

## ROTIFERS OF THE MOST POLLUTED POOL OF BACKWATER „GYÁLAI-HOLT-TISZA”, COMPARED TO THE NEIGHBOURING SITE’S FAUNA

J. Márton

*Márton, J. (2007): Rotifers of the most polluted part of backwater „Gyálai-Holt-Tisza”, compared to the neighbouring site’s fauna. – Tiscia 36, 3-6.*

**Abstract.** The investigation was about the Rotatoria fauna of the most polluted pool of Gyálai-Holt-Tisza, the „Fekete-víz”. The aim was to find the most important factors that form the rotifer fauna at this pool. Sampling took place between April and October, 2005, in 4 periods. Five sampling sites were set out, 4 of them were at „Fekete-víz”, and the fifth at the neighbouring pool, „Fehér-part”, which served as a control site, as the earlier investigations showed the differences between them. Thirty-one Rotatoria-taxa were identified (20 species, 10 genera and a class). During the last examination (Rédei 2002) only 11 species were found. PCA and cluster-analysis distinguished the samples of the periods, which means seasonality, but 4 of the 5 sampling sites overlapped, and one partly overlapped, which means that spatial differentiation occurred only at one site. Rotifers reached peak in density in the summer, while in the autumn period there were almost no individuals in the 3 sites between „Hattyasi átjáró” and the sluice of „Fehér-parti átjáró”. No correlation was found between the measured water parameters and the number of rotifers. The opened or closed state of the sluice of „Fehér-parti átjáró” seems to be the most important factor to influence the fauna: during opened periods large number of rotifers flow into the pool. After closing, the number decreases fast due to the water quality (toxicity of the thermal inflow, low dissolved oxygen content) or some invertebrate predators. The exception was the site farthest from the sluice, where specific dynamics were discovered, with no or little influence of the sluice. The investigations showed that the water of „Fekete-víz” between the sluice and „Hattyasi átjáró” is as heavily polluted that rotifers cannot survive in it without refreshing the water.

*Keywords: disturbed water, species composition, species dynamics, salt load*

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### Introduction

The backwater Gyálai-Holt-Tisza was created at the 19<sup>th</sup> century as the 90<sup>th</sup> cut-off of the Tisza. Its length is 18,7 km, and average width is 86 m. It is divided into three sections by dams and sluices (Pálfai 2003).

The water quality is changing from the southern to the northern pool, the northern one is the most polluted. Thus, the utilization of the pools is different. The lower pool is a fishing area, the middle one is used for angling, and both provide water for irrigation.

The upper part is separated by “Hattyasi átjáró”

and used for storing waters. It gets water from run-off from the city of Szeged, some sewage-water and has a run-off of thermal waters, which causes heat- and salt-load to the pool. From 2001, the construction of a sewage system results no more diffuse pollution to the section, though household sewage still gets into it.

The rotifer fauna of the upper section is almost unknown. In an investigation in 2000–2001 (Rédei 2002) rotifers were found in lesser species and individual numbers than the in the neighbouring parts. The fauna of the part near the sewage system was not investigated before.

## Material and methods

Samples were collected with a 10 litre plastic container from the surface and filtered with a net with a mesh size of 40 µm, at five points of the backwater: four of them were in „Fekete-víz” (Pool 3) (sampling sites 2, 3, 4 and 5) and one at the control area of „Fehér-part” (Pool 2) (sampling site 1) (Fig. 1). Geographical coordinates of the sampling sites are listed in Table 1.

Table 1: Geographical coordinates of the sampling sites

Sampling site code	Locality	
1	46°13'35.8"	20°05'48.9"
2	46°13'41.2"	20°05'59.8"
3	46°13'42.1"	20°06'10.5"
4	46°13'37.3"	20°06'44.1"
5	46°13'04.0"	20°07'04.1"

Sampling periods took place 4 times in 2005. The first period was between 6. April and 4. May (average gap of 2 days between sampling dates), the second one between 25. June and 8. July (daily sampling), the third one between 15–27. August (daily), and the last one between 29. September and 12. October (daily). The samples were fixed with 35% formol solution.

Three samples were collected at one time in each sampling site.

The following parameters were measured during the sampling: pH and water temperature with Milwaukee SM 102 digital device, conductivity with Milwaukee SM 302 (0–10 µS) and transparency with a Secchi-disk.

The conductivity (G) data, to be comparable, must be standardized to a constant temperature (20 °C) with an

$$f_t = \frac{1}{1 + 0.023 \times (t - 20)}$$

component, where  $t$  is temperature. The standardized data can be converted into whole ion content, as

$$\text{whole ion [g/m}^3\text{]} = 0.63 \times G_{20} [\mu\text{S/cm}]$$

(Németh 1998).

Samples were filtered to a 10–70 cm<sup>3</sup> final volume, depending on the density. Individuals of taxa in a known volume were counted, at least 100 individuals per sample. In some cases dilution was needed. The final number was transformed into individuals per litre.

The statistical analysis was performed with the programme „Palaeontological Statistics” (PAST) (Hammer *et al.* 2001).

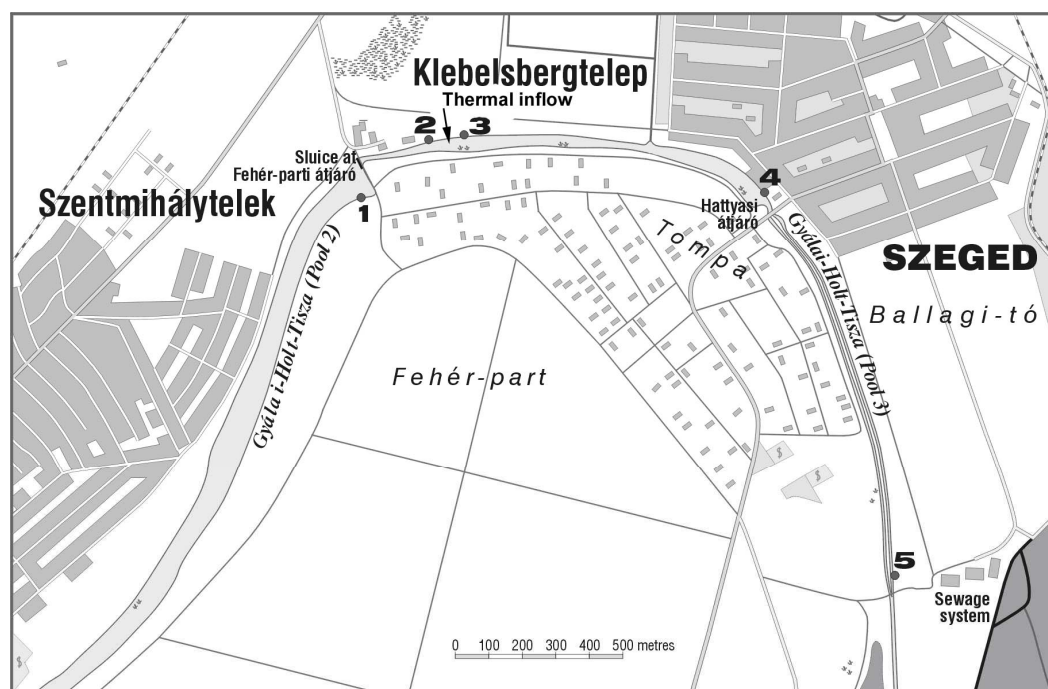


Fig. 1. The sampling sites at „Gyálai-Holt-Tisza”

## Results

Thirty-one taxa of Rotatoria were identified: 20 of them are species, 10 genera and 1 class (Bdelloidea, the individuals were unable to be identified after fixation).

Water parameters changed daily and seasonally. The most constant values were measured at sampling sites 1 and 5, though there was fluctuation at them according to the weather conditions.

Water temperature was the lowest at sites 1 and 5, and, according to the thermal inflow and the dark colour of the water body, at sites 2–4 higher temperatures were detected.

The pH was alkalic (7,9–9,3) in the whole year, there was a gradient-like spatial decrease in its values from sampling sites 1 to 5.

The whole ion content was the lowest at site 1 and the highest at sites 3–4, and a medium value was calculated for site 5.

There was no tendency of significant correlation between the daily average data of water parameters and the individual number of the most dominant rotifer species.

The seasonal average individual number of every sampling place was transformed to percent values. Principal component analysis (PCA) was made on those relative abundance values.

PCA analysis showed seasonality, as the seasonal polygons do not overlap (Fig. 2.), while the sampling sites do not separate from each other, as the sampling sites' polygons overlap in four cases (sampling sites 1–4) with the exception of site 5 (Fig. 3.).

Daily Rotatoria individual numbers of sites 2–5 were compared to those of site 1, in connection with the opening and closing events of the sluice at „Fehér-parti átjáró”. During the open periods rotifers appeared in the samples in very high numbers at „Fekete-víz” compared to the closed periods. After closing the sluice the individual number decreased fast to a smaller level. The difference was often at the  $10^5$  times level. With the distance from the sluice, some delay occurred in detecting the peak number of rotifers. At site 2, the peak number appeared right the day of the opening, at site 3 on the day of the opening, or one day later, at point 4 two or three days delay was detected. Site 5 was too far from the sluice or the two weeks period was not enough to see a connection.

During the sampling period in October the sluice was not opened, thermal water flew in and almost no rotifers were found in the samples of sites 3 and 4, and only few species occurred at site 2. At sites 1 and 5 several species appeared, and different fauna was found in the two places.

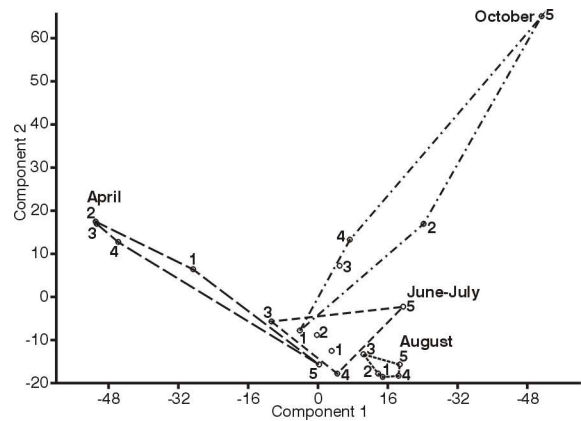


Fig. 2. Result of the principal component analysis. Dots of the same period are connected.

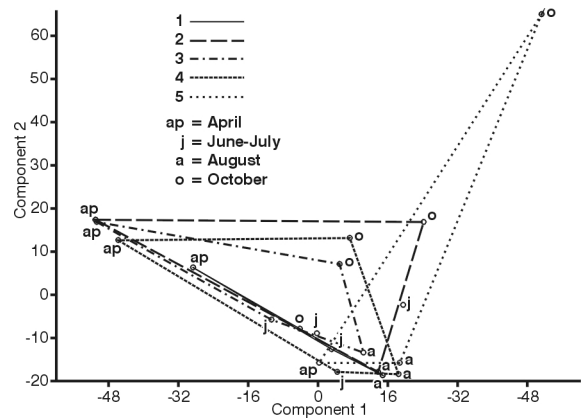


Fig. 3. Result of the principal component analysis. Dots of the same sampling site are connected.

## Discussion

The investigated pool was dominated by eutrophic, cosmopolite, planktonic species that tolerate more or less the salt load of the thermal flow.

The lack of macrovegetation predicts less diverse fauna. Pelagic environments are dominated by *Keratella*, *Brachionus*, *Hexarthra* and *Polyarthra* species, while on eutrophic waters *Trichocerca* and *Filinia* species are common (Castro *et al.* 2005).

At a former investigation in 1950–1951 (Székelyné 1954) 66 species and 14 varieties were found. Various places were sampled: coastal area, open water, among the vegetation, sediment and tekton, though the exact place is not known, the description suggests that at Pool 3, between the sluice and “Hattyasi átjáró”. Constant and high level of plankton species was detected. The relation of the species differed from that of nowadays: the former most common species, *Testudinella* and *Lepadella* decreased, while *Brachionus* species became more usual by this time.

In 2000–2001, Rédei (2002) found only 11 species in this pool, most of them were *Brachionus* species. He investigated the neighbourhood of the sluice.

The difference in the rotifer fauna between these two investigations show a radical change in the water quality. From 1962, the pool served as sewage container, and the pumping station of Hattyasi („Hattyasi szivattyútelep”) pumped the sewage water to the Tisza. The mud of the sewage added much to the decrease of the water quality (Jusztinné 2001).

With the load of organic materials, bacteria proliferate, they use the oxygen of the water body, and other organisms die out. Anaerobic bacteria and organisms that tolerate the lack of oxygen appear in large numbers (Felföldy 1981).

Though an influence of the weather was detected, the parameters of the water were more constant at site 1, than those of at the four other sites, where the most important influencing factors were thermal, salty inflowing water, mainly in spring and autumn, and the easily changing parameters caused by the shallowness. After opening the sluice, conditions became more similar in the two pools, except site 5, which was too far from the sluice.

Though many investigations showed that pH, water temperature, conductivity and transparency have a great influence on the composition and density of zooplankton (Spoljar *et al.* 2005 and Devetter 1998), they could not modify the fauna here. An important, but not measured factor must be dissolved oxygen level. Balázs (2003) could detect near 0 level of dissolved oxygen even in laboratory, and none at the surface water in the field at Pool 3, on the other hand laboratory measurement showed about 100 times higher level of oxygen at the water of „Fehér-part”.

It was raining many times in 2005, which caused frequent openings and closings of the sluice. According to the flow, there might have been a higher level of dissolved oxygen, which could have helped the rotifers to survive longer and in higher numbers in individuals than during the year of the former investigation.

Seasonality was pointed out, but the sampling points did not differ much from each other during a sampling season. The exception was October, when the sluice was not opened, rotifers did not flow into the pool, and according to the conditions: possibly the lack of oxygen, or the higher salt concentration – above 2–3 g/l NaCl concentration rotifers are unable to reproduce (Sarma *et al.* 2006) – there were almost no rotifers in the samples. At the other end of the pool, water was clearer, and the fauna consisted of

several very abundant species, and some less abundant species that were found only at site 5.

These prove that the pool between the „Fehér-parti átjáró” and the „Hattyasi átjáró” has no constant rotifer fauna. Most (or maybe all) individuals come from the neighbouring pool after opening the sluice. After the flow is interrupted, rotifer level decreases due to oxygen-lack, some toxic substances or invertebrate predators (Williamson 1983).

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## COMMUNITY BOUNDARIES AND EDAPHIC FACTORS IN SALINE-SODIC GRASSLAND COMMUNITIES ALONG AN ELEVATION GRADIENT

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*Zalatnai, M., Körmöczi, L. and Tóth, T. (2007): Community boundaries and edaphic factors in saline-sodic grassland communities along an elevation gradient. – Tiscia 36, 7-15.*

**Abstract.** In the characteristic saline-sodic grassland of Miklapusza a 15 m transect with 30 cm elevation difference was delineated. After the survey of 150×6 micro-quadrates and soil sampling in each 10 cm interval, the vegetation boundaries and soil-plant relationships were studied with moving split window (MSW) and correlation techniques.

Our objective was to test how precisely can the visible boundaries of the community patches distinguished during field observation coincide with the boundaries determined by MSW from the vegetation and soil data. Data showed that the best coincidence of the boundaries was in the depression, the most saline and sodic part of the transect. The interpretation of the data supported the hypothesis, that the higher the soil salinity and sodicity, the better is the coincidence of the vegetation and soil section boundaries.

*Keywords: moving split window, environmental gradient, soil parameters, solonchak-solonetzic soil*

**Nomenclature:** Borhidi (2003) for coenotaxa.

**Abbreviations:** MSW – moving split window, SED – Squared Euclidean Distance, DREN – complement of Renkonen similarity index, EC – electrical conductivity

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### Introduction

Zonation along elevation gradients is one of the basic features of vegetation distribution (Whittaker 1975). The zonation of plant community patches and the establishment of their boundaries are generally closely related to the edaphic factors (Begon *et al.* 1986, van der Maarel 1976). Sharp vegetation boundary occurs between the communities of edaphic grasslands at those places where there are abrupt changes in edaphic parameters, and the boundaries are wider if the variation of edaphic parameters is gradual (Hobbs 1986, Begon 1986).

In the case of saline areas the spatial pattern of the vegetation is often micromosaic-like and the zonation appears at small distances due to the strong

ecological stresses of soil salinity, sodicity, alkalinity and waterlogging/drought (Bodrogközy 1965, 1970, Tóth *et al.* 1991, Tóth and Rajkai 1994). The variation of the above edaphic parameters is often abrupt at small distances, which is highlighted by the vegetation boundaries (Zalatnai and Körmöczi 2004).

In Hungary, a country with a wide range of soil conditions, there are large areas covered by natural and semi natural grassland vegetation (Fekete and Varga 2006). Recently much interest has been focused on the saline and sodic grasslands (Molnár and Borhidi 2003), because there is a tendency of decreasing soil salinity (Harmati 2000) and changing vegetation in the central part of Hungary (Molnár and Borhidi 2003). A range of techniques is being tested for monitoring the changes, such as satellite

imagery and aerial photos for detecting shifting boundaries of microerosional mounds (Rakonczai and Kovács 2000). From a vegetation ecologist's point of view it is important to follow the temporal changes in the vegetation boundaries in those saline grasslands and to reveal the strength of the relationships of the boundaries with edaphic parameters.

There are several methods for the examination of vegetation boundaries (Kent *et al.* 1997, 2006, Fortin and Dale 2006). We applied moving split window (MSW) boundary analysis that was used first by soil scientists (Webster 1973) and recently is applied by ecologists to detect ecotones and landscape boundaries from one and two dimensional data sets (Johnston *et al.* 1992. ) and in two publications we already tested the methods in fine-scale studies (Zalatnai and Körmöczi 2004, Körmöczi 2005).

In this paper we described the soil-plant relationships and the establishment of their boundaries in the zonation of saline-sodic grassland communities along an elevation gradient.

Our basic questions were:

1. Do the boundaries of the vegetation units, visible in a field observation, coincide well with the boundaries determined by MSW from the vegetation and soil data?

2. How strong is the relationship between the elevation and the dependent edaphic parameters and the establishment of community boundaries?

3. Does increasing soil salinity level result in sharper boundary between vegetation patches?

## Materials and methods

### Study region

The sampling region was Miklapusztá, the largest alkali habitat complex of the Danube-Tisza interfluvial region; it belongs to the territory of the Kiskunság National Park, Hungary. The area is a mosaic complex of the patches of diverse halophytic habitats, such as salt marshes, saline meadows, alkali bare hollow communities and saline pusztá (Horváth 1997). It is situated in the middle of the Danube valley, its total area is 6241 ha. The climate of the region is continental, with mean January temperature of  $-1.4$ , mean July temperature of  $21.8$  °C, and mean annual temperature of  $10.7$  °C. Mean annual precipitation is 577 mm. It was the former floodplain of the river Danube which was built up in the middle Pleistocene by gravel and sandy gravel sediments. Later, silt and clayey silt layers were deposited above the fluvial sand in the Holocene and then these silt and clayey silt deposits have become salt affected in large areas in the Danube valley (Pécsi 1967).

### Sampling site

The sampling site was located in the south-west part of the area, near Felsőerek village (N  $16^{\circ} 36' 25''$  E  $19^{\circ} 05' 40''$ ).

It is dominated by solonchak and solonchak-solonetz soil types (Pécsi 1967) covered with different types of halophyte vegetation and meadow chernozem soil at higher elevation with glycophytic vegetation. The erosion activity of the former inundations and the water resulting from snow melting formed diverse microtopography. The erosion of the nonsaline A horizon and the high level of ground water resulted in varied environmental conditions due to the different surfaces of steps ("szik banks") characterised by distinct soil types, salt content, water supply and alkalinity. This special geomorphological formation has received already much attention by Strömpl 1931, Tóth 2001, Kovács *et al.* 2006. Due to the varied effects of the diverse environmental conditions, the plant communities are distributed in a zonation-like manner along the elevation, salt accumulation and soil water supply gradients (Horváth 1997).

In higher terrains *Achilleo setaceae-Festucetum pseudovinae* Soó 1933 corr. Borhidi 1996 association forms large stands (Horváth 1997). It is a species-rich, dry, slightly salt affected pasture; its soil type is meadow chernozem with higher salinity in greater depth below the zone of the roots, characterized by thick nonsaline A horizon (approx. 30 cm) and neutral soil reaction.

The characteristic association of the slopes and microerosional plateaus of "szik banks" is *Artemisio santonici-Festucetum pseudovinae* Soó 1933 corr. Borhidi 1996 (Horváth 1997). It is characterized by thin nonsaline A horizon (approx. 10 cm) and saline B horizon, slightly alkaline soil reaction, and extreme unbalanced water supply. The soil type is meadow solonetz. The vegetation is composed of halotolerant species. Here the stands are small and they have strongly transitional character.

At the foot of the slopes, at the lowest elevation where the A horizon is completely eroded, the plants can survive on the hard, saline B horizon under extreme habitat conditions where the salts accumulated close to the surface of the soil because of the high level of groundwater. Its soil type is solonchak, the soil reaction is alkaline. This vegetation zone is characterized by the halophyte and species poor *Lepidio crassifolii-Puccinellietum limosae* Soó 1947 association (Horváth 1997).

In the lowest depressions, small stands of *Agrostio-Caricetum distantis* Rapaics ex Soó 1938 are located on slightly solonchakized meadow soils (Horváth 1997). The soil reaction is slightly alkaline.

The soil surface is covered with shallow water in the spring period and can be wet during summer as well.

#### Vegetation sampling

We established a fine scale contiguous belt transect perpendicular to an ephemeral streamlet. Four different plant communities could be identified along the transect where the elevation, the level of salt accumulation and water content of the soil constituted the background gradients (Fig. 2). The communities were the following: *Achilleo-Festucetum pseudovinae* on higher elevation, on the szik bank, *Artemisio-Festucetum pseudovinae* on the slopes of the szik bank, *Agrostio-Caricetum distantis* in the lowest and wetter part of the depression and *Lepidio-Puccinellietum limosae* at the foot of the slope in the drier part of the depression (Fig. 2, Table 1).

Vegetation and soil samples were taken in regular arrangement. The transect was 15 m long and the largest elevation difference was 30 cm.

The transect consisted of 150×6 contiguous micro-quadrats, 10×10 cm size each. Presence/absence data of the plant species were recorded in the quadrats once in May of 2001. The location of the vegetation patches and boundaries were also observed visually along the transect.

#### Soil sampling and laboratory analysis

Soil sampling was done at the time of the vegetation relevés in regular arrangement. Samples were collected from the centre of the outermost quadrats of each row from 0-10 cm depth. Laboratory analysis of the soil samples was carried out according to Buzás (1988).

Soil pH was measured in 1:2.5 soil:water suspension with a glass electrode after 12 hour equilibrium time. Soil organic matter content was measured with spectrophotometer after wet oxidation by potassium dichromate and sulphuric acid. Na<sup>+</sup> ion content was measured in 1:5 soil:water suspension with flame photometer. Electrical conductivity (EC) was measured in 1:2.5 soil:water suspension with conductometer (WTW multi 340i).

#### Statistical analysis

First the presence/absence values (zero or one) of plant species were summed in the six microquadrats perpendicular to the main axis of the transect at each 10 cm interval, resulting in local frequency values ranging from 0 to 6 for each species. We used these local frequency values in moving split window and multivariate analyses.

The distribution of each species was visualized

along the transect from these frequency values (Fig. 1).

The moving split window technique (Webster 1973, Ludwig and Cornelius 1987, Johnston *et al.* 1992) was used to detect and characterise the boundaries between associations along the transect. Squared Euclidean Distance function (Brunt and Conley 1990) and the complement of Renkonen similarity index given by

$$DREN_{jk} = 1 - \sum_{i=1}^n \min \left\{ \frac{x_{ij}}{\sum_{i=1}^n x_{ij}}, \frac{x_{ik}}{\sum_{i=1}^n x_{ik}} \right\}$$

( $n$ : number of species,  $x_{ij}$ : frequency of species  $i$  in quadrat  $j$ ,  $x_{ik}$ : frequency of species  $i$  in quadrat  $k$ ) was used to compare the two halves –  $j$  and  $k$  – of the window. (For the detailed description of the methods see Zalatnai and Körmöczki 2004, Körmöczki 2005.). The same boundaries can be obtained by both functions but SED results in sharper peaks and it is more sensitive to differences in species abundance than DREN whereas DREN is more sensitive to differences in species composition than SED (Körmöczki 2005). We used both functions to make clear which factor is decisive in the development of the boundary zone in the transect.

Plotting the average Z-score transformed values of the SED function vs. window midpoint position results in a profile diagram where a significant peak is identified as a vegetation boundary. We computed the values of the function in several scales (half window sizes) from 1 to 20. In our case the half window size 1 means a 25 cm segment of the transect.

The significance of the peaks was tested with the Z-score transformation of the squared Euclidean distance values (Cornelius and Reynolds 1991, Hennenberg *et al.* 2005). Z-score transformation is given as:

$$Z = \frac{d_{i,k} - \bar{d}_{exp.,k}}{SD_{exp.,k}}$$

where  $d_{i,k}$  is the SED value for the  $i^{\text{th}}$  window midpoint position for  $k$  half-window size,  $\bar{d}_{exp.,k}$  is the overall mean SED value from randomized data for  $k$  half-window size (expected mean), and  $SD_{exp.,k}$  is standard deviation of SED values from randomized data for  $k$  half-window size.

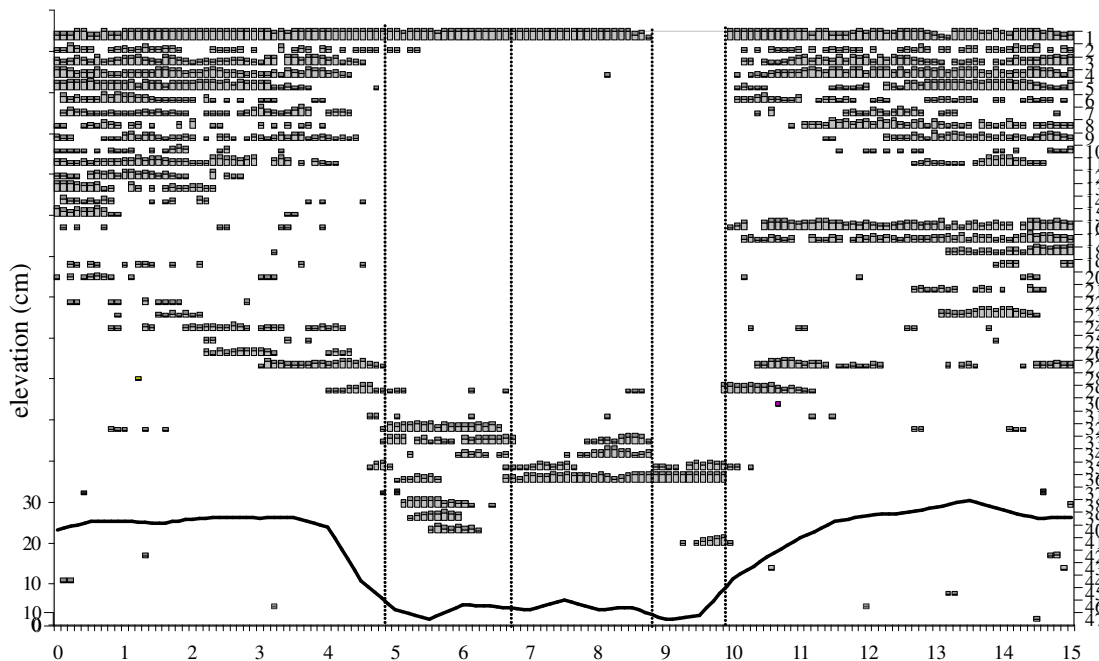


Figure 1. Spatial distribution of local frequency of the plant populations along the transect. The broken lines sign the boundaries revealed by MSW analysis, elevation is also indicated. The plant species are marked by numbers:

1. *Festuca pseudovina*, 2. *Ornithogalum umbellatum*, 3. *Cynodon dactylon*, 4. *Achillea setacea*, 5. *Medicago falcata*, 6. *Potentilla arenaria*, 7. *Vicia angustifolia*, 8. *Koeleria cristata*, 9. *Thymus glabrescens*, 10. *Plantago lanceolata* 11. *Galium verum* 12. *Carex liparicarpos*, 13. *Stipa capillata*, 14. *Centaurea pannonica*, 15. *Bromus inermis*, 16. *Cerastium semidecandrum*, 17. *Erophila verna*, 18. *Arenaria serpyllifolia*, 19. *Poa angustifolia*, 20. *Veronica prostrata*, 21. *Fragaria viridis*, 22. *Gypsophila muralis*, 23. *Chrysopogon gryllus*, 24. *Euphorbia cyparissias*, 25. *Plantago media*, 26. *Botriochloa ischemum*, 27. *Agropyron repens*, 28. *Scabiosa ochroleuca*, 29. *Artemisia santonicum*, 30. *Plantago maritima*, 31. *Podospermum canum*, 32. *Lotus corniculatus*, 33. *Aster tripolium*, 34. *Carex stenophylla*, 35. *Lepidium crassifolium*, 36. *Puccinellia limosa*, 37. *Bromus mollis*, 38. *Agrostis stolonifera* 39. *Juncus gerardii*, 40. *Hordeum hystrix*, 41. *Camphorosma annua*, 42. *Leontodon autumnalis*, 43. *Medicago minima*, 44. *Asperula cynanchica*, 45. *Veronica spicata*, 46. *Salvia pratensis*, 47. *Carduus nutans*.

Random reference was made with Monte Carlo method: the population patterns were randomly shifted compared to each other (Horváth 1998), thus the distributions of the single populations remained unchanged. SED or DREN values were then computed for each window position. Overall mean and standard deviation of distances were calculated after 1000 randomization, these are considered as expected values. Expected means and standard deviations were computed for each window sizes. The differential profiles were then drawn from Z-scores averaged over 1 to 20 half-window sizes.

As the distribution of the expected mean is very close to normal distribution, Z-scores greater than 1.65 are considered significant at 5% probability level and Z-scores greater than 1.28 are considered significant at 10 % probability level.

The measured abiotic parameters (elevation, pH, organic matter, Na<sup>+</sup> ion content, EC) were also

analyzed by MSW with the application of SED function, before the analysis they were standardized by the range. For the average Z-score profile diagram of abiotic parameters the same significance test was used as for the vegetation data.

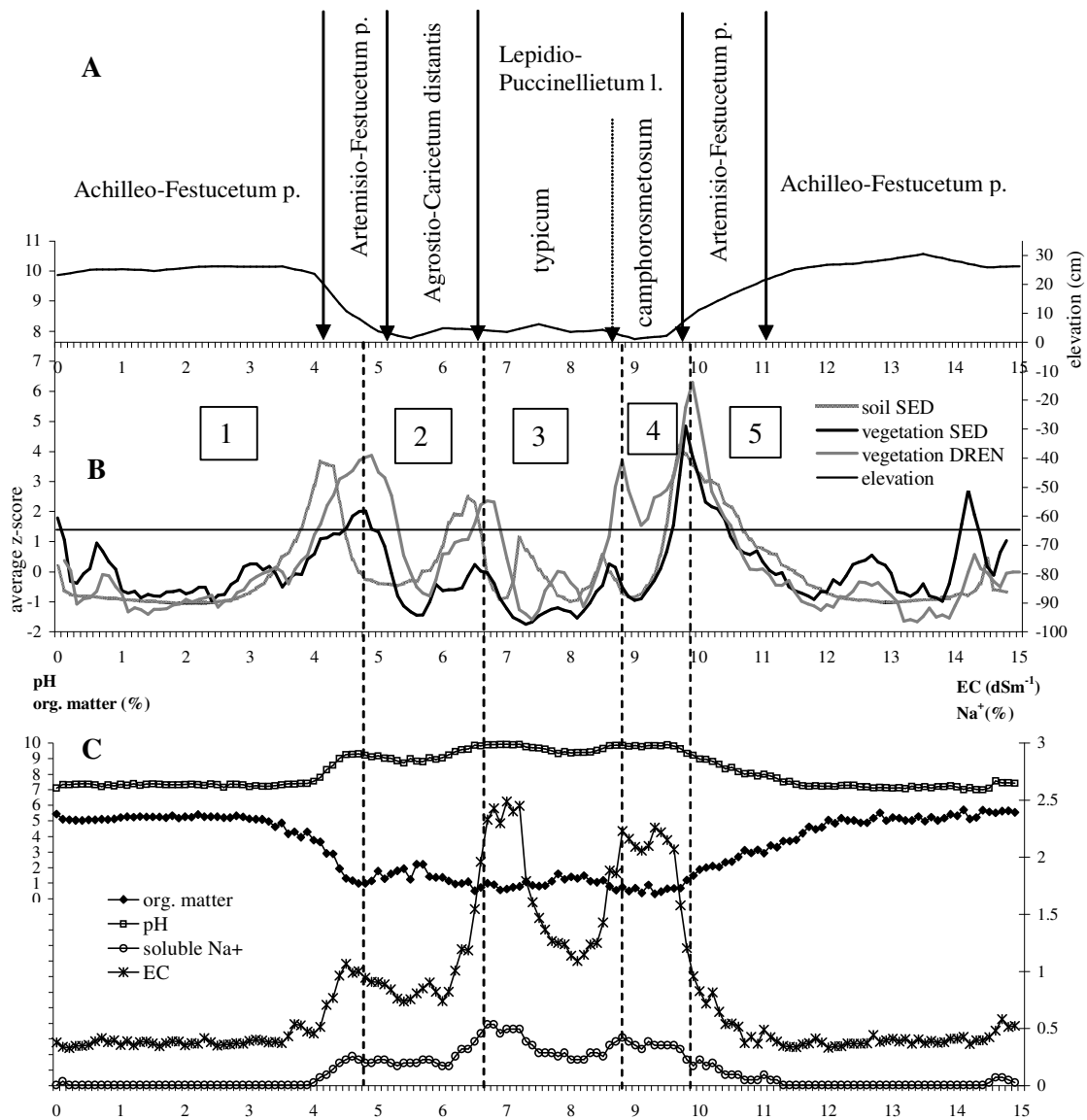
Pair-wise correlations were computed between the measured abiotic parameters (elevation, pH, organic matter, Na<sup>+</sup> ion content, EC) with SPSS 11 program package to reveal their interdependence.

Finally, in the five vegetation sections separated by MSW (Table 2), we examined the relationships between the above abiotic parameters and the local frequency values of plant species via factor analysis (Tóth *et al.* 1995, Boeye and Verheyen 1994). In each section we computed with exploratory PCA the first factor from the abiotic parameters and with a separate computation the first factor from the frequency values of the plant species in the same section. Than in each section we computed the



Pearson-correlation coefficient between the respective first factors of abiotic parameters and of the local frequency values of plant species. SPSS11

program package (Howitt and Cramer 2002) was used in factor analysis and computing correlation coefficients.



**Figure 2.** A: The spatial distribution of the community patches along the transect and the elevation profile of the transect. Arrows sign the visual boundary of the communities B: Average Z-score profile diagrams of vegetation (with SED and DREN functions) and soil factors (with SED function) obtained by MSW along the transect. Z-scores are averaged over 1-20 half window sizes. C: Changes of the abiotic parameters (pH, Na ion content, EC, organic matter content) along the transect. The broken lines sign the boundaries revealed by MSW analysis.

## Results

### *The distribution of the populations along the transect*

Individuals of 47 plant populations occurred along the transect local frequency distribution of which is presented in Fig. 1.

The populations correspond well with the five community patches. The separation of the patches is clear, the spatial distribution of only few species overlap in certain degree.

### *MSW analysis*

In the case of the vegetation data four sharp peaks appeared on the average Z-score profile with DREN function and five sharp peaks appeared with SED function (Fig. 2.B). The shape and the location of four peaks with both functions coincided well and separated the vegetation into five section, these sections were referred in Table 2. At 14.5 m only SED function reaches a significant peak but it is rather close to the end of the transect thus cannot be considered.

Table 1. The spatial distribution of the community patches along the transect by visual observation

<i>Achilleo-Festucetum pseudovinae</i>	0-4.2 m, 11.1-15 m
<i>Artemisio-Festucetum pseudovinae</i>	4.2-5.2 m, 9.8-11.1 m
<i>Agrostio-Caricetum distantis</i>	5.2-6.6 m
<i>Lepidio-Puccinellietum typicum</i>	6.6-8.7m
<i>Lepidio-Puccinellietum camphorosmetosum</i>	8.7-9.8

Table 2. Vegetation sections along the transect made by MSW

1.	2.	3.	4.	5.
0-4.8 m	4.8-6.7 m	6.7-8.9 m	8.9-9.9 m	9.9-15 m

All of the DREN peaks were significant but only two SED peaks were significant. Since the saline grasslands generally have few species, the values of the SED function were low. Therefore we consider vegetation boundary where DREN or both functions have significant peak.

The location of the peaks coincided in three cases with the visual boundary of the community patches (Table 1, Fig. 2.A,B) but the peak at 4.8 m is located between the two visual community boundaries.

In the case of the soil parameters, the MSW analysis showed three marked significant peaks. The peak at 9.9 m coincided well with the peaks of the vegetation data but in the position of 4.2 and 6.5 m the peaks of soil and vegetation data were in 60 cm and 20 cm distances, respectively.

The peak at 4.2 m coincided well with the visual boundary of community patches.

### *Soil conditions*

Changes in the values of pH, electrical conductivity, soluble Na<sup>+</sup> ion content and soil organic matter content were plotted against the relative elevation (Fig. 2.C) along the transect. pH was neutral (approximately 7) on the szik banks. The soil reaction of the slopes was slightly alkaline (between 7 and 9 pH) and that of the depression was strongly alkaline (between 9 and 10 pH). Soluble Na<sup>+</sup> ion content was zero on the top of the szik bank, on the slopes and on the depression it ranged from 0 to 0.6%. The values of the electrical conductivity were low on the top of the szik bank (between 0.3 and 0.5 dS/m), and ranged from 0.5 to 1 dS/m on the slopes and from 1 to 2.5 dS/m in the depression depending on the elevation. The organic matter content was high on the top of the szik bank, it changed between 5% and 6 %, between 2% and 4% on the slope, and between 0 and 2% in the depression depending on the elevation.

Organic matter content values positively correlated with the elevation: they were high on the top of the szik bank and decreased continuously on the slopes until reaching a minimum at the depression. pH values showed large variation along the transect and closely correlated with either electrical conductivity or Na<sup>+</sup> ion content. pH, Na<sup>+</sup> ion content and electrical conductivity correlated negatively with the elevation, their values were low on the top of the szik bank and increased continuously on the slopes until reaching their maximum at the depression.

Table 3. Pair-wise correlations between the measured abiotic variables.

	organic matter	pH	EC	soluble Na
elevation	0.961**	-0.970**	-0.820**	-0.910**
organic matter	-	-0.977**	-0.831**	-0.912**
pH		-	0.891**	0.959**
EC			-	0.959**

\*\* Correlation is significant at the 0.01 level (2-tailed).

The pair-wise correlations were significant ( $p < 0.01$ ) between the measured abiotic parameters, indicating that the saline-sodic grassland had very strong organization (Table 3). Elevation is the most important factor with respect to the soil properties, as all other variables depend on it. Therefore the correlation between each pair of variables is statistically significant. It is the salt accumulation that primarily depends on the elevation increasing with the decrease of relative height, and therefore there is a negative correlation between these two variables. Electrical conductivity depends basically on the Na<sup>+</sup> ion content, therefore the higher the Na<sup>+</sup> ion content the higher the EC is. pH depends on the

salt content in this soil which contains dominantly sodium-carbonate. The higher the Na ion content the less the microbial activity and plant biomass are, that is to say soil organic matter content. Therefore there is a negative correlation between soil pH, EC, and Na<sup>+</sup> ion content and soil organic matter, and there is a strong positive correlation between the elevation and soil organic matter. This pattern is also strongly affected by the water supply: precipitation water regularly accumulates in the depression.

Table 4. Pearson correlations between the first factors of the measured abiotic parameters and those of the frequency values of plant species in the five sections of the transect.

	1	2	3	4	5
	0-4.8 m	4.9-6.7 m	6.8-8.9 m	9-9.9 m	10-15 m
Correlation coefficient	-0.685	0.533	-0.569	-0.859	-0.814
Level of significance	0.01	0.01	0.01	0.01	0.01

The results of the factor analysis showed that in the five vegetation sections separated by MSW the correlation coefficients were significant ( $p < 0.01$ ) between the first factors of the soil parameters and those of the abundance values of the plant populations (Table 4). The strongest correlation in absolute value was found in the fourth and the fifth sections where the peaks in the average Z-score profile were the highest between the fourth and fifth section (Fig. 2.B).

## Discussion

The closest coincidence (less than 10 cm horizontal difference) of the visible boundaries and the boundaries determined by MSW from the vegetation and soil data was at 10 m between the *Lepidio-Puccinellietum limosae camphorosmetosum* and *Achilleo-Festucetum pseudovinae* (sections 4 and 5). Between these two sections each MSW peaks (DREN, SED, soil data) were significant and their positions were the same. In these two sections the correlation was the largest (Table 4) between the first factors of the local frequency of plant populations and those of the soil parameters, therefore it can be stated that the species composition and the variation of the species composition strongly dependent on abiotic conditions in this section. Inside both sections the horizontal change of the values of the soil parameters were the highest (Fig. 2.C) and the species composition changed with the continuous change of the soil parameters by the transect (Fig. 1).

Between sections 3 and 4 (boundary of the two subassociations of *Lepidio-Puccinellietum limosae*)

the visible vegetation boundary and MSW peaks of DREN and SED coincided, although the peak of SED was not significant because of the low species number (4-5 species). The MSW peak of soil data was not significant because the rate of change in the values of soil parameters was low and the elevation difference was small too.

Between the sections 2 and 3 (boundary of the *Agrostio-Caricetum distantis* and *Lepidio-Puccinellietum limosae*) the visible vegetation boundary and the MSW peaks of DREN and SED coincided, although the peak of SED was not significant because of the low species number (4-5 species). The MSW peak of soil data did not coincide well with the MSW peaks of DREN and SED, there was 30 cm lateral difference. Although the elevation difference was small, the rate of lateral change in the values of EC and Na ion content was high, consequently the MSW peak of the soil data was significant.

Between sections 1 and 2 (inside the community of *Artemisio-Festucetum pseudovinae*) the visible vegetation boundary, the MSW peaks of DREN and SED and the MSW peak of soil parameters did not coincide. The DREN and SED peaks were formed in the middle of *Artemisio-Festucetum pseudovinae* community patch and the MSW peak of the soil parameters coincided with the visible boundary of *Achilleo-Festucetum pseudovinae* and *Artemisio-Festucetum pseudovinae*. Inside the area of *Artemisio-Festucetum pseudovinae* there is an abrupt change in the elevation and soil parameters and they have intermediate values between the szik bank and the depression, thus they indicate environmental conditions in which the characteristic species of the two vegetation patches co-occur and *Artemisia santonicum* occurs only here (Fig. 2). Zalatnai and Körmöczi (2004) had similar result in the same sampling site. According to their explanation this 1 m wide vegetation zone cannot be considered as a distinct community here, but this patch should be considered as an ecotone (van der Maarel 1990).

There is a similar situation in the other slope of the szik-bank with *Artemisio-Festucetum pseudovinae*, between 9.9 and 11 m, where the visible boundary between *Artemisio-Festucetum pseudovine* and *Achilleo-Festucetum pseudovinae* could be justified with neither MSW analysis nor multivariate methods (Zalatnai and Körmöczi 2004). There was not large difference in the species composition between *Artemisio-Festucetum pseudovinae* and *Achilleo-Festucetum pseudovinae*, except the occurrence of *Artemisia santonicum*. In the patch of *Artemisio-Festucetum pseudovinae* the rate of

change of soil parameters was large, although the alteration in elevation and soil parameters were gradual.

There was a significant SED peak at 14.5 m, but it was not considered a boundary, because there was not significant change in the species composition nor in the edaphic parameters. At this location a small depression was formed, where EC and Na<sup>+</sup> ion content became larger, but not each soil parameters changed. The vegetation highlighted this small variation at this point and some species disappeared (*Chrysopogon gryllus*, *Galium verum*), whereas other species appeared (*Plantago lanceolata*, *Agropyron repens*) and the abundance of certain species changed (*Cynodon dactylon*, *Thymus glabrescens*, *Arenaria serpyllifolium*) and all these changes resulted in the increase of the values of SED function.

Our results showed that the boundaries determined by MSW from vegetation and from soil parameters were coincident precisely only in one case. In the other three cases the MSW peaks of soil parameters were situated in the graph (Fig. 2.B) prior to the peaks of the vegetation data, the difference between the two kinds of peaks were 20, 30 and 60 cm, respectively. This was caused by the fact that the vegetation boundary (both visual and MSW determined) was situated where the values of the soil parameters reached their local maxima or minima and remained at those values throughout the given section. On the contrary the MSW boundaries of the soil parameters appeared, where the rate of horizontal change in the values of soil parameters was the largest. This means that the vegetation boundaries were formed at the point where the soil parameters remained unchanged and not in the section of the change. It seems that the vegetation follows with a delay the horizontal changes of the soil parameters. At the point where the MSW peaks of the vegetation and of soil data coincided precisely each soil parameters showed intense and simultaneous changes.

The establishment of the vegetation boundaries was strongly influenced by soil parameters as shown by the correlation values (Table 2) which are not smaller than those reported by Tóth *et al.* 1995 in saline grasslands. The elevation has determining role in the variation of edaphic parameters and the zonation of the vegetation patches. In the depression small elevation differences resulted in a change of species composition (Fig 2.A,B). The reason for it was that the limiting effect of the high soil salt content in the depression was influenced by the temporal waterlogging resulting from differences of the elevation. We concluded that the higher the soil

salinity, the stronger is the role of elevation in the separation of vegetation patches (Tóth and Rajkai 1994).

## Conclusions

The differences between the species composition of community patches and the position of the community boundaries can be explained principally by the elevation differences and the related variation in salinity, sodicity and alkalinity along the transect.

The salinity, sodicity and the rate of change in edaphic parameters are the most important factors behind the coincidence of the visual vegetation boundaries and MSW boundaries of vegetation and soil parameters. The larger the salinity, sodicity and the rate of lateral change of edaphic parameters along the transect, the better is the coincidence of this three types of boundaries.

The narrow community belts of *Artemisio-Festucetum pseudovinae* have special state here because neither MSW nor multivariate methods could separate these as independent community patches. According to our earlier and recent results, these narrow vegetation zones should be consider rather ecotones than independent community patches.

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## EXTRA-PAIR PATERNITY OF TREE SPARROW (*PASSER MONTANUS*) IN A SEMI-URBAN POPULATION

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Seress, G., Szabó, K. Nagy, D., Liker, A. and Péntzes, Zs. (2007): Extra-pair paternity of Tree Sparrow (*Passer montanus*) in a semi-urban population. – *Tiscia* 36, 17-21.

**Abstract.** The level of extra-pair paternity (EPP) of birds is investigated in a great number of studies, revealing high variance in this trait among bird species. EPP in the House Sparrow, *Passer domesticus* has been also reported by many authors but there are much less data on the promiscuous behaviour of the closely related Tree Sparrow, *Passer montanus*. In this paper we tested whether microsatellite markers developed for House Sparrows are suitable for determining the level of EPP in a Tree Sparrow population. Three of seven candidate loci (Pdo3, Pdo5 and Pdo9) showed appropriate level of polymorphism and were used in the paternity analyses. We found that 9.2% of the chicks (76/7) were sired by extra-pair mates and 21.05% (19/4) of the broods contained at least one extra-pair young (EPY).

**Keywords:** *Tree Sparrow (Passer montanus), extra-pair paternity, microsatellite*

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### Introduction

In the last 15 years it has become evident that social and genetic mating systems are different in many species, particularly in birds. It is now accepted that genetic mating systems cannot be predicted by simply observing the pattern of social bonds. The advances of the methods in paternity analysis have shown that promiscuous behaviour (the occurrence of extra-pair paternity, EPP) is common in many apparently socially monogamous species (Birkhead and Moller 1992, 1998). This means that the extra-pair young (EPY) are sired by a male other than the single putative father in socially monogamous species, whereas in polyandrous species, extra-pair young are those sired by a male outside of the social bond. EPP are common even among socially monogamous bird species: molecular genetic applications have revealed that, based on a review of 150 studies with near 130 Passerine species, true genetic monogamy (no EPP) has been

found in less than 25% of the studied socially monogamous species (Hasselquist and Sherman 2001). According to this dataset, average frequency of extra-pair youngs in socially monogamous species was 11.1 %

There is a remarkable variation among species and populations in the frequency of extra-pair copulations (EPC, Ligon 1999). It has been suggested that differences in individual quality or age (Moller and Ninni 1998), as well as ecological factors (e.g. breeding density, Wink and Dyrce 1999, Westneat and Sherman 1997), and behavioural responses to ecological factors (such as breeding synchrony, Stutchbury and Morton 1995) might have an influence on the level of extra-pair fertilizations (EPFs) within species.

To understand the variation in the frequency of EPCs we also have to consider the potential costs and benefits of this behaviour for both sexes. For males, it is obvious that they can easily enhance their reproductive success with the extra-pair copulations

(if it results in EPP). On the other hand, seeking of EPCs can be costly by reducing the male's effectivity in mate guarding, parental care, territorial defence or self-advertisement (e.g. Poston *et al.* 1998, Sherman and Morton 1988) or increasing his chances to get infected by parasites (Sheldon 1993). For females, EPCs may yield direct benefits, e.g. access to good territories or other kind of resources (Hunter and Davies 1998), additional help in parental care (Wagner 1992), insurance of fertile mating (Wetton and Parkin 1991). The female may gain indirect benefits from EPCs in form of "good genes" (Gowaty 1996, Hasselquist *et al.* 1994) or increased genetic diversity in the brood (Westneat *et al.* 1990). Costs for the females may include the increased risk of getting sexually transmitted diseases (STDs, Lombardo and Thorpe 2000, Westneat and Rambo 2000) aggression by the extra-pair male's mate (Mays and Hopper 2003) or the retaliation by their social mate. Namely, the social mate can respond to the cuckoldry by physical retaliation (Westneat *et al.* 1990), by reducing parental care (Chuang-Dobbs *et al.* 2001a, Moller and Cuervo 2000, Moller and Birkhead 1993a), or by deserting the female (Cézilly and Nager 1995). Finally, females sometimes do not resist unsolicited EPCs from unknown, nonpreferred males when resistance to this sexual harassment could result in physical injuries (e.g., McKinney and Evarts 1998, Frederick 1987).

The promiscuous behaviour of the House Sparrow *Passer domesticus* has been widely investigated (e.g., Griffith *et al.* 1999, Cordero *et al.* 1999, Wetton *et al.* 1995), but to our best knowledge, only one study has examined the frequency of EPFs in the closely related Tree Sparrow *Passer montanus* (Cordero *et al.* 2002). In this paper, authors have investigated the frequency of EPFs in two separated Tree Sparrow populations. Using single-locus minisatellites developed for House Sparrow, as well as universal multilocus DNA-fingerprinting probes, they found that 8 and 10% of the nestlings were sired by extra-pair mates.

Despite of the fact that there are many microsatellite markers developed for House Sparrow (e.g. Neumann and Wetton 1996, Griffith *et al.* 1999), there are no such specific markers for Tree Sparrow. In this study, therefore, we had two main goals: first, our aim was to test whether microsatellite markers developed for House Sparrow could work on Tree Sparrow, showing sufficient level of polymorphism to use them in paternity analyses. Second, we examined the frequency of extra-pair fertilizations (EPFs) in a Tree Sparrow population.

## Methods

### *Fieldwork*

We studied a nestbox colony population of Tree Sparrows living in an urban park in Szeged, South-East Hungary. Nestboxes were arranged on the trunks of a platan (*Platanus hybrida*) avenue at a height of 5-6 meters and approximately 10-15 meters apart. Adult birds were captured using mist nets during the whole year, from November 2005 to August 2006. They were ringed and individually marked with a unique combination of three colour rings. Blood samples (ca. 20-50 ml) for parentage analyses were also taken by puncturing their ulnar vein. Samples were stored in Queen's lysis buffer (Seutin *et al.* 1991) at 4 °C until laboratory procedures.

In the breeding season, captured adults were sexed by the presence of the incubation patch (Summers-Smith 1995). When possible, sex was confirmed by the observation of sex-specific behavioural traits (displaying, mating, nest defence, provisioning or incubation).

In March, 2006 we started to monitor the nestbox occupation of the Tree Sparrows. For each nest, observed social parents were recorded (if they had been already ringed), standard reproductive biology traits (date of egg laying, clutch size, length of the incubation period, hatching date and success, length of the provisioning period, and number of the fledgelings leaving the nest) were registered during the whole breeding season. Blood samples were taken also from the nestlings (when they were 8-12 days old), with the same procedures as in the case of adults. Broods of altogether three breeding attempts were involved in this study.

All manipulation of the birds was carried out under the appropriate licenses and complied with the current laws of Hungary where the study was undertaken.

### *Molecular sexing*

DNA extraction from blood samples was performed with standard proteinase-K/phenol-chloroform extraction (Kawasaki 1990). Since the Tree Sparrow is sexually monochromatic, male and female birds are almost indistinguishable in the hand. Sexing of adult birds by the presence of incubation patch is feasible only in the breeding season, therefore, sex of adult birds were confirmed by molecular sexing techniques. This was performed by the amplification of the CHD1-W and CHD1-Z genes (Ellegren and Sheldon 1997) using the primers

2550F and 2718R (Fridolfsson and Ellegren 1999). PCR products were separated by electrophoresis using 1% agarose gels containing ethidium bromide and visualized under UV light. Sexing of nestlings were performed with the same procedures as in the case of adults. The results of field and molecular sex determination were matching in almost all cases (34 of 35 adult birds captured in the breeding period).

#### *Microsatellite optimisation and analysis*

Seven candidate microsatellite loci were tested on our Tree Sparrow samples (Table 1). Six of these markers were developed for House Sparrow (Pdo1, Pdo2, Pdo3 [Neumann and Wetton 1996], Pdo5 [Griffith *et al.* 1999], Pdo8 [GenBank: AF354422], Pdo9, AF354423) and one for the Superb Fairy-wren *Malurus cyaneus* (McyU4, Double *et al.* 1997). The level of polymorphism was estimated on ten adults selected randomly. Loci with more than two alleles were considered to be polymorphic.

In each primer pair, forward primers were fluorescently labelled on the 5'-end with HEX, JOE or FAM-6 dyes (Applied Biosystems Inc.) for further visualization of the PCR products. PCR reactions consisted of approximately 100 ng of template DNA, 0.5 µM of each primer, 0.2 mM dNTPs, 2 mM MgCl<sub>2</sub>, 1 unit of Taq dna polymerase (Fermentas) and the 10X Taq buffer in a final volume of 25 µl. At every examined locus, we gained the predicted size of PCR products, but only three of them showed appropriate level of polymorphism: Pdo3, Pdo5 and Pdo9 (Table 1). Further genotyping of the sparrow families were therefore performed using these three loci. To resolve alleles, amplified PCR products were analyzed on an Abi Prism 3100 Genetic Analyzer (Applied Biosystems Inc.) at the Biomi Ltd. (Gödöllő, Hungary) using ROX-labeled ILS-

600 internal standard (Promega). The data were analyzed with the GeneScan software (Applied Biosystems Inc.).

#### *Data analysis*

As there were cases where only one parent was known to us, we had several incomplete families to work with. In this cases we used the number of the different alleles in each brood to determine the presence of extra-pair paternity. In families where alleles of one parent were unknown to us we analysed only broods with at least three offsprings, because the detection of the extra pair alleles is impossible with fewer chicks. When we found five or more alleles in a brood we considered that a result of EPP.

Because of the low number of suitable microsatellite loci, chicks were regarded as extra-pair young (EPY) only when alleles were mismatching leastways at two different loci. Since microsatellite loci show a high mutation rate, we did not consider a young as an EPY when it had mismatching allele(s) at only one locus. We used this method to minimize the effects of genotyping errors and occurrent mismatching alleles between real descendants caused by the high mutational rate of microsatellites (Jarne and Lagoda 1996).

We assumed that two random individuals (potential fathers) matching in two or three examined loci is a very rare event in the population. Therefore, our assessment must be conservative.

To determine the parentage, we first examined whether the hypothetical (observed) female was the mother of all young in the brood. When we found nestlings with alleles different from the supposed mother's alleles, the brood was excluded (in the case of two broods).

Table 1. Details of the microsatellite loci involved in the microsatellite optimization. The three loci typed bold were used for genotyping.

Locus name	GeneBank Acc. No.	Repeating motif	Originally described on	Size of the PCR products on the original species	Number of alleles in the original species	Size of PCR product in <i>P. montanus</i>	Number of alleles in <i>P. montanus</i>
pdo1	X93503	TG	<i>P. domseticus</i>	154-208 bp	14	154 bp	1
pdo2	X93504	TG	<i>P. domseticus</i>	170-208 bp	13	170-172 bp	2
pdo3	X93506	CCAT	<i>P. domseticus</i>	113-167 bp	14	117-145 bp	8
pdo5	Y15126	TG	<i>P. domseticus</i>	203-259 bp	16	222-261 bp	10
pdo8	AF354422	GA	<i>P. domseticus</i>	193-229 bp	15	179-191 bp	2
pdo9	AF354423	ATT	<i>P. domseticus</i>	375-426 bp	14	408-461 bp	9
mcyu4	U82388	GT	<i>M. cyaneus</i>	178-200 bp	11	170-172 bp	2



Table 2. Detailed data of the breeding biology and data collection

	1st attempt	2nd attempt	3rd attempt	Total
Number of broods investigated	14	14	11	43
Successful <sup>1</sup> broods	13 (93%)	11 (78%)	7 (46%)	31 (72%)
Number of broods involved in genotyping	9	8	6	23
Number of broods involved in paternity analysis <sup>2</sup>	8	7	4	19
Total number of eggs laid	83	90	70	243
Average egg number in broods	5.93	6.42	4.6	5.65
Number of eggs successfully hatched	57 (69%)	55 (61%)	26 (37%)	138 (57%)
Fledged chicks and fledging success <sup>3</sup>	50 (60%)	41 (45%)	19 (27%)	117 (48%)
Number of chicks taken blood from	36	32	19	87
Number of chicks involved in paternity analysis <sup>4</sup>	35	29	12	76

<sup>1</sup>: At least one fledged young per brood.

<sup>2,4</sup>: Some of the broods were excluded, in cases when we found nestlings with alleles different from the supposed mother's alleles.

<sup>3</sup>: Compared to the number of laid eggs.

Differential mortality within brood may also affect the estimation. No significant mortality had been detected during the period of the study. Because of the limited number of cases, this factor had not been analysed further.

## Results and discussion

In this study we undertook to detect the EPP offsprings in a Tree Sparrow breeding colony living in an urban park in Szeged. Among seven candidate microsatellite markers developed for the House Sparrow, three loci (Pdo3, Pdo5, Pdo9) showed appropriate level of polymorphism in Tree Sparrows and were used successfully in the paternity analysis (Table 1).

During the three breeding attempts we totally recorded 43 broods in 21 occupied nestboxes. 31 of these can be considered successful (at least one fledged chick per brood): 14/13 (93%) successful attempts in the first breeding period, 14/11 (78%) in the second and 15/7 (46%) in the last, third period. Detailed data of the breeding biology is shown in Table 2.

Because of the insufficient data, 12 broods were excluded from the paternity analysis (parents were unknown, their bloodsample was lacking, offspring bloodsample was lacking or there were less than three offsprings with only one known parent). Finally, data of 19 broods and 76 chicks were involved in the paternity analyses.

Four of the total 19 nests (21,05%) contained at least one extra-pair young and 9,2% of the youngs (76/7) were sired by extra-pair mates. 10,5% of the broods contained only one EP offspring (19/2), 5,3% of them contained two EPYs (19/1) and 5,3% three (19/1) extra-pair youngs. We could not find more than three extra-pair young in any of the examined broods.

Our results suggest similar frequency of EPP to the level of EPP found in a Swiss and Spanish Tree Sparrow population (Cordero *et al.* 1999). They found that 25% (10/40) of Tree Sparrow broods in Spain and 23% (8/35) in Switzerland had at least one extra-pair offspring, and that 8% (12/151) of nestlings in Spain and 10% (12/114) in Switzerland were sired by extra-pair mates.

Because of the insufficient data, our results can be considered only preliminary. The number of incomplete families (one parent is unidentified, with no ring and blood sample) in the study was quite high, due to the low efficiency in catching and observing the parent birds. Identification of the adult Tree Sparrows (by observing them near to the nest) was sometimes problematical because of their confusing behaviour (nest boxes were close to each other and some of the adult birds were observed on several different nests in the same breeding attempt). Using nest traps, ratio of unidentified parents could have lowered, but adult birds showed considerable susceptibility to disturbance, so we determined not to apply this method. Additionally, accuracy of the parental analyses of the involved families could have been much greater if we could involve more than three microsatellite loci or loci especially developed for Tree Sparrow.

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## NUTRITION OF THE MUDMINNOW (*UMBRA KRAMERI* WALBAUM) IN THE BASIN OF THE ÉR RIVER

S. Wilhelm

Wilhelm, S. (2007): Nutrition of the mudminnow (*Umbra krameri* Walbaum) in the basin of the Ér river. – *Tiscia* 36, 23-28.

**Abstract.** The study of nutrition of the mudminnow in the Ér River was performed by counting, determining and measuring the organisms found in the alimentary canal of 260 specimen, which were of different age, sex and were gathered at different date. The results were compared with literature data. It was found that the mud minnow feeds on tiny animals, mainly on the Diptera larvae. No signs of predatory behaviour were observed. It was found that the nutrition of the populations living in different territories differs significantly, and the qualitative and quantitative composition of the food is determined by the distribution of the nutrient organisms in the environment.

Keywords: nutrition, composition of food, fullness index, saturation of the stomach

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### Introduction

The mudminnow is an endemic fish species in the basins of the Danube and Nester rivers. It lives in moors and swamps, and due to the reduction of its habitat the population of the mudminnow decreased in all its geographic range. Therefore, Maitland (1991) considered the mudminnow a severely endangered species.

In the literature there are several studies about the nutrition of the mudminnow. Geyer (1940) published his results about the nutrition of the mudminnow of the Balaton region based on the examination of the gut of more than 200 fish. In the material examined by him the nutrient organisms were dominated by tiny crustaceans (Amphipoda, Ostracoda, Isopoda, Copepoda), and the rest was formed by insects (Coleoptera, Ephemeroptera, Chironomidae, Odonata), snails and spiders. He found that smaller individuals were feeding more diversely. The composition of the food of the individuals gathered at different date differed significantly, moreover, this is true for individuals gathered at the same time but at different areas.

By examining the nutrition of the mudminnow populations from the lakes of the flooding areas of the Danube at the Szentendre island, Jászfalusi

(1950) mentioned about mosquito larvae (Tendipedidae), tiny crustaceans (*Bosmina*, *Cyclops*), mayfly larvae and tiny bugs. However, he also found vegetal fibres in the intestines of the mudminnows.

Libosvárský and Kux (1958) published detailed nutritional data from Slovakia. They found that the majority of the food of the mudminnow was formed by inferior crustaceans. Mainly Cladocera and Ostracoda species have a major role, while Amphipoda are less important. The insects were found to be of lower importance. The most frequent insect groups were Coleoptera and Diptera, while Ephemeroptera, Odonata and Notonecta species were much less frequent. Libosvárský and Kux (1958) also found Rotatoria, Mollusca and Hirudinea, and their eggs as well, moreover, the statoblasts of Briozoa. They also found that the younger individuals were feeding more diversely compared to the older ones.

More recent data were published by Guti *et al.* (1991) about the nutrition of the mudminnow population of the Ócsa landscape protection area. Seven specimens of 33 had an empty alimentary tract. Here insects were dominant in the food of fish, mainly the larvae of *Velia* sp., followed by bugs. Among Diptera the flies (Muscidae) were dominant

and surprisingly only few mosquito larvae (Ceratopogonidae, Chironomidae) were found. Some mayfly and dragonfly larvae have also been found. Surprisingly the crustaceans were represented only by Ostracoda, however, these were relatively frequent. Some molluscs and Hydracarina have also been found. Moreover, in 11 specimen remains of vegetal origin (*Lemna* sp.) were present.

### Material and methods

Material used in this study was gathered between 1973 and 1995 using a scratching net. Standard and total length, as well as the weight of the individuals were taken. Age of the individuals was determined based on the annual rings of the scales (Wilhelm 2003).

The alimentary tract of the dissected fish was kept in 4% formaldehyde solution (Hyslop 1980). The alimentary tract was opened in its total length and the content was put on a watch-glass. The components were selected, determined as precisely

as possible, than measured and processed after the method of Gyurkó *et al.* (1965, 1967).

Frequency of the nutrient organisms was determined by dividing the occurrence of the individual components by the number of fish. The abundance of the components was determined by dividing the number of the components by the number of the fish. This latter was not possible in the case of vegetal components. Considering the frequency and abundance data, we tried to draw conclusions regarding the preference to nutrient components of the fish species.

Based on the recalculated weight of the food components, the quantitative distribution of the food composition was determined. By comparing the total weight of food found in one specimen to the weight of the individual fish, the fullness index was calculated, that represents the intensity of feeding.

The saturation of the stomach was scored on a scale from 1 to 5, using the method suggested by Hynes (1950). These data were compared to the number of fish. These data also represent the

Table 1. The frequency distribution of the different food items according to sex, season and age

Food components	Total	Males	Females	Seasons				Age						
				Spring	Summer	Autumn	Winter	0 year	1 year	2years	3 years	4 years	5 years	6-7 y-s
Oligochaeta	0.054	0.039	0.068	0.036	0.040	0.083	0.013	0.214	0.045	0.077	0.000	0.000	0.000	0.000
Hirudinea	0.012	0.000	0.023	0.000	0.000	0.008	0.027	0.000	0.000	0.011	0.000	0.059	0.100	0.000
Gastropoda	0.004	0.000	0.008	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.143
Phyllopora	0.027	0.016	0.030	0.107	0.000	0.015	0.013	0.000	0.011	0.033	0.031	0.000	0.000	0.143
Cladocera	0.046	0.039	0.053	0.107	0.080	0.023	0.053	0.000	0.011	0.044	0.125	0.118	0.100	0.000
Ostracoda	0.077	0.070	0.083	0.214	0.000	0.053	0.093	0.071	0.067	0.077	0.156	0.059	0.000	0.000
Amphipoda	0.065	0.031	0.098	0.143	0.000	0.023	0.013	0.071	0.045	0.022	0.125	0.118	0.100	0.429
Ephemeroptera l.	0.119	0.117	0.121	0.107	0.240	0.114	0.093	0.071	0.101	0.110	0.188	0.176	0.100	0.143
Odonata l.	0.027	0.023	0.030	0.107	0.000	0.030	0.000	0.000	0.022	0.011	0.094	0.059	0.000	0.000
Heteroptera	0.031	0.016	0.045	0.036	0.000	0.023	0.053	0.000	0.000	0.033	0.031	0.118	0.100	0.143
Coleoptera l.	0.042	0.039	0.045	0.000	0.080	0.053	0.000	0.214	0.034	0.044	0.031	0.000	0.000	0.000
Coleoptera p.	0.012	0.023	0.000	0.000	0.000	0.023	0.000	0.071	0.011	0.11	0.000	0.000	0.000	0.000
Coleoptera ad.	0.038	0.055	0.023	0.036	0.000	0.068	0.000	0.214	0.034	0.022	0.031	0.059	0.000	0.000
Trichoptera l.	0.058	0.039	0.076	0.036	0.200	0.045	0.040	0.071	0.045	0.044	0.063	0.059	0.100	0.286
Diptera l.	0.808	0.820	0.795	0.750	0.760	0.856	0.760	0.857	0.876	0.802	0.844	0.706	0.500	0.429
Diptera p.	0.196	0.172	0.220	0.143	0.000	0.288	0.120	0.286	0.247	0.143	0.156	0.176	0.100	0.286
Diptera ad.	0.008	0.008	0.008	0.000	0.000	0.015	0.000	0.000	0.022	0.000	0.000	0.000	0.000	0.000
Hymenoptera ad.	0.012	0.016	0.008	0.071	0.000	0.000	0.013	0.000	0.000	0.011	0.063	0.000	0.000	0.000
Araneidae	0.004	0.008	0.000	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059	0.000	0.000
Hydracarina	0.015	0.008	0.023	0.000	0.000	0.030	0.000	0.000	0.022	0.022	0.000	0.000	0.000	0.000
Invertebrate eggs	0.119	0.117	0.121	0.250	0.040	0.121	0.093	0.143	0.135	0.121	0.063	0.118	0.000	0.143
Scale	0.015	0.016	0.015	0.000	0.040	0.008	0.027	0.000	0.011	0.022	0.031	0.000	0.000	0.000
Algae	0.062	0.039	0.083	0.000	0.000	0.083	0.067	0.071	0.067	0.033	0.125	0.000	0.200	0.000
Plant remain	0.050	0.063	0.038	0.036	0.120	0.053	0.027	0.071	0.045	0.044	0.031	0.176	0.000	0.000
Plant seed	0.050	0.039	0.061	0.000	0.080	0.076	0.013	0.071	0.079	0.033	0.000	0.118	0.000	0.000
Debris	0.688	0.719	0.659	0.679	0.680	0.750	0.587	0.643	0.787	0.681	0.563	0.588	0.500	0.714

intensity of feeding.

The data were calculated for sex, season and age groups as well.

## Results

Regarding the number of the food components, altogether 26 components were identified, including worms, snails, inferior crustaceans, insects, spiders, algae, vegetal tissues and seeds, and in addition eggs of invertebrates, fish scales and undeterminable debris. There is little difference between the qualities of food of the two sexes: there were no leeches and snails in case of males and no beetle's pupae and spiders in case of females. However, the difference between the seasons is much more important. While the spring and autumn food spectra contain the whole menu, the nutrition in summer (11 components) and winter (18 components) is much less diverse. Regarding the different age groups, the most diverse is the menu of the 1, 2 and 3-year-old group, while later feeding gets stabilized and the number of components decreases.

The frequency distribution of the different food components (Table 1.) shows that in all groups the most frequent components are the Diptera larvae and

pupae: the most frequent of them are *Chaoborus*, *Tendipes*, *Ablabesmyia*, *Culicoides*. The same frequency is reached only by the debris; a part of this is made of undeterminable animal remains. Among the insects mayfly larvae (*Cloëon*, *Ephemerella*) are relatively frequent, however, the larvae of dragonflies (*Calopteryx*, *Agrion*), aquatic bugs (*Corixa*, *Sigara*) and beetle larvae are much rarer. The occurrence of different inferior crustaceans is surprisingly low (Copepoda: *Cyclops*; Cladocera: *Moina*, *Bosmina*, *Daphnia*; Ostracoda; Amphipoda: *Gammarus*). The Oligochaeta (*Tubifex*, *Nais*) are eaten only by the younger age groups, while snails (young *Viviparus*) are preferred only by the older specimen. The Hymenoptera are represented by ants fallen into the water.

Regarding the abundance of the different food components (Table 2.), a leading role of Diptera larvae and pupae was found here as well, showing that these are consumed not only frequently but also in a large amount. Mayfly larvae and eggs of invertebrates are also consumed abundantly and frequently, while from the inferior crustaceans only the Cladocera, Ostracoda and Copepoda are consumed abundantly but only occasionally.

Table 2. The abundance distribution of the food items according to sex, season and age

Food items	Total	Males	Females	Seasons				Age						
				Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
Oligochaeta	0.096	0.070	0.122	0.035	0.040	0.015	0.013	0.571	0.101	0.087	0.000	0.000	0.000	0.000
Hirudinea	0.011	0.000	0.022	0.000	0.000	0.007	0.026	0.000	0.000	0.010	0.000	0.058	0.100	0.000
Gastropoda	0.026	0.000	0.053	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
Phyllopoda	0.115	0.039	0.075	0.250	0.000	0.015	0.080	0.000	0.011	0.076	0.031	0.000	0.000	0.857
Cladocera	0.246	0.039	0.446	1.785	0.080	0.037	1.400	0.000	0.011	0.560	0.187	0.294	0.100	0.000
Ostracoda	0.223	0.226	0.219	0.857	0.000	0.090	0.293	0.142	0.112	0.168	0.750	0.294	0.000	0.000
Amphipoda	0.173	0.078	0.265	0.285	0.000	0.060	0.386	0.071	0.123	0.021	0.250	0.352	0.200	2.142
Ephemeroptera larvae	0.192	0.187	0.196	0.178	0.520	0.189	0.093	0.142	0.202	0.120	0.281	0.470	0.100	0.142
Odonata larvae	0.111	0.187	0.037	0.857	0.000	0.037	0.000	0.000	0.258	0.021	0.093	0.058	0.000	0.000
Heteroptera	0.103	0.015	0.189	0.107	0.000	0.113	0.120	0.000	0.000	0.043	0.031	0.235	1.200	0.857
Coleoptera larvae	0.069	0.054	0.083	0.071	0.120	0.098	0.000	0.571	0.033	0.054	0.062	0.000	0.000	0.000
Coleoptera pupae	0.011	0.023	0.000	0.000	0.000	0.022	0.000	0.071	0.011	0.010	0.000	0.000	0.000	0.000
Coleoptera adults	0.038	0.054	0.022	0.035	0.000	0.068	0.000	0.218	0.033	0.021	0.0312	0.058	0.000	0.000
Trichoptera larvae	0.076	0.039	0.113	0.035	0.200	0.060	0.080	0.071	0.067	0.043	0.062	0.058	0.100	0.714
Diptera larvae	6.400	5.578	7.196	4.642	5.520	6.666	6.880	5.857	6.752	6.945	7.093	3.117	6.300	0.857
Diptera pupae	0.657	0.414	0.893	0.250	0.000	1.121	0.213	0.857	1.168	0.340	0.428	0.352	0.100	0.285
Diptera adults	0.011	0.007	0.015	0.000	0.000	0.022	0.000	0.000	0.033	0.000	0.000	0.000	0.000	0.000
Hymenoptera adults	0.011	0.015	0.007	0.071	0.000	0.000	0.013	0.000	0.000	0.010	0.062	0.000	0.000	0.000
Araneidae	0.003	0.007	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.058	0.000	0.000
Hydracarina	0.026	0.015	0.037	0.000	0.000	0.053	0.000	0.000	0.033	0.043	0.000	0.000	0.000	0.000
Invertebrate eggs	1.146	1.703	0.606	7.960	0.080	0.265	0.506	0.214	2.460	0.626	0.281	0.411	0.000	1.142
Scales	0.015	0.166	0.015	0.000	0.000	0.007	0.026	0.000	0.011	0.021	0.031	0.000	0.000	0.000

Table 3. Percentage distribution of the recalculated weight of different food components according to sex, season and age

Food items	Total	Males	Females	Seasons				Age						
				Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
Oligochaeta	0.47	0.53	0.44	0.30	0.26	0.86	0.11	1.81	0.67	0.54	0.00	0.00	0.00	0.00
Hirudinea	0.28	0.00	0.46	0.00	0.00	0.09	0.68	0.00	0.00	0.12	0.00	2.40	1.95	0.00
Gastropoda	0.85	0.00	1.37	6.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.67
Phyllopoda	1.15	0.95	1.27	3.29	0.00	0.23	1.71	0.00	0.13	1.32	0.41	0.00	0.00	11.19
Cladocera	2.98	0.74	4.38	15.12	1.28	0.46	1.83	0.00	0.07	6.43	2.45	6.51	1.17	0.00
Ostracoda	1.23	1.52	1.04	3.59	0.00	0.70	1.26	0.80	0.87	1.02	3.26	1.71	0.00	0.00
Amphipoda	4.25	1.58	5.91	4.94	0.00	1.02	8.90	0.40	2.27	0.30	5.30	10.27	4.67	33.58
Ephemeroptera larvae	2.82	3.47	2.42	2.10	11.48	2.74	1.26	2.41	2.67	1.74	4.08	9.93	1.17	1.12
Odonata larvae	0.81	1.47	0.39	4.19	0.00	0.56	0.00	0.00	1.67	0.24	1.09	1.03	0.00	0.00
Heteroptera	2.34	0.32	3.59	1.80	0.00	2.65	2.68	0.00	0.00	0.72	0.82	4.79	18.68	13.43
Coleoptera larvae	1.01	0.95	1.04	0.90	2.30	1.63	0.00	8.85	0.53	0.84	0.82	0.00	0.00	0.00
Coleoptera pupae	0.14	0.37	0.00	0.00	0.00	0.33	0.00	0.40	0.20	0.18	0.00	0.00	0.00	0.00
Coleoptera adults	0.44	0.68	0.29	0.45	0.00	0.88	0.00	2.41	0.40	0.24	0.27	1.37	0.00	0.00
Trichoptera larvae	1.25	0.79	1.53	0.45	3.32	0.93	1.48	1.21	0.93	0.78	0.54	0.68	1.17	8.58
Diptera larvae	61.91	68.84	57.60	37.43	69.64	62.36	68.95	58.75	65.71	69.01	66.44	43.49	63.81	5.22
Diptera pupae	5.72	3.78	6.92	2.25	0.00	10.59	2.34	12.88	9.94	2.94	5.03	3.42	0.78	1.87
Diptera adults	0.08	0.11	0.07	0.00	0.00	0.19	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00
Hymenoptera adults	0.20	0.37	0.10	1.05	0.00	0.00	0.17	0.00	0.00	0.18	0.95	0.00	0.00	0.00
Araneidae	0.04	0.11	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00
Hydracarina	0.16	0.11	0.20	0.00	0.00	0.37	0.00	0.00	0.20	0.30	0.00	0.00	0.00	0.00
Invertebrate eggs	2.62	2.10	2.94	8.83	0.51	1.58	2.00	2.01	2.40	3.54	1.22	4.11	0.00	3.36
Scales	0.08	0.11	0.07	0.00	0.26	0.05	0.11	0.00	0.07	0.12	0.14	0.00	0.00	0.00

The quantitative composition of the food (Table 3.) shows that in the Ěr basin the main food of the mud minnow is represented by the larvae (61.91%) and pupae of mosquitoes. As secondary food debris (7.83%), Amphipoda (4.25%), mayfly larvae (2.82%) and eggs (2.62%) are considered. The rest of the animals is only an occasional food source, while the vegetal components are probably only additional nutrients.

There are no significant differences regarding the two sexes. In case of males the dominance of Diptera species and debris is even more pronounced, while the leeches and snails are missing. In case of females the later are present. Moreover, the number of Cladocera, Amphipoda and aquatic bugs is higher.

There are differences in the food composition among different seasons. Although Diptera species are dominant in every season, in spring they represent a much lower amount. Snails are only present during spring (6.29%) (later they probably grow too big for such a small fish species). At this time crustaceans become the most important (Copepoda 3.29%, Cladocera 15.12%, Ostracoda 3.59%, Amphipoda 4.94%), and also the eggs of invertebrates (8.83%). In summer, beside the Diptera larvae, the dominant components are mayfly larvae

(11.48%), Trichoptera larvae (3.32%) and beetle larvae (2.29%). In autumn the food is very diverse, the most important components are the Diptera larvae and pupae, and debris. Furthermore, mayfly larvae (2.74%) and aquatic bugs (2.65%) represent major components. In winter the nutrition is much less diverse, debris (5.70%) is the most important beside Diptera, completed by Amphipoda (8.90%) and bugs (2.65%).

Composition of the food of the different age groups is very interesting. Oligochaeta worms are consumed only by younger age groups, while leeches are consumed by the older ones. The role of Copepoda and Amphipoda increases with the age and the role of Diptera decreases. Snails are consumed only by the older age groups. The older age groups, however, consume almost no vegetal food. In short, the food of the younger age groups is much more diverse.

The fullness index (Table 4.) shows a more intensive feeding of the females compared to that of males. In spring and autumn, i.e. during preparations for mating and winter, respectively, the intensity of feeding is maximal. In winter the feeding intensity is the lowest, although the mudminnow is feeding during the whole year.

Table 4. The fullness index of different groups

Groups	Total	Sex		Seasons				Age						
		Males	Females	Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
n	260	128	132	28	25	132	75	14	89	91	32	17	10	7
Fullness index	0.078	0.662	0.094	0.135	0.034	0.112	0.017	0.0209	0.094	0.071	0.027	0.061	0.018	0.093

The number of full stomachs of males (Table 5.) is higher than those of females, and regarding the seasons the stomach fullness is higher in winter. This is probably due to the slower digestion. Regarding the age groups, stomach fullness is surprisingly high in case of very young and very old individuals; it is impressively high at two-year old individuals.

Table 5. The number of full stomachs

Groups	Total	Sex		Seasons				Age						
		Males	Females	Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
n	260	128	132	28	25	132	75	14	89	91	32	17	10	7
Full stomachs	2.94	3.931	1.977	1.625	1.460	1.971	5.625	2.571	1.878	4.966	1.796	1.705	0.900	3.214

## Discussion

The mudminnow is a typically tiny animal-consuming (zoophagous) fish. Although Otto Herman (1887) considered it a predator inclined to cannibalism and several review studies (Bănărescu, 1964; Gyurkó, 1972; Pintér, 1989; Harka and Sallai, 2004) mention about occasional fish consumption, no signs of this were found in either any detailed study or in the present work.

Different authors describe different data regarding the composition of the food. According to Geyer (1940) and Libosvárský and Kux (1958) the main food components are represented by tiny crustaceans, according to Jászfalusi (1950) by mosquito larvae, according to Guti *et al.* (1991) by the aquatic bugs and beetle larvae. According to our studies the mosquito larvae are primordial. Considering all the above data, we can conclude that the mudminnow is an euriphagous, opportunistic species, capable of exploiting the available nutritive resources.

Both Geyer (1940) and Libosvárský and Kux (1958) underline the more diverse feeding of the younger ages. This is supported by our studies as well.

According to the studies of Jászfalusi (1950) and of Guti *et al.* (1991) from the Danube region, vegetal components can also be found in the food of the mudminnow. Our results are in accordance with these data, since the mudminnow population of the Ér basin consumes occasionally not only algae, but the remains of higher plants and the seeds of these as well.

Several studies suggest that it would be worth spreading the mudminnow for mosquito destruction instead of the mosquitofish (*Gambusia*) of Central American origin, since this way we would support one of our rare and endemic fish species, and not an introduced species. For this reason first we need to solve the problem of large scale artificial breeding of the mudminnow.

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## RELATIONSHIPS BETWEEN CHIRONOMID COMMUNITIES (DIPTERA: CHIRONOMIDAE) AND ENVIRONMENTAL PARAMETERS IN SAZLIDERE STREAM (TURKISH THRACE)

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*Ozkan, N. and Camur-Elipek, B. (2007): Relationships between chironomid communities (Diptera: Chironomidae) and environmental parameters in Sazlidere stream (Turkish Thrace). – Tiscia 36, 29-34.*

**Abstract.** In this study, Sazlidere stream in European part of Turkey was studied from September 1995 to August 1996 to identify chironomid larvae present, determine physicochemical properties of the water, and describe the relationships between species composition of the chironomid communities and environmental parameters. Samplings were made monthly at four different stations of the stream. A total of 57 chironomid taxa was identified and 421 individuals per m<sup>2</sup> were recorded in average. Also, the structure of sediment in each station was revealed to determine the substratum preference of the larvae.

Although chironomids have broad ecological tolerance, it was found only one species, *Procladius (Holotanypus) sp.*, in station 3. which was determined by the most polluted locality. Results were also supported statistically by Shannon diversity index. Species diversity for chironomid larvae was found to be the highest at 2. station and substratum with mud/detritus had the highest diversity, too. According to Bray-Curtis index, it was found that stations 1. and 2., seasons spring and winter are the most similar to each other for larval chironomid communities, both in terms of number of species and number of individuals.

Furthermore, Spearman correlation index indicated that the stronger relationships between the distribution of larval chironomid individuals and some environmental variables such as water temperature, pH, DO, BOD, COD, and NO<sub>2</sub><sup>-1</sup>-N.

*Key words: Chironomidae larvae, Species diversity, Sazlidere Stream, Turkish Thrace*

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### Introduction

Larval period of Chironomidae is the largest in their life cycle. Most larvae are aquatic, and are found in all types of freshwater habitats worldwide owing to their broad ecological tolerance (Freimuth and Bass, 1994; Armitage *et al.*, 1995; Francis, 2004). Under certain conditions, such as low level of dissolved oxygen, larval chironomids may be the only insect present in benthic sediments (Armitage *et al.*, 1995). In many cases chironomid larvae could be very important for benthic biomass. The dynamics (distribution both in terms of species and number of individuals) and biomass production of these larvae

may vary in different types of water bodies, in time of year, etc. (Epler, 2001). The abundances and distribution of the taxa are related to current environmental conditions, such as water temperature, conductivity, pH, water clarity, and so forth (Francis, 2004 and references there in; Ozkan and Camur-Elipek, 2006).

Until the present, Kirgiz (1988), Sahin (1991), Kirgiz and Guher (1992), Ozkan and Kirgiz (1995), Sever (1997), Ozkan (2003), Ozkan and Camur-Elipek (2006) discussed the Chironomidae larvae in the European part of Turkey (Turkish Thrace).

Increased number of settlements, industrial factories and agricultural areas around the Sazlidere

Stream (Turkish Thrace) has threatened the quality levels of the water (Anonymous, 1989). This research was carried out to determine the species composition and diversity of Chironomidae larvae of Sazlidere Stream in relation to some environmental features.

## Methods

**Study Area.** The Sazlidere Stream is the left-hand tributary of the Meric River (Maritza, Evros) and never dries out during the summer. The stream is 59 km long and its maximum depth is 80 cm. The bank of Sazlidere is accompanied by macrovegetation consisting of *Phragmites australis*, *Lemna* sp., *Cyperus* sp., *Lipidium* sp. (Secmen and Leblebici, 1991). The stream is characterized by variable habitat structure along its gradient, due to those agricultural areas, settlements and different factories surrounding it and their sewage water pouring into the stream (Anonymous, 1989).

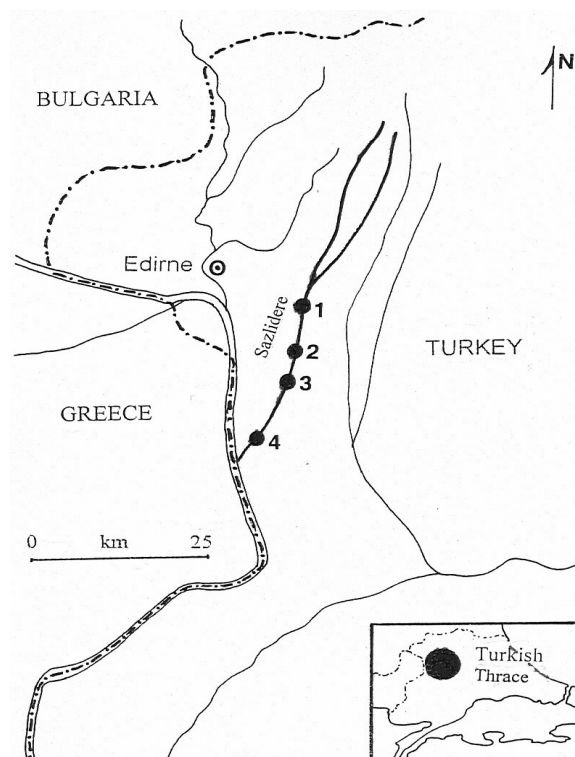


Figure 1. Geographical situation of Sazlidere Stream and sampling stations.

Four characteristic stations were chosen along the stream for sampling in this study (Figure 1): Station 1: Near the Iskender Village. There is no factory around this location. Sewage water does not

reach the stream from settlements at this location; Station 2: About 50 meters ahead of a sewage inflow of a textile factory; Station 3: About 100 meters ahead of a sewage inflow of a paper factory. There are a lot of agricultural areas and settlements around this location; Station 4: About 200 meters from the mouth to the Meric River. There is no factory around this location.

**Sampling.** The sampling stations were sampled monthly from September 1995 to August 1996 to determine the composition of the chironomid larvae and the physicochemical features of the water. In February 1996, sampling could not be made because of excessive rain.

Sediment samples were taken with the help of an Ekman dredge (15×15 cm<sup>2</sup>) and washed through a 0.5 mm mesh net. The remaining Chironomidae larvae were kept in plastic bottles preserved in 70% ethanol. Also, the structure of sediment was recorded in each station to determine the preference of the larvae. In the laboratory, samples were examined by preparing temporary (using a glycerine-water (1:5) solution) or permanent preparations (using Canada balsam). Chironomid larvae were identified at the lowest possible taxonomic level using the following works: Chernovskij (1961), Fittkau (1962), Beck and Beck (1969), Bryce and Hobart (1972), Sæther (1977), Møller-Pillot (1978-1979, 1984), Sahin (1984, 1987, 1991), Fittkau and Roback (1983), Sahin *et al.* (1988), Armitage *et al.* (1995), and Epler (2001).

While some physicochemical parameters including water temperature, conductivity, and pH were measured in surface water (using ordinary thermometer, Jenway 3040 mark ion analyser, and WPA CM35 mark conductivity meter, respectively) at the time of the sampling of benthos, water samples taken by Ruttner water sampler were carried to the laboratory to measure the other parameters including dissolved oxygen, biological and chemical oxygen demands, Ca<sup>+2</sup>, Mg<sup>+2</sup>, Cl<sup>-1</sup>, NO<sub>3</sub><sup>-1</sup>-N, NO<sub>2</sub><sup>-1</sup>-N, PO<sub>4</sub><sup>-3</sup>, and Cr<sup>+6</sup>. Some classical titration methods and spectrophotometer were used to determine the above parameters (Egemen and Sunlu, 1999). Quality grades of the water at the sampling sites were determined using SKKY (2004).

**Statistical Analysis.** Data belonging to chironomid larvae were also evaluated statistically. Shannon diversity index and Bray-Curtis similarity index were computed (Krebs, 1999). Relationships between the distribution of chironomid larvae and environmental variables were determined using Spearman correlation in SPSS 9.0 for windows.

## Results and Discussion

A total of 57 chironomid taxa was collected in Sazlidere stream during this study. The average number of chironomid larvae was 421 ind./m<sup>2</sup>. Thirty five species were found in muddy/detritus-rich substratum (MD), 33 species in sandy (S), 23 species

in sandy/muddy (SM), 18 species in muddy (M), and 8 species in all substratum types (A) (Table 1).

At all the stations considerable differences were observed in the composition of chironomid communities. Station 2. was found to be having the highest number of taxa followed by stations 1. and 4., respectively. On the other hand, only one taxon,

Table-1. Distribution of Chironomidae species in Sazlidere Stream according to the stations, seasons and the substratum types of the habitats.

	1 <sup>st</sup> station	2 <sup>nd</sup> station	3 <sup>rd</sup> station	4 <sup>th</sup> station	Spring	Summer	Autumn	Winter	Sand	Mud	Sand/Mud	Mud/Detritus	Average	Abundance
<i>Camptochironomus tentans</i> (Fabricius, 1805)	16	-	-	126	-	126	16	-	16	-	126	-	36	8.6%
<i>Chaetocladius</i> sp.	6	2	-	-	2	-	-	6	6	-	2	2	2	0.5%
<i>Chironomus anthracinus</i> Zetterstedt, 1860	110	28	-	8	42	80	16	6	78	30	12	26	36	8.6%
<i>Chironomus aprilinus</i> Meigen, 1830	12	4	-	10	-	16	8	2	12	-	12	2	6	1.4%
<i>Chironomus plumosus</i> (Linnaeus, 1758)	4	-	-	110	-	110	4	-	4	-	109	-	28	6.7%
<i>Chironomus riparius</i> Meigen, 1804	-	-	-	4	-	4	-	-	-	-	4	-	1	0.2%
<i>Chironomus</i> sp.-1	40	32	-	8	18	32	12	18	26	16	22	16	20	4.8%
<i>Chironomus</i> sp.-2	8	-	-	28	-	34	2	-	8	-	28	-	9	2.2%
<i>Cladotanytarsus mancus</i> Walker, 1856	92	-	-	-	2	38	52	-	89	2	-	-	23	5.5%
<i>Clinotanypus pinguis</i> (Loew, 1861)	10	-	-	-	-	-	-	10	2	8	-	-	2	0.5%
<i>Cricotopus albiforceps</i> (Kieffer, 1916)	4	-	-	-	-	-	2	2	2	2	-	-	1	0.2%
<i>Cricotopus bicinctus</i> (Meigen, 1818)	8	-	-	4	8	2	-	2	2	-	10	-	3	0.7%
<i>Cricotopus fuscus</i> (Kieffer, 1909)	2	-	-	-	-	-	2	-	2	-	-	-	1	0.2%
<i>Cricotopus sylvestris</i> (Fabricius, 1794)	4	2	-	2	2	2	4	-	4	-	2	2	2	0.5%
<i>Cricotopus vierriensis</i> Goetghebuer, 1835	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%
<i>Cryptochironomus defectus</i> (Kieffer, 1913)	6	4	-	-	4	4	2	-	6	-	-	4	2	0.5%
<i>Cryptochironomus</i> sp.	-	2	-	2	-	4	-	-	-	2	2	-	1	0.2%
<i>Dicrotendipes nervosus</i> (Staeger, 1839)	2	-	-	2	-	2	2	-	2	-	2	-	1	0.2%
<i>Diplocladius cultriger</i> Kieffer, 1908	-	2	-	-	-	-	-	2	-	-	-	2	1	0.2%
<i>Einfeldia pagana</i> (Meigen, 1838)	-	2	-	-	-	-	-	2	-	-	-	2	1	0.2%
<i>Hydrobaenus pilipes</i> (Malloch, 1915)	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%
<i>Macropelopia</i> sp.	2	-	-	-	2	-	-	-	-	-	-	2	1	0.2%
<i>Micropsectra</i> sp.-1	-	4	-	-	4	-	-	-	-	-	-	4	1	0.2%
<i>Micropsectra</i> sp.-2	-	4	-	-	4	-	-	-	-	-	-	4	1	0.2%
<i>Microtendipes chloris</i> (Meigen, 1818)	26	22	-	-	26	-	4	18	16	8	2	22	12	2.9%
<i>Monopelopia tenuicalcar</i> (Kieffer, 1918)	2	-	-	-	-	-	2	-	2	-	-	-	1	0.2%
<i>Paracladius conversus</i> (Walker, 1856)	4	18	-	-	16	2	-	4	2	2	-	18	5	1.3%
<i>Paralauterborniella nigrohalteralis</i> (Malloch, 1915)	4	-	-	-	2	-	2	-	2	2	-	-	1	0.2%
<i>Paratanytarsus lauterborni</i> (Kieffer, 1909)	2	-	-	-	-	-	2	-	2	-	-	-	1	0.2%
<i>Paratendipes albimanus</i> (Meigen, 1818)	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%
<i>Paratendipes nubilus</i> (Meigen, 1830)	2	-	-	2	-	-	-	4	4	-	-	-	1	0.2%
<i>Paratendipes</i> sp.	-	-	-	2	2	-	-	-	-	-	2	-	1	0.2%
<i>Paratrissocladius excerptus</i> (Walker, 1856)	-	4	-	-	4	-	-	-	-	-	-	4	1	0.2%
<i>Paratrichocladius rufiventris</i> (Meigen, 1830)	4	-	-	-	-	-	-	4	4	-	-	-	1	0.2%
<i>Polypedilum convictum</i> (Walker, 1856)	8	8	-	4	10	6	2	2	4	4	4	8	5	1.3%
<i>Polypedilum exsectum</i> (Kieffer, 1916)	-	12	-	-	4	-	8	-	-	-	-	12	3	0.7%
<i>Polypedilum nubeculosum</i> (Meigen, 1804)	-	28	-	8	18	6	-	12	-	-	12	24	9	2.2%
<i>Polypedilum nubifer</i> (Skuse, 1889)	36	4	-	42	2	48	32	-	36	2	42	2	20	4.8%
<i>Polypedilum pedestre</i> (Meigen, 1830)	4	2	-	-	2	-	-	4	4	-	-	2	1	0.2%
<i>Polypedilum scalaenum</i> (Schrank, 1803)	6	-	-	2	-	6	2	-	6	-	2	-	2	0.5%
<i>Polypedilum</i> sp.	4	-	-	-	2	-	2	-	2	-	2	-	1	0.2%
<i>Potthastia gaedii</i> (Meigen, 1838)	4	-	-	-	4	-	-	-	-	-	4	-	1	0.2%
<i>Prodiamesa olivacea</i> (Meigen, 1818)	14	50	-	-	50	2	-	12	12	2	4	46	16	3.8%
<i>Procladius</i> (Holotanypus) sp.	93	65	4	-	42	2	80	40	93	2	6	61	41	9.7%
<i>Psectrocladius barbimanus</i> (Edwards, 1929)	-	2	-	-	2	-	-	-	-	-	-	2	1	0.2%

Table 1. Continued

	1 <sup>st</sup> station	2 <sup>nd</sup> station	3 <sup>rd</sup> station	4 <sup>th</sup> station	Spring	Summer	Autumn	Winter	Sand	Mud	Sand/Mud	Mud/Detritus	Average	Abundance
<i>Psectrocladius calcaratus</i> (Edwards, 1929)	-	22	-	-	22	-	-	-	-	-	-	22	5	1.3%
<i>Psectrocladius limbatellus</i> (Holmgren, 1869)	-	8	-	-	8	-	-	-	-	-	-	8	2	0.5%
<i>Psectrotanytus varius</i> (Fabricius, 1787)	-	2	-	-	-	-	2	-	-	-	-	2	1	0.2%
<i>Rheotanytarsus</i> sp.	-	6	-	-	6	-	-	-	-	-	-	6	1	0.2%
<i>Robackia demeijerei</i> (Kruseman, 1933)	-	2	-	-	-	2	-	-	-	2	-	-	1	0.2%
<i>Smittia</i> sp.	-	2	-	4	2	-	4	-	-	4	-	2	1	0.2%
<i>Stictochironomus</i> sp.	254	14	-	-	44	82	92	50	174	80	-	14	67	16%
<i>Tanytus punctipennis</i> Meigen, 1818	44	2	-	-	4	16	20	6	40	4	-	2	11	2.6%
<i>Tanytarsus gregarius</i> Kieffer, 1909	14	36	-	2	34	2	12	4	15	4	2	32	13	3.1%
<i>Tanytarsus</i> sp.	-	10	-	-	10	-	-	-	-	-	-	10	2	0.5%
<i>Thienemannimyia geijskesi</i> (Goetghebuer, 1834)	-	23	-	-	23	-	-	-	-	-	-	23	5	1.3%
<i>Virgotanytarsus</i> sp.	22	-	-	2	-	12	12	-	22	-	2	-	6	1.4%
Total number of individuals	873	434	4	372	433	640	400	210	699	176	413	394	421	
Number of taxa	35	36	1	20	37	25	28	21	33	18	23	35	57	
Shannon H'	2.57	2.98	0.00	1.93	3.02	2.44	2.50	2.49	2.58	1.96	2.15	2.98		

*Procladius (Holotanypus)* sp., was found on station 3. which receives sewage water from a paper factory and has a substratum with only mud and brownish-black colour of water. Since this species has some morphological adaptations that serve to enhance the absorption and transportation of the dissolved oxygen from the water-sediment interphase (Juarez-Flores and Ibanez-Aguirre, 2003), it may tolerate the low oxygen level of the water.

The most abundant taxa in average were *Stictochironomus* sp., *Procladius (Holotanypus)* sp., *Chironomus anthracinus*, and *Camptochironomus tentans*, comprising 16%, 9.7%, 8.6%, and 8.6% of the total specimens, respectively (Table 1). Furthermore, *Stictochironomus* sp. is the most abundant species in station 1. followed by *Chironomus anthracinus*, *Procladius (Holotanypus)* sp., and *Cladotanytarsus mancus*, respectively (Table 1). *Procladius (Holotanypus)* sp. is the most abundant species in station 2. while *Camptochironomus tentans* is the most abundant species in station 4. (Table 1).

It was found that the abundance of chironomid larvae was very high on station 1. (total number of individuals is 873 per m<sup>2</sup>) while station 3. was found to be the poorest (total number of individuals is 4 per m<sup>2</sup>) (Table 1). According to Shannon diversity index, station 2. was determined to have the highest diversity while station 3. was the least diverse (Table 1).

Remarkable seasonal changes were also detected in the distribution of chironomid larvae (Table 1). The greatest individual numbers were observed in summer whereas they decreased during winter. The most diverse season was spring when altogether 37

taxa occurred (Table 1).

Results of the Bray-Curtis similarity index show that stations 1. and 2. are the most similar (33% similarity) whereas stations 3. and 4. are the most different from each other (0% similarity) in terms of compositions of larval Chironomidae species. Results of the Bray-Curtis similarity index also showed that the composition of the larvae in seasons spring and winter were the most similar (53% similarity) whereas summer and winter were the most different from each other (23% similarity) (Table 2).

Table-2. Bray-Curtis similarity index results of stations and seasons for larval chironomid specimens (both in terms of number of species and number of individuals).

Proportions of the Similarities for sampling stations

	2nd station	3rd station	4th station
1st station	33,8 %	0,9 %	17,6 %
2nd station	*	1,8 %	10,9 %
3rd station	*	*	0 %

Proportions of the similarities for sampling seasons

	Summer	Autmn	Winter
Spring	26,1 %	36,9 %	52,9 %
Summer	*	48,5 %	23,5 %
Autmn	*	*	41,9 %

It was observed that the substratum type with mud-detritus is the most preferred for chironomid larvae whereas only mud is the least preferred substratum type. Shannon index has also supported these results (Table 1). Furthermore, only five species (*Cricotopus fuscus*, *Monopelopia tenuicalcar*, *Paratanytarsus lauterborni*, *Paratendipes*

Table 3. Physicochemical conditions of Sazlidere Stream during the investigation (D.O.: dissolved oxygen; BOD5: Biological Oxygen demand; COD: Chemical Oxygen demand; WT: water temperature; st.:station).

	Conductivity ( $\mu\text{S cm}^{-1}$ )	pH	D.O. (mg L <sup>-1</sup> )	BOD5 (mg L <sup>-1</sup> )	COD (mg L <sup>-1</sup> )	Ca <sup>+2</sup> (mg L <sup>-1</sup> )	Mg <sup>+2</sup> (mg L <sup>-1</sup> )	Cl <sup>-1</sup> (mg L <sup>-1</sup> )	NO <sub>3</sub> <sup>-1</sup> N (mg L <sup>-1</sup> )	NO <sub>2</sub> <sup>-1</sup> N (mg L <sup>-1</sup> )	PO <sub>4</sub> <sup>-3</sup> (mg L <sup>-1</sup> )	Cr <sup>+6</sup> ( $\mu\text{g L}^{-1}$ )	WT (°C)
Sep.	362	6.0	1.9	0.8	604	129	18	117	33	0.2	0.05	0.37	21
Oct.	282	6.8	2.7	1.4	500	133	34	179	31	0.7	0.15	1.08	13
Nov.	260	7.0	3.0	1.6	495	121	29	200	5	0.2	0.10	0.35	13
Dec.	122	7.5	5.5	2.9	581	109	25	115	6	0.3	0.14	0.46	8
Jan.	207	7.6	8.8	3.4	882	99	32	159	16	0.5	0.11	0.99	3
Mar.	162	7.4	11.4	5.4	140	94	33	132	19	0.2	0.08	0.15	5
Apr.	218	7.2	6.9	3.4	95	78	36	138	13	0.1	0.02	0.01	14
May	332	7.0	2.7	1.3	112	86	14	121	7	0.2	0.04	0.05	20
Jun.	477	6.7	2.7	1.3	365	70	13	130	9	0.2	0.06	0.15	19
Jul.	505	6.7	2.3	1.6	1958	105	21	270	17	0.8	0.16	1.33	26
Aug.	494	6.8	1.8	0.9	922	85	18	203	9	0.3	0.07	0.03	27
1st st.	208	6.8	5.9	1.5	215	78	25	123	15	0.07	0.02	0.03	13
2nd st.	312	7.2	5.9	3.4	191	70	23	168	10	0.13	0.03	0.08	14.5
3rd st.	421	7.0	3.2	2.2	1923	162	28	219	27	0.98	0.22	1.53	18.5
4th st.	303	6.9	3.8	1.9	327	93	21	132	9	0.25	0.07	0.33	16

*nubilus*, *Paratrissocladius rufiventris*) were found in sandy substratum; and only two species (*Chironomus riparius*, *Pothastia gaedii*) in sand/mud substratum. A total of 15 species inhabited mud/detritus substratum and only one species (*Robackia demeijerei*) was found in mud substratum (Table 1).

The physicochemical parameters that were measured during this study are summarized in Table 3. In Sazlidere Stream BOD, PO<sub>4</sub><sup>-3</sup> and water temperature were found at first quality level whereas COD, NO<sub>2</sub><sup>-1</sup>-N, Cr<sup>+6</sup> were found at fourth quality (SKKY, 2004). Chloride and pH were found of second quality level while dissolved oxygen and NO<sub>3</sub><sup>-1</sup>-N were between second and fourth quality levels (SKKY, 2004). Calcium, Magnesium and conductivity were at normal levels.

Spearman rank correlation was used for stations separately because each stations were considerably different from each other in the composition of the larvae. Results showed that pH, DO, BOD, and water temperature influence the abundance of larval chironomid fauna in station 3. ( $r = +0.61$ ,  $r = +0.66$ ,  $r = +0.62$ , and  $r = -0.67$  at  $p < 0.05$ , respectively). Significant positive correlations were also found between the number of chironomid larvae and some chemical variables (COD and NO<sub>2</sub>-N) at station 4. ( $r = +0.66$ ,  $r = +0.70$  at  $p < 0.05$ , respectively) whereas significant negative correlations were found between the number of the larvae and pH, DO, and BOD at station 1. ( $r = -0.60$ ,  $r = -0.63$  at  $p < 0.05$ , and  $r = -0.75$

at  $p < 0.01$ , respectively). The correlations between the number of larvae and the other parameters were determined not significant statistically.

If this study is compared to that performed by Kirgiz and Guher (1992) in Sazlidere Stream, the difference is that they considered all the Chironomidae larvae as a single group. They collected 515 Chironomidae larvae per m<sup>2</sup> in the average of total chironomid fauna, but they did not carry out the taxonomic identification of the chironomid larvae. An average individual number of 421 larvae per m<sup>2</sup> which was found during present study showed a certain decrease in larval chironomids in Sazlidere between the years 1992 and 1996.

Waste water of settlements, industrial factories and agricultural areas around the stream, which can effect qualitative and quantitative distributions of the larvae, are potential danger for the stream and the other water sources which are fed by Sazlidere. Consequently, it can be suggested that limnological studies must be performed periodically in Sazlidere to predict the future of the stream and its aquatic fauna.

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## AN ECOSYSTEM SERVICES APPROACH IN THE TISZA RIVER BASIN

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*Minca, E. L., Petz, K. and Werners, S. (2007): An ecosystem services approach in the Tisza River Basin. — Tiscia 36, 35-40*

**Abstract.** The Tisza River Basin in Hungary and Romania is increasingly impacted by floods and droughts. Ecosystems have the capacity to mitigate the effect of these weather extremes. The provision of ecosystem services – the benefits people obtain from ecosystems – is strongly affected by the way in which ecosystems are managed. This research assesses the influence of land and water management and weather extremes on ecosystems services as well as their importance in the Tisza River Basin. It is concluded that current water management impairs the natural capacity of ecosystems to fully provide their services, especially the water regulation, natural hazard regulation and water purification. For years water management has favoured wetland drainage and cutting river arms, ignoring ecosystem services. Recently some of the water and land management initiatives – in particular in Hungary – aim to capitalize on the potential of ecosystems to regulate floods and droughts.

*Keywords: ecosystem services; integrated assessment; water and land management*

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### Introduction<sup>1</sup>

The Millennium Ecosystem Assessment (MA) defines ecosystem services as the benefits people obtain from ecosystems (MA 2003). Thus ecosystem services support human well-being. The provision of ecosystem services is highly influenced by factors such as climatic conditions and water management. The combined effect of past and current human management, floods and droughts and climate change has resulted in ecosystems whose capacity to generate ecosystem services has been degraded (Folke *et al.* 2004). Although it is increasingly recognized scientifically that human well-being depends critically on all ecosystem services, they are often neglected in planning (de Groot 2006). The Tisza River Basin in Hungary and in Romania is

increasingly facing the impacts of floods and droughts (Hungarian Academy of Science, 2006). The inclusion of ecosystem services in spatial and policy planning is important since an adequate inclusion may have the capacity to reduce or mitigate the effect of climate related extremes.

The aim of the research is to assess the influence of land and water management and weather extremes on ecosystems services as well as their importance in the Tisza River Basin. The paper distinguishes between three main classes of ecosystem services: provisioning services (e.g. providing food and raw materials), regulating services (providing flood regulation and erosion control) and cultural services (e.g. recreation and cultural value).

In the light of climate change, Balogh (2001) argued that merely the current structural measures for fighting water (e.g. dams, dykes and canals) might prove ineffective for protecting the natural and human environment. Instead, the idea of natural water retention, which holds water in former natural waterways – floodplains and oxbows – is emerging (Botos *et al.* 2002). Water retention also enhances the revitalization of water-dependent ecosystems and

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<sup>1</sup> The conducted research is part of the “Adaptation and Mitigation Strategies” EU-project (ADAM; [www.adamproject.eu](http://www.adamproject.eu)). The Tisza River Basin was chosen by ADAM to illustrate distinct climate-change related environmental problems and a range of regional environmental policy challenges.

it is highly connected with land use and land management. In the engineering dominated water management system along the Tisza (e.g. water regulated by dams, dykes and canals) the ecosystems are restricted in providing their services. Especially the regulating services are affected. A more natural system facilitates the natural capacity of ecosystems to deliver services. In this context, multi-functional land use that implies more than one function per unit of land, gains attention (Rodenburg *et al* 2002). To assess the influence of water management practices and land use change on the ecosystem services, two cases are analyzed and compared in the Tisza River Basin. The data processing is based on information collected through literature, interviews and field observation. The results underline that the structural water management measures and the underestimation of the benefits provided by ecosystems leads to a reduced performance of ecosystem services.

## Methods

The MA (2003) defined the term “ecosystem services” as the benefits people derive from ecosystems including the functional processes and components of the ecosystems providing them. The MA typology established the following categories of ecosystem services: provisioning services, regulating services, supporting services and cultural services. This study adopted the term and classification of ecosystem services from the MA framework. The selection of investigated ecosystem services relies both on the MA and de Groot (2002) typologies.

Seven land cover types – arable land, grassland, forest, orchard, wetland, water body and urban environment – were investigated in the study areas. For each a set of fourteen ecosystem services was chosen, representing the three main classes of services:

- Provisioning services: food, freshwater, raw materials, genetic resources and medicinal resources;
- Regulating services: water regulation, water purification, erosion control, pest regulation, natural hazard regulation and soil quality regulation;
- Cultural services: aesthetic value, recreation and ecotourism and cultural value.

The selected cases are the Bereg Region in Hungary and the Crişuri Plain in Romania (Fig. 1). The Bereg Region, as a consequence of being protected by dykes directly on the Tisza River, faces high inland water stagnation risk but still increased

flood risk (Balogh 2001). To mitigate the risks emerging from the inappropriate water management and to utilize the water in a more efficient way a specific water management project was developed – in the frame of the Hungarian-Ukrainian European INTERREG Neighbourhood Programme. The project aims to design a water retention based management and mosaic land use by establishing a water retention polder near Jánd village (European INTERREG Neighbourhood Programme of Hungary and Ukraine 2006).

The Crişuri Plain case is less exposed to flood risks due to its slightly hilly setting along the Crişul Negru River. Here the new water management plan, initiated by the Ministry of Environment, focuses on the creation of wet areas in three artificially cut river bends that are partly surrounded by dykes near Tinca village. The aim of the plan is to improve the water flow in case of high water level and increase the tourism activities (Dimache 2007). However, there is no specification about the newly created ecosystems in the wet areas. The water management plans will affect 75% of the Hungarian case region, compared to only 5% in the Romanian case.

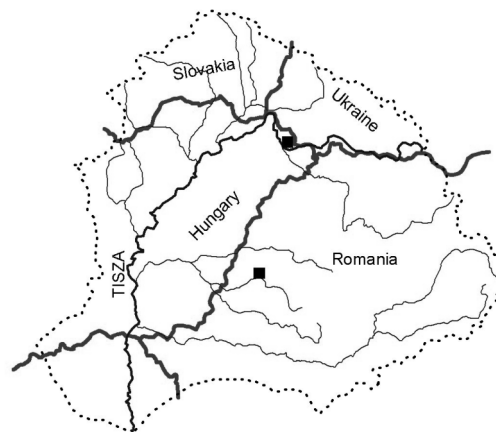


Figure 1. Location of the two case studies in the Tisza River Basin

In order to assess ecosystem services in the context of land and water management and weather extremes, the terms “performance” and “recognition” are introduced. The performance is considered as the degree at which an ecosystem service is delivered. At the same time, recognition stands for the perception of ecosystem services by the people, pointing at the extent at which these services are important to people. The selected ecosystem services were investigated with the help of different environmental indicators. Examples for indicators are the condition and number of canals for the water



regulation service or yield/ha for the food production service. The indicators served as backbone of the interviews and the field observations during the three months fieldwork both in Hungary and Romania.

We used a semi-structured interviewing technique based on the indicator list. The interviewees ranged from scientific experts and higher level stakeholders (e.g. climatologists and water management boards) to local authorities and local agents (e.g. mayors and NGO representatives). In both cases approximately twenty interviews were conducted with an even distribution between the above mentioned categories. The findings offered a good insight on the power web of stakeholders, the stage, opportunities and restraining factors of the land and water management plans, as well as useful information about the indicators of ecosystem services and flood and drought regimes.

The one week field observation served the better understanding of the studied phenomena. The observation was documented using a check list and the findings were summarized in an observation report. Moreover, numerous pictures were taken in order to visualize the physical condition of ecosystems.

The investigated written documents consist of scientific articles, books, as well as internal reports and statistics from stakeholders.

The collected information was used to evaluate ecosystem services on a four-step scale, where “0” stands for no performance/recognition and “3” for high performance/recognition. We assigned these values subjectively based on the overall view obtained from all information sources.

## Results

This section summarizes the findings about how land and water management, weather extremes and perception affect ecosystem services in the Tisza River Basin.

Regarding the influence of weather extremes on ecosystem services, the food provisioning service is perceived to be the most impacted, followed by several regulating services. The high perceived affectedness of the food is emerging from the fact that there is considerably more literature available on the observed effect of weather extremes on food compared to the other services. The cultural value and aesthetic value are the least impacted.

The interviews showed that people associate specific ecosystem types with certain services. First of all, the food provided by the arable land is the most valued ecosystem service by locals (Photo 1). Furthermore, the recreation possibilities provided by the Tisza River bank in the Bereg and the forests in

the Crişuri Plain are highly appreciated by the villagers. On the contrary, food provided by waters and forest are less recognized and hardly any services are assigned to wetlands.



Photo 1: Food production on arable land in Bereg (upper) and Crişuri Plain (lower) (Photos by Katalin Petz and Elena Livia Minca)

In Romania, there is a better acknowledgement of the basic, local products and services, including raw materials, freshwater, cultural value compared to Hungary (Fig. 2). This is supported by the fact that in Hungary people utilize the local resources, such as berries, corn and wood less. Furthermore, the not palpable and abstract services – genetic resources, water purification, water regulation, natural hazard regulation, recreation and ecotourism and aesthetic value – are more recognized in Hungary than in Romania. The interviews and the observation show that the performance of the provisioning and cultural services matches their recognition by people. This means that when people are aware of the importance of a service, the service also performs better, e.g. food supply from arable land. In contrast, the performance of the regulating services does not

always correspond with their recognition. The performance of the regulating services is more dependent on the natural conditions than on the recognition. Consequently they are influenced directly by water and land management. For instance, even if natural hazard regulation is partly recognized by local experts, it has a low performance due to the structural water engineering measures.

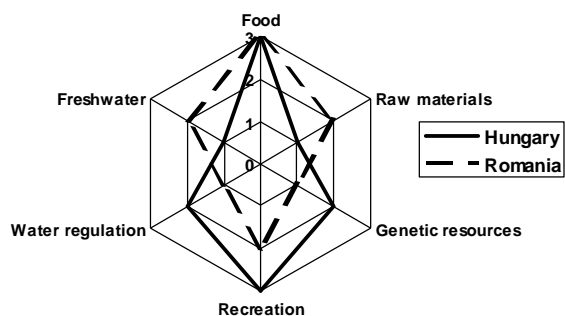


Figure 2. Recognition of services in Hungary and Romania: “basic” services (freshwater, food and raw material) and “abstract” services (water regulation, recreation and genetic resources)

Differences in water management between the two countries are reflected in the delivery of ecosystem services. In the Bereg Region the floodplain played an important role in the mitigation and retention of annual floods of the Tisza. After river regulation started 150 years ago the floodplain ecosystems were separated by dykes from the Tisza (Bellon 2004). This has led to the reduced capacity of ecosystem service provisioning. This is most obvious in the case of water regulation, natural hazard regulation and water purification services. The new water and land management plan aims at re-establishing the link between the river and the floodplain. The realization of the flood retention polder and the introduction of mosaic landscape management is designed to increase ecosystem services in the entire Hungarian study area (Molnár *et al.* 2007). For example, the polder would give space for the water retention and therefore for flood and drought mitigation. The regular water inundation of the flood retention polder would also enable wetlands to filter and purify the water.

In the Crişuri Plain the hilly natural characteristics reflected in lower intensity and frequency of floods. However, the inappropriate maintenance of water ways and canals hinders the performance of water regulation and water purification services (Photo 2). The water management plan aims to create bigger flood security and recreational opportunities by retaining

water in previously cut river arms. Despite the initial conceptual idea, the disconnection of these new wet areas from the surrounding ecosystems by dykes may hinder the fulfilment of the objectives. This would lead to a poorer performance of water related services.

In Hungary a broader awareness of ecosystem provided benefits was observed, particularly from the side of independent bodies (e.g. E-Misszió and Bokartisz NGOs) and related scientists. Although the term is not adopted in practice, local experts and mayors in the Bereg are acquainted with the meaning of ecosystem services. In Romania, the concept of ecosystem services is not known as such by any of the interviewees. The local people who work the land recognize some of the benefits they get from ecosystems. Among scientists and authorities there is understanding about the concept, but it has never been used, nor considered in their activities.



Photo 2: Poor water regulation in Bereg (upper) and Crişuri Plain (lower) (Photos by Katalin Petz and Elena Livia Minca)

## Discussion

This section focuses on the methodological difficulties and validity of the results.

Ecosystem services assessment in Hungary and Romania is pioneering work, since no similar studies have been conducted in these countries before. The biggest challenge of this research was establishing an appropriate assessment framework. First of all, the national research focuses mainly on mono-disciplinary studies matching for example the food provisioning or recreational services of ecosystems (e.g. Agro-21 Brochures in Hungary). Moreover, ecosystem services oriented research has not emerged in Hungary and Romania yet. Overall, there is no framework on assessing how ecosystem services are recognized by people and influenced by weather extremes.

The importance of this research lies – besides the scientific outcomes – in directly introducing stakeholders and local people to the integrated ecosystem approach in the interviews. Regarding the data analysis, broader knowledge was gained by combining theoretical deskwork and practical fieldwork. Since this combination is not a common practice in Hungary or in Romania, the present study is a good example of the benefits of joining theoretical and practical research.

Due to the limited time available for field visits and interviews (no inclusion of villagers), the evaluation of ecosystem services performance and recognition is necessarily based on personal interpretation and subjective. Yet the results of the assessment are very valuable in establishing the link between ecosystems, their services, human perception and water management plans. Overall, the outcomes can serve as a base for further ecosystem assessment and valuation studies in both countries as well as for the realization of ecosystems' value.

## Conclusions

As a conclusion it can be stated that in the current water management system, the natural capacity of ecosystems to fully provide their services is impaired, especially the water related ones. This is not only the effect of the human activity but also of the services' ignorance in planning and the consequence of wetland drainage and cutting river arms. Recently new water and land management initiatives – in particular in Hungary – aim to capitalize on the potential of ecosystems to regulate floods and droughts. To our best knowledge however, the concept of ecosystem services is not adopted yet in any of the countries. In Hungary, the

concept of benefits provided by the ecosystems was touched only by few scientists (e.g. economic valuation of the environment was applied by the Corvinus University of Budapest). In Romania no studies or institutions could be found using the concept of ecosystem services.

With respect to the ecosystem services delivery influenced by the new water and land management plans, bigger changes can be expected in the Hungarian case than in the Romanian one. The explanation resides in the larger extension of the Hungarian polder area – 75% of the study area is affected in Hungary, but only 5% in Romania – and the different character of the water management plans: the natural topography dictated water spread versus dyke surrounded wet areas. Overall, the ecosystem services have a lot of potential that can be capitalized upon through water and land management close to natural conditions.

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