and high rate of degradation of organic load downstream of sewage effluent. Also, huge amount of building material that has plunged into the riverbed due to Novi Sad bridges destruction by NATO bombardment has drastically changed the course of main current of the river Danube, as well as the bank water currents. Consequently, the course of municipal wastewater has been changed, what caused the changes in the river Danube water quality considering the river water horizontal profiles.

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3.9. ATMOSPHERIC HEAVY METAL DEPOSITION ALONG FOUR MAJOR HUNGARIAN RIVER VALLEYS

Ötvös, E., Lehoczki, R. and Tuba, Z.

3.9.1. Introduction

River valleys are the most populated areas of Hungary and the industrial centres are also located here. On the other hand these regions mean biotops for many plant and animal associations included protected species. Environmental pollution accidents and damages, as e.g. recent cyanide pollution in the north-eastern rivers (Febr. 2000), Szamos and Tisza may prove the importance of biomonitoring studies over large areas.

Bryophytes have been widely used as bioindicators of air contaminants for the past few decades, especially to estimate heavy metal, organic and radioactive pollution (Berg *et al*., 1996; Markert ed., 1993; Knulst *et al*., 1995). Numerous studies (Gydesen *et al*., 1983; Herpin *et al*., 1996; Markert *et al*., 1996; Meenks *et al*., 1991; Rühling *et al*., 1987; Rühling ed., 1994; Steinnes *et al*., 1994; Tuba *et al*., 1994) have shown that surveys of the heavy metals by cryptogams are valuable, easy and cheap method to identify the possible emission sources and long range transport of pollutants. Mosses have no root system, so they can take up nutrients and chemical substances mainly from dust-fall and precipitation. They are good bioaccumulators because of their high capacity to retain many trace elements.

An international moss monitoring programme (Rühling *et al*., 1987; Rühling ed., 1994) was initiated and conducted by Nordic Countries under the Nordic Council of Ministers in 1985 to characterize quantitatively and qualitatively the regional and atmospheric deposition pattern of heavy metals. In 1995-1996, about 30 European countries joint this project, considering methods of Scandinavian guidelines to map and to compare results among different areas.

In the Nordic countries there is a long-term survey, data from 1985 to 1995 show a general decline in concentrations of most metals, e.g. in the cadmium deposition with a reduction in 35 % in Denmark or in the lead deposition with a decrease about 30% in Sweden, and present that the deposition is dominated by long-range transport (Rühling *et al*., 1987; Rühling ed., 1994; Gydesen *et al*., 1983; Berg *et al*., 1996; Steinnes *et al*., 1994. The decrease in concentrations of metals is mainly due to stricter emission legislation, filter technique, closure of old polluting industrial plants and use of petrol without lead.

Our present study is the first attempt to provide data on pollution with heavy metals by moss analysis at a larger scale, along main river valleys *(see Fig.1.)* including the Danube which is 417 km long, Tisza with length of 597 km, K őrös with 219 km and Rába with 192 km in Hungary.

3.9.2. Materials and methods

Samples of the moss species *Hypnum cupressiforme* were collected from 47 sites up to a distance of 15 km from rivers, from September to November, during a relatively dry autumn in 1997. This carpet-forming moss growing on stumps, barks, rocks, walls and soils is widespread in Hungary, and very useful for bioindication because heavy metal content analysis can be done months or later after the collection.

Procedure of sampling was performed according to the Scandinavian guidelines; the samples were taken mainly from forests, not exposed directly to precipitation. The sampling sites were at least 300 m far from main roads and built-up areas, and at least 100 m far from any roads and buildings. 5-10 subsamples were collected and mixed from each sample point (50 x 50 m). Each sample was analysed in three repetitions.

The green parts of mosses were cleaned carefully without washing and then dried at 70 °C. Samples of 0,2 g were digested with 2 cm^3 of cc. HNO_3 and 2 cm^3 of cc. H_2O_2 at 130°C under pressure in Teflon bombs for 45 min. Then it was filtered through Whatman No. 42 filter paper and brought to a volume of 10 ml with bi-distilled water. Cd, Cr, Cu, Ni, Pb, V and Zn concentrations were determined with ICP-AES measurement technique.

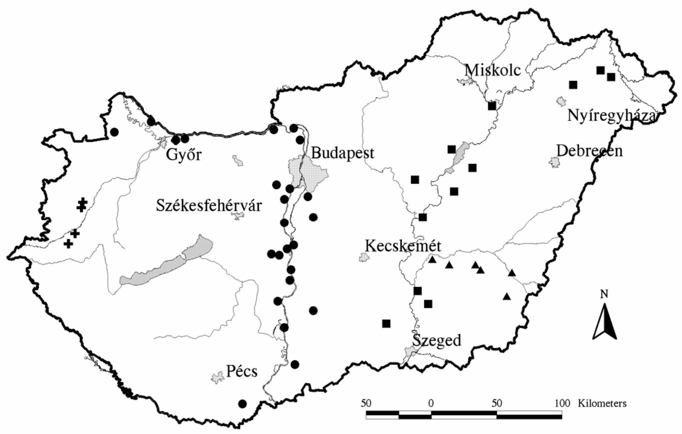

Fig. 1. Map of Hungary with sampling sites

3.9.3. Results and Discussion

The heavy metal concentrations data (Tables 1, 2 and Fig. 2) show that the highest values were measured at the rivers Danube and Tisza, close to industrial towns. The maximum concentrations were found at the sampling sites surrounding Budapest, Százhalombatta, Dunaújváros, Szolnok and Tiszaújváros. Effect of traffic compared to influence of industry is much milder as the sampling points were not close to the roads and contamination is rapidly reduced with distance (Tuba *et al*., 1994).

Cadmium

Background average level for cadmium is 0.86 µg g^{-1} that is higher than the mean European values (0,2-0,7 µg g^{-1}) and similar to Russia (Rühling 1994). Main emission sources may be metal industry, mining and use of phosphate fertilizers in agriculture. The highest values are found along Danube around Budapest, Százhalombatta and Dunaújváros, and near the river Tisza (Tiszaújváros) due to industrial activities. There is also a high concentration of Cd in the village of Ásványráró (2,08 µg g^{-1}) that suggests that the cadmium may be transported to Hungary from the neighbouring regions (Slovakia and Austria) (Rühling ed., 1994).

Table 1 Concentrations of heavy metals in mosses taken near four river valleys (ìg g^{-1} d.w.)

		Cd	Cr	Ni	V	Cu	Pb	Zn
DUNA	median	0,9	2,3	4,5	3,9	11,0	15,4	60,1
	mean	1,0	3,4	6,0	6,9	11,4	18,7	62,5
	min	0,3	0,9	2,1	1,5	6,7	5,4	32,1
	max	2,1	7,3	19,9	46,7	17,2	43,4	115,7
RÁBA	median	0,7	1,4	4,3	1,9	11,9	9,7	38,1
	mean	0,6	1,6	4,1	2,7	10,0	15,7	43,1
	min	0,3	0,9	3,1	1,0	6,6	5,4	32,7
	max	0,7	2,5	4,9	4,6	12,8	31,0	60,6
TISZA	median	0,8	1,7	3,0	1,9	10,4	14,1	45,7
	mean	1,0	3,2	5,6	11,8	10,1	15,8	56,5
	min	0,3	0,3	1,0	1,7	7,3	7,9	32,2
	max	2,1	14,0	30,4	86,0	15,2	35,6	128,2
K ŐRÖS	median	0,6	2,7	4,1	2,7	11,0	14,7	48,9
	mean	0,6	2,4	4,6	2,9	11,2	16,7	55,0
	min	0,3	0,7	2,5	1,7	7,2	9,7	37,6
	max	0,7	4,3	7,8	4,8	16,0	25,6	82,9
AVERAGE	median	**0,7**	**2,4**	**4,4**	**2,8**	**11,0**	**15,5**	**51,9**
	mean	**0,8**	**3,1**	**6,7**	**11,4**	**11,0**	**17,8**	**58,2**
	min	**0,3**	**0,3**	**1,0**	**1,0**	**6,6**	**5,4**	**32,1**
	max	**2,1**	**14,0**	**30,4**	**86,0**	**17,2**	**43,4**	**128,2**

Chromium

The European baseline level for chromium in rural areas is around 1 µg g^{-1}(Rühling ed., 1994). Among investigated sites, environs of river Rába is the less polluted with range 0,93-2,07 µg g^{-1}. Higher concentrations are found around Budapest and in Dunaújváros (7.33 µg g^{-1}) by the rivers Danube because the local industry, especially iron and steel mills cause contamination. The river K őrös and Tisza are more polluted than Rába, due to effects of industry of bordering country. The values were measured above 21 µg g^{-1} close to the frontier in Romania. A peak value was noted near industrial chemical centre of Tiszaújváros 13,98 µg g^{-1}.

Nickel

The main emission sources of Ni are steel industry, oil and coal burning. In most of European countries the concentration varies between 2-4 µg g-1 in mosses, higher concentrations (10-20 µg g-1) are measured near to smelters and chemical company (Rühling ed., 1994). The Hungarian average level is about 4-6µg g-1, but there are some local emittors. Elevated concentrations were found at Esztergom (10,28 µg g-1), Bugyi (15,02 µg g-1), Dunaföldvár (9,34 µg g-1), Mezőberény (7,76 µg g-1), Gyoma (11,03 µg g-1) Százhalombatta (19,86 µg g-1) and Tiszaújváros (30,39 µg g-1). Only background contamination (~ 4µg g-1) could be detected at the river Rába. Pollution of Ni is also relatively low at the river Tisza apart from values of Tiszaújváros and Tiszafüred.

Vanadium

Vanadium is mainly originated from coil and oil burning. Deposition of V in Hungary does not reach a considerable amount and it is similar to values of West-European countries (4-6 µg g^{-1}) (Rühling ed., 1994). The concentrations of V show strong relationship with Ni levels, the most polluted areas are the same as we have already mentioned at Ni. There are only three industrial establishments representing potential pollution sources: an oil refinary and an oil-fuelled heat power station located in Százhalombatta (46,69 µg g^{-1}) (Tuba *et al.*, 1994) and a chemical company in Tiszaújváros 30,39 µg g^{-1}).

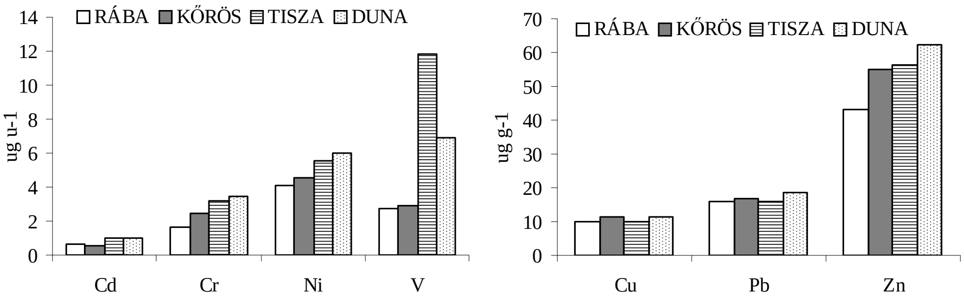

Fig. 2. Mean concentrations of heavy metals in mosses in the regions of four rivers (ìg g^{-1} d.w.)

Copper

Copper can be originated from metal industry and from copper-containing fungicides used by agriculture. The background concentration of copper is about 10 µg g-1 in Hungary that is similar to European values (Rühling ed., 1994). Local effects could be not detected, however the input from bordering countries is remarkable. Eastern part of the country (at river K őrös) is notably more contaminated than the others. (Timişoara, Romania 126 µg g^{-1}).

Lead

The main sources of lead the combustion of leaded fuel, waste incineration and industry. As we measured background contamination of the country, our values are relatively low (10-20 µg g^{-1}) to compared with other countries (Rühling ed., 1994). Background levels near rivers Rába and K őrös are the lowest. Higher concentration can be observed near towns, in the region Budapest (10-43 µg g^{-1}) due to a long-range transport of lead from extensive traffic.

Zinc

Zinc contamination is related with metal industries and use of pesticides in the agriculture. Zn level in European countries usually is less than 40 µg g^{-1} (Rühling ed., 1994), the average values in Hungary are between 30-50 µg g^{-1}. The background contamination of Zn is the highest by Danube, input from Austria and Slovakia could be well detected at the Upper Danube (60-116 µg g^{-1}). Locally increased Zn levels were also found near to central part of river, but a purification can be definitely observed at the Lower Danube (32-47 µg g^{-1}). Peak concentrations were found close to the capital (Érd 116 µg g^{-1}) and at Tiszaújváros (128 µg g^{-1}).

Table 2 Sampling sites and concentrations of heavy metals measured in collected mosses (µg g^{-1} dry weight)

	Duna	**Cd**	**Cr**	**Ni**	**V**	**Cu**	**Pb**	**Zn**
1	Ásványráró	2,1	2,3	5,7	9,0	9,8	13,9	50,0
2	Mosonszentmiklós	0,4	1,8	3,2	2,0	11,0	7,5	81,2
3	Gönyü	0,6	1,4	4,9	1,9	12,8	5,4	60,6
4	Nagyszentjános	0,5	2,1	3,0	2,5	6,7	13,0	36,4
5	Esztergom	1,6	5,9	10,3	9,8	10,2	11,7	87,9
6	Visegrád	1,7	7,0	7,1	12,3	13,6	27,0	75,9
7	Leányfalu	1,1	3,4	4,1	4,9	11,0	21,7	65,0
8	Pusztazámor	0,8	4,8	8,7	12,8	15,3	43,4	61,5
9	Érd	0,9	5,7	9,9	11,7	17,2	17,4	115,7
10	Alsónémedi	0,9	3,4	4,9	5,2	11,9	22,9	59,6
11	Bugyi	1,5	6,1	15,0	6,8	15,8	28,5	105,0
12	Szalkszentmárton	1,2	2,3	2,4	2,5	9,0	7,9	54,3
13	Százhalombatta	1,9	6,0	19,9	46,7	13,9	37,9	73,2
14	Adony	1,0	3,9	5,1	4,8	14,8	42,3	49,3
15	Mez őfalva	1,4	1,9	2,5	3,0	9,5	21,0	40,7
16	Dunaújváros	1,8	7,3	8,6	7,4	13,4	27,9	94,0
17	Baracs	0,9	2,3	3,8	2,3	10,3	11,2	57,1
18	Dunaföldvár	1,3	6,8	9,3	6,1	14,0	14,1	63,6
19	Bölcske	0,7	1,4	2,1	2,2	8,1	9,0	61,0
20	Paks	0,9	0,9	2,6	3,1	11,3	22,4	37,0
21	Kalocsa	0,6	1,0	2,2	1,5	6,7	6,7	47,2
22	Dombori	0,5	1,0	2,5	2,9	8,7	7,4	46,2
23	Baja	0,3	1,8	2,9	2,5	10,5	13,1	32,1
24	Pócsa	0,5	1,9	3,3	2,4	8,3	16,8	45,2
	Tisza	**Cd**	**Cr**	**Ni**	**V**	**Cu**	**Pb**	**Zn**
1	Vásárosnamény	0,5	2,4	3,7	2,0	7,6	14,8	43,1
2	Kisvárda	0,6	3,0	4,3	3,3	10,6	21,6	80,3
3	Nyírbogdány	0,3	1,2	1,8	1,8	11,0	35,6	46,1
4	Tiszaújváros	1,9	14,0	30,4	86,0	15,2	18,9	128,2
5	Poroszló	1,2	3,0	4,3	14,2	12,2	13,3	74,3
6	Tiszafüred	1,9	7,5	8,6	23,2	10,3	13,2	67,5
7	Jászkísér	0,9	1,6	4,0	1,8	8,6	14,2	45,4
8	Kunhegyes	0,3	1,5	2,4	2,0	11,7	14,0	34,5
9	Szolnok	2,1	0,4	1,9	1,8	8,2	15,1	55,4
10	Szentes	0,7	0,3	1,0	1,7	7,4	8,3	36,8
11	Derekegyháza	0,8	1,0	2,3	1,8	7,3	12,5	33,8
12	Kistelek	0,7	1,8	2,4	1,7	11,3	7,9	32,2
	Rába	**Cd**	**Cr**	**Ni**	**V**	**Cu**	**Pb**	**Zn**
1	Körmend	0,7	1,2	3,4	1,9	6,6	9,7	32,7
2	Vasvár	0,7	2,5	4,3	4,6	11,9	31,0	50,3
3	Sárvár	0,3	0,9	3,1	1,0	6,6	7,9	33,7
4	Vág	0,7	2,1	4,6	4,2	12,1	24,5	38,1
5	Gönyü	0,6	1,4	4,9	1,9	12,8	5,4	60,6
	K őrös	**Cd**	**Cr**	**Ni**	**V**	**Cu**	**Pb**	**Zn**
1	Gyula	0,6	3,0	4,2	3,2	14,3	15,7	82,9
2	Doboz	0,3	2,6	4,0	2,3	7,6	13,6	37,6
3	Mez őberény	0,6	4,3	7,8	4,8	13,2	23,4	52,5
4	Gyoma	0,6	0,7	3,0	1,7	7,2	9,7	72,6
5	Szarvas	0,7	1,1	2,5	1,8	8,8	12,2	45,3
6	Öcsöd	0,5	2,7	5,8	4,0	16,0	25,6	39,2

3.9.4. Conclusion

Effects of the major pollution sources located in river valleys and influence of the long-distance transport from bordering countries could be well detected on base of moss analysis. The local emittors are steel, metal and chemical industry, oil refinery and heat power plants, the burning of coil and oil, cement production and transport. Peak concentrations along four major river valleys were measured in the region of Budapest, near Százhalombatta, Dunaújváros, Tiszaújváros, Tiszafüred and Gyoma. The Hungarian background concentrations of Cd, Cr, Cu and Zn are mildly elevated on an international scale (Rühling 1994).

The level of Ni is increased compared to other countries, but it is mainly due to input from industry of neighbouring countries (Rühling 1994). The values of Pb and V were found similar to European average (Rühling 1994).

Among the investigated river valleys, the most polluted one is the Danube, especially higher values of Cr, Ni and Zn were measured by upper and central region. The valley of the Rába is less contamined by Cr and Pb, but levels of Ni and Cu are elevated. Cd and Pb concentration are mildly increased at surroundings of river Tisza, local sources and Romanian input seems to be significant in cases of Ni and V. The area of river K őrös is less polluted by Cd, but average values of Cr, Ni and V are elevated.

The present survey of heavy metal deposition reflects a mildly increased pollution in Hungary in 1997 compared to European values of 1995 (Rühling 1994). Our presented data serve a reference data base for the future to follow-up any changes and trends of the background heavy metal pollution due to atmospheric deposition.

3.9.5. Summary

The atmosphere is an important pathway for transport and deposition of the pollutants to both aquatic and terrestrial ecosystems. Hungary, due to its geographical situation in the Carpathian Basin can be regarded as a deposit area of the contaminants. There is a significant anthropogenic impact from neighbouring countries, adding to it an important internal emission, especially from the industrial centers located mainly near rivers. As a great part of population lives in the rivers valleys, and these regions are biotops for many rare species, there is a demand to estimate the state of their surroundings.

The aim of this paper is to characterize the atmospheric deposition of *Cd, Cr, Cu, Ni, Pb, V* and *Zn* in largest Hungarian river valleys (*Duna = Danube, Tisza, K őrös, Rába*) to present days. Our studies join an international mapping project (*Atmospheric Heavy Metal Deposition in Europe)* (Rühling *et al*., 1987; Rühling ed., 1994) following their standardized methods. Samples of moss *Hypnum cupressiforme* were collected at a total of 47 sampling points near the rivers during the autumn of 1997 and were analysed by atomic emission spectrometry with inductively coupled plasma *(ICP-AES)*. Results prove that major pollution sources are the industrial towns *(Százhalombatta, Dunaújváros, Tiszaújváros)*, and mean concentrations of heavy metals are higher than in most European countries, particularly in cases of cadmium and chromium. There also is significant input of nickel by atmospheric transport from bordering countries. The values of Cu, Pb, V and Zn were measured similar to European levels.

3.9.6. Acknowledgements

This work was supported by ECOCRAFT and MEGARICH EU R&D projects, Hungarian Scientific Research Foundation (OTKA 10009), Research Development in Higher Education (FKP 0472/97) and by Hungarian Academy of Sciences, Research Group.

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3.10. WATER QALITY OF THE GORNJE PODUNAVLJE PROTECTED AREA ESTIMATED ON THE BASIS OF BIOINDICATORS

Brankovic, D. and Budakov, L.

3.10.1. Introduction

Along the Yugoslav section of the Danube some flooded aleas still exist (Brankovic *et al.* 1998), and among them, the floodplain within the Gornje Podunavlje protected area is the largest one (Budakov *et al.*, 1995). Protection of these floodplains is in accordance with the Pan-European Biological and Landscape Diversity Strategy (Strasbourg, 1995), Convention on Biological Diversity (Rio de Janeiro, 1992) and Convention on Wetlands (Ramsar, 1971), as well as with the Resolution on Biodiversity Conservation Policy in FR Yugoslavia (Beograd, 1993).

The Gornje Podunavlje is situated along the left bank, between 1347 and 1433 km of the Danube course. It is a swampy complex divided by the embankment into the two parts. The Apatinski Rit, being the part directly conected with the Danube, is under the influence of flooded waters.The part which comprises Monostorski Rit, a lot of canals and permanent and ephemeral pools is separated from the Danube by the embancment and is under the influence of underground waters.

In order to recognize quality of the Gornje Podunavlje natural values as a basis for protection and conservation, the Institute for Protectione of Nature of Serbia carried out various investigations, including phytoplankton community and ichthyofauna which are very important members of aquatic biocenoses. The phytoplankton and ichthyofauna are not only good indicators of water quality and condition of all the water ecosystem, but they play an important role in selfpurification of the water and maintenance of ecolological balance.

3.10.2. Material and Methods

The phytoplankton and ichthyofauna of the Gornje Podunavlje protected area were investigated in the period of 1996-1998.

During the algological and saprobiological investigations, standard limnological methods were used (Sladecek *et al.*, 1973). Qualitative composition of the phytoplankton community was shown as a participation of the different algal groups in the total number of taxa, and quantitative composition as a participation of algal groups in the total number of algae. The density of the phytoplankton community was expressed as a number of individuals per 1 cm^3 (ind/cm^3).

Fish species were sampled by electrofisher and nets.

The saprobity index was calculated after Pantle & Buck (1955) on the basis of phytoplankton and fish species as bioindicators.

3.10.3. Results and Discussion

Within the Gornje Podunavlje protected area, during the study period, very diverse phytoplankton community was recorded - 377 species, varieties and forms of algae (Fig. 1).

Chlorophyta was the most diverse group, making 47.5 % of all taxa. Among the green algae, the following genera were represented by the largest number of species, varieties and forms: *Scenedesmus* (23 taxa), *Cosmarium* (20), *Staurastrum* (18), *Closterium* (12), *Tetraedron* (11). The species, such as *Actinastrum hantzschii* Lagerh., *Eudorina elegans* Ehr., *Micratinium pusillum* Fresen, although the only representatives of their genera, were wide spread in the investigated waters.

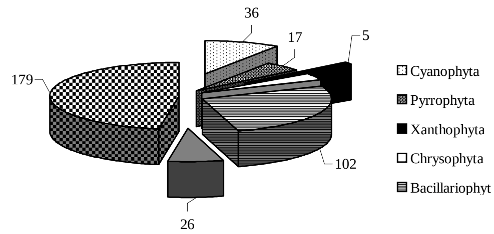

Fig.1. Diversity of Phytoplankton Community

Among Bacillariophyta, to which belonged 27.1 % of all recorded taxa , the genera: *Navicula* (14 taxa), *Cymbella* (9), *Gomphonema* (8) and *Nitzschia* (8) were the most heterogenous ones. Although represented by a small number or only one taxa, the genera: *Stephanodiscus*, *Cyclotella*, *Melosira*, *Asterionella*, *Fragilaria*, *Diatoma*, *Amphora*, *Cocconeis*, *Anomoeneis* were characteristic representatives of the silicate algae of the investigated waters.

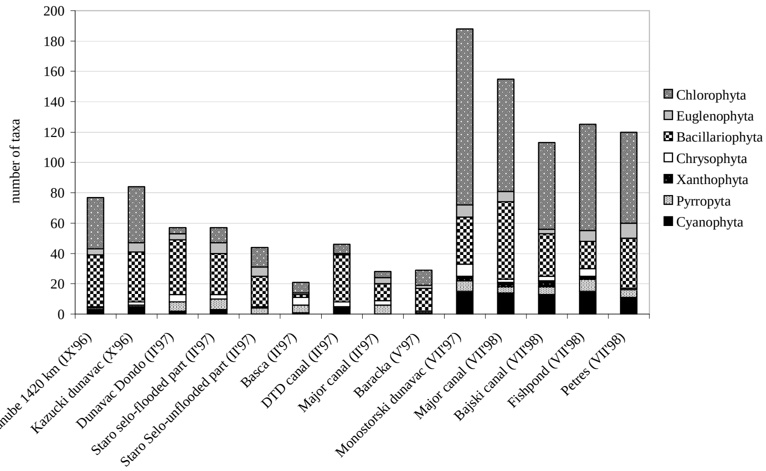

Fig.2. Qualitative Composition of Phytoplankton Community

Cyanophyta-with 9.5 % of all taxa, Euglenophyta-with 6.9 %, Pyrrophyta-with 4.5 %, Chrysophyta with-3.1 % and Xanthophyta-with 1.3 % were represented by a significantly smaller number of taxa. Among Cyanophyta, the *Oscillatoria* genus, with 7 taxa, was the most divers one but, the species: *Aphanisonenon flos-aquae* (L.) Ralfs and *Microcystis aeruginosa* Kutz. were present in almost all the samples. *Trachelomonas*, with 11 taxa, was the most diverse genus within the Euglenophyta group, and within the Pyrrophyta group, the *Peridinium* genus, with 7 taxa.

The diversity and qualitative composition of phytoplankton community (Fig. 2) varied, depending on the sampling time and locality. But, variation was dependent, to a greater extent, on the sampling time than on the locality. The diversity of phytoplankton community was the highest during the summer, and the lowest during the winter and spring. The Chlorophyta group was characterized by the most apparent variation. During the summer, a large number of taxa, from 57 to 116, of the Chlorophyta group were recorded, while in the samples collected during the winter their number rarely exceeded 10.

The diversity of Cyanophyta was, to a certain extent, dependent on the sampling time, as well. The representatives of this group were recorded in all the samples collected during the summer, and their number varied between 11 and 15. In the winter, Cyanophyta appeared sporadically, with no more than 4 taxa. The members of Xantophyta group were recorded only in the samples collected during the summer. The diversity of the other algal groups was rather similar during all the study period.

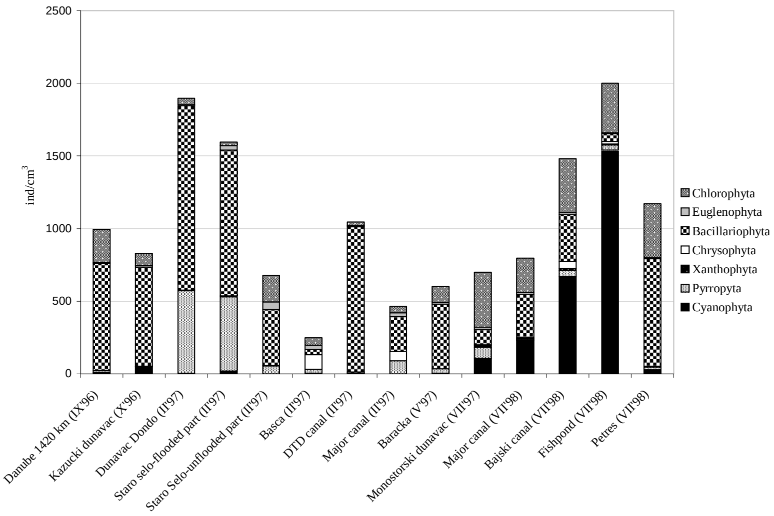

Fig.3. Quantitative Composition of Phytoplankton Community

The density of phytoplankton community varied from 247 to 2000 ind/cm^3 (Fig. 4).

A common characteristic of the phytoplankton community was prevalent quantitative domination of Bacillariophyta (Fig. 3). But, the following samples were exception: Basca (II’97) with Chrysophyta domination, Monostorski Dunavac (VII’97) in which the Chlorophyta group was the dominant, and Bajski canal (VII’98) and Fishpond (VII’98), within the Bajski canal, which were characterized by Cyanophyta domination. In the localities which were under direct influence of the flooded waters of the Danube (Dunavac

Dondo and Staro Selo), significant participation of Pyrrophyta was recorded.

Stephanodiscus hantzschii Grun., *Cyclotella meneghiniana* Kutz., *Melosira granulata* (Ehr.) Ralfs, *Asterionella formosa* Hassal, were the most abundant representatives of Bacillariophyta, and among Chlorophyta, the species of the genera: *Scenedesmus, Ankistrodesmus, Pediastrum, Crucigenia, Chlamydomonas, Cosmarium* were the most abundant. Among Cyanophyta, participation of *Aphanisomenon flos-aquae* (L.) Ralfs, as well as participation of the species of the genera *Anabaena* and *Oscillatoria* were significant. The Pyrrophyta group was characterized by significant participation of the genera: *Cryptomonas* and *Peridinium*, while the Chrysophyta group was characterized by significant participation of the *Dinobryon* genus. Generally, participation of the Euglenophyta group was low, and the *Trachelomonas* genus was the most abundant.

The saprobity index values, calculated on the basis of phytoplankton species as bioindicators, varied from 1.9 to 2.8 (Fig. 4), indicating ♌ mesosaprob, ♌-♋ mesosaprob, and ♋ mesosaprob degree - eutrophic waters.

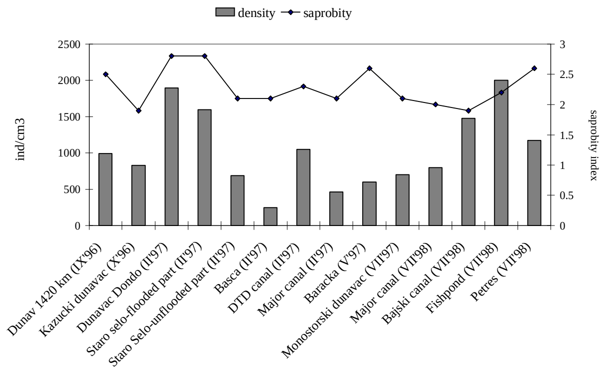

Fig.4. Relationship Between Density of Phytoplankton Community and saprobity

The saprobity index values were usually in the correlation with the density of phytoplankton community (Fig.4) that was expected knowing that algae respond to the increase of nutrients accelerating development.

In the water ecosystems of the Gornje Podunavlje protected area 55 fish species were recorded. Among them, the indicators of oligosaprob degree, such as *Alburnoides bipunctatus* Bloch, *Cottus gobio* L., indicators of oligo-♌ mesosaprob degree, such as *Lota lota* L., *Sander lucioperca* L., indicators of ♌ mesosaprob degree, such as *Esox lucius* L., *Rutilus rutilus* Vladikov, *Leuciscus leuciscus* L., *L.cephalus* L., *Scardinius erythrophtalmus* L., *Alburnus alburnus* L., *Blicca bjoerkna* L., *Abramis brama* Pavlov, *Chondrostoma nasus* L., *Rhodeus sericeus amarus* Holcik, *Gobio gobio* L., *Barbus barbus* L., *Cyprinus carpio* L., *Orthrius barbatulus* L., *Silurus glanis* L., *Anguilla anguilla* L., *Perca fluviatilis* L., *Gymnocephalus cernua* L, indicators of ♌-♋ mesosaprob degree, such as *Tinca tinca* L.,*Carassius carassius* L., indicators of ♋ mesosaprob degree, such as *Carassius auratus gibelio* Bloch, *Lepomis gibbosus* L. were recorded.

The saprobity index value, calculated on the basis of the fish indicator species, was 2.0, indicating ♌ mesosaprob degree. That is in correlation with the results obtained on the basis of the phytoplankton.

On the basis of the presented results and literature data (Brankovic *et al.*, 1997;

Budakov *et al.*, 1997; Budakov and Brankovic 1999; Djukic *et al*., 1997; Gayin *et al*., 1998; Jankovic *et al*., in Jankovic and Jovicic 1994, 1994; Maletin *et al*., 1997; Obuskovic in Jankovic & Jovicic, 1994; Pujin *et al*., 1997) it could be concluded that the waters of the Gornje Podunavlje protected area are more or less eutrophic ones, with the phytoplankton and ichthyofauna which are characteristic for the lowland water ecosystems of this region.

3.10.4. Summary

The Gornje Podunavlje is situated along the left bank, between 1347 and 1433 km of the Danube course. It is a swampy complex divided by the embankment into the two parts.

The phytoplankton and ichthyofauna of the Gornje Podunavlje protected area have been were investigated in the period from 1996 to 1998.

During the study period, very diverse phytoplankton community was recorded, 377 species, varieties and forms, and Chlorophyta was the most diverse group. A common characteristic of the phytoplankton community was prevalent qvantitative domination of Bacillariophyta.

In the water ecosystems of the Gornje Podunavlje protected area, 55 fish species were recorded.

The saprobity index values, calculated on the basis of phytoplankton and fish species as bioindicators, varied from 1.9 to 2.8, indicating ♌ mesosaprob, ♌-♋ mesosaprob, and ♋ mesosaprob degree - eutrophic waters.

On the basis of the presented results and literature data it could be concluded that the waters of the Gornje Podunavlje protected area are more or less eutrophic ones, with the phytoplankton and ichthyofauna which are characteristic for the lowland water ecosystems of this region.

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3.11. MICROALGAL BIOMASS PRODUCTION DURING THE PURIFICATION OF THERMOMINERAL WATER

Zorica, S., Gajin, S., Petrovic, O., Simeunovic, J. and Markovic, S.

3.11.1. Introduction

The south-eastern part of Pannonian plane, which belongs to Serbia, can be treated as relatively perspective resource for obtaining and usage of geothermal and thermomineral water (Milosavljeviæ et al, 1995).

During the thermomineral water treatment with microalgae, high quantity of algal biomass and the mineral salts concentration decrease would be provided in both natural and economic way, since the specific microalgae species can utilize most of the minerals during their growth. Special attention should be given to the cyanobacteria — *Spirulina platensis*, because of its significantly easier cultivation and higher biomass quality comparing with other microorganisms or higher plants (Ciferri, 1983; Ciferri and Tiboni, 1985; Richmond, 1986). Green algae *Scenedesmus* and *Dunaliella* are also actual worldwide producers of biomass in biotechnology (Soong, 1980).

In order to racionalize the thermomineral waters exploatation, the main aim of this research was to examine possible cyanobacteria (*Spirulina platensis*) and green algae (*Scenedesmus quadricauda* and *Dunaliella* sp.) usage as both biomass producers and thermomineral waters purificators. Biomass could be considered as an alternative high calorie food and source of different industrialy importamt compounds. At the same time, high concentration of the minerals, as limithing factor in of thermomineral waters usage, would be reduced during the microalgal cultivation.

3.11.2. Material and methods

Microalgal strains (*Spirulina platensis, Scenedesmus quadricauda* and *Dunaliella* sp.) are part of the Microbiology laboratory collection (Institute of Biology, University of Novi Sad). The analyses of the total samples mineralization have been made after 3, 5, 7, 9 and 14 days during the thermomineral water purification (demineralization) by microalga *Spirulina platensis.*

Cultivation of microalgae in diluted and undiluted thermomineral water (20%, 40%, 60%, 80%, 100%) and in undiluted water (100%) enriched with 5% liquid swine manure lasted for 15 days. Liquid pig manure was added in order to provide higher nitrogen and phosphorus concentrations. Cultures incubation occurred in Erlenmeyer flasks, at the temperature of 30^0C, with fluorescent light intensity of 850 LUX.

Spirulina platensis biomass was performed indirectly by chlorophyll a concentration analysis (Mackinney, 1941). The biomass concentrations of *Scenedesmus quadricauda* and *Dunaliella* sp. were measured by direct absorbency analyses on spectrophotometer. All results are the average values of four repeated measurements.

3.11.3. Results and discussion

Cultivation of microalgal strains has been done in water samples taken from three geothermal drill-holes, in order to examine possible exploitation of Vojvodinian thermomineral waters. According to our results, examined microalgal strains showed specific growth in diluted thermomineral water, as in undiluted water samples enriched with 5% liquid pig manure. However, the growth was very characteristic for different microalgal species applied.

The increase of *Spirulina platensis* biomass (µg chl a/ml) was directly correlated to increase of thermomineral water concentration (Table 1).

Table 1. The increase of *Spirulina platensis* biomass grown in different dilutions of thermomineral water comparing with the control medium

THERMOMINERAL WATER (%)	Pb-1/H	Mk-1/H	Sr-1/H
20%	1.105	1.298	1.162
40%	1.421	2.055	1.374
60%	1.484	2.911	2.621
80%	2.210	3.476	2.637
100%	2.386	3.941	**4.020**
100% + 5% pig manure	**3.473**	**4.357**	2.116
CONTROL (SOT)	3.156	4.124	3.500

Spirulina biomass was extremely high in the water samples taken from Pb-1/H and Mk-1/H (+ 5% liquid swine manure). It has been shown that cultivation of *Spirulina platensis* should be carried out in undiluted thermomineral water. Comparing the biomass quantity in control mineral nutritive medium (SOT), water samples from Sr-1/H demonstrated even better growing conditions for Spirulina cultivation (Table 1). Water samples from Mk-1/H and Pb-1/H showed to be less corresponding media, but enriched by swine manure as additive substance, the deficiency of important elements would be provided.

Green alga *Scenedesmus quadricauda* manifested very good biomass increase in water samples diluted up to 80% (Sr-1/H and Pb-1/H) and in all samples taken from Mk-1/H, with exception of the samples enriched with swine manure (Table 2).

Table 2. *Scenedesmus quadricauda* growth in different dilutions of thermomineral water comparing with the control medium

THERMOMINERAL WATER (%)	Pb-1/H	Mk-1/H	Sr-1/H
20%	0.511	0.345	0.418
40%	0.714	0.719	0.694
60%	**1.149**	1.362	1.217
80%	0.538	1.567	**1.414**
100%	0.406	**1.722**	1.109
100% + 5% pig manure	0.321	1.595	0.823
CONTROL („148”)	1.760	1.983	1.814

Comparing these results with the growth of control culture in „148” mineral medium, the water sample Mk-1/H made this green alga cultivation the most efficacious.

In the case of *Dunaliella* sp., all thermomineral water samples inhibited green alga growth (Table 3).

Table 3. *Dunaliella sp.* growth in different dilutions of thermomineral water comparing with the control medium

THERMOMINERAL WATER (%)	Pb-1/H	Mk-1/H	Sr-1/H
20%	0.314	0.294	0.318
40%	**0.389**	0.349	0.308
60%	0.286	0.364	0.339
80%	0.311	0.401	**0.618**
100%	0.305	0.411	0.406
100% + 5% pig manure	0.319	**0.447**	0.433
CONTROL („148”)	2.680	2.735	2.842

Generally speaking, *Dunaliella* sp. biomass quantity (μg chl a/ml) increases when undiluted water is enriched with pig manure. Much lower quantities of biomass has been produced in all water samples comparing to control („148” medium).

The aims of microalgal cultivation in thermomineral waters were both biomass production of microalgae and thermomineral waters purification in order to decrease minerals concentrations, which could cause the high level of eutrofication in water recipients. Accordingly, *Spirulina platensis* cultivation in thermomineral water samples has been followed by significant reduction of total minerals. The biomass increase after the seventh day of cultivation has been demonstrated during the *Spirulina* cultivation in Pb-1/H and Sr-1/H undiluted water samples (Figs 1 and 2).

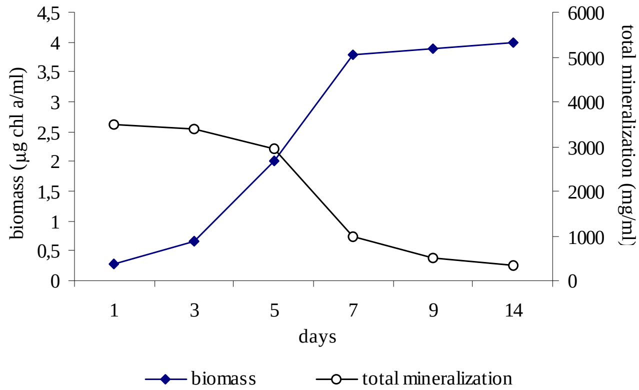

Fig. 1. Comparison of *Spirulina platensis* biomass increase and total mineralization decrease in Sr-1/H water sample.

Until the fourteenth day, water demineralization lasted unperceptibly. *Spirulina platensis* biomass growth stagnated in Mk-1/H water sample, as well as the minerals concentration until seventh day. Sudden minerals decrease and biomass production have been measured after the seventh day (Fig. 3), which can be connected with eventual bacterial occurrence in algal culture.

Even very encouraging results about Vojvodinian thermomineral waters exploitation in order to produce Spirulina biomass were published ten years ago in Yugoslavia (Obreht, 1988), no practical use of experimental experiences exists until today. Vietnam is the only country with commercial production of *Spirulina platensis* in thermomineral waters (Nguen hun Thuoc et al, 1989) and the chemical composition of those waters is quite similar to the Vojvodinian. The cultivation of *Spirulina platensis* in thermomineral water could be followed by incredible benefits (Ciferri and Tiboni, 1985; Ciferri, 1983): it can be used in purification of thermomineral water, there are no inapplicable parts during the biomass production process (as like higher plants), the growth is extremely fast (in wet or dry climate), *Spirulina* is not competitive with other microorganisms, *Spirulina* is source of some chemical compounds in medicine and industry (great percentage of proteins and vitamins) (Richmond, 1986).

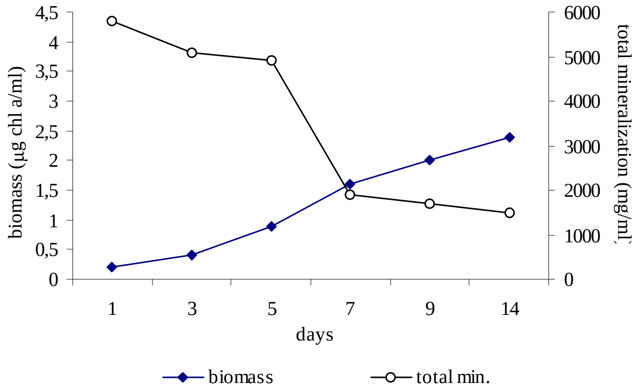

Fig. 2. Comparison of *Spirulina platensis* biomass increase and total mineralization decrease in Pb-1/H water sample.

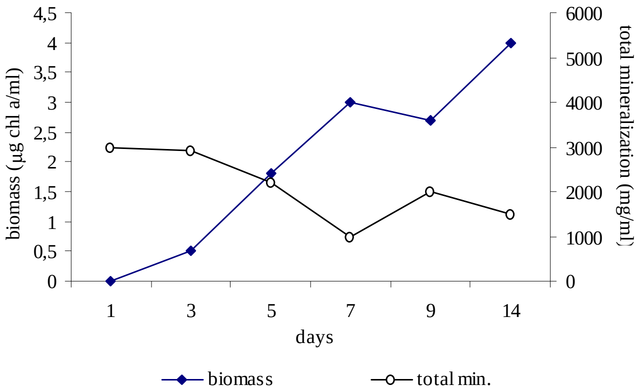

Fig. 3. Comparison of *Spirulina platensis* biomass increase and total mineralization decrease in Mk-1/H water sample.

According to our results, *Spirulina platensis* demonstrated significant reduction of total minerals and the biomass increase after the seventh day of cultivation, which can be considered as indication of future *Spirulina* usage in thermomineral waters purification.

3.11.4. Summary

The growth of the microalgal species *Spirulina platensis*, *Scenedesmus quadricauda* and *Dunalliela* sp., cultivated in water from three Vojvodinian geothermal drill-holes, were examined during 15 days. Microalgae were grown in thermomineral water, in different dilutions (0%, 20%, 40%, 60%, 80%), as well as in the thermomineral water enriched with 5% liquid swine manure. However, the growth was characterized by different biomass production for every microalgal species: *Spirulina platensis* showed very significant biomass increase in all treatment, specially in one with 5% liquid pig manure. Green alga *Scenedesmus* quadricauda grew only in diluted water samples (<80%). The growth of *Dunalliela* sp. was inhibited during the cultivation in thermomineral water. In the case of *Spirulina platensis*, the effect of microalgal growth on the thermomineral water demineralization was noticed after 7 days of cultivation.

3.11.5. References

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Chapter 4

Flora and fauna

4.1. SURVEY INTO THE AQUATIC MACROPHYTES OF THE ZASAVICA NATURAL RESERVATION (YUGOSLAVIA)

Vukov, D., Igic, R., Boza, P., Anackov, G. and Butorac, B.

4.1.1. Introduction

The Natural Reservation Zasavica extending over an 671ha. area covers southern Voivodina and northern Macva regions (Yugoslavia). Due to legislative measures in 1991 it became a Special Reservation while in 1992 following IUCN classification their habitats and wildlife were preserved.

A very important role within this Special Natural Reservation plays the river Zasavica with its high diversity and richness of plant and animal world. The two streams Prekopac and Jovaca joins together making 33.1km long Zasavica river flowing southwest-northeast and empting into the Sava river near Macvanska Mitrovica. Numerous depression springs supply it with water during the whole year. The Banovo Polje locality rich in springs imposing specific ecological conditions extends over about 700m river stream. Water temperature during summer is between 16° and 21° C, pH between 8 and 9. Its ecological characteristics make the Banovo Polje locality a valuable and attractive habitat of aquatic plants.

4.1.2. Material and Methods

The field investigations were performed in 1998 - 1999 period. Plant material was collected and preserved in Herbarium of the Institute of Biology, Novi Sad. Plant determination was done after Flora Europaea (Tutin et al., 1964; Tutin et al., 1968-1980), Hungarian flora (Soó, 1964-1973), and Hínár határozó (Felföldy, 1990). Nomenclature of plants was adjusted to Flora Europaea. Floral elements were given after Soó (1964-1973).

The Banovo Polje locality covering about 700m stream of the Zasavica was divided into the seven sections (100m each). Within each section water temperature and pH were measured, plant material was collected, and biomass of each recorded plant species using a five degree scale was estimated (Kohler,1978). Data were processed after Pall et al. (1996) while the results presented graphically. Plant life forms were also analyzed (Luther,1949; Pall et al., 1996).

4.1.3. Results and Discussion

The depression springs have a great impact upon the ecological conditions of the river, water temperature and pH in particular. In summer, temperature and pH values were measured (Table 1). Rather balanced pH ranged from 8 to 9 , whereas oscilating water temperature rellied upon stream proximity. The lowest temperature of 16° C was recorded in study section VII, whereas the highest of 21° C in section V.

Table 1. Temperature and pH values recorded at Banovo Polje locality

No. of section	t (°C)	pH
1	18	9
2	20	8.5
3	19	9
4	19	8.5
5	21	8
6	18	9
7	16	8.5

The floristic data related to the region of the Zasavica river and its surrounding are poor. Only a few data may be found in Flora SR Srbije (Josifovic, 1970-1976; Saric, 1980) and Flora Srbije I (Saric, 1992). Our survey in the period 1998-1999 revealed 22 aquatic plants at the Banovo Polje locality (Table 2).

Table 2. List of aquatic macrophytes, life forms, and floral elements

Species	abbreviation	Growth form	Floral elements
Ceratophyllum submersum L.	Cer sub	Bp	Eurasian (-mediterranean)
Ceratophyllumdemersum L.	Cer dem	Bp	circumpolar
Hotonia palustris L.	Hot pal	Bp	Evropska
Hydrocharis morsus-ranae L.	Hyd mor	Ap	Eurasian
Hyppuris vulgaris L.	Hyp vul	H	circumpolar (-cosmopolitan)
Lemna minor L.	Lem min	Ap	cosmopolitan
Lemna trisulca L.	Lem tri	Mp	cosmopolitan
Myriophyllum spicatum L.	Myr spi	Bp	circumpolar
Myriophyllum verticilatum L.	Myr ver	Bp	circumpolar
Nuphar lutea (L.) Sibth. & Sm.	Nup lut	F	Eurasian (-mediterranean)
Nymphaea alba L.	Nym alb	F	Eurasian (-mediterranean)
Phragmites australis (Cav.) Trin. Ex Steudei	Phr aus	H	cosmopolitan
Potamogeton pectinatus L.	Pot pec	Bp	cosmopolitan
Potamogeton lucens L.	Pot luc	Bp	Eurasian (-mediterranean)
Sagittaria sagittifolia L.	Sag sag	H	Eurasian (-mediterranean)
Salvinia natans (L.) All.	Sal nat	Ap	Eurasian, European and submediterranean charachters
Scirpus lacustris L.	Sci lac	H	Eurasian
Sparganium emersum Rehmann.	Spa ere	H	Eurasian
Spirodela polyrrhiza (L.) Schleid.	Spi pol	Ap	circumpolar
Stratiotes aloides L.	Str alo	F	Eurasian (Eurosiberian)
Typha angustifolia L.	Typ ang	H	cosmopolitan
Typha latifolia (L.) Hoffm.	Typ lat	H	circumpolar-africanean

Floristic analysis shows that the majority of plants belongs to the eurichorn species group with wide area range (circumpolar, Eurasian, cosmopolitan), some are the remnants of Tertiary flora of north and central Europe (Meusel, 1968) while their relict character in the Pannonian Plains was also reported (Budak et al.,1992). The two ornamental floating species, *Nymphaea alba* and *Nuphar luteum* otherwise known by their European (Mediterranean) and Eurasian (Mediterranean) distribution deserve a mention (Soó, 1964-1973). Another Tertiary relict of aquatic and marsh vegetation of central and southeastern Europe is Eurasian (Eusiberian) species (Soó, 1964-1973) *Stratiotes aloides* restricted to the plains of the Pannonian region. All the plants cited above are protected by legislative measures as Natural rarities. The two plants, *Hottonia palustris* and *Hippuris vulgaris* are under the risk of extinction therefore included in the Red Book of the Serbian Flora (Butorac, 1999; Vuckovic and Panjkovic, 1999).

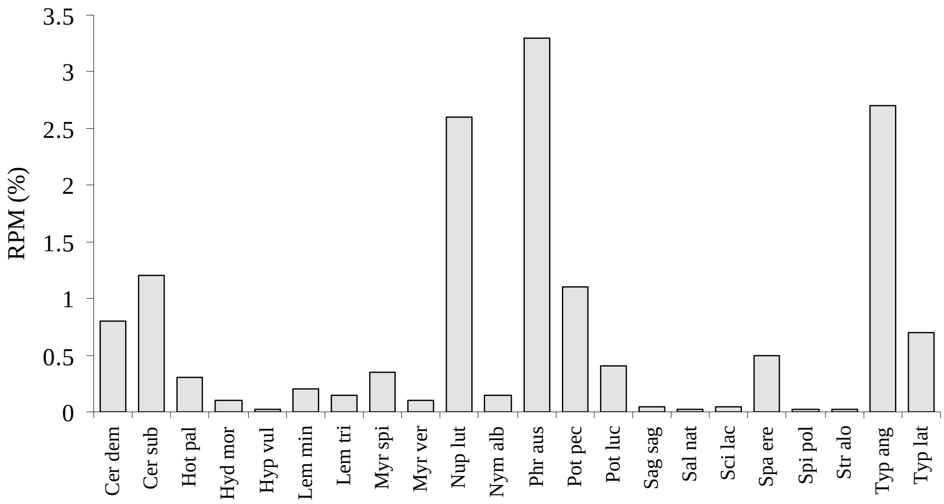

Fig. 1. Distribution of percentage relative biomass (RPM (%)) of aquatic plant species.

Our survey of the area shows that the highest percentages were found with *Phragmites australis* (3.35%), then *Typha angustifolia* (2.66%), *Nuphar luteum* (2.11%), *Ceratophyllum submersum* (1.16%), and finally *Potamogeton pectinatus* (1.08%), whereas the remaining species were recorded with the values less than 1%.

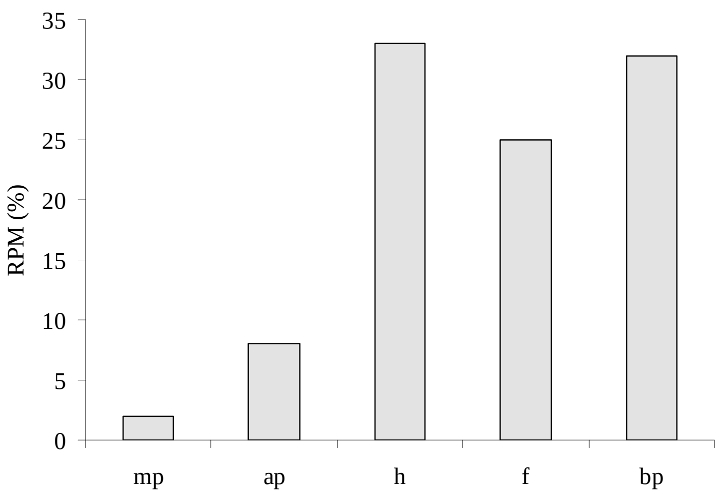

Fig. 2. Relative percentage biomass of different life forms of aquatic plants

Life form analyses (Fig. 2) show the dominance of helophytes (h-33.42%), then benthopleustophytes (bp-31.50), and floating aquatics (f-25.60%) while acropleustophytes and mesopleustophytes were far less frequent (ap-7.50 and mp-1.98%, respectively).

4.1.4. Conclusions

The method after Kohler was employed to study aquatic macrophytes of the Banovo Polje locality (Zasavica Natural Reservation). Most of 22 aquatics are widespread while the Tertiary relicts of water and marsh vegetation like *Nymphaea alba*, *Nuphar lutea*, and *Stratiotes aloides* conserved due to legislative measures are also present. Among the species being at risk of extinction are *Hottonia palustris* and *Hippuris vulgaris* included in the Red Book of endangered species. The highest RPM values were found with *Phragmites* australis, *Typha angustifolia*, *Nuphar luteum*, *Ceratophyllum submersum*, and *Potamogeton pectinatus* while the remaining aquatics were less present (less than 1%). Life form analyses show the dominance of helophytes, then benthopleustophytes, floating aquatics, and acropleustophytes, whereas only one species of the mesopleustophyte group was observed.

4.1.5. Summary

Using the method after Kohler the aquatic macrophytes of the Special Natural Reservation Zasavica (Yugoslavia) were assessed. Of 22 recorded aquatics most interesting are the Tertiary relicts of water and marsh vegetation like *Nymphaea alba*, *Nuphar luteum*, and *Stratiotes aloides*, as well as species at a high risk of total extinction like *Hottonia palustris* and *Hippuris vulgaris* included in the Red Book of the Serbian flora. According to the RPM values the highest percentages were obtained with *Phragmites australis*, then *Typha angustifolia*, *Nuphar luteum*, *Ceratophyllum submersum*, and *Potamogeton pectinatus*. The analysis of life forms shows the dominance of helophytes, then benthopleustophytes, floating aquatics, and acropleustophytes, whereas only a species of mesopleustophyte group was recorded.

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“Sluzbeni glasnik R Srbije” 66/91
“Sluzbeni glasnik R Srbije” 30/92
“Sluzbeni glasnik R Srbije” 50/93

4.2. THE MACROZOOBENTHOS OF THE RIVER BODROG REGION AND ITS TRIBUTARIES

Szító, A.

4.2.1. Introduction

The River Tisza and its tributaries serve a possibility for organisms, living in water to migrate as in a corridor. The drifting of different animals is well known, which is a passive travelling form for them. Fishes often swim against the stream.

Scientific data showed that other animals were able to migrate against to water stream too. Invertebrates, such the snail species of *Theodoxus fluviatilis* (Soós, 1965), a fresh water mussel (*Dreisena polimorpha*: Mollusca, Bivalvia) or a worm species (*Hypania invalida*: Annelida, Polychaeta) showed the praxis of the migration form in the last years. *Hypania invalida* was detected first in 1969 near Szeged (Ferencz, 1969), and its specimens were common in River Tisza near Tokaj nowadays (Szító, 1996).

The different parts of rivers serve as a refuge for the species.

There were no literature sources of Oligochaeta and Chironomid fauna in Upper Tisza Region (Pop, 1943, 1950; Albu, 1966), and therefore our present data collection will be a basic, showing the situation nowadays.

The main goals were as follows: to make a data collection, which shows the present situation of the species, and the identification of the species and their richness in different parts of the river system; to find the character species on different river courses, and to try the qualification of the river profiles by presence or absence of indicator species in river courses. This work is a part of the data collection and the evaluation of the state of ecological health in the River Tisza and its tributaries now, and serve as a standard for the ecological changes in the future (Szító, 1995). The present work followed the previous data collections in Bodrog and its tributaries now.

4.2.2. Materials and methods

Detailed sampling sites presented with the results together and see Tables 1-3.

Samples were collected by hand net and washed throughout net with 250 mesh size. After sampling we conserved the remained material in 3 per cent of formol solution. Finishing the expedition, animals were picked up from the organic and inorganic material and conserved in 80 % alcohol solution and it followed the species determination.

For taxonomic identification the following works were used: (Bíró, 1981; Brinkhurst and Jamieson, 1971; Cranston et al. 1983; Ferencz, 1979, Fittkau, 1962; Fittkau et al. 1983; Pinder et al. 1983; Pop, 1943, 1950).

4.2.3. Results and discussion

We found 769 individuals of 91 species during the expedition. The richest was the benthos in River Ung on the spring area by Storozhnica, where 13 species found on both the running and standing water area as well. The collected species differed on the mentioned sampling places, and therefore 26 species characterized the sampling place. 19 individuals of the *Psammoryctides moravicus* (Oligochaeta) and 4-4 ind. of *Potamothrix vejdowskyi* and *Limnodrilus hoffmeisteri* were present here.

12 species of chironomids were present in standing water area, and 11 species were in the running water type too. *Chironomus riparius* was characteristic and dominant in standing water. Temporary ecosystems had rich food source after inundations for different insect larvae. The primary production and detrite in these temporary ecosystems were the food source for chironomid larve.

1-3 individuals of other 11 chironomid species were present here and showed a big diversity of the sampling place. The most of the chironomid species were very tolerant to environmental factors, living here (Table 1).

The hard running water with boulders and gravels was characteristic ecosystem. Some sedimentation started under the gravels covered by epiphiton their surface, which was living place and food source for them. Both of the Eukiefferiella and Dicrotendipes had high individual richness. The species of Eukiefferiella genus were common in epiphiton, bacteria and algae served as food source them, but the species of Dicrotendipes was characteristic for sediment, its larvae often lived in epiphiton too.

River Ung by Nevicke upstream (2^{nd} sampling site). The main food source was the algal epiphiton on the boulders. Some sedimentation with sand was detected in stagnant water parts and formed benthos there. 2 chironomid species and the *Perlodes microcephalus* (Plecoptera) were present in the main current. 1-2 individuals of other chironomid species were present here characterized the clean water, living in epiphiton, for example as the species of Cricotopus, or Cladotanytarsus and Tanytarsus, which species tolerated the ecological factors both of the current and stagnant waters.

2 Oligochaeta species and 8 chironomid species were present in mady sediment. Oligochaeta were not present near the banks, only 10 chironomid species formed the macrobenthos here. *Krenopelopia binotata* and *Cryptochironomus redekei* were common for mudy part and for sandy place near the bank. *Chironomus riparius* was dominant from the mudy sediment, and the other chironomid species were present with 1-2 individuals only (Table 1).

Macrozoobenthos was absent in the spring area of the river Ung (site 3), but 2 Oligochaeta species and one chironomid species were present with some distance from here, by Stavne upstream. *Tubifex nevaensis* characterized a clean water area, but *Nais pseudobtusa* was most tolerant for environmental factors. 6 individuals of *Macropelopia nebulosa* presented here. Species of Cricotopus and Eukiefferiella were typical here because of the large periphiton. There were Polypedilum species living both in the periphiton and sediment. The *Perlodes microcephalus* (Plecoptera) found here too (Table 1). The River Latorica by Pidpolozja was bad in species on the spring area (site 4). Only one Oligochaeta species, *Tubifex nevaensis* and 5 chironomid species formed the fauna here. The presented Oligochaeta species indicated a clean water area, and the chironomid species were tolerant to the environmental factors.

Oligochaeta were absent in Latorica by Pasika downstream (site 5), but the *Baëtis pumilus* (Ephemeroptera) and 12 of chironomid species detected. The large number of Eukiefferiella collected here, but the highest richness had the *Pentapedilum sordens* with 28 individuals, that showed a trophic ecosystem here.

Table 1.The macrozoobenthos in River Bodrog and its tributaries between August 2-16, 1999

Table 1. (cont.)

Sampling sites / Species	Ung 1. Storozhnica stagnant w.	Ung current w.	Ung 2. Nevickeupstr. the main current	Ung Nevicke upstr. mudy	Ung Nevicke upstr. near bank	Ung 3. Uzhok spring area	Ung 3/a Stavne upstr.	Latorca 4. Pidpolozja the main current	Latorca 5. Pasika	Latorca 6. Chop upstr.	Ung 7. Pavlovce	Latorca 8. Velk. Kap.
Endochironomus tendens (Fabricius 1775)									1			
Microtendipes chloris (Meigen 1818)	1				1							
Cladotanytarsus mancus (Walker 1856)			3									
Constempellina brevicosta (Edwards 1937)									8			
Micropsectra atrofasciata (Kieffer 1911)								2				
Micropsectra junci (Meigen 1818)		1										
Rheotanytarsus curtistylus (Goetghebuer 1921)		1			1							
Tanytarsus gregarius (Kieffer 1909)	2		2		1			4	2			
Tanytarsus gregarius (Kieffer 1913)												
Dicrotendipes nervosus (Staeger 1838)	1	14										
Dicrotendipes tritomus (Kieffer 1916)		5										
Parachironomus arcuatus (Goetghebuer 1919)												
Paracladopelma nigritula (Goetghebuer 1942)					1							
Paralauterborniella nigrohalteralis (Malloch 1915)				3								
Polypedilum convictum (Walker 1856)									1			
Polypedilum laetum (Meigen 1818)							2	1	4			
Polypedilum nubifer (Skuse 1889)											12	
Tripodura scalaenum (Schrank 1803)	5				1		1					
Pentapedilum sordens (van d. Wulp 1874)							1		28			
Sergentia longiventris (Kieffer 1924)			1									
Ephemeroptera (Kérészek)												
Baëtis pumilus (Burmeister 1839)									2			
Plecoptera (Álkérészek)												
Perlodes microcephalus (Pictet 1833)			1				1					
Perla sp.												
Species no.	**13**	**13**	**8**	**9**	**10**		**14**	**6**	**13**	**0**	**2**	**2**

The River Latorica had no benthos by Chop upstream (site 6).

The River Ung by Pavlovce (site 7) was rich in food sources for benthos. 18 individuals of *Chironomus riparius*, 12 ind. of *Polypedilum nubifer* and 13 ind. of *Tripodura scalaenum* were present here. The presence of *Chironomus riparius* and Polypedilum species, and their individual richness showed a probability of temporary human pollution (Table 1).

Perla sp. and 10 chironomid species formed the macrozoobenthos in River Laborec by Certizne upstream, in spring area. All the species were clean water indicator.

The presence of 6 individuals of the predator chironomid Apsectrotanypus suggested food richness for them in River Laborec by Koskovce downstream (site 9). Chironomid species were present, which were common living both in the periphiton and sediment.

River Laborec by Petrovce downstream (site 10). Oligochaeta absent, 6 chironomid species was present. Species of Cricotopus and Eukiefferiella were present in the periphiton, the others were common for both the periphiton and sediment too (Table 1.)

The River Laborec was bad in species by Stretavka downstream (site 11). The deep and in organic material rich sediment had a bad zoocoenose. 6 individuals of the tolerant *Limnodrillus hoffmeisteri*, 8 ind. of *Chironomus riparius*, and 4 ind. of both the *Polypedilum nubifer* and *Polypedilum convictum* showed an eutrophic environment in the left bank river side (Table 2).

The sediment of River Latorica was rich in organic material by Zlatin (site 12), but the left river bank side was bad in species. 6 ind. of *Limnodrilus hoffmeisteri*, 8 ind. of *Chironomus riparius*, and 4 ind. of both the *Polipedilum convictum* and *Polypedilum nubifer* were present here. Both the species and their individual richness indicated the probability of the richness of the organic materials in the sediment (Table 2).

River Bodrog by Vinicky showed deep mudy sediment (site 13). Only one individum of *Branchiura sowerbyi* (Oligochaeta) was found. It was the only one from the investigated area during the expedition. We don't know its earlier data from these rivers, and it presence indicated the food richness in sediment as soon as *Limnodrilus hoffmeisteri*, which was present with 13 individuals too. The *Chaoborus crystallinus* and *Cloëon dipterum* were also present here. Moreower 5 chironomid species were detected, the presence and high individual richness of *Chironomus riparius* showed eutrophic sediment (Table 2).

River Ondava, spring area by Nizny Milosow (site 14). 10 individuals of *Baëtis pumilus* presence indicated a clean water area, Oligochaeta absent, 7 species of chironomid were present. 12 ind. of the predator *Apsectrotanypus trifascipennis* (Chironomidae) indicated food richness for them. The epiphiton living species were characteristic for this area (Table 2).

River Ondava by Cicava (site 15). The periphiton was thin, and the sedimentation was not optimal for benthos. Oligochaeta absent, 3 chironomid species formed the fauna with dominant amphipods. *Baëtis fuscus* indicated a clean water area with the other species.

River Ondava by Horovce (site 16). Oligochaeta absent, 1 ind. of *Cloëon dipterum* found with 6 chironomid species. 16 individum of *Tripodura scalaenum* were more than the total ind. of other species (Table 2).

The mouth area of River Ondava by Brechov had deep sediment. The *Gomphus flavipes* was the only species here. Some species presence of Oligochate and chironomid would be prognostized with high individual richness by the environment, but we don't know the cause of their lack.

River Bodrog by Fels őberecki (site 18). The sediment was deep with aerobic surface. The lack of the fauna was surprising (Table 2).

River Bodorog by Bodrogolaszi (site 19). The sediment was rich in organic material by right side of the river bank. The very tolerant *Limnodrilus hoffmeisteri* (Oligochaeta) species was present only, but the tolerant chironomid species absent.

River Bodrog by Bodrogkeresztúr, mouth area (site 20). It was rich in organic materials. 4 species found. The *Limnodrilus hoffmeisteri* was the only Oligochaeta species present here, 3 chironomid species were present with 1-2 individuals only. The fauna was bad both in species and individuals too (Table 2).

Table 2. The macrozoobenthos in River Bodrog and its tributaries between August 2-16, 1999

Species	11. Stretawka downstream Laborec	12. Zatin Latorca	13. Vinicky Bodrog	spring area 14. Nizny Milosow Ondava	15. Cicava Ondava	16. Horovce Ondava	17. Brehov Ondava tork. vid.	18. Felsőberecki Bodrog	19. B. olaszi Bodrog	20. Bodrogkeresztúr Bodrog
Oligochaeta				Individuals in samples						
Branchiura sowerbyi (Beddard 1892)			1							
Tubifex nevaensis (Michaelsen 1903)	8									
Limnodrilus hoffmesiteri (Claparéde 1862)	8	6	13						5	1
Chironomidae										
Anatopynia plumipes (Fries 1823)			6							
Apsectrotanypus trifascipennis (Zetterstedt 1838)				12						
Procladius choreus (Meigen 1804)										1
Prodiamesa olivacea (Meigen 1818)					1					
Cricotopus bicinctus (Meigen 1818)				3						1
Cricotopus flavocinctus (Kieffer 1924)						2				
Rheocricotopus effusus (Walker 1856)				4						
Eukiefferiella brevicalcar (Kieffer 1911)				2		1				
Eukiefferiella clypeata(Kieffer 1923)				8						
Chironomus riparius (Meigen 1804)	12	8	7							
Tanytarsus gregarius (Kieffer 1909)						3				
Paracladopelma camptolabis (Kieffer 1913)			1							
Paralauterborniella nigrohalteralis (Malloch 1915)										2
Polypedilum convictum (Walker 1856)		4								
Polypedilum nubifer (Skuse 1889)	6	4								
Tripodura scalaenum (Schrank 1803)			1	2	1	17				
Pentapedilum sordens (van d. Wulp 1874)				22	1	1				
Amphipoda (Felemáslábú rákok)										
Dikerogammarus haemobaphes fluviatilis (Martinov 1919)					34	2				
Odonata (Szitakötők)										
Gomphus flavipes (Charpentier 1825)					1		1			
Ephemeroptera (Kérészek)										
Baëtis pumilus (Burmeister 1839)				10						
Habrophlebia fusca (Curtis 1831)					4					
Cloëon dipterum (Linnaeus 1761)			2			1				
Culicidae (szúnyogok)										
Chaoborus crystallinus (De Geer 1776)			7							
Species no.	**4**	**4**	**8**	**8**	**6**	**7**	**1**	**0**	**1**	**4**

4.2.4. Summary

The investigations and the indicator species showed that River Ung, Latorica, Ondava, Laborec and River Bodrog were clean mostly. The rivers were polluted on some sampling areas as follows: River Latorica by Chop upstream, River Ung by Pavlovce, River Latorica by Velky Kapusany downstream, River Laborec by Koskovce and Stretavka downstream, River Latorica by Zlatin, River Bodrog by Vinicky, River Ondava mouth area by Brechov, River Bodrog by Fels őberecki and Bodrogolaszi.

The backwaters were hypertrophic and therefore anaerobic conditions were during summer periods on the sediment surface. The benthos mostly absent or very bad, if it present.

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4.3. DOMINANT PLANT AND ANIMAL SPECIES IN AQUATIC BIOTOPES OF KOVILJSKI RIT MARSH AREA (VOIVODINA, YUGOSLAVIA)

Popovic, E., Vuckovic, M., Radulovic, S., Pajevic, S., Kostic, D., Bjelic-Cabrilo, O., Miljanovic, B.

4.3.1. Introduction

Unlike other cities, in the vicinity of Novi Sad aquatic habitats like marshes, pools, backwaters, and even those closely related to water regimen (river islands) are found. They are refuges and maybe last oases for many rare plants and animals. In past, natural aquatic ecosystems showing a powerful biological diversity were widespread in the plains of Voivodina. In the response to the impact of humans however, they are in most part destroyed or degraded following changes in ecological conditions, disturbed biocoenotyc relationships, and the ecological balance in general. Consequently, many plant and animal species are extinct in their natural habitats, some withdrawn, or under the threat of extincion. Taking into consideration the fact that the Novi Sad region in last year was exposed to harmful effects like crude oil flowing off, combustion of oil derivates, sulfur compounds, canceregenous and other harmful substances, the living conditions have become worse. The main aim of these investigations was to establish a present status of plant and animal compositions in aquatic ecosistems of the region of the Novi Sad city and its surroundings, i.e. to recognize possible consequences and changes of the biological component affected by war destruction. Investigation were aimed at Koviljski rit Marsh taking into consideration its considerable endangereness with substances after the oil rafinery was destroyed.

Koviljski Rit Marsh is situated on the left bank of the Danube (between 1230 and 1249 river km) downstream of Novi Sad. In 1998, this 4860 ha area of an extraordinary importance legislatively became a special natural reservation. In addition, it is registered among the internationally important European bird regions (IBA). It has also been put on a list of marshes, candidates for a list of regions of the internationally recognized importance (Ramsar convencion, 1971)

4.3.2. Material and Methods

The investigations were carried out in the period June-December of 1999. Determination and nomenclature of plant taxa were done according to Flora SR Srbije (Josifovic 1970-1977; Saric and Diclic 1986), Iconographia Florae Partis Austro-Orientalis Europae Centralis (Javorka and Csapody 1975) and Felföldy (1990).

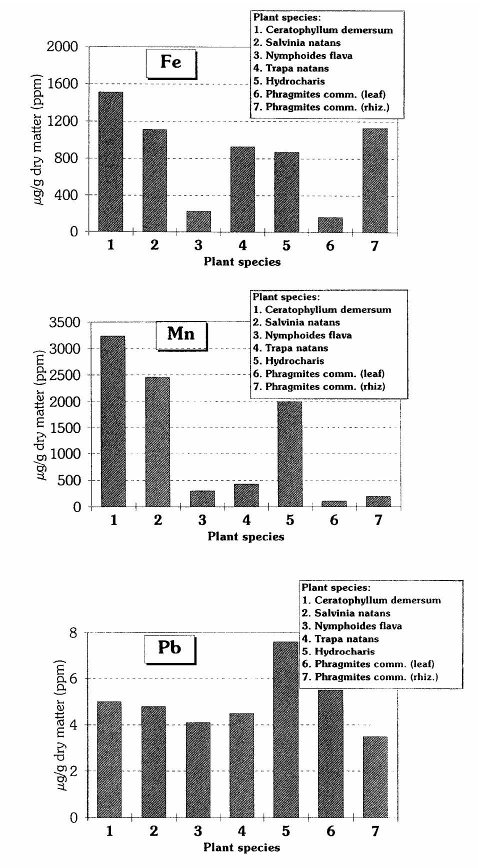
The total metal concentrations were determined by atomic absorption spectrophotometry.

At the area of Koviljski rit marsh 28 specimens of green frogs were cought by random sample principe. Collected material was used for parasitological and food composition, investigations of this species.

To analyze qualitative and quantitative fish fauna composition electrofishing at moderate water level was employed. Body mass, total and standard body length, and sex and age determination were performed (Cugunova, 1959).

4.3.3. Results and Discussion

When qualitative floristic structure is discussed plant investigation results show that aquatic habitats of Koviljski Rit Marsh area are still preserved, i.e. a great diversity of plant species occur. More than fifty species of vascular macrophytes have been recorded. The greatest abundance was established in: *Ceratophyllum demersum* L., *Myriophyllum spicatum* L., *Nymphaea alba* L., *Nuphar luteum* (L)Sm, *Nymphoides flava* Hill., *Salvinia natans* (L) All., *Azolla caroliniana, Spirodela polyrrhiza* L., *Lemna minor* L., *Lemna gibba* L., *Hydrocharis morsus ranae* L., *Trapa longicarpa* Jank., *Potamogeton crispus* L., *Potamogeton lucens* L., *Potamogeton perfoliatus* L , *Phragmites communis* Trin., *Iris pseudacorus* L. and *Butomus umbellatus* L..



	Water μg ml^{-1}	Mud μg g^{-1}
Fe	0.73	16154
Mn	<0.03	496.0
Pb	<0.04	29.6
Cd	<0.05	0.6

Fig. 1. Concentration of Fe, Mn and Pb in some macrophytes of the Koviljki rit. Concentration of Cd <0.5μg/g dry matter.

To determine heavy metal pollution in samples of six indicator plant species, concentration of micronutrients (Fe and Mn) and polutants (Pb and Cd) was analyzed. An extremely high Fe (up to 1600 µ/g dry mass) due to chemical composition of sediments was obtained. A submersed *C. demersum* showed the highest bioaccumulation rate while pollution was not indicated by tissue Pb and Cd. High values of mud Fe and Mn were evident (Fig. 1).

Changes of ecological conditions in an environment may also be indicated by the presence of certain fish species and tailless amphibians together with their parasites. Koviljski Rit Marsh area is dominated by edible frog (*Rana "kl". esculenta*). Stomach content analyses of *Rana lessonae* and *R. "kl". esculenta* show the presence of insects (87%), snails (8.7%), and araneids (4.3%). In addition, the four fluke and four nematode species among which *Diplodiscus subclavatus*, *Cosmocerca ornata*, and *Aplectana acuminata* dominated were observed (Tables 1 and 2).

Table 1. Fluke infestation extensity of Rana hosts

TREMATODA SPECIES	♋				♊			
	Hosts		Trematodes		Hosts		Trematodes	
	N°	%	N°	%	N°	%	N°	%
Haematoloechus schulzei	1	11.11	1	1.89				
H. variegatus dubininae					1	25	1	5.88
Haematoloechus sp.					1	25	1	5.88
Opisthioglyphe ranae	1	11.11	2	3.77	1	25	3	17.65
Diplodiscus subclavatus	7	77.78	50	94.34	3	75	12	70.59
S			53				17	

Table 2. Nematode infestation extensity and percentages in Rana hosts

Organon	Nematoda species	N^0 of hosts	Ext. inf. (%)	N^0 of nematodes	% of S nematodes
Pulmo	***Rhabdias bufonis***	3	16.67	4	2.22
Int.	***Oswaldocruzia filiformis***	1	5.55	7	3.89
	Cosmocerca ornata	3	16.67	9	5.00
	Aplectana acuminata	2	11.11	5	2.77
Rectum	***Cosmocerca ornata***	8	44.44	110	61.11
	Aplectana acuminata	9	50.00	43	23.89
V. urin.	***Cosmocerca ornata***	1	5.55	2	1.11
S		18	64.28	180	

The fish fauna included twelve fish species in five families (Table 4), three allochthonous and the remaining autochthonous fishes. With eight observed species the abundance of Cyprinidae was evident. The highest percentages were obtained with *Rutilus rutilus*, then *Lepomis gibossus* while in total mass an introduced species *Carassius auratus gibelio* diminated. Economically important fish species were rare since only very small percentages of *Cyprinus carpio* and *Esox lucius* were recorded. Fish age was between 1+ and 4+. In summary, Koviljski Rit Marsh waters belong to II class.

Research results only show the present status of the ecosystem conditions. Further complex hydrobiological investigations showing a more clear picture of this and other valuable natural aquatic resources surrounding Novi Sad are need.

Table 3. Fish fauna composition

FAMILY AND FISH SPECIES	% OF TOTAL INDIVIDUAL NUMBER
Fam. Cyprinidae	
Cyprinus carpio L.	0.47
Blicca bjoerkna L.	0.93
Aspius aspius L.	0.93
Carassius auratus gibelio Bloch	17.76
Scardinius erytrophthalmus L.	11.68
Rutilus rutilus L.	42.99
Alburnus alburnus L.	1.40
Leuciscus cephalus L.	1.40
Fam. Esocidae	
Esox lucius L.	0.47
Fam. Percidae	
Perca fluviatilis L.	0.47
Fam. Centrarchidae	
Lepomis gibbosus L.	20.09
Fam. Ictaluridae	
Ictalurus nebulosus Le Sueur	1.40
NUMBER OF FAMILIES	5
NUMBER OF FISH SPECIES	12
NUMBER OF SPECIMENTS	214

4.3.4. Summary

The paper is a contribution to a complex hydrobiological investigations into the Koviljski Rit Marsh area covering a flood zone of middle Danube (between 1230 and 1249 river stream km) .

A relatively great species diversity of this area is correlated with plant world inhabiting aquatic biotopes. Over fifty species of vascular macrophytes have been recorded. Among them, a considerable number of Tertiary relict, rare, and endangered plants occur. In addition, dominance of Rana species was studied. Stomach content analysis of showed the occurrence of insects (87%), snails (8.7%), and araneids (4.3%) while in helminthological investigations four fluke and four nematode species were recorded. Fish fauna includes twelve species in five families with most abundant Cyprinidae representatives.

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4.4. FISH-FAUNISTIC SURVEY OF THE JÁSZSÁGI CANAL SYSTEM

Pekli, J. and Zsuga, K.

4.4.1. Introduction

The Jászsági main canal is one of the biggest irrigation canals branching out of the Kisköre Reservoir. The primary role of the canal system part the which is to provide irrigation water for the agricultural production and to fulfil the water demand of many fish ponds. With the continuous expansion of the canal system, nowadays there is an artificial surface water spread to the whole Jászsági-plain formed.

Only few data were available on the fish fauna of the Jászsági canal system. Endes and Harka (1985, 1987) examined the vertebrate fauna of the Jászsági-plain and the Heves-Borsodi-plain. An important survey is given by Harka (1985, 1987), about the fishes of Kisköre Reservoir. More current data can be found in the works of Kovács (1990, 1995) and Györe (1995 a,b). Considering a wider region, Harka (1988) redorded the spread of the Proteorhinus marmoratus in the catchment area of the River Tisza. Pintér (1991) described the appearance of another, previously rare fish species. He investigated the spread of the Ictalurus melas in the water system of the River Tisza. In his opinion, the fish-farms dealing with this species are responsible for its spread.

4.4.2. Materials and methods

During the faunistical survey we investigated the segment of the so-called J-III-1 and J-III-2 irrigation canal at Sajfok-K őtelek and the segment of the Dobai main canal between Tiszasüly and K őtelek. These canals provide water to the fish ponds.

For the survey of the fish fauna we applied several methods. The most data derived from yearly fishing. With this method we gained information mainly on the bigger and older fishes. Thus, we had to complete our survey with the fishing pointing to the smaller-sized species. We compared our results with the literature data concerning the fish fauna of the water regions (upper segment of the Jászsági main canal, Millér main canal, Kisköre Reservoir) in this area.

Besides our own investigations we followed the official fishing. Moreover, we included our previous faunistical investigations done at a canal joining the Jászsági canal system.

In the nomenclature, we followed Pintér (1992).

The Jászsági main canal receives its water from the Kisköre Reservoir. The water supply provides the irrigation water and fish pond nutriment water from the first half of March until the end of October and the beginning of November. The water amount given off to the main canal is about 2-5m^3/sec usually. During summer these values are often much higher to fulfil the higher demands, for the spring this is lower-rate.

The water quality of the Jászság main canal and its side branches can be regarded good as for the fish pond-utilisation. The water of the canal system is first-class in the most cases but sometimes second-class water quality occurred for some components (dissolved oxygen, nitrite, dissolved orthophosphate content).

4.4.3. Results

Following fish species were recorded

Acipenseridae:

Acipenser ruthenus L. Rare. Nowadays we can find less individuals even in the River Tisza.

Esocidae:

Esox lucius L. It is often occurring in the canal system, even according to the literature data. Its reproduction guild is phytophil (Bíró, 1993), so the floating and fixed pondweeds of the canals provide the conditions of its reproduction.

Cyprinidae:

Rutilus rutilus L. Common almost everywhere, it appeared in high numbers in all three years and literature data also mention it. Its reproduction guild is phyto-lytophil, so it can reproduce in the canal.

Ctenopharyngodon idella Cuv. et Val. Its constant appearance in the investigated area is due to the supply from the fish ponds and the introduction. Its presence helps to maintain the physical state of the macrovegetation by consumption.

Hypophthalmichthys molitrix Cuv. et Val. Its population is mainly from introduction and it likely can colonize frrom the from fish ponds, too.

Aristichthys mobilis Rich. Appears every year but in a smaller number than the Hypophthalmichthys molitrix Cuv. et Val. No data on this species in the literature.

Scardinius erythrophtalmus L. Appears in low numbers but often. Literature data also include it (Endes and Harka 1985, 1987)

Leuciscus idus L. Occurred every year but in low numbers.

Leucaspius delineatus Heckel It occurred only in 1994 in the canal but Endes and Harka (1985) recorded from the Millér and the Jászság canals. Although it is phytophil, making it possible, it still could not spread in the canal system. This can be explained by its higher oxygen demand, which not provided during summer in the canal.

Aspius aspius L. It is recorded by Endes and Harka (1987). No reproduction can take place in the canal.

Alburnus alburnus L. Common. As a phyto-lytophil species, it can reproduce in the investigated area.

Blicca bjoerkna L. Endes and Harka caught in the Jászsági canal and the Millér main canal. It is rare in the investigated area.

Abramis brama L. Frequent species, reproduction is also possible in the canal system.

Abramis sapa L. Rare.

Tinca tinca L. It appears everywhere and constantly because of the slow water flow and the steady water-type.

Chondrostoma nasus L. It appears at Jászsági canal accidentally from the reservoir. No reproduction in the canal.

Barbus barbus L. Its appearance is similar to *Chondrostoma nasus* L.

Gobio gobio L. As a psammophilous species, cannot reproduce in the canal.

Pseudorasbora parva Schegel It is high number everywhere. Its population is increasing. In fishponds its overproduction can cause a damage.

Rhodeus sericeus amarus Bloch Our only ostracophyl fish species. A significant shell population is likely to be present, on the basis of the appearance of this species in masses.

Carassius carassius L. Frequent species.

Carassius auratus L. It breeds in the Kolopi Fishfarm, the population may originated from there. The environmental conditions are favourable for its reproduction.

Cyprinus carpio L. Common everywhere in the canal.

Cobitidae:

Cobitis taenia L. Reproduces in the canal. It occurs probably in several localities.

Siluridae:

Silurus glanis L. Introduced and coming from the fish ponds.

Ictaluridae:

Ictalurus nebulosus Le Sueur The conditions are favourable for this species everywhere in the canal. Therefore, its populations are growing.

Ictalurus melas Rafinesque A few individuals come out of the Kolop Fishfarm. It probably has a stable populaiton. The way of life is similar to that of the Ictalurus nebulosus. Pintér recorded from the River Tisza in 1991. Thus, its appearance in other segments of the canal system is possible. It reached Tiszasüly in May 1995 from HAKI in Szarvas and two months later it ran away from the fish ponds to the canal.

Centarchidae:

Lepomis gibbosus L. Occurs everywhere but in a small number.

Percidae:

Perca fluviatilis L. Everywhere common. It appeared in the canal every year, the literature mentions it, too.

Gymnocephalus cernuus L. Its distribution is similar to that of the Perca fluviatilis.

Stizostedion lucioperca L. It is an important part of the good haul of fishermen of the canal. It can come from the reservoir and the two big fish farms.

Gobiidae:

Proterorhinus marmoratus Pall. Previous data mention it from the Danube. Harka found it first in the water system of the River Tisza and its further distribution in East Hungary is possible. During our investigations it appeared in 1993 at one of the fish ponds. This fish pond next to Szolnok gets its water supply from the Millér main canal that is part of the Jászsági canal system. Its presence is possible in the whole canal system.

4.4.4. Discussion

During our survey, we found 30 species in the investigated area, this is more than mentioned in literature (Endes and Harka, 1985, 1987). But fewer than in the Kisköre Reservoir. This differences are brought about by the environmental conditions and the different investigation intervals. The dominance situations are similar. From the fishing data the *Cyprinus carpio* and the *Carassius species* are characteristic for the Kisköre Reservoir. (Tájékoztató 1995) According to our survey these species were the most frequent. From the 11 protected species, two occurred in the canal system, *Leucaspius delineatus* and *Cobitis taenia*.

The fish fauna of the Jászsági canal system represents a shift between the species of the river and the lake associations. The water flows slowly in the canal, thus due to the strong sedimentation those fish species disappear that prefer the fast flowing water and the sandy, flinty riverbed (e.g. *Chondrostoma nasus, Barbus barbus*). The appearance of these species is accidental and they cannot reproduce here. Those species occur in high numbers that prefer steady and slow water and gain their nutriment from the silt (*Tinca tinca*, *Cyprinus carpio*). From the predatory fish, Ictalurus nebulasus occurs in the highest rate but Esox lucius and the *Stizostedion lucioperca* can be found, too.

The fish pond farming has an effect on the composition of the fish fauna. The presence of the ornamental fish species in the samples shows this well. The appearance of Ictalurus meals and the distribution of Pseudorasbora parva is due to the water-management in fishponds. Pseudorasbora parva can overproduce in the fish ponds, where fish are fed and in the canal it is a competitor of other species.

The fish fauna of the canal system is influenced by the various utilisation methods. The upper part of the Jászsági main canal is rather angling water, whereas the lower is used for fishing. During the fish introductions of the past years 3 years *Cyprinus carpio* were disposed to the canal.

In the fish industry it is impossible to take the long-term interests into consideration. Under the present uncertain economic and regulations conditions the investments can only be recovered in a short term.

4.4.5. Summary

The Jászsági canal system was established at the same time the Kisköre

Reservoir was built. The fish fauna of the canal system has been examined by few researchers, and the previous data relate to the reach of Jászsági main canal at Heves county. In the present fish-faunistic survey the reach of J-III-2 irrigation canal at Sajfok-K őtelek and the connecting to this reach of the Dobai-canal at Tiszasüly-K őtelek was examined. In the course of the qualitative and quantitative survey, completed with the data of previous observations, altogether 30 species were found at the examined area. It is proved that the fish fauna of canal system shows transition between river's and pond's fauna. In addition to environmental conditions the different economical utilisation and the fish breeding affect the composition of the fish fauna, too.

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