

## THE EFFECT OF CURRENT DYNAMICAL STATE OF A LOESS STEPPE COMMUNITY ON ITS RESPONSES TO DISTURBANCES

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*Virágh, K. and Bartha, S. (1996): The effect of current dynamical state of a loess steppe community on its responses to disturbances. — Tiscia 30, 3-13.*

**Abstract.** The impact of site history and current dynamical state of a loess steppe grassland community on its coenological changes caused by different disturbances were studied in permanent plots. Disturbance agents applied were the enclosure by fence and the resumed grazing.

We investigated the coenological responses to grazing and lack of this management of 2 stands of a *Pulsatillo-Festucetum rupicolae* community with different structure, dynamical status and management history. One type of these stands was a species rich, well-organized "intact" stand, usually avoided by sheep. It was considered to be in a dynamically stable state. The other stand was a slightly degraded one, which was more frequented by the animals. This *Festuca pseudovina* type of the *Pulsatillo-Festucetum rupicolae* association had been used as a grazing land for a long time, but the regular grazing was stopped about 10 years before our experiments started.

Our results demonstrated that effects of enclosure were entirely different in a relatively intact semi-natural dense community and in a formerly grazed degraded community. We pointed out the great importance of site management history and current coenological and dynamical states of the community on its responses to fencing.

Drastic coenological changes (significant decrease in species richness, vegetation cover and living phytomass) were detected in a very short time-period (3 years) when sheep were excluded in the formerly regularly grazed stand, while only slight floristic and coenological changes could be measured in the relatively "intact" community even for several years (9 years) after fencing.

Our results of resuming grazing experiment in the degraded stand showed that the species richness, species diversity, average vegetation cover, as well as the living and dead parts of plant biomass were relatively unchanged in the slightly grazed plots. It was concluded that slight grazing management in a traditionally grazed old meadow was necessary for maintaining its floristic composition and coenological state. We emphasized that relative importance of grazing also differed between various types of a grassland community and depended on their current floristic and dynamical states and the past grazing pressures.

*Keywords: sheep grazing, fencing, site history, coenological changes, diversity*

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### Introduction

The significant role of disturbances in forming, maintaining and altering floristic states and dynamics of plant communities is generally accepted. Various hypotheses and ecological theories have been developed to explain how local diversity is produced and maintained by disturbances (Sousa 1984, White and Pickett 1985, Collins 1987, Pickett *et al.* 1989,

Chaneton and Facelli 1991). It was documented that the effect of disturbances on species diversity is strongly dependent not only on disturbance regime (type, frequency, intensity, duration of disturbance, site history) but also on the studied temporal and spatial scales (Collins and Glenn 1988, Matus and Tóthmérész 1990, Podani 1982, Wiens *et al.* 1986, Wiens 1989). It became obvious that plant communities show very high variations in their dynamic be-

behaviour and the predictability of floristic changes and community responses after disturbances is often uncertain. Understanding the disturbance-induced community changes and revealing their mechanisms are difficult because of lack of information on past events. Relevance of site history has been emphasized (Drake 1990, Facelli and Pickett 1990) in several contexts, but our knowledge about the role of past history is rather insufficient. Our present work aimed to study the impact of site history and the current dynamical state of a loess steppe grassland community on its coenological changes caused by disturbances: grazing and lack of grazing.

Considerable empirical and theoretical work has been done on the effects of grazing on grassland structure and diversity (reviewed by Looman 1983, Milchunas *et al.* 1988, 1993). Many controlled grazing and enclosure experiments were established for investigating long-term effects of grazing or protection from grazing in different types of grasslands (Klippe and Costello 1960, McNaughton 1979, 1983, Collins and Barber 1985, Hill *et al.* 1992, Noy Meir 1995). These studies suggest that changes in species composition due to grazing were primarily a function of net primary production and the history of grazing of the site. It was also stated that community responses to grazing can be modified by soil and weather conditions (eg. soil moisture, and yearly rainfall). Chaneton and Facelli (1991) and Allen *et al.* (1995) emphasized the importance of site history, initial species composition and dominance hierarchy of species.

Most of the observations on the effects of grazing on grassland vegetation has accumulated over the last centuries, particularly in North America (reviewed by Ellison 1960, Stoddart *et al.* 1975, Noy Meir *et al.* 1989, Milchunas *et al.* 1988, Laurenroth *et al.* 1994). In parallel, some ecological hypotheses have also been developed that attempt to explain and predict grazing effects.

Majority of the enormous number of publications on this topic, however, is connected with typical grazing lands of long evolutionary grazing history and adaptation. Most of the studied grasslands has been grazed by domestic grazers for more than 5000 years (Noy Meir and Seligman 1979). It is not the same situation in our young loess grassland area. The study site was not covered originally by grasslands. The present vegetation was formed after the deforestation (ca. 400-500 years ago) (Military Survey Map I 1783) and shaped by past grazing disturbances in different degree, but only for some centuries, and without intensive use as a typical pasture neither in the past.

Our present study analyzes the effect of exclud-

ing sheep-grazing from a stabilized subclimax slope-steppe community (*Pulsatillo-Festucetum rupicolae*) formed after deforestation. We used enclosure to understand what will happen in the secondary steppe grasslands when sheep will be removed in the future, hereby giving useful information also from practical point of view. It is also important because there is no traditional nature conservation management practice in Hungary for maintaining diversity of this type of loess grasslands. The enclosure experiment may be a step towards understanding the importance of grazing and small localized disturbances in the maintenance of species-richness, compositional state and regeneration capability of a rarely or periodically grazed old loess steppe grassland community and of a formerly regularly grazed one. Furthermore, resuming grazing experiment will help to reveal the role of grazing in sustaining of current coenological states.

The aims of our investigation were:

1) to compare the floristic and coenological changes after grazing has been excluded from 2 stands of slope steppe meadows of different dynamic states and histories (enclosure experiments);

2) to study the effect of experimental sheep grazing on the coenological changes of a slightly degraded stand of *Pulsatillo-Festucetum rupicolae* community (resuming grazing experiment).

## Material and method

### *Study area and field experiments*

Our study was carried out on a dry, wind-exposed hill, at the southern foot of the Bükk Mountains (NE-Hungary), at an elevation of about 200-300 m. The subcontinental climate of this gentle hilly country represents an intermediate position between the Great Hungarian Plain and the mountainous region. The annual mean temperature is 9 °C, the total precipitation is about 600 mm. The soil is brown forest soil of chernozem character, formed on loess (Virágh 1982).

The climatic zonal forest before the deforestation was *Aceri tatarico-Quercetum* reaching far from the Great Hungarian Plain, as proved by relic species (*Quercus pubescens*, *Acer tataricum*, *Nepeta pannonica*, *Phlomis tuberosa* etc.) and remnant forest fragments existing even today. Nowadays different secondary steppe meadows (Virágh and Fekete 1984) and their degraded types due to intensive grazing cover almost the whole area and only small remnants of forest steppe meadow rich in *Festuca rupicola* can be found.

Controlled disturbance experiments were conducted for 10 years to study the secondary succession, as well as the regeneration capability (community resilience) of a loess steppe grassland community (Virágh 1982, 1989a,b). The internal coenodynamics of a grazed slope-steppe meadow was also investigated and the secondary xeroseries, e. g. : degradation stages created by past grazing in a hilly country were characterized (Virágh and Fekete 1984).

A slope-steppe meadow, *Pulsatillo-Festucetum rupicola* (Máthé and Kovács 1962) was chosen for our detailed studies. This community can be considered as the final stage (subclimax community) in the successional series of grasslands in the given area. Detailed description of this community and the sources of richness of flora are presented in Virágh (1982) and Virágh and Fekete (1984). Two uniform stands of this community were selected for our experiments in order to eliminate the effects of spatial heterogeneity.

The first stand situated on the hill top. In spite of its mild slope it was relatively protected from grazing because the animals were usually driven on from this field. Moreover, probably due to the presence of great number of slightly poisonous *Pulsatilla nigricans*, the stand was mostly avoided by sheep. It was rich in plant species, consisted of 80-100 species. It was considered to be a relatively intact, natural or semi-natural typical stand of the *Pulsatillo-Festucetum rupicola* association (Virágh 1989a, b, Virágh 1992a, b).

The second stand, nearer the village, towards the bottom of the slope was slightly degraded one, which was more frequented by the animals. Decrease and disappearance of many codominant and rare species (*Pulsatilla nigricans*, *Genista tinctoria*, *Dianthus pontederiae*, *Asperula cynanchica* and *Arenaria graminifolia*, *Asparagus officinalis*, *Stipa capillata*) and the increasing abundance of grazing tolerant species (*Hieracium pilosella*, *Plantago lanceolata*, *Euphorbia cyparissias*) was characteristic here. Owing to the selective grazing, the abundance of *Festuca rupicola*, a species preferred by animals, also decreased and replaced by the less preferred *Festuca pseudovina*. It can be classified as *Festuca pseudovina* type of the *Pulsatillo-Festucetum rupicola* association, tainted also with several ruderals. This stand had been used as a "grazing land", but the regular grazing was stopped about 10 years before our experiments started.

The species list of the quadrats selected for our studies is presented in Table 1 with the indication of average cover. The flora of the studied area is rich both in the intact "ungrazed" plots and the slightly

degraded ones. The total species number of the intact plots is 73, however, it is much smaller (53) in the degraded plots. It is remarkable that there is a large number of species with low cover and the total cover of the degraded quadrats is resulted mostly by a very few dominant species. Great differences in the species dominance hierarchy between the 2 stands are demonstrated in Table 2. It is indicated that several species are codominant and many species of intermediate importance values occur in the intact quadrats but only 2 grasses are predominant having a 50 % share of the total cover in the slightly degraded (grazed) quadrats.

### Experiments

#### 1) Enclosure experiments:

a) The area of 40 × 30 m in the intact, "ungrazed" community (stand A) was fenced in 1979 to study major floristic changes in permanent quadrats over 9 years.

b) Enclosure by fence was also applied in the degraded, formerly intensively grazed stand in the area of 5 × 5 m (stand B) to study the effect of protection from grazing after 3 years.

Extent of the 2 fenced areas was dissimilar, because some other experiments (Virágh 1982, 1992) were also carried out in the stand A, but the comparable data were both originated from the area of 5 m<sup>2</sup> that proved to be representative for the whole stand (Virágh 1992, 1994).

#### 2) Experiment of resuming grazing:

The slightly degraded "grazed" stand (stand B) was experimentally grazed at a low stocking rate (grazed by a flock of four sheep; Gibson 1988, Gibson *et al.* 1987) from 1987. It was continued for 3 years and then the influences on floristic and coenological changes were analysed.

### Sampling

The experiments were followed in permanent plots of 1 m<sup>2</sup> with 5 replications per treatments. The detailed investigations were made in 1 × 1 m quadrats covered with a grid of 20 × 20 cm. Presence — absence and percentage cover of each species, visually estimated, were recorded in a set of contiguous subquadrats (125 in total per treatments). The values detected at 400 cm<sup>2</sup> were summed or averaged for 1 m<sup>2</sup> and 5 m<sup>2</sup> quadrats in each experiment.

### Remarks on the relevant plot sizes

Our previous studies (Virágh 1992, 1994) indicated that:

— Maximum value of the cover-based significant interspecific correlation (ISC) appeared at 400

cm<sup>2</sup> plot size on the study-site (Bartha 1983). The number of species combination was also the highest and the stand proved to be the most heterogeneous at this characteristic area for the most abundant species. The floristic changes at this spatial microscale were indicated very sensitively (Virágh 1994).

— At 1 m<sup>2</sup> plot size summation of the smaller scale dynamics was manifested. Variability among these plots, resulted from the plots differed in species composition and abundance, reflected the local spatial heterogeneity, characteristic for the whole stand of small extent.

— Considering all of the species, the 5 m<sup>2</sup> size of plots contained a portion of the stand large enough to be floristically homogeneous and characteristic for the stand.

Floristic composition was recorded in June from 1979 to 1983 and then in 1987 in the case of experiment 1a. Presence — absence and cover data for each species in the other experiments (1b, 2) were assessed before the treatments and 3 years later, at the end of May in 1987 and 1990.

In the 2 latter experiments (1b, 2) simultaneously with the recordings, samples were taken for production investigations (by monolith sampler of 20 × 20 × 10 cm). The samples were separated into monocots and dicots. Weight measurements of above-ground living plant parts and above-ground dead plant parts were carried out after a drying on 105 °C.

#### Methods used

1) Community responses to disturbances were assessed with respect to major floristic changes and some community attributes, mainly based on the cover of every species. These were the following:

- a) total cover of vegetation, species richness, species diversity and evenness
- b) plant production (living and dead plant biomass).

Species richness is the total number of species for each date of sampling in each experiment. Species diversity was calculated as:

$$H = -\sum p_i \ln p_i$$

(Shannon 1948), where  $p_i$  is the relative cover of species "i". The evenness measure used here is based on this diversity index and is defined as:

$$E = \frac{H}{H_{\max}}$$

where  $H_{\max} = \ln S$ ,  $S$  is the species number

- 2) Dissimilarity indices were used to analyse the

effect of treatments on the rate of change. The changes referring to the first sampling date, namely the trend of changes during the investigated period were calculated by Sørensen (1948) and Czekanowski (1909) indices.

Percentage dissimilarity index and principal coordinates ordinations based on Czekanowski index were also applied (Podani 1991) to estimate the degree of floristic change induced by disturbances and to reveal trends in temporal variation of species composition over years.

## Results and discussion

### *Effect of enclosure by fence (excluding sheep grazing)*

#### *1a) Floristic and structural changes after fencing in the "intact", ungrazed stand of a semi-natural community for 9 years*

In the closed, very dense intact community a large number of species coexisted (Table 1).

Total percentage cover of vegetation (Fig. 2a) showed some significant changes during the 9 years, indicating mainly the effect of climatic differences between years. When the total precipitation of the growing season (Fig. 1) was high above the 50 years average in 1980 and 1981, the vegetation cover was the highest. There was a significant decrease in vegetation cover from 1982 to 1987 in response to the dry summer periods, but the vegetation still remained closed with relatively high cover values (>80 %) 9 years after the fencing in this stand.

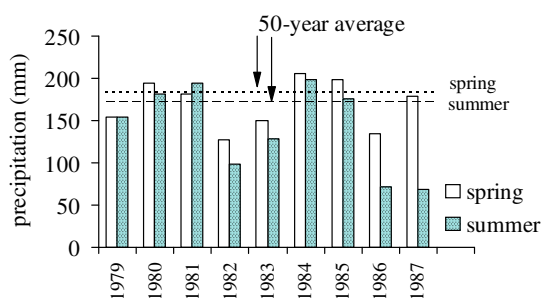


Fig. 1. Spring and summer precipitation from 1979 to 1987.

Species diversity ( $H$ ) (Fig. 2b), species richness ( $S$ ) (Fig. 2c) and evenness ( $E$ ) (Fig. 2d) were very similar during the investigated period. Changes of species richness were insignificant from 1979 to 1987, indicating that this community was able to preserve its species number for several years. Species diversity and evenness values changed within a

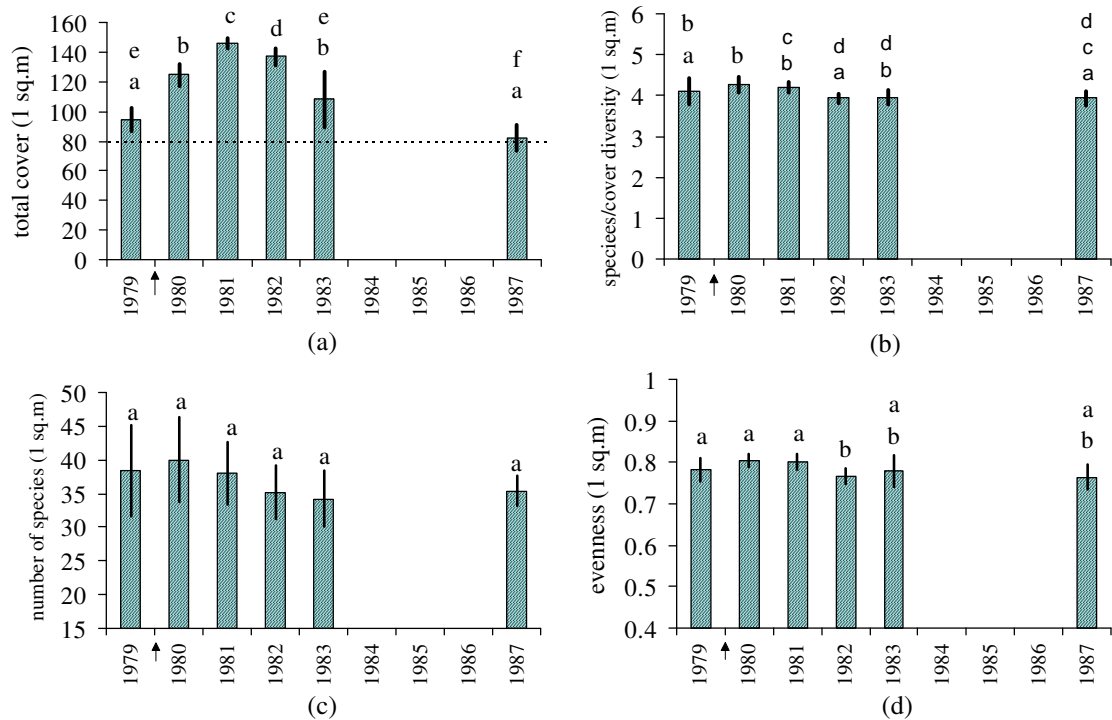


Fig. 2. Changes of total cover (a), species diversity(b), number of species (c) and evenness (d) in the intact stand over 9 years. (Arrow indicates date of fencing. Data marked with the same letters had no significant differences (t-test,  $p < 0.05$ ))

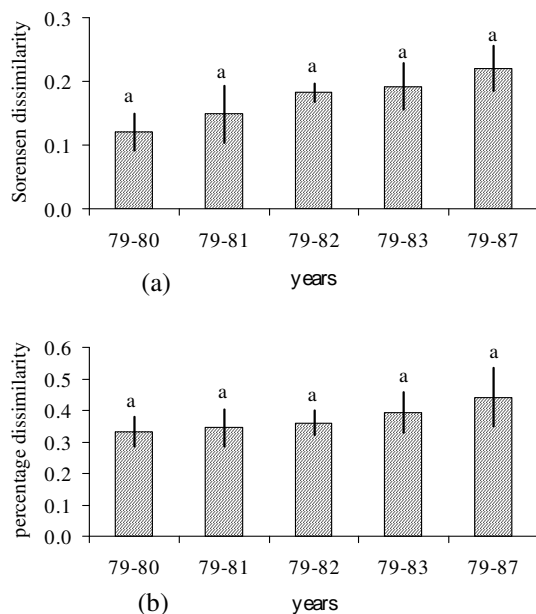


Fig. 3. Trends of floristic change (a) and cover-based change (b) in the intact stand over 9 years. (Non-significant differences marked in the same way as in Fig. 2.)

relatively narrow range from 3.9 to 4.3 and 0.76 to 0.80, respectively. The lowest values of these community attributes were measured in the dry years. According to the climatic differences between years the t-test showed some significant differences between the average diversity and evenness values, however these statistically significant changes could be considered rather "fluctuation" than ecologically significant changes referring to the whole period, because in 1987 both the diversity and evenness values were almost the same as 9 years before, in 1979.

The results of dissimilarity analyses (Figs 3a and b) demonstrated the differences in the temporal variation of floristic composition. Sørensen dissimilarity values referring to the first year changed between 12-22%. Because of the high species number and many rare species these dissimilarities could be considered relatively low. The Czekanowski dissimilarities based on species cover always showed higher dissimilarities than the Sørensen values. During the 9 years the changes were between 33-44%. Both dissimilarity indices increased by about 10% probably induced by the variation in weather, but significant changes could not be detected among the average values of the dissimilarity indices over the study-period.

Table 1. Species list of the intact stand (A) and the slightly degraded stand (B) before the treatments. Nomenclature follows Soó (1980). Average cover of each species was calculated for 1 m<sup>2</sup> quadrats.

Name of species	Average cover %		Name of species	Average cover %	
	stand A	stand B		stand A	stand B
<b>Gramineae</b>					
<i>Agrostis canina</i>	10.85 ± 0.99	13.96 ± 2.10	<i>Hieracium bauginii</i>	2.12 ± 0.32	0.39 ± 0.19
<i>Anthoxanthum odoratum</i>	3.56 ± 0.33	4.18 ± 0.77	<i>Hieracium pilosella</i>	2.74 ± 0.71	0.52 ± 0.12
<i>Bothriochloa ischaemum</i>	8.18 ± 1.05	-	<i>Hypericum perforatum</i>	0.92 ± 0.16	-
<i>Briza media</i>	0.20 ± 0.11	-	<i>Inula britannica</i>	0.20 ± 0.11	< 0.10
<i>Bromus mollis</i>	< 0.10	-	<i>Leontodon hispidus</i>	13.18 ± 1.49	4.52 ± 0.87
<i>Chrysopogon gryllus</i>	< 0.10	< 0.10	<i>Linum catharticum</i>	-	< 0.10
<i>Danthonia alpina</i>	2.93 ± 0.78	3.05 ± 0.94	<i>Lotus corniculatus</i>	-	1.46 ± 0.36
<i>Danthonia decumbens</i>	0.85 ± 0.24	-	<i>Myosotis stricta</i>	< 0.10	-
<i>Festuca rupicola et</i>	23.13 ± 2.01	21.92 ± 1.94	<i>Ononis spinosa</i>	-	0.17 ± 0.05
<i>Festuca pseudovina</i>			<i>Orchis morio</i>	< 0.10	< 0.10
<i>Koeleria cristata</i>	0.48 ± 0.17	0.86 ± 0.16	<i>Pimpinella saxifraga</i>	0.70 ± 0.19	0.55 ± 0.15
<i>Stipa capillata</i>	< 0.10	< 0.10	<i>Plantago lanceolata</i>	1.04 ± 0.18	1.15 ± 0.34
			<i>Plantago media</i>	0.76 ± 0.25	0.21 ± 0.11
<b>Other Monocotyledons</b>			<i>Polygala comosa</i>	0.25 ± 0.08	< 0.10
<i>Anthericum ramosum</i>	0.16 ± 0.03	-	<i>Potentilla arenaria</i>	3.24 ± 0.40	< 0.10
<i>Asparagus officinalis</i>	0.40 ± 0.01	-	<i>Potentilla argentea</i>	0.33 ± 0.14	-
<i>Carex caryophyllaea</i>	8.95 ± 1.07	1.86 ± 0.27	<i>Pulsatilla nigricans</i>	1.84 ± 0.46	< 0.10
<i>Luzula campestris</i>	7.92 ± 0.51	1.47 ± 0.43	<i>Prunella laciniata</i>	< 0.10	< 0.10
			<i>Prunus spinosa</i>	< 0.10	-
<b>Dicotyledons</b>			<i>Ranunculus repens</i>	-	< 0.10
<i>Achillea collina</i>	6.64 ± 0.35	2.88 ± 0.47	<i>Rumex acetosella</i>	0.57 ± 0.14	< 0.10
<i>Ajuga genevensis</i>	0.16 ± 0.01	< 0.10	<i>Rumex thyrsoiflorus</i>	0.23 ± 0.13	-
<i>Arenaria graminifolia</i>	< 0.10	-	<i>Salvia pratensis</i>	< 0.10	< 0.10
<i>Arenaria serpyllifolia</i>	< 0.10	< 0.10	<i>Saxifraga bulbifera</i>	< 0.10	< 0.10
<i>Asperula cynanchica</i>	1.41 ± 0.25	< 0.10	<i>Scabiosa ochroleuca</i>	1.09 ± 0.27	0.126 ± 0.05
<i>Campanula rotundifolia</i>	< 0.10	-	<i>Senecio jacobaea</i>	< 0.10	-
<i>Carlina vulgaris</i>	1.91 ± 0.34	< 0.10	<i>Seseli annuum</i>	2.56 ± 0.30	2.58 ± 0.44
<i>Centaurea pannonica</i>	0.27 ± 0.17	0.53 ± 0.33	<i>Silene otites</i>	0.25 ± 0.10	< 0.10
<i>Centaureum erythraea</i>	< 0.10	-	<i>Stellaria graminea</i>	< 0.10	-
<i>Cerastium brachypetalum</i>	< 0.10	< 0.10	<i>Taraxacum officinalis</i>	0.39 ± 0.15	-
<i>Crataegus monogyna</i>	< 0.10	< 0.10	<i>Teucrium chamaedrys</i>	0.58 ± 0.31	-
<i>Dianthus pontederiae</i>	2.16 ± 0.32	-	<i>Thesium ramosum</i>	0.20 ± 0.07	-
<i>Dorycnium herbaceum</i>	< 0.10	-	<i>Thlaspi jankae</i>	< 0.10	-
<i>Echium vulgare</i>	< 0.10	-	<i>Thymus marschallianus</i>	12.11 ± 1.06	3.51 ± 0.44
<i>Eryngium campestre</i>	1.21 ± 0.55	< 0.10	<i>Trifolium alpestre</i>	0.57 ± 0.21	-
<i>Euphorbia cyparissias</i>	2.40 ± 0.27	0.36 ± 0.07	<i>Trifolium campestre</i>	0.11 ± 0.01	0.40 ± 0.01
<i>Euphrasia tatarica</i>	0.79 ± 0.10	0.11 ± 0.02	<i>Trifolium montanum</i>	< 0.10	< 0.10
<i>Filipendula vulgaris</i>	2.33 ± 0.77	1.93 ± 0.25	<i>Trifolium repens</i>	-	< 0.10
<i>Fragaria viridis</i>	1.15 ± 0.23	0.33 ± 0.14	<i>Verbascum phoeniceum</i>	1.44 ± 0.35	-
<i>Galium verum</i>	< 0.10	< 0.10	<i>Veronica prostrata</i>	-	< 0.10
<i>Genista tinctoria</i>	2.88 ± 0.39	-	<i>Veronica spicata</i>	1.09 ± 0.21	0.96 ± 0.19
			<i>Vicia cracca</i>	-	< 0.10
			<i>Viola arenaria</i>	5.60 ± 0.17	0.13 ± 0.03
			<i>Viscaria vulgaris</i>	3.79 ± 0.82	-

Our results suggested that the most important influential factor in the intact grassland community dynamics may be the climatic-year heterogeneity (cf. Virágh 1986, 1987). Vegetation cover changed as a result of year to year changes in species abundances also influenced by climatic differences between years. Fencing did not change significantly species richness, diversity and evenness, as well as the degree of floristic composition changes within 9 years.

All community attributes except the total cover of vegetation and dissimilarity indices changed within a narrow range during the study period, showing the intact community in a dynamically stable state. In spite of the protection of the stand from the large animal disturbances, as well as the great annual climatic changes and fluctuation in species abundances (Virágh 1989a, b), the community was able to maintain its floristic composition. It was also found that

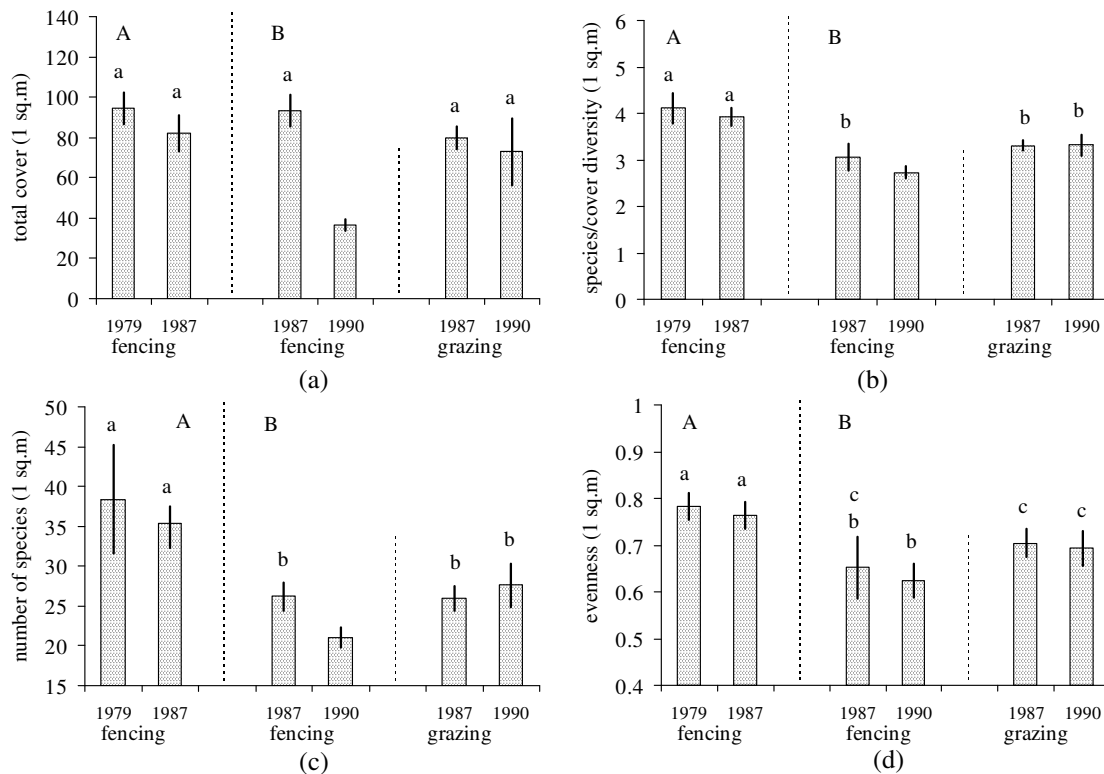


Fig. 4. Effect of treatments on the total cover changes (a), changes of species diversity (b), number of species (c) and species evenness (d) in the intact stand (A) and the slightly degraded stand (B), (non-significant differences marked in the same way as in Fig. 2).

the relative importance of most of the species remained fairly constant and a relatively fixed abundance-dominance hierarchy of the species was revealed for 9 years, as had already been discussed in Virágh (1989a).

*1b) Floristic and structural changes in the slightly degraded stand after fencing over 3 years*

The enclosure experiment in the degraded stand led to significant decreases in the average vegetation cover (<40%) (Fig. 4a), indicating that the stand seriously opened up. Monocots accounted for 71% of the total cover in 1990 which proportion was 15% higher than in 1987. This considerable increase of proportion between monocots and dicots after excluding grazing was not surprising because sheep prefer graminoids over other types of forage. The significant cover decrease was probably also due to a build-up in dead biomass, which was 4.5 times higher as compared to the living biomass.

Fencing did not change evenness but it significantly reduced species richness and diversity during 3 years (Fig. 4). One of the most significant changes in the formerly grazed stand after the enclosure was

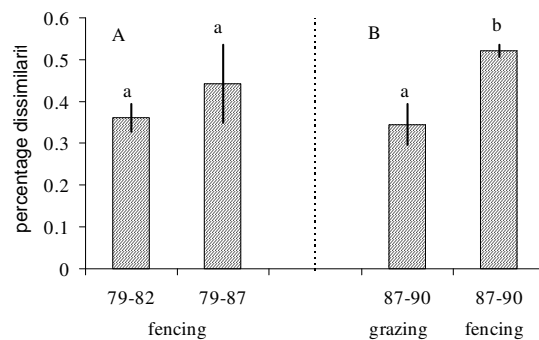


Fig. 5. Coenological changes induced by the treatments in the intact stand (A) and the slightly degraded stand (B) over 3 years (see Fig. 2 for explanation of symbols).

the considerable decrease of species number (Fig. 4c), primarily as a result of disappearance of many subordinate dicots (*Asperula cynanchica*, *Linum catharticum*, *Pimpinella saxifraga*, *Polygala comosa*) and more increasing dominance (predominance) of *Festuca pseudovina et rupicola*.

Drastic coenological changes (Fig. 5) within a 3-year period were also detected by the percentage dis-

similarity index which showed the degree of community changes with a rather high dissimilarity value (>50%).

Our results indicated that fencing differentially affected species composition and community structure in the dynamically stable intact stand and in the degraded, formerly regularly grazed stand.

Table 2. Dominance hierarchy of the species in the intact stand (A) and the slightly degraded stand (B) before the treatments.

<b>A</b>	Name of species	Rel. dom. %	Cum. rel. dom. %
1	<i>Festuca rupicola</i>	15.82	15.82
2	<i>Leontodon hispidus</i>	9.01	24.84
3	<i>Thymus marschallianus</i>	8.28	33.12
4	<i>Agrostis canina</i>	7.42	40.55
5	<i>Carex caryophyllea</i>	6.12	46.67
6	<i>Bothriochloa ischaemum</i>	5.59	52.27
7	<i>Luzula campestris</i>	5.41	57.69
8	<i>Achillea collina</i>	4.54	62.23
9	<i>Viscaria vulgaris</i>	2.59	64.82
10	<i>Anthoxanthum odoratum</i>	2.43	67.26
11	<i>Filipendula vulgaris</i>	2.27	69.53
12	<i>Potentilla arenaria</i>	2.22	71.75
13	<i>Danthonia alpina</i>	2.00	73.76
14	<i>Genista tinctoria</i>	1.97	75.74
15	<i>Hieracium pilosella</i>	1.87	77.61
16	<i>Seseli annuum</i>	1.75	79.37
17	<i>Euphorbia cyparissias</i>	1.64	81.02
18	<i>Eryngium campestre</i>	1.51	82.53
19	<i>Dianthus pottederae</i>	1.47	84.01
20	<i>Hieracium bauhinii</i>	1.45	85.47
21	<i>Carlina vulgaris</i>	1.30	86.77
22	<i>Pulsatilla nigricans</i>	1.25	88.03
23	<i>Verbascum phoeniceum</i>	0.99	89.02
24	<i>Asperula cynanchica</i>	0.96	89.99
25	<i>Fragaria viridis</i>	0.78	90.78
26	<i>Scabiosa ochroleuca</i>	0.74	91.53
27	<i>Plantago lanceolata</i>	0.71	92.24
28	<i>Veronica spicata</i>	0.65	92.89
29	<i>Hypericum perforatum</i>	0.63	93.50

<b>B</b>	Name of species	Rel. dom. %	Cum. rel. dom. %
1	<i>Festuca rupicola</i>	31.06	31.06
2	<i>Agrostis canina</i>	19.79	50.86
3	<i>Leontodon hispidus</i>	6.38	57.25
4	<i>Anthoxanthum odoratum</i>	5.92	63.17
5	<i>Thymus marschallianus</i>	4.97	68.15
6	<i>Danthonia alpina</i>	4.32	72.47
7	<i>Achillea collina</i>	4.08	76.55
8	<i>Seseli annuum</i>	3.66	80.22
9	<i>Filipendula vulgaris</i>	2.73	82.95
10	<i>Carex caryophyllea</i>	2.64	85.60
11	<i>Luzula campestris</i>	2.08	87.69
12	<i>Lotus corniculatus</i>	2.06	89.75
13	<i>Plantago lanceolata</i>	1.63	91.38
14	<i>Veronica spicata</i>	1.36	92.74
15	<i>Koeleria cristata</i>	1.23	93.97

Fencing had significant effects on species diversity and species richness only in the degraded stand, while the intact dense stand kept its composition practically unchanged for 9 years. Proportion of monocots, accounting for 40-50 % of the total cover, remained about the same in the intact stand over 9 years (Virágh, 1989a), but the proportion of monocots and dominance structure in the degraded stand had considerably changed (from 56% to 71%) in a very short time period (3 years). The degree of coenological changes had already been rather high over 3 years (50%) when sheep were excluded in the degraded stand while in the intact stand it was not so high after 9 years, either.

The effect of protection from large animals on the vegetation cover changes was entirely different on the 2 stands. However, our evaluation in this comparison could be only limited, because we had no data for both stands during the same years, so the year to year climatic variability might be considerably masked our differences obtained on the 2 stands.

#### *Effect of resuming grazing at low stocking rate on the floristic and structural changes over 3 years*

Resuming grazing experiment demonstrated that the species richness, species diversity and evenness, as well as the average vegetation cover were unchanged in the moderately grazed plots during the investigated 3 years (Fig. 4). Proportion of monocots of the total vegetation cover was also similar (64-65%) from 1987 to 1990. Percentage dissimilarity value, which expressed the degree of coenological changes over 3 years, was almost the same as in the case of the intact, hardly grazed stand (Fig. 5).

Moderately grazed and ungrazed-fenced plots in the degraded stand were compared to determine the effect of grazing and protection from grazing on floristic state and biomass production, as well.

The ordination based on cover data (Fig. 6) showed great compositional similarities among the initial pre-disturbed states (1987). Separation of the fenced plots in 1990 from both the initial states and the moderately grazed states after 3 years was also well-demonstrated, indicating larger floristic changes caused by exclusion of grazing than grazing.

The results, that species richness and diversity remained very similar in grazed plots for 3 years but these attributes decreased in the fenced plots, were also obtained by Belsky (1992) in Mediterranean grasslands. Singh and Misra (1969) also reported a decline in species diversity in enclosures for an alluvial grassland and McNaughton (1979, 1983) and Belsky (1986, 1992) for several Serengeti communi-



ties. However, many reverse situation had also been observed ( Noy-Meir *et al.* 1989, Allen *et al.* 1995) in various grasslands. We suggest that these results are strongly dependent on the current dynamical state of community, its species composition, as well as the climatic condition and intensity and duration of former grazing impact (site management history).

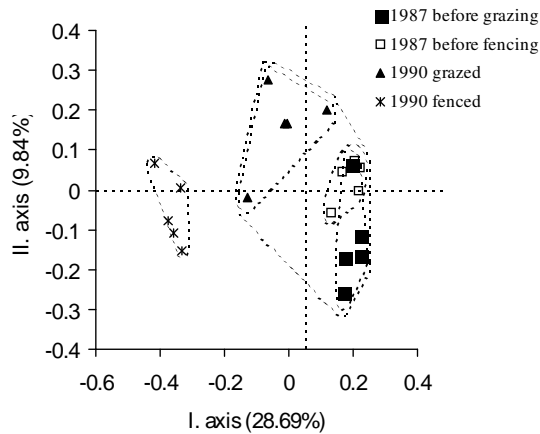


Fig. 6. Principal coordinates ordination (based on Czekanowski index) of 1 m<sup>2</sup> sampling plots in the degraded stand.

It is surprising that in our grazing experiment the total vegetation cover (Fig. 4a) was unchanged in grazed quadrats within 3 years but during the same time significant changes were induced by fencing in ungrazed quadrats. Belsky (1992) experienced that 1 year after the enclosure the total live cover was higher in ungrazed than in grazed plots, however over the next 4 years live cover declined in the ungrazed plots.

It is likely that in our case the greater accumulation of litter on fenced plots compared to grazed ones (Fig. 7) can be responsible for this difference. Litter in the fenced plots was 4.5 times higher than the living biomass while this ratio was only 2 in the grazed plots. Greater accumulation of litter on ungrazed sites compared to grazed ones is commonly reported for several grassland types (Belsky 1992, Kelly and Walker 1976, Knapp and Seastedt 1986, Cid *et al.* 1991). Three years after our treatments drastic changes in the biomass fractions was well-detected. We suggest that the great number of litter fraction could inhibit the normal regeneration grassland dynamics and the process of establishment of new species. It may also be the reason for the great decrease of species number due to lack of grazing, too.

In the comparison of 3 treatments (Fig. 8) the relative importance of site effects was well-

demonstrated. The ordination revealed the similarity relationships among the treatments and showed the impact of fencing and grazing in the intact, hardly grazed and the slightly degraded stands. The result presented that the most influential factor was the difference between the 2 sites. Separation of the intact quadrats from the degraded ones was rather strong on the principal coordinates axis 1 accounting for 36 % of the total variance, while compared to this, the effect of treatments was only slight.

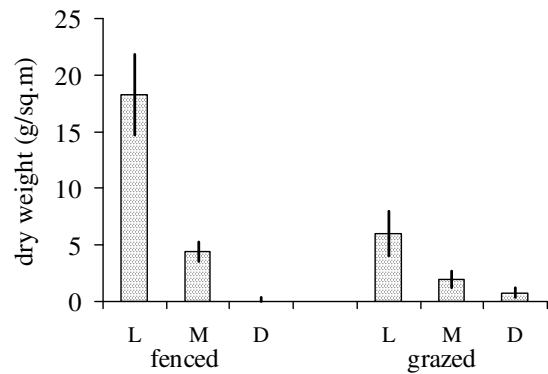


Fig. 7. Biomass fractions in the slightly degraded stand in the 3rd year of the treatments (L: litter; M: monocots; D: dicots).

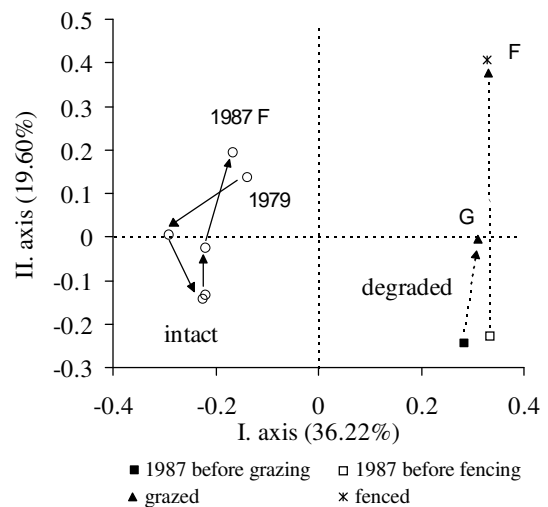


Fig. 8. Effect of treatments in the intact and degraded stands. Principal coordinates ordination (based on Czekanowski index) of 5 m<sup>2</sup> sampling plots.

### Concluding remarks

Our investigations demonstrated the differences in the coenological changes of a formerly grazed and an ungrazed community after fencing, and the differences inside of enclosure and in the area subjected

to resuming slight grazing. Great importance of site management history was emphasized in the community responses to disturbances.

The effect of enclosure was entirely different in a relatively intact, semi-natural community and in a formerly often grazed degraded community. Significant coenological changes were only found in the degraded stand, where drastic changes took place already within a very short time period (3 years). Considerable decrease in species richness, diversity and vegetation cover was observed here. Protection led to the predominance of a few species and a very high litter fraction of biomass. On the contrary, the intact dense community kept its floristic composition and coenological structure practically unchanged for several years (9 years).

In the degraded community resuming grazing promoted maintenance of species richness, diversity, vegetation cover and living and dead parts of plant biomass on similar level.

The results of present study also suggested that in order to preserve the current compositional state of the regularly grazed communities slight grazing has to be used. Relative importance of grazing strongly differed between the various types of a grassland community and depended on their current compositional and dynamic state and the past grazing pressure. It was apparent that slight grazing management is necessary for maintaining the coenological state of the formerly grazed community. However, high species diversity and coenological structure of the relatively intact, formerly hardly grazed community can only be reserved by exclusion of regular sheep grazing in our study site. Strong protection by fencing is not proposed, because small natural animal activities are probably needed for persistence of plant species and normal grassland dynamics for a long time period.

This work focussed on the community changes after disturbances with only emphasis on some aspects of compositional changes without studies on particular population. It is a preliminary experiment because of the limitation of few years of enclosure and grazing treatments. Long term study of the impact of slight grazing and lack of grazing management (fencing) on the loess grassland area is needed. Our results can be useful for nature conservation practice which has to aim at both preserving the ancient loess steppe fragments and sustaining existing floristic diversity and maintaining all successional stages influenced by very variable past grazing intensity on the study area.

## Acknowledgement

Present work was supported by the grant of the National Scientific Research Foundation (OTKA grant No. 5032).

## References

- Allen, R. B., Wilson, J. B. and Mason, C. R. (1995): Vegetation change following exclusion of grazing animals in depleted grassland, Central Otago, New Zealand. — *J. Veg. Sci.* 6, 615-626.
- Bartha, S. (1983): Plexus gráfok térfolyamatban (Plexus graphs in spatial process) — Vácátót (M. Sc. thesis).
- Belsky, A. J. (1986): Revegetation of artificial disturbances in grasslands of the Serengeti National Park, Tanzania. II. Five years of successional changes. — *J. Ecol.* 74, 937-951.
- Belsky, A. J. (1992): Effects of grazing, competition, disturbance and fire on species composition on diversity in grassland communities. — *J. Veg. Sci.* 3, 187-200.
- Chaneton, E. J. and Facelli, J. M. (1991): Disturbance effects on plant community diversity: spatial scales and dominance hierarchies. — *Vegetatio* 93, 143-155.
- Cid, M. S., Detling, J. K., Whicker, A. D. and Brizuela, M. A. (1991): Vegetational responses of a mixed-grass prairie site following exclusion of prairie dogs and bison. — *J. Range Manage.* 44, 100-105.
- Collins, S. L. (1987): Interaction of disturbances in tallgrass prairie: a field experiment. — *Ecology* 68, 1243-1250.
- Collins, S. L. and Barber, S. C. (1985): Effects of disturbance on diversity in mixed-grass prairie. — *Vegetatio* 64, 87-94.
- Collins, S. L. and Glenn, S. M. (1988): Disturbance and community structure in North American prairies. In: During, H. J., Werger, M. J. and Williams, H. J. (eds): Diversity and pattern in plant communities. — SPB Academic, The Hague.
- Czekanowski, J. (1909): Differentialdiagnose der Neandertalgruppe. — *Korrespbl. dt. Ges. Anthrop.* 40, 44-47.
- Drake, J. A. (1990): Communities as assembled structures: Do rules govern pattern? — *TREE* 5, 159-164.
- Ellison, L. (1960): Influence of grazing on plant succession of rangelands. — *Bot. Rev.* 26, 1-78.
- Facelli, J. M. and Pickett, S. T. A. (1990): Markovian chains and the role of history in succession. — *TREE* 5, 27-30.
- Gibson, D. J. (1988): The relationship of sheep grazing and soil heterogeneity to plant spatial patterns in dune grassland. — *J. Ecol.* 76, 233-252.
- Gibson, D. J., Watt, T. A. and Brown, V. K. (1987): The use of sheep grazing to recreate species-rich grassland from abandoned arable land. — *Biol. Conservation* 42, 165-183.
- Hill, M. O., Evans, D. F. and Bell, S. A. (1992): Long-term effects of excluding sheep from hill pastures in North Wales. — *J. Ecol.* 80, 1-13.
- Kelly, R. D. and Walker, B. H. (1976): The effects of different forms of land use on the ecology of a semi-arid region in south-eastern Rhodesia. — *J. Ecol.* 64, 553-576.
- Klippe, G. E. and Costello, D. F. (1960): Vegetation and cattle responses to different intensities of grazing on short-grass ranges on the central Great Plains. — *USDA Tech. Bull.* 1216. Washington D. C. 82 pp.

- Knapp, A. K. and Seastedt, T. R. (1986): Detritus accumulation limits productivity of tallgrass prairies. — *Bioscience* 36, 662-668.
- Laurenroth, W. K., Milchunas, D. G., Dodd, J. L., Hart, R. H., Heitschmidt, R. K. and Rittenhouse, L. R. (1994): Effects of grazing on ecosystems of the great plains. In: Vavra, M., Laycock, W. A. and Pieper, R. D. (eds): Ecological implications of livestock herbivory in the west. — *Soc. Range Manage.* 69-101 pp.
- Looman, J. (1983): Grassland as natural or semi-natural vegetation. In: Holzner, W., Werger, M. J. A. and Ikusima, I. (eds): Man's impact on vegetation. — The Junk Publ., The Hague-Boston-London. 173-183 pp.
- Matus, G. and Tóthmérész, B. (1990): The effect of grazing on the structure of a sandy grassland. In: Krahulec, F., Agnew, A. D. Q., Agnew, S. and Williems, J. H. (eds): Spatial processes in Plant Communities. — Academia, Praha. 23-31 pp.
- Máthé, I. and Kovács, M. (1962): Die Vegetation des Sárhegy bei Gyöngyös. — *Bot. Közlem.* 49, 309-328.
- McNaughton, S. J. (1979): Grazing as an optimization process: grass-ungulate relationships in the Serengeti. — *Am. Nat.* 113, 691-703.
- McNaughton, S. J. (1983): Serengeti grassland ecology: the role of composite environmental factors and contingency in community organization. — *Ecol. Monogr.* 53, 291-320.
- Milchunas, D. G., Sala, O. E. and Laurenroth, W. K. (1988): A generalized model of the effects of grazing by large herbivores on grassland community structure. — *Am. Nat.* 132, 87-106.
- Milchunas, D. G., Laurenroth, W. K., Chapman, P. L. and Kazempour, M. K. (1989): Effects of grazing, topography and precipitation on the structure of a semiarid grassland. — *Vegetatio* 80, 11-23.
- Milchunas, D. G. and Laurenroth, W. K. (1993): Quantitative effects of grazing on vegetation and soils over a global range of environments. — *Ecol. Monogr.* 63, 327-366.
- Noy-Meir, I. (1995): Interactive effects of fire and grazing on structure and diversity of Mediterranean grasslands. — *J. Veg. Sci.* 6, 701-710.
- Noy-Meir, I., Gutman, M. and Kaplan, Y. (1989): Responses of Mediterranean grassland plants to grazing and protection. — *J. Ecol.* 77, 290-310.
- Noy-Meir, I. and Seligman, N. G. (1979): Management of semi-arid ecosystems in Israel. In: Walker, B. H. (ed.): Management of Semi-Arid Ecosystems. — Elsevier, Amsterdam, 113-160 pp.
- Pickett, S. T. A., Kolasa, J., Armesto, J. J. and Collins, S. J. (1989): The ecological concept of disturbance and its expression at various hierarchical levels. — *Oikos* 54, 129-136.
- Podani, J. (1982): Spatial processes in the analysis of vegetation. — University of Western Ontario, London. Nat. Library of Canada Microfiche. No. TC56124 (Ph. D. thesis).
- Podani, J. (1991): SYN-TAX IV. Computer programs for data analysis in ecology and systematics. In: Feoli, E. and Orlóci, L. (eds): Computer Assisted Vegetation Analysis. — Kluwer, The Netherlands, 437-452 pp.
- Shannon, C. E. (1948): A mathematical theory of communication. — *Bell. Sys. Tech. J.* 27, 379-623.
- Singh, J. S. and Misra, R. (1969): Diversity, dominance, stability and net production in the grasslands at Varanasi, India. — *Can. J. Bot.* 47, 425-427.
- Soó, R. (1980): Taxonomical and phytogeographical handbook of the Hungarian flora. VI. Akad. Kiadó, Budapest, 557 pp.
- Sørensen, T. (1948): A method for establishing groups of equal species content and its application to analyses of the vegetation on Danish commons. — *Biol. Skr.* 5, 1-34.
- Sousa, W. P. (1984): The role of disturbance in natural communities. — *Ann. Rev. Ecol. Syst.* 15, 353-391.
- Stoddart, D. R., Smith, A. D. and Box, T. W. (1975): Range Management. — McGraw-Hill, New York.
- Virágh, K. (1982): Vegetation dynamics induced by some herbicides in a perennial grassland community. — *Acta Bot. Acad. Sci. Hung.* 28, 424-447.
- Virágh, K. (1986): The effect of herbicides on vegetation dynamics: a multivariate study. — *Abstracta Botanica* 10, 317-140.
- Virágh, K. (1987): The effect of herbicides on vegetation dynamics: A 5-year study of temporal variation of species composition in permanent grassland plots. — *Folia Geobot. Phytotax.*, Praha 22, 385-405.
- Virágh, K. (1989a): The effect of selective herbicides on structural changes of an old perennial grassland community. An experimental approach to the study of community stability: resilience and resistance. — *Acta Bot. Acad. Sci. Hung.* 35, 99-125.
- Virágh, K. (1989b): The effect of selective herbicides on temporal population patterns in an old perennial grassland community. — *Acta Bot. Acad. Sci. Hung.* 35, 127-143.
- Virágh, K. (1992a): Disztribúciót követő vegetációdinamizmus egy sztyeppetársulásban. (Vegetation dynamics after disturbances in a loess-steppe grassland community.) — Vácrátót (PhD. Thesis).
- Virágh, K. (1992b): Regenerative microsuccession induced by herbicide-disturbance in a perennial grassland community. — *MESOGEE, Bulletin de Museum D'Histoire Naturelle de Marseille* 52, 21.
- Virágh, K. (1994): Spatial aspects of vegetation dynamics induced by herbicide disturbances in a Hungarian loess grassland community. — *Tiscia* 28, 3-13.
- Virágh, K. and Fekete, G. (1984): Degradation stages in a xeroseries: composition, similarity, grouping, coordination. — *Acta Bot. Acad. Sci. Hung.* 35, 127-143.
- White, P. S. and Pickett, S. T. A. (1985): Natural disturbance and patch dynamics. In: Pickett, S. T. A. and White, P. (eds): The ecology of natural disturbance and patch dynamics. - Academic Press, New York.
- Wiens, J. A., Addicott, J. F., Case, T. J. and Diamond, J. (1986): Overview: the importance of spatial and temporal scale in ecological investigations. In: Diamond, J. and Case, T. J. (eds): Community ecology. — Harper Row, New York.
- Wiens, J. A. (1989): Spatial scaling in ecology. — *Functional Ecology* 3, 385-197.
- Military Survey Map. I. (1783) Institute of War History, Budapest.

## VEGETATION HISTORY OF THE KARDOSKÚT AREA (S.E. HUNGARY) I.: REGIONAL VERSUS LOCAL HISTORY, ANCIENT VERSUS RECENT HABITATS

Zs. Molnár and M. Biró

*Molnár, Zs. and Biró, M. (1996):* Vegetation history of the Kardoskút area (S.E. Hungary) I.: Regional versus local history, ancient versus recent habitats. — *Tiscia* 30, 15-25.

**Abstract.** Reconstruction of past events and states provides useful information for the explanation of present vegetation patterns. Based on data from historical documents, old survey maps, the living memories of inhabitants and a detailed survey of present vegetation, the local history of the Kardoskút steppe was drawn and compared with the regional history of the Great Hungarian Plain. Special emphasis was put on distinguishing ancient and recent loess grasslands, alkali steppes and woodlands.

The Kardoskút steppe landscape was shaped mainly by nomadic animal husbandry till 1847. From that time till the 1970's, fine scale capitalist small-farm agriculture was the main landscape forming force. Cultivation was strongly controlled by soil conditions. Since the 1970's, the combination of a socialist planned economy and nature conservation management induced considerable changes in grassland distribution and quality.

*Keywords:* 18-20th centuries, map series analysis, landscape history.

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### Introduction

Landscape historical studies provide opportunities to reveal those past external constraining or enabling conditions, as well as, the order of events and system states which could have played an important role in the creation of present vegetation patterns and dynamics (Pickett 1989, 1991). A main feature of vegetation is its "memory" ("echoes of the past", Pickett 1991), present vegetation pattern reflects more the past environmental and competitive relations than the present ones (cf. Foster 1992).

There is a number of disciplines which study the history of vegetation and landscape and the interaction of land-use and vegetation. Landscape archaeology reconstructs past land-use and landscape using archaeological evidence (Aston 1985, Widgren 1979), cultural palynology reconstructs human impacts on landscape as recorded in pollen diagrams (Behre 1986, Jackson *et al.* 1988, Braun *et al.* 1993) and historical geography investigates the interaction of socio-economic and landscape changes (Woodell

1985, Frisnyák 1990). A multidisciplinary approach was used to draw the very detailed 6000 years history of a Swedish landscape (Berglund 1991).

In order to understand present vegetation, Central European plant sociologists have studied vegetation pattern at the Holocene time and Eurasian spatial scale (e.g. Zólyomi 1958). The map of Hungary's natural vegetation (Zólyomi 1989) and the detailed history of vegetation (Zólyomi 1958, Járαι-Komlódi 1987) were reconstructed on the basis of this knowledge. Less attention was paid, however, to the vegetation transformations of the last centuries, when human land-use rather than climate played a significant role in shaping the vegetation (Berglund 1991, Cole and Taylor 1995, Zólyomi 1946, Frisnyák 1990).

Detailed maps and documentary information help historical reconstruction at the century scale. Since more data are available for trees and water bodies, woodland and wetland historical studies are more frequent (e.g. Foster 1992, Majer 1988, Prince 1995, Winsor 1987) than investigations of changing

grassland vegetation (e.g. Zólyomi 1946, Mitchell 1991, Jeans 1978, Molnár 1995a,b). Data have also been successfully linked from historical sources with information from present day vegetation (Rackham 1980, Vartainen 1988, Peterken and Game 1984, Zólyomi 1969a, 1989).

Botanists and ecologists usually neglect historical sources and maps when studying present vegetation phenomena. Though the necessary data is scattered in the literature, an adequate and sufficient historical reconstruction can often be made which e.g. explains specialties of local patterns and helps to distinguish ancient and recent habitats (Foster 1992, Peterken and Game 1984, Molnár 1995a).

Historical studies can either substitute or rather propose long-term studies or can help to plan them by generating hypotheses on dynamic aspects of vegetation (Pickett 1989). Landscape models, study site selection, interpretation and regionalization of small scale results also often require historical information of past landscape transformations (Costanza *et al.* 1990, Baker 1989, Mitchell 1991). A better understanding of the past can also improve our predictions about future vegetation changes. Proper nature conservation management requires historical data about the systems to be managed, e.g. what were the main constraints in the past which played an important role in the development of present biodiversity.

#### *The Great Hungarian Plain in the last 300 years*

In the Plain, where human induced landscape transformation has been much bigger than in the surrounding mountains and where natural vegetation patterns and dynamics have changed so radically (treeless floodplains, lost loess steppes, drainage — Zólyomi 1946, Frisnyák 1990), it is hardly possible to understand present vegetation without a thorough knowledge of past human interference.

In the Great Plain, the 18th century is the period of resettlement and the re-emergence of the cultural landscape. Between 1596 and the beginning of the 18th century — during the Turkish Occupation, — the human population was wiped out and the former medieval agricultural landscape was ruined. Villages, farms, arable fields, vineyards, orchards and small roads disappeared (Frisnyák 1990, Hanák 1991, Szeremlei 1907). Vast areas turned into secondary steppes.

In the 17th and the first half of the 18th century, nomadic grey cattle grazing was characteristic making the landscape probably even more homogeneous. During the 18th century, the dominant nomadic animal husbandry was replaced by wheat cultivation,

which by the end of the century, became the dominant feature of the Plain (Frisnyák 1990, Szeremlei 1907).

In the Great Plain, the anthropogenic features of the present-day landscape structure and its dynamics developed almost entirely in the last 200-250 years (e.g. pattern of cultivated areas and settlements, drained wetlands and secondary forests). Only the larger settlements and the main roads survived from the medieval cultural landscape (Frisnyák 1990).

#### *Kardoskút steppes*

The Kardoskút area is particularly suitable for landscape historical studies. As a consequence of the two neighbouring towns and the famous lake, historical sources are more abundant than usual.

The aims of our study are to find out the differences between the regional landscape history of the Great Plain and the local history at Kardoskút, and to point out local specificities which contributed to the development of the local landscape.

Opinions are divided about the ancient or recent character of certain vegetation types of the Plain (woodlands, loess grasslands, alkali steppes - Zólyomi 1969a, Somogyi 1994, Bodrogekőzy 1965a, Szabolcs 1961). Based on historical data, the ancient or recent character of these habitats was reconstructed in the region.

The general vegetation and land-use history of the last 250 years was also reconstructed. Historical data was sorted and interpreted to make this readily accessible to other botanists and ecologists.

#### **Study area**

Kardoskút lies in SE. Hungary on the Békés-Csanád alluvial fan, where extensive arable fields on chernozem soils (with corn, wheat, barley and onion), alkali steppes and wetlands are the dominant features of the landscape (Fig. 1). The average annual temperature is 10.5 Celsius, and rainfall is 550 mm (maximum in June, drought in July and August; Pécsi 1989).

The Great Hungarian Plain belongs to the Eurasian wooded-steppe zone, its vegetation boundary coincides with the orographic boundary of the basin (Zólyomi and Fekete 1994). Edaphic (mainly hydrological) patterns are responsible for the formation of woodland-grassland mosaics on sand, alkali and loess soils, respectively (Soó 1929, Zólyomi 1958). Vegetation and landscape development of the south-eastern part of the Plain was reconstructed by Zólyomi (1946, 1958, 1969a, b). In the Post-glacial and Boreal periods climatic steppes were widespread. In the Atlantic, woodland might have devel-

oped in some steppe areas but the land-use of the late Neolithic and Bronze Age probably prevented or hindered this process.

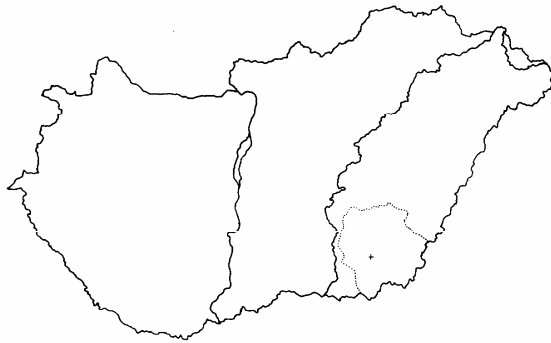


Fig. 1. Location of the study area. The Kardoskút-steppe (marked with '+') is located in the Tiszántúl part of the Great Hungarian Plain, in the basin of the Békés-Csanád alluvial fan which was built by the river Maros in the Pleistocene. (Pécsi 1989).

The area has been inhabited since the late Neolithic, mostly by nomadic tribes such as Körös culture, Baden culture, early and late Iron Age, Scythians, Jazyg-Sarmatians, Avars and Gepids (Szeremlei 1907, Banner 1943, Nagy and Szigeti 1984).

The Kardoskút steppe is a characteristic, fine scale mosaic of loess, alkali and wet areas (Fig. 2). A temporal lake lies in the center of the basin. North and south of the lake, dry and wet alkali grasslands can be found. On higher elevations (the differences are only 0.5-2 meters) arable fields with chernozem and slightly alkali soils are typical. The Hungarian alkali steppes are partly ancient (similar to the Ukrainian steppes; Soó 1929) and partly recent i.e. developed as a consequence of river control and drainage in the 19th century (Szabolcs 1961). Their fine scale mosaic pattern is determined by surface water erosion, the depths of soil water, and salt content of the B horizon (Bodrogközy 1965a,b, 1977).

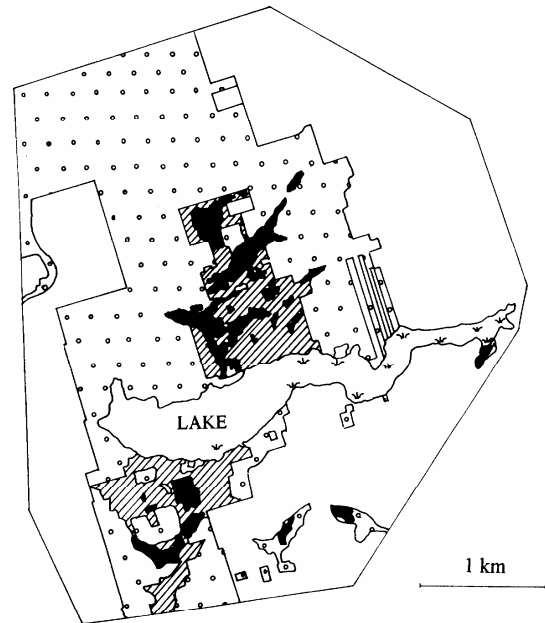
## Methods

The period before the 18th century was reconstructed because of a total lack of palaeopolynological data based on the scattered written documents and archaeological evidence (cf. Zólyomi 1946), and toponyms (cf. Zólyomi 1969b, Garcia Latorre and Garcia Latorre 1995).

From the 18th century onwards historical data are more abundant (e.g. military survey maps, Szeremlei 1907, Nagy and Szigeti 1984, Szenti 1983, Nagy 1975). In the 1960's, a multidisciplinary research project was set up by the Hungarian

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Academy of Sciences to study the area e.g. Bodrogközy 1965a, 1965b, 1966, Kiss 1963, Sterbetz 1974, 1977, 1992, Molnár and Mucsi 1966.



1. ▨ 2. ■ 3. ▤ 4. ▩ 5. □

Fig. 2. Map of the Kardoskút steppe and the lake Fehér-tó. The area is a mosaic of loess, alkali and wetland areas. 1. ancient steppes on alkali soils, 2. wetlands and bare alkali patches, 3. secondary steppes, 4. lake bed and alkali marsh vegetation, 5. arable fields on loess.

All the available survey maps (1784, 1861-66, 1884, 1970 and 1983) and aerial photos (1950, 2 from 1953, 1964, 1976, 1981, 1987 and 1991) were studied in detail. In June 1995, colour aerial photos were made from a hang-glider.

Dependence of land-use on soil conditions was analyzed by comparing the soil map of Hahn and Witkowsky (1938) and the grassland-arable field mosaic for 1784, 1861-66, 1884, 1950-53 and 1970 redrawn on a transillumination table from maps and aerial photos. Areas which had been grasslands on all the 4 maps and photos were treated as ancient, and areas which were continuously ploughed between 1861-66 and 1970 were regarded as permanent fields. It has to be mentioned that the inaccuracy of 18th and 19th century maps (originated partly from the process of copying) could have caused an error of a magnitude of several %.

A more detailed reconstruction of the land-use could only be made from the 1930's, based on the living memories of the inhabitants. Data from per-

sonal communications often involve the risk of subjectivity (cf. Winsor 1987, Mitchell 1991, Clarke and Finnegan 1984), therefore the most important data were verified.

Nomenclature of species follows Soó (1964-80).

## Results

### Vegetation

The first vegetation description of the area was prepared by Bodrogeközy (1965a,b), but this data were collected from a much bigger area. During 1995 the vegetation of the area under investigation was resurveyed.

The most common vegetation type of the steppes is the *Festuca pseudovina* dominated, dry continental alkali grassland. In its more alkali subtype, *Artemisia santonicum*, *Matricaria chamomilla*, *Podospermum canum*, *Atriplex litoralis*, *Trifolium angulatum* are common. Its less alkali subtype, the *Achillea* steppe, can be characterized by disturbance tolerant, generalist species like *Bromus mollis*, *Poa bulbosa*, *Cruciata pedemontana* and *Veronica arvensis*. The *Achillea* steppe is more common, since it can also develop from *Artemisia* steppes by degradation (caused e.g. by fertilization or liming; cf. Sterbetz 1995).

To the north and south of the lake alkali meadows and temporary marshes (which dry out by May or June) with *Agrostis stolonifera*, *Alopecurus pratensis*, *Beckmannia eruciformis* and *Bolboschoenus maritimus* fill the depressions. On the most alkali patches, where the salt content reaches 0.3-1.2 % (Bodrogeközy 1965a), partially vegetation free white patches with *Camphorosma annua* are typical.

Embedded in the alkali steppe, small stands of loess grasslands represent the last remnants of the former vast loess steppes. The only tiny ancient stand (ca. 0.2 hectare) is overgrazed, dominated by weeds and poor in specialist species (only *Sternbergia colchiciflora*, *Thalictrum minus* and *Astragalus austriacus*). The other loess grassland patches are secondary and dominated by *Festuca pseudovina*, *Salvia austriaca*, *Poa angustifolia*, *Cynodon dactylon* and *Euphorbia cyprarissias*.

## History of the steppes

### Before and during the Turkish Occupation (10-17th centuries)

Though the area belongs to the wooded-steppe zone (Zólyomi 1946, 1969a), there are no data available which point to the presence of ancient woodlands on the alluvial fan. In documents from the Árpád period (10-13th century), the following

toponyms with woody species names were found (Blazovich 1985): *Cornus* sp. (species of mesophilous broad-leaved woodlands), *Corylus avellana* (common in xero-mesophilous oak woodlands with continental character), *Prunus spinosa* (species of fringes of xero- and mesophilous woodlands), *Sambucus nigra* (Nitrogen frequent species of degraded woodlands and clear cuts), Thorny thicket (thickets presumably with *Prunus*, *Crataegus* and *Rosa* species) and none for oak, elm or ash, the common woodland trees of the Plain.

From this period, there are no data available about the grasslands. The typical methods of agriculture were rotation of pastures and fields, or fields and fallows (Frisnyák 1990). The size and density of archaeological sites points to many, small, short-lived settlements (Blazovich 1985).

From the second half of the 13th century onwards, people began to move into nucleated settlements and small villages became abandoned. The height of this process was at the turn of the 16th and 17th centuries. The vast deserted steppes were used for nomadic grey cattle grazing (Blazovich 1985).

In the Middle Ages, the Kardoskút steppe was inhabited for centuries by farmers and stock breeders. Between 1693 and 1700, the area became deserted and later it was used for nomadic grazing (Szeremlei 1907, Szenti 1983). Settlements and fields disappeared, grasslands expanded and the landscape became more homogenous.

### The period of extensive pastures (1743-1847)

In the 18th century, the steppe was still used for nomadic-style animal husbandry. This type of pasturing has been replaced by stabling, only since the end of the 1st World War. Overgrazing was common (Szenti 1983). In the beginning of the 18th century, the area was described as a steppe with extensive temporal wetlands, where, with the exception of one pear tree, no trees could be found (Nagy 1975). Lack of trees can also be seen on the 1784 map. In 1743, the area was separated as a town pasture and land-use was restricted to grazing (previously mowing was also allowed; Szenti 1983).

Since in the spring, inland floodings threatened arable fields, drainage works began early. Already by 1805 dams were built to keep water in the steppe area away from the neighbouring arable fields (Szenti 1983). This method of drainage survived till the 1930's (A. Gyömrei personal communication), later water was drained away into the Maros river.

The first botanist who visited this region was Kitaibel, who travelled through the alluvial fan in 1798 and 1810 (Gombocz 1945, Radics after 1970).

He listed the following habitat types from the vicinity of Csanád, Mezöhegyes and Kondoros: arable fields, fallows, pastures and meadows, alkali steppes, road verges, dams and settlements. The flora of the arable fields was more diverse than today. On the fallows specialist species of the loess grasslands appeared already in the first years of succession (e.g. *Carduus hamulosus*, *Anthemis tinctoria*, *Astragalus austriacus* and *Euphorbia pannonica*). The dominant grass of pastures was *Festuca* (sp.), common weeds were: *Carduus nutans*, *Carthamus lanatus*, *Marrubium peregrinum* and *Artemisia absinthium*. Some of the loess specialists which are now very rare or extinct (Molnár 1992) are mentioned too (*Silene longiflora*, *Inula oculus-christi* and *Astragalus onobrychis*). Loess specialists, however, were mostly found on road verges (*Crambe tataria*, *Ajuga laxmannii*, *Dictamnus albus*, *Brassica elongata*, *Chamaecytisus hirsutus*, *Amygdalus nana*, *Campanula sibirica* and *Rosa gallica*). From alkali habitats *Limonium gmelini*, *Lepidium ruderale*, *Matricaria chamomilla*, *Hordeum hystrix* and *Lepidium crassifolium* were listed. The landscape was still nearly treeless. Kitaibel has not seen any woodland, only a young oak plantation, and single trees of *Ulmus minor* and *Pyrus* sp.

#### *The small-farm system (1847-1950)*

In the first half of the 19th century, the area of the steppe decreased continuously from the edges. Demand for arable fields increased so much, that between 1847 and 1860 the steppe had to be parcelled out by the town (Szenti 1983). In a little more than 10 years nearly all of the suitable land was ploughed (64% of the study area; Fig. 3, Table 1). Between 1861-1866 and 1884, more ancient grasslands were broken up, but at the same time abandonment of land also began. By 1884, all land that was suitable for farming had been ploughed. The remaining grasslands were used for extensive animal husbandry (Nagy 1975). Ploughing of grasslands did not cease, but was confined to secondary grasslands originating from arable fields. Between 1884 and 1950, there were only slight changes in the area of ancient grasslands.

Between 1847 and 1970, ploughing and abandonment was strongly controlled by site conditions. Land-use was fine-grained. Since peasants owned very small bits of land, they had no alternative but to plough even the smallest suitable piece of land (A. Gyömrei personal communication). As a consequence, till the late 1940's, the small loess grassland patches were also used e.g. as a vegetable garden or a quince orchard (Antal Gyömrei personal communication, aerial photos from 1950 and 1953). Today,

these loess grasslands are poor in specialists, the characteristic dominant species are all disturbance tolerant generalists (*Salvia austriaca*, *Ornithogalum orthophyllum*, *Cynodon dactylon*, *Festuca pseudovina*, *Achillea collina*, *Poa angustifolia*, *Cruciata pedemontana* and *Euphorbia cyparissias*).

Land-use mainly depended on soil conditions (Fig. 4, Table 2). 84 % of the permanent fields were on chernozem soil. Only 0.5 % of the chernozem was never ploughed, but this area seems to be even smaller (0.1%) on the basis of field survey. 49 % of the alkali soils were ploughed, but only 29 % of them became a permanent field. 42 % of the alkali arable fields were abandoned later, but only 12 % of the fields on chernozem.

#### *Socialist agriculture and nature conservation (1950-1995)*

Land-use changed remarkably between 1950 and 1995 (cf. Sterbetz 1977, 1992). In 1950-53 (based on aerial photos) the traditional small-farm system was still the dominant landscape forming force. Later, the number of occupied farm-houses decreased (e.g. on the steppes around the lake: in 1950-53: 31, in 1964: 21, in 1981: 9, in 1991: 3, and in 1995: 1), while socialist agriculture became more and more dominant. Abandoned houses were demolished, small fields and fragments of pastures were aggregated into huge fields.

In the early 1970's, north of the lake, ca. 70 ha of arable field was turned into grassland for nature conservational reasons. From the 1960's onwards, the improvement of ancient grasslands accelerated, first by fertilization, but between 1976 and 1982, also by harrowing and overseeding, or even by breaking up the grasslands and creating a new one (I. Gojdar and I. Sterbetz personal communication). In this period, 40 % of the ancient grasslands were degraded (see Fig. 2). Specialist species like *Artemisia santonicum*, *Limonium gmelini*, *Camphorosma annua* and *Matricaria chamomilla* disappeared (Sterbetz 1995), together with specialist bird species like *Otis tarda*, *Glareola pratincola*, *Burhinus oedicephalus* and *Charadrius alexandrinus* (Sterbetz 1992, Nagy 1993). In addition to these factors, the 15 years long drought period has also caused transformations, mainly in wetlands. Though monocotyledons of steppe wetlands have a good resistance to dryness, the opening of the canopy and spread of weeds shows the degradation process. The area of bare alkali patches with *Camphorosma* has also decreased, which was caused by the less intensive grazing and the shorter inundation in the spring (Sterbetz 1992, Z. Varga personal communication).



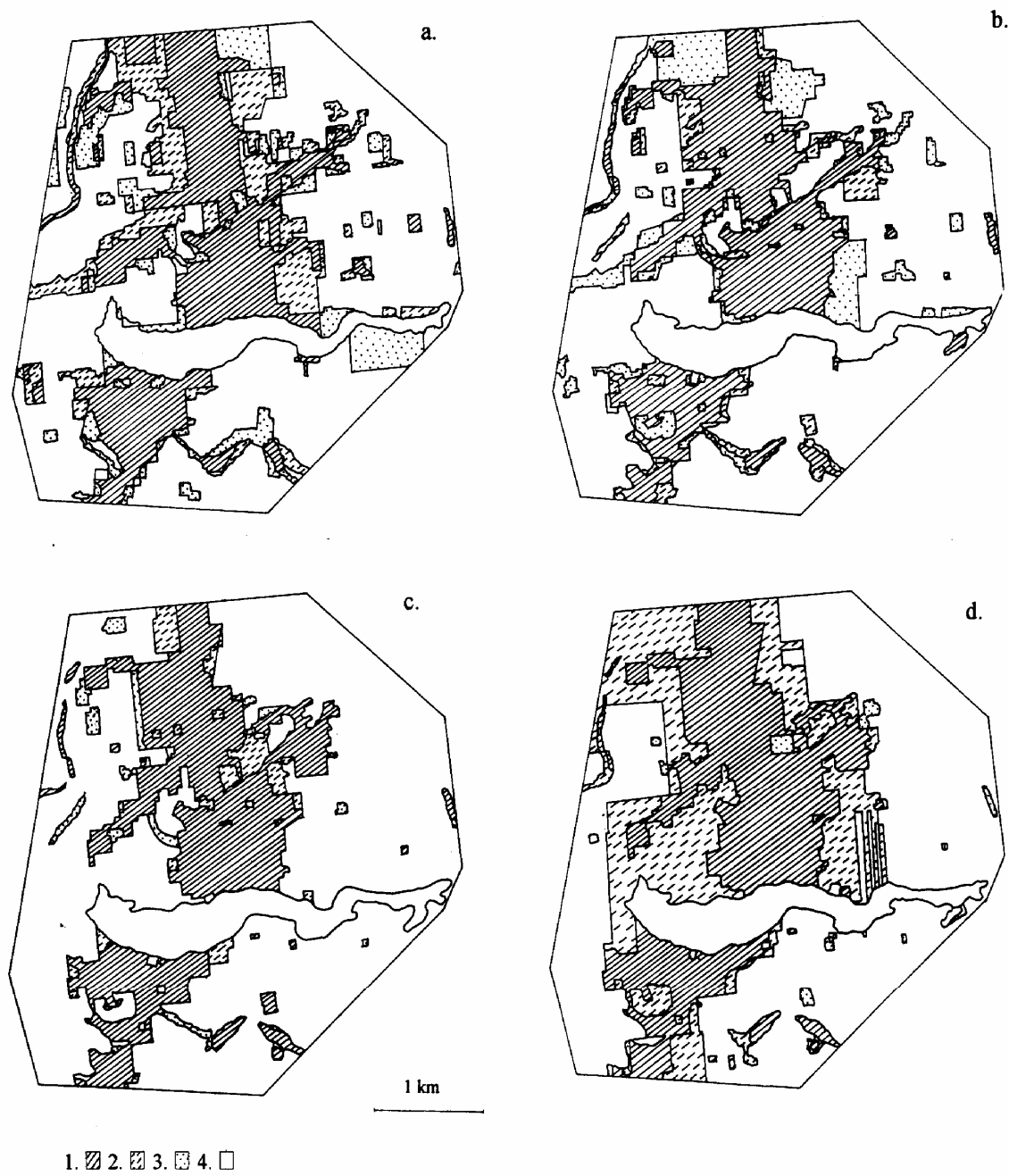


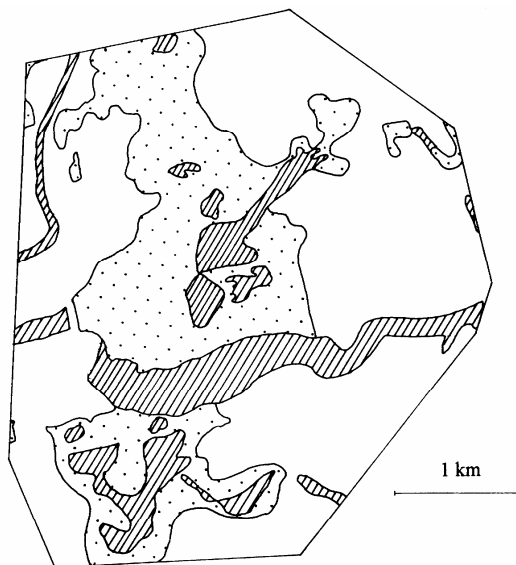
Fig. 3. Changes of the grassland - arable field mosaic at Kardoskút from 1861-66 till the present, based on the comparison of subsequent maps and aerial photos. Both ploughing and abandonment can be observed during the whole period. 1. Remained a grassland in the period, 2. Became a grassland in the period, 3. Ploughed in the period, 4. Remained an arable field in the period. Periods: a: 1861-66 - 1884, b: 1884 - 1950-53, c: 1950-53 - 1970, and d: 1970 - 1995.

Table 1. Changes in the area of grasslands and fields at Kardoskút from 1784 till present, between subsequent maps and photos. Numbers indicate the area of certain types as a % of the total area.

Time period	Remained a grassland	Became a grassland	Ancient grassland	Total grassland	Ploughed grassland	Remained a field	Total field
1784 - 1861-66	36	0	36	36	64	0	64
1861-66 - 1884	31	9	27	40	5	55	60
1884 - 1950-53	28	4	26	32	12	56	68
1950-53 - 1970	30	4	25	34	2	64	66
1970 - 1995	33	31	14	64	1	35	36

Table 2. Control of land-use by site conditions in the period of 1861-66 and 1970 at Kardoskút. Soil moisture and salt content controlled land-use, with the wet sites being used as hay meadows or pastures and thus remaining ancient grasslands, dry alkaline sites being utilized for grazing and cultivation and dry sites with chernozem soils being used for cultivation. Numbers indicate the area of certain types as a % of the total area.

Land-use / soil type	Flooded alkali	Alkali	Chernozem
Permanent arable field	0.8	9	51
Ploughed but abandoned later	1.2	6.5	7
Ancient grassland	8	16	0.5



1. □ 2. ▨ 3. ▩

Fig. 4. Soil map of the area after Hahn and Witkowsky (1938).  
1. Chernozem soils, 2. alkali soils, 3. highly alkali and flooded soils.

## Discussion

### *Regional versus local history*

Cultural landscape transformations are often abrupt, strongly bound to cultural changes or technical innovations. These changes are, however,

scale dependent and local and regional timing of events do not necessarily coincide (Berglund 1991). Variances between individual landscapes may often be ascribed — beside the abiotic differences — to different local land-use histories.

### 1. Regional scale processes in the Great Plain

The broad outlines of the last 300 years of landscape history in the Plain are relatively simple: Desertification and nomadic animal husbandry in the 16-17th centuries, re-emergence of the cultural landscape in the 18th and partly in the 19th century, development of the small-farm system, river control and drainage in the 19th century till the 1950's and since then disintegration of the small-farm system and the development of the socialist agriculture (Frisnyák 1990).

The re-emergence of the cultural landscape in the 18th century was in many respects similar to the encroachment of civilization onto the North American or Argentinean steppes (Hollander 1947) or to the large-scale deforestations in east North-America between 1810 and 1860 (Williams 1982), though in Hungary encroachment was not frontier-like, but more patchy as a consequence of the more heterogeneous landscape. Agricultural activity in the Plain was generally strongly controlled by site conditions, chernozem soils used as arable fields, alkali areas for grazing and meadow soils for mowing (Frisnyák 1990).

### 2. Local features of the Kardoskút steppes

At Kardoskút, the turning of grasslands into arable fields could also be observed, though it happened later than in the region (I. military map, Szeremlei 1907, Molnár 1995a), since the town was able to conserve extensive pastures till the late 1840's (Szenti 1983). In the study area, site conditions like soil moisture and salt content controlled land-use (with wet sites used as hay meadows or pastures, dry alkaline sites for grazing and cultivation and dry sites on chernozem soils for cultivation) but ploughing pressure (Elek 1937) was higher than general in the Plain. Consequently, a large propor-

tion (49 %) of alkali areas were also ploughed for cultivation, although 42 % of it was later abandoned. Even the smallest loess grasslands were used as a field. This small scale land-use can best be seen during the small-farm system period (1847-1950's). Present landscape pattern was basically developed between 1847 and 1884, though by the time of the disintegration of the small-farm system (1950's - 1970's), land-use changed fundamentally and became coarser-scale.

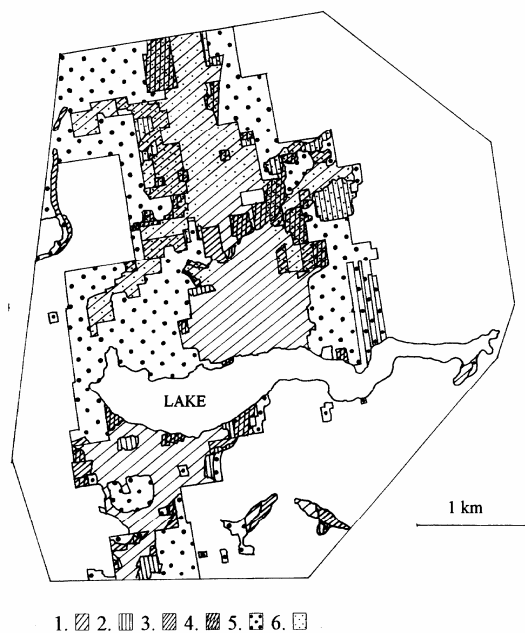


Fig. 5. As a consequence of the continuous ploughing and abandonment since the 19th century, the grasslands of the present steppe are of a different age. The map was constructed on the basis of the map series shown on Fig. 4 1. Ancient grasslands 2. Abandoned between 1861-66 and 1884, 3. Abandoned between 1884 and 1950-53, 4. Abandoned between 1950-53 and 1970, 5. Abandoned after 1970, 6. Improved since 1970.

Contrary to the other areas in the region (Molnár 1995a) already in the second half of the 19th century the abandonment of fields could be observed, since many non-productive alkali areas were broken up in the 1850's. One fifth (19 %) of the cultivated area was abandoned between 1861-66 and 1970, nearly half of it (44 %) was on alkali soils. As a consequence of the abandonments of the last 130 years, the age of present-day grasslands are different (Fig. 5). Ancient and mixed aged recent secondary grasslands form a fine mosaic patterns, where patches are often hardly distinguishable in the field, because dominant weeds conceal differences in species composition. Lack of specialists and/or unnaturally shaped boundaries help point out secondary patches.

In the Great Plain, during the last 150 years, the sharp decrease of wetlands is striking (Szabolcs 1961). At Kardoskút, from the 19th century up to the 1930's, regional drainage resulted in more water locally, since the area of alkali pastures was used as a water reservoir to keep flooding water away from the arable fields nearby (Szenti 1983, A. Gyömrei personal communication.).

#### *Ancient versus recent habitats*

Since it is often difficult to prove that a certain vegetation patch is primary, with historical continuity from the pre-Neolithic Period, we usually distinguish ancient and recent patches (Rackham 1980, Peterken and Game 1984). Ancient patches in the Hungarian Great Plain are those which developed before 1783 (the publication of the first military survey map), whilst recent patches are those that are less than about 200 years old. Ancient patches retain undisturbed, unploughed soils and have kept more valuable species than our recent and thus secondary vegetation patches. Reliable identification of ancient grasslands and woods is, therefore, important for nature conservation.

#### 1. Woodlands in the region

Opinions are divided as to what extent the Békés-Csanád alluvial fan was wooded a 1000 years ago. According to Zólyomi (1969a), Blazovich (1985) and Rapaics (1918), the area was probably nearly completely deforested, Somogyi (1994), however, assumes that extensive loess oak woodlands were still present. Based on toponyms from the 10-13th centuries (Blazovich 1985), only shrub vegetation could have presumed to have been in the region ca. 1000 years ago, which could look similar to the steppe-thickets described by Rapaics (1918) from the Serbian Titel-plateau. Since later historical data (Kitaibel in Gombocz 1945, Radics after 1970, Thaisz 1905, Szenti 1983, Nagy 1975, I., II. and III. military survey maps) also do not indicate ancient woodlands, it can be concluded that in the last 1000 years ancient woodlands were absent from the alluvial fan.

#### 2. Degradation of the loess grasslands

Loess grasslands of the area are species poor, which was explained by Bodrogekőzy (1965a) by the high salt content of the B horizon of the soil, since patches adjacent to alkali grasslands could only survive. It was shown, however, that species rich loess grasslands can survive even if salt accumulates to depths of 1 meter, if grazing pressure is low (Biró 1990). At Kardoskút, species richness is probably controlled more by the ancient or recent character of

the loess grassland stands, than by conditions of deeper soil layers.

Based on the known methods of agriculture (Szeremlei 1907) and the two medieval villages at the lake (Blazovich 1985, Banner 1943, Olasz 1959), intensive use of loess areas can be assumed in the Middle Ages. Later during desertification (Blazovich 1985), secondary grasslands could develop on the place of former cultivated fields. In the 18th century, overgrazing (Szenti 1983) might result in degraded loess pastures. These secondary loess steppes were described by Kitaibel (in Gombocz 1945, Radics after 1970) and later by Jankó (1886). In their species lists, specialist species show the ancient character of the grasslands (cf. Peterken and Game 1984), while the long list of weed species point to their degraded character (Molnár 1995a). Concentration of specialists on the road verges (see Kitaibel) shows the secondary character of these pastures. It has also been shown that nomadic-like cattle or sheep grazing does not prevent the survival of steppe specialists (Molnár 1992). At Pitvaros, nearly half (47 %) of the specialists of the area could survive in grazed loess grasslands. This part of the Pitvaros steppes belonged to a large estate where land-use was coarser-scale (compared to Kardoskút), thus the small loess grasslands, embedded in alkali steppes, remained pastures. Today, even rare loess specialists can be found in them (*Sternbergia colchiciflora*, *Phlomis tuberosa*, *Ranunculus illyricus*, *Thalictrum minus*, *Adonis vernalis* *Trifolium ochroleucum*, etc.; Molnár 1992).

At Kardoskút, loess grasslands were nearly completely ploughed (99.9%) between 1847 and 1970. The species richness of recent stands is very low, since till the 1940's, they had been used for cultivation. In the early 1970's, extensive secondary grasslands were created on the chernozem soils (I. Sterbetz, I. Gojdár personal communication). The potential vegetation of these areas is the loess grassland, but the long history of land-use resulted in a locally very poor propagulum source, which prevents their regeneration. Based on the observations of 40-50 years old abandoned fields, a decrease of weed cover and an increase of the dominant generalist grasses, can only be expected (*Festuca pseudovina*, *Poa angustifolia* and *Cynodon dactylon*; Molnár unpublished data).

### 3. Alkali steppes

Most of the alkali steppes of the Hungarian Great Plain developed as a consequence of the river controls and drainage works of the last 150 years (Somogyi 1965, Szabolcs 1961). These secondary steppes are usually poor in specialist species. Identifi-

fication of ancient areas is sometimes difficult, especially when they are impoverished by overgrazing. Historical data can help distinguish ancient and secondary steppes by reconstructing past hydrological, soil and land-use conditions (Molnár 1995a, b). Based on the data of Kiss (1963), Bodrogekőzy (1965a, b, 1966) and Szenti (1983), the Kardoskút steppes and the lake can be regarded as ancient, though some parts are being turned into secondary steppes by pasture improvements (cf. Sterbetz 1992).

## Conclusion

The vegetation of the Kardoskút steppe has undergone considerable changes in the last 250 years. Based on historical documents, survey maps, the present vegetation and the living memories of inhabitants, this history could be reconstructed in detail. Past events and states have had fundamental effects on the present state and dynamic of vegetation. Many of these effects were not deducible from present vegetation pattern.

Historical reconstruction at the century scale can provide essential information for explanations of present and predictions for the future vegetation.

## Acknowledgements

István Sterbetz, István Farkas, Ernő Olasz, István Farkas Jr., István Gojdár and Antal Gyömrei provided valuable insights into the 20th century history of the area. Bertalan Andrásfalvy, László Blazovich, Pál Halmágyi, Sándor Hévízi, Ferenc Kőszegfalvi, Gyula Nagy, András Pleskonics, Tibor Szenti and Ferenc Tóth helped in collecting the literature. László Bagi made the aerial photos from the area. Sándor Bartha, Gábor Fekete and István Sterbetz offered constructive comments on a former version of the manuscript. I would like to thank Liam Holloway for checking the English content. This study was supported by the Nature Conservation Directorate of Körös-Maros, Szarvas and by the National Scientific Research Foundation (OTKA grant No. T-16390).

## References

- Aston, M. (1985): Interpreting the landscape: landscape archaeology in local studies. — Batsford, London.
- Baker, W. L. (1989): A review of models of landscape change. — *Landscape Ecology* 2, 111-133.
- Banner, J. (1943): Településtörténeti kutatások Hódmezővásárhely-Fehértó partján (Settlement historical studies on the shore of Hódmezővásárhely-Fehértó). — *Dolgozatok a Szegedi Egyetem Régiségtudományi Intézetéből* 9, 195-201.

- Behre, K.-L. (ed.) (1986): Anthropogenic indicators in pollen diagrams. — Balkema, Rotterdam.
- Berglund, B. E. (ed.) (1991): The cultural landscape during 6000 years in southern Sweden — the Ystad Project. — *Ecological Bulletin*, 41, Copenhagen.
- Biró, M. (1990): Löszpusztagyep-foltok zonációviszonyainak és szikes degradációjának vizsgálata (Zonation pattern and alkali degradation of loess grassland patches). — Msc Thesis, Szeged.
- Blazovich, L. (1985): A Körös-Tisza-Maros köz középkori településrendje (Medieval settlements of the area between the Körös, Tisza and Maros). — *Dél-alföldi Századok*, Békéscsaba, Szeged.
- Bodroγκöz, Gy. (1965a): Ecology of the halophilic vegetation of the Pannonicum. III. Results of the solonetz of Orosháza. — *Acta Biol. Szeged*, 11, 3-25.
- Bodroγκöz, Gy. (1965b): Ecology of the halophilic vegetation of the Pannonicum. IV. Investigations on the solonetz meadow soils of Orosháza. — *Acta Biol. Szeged*, 11, 208-227.
- Bodroγκöz, Gy. (1966): Ecology of the halophilic vegetation of the Pannonicum. V. Results of the Investigation of the "Fehértó" of Orosháza. — *Acta Bot. Hung.* 12, 9-26.
- Bodroγκöz, Gy. (1977): A Pannonicum halophiton társulásainak rendszere és szinökológiája (Halophilic plant associations of the Pannonicum and their synecology). — PhD. Thesis, Szeged.
- Braun, M., Sümegi, P., Szűcs, L. and Szőör, Gy. (1993): The history and development of the Nagy-Mohos fen at Kállósején (Man induced fen formation and the "archaic fen" concept.). — *Jósa Múzeum Évkönyve 33-34*, 335-366.
- Clarke, J. and Finnegan, G. F. (1984): Colonial survey records and the vegetation of Essex County, Ontario. — *J. Historical Geography* 10, 119-138.
- Cole, K. L. and Taylor, R. S. (1995): Past and current trends of change in a dune prairie/oak savanna reconstructed through a multiple-scale history. — *J. Veg. Sci.* 6, 399-410.
- Costanza, R., Sklar, F. H. and White, M. L. (1990): Modeling Coastal Landscape Dynamics. — *BioScience* 40, 91-107.
- Elek, P. (1937): Gazdaságföldrajzi kutatások Szarvas és Szentes vidékén (Historical geographical studies in the Szarvas-Szentes region). — Budapest.
- Foster, D. R. (1992): Land-use history (1730-1990) and vegetation dynamics in central New England, USA. — *J. Ecol.* 80, 753-772.
- Frisnyák, S. (1990): Magyarország történeti földrajza (Historical geography of Hungary). — Tankönyvkiadó, Budapest.
- García Latorre, J. and García Latorre, J. (1995): The forests of the most arid zone of Western Europe — a new interpretation. — 7th European Ecological Congress: Ecological Processes: Current Status and Perspectives. Abstracts, Budapest, p. 142.
- Gombocz, E. (1945): *Diaria Itinerum Pauli* Kitaibelii I. — Budapest.
- Hanák, P. (ed.) (1991): The Corvina history of Hungary — From the earliest times until the present day. — Corvina Books, Budapest.
- Hollander den, A. N. J. (1947): *Nederzettingvormen en -problemen in de Groote Hongaarsche Laagvlakte — Een Europeesch "Frontier" Gebied.* — J. M. Meulenhoff, Amsterdam.
- Jackson, S. T., Futyma, R. P. and Wilcox, D. A. (1988): A paleoecological test of a classical hydrosere in the lake Michigan dunes. — *Ecology* 69, 928-936.
- Jankó, J. (1886): Tótkomlós flórája (Flora of Tótkomlós). — *Természetrjai Füzetek* 10, 175-180.
- Járai-Komlódi, M. (1987): Postglacial climate and vegetation in Hungary. In: Pécsi, M. and Kordos, L. (eds): *Holocene environment in Hungary.* — Geographic Research Institute, Budapest, 37-47 pp.
- Jeans, D. N. (1978): Use of historical evidence for vegetation mapping in New South Wales. — *Australian Geographist* 14, 93-97.
- Kiss, I. (1963): *Vízfeltörések vizsgálata az Orosháza környéki szikes területeken, különös tekintettel a talajállapot és a növényzet változásaira* (Studies of surface wells in the alkali areas near Orosháza with special reference to the changes of soil and vegetation). — *Szegedi Tanárképző Főiskola Tudományos Közleményei* 8, 43-82.
- Majer, A. (1988): *Fenyves a Bakonyalján* (A conifer wood in the Bakonyalja region). — Akadémiai Kiadó Budapest.
- Mitchell, P. B. (1991): Historical perspectives on some vegetation and soil changes in semi-arid New South Wales. — *Vegetatio* 91, 169-182.
- Molnár, B. and Mucsi, M. (1966): A Kardoskúti-Fehértó vízföldtani viszonyai (Hydrogeological studies of the Fehértó at Kardoskút). — *Hidrológiai Közöny* 46, 413-420.
- Molnár, Zs. (1992): A Pitvarosi-puszták növényvilága különös tekintettel a löszpusztagyepre (Vegetation of the Pitvarosi-puszták with special reference to the loess grasslands). — *Bot. Közlem.* 79, 19-27.
- Molnár, Zs. (1995a): A Pitvarosi-puszták vegetáció- és a tájtörténete az Árpád-kortól napjainkig (Vegetation and landscape history of the Pitvarosi-puszták from the Middle Ages to the Present). — *Natura Bekesiensis* (in print)
- Molnár, Zs. (1995b): Landscape and vegetation history of Pitvarosi-puszták (steppes in SE Hungary) since the Middle Ages. — 7th European Ecological Congress: Ecological Processes: Current Status and Perspectives. Abstracts, Budapest, 142 p.
- Nagy, Gy. (1975): *Parasztélet a Vásárhelyi-pusztán* (Peasant life in the Vásárhelyi-pusztá). — Békéscsaba
- Nagy, I. and Szigeti, J. (1984): *Hódmezővásárhely története I* (History of Hódmezővásárhely). — Hódmezővásárhely.
- Nagy, Sz. (1993): *Jelentés a Kardoskút Természetvédelmi Terület és a csatlakozó területek, mint Európai jelentőségű madárelőhely állapotáról* (Report on the status of the Kardoskút Nature Reserve and neighbouring areas, as bird habitats of European importance). — MME, Manuscript.
- Olasz, E. (1959): *Elpusztult 11-16. századi falvak Kardoskút, Tótkomlós és Békéssámsón környékén* (11-16th century destroyed villages near Kardoskút, Tótkomlós and Békéssámsón). — Szántó-Kovács János Múzeum Évkönyve, Orosháza 1, 31-39.
- Pécsi, M. (ed.) (1989): *National Atlas of Hungary.* — Kartográfiai Vállalat, Budapest.
- Peterken, G., and Game, M. (1981): Historical factors affecting the number and distribution of vascular plant species in the woodlands of central Lincolnshire. — *J. Ecol.* 72, 155-182.
- Pickett, S. T. A. (1989): Space-for-time substitution as an alternative to long-term studies. In: Likens, G. E. (ed.): *Long-term studies in ecology: Approaches and Alternatives.* Springer Verlag, 110-135pp.
- Pickett, S. T. A. (1991): Long-term studies: past experience and recommendations for the future. In: Gisser, P. G. (ed.): *Long-term ecological research.* SCOPE, John Wiley and Sons 71-88 pp.
- Prince, H. (1995): *A marshland chronicle, 1830-1960: from artificial drainage to outdoor recreation in central Wisconsin.* — *J. Historical Geography* 21, 3-22.

- Rackham, O. (1980): Ancient woodland. — Arnold, London.
- Radics, F. (after 1970): Iter Banaticum Tertium Paulii Kitaibelii. — Manuscript, TTM Növénytár, Tudománytörténeti Gyűjtemény, Budapest.
- Rapaics, R. (1918): Az Alföld növényföldrajzi jelleme (Plant geographical features of the Great Hungarian Plain). — Erdészeti Kísérletek 21, 1-146.
- Somogyi, S. (1965): A szikesek elterjedésének időbeli változásai Magyarországon (History of distribution of alkali areas in Hungary). — Földrajzi Közlemények 11, 41-55.
- Somogyi, S. (1994): Az Alföld földrajzi képe a honfoglalás és a magyar középkor időszakában (Geography of the Great Hungarian Plain at the time of conquest and in the Middle Ages). — Észak- és Kelet-Magyarországi Földrajzi Évkönyv 1, 61-75.
- Soó, R. (1964-80): Synopsis Systematico-Geobotanica Florae Vegetationesque Hungariae I-VII. — Akadémiai Kiadó, Budapest.
- Soó, R. (1929): Die Vegetation und die Entstehung der ungarischen Puszta. — Ecology 17, 329-350.
- Sterbetz, I. (1974): A Kardoskúti Természetvédelmi Terület madárvilága 1952-1973 időközében (Bird life in the Kardoskút Nature Reserve between 1952 and 19973). — Aquila 80-81, 91-120.
- Sterbetz, I. (1977): Einfluss der Veränderungen der Agrarumwelt auf die Tierwelt des Naturschutzgebietes Kardoskút. — Aquila 84, 65-81.
- Sterbetz, I. (1992): A Vásárhelyi-pusztán fészkelő széki lile populáció (*Charadrius alexandrinus* L., 1758) elsovadásának vizsgálata (Gradual disappearance of population of *Charadrius alexandrinus* L., 1758 from the Vásárhelyi-pusztá). — Állattani Közlemények 78, 89-93.
- Sterbetz, I. (1995): Vizsgálatok a tervezett Körös-Maros közti Nemzeti Park legeltető állattartásának szervezéséhez (Studies for the organization of animal husbandry of the future Körös-Maros National Park). In: Kovács, G., Márkus, F. and Sterbetz, I. (eds.): Alföldi Mozaik, A KTM Természetvédelmi Hivatalának Tanulmánykötetei, 2. — TermészetBÚVÁR Alapítvány Kiadó, Budapest, 99-151 pp.
- Szabolcs, I. (1961): A vízrendezések és öntözések hatása a tiszántúli talajképződési folyamatokra (The effect of drainage and irrigation on the soil forming processes in the Tiszántúl). — Akadémiai Kiadó, Budapest.
- Szenti, T. (1983): Újabb levéltári adatok a Vásárhelyi-pusztáról (New documentary evidence to the history of the Vásárhelyi-pusztá). — Békés megyei Múzeumok Közleményei 7, 279-295.
- Szeremlei, S. (1907): Hód-Mező-Vásárhely története I (History of Hód-Mező-Vásárhely). — Hódmezővásárhely.
- Thaisz, L. (cca. 1905): Csanád megye flórakatalógusa (Flora of Csanád county). — Manuscript, TTM Növénytár, Tudománytörténeti Gyűjtemény, Budapest.
- Vartainen, T. (1988): Vegetation development on the outer island of the Bothnian Bay. — Vegetatio 77, 149-158.
- Widgren, M. (1979): A simulation model of farming systems and land use in Sweden during the early Iron Age, c.500 B.C. — A.D. 550. — J. Historical Geography 5, 21-32.
- Williams, M. (1982): Clearing the United States forests: pivotal years 1810-1860. — J. Historical Geography 8, 12-28.
- Winsor, R. A. (1987): Environmental imagery of the wet prairie of east central Illinois, 1820-1920. — J. Historical Geography 13, 375-397.
- Woodell, S. R. J. (ed.) (1985): The English landscape: past, present and future. — Oxford University Press, Oxford.
- Zólyomi, B. (1946): Természetes növénytakaró a tiszafüredi öntözőrendszer területén (Natural vegetation of the Middle Tisza region). — Öntözésügyi Közlemények 7-8, 62-75.
- Zólyomi, B. (1958): Budapest és környékének természetes növénytakarója (Natural vegetation of Budapest and its surroundings). In: Pécsi, M. (ed.): Budapest természeti képe. — Budapest 509-642 pp.
- Zólyomi, B. (1969a): A Tiszai Alföld természetes növényzete (Natural vegetation of the eastern part of the Great Hungarian Plain). In: Pécsi, M. (ed.): Magyarország Tájföldrajza. II. A tiszai Alföld. Akadémiai Kiadó, Budapest
- Zólyomi, B. (1969b): Földvárak, sáncok, határmezsgyék és a természetvédelem (Ancient vegetation on earthworks and road verges and their conservation). — Természet Világa 100, 550-553.
- Zólyomi, B. (1989): Natural vegetation of Hungary. In: Pécsi, M. (ed.): National Atlas of Hungary. — Kartográfiai Vállalat, Budapest.
- Zólyomi, B. and Fekete, G. (1994): The Pannonian loess steppe: differentiation in space and time. — Abstracta Botanica 18, 29-41.

### Maps and aerial photographs

- 1st (1784), 2nd (1861-66) and 3rd (1884) Military Survey, Museum of War History, Budapest
- 5th Military Survey Map (1: 25 000 — 1970, 1: 10 000 — 1983), Institute of Geodesy and Remote Sensing, Budapest
- Han, F., Witkowsky, E. (1938): A tótkomlói térképlap talajainak regionális leírása (Regional description of soils of Tótkomlós segment). In: Kreybig Soil Survey, Budapest.
- Black and white aerial photographs from 1950, 1953, 1964, 1981, 1989 and 1991, Carthographic Institute of the Ministry of Defence, Budapest.
- Black and white aerial photograph from 1976, Institute of Geodesy and Remote Sensing, Budapest
- Colour aerial photograph from 1995, at the author.

## VEGETATION HISTORY OF THE KARDOSKÚT AREA (SE. HUNGARY) II.: THE LAKE FEHÉR-TÓ IN THE LAST 200 YEARS

Zs. Molnár

*Molnár, Zs. (1996): Vegetation history of the Kardoskút area (SE. Hungary) II.: The lake Fehér-tó in the last 200 years. — Tiscia 30, 27-34.*

**Abstract.** Reconstruction of past vegetation changes provides useful information for the understanding of present vegetation. Based on historical data, old aerial photos and maps, a detailed vegetation survey, and the vegetation description by György Bodrogekőzy from the 1960's, the vegetation history of the lake Fehér-tó at Kardoskút for the last 200 years was drawn.

Historical data indicates that the lake remained in a near-natural state till the late 1970's. Since 1980, climatic drought has induced fundamental vegetation changes which differ in the 3 parts of the lake, probably as a consequence of differences in geological history. Predictions about the future of the lake vegetation, based on historical data and comparisons with other drying alkali lakes, are also given.

*Keywords:* drought, nature conservation, repeated vegetation mapping, succession.

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### Introduction

There is a wide choice of methods for studying vegetation dynamics. At the year-decade time scale changes can, for example, be followed by permanent quadrates or by remapping the vegetation pattern. Indirect approaches, which create artificial chronosequences and palaeobiological methods, help larger scale studies (Dierschke 1994).

Historical botanical data can provide important data for studies of vegetation dynamics. Floristic surveys, cenological studies or vegetation maps provide direct data about past vegetation, though this data is often scarce and incomplete. In Hungary, historical data are available since the late 18th century (Kitaibel in Gombocz 1945). From the middle of the 19th century onwards, floristic data are abundant. Since the 1910's more and more cenological descriptions and vegetation maps have been prepared.

Spatial changes of vegetation can be best analysed by vegetation maps. Generally, those situations were remapped where anthropogenic degradation caused profound changes or where regeneration after disturbance or perturbation resulted in a fast vegetation change (Dierschke 1994). The time scale of

these studies is generally several years or a couple of decades.

In the Great Hungarian Plain river control, drainage and recent climatic drought resulted in dryness induced successional changes (cf. Zólyomi 1931, Szabolcs 1961, Bagi 1995). Though the alkali lake studied was also temporal in the past, as a consequence of the drought period of the last 15 years, the water regime of the lake has changed considerably for the worse. A vegetation map from 1962-63 (Bodrogekőzy 1966) serves as a detailed reference to follow changes.

The goal of our study was to answer the following questions:

- Has the vegetation of the lake bed changed as a consequence of the drought?
- What vegetation types changed the most?
- What vegetation types changed the least?
- Do the real successional changes correspond with the theoretical trajectories established by Bodrogekőzy?

Based on the historical data prior to the 1960's, the brief history of the lake has been drawn. The goal of this reconstruction was to trace back the present twofold character of the lake vegetation to past features.

The area is a bird migratory site of European importance (Ramsar site; Nagy 1993) and is managed by the Nature Conservation Directorate of Körös-Maros. Since the lake and the neighbouring wetlands are drying out, which threatens the famous bird life, a research project was started in 1992. Based on the historical reconstruction, the management of the area was reevaluated (Molnár and Biró 1995).

### Study area

Kardoskút lies in SE. Hungary, in the Tiszántúl region, on the alluvial fan of the river Maros. The lake is surrounded by continental alkali steppes and cultivated fields.

The lake (called Fehér-tó after its white appearance in late summer) originated in the Holocene from two Maros meanders. The western has clayey deposits, the eastern part has more sandy deposits. The two lakes merged later (Molnár and Mucsi 1966). The Copper, Bronze and Iron Age mollusk fauna indicates high habitat diversity, presence of woodlands, permanent and temporary water bodies, and densely vegetated marshes (Domokos 1984).

At present the lake is temporary with maximum water in April, and a dry bed in July and August. The water has a high  $\text{NaHCO}_3$ ,  $\text{NaCl}$  and  $\text{Na}_2\text{SO}_4$  content and its pH is about 8.5-10 (Megyeri 1963). The bed is a highly salty solontchak originating from redeposited Pleistocene loess (Bodrogekőzy 1966). Till the late 1970's, as a unique feature, in the dried out lake bed circular, dark muddy patches appeared, where soil water reached the near-surface layers or even the surface. These wells played a crucial role in the water regime of the lake (Kiss 1963). Since 1980, the lake has been gradually drying out (Sterbetz 1992, Nagy 1993). From 1988, water from deep bored wells has been added in spring and autumn to provide habitat for migrating birds.

The area around the lake has been inhabited since the late Neolithic, mostly by nomadic tribes such as Körös culture, Baden culture, early and late Iron Age, Scythians, Jazyg-Sarmatians, Avars and Gepids (Szeremlei 1907, Banner 1943, Nagy and Szigeti 1984).

### Methods

Earlier historical records about the lake are scarce (military survey maps, Bodnár 1928, Szent 1983). In the 1960's, a multidisciplinary research project was set up by the Hungarian Academy of Sciences to study the lake's special features. The project covered the fields of botany and pedology

(Bodrogekőzy 1966, Kiss 1959), zoology (Sterbetz 1966, 1974, 1977, 1992, Marián 1966, Megyeri 1963) and geology and hydrology (Molnár and Mucsi 1966, Kiss 1963).

For the historical reconstruction, some documentary sources provided direct information, others could be interpreted by the preferences of plant species. The Hungarian plant sociological school has collected a great deal of data on the cenological, water, pH, nitrogen, etc. preferences of species and estimated their disturbance tolerance and specificity (for a detailed data base see Horváth *et al.* 1995). This data provided a good opportunity to recognize and follow changes in site conditions (e.g. decreasing salt content and drying).

Survey maps (1784, 1861-66, 1884, 1970 and 1983) and aerial photos (1950, 2 from 1953, 1964, 1976, 1981, 1987 and 1991) provided valuable information. In June 1995, colour aerial photos were made. Spatial movement and physiognomic transformation of vegetation patches in the lake bed were followed by documentary photos, made between 1966 and 1980, by István Sterbetz.

The map of present vegetation was prepared in July 1995. In each of the vegetation patches, cover values (%) of the most important species of the lake were recorded (*Crypsis aculeata*, *Suaeda maritima*, *Salsola soda*, *Puccinellia limosa*, *Camphorosma annua*, *Phragmites australis*, *Bolboschoenus maritimus*, *Aster tripolium ssp. pannonicum* and the cover of the meadow, dry grassland and weed species). Classification of patches was based on the dominant species combination.

Nomenclature of species follows Soó (1964-80).

### Results

#### *Vegetation of the lake*

Plant communities of alkali habitats are usually species poor and can be easily characterized by several dominant species. The first detailed vegetation description of the area was prepared by Bodrogekőzy (1966). Since the 1960's, vegetation has undergone considerable changes (Figs 1, 2 and 3, Table 1).

Lake bed vegetation: the lake dries out in the summer. On the mud surfaces *Crypsis aculeata* is the first colonizer. Stands are often monodominated. On drier mud surfaces, *Suaeda maritima* is typical. The next zone is formed by the tussocky perennial grass, *Puccinellia limosa*. At the edge of the lake, on the driest and most alkali surfaces, *Camphorosma annua* is characteristic.

Alkali marshes: in the alkali marshes of the lake, *Bolboschoenus maritimus* and *Phragmites australis* or often only one of them, are the dominant species.



This habitat adjoins on the *Puccinellia* or often the *Crypsis* zones. In the upper zone of the alkali marshes, *Aster tripolium ssp. pannonicum* becomes dominant.

Table 1. Distribution of the mapped habitat types in the lake bed. “+++” indicates a common and typical habitat, while “+” a rare and non-typical one. Grouping corresponds to Fig. 1.

Habitats	Western basin	Transition	Eastern basin
1.a. Open water	++	-	-
1.b. <i>Crypsis</i> zone	+++	+++	++
1.c. <i>Suaeda</i> zone	+++	++	+
1.d. <i>Puccinellia</i> zone	+++	+++	++
1.e. Bare patches with <i>Camphorosma</i>	+++	++	+
1.f. <i>Phragmites</i> stands with <i>Puccinellia</i>	-	+++	++
2.a. <i>Phragmites</i> and <i>Bolboschoenus</i> stands	-	+	+++
2.b. <i>Phragmites</i> and <i>Bolboschoenus</i> stands with <i>Aster</i>	-	+	+++
3.a. Drying out <i>Phragmites</i> , <i>Bolboschoenus</i> and <i>Puccinellia</i> stands	-	+	+++
3.b. Dried out marshes and <i>Agrostis-Carex</i> meadows	-	-	+++

Drying and dried out marshes: if drying is fast and salt is lost, weed species appear. Stands dominated by the original species were considered as drying marshes and stands dominated by weeds as dried out marshes.

Meadows: a unique habitat of the lake is the *Agrostis alba* and *Carex distans* dominated solonchak meadow (Bodrogekőzy 1966). Typical species, besides the *Agrostis* and *Carex*, are *Taraxacum bessarabicum* and *Scorzonera parviflora*. Since this habitat needs less alkali soils, which are humid also in summer, it only occurs in the Eastern basin, at the edge of the lake where undersurface wells were common (Bodrogekőzy 1966). As a consequence of drought, this habitat is quickly disappearing.

## History of the lake

### Middle Ages

In the Middle Ages there were two villages near the northern shore (Szeremlei 1907, Banner 1943, Olasz 1959, Blazovich 1985). Apácaegyház was a straggling village, mentioned first in the beginning of the 11th century and destroyed by the Mongolians in the middle of the 13th century. The other village, Bagd, was ruined in the 16th or 17th century. Though we have no direct information about the medieval lake, these settlements show its importance in this steppe landscape.

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### 1784 to 1960

From the 18th century onwards, there are more and more available data about the lake. The wells of the Eastern basin were mentioned first in 1794, when one of them was cased (Szenti 1983).

In the 1850's, water of the lake usually shrank in the summer, became highly salty and was therefore unsuitable for drinking (Szenti 1983). On the military survey maps from 1784, 1861–66 and 1884 the shape of the lake is different. In 1784, part of the Western basin is shown to be more temporary. In 1861-66, the joining basins seem to be part of the lake. Bodnár (1928) also mentions that in the 19th century, the shape of the lake was temporally different. Since 1847, the lake has probably been used more intensively, e.g. for grazing and reed harvesting after farm-houses were built on the shore (Szenti 1983).

Bodnár (1928) describes the lake in detail. The water level changed considerably. In normal years the lake was permanent throughout the year, but in dry years it dried out. In the Eastern basin, a small marsh usually remained. During extremely dry periods, even this part dried out and vegetation became sparse. Vegetation in the two basins was different as a consequence of the wells. In the Western basin, small amounts of vegetation were confined to the edges whilst in the Eastern basin, marsh vegetation with *Phragmites* and *Schoenoplectus* could be found.

### The last water rich period (1960 to 1980)

In the springs of the 1960-70's, maximum water depths reached 40 to 50 cm and sometimes even 70 cm. The lake usually dried out by July or August. In November, the water was again 20 to 30 cm deep.

The Eastern basin, where frogs and leeches were common, was more permanent than the western (Marián 1966, A. Gyömrei personal communication). This difference was caused by the “Seven Wells” (I. Sterbetz, I. Farkas, F. Panyik personal communication). Owing to the work of Bodrogekőzy (1966), the vegetation of the lake in this period is well known (Fig. 3). There is also a high quality aerial photograph from 1964. This period was used for a reference to follow the changes caused by drought after 1980.

Though in the 1960's water conditions were more favourable, there was no aquatic and freshwater marsh vegetation in the lake bed. The Western basin was covered with *Crypsis* and *Suaeda* whilst near the edges *Puccinellia* and *Camphorosma* appeared in patches. In the Eastern basin, *Phragmites* and *Bolboschoenus* dominated alkali marshes with *Aster tripolium* and containing less than 5 % weed

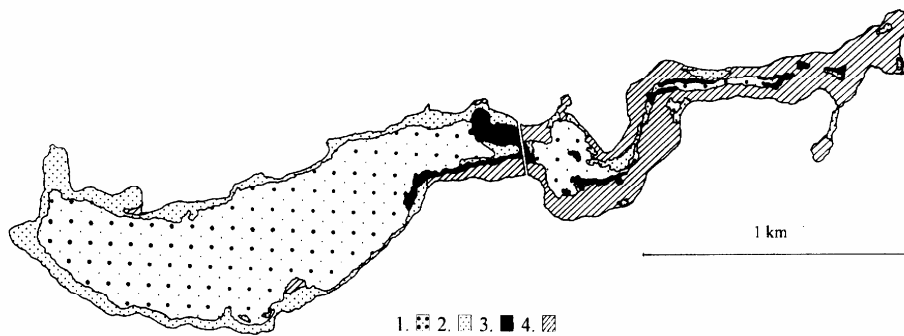


Fig. 1. Vegetation map of the lake Fehér-tó at Kardoskút. The map was made in July 1995, based on a recent colour aerial photograph and field survey. 10 vegetation types (see Table 1) were distinguished on the basis of dominant species that were later grouped as follows: Zone A: 1. *Crypsis* and *Suaeda* mud vegetation, 2. *Puccinellia* and *Camphorosma* swards, Zone B: 3. *Phragmites-Bolboschoenus* alkali marshes with *Aster* and *Puccinellia*, Zone C.: 4. Drying and dried out marshes and *Agrostis-Carex* meadows.

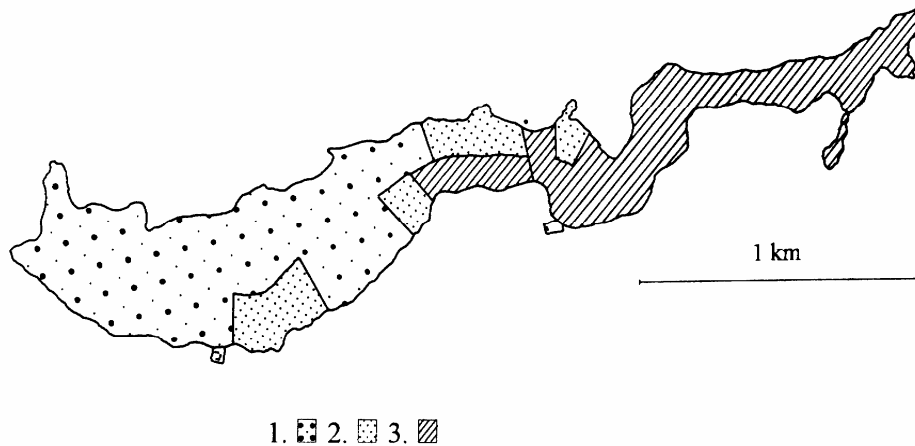


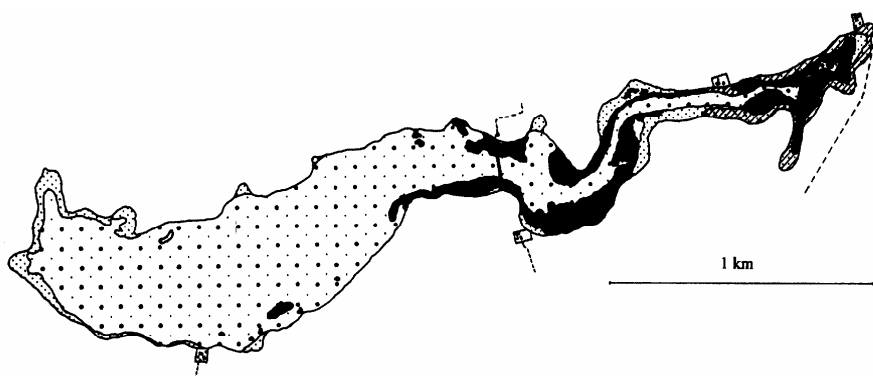
Fig. 2. Spatial partitioning of the lake vegetation. Based on the zonation pattern along the shore line, the lake was divided into three parts: 1. Western basin (only zone A), 2. Transition zone (zone A and B), and 3. Eastern basin (all 3 zones; for an explanation of the zones see Fig. 1). This partitioning coincides with the known distribution of wells (occurring only in the Eastern basin and the Transition zone - Bodrogekőzy 1966), the widths of the lake and may be a result of the geological history of the lake.

cover, were widespread. The distribution of these marshes and the wells coincide, because in these areas soil is more leached, less salty and more humid (Bodrogekőzy 1966). In the Eastern basin, *Crypsis* and *Suaeda* were less common and *Puccinellia* appeared in patches. Some of these stands were secondary, developed in the place of marshes as a consequence of cattle grazing (I. Farkas personal communication.). The most dense marshes were in the easternmost part of the basin, where the abundance of water was the highest. The height of the reeds reached 3 meters. In the 1940-50's, the reeds were smaller (I. Farkas and A. Gyömrei personal communication) which could be explained by either the drier climate or the more intensive grazing prior to nature conservation (1966, Nagy 1993). Solontchak

*Agrostis-Carex* meadows appeared only in the Eastern basin. Their species composition shows that in the 1960's they were still in a near-natural state.

#### *Drought period of the last 15 years (1980 to 1995)*

Since the 1960's, precipitation in the Hungarian Great Plain has decreased considerably (Ráth 1994) which has caused fundamental changes in the water regime of the lake. The quantity of water falling directly into the lake and flowing into it from the surrounding alkali surfaces decreased considerably (Sterbetz 1992). The discharge from wells also decreased (I. Farkas and F. Panyik personal communication). Later reduction in water level was caused by the lowered soil water table in the sur-



1. 2. 3. 4.

Fig. 3. Vegetation map of the Kardoskút alkali lake from 1962-63 (Bodrozközy 1966). This map was used as a reference to evaluate successional changes induced by the drought period. To help comparisons, the original map was adjusted to a 1: 10 000 map and corrected by the aerial photo from 1964. Note the similar twofold general vegetation pattern and the profound but spatially uneven changes in vegetation types between 1962-63 and 1995. 1. *Crypsis* and *Suaeda* mud vegetation, 2. *Puccinellia* and *Camphorosma* swards, 3. *Phragmites-Bolboschoenus* alkali marshes with *Aster* and *Puccinellia*, 4. *Agrostis-Carex* solontchak meadows.

rounding loess areas. Between 1970 and 1994, soil water table decreased by 0.8 meter (Kardoskút, Well No. 467, ATIVIZIG).

Since 1981, István Farkas has recorded the date of complete drying out, which fell between mid-May (1993, 1994) and early September (1981). Between 1982 and 1987 it was in July and August. Since 1988 it has been earlier, in May and June (except in 1991). The shortage of water had more serious affects in the spring than in the summer. Maximum water level in April decreased from 40-70 cm to 15-30 cm. This meant that in the last 15 years only the *Crypsis* and *Suaeda* (sometimes also the *Puccinellia*) zones have been flooded. Alkali marshes and meadows which were usually flooded till early summer, have remained dry throughout the year (I. Farkas, jr. personal communication, photos of I. Sterbetz).

Drought has brought about successional changes in the lake bed. Vegetation transformations include changes in the dominance and number of species of natural habitats, disappearance, movement, expansion and physiognomic changes of certain vegetation types.

The Western basin has changed the least. *Crypsis* and *Suaeda* are still the dominant species. *Puccinellia* zone has become contiguous and wider by 25 to 35 m, *Camphorosma* patches have not changed noticeably. The transition zone, where the mosaic of *Phragmites* and *Puccinellia* patches was characteristic, has changed to a greater extent. Reed stands have dried out, become shorter and have opened. The *Puccinellia* zone has expanded and encroached upon the reed patches.

Considerable transformations occurred in the Eastern basin. The *Phragmites-Bolboschoenus-Aster*

stands, the solontchak meadows and the *Puccinellia* patches near the edges have dried out and weeds like *Poa angustifolia*, *Festuca pseudovina*, *Agropyron repens*, *Carex vulpina*, *Sonchus arvensis*, *Cichorium intybus*, *Achillea collina* and *Cirsium arvense* often became the dominant species (60 to 80 %). Some of the specialists, like *Acorellus pannonicus* and *Triglochin palustre* have died out. The *Crypsis* zone has shrunk. In the *Suaeda* and the wetter *Puccinellia* stands there has been little change.

The general "theoretical" successional sequence of the lake bed was described by Bodrozközy (1966, 1977): open water — *Crypsis* — *Suaeda* — *Puccinellia* — *Bolboschoenus* and *Phragmites* — *Bolboschoenus* and *Phragmites* with *Aster* — *Agrostis-Carex* — *Camphorosma*. Drought induced successional trajectories, however, do not always follow this sequence and differ in the three parts of the lake (Fig. 4). In the Western basin, *Puccinellia* is often followed by *Camphorosma* and not by an alkali marsh. Direct open water — *Suaeda* and *Crypsis* — *Puccinellia* transitions are also common. In the Eastern basin, drying *Crypsis* stands are often invaded by the *Bolboschoenus* — *Phragmites* marshes. Alkali marshes have not turned into meadows, but became weedy, changing into dry *Festuca* grasslands.

The two main types of changes were the movement of zones towards the lake bottom and the changes in species composition of non-moving stands. *Crypsis*, *Suaeda*, *Puccinellia*, *Aster* and *Festuca* were moving relatively fast, while *Bolboschoenus*, *Phragmites* and *Carex distans* are relatively slow.

The differences in speed resulted in zone inversions. For example, in the transition zone the spatial pattern and extension of the *Phragmites* stands has changed very little in the last 15 years (photos of I. Sterbetz from 1980). At the same time, the *Puccinellia* zone has moved towards the lake by 20-25 m. *Puccinellia* invaded the opened *Phragmites* stands and even formed a zone below the *Phragmites* zone. The upper and lower *Puccinellia* zones are, however, different, the lower zone being in terms of species composition (Bodrogeközy 1966) and physiognomy (photos of I. Sterbetz from 1980) very similar to the stands of the 1960-70's, while the upper zone shows the signs of drying (*Aster tripolium*, *Lepidium perforiatum*, *Agrostis stolonifera*, *Poa angustifolia*).

### Discussions

#### *The twofold character of the lake and its effect on drought induced succession*

The twofold character of the lake has been only mentioned by Molnár and Mucsi (1966) and Nagy (1993), though it is easy to recognize by the distribution of wells (Kiss 1963, Bodrogeközy 1966 — at normal water conditions) and by the vegetation pattern or the shape of the lake. The lake behaves as if were two independent lakes. Also the dynamics of vegetation differs considerably in the two basins. Differences may be ascribed to geological history.

The presence of marsh vegetation in the Eastern

basin was explained by fertilizer pollution, since arable fields border this basin, while grasslands border the other (Nagy 1993). The humus content of the deposits (Molnár and Mucsi 1966), and the presence of marsh specialist mollusc species from the Copper-Iron Ages (Domokos 1984) indicate, however, that the marshes of the Eastern basin might have existed for thousands of years. In the 1920's (before the increased use of fertilizers), the vegetation of the lake was already similar to the present situation. *Agrostis-Carex* meadows also produce evidence for the long functioning of the wells, since these meadows can only develop and survive where wells provide damp soil throughout the year (Bodrogeközy 1966). Specialist species of these meadows (*Carex distans*, *Taraxacum bessarabicum*, *Triglochin palustre* and *Scorzonera parviflora*) do not or rarely occur in the Tiszántúl region (Soó and Máthé 1938) and thus also show the ancient character of this habitat.

The climatic drought of the last 15 years induced substantial successional changes in the lake. These changes provide fine examples of how past events control present vegetation dynamics (cf. Foster 1992, Peterken and Game 1984, Jackson *et al.* 1988). In the Western basin, changes are slow and vegetation zones follow the changes in site conditions. This can be ascribed to the finer sediments which prevent greater water and salt loss. In the Eastern basin, changes are more striking. Here the sediments are sandy and the wells provided access water and

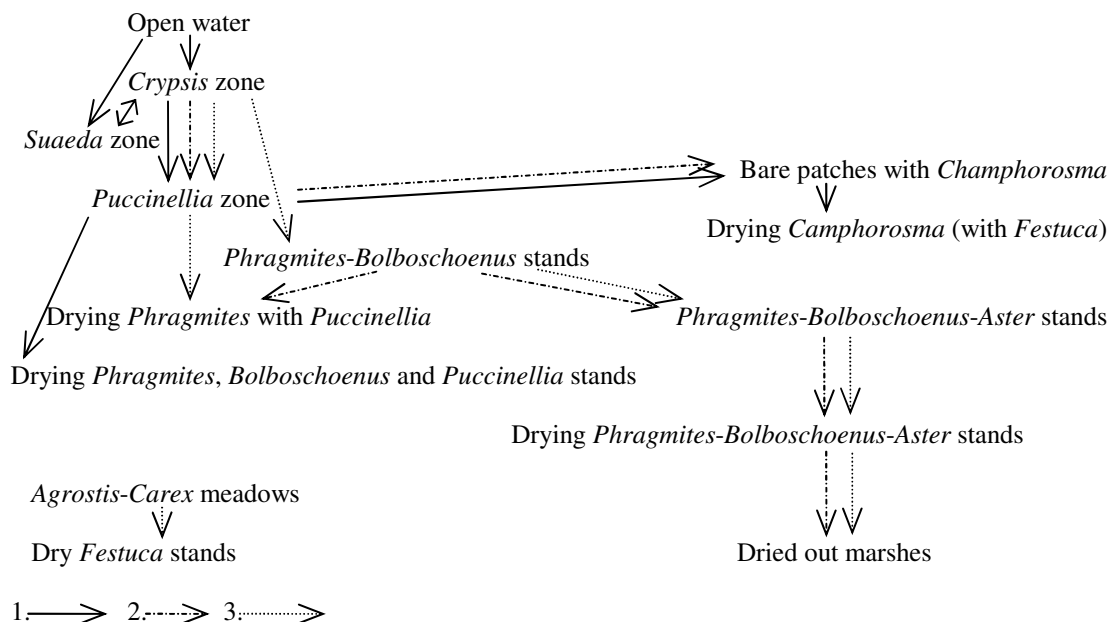


Fig. 4. Successional pathways in the 3 parts of the lake bed differ as a consequence of different history and physical characteristics. 1: Western basin, 2: Transition zone, 3: Eastern basin.

caused leaching (Bodrogközy 1966, Molnár and Mucsi 1966). Site conditions were more favourable in the past if compared with the Western basin. The effects of drought are thus greater, vegetation zones were not able to follow these fast changes and consequently stands became invaded with weeds.

#### *Future of the lake*

Historical data (Szenti 1983, Bodnár 1928, Military survey maps) showed that the temporal character and the vegetation of the lake changed little from the middle of the 19th century till the late 1970's. The lack of weed dominant patches in the 60's (Bodrogközy 1966) also indicate near-natural conditions. Thus the state of the lake in the 60's can be regarded as near-natural, and hence can be used as a reference to evaluate changes caused by the drought. Predictions on the future of the lake were based partly on the local history and dynamics and partly on transformations of other drying alkali lakes (Bagi 1995, Molnár unpubl.). It was presumed that the present drought period is more serious than those in the past 300 years (Pálfai 1991), and that drainage influenced well discharge adversely.

If water conditions can not be improved, in the Western basin, *Puccinellia* will spread slowly further towards the lake bottom and in the Eastern basin *Crypsis* and *Puccinellia* stands will be shortly invaded by *Bolboschoenus* and *Phragmites*. Drying will cause further salt loss, weed species will become even more dominant and solontchak meadows will disappear totally. Regeneration of the lake is only possible if natural water supply from the wells can be restored or if artificial water supply can imitate natural water level changes. Based on historical data (Bodrogközy 1966, Kiss 1959, 1963, Sterbetz 1992, I. Farkas and I. Sterbetz personal communication), this means a maximum of 40 to 70 cm in April, a dry lake bed in July and August and a second water maximum (20 to 30 cm) in November.

#### **Acknowledgements**

István Sterbetz, István Farkas, István Farkas jr., Antal Gyömrei and Ferenc Panyik provided valuable insights into the 20th century history of the area. Sándor Hévízi, Ferenc Kőszegfalvi and Tibor Szenti helped to collect the literature. Marianna Biró constructed the maps. László Bagi made the aerial photos from the lake. Sándor Bartha, Gábor Fekete, István Sterbetz offered constructive comments on a former version of the manuscript. I would like to thank Liam Holloway for checking the English content. This study was supported by the Nature Conservation Directorate of Körös-Maros, Szarvas.

#### **References**

- Bagi, I. (1995): A JATE Növénytani Tanszéke cönológiai és botanikai kutatásai a Kiskunsági Nemzeti Parkban, 1984-1995 (Phytocenological and botanical researches of the Department of Botany of the A. J. University, in the Kiskunság National Park, 1984-1995). In: Tóth, K. (ed.): 20 éves a Kiskunsági Nemzeti Park. — Kecskemét, 133-146 pp.
- Banner, J. (1943): Településtörténeti kutatások Hódmezővásárhely-Fehértó partján (Settlement historical studies on the shore of Hódmezővásárhely-Fehértó). — Dolgozatok a Szegedi Egyetem Régiségstudományi Intézetéből 9, 195-201.
- Blazovich, L. (1985): A Körös-Tisza-Maros köz középkori településrendje (Medieval settlements of the area between the Körös, Tisza and Maros). — Dél-alföldi Századok, Békéscsaba, Szeged.
- Bodnár, B. (1928): Hódmezővásárhely és környékének régi vízrajza (Ancient hydrology of Hódmezővásárhely and its surroundings). — Szeged.
- Bodrogközy, Gy. (1966): Ecology of the halophilic vegetation of the Pannonicum. V. Results of the Investigation of the "Fehértó" of Orosháza. — Acta Bot. Hung. 12, 9-26.
- Bodrogközy, Gy. (1977): A Pannonicum halophiton társulásainak rendszere és synökológiája (Halophilic plant associations of the Pannonicum and their synecology). — PhD. Thesis, Szeged.
- Dierschke (1994): Pflanzensoziologie. — Verlag Eugen Ulmer, Stuttgart.
- Domokos, T. (1984): Adatok a kardoskúti Fehértó holocén Mollusca faunájának vizsgálatához (New data to the mollusc fauna of the Fehértó at Kardoskút). — Alföldi Tanulmányok 8, 59-80.
- Foster, D. R. (1992): Land-use history (1730-1990) and vegetation dynamics in central New England, USA. — J. Ecol. 80, 753-772.
- Frisnyák, S. (1990): Magyarország történeti földrajza (Historical geography of Hungary). — Tankönyvkiadó, Budapest.
- Horváth, F., Dobolyi, K., Morschhauser, T., Lőkös, L., Karas, L. and Szerdahelyi, T. (1995): Flóra adatbázis 1.2, Taxonlista és attributumállomány (Flora database 1.2: Taxonlist and attributes). — Flóra Munkacsoport, MTA Ökológiai és Botanikai Kutatóintézete, MTM Növénytár, Vácrátót.
- Jackson, S. T., Futyma, R. P. and Wilcox, D. A. (1988): A paleoecological test of a classical hydrosere in the lake Michigan dunes. — Ecology 69, 928-936.
- Kiss, I. (1959): A kardoskút-pusztaközponti Fehértó mikrovegetációja (Microvegetation of the Fehértó at Kardoskút-Pusztaközpont). — Szegedi Pedagógiai Főiskola Évkönyve 5, 23-56.
- Kiss, I. (1963): Vízfeltörések vizsgálata az Orosháza környéki szikes területeken, különös tekintettel a talajállapot és a növényzet változásaira (Studies of surface wells in the alkali areas near Orosháza with special reference to the changes of soil and vegetation). — Szegedi Tanárképző Főiskola Tudományos Közleményei 8, 43-82.
- Marián, M. (1966): The Herpetofauna of the Fehértó near Kardoskút. — Vertebrata Hungarica 8, 94-103.
- Megyeri, J. (1963): Vergleichende hydrofaunistische Untersuchungen an zwei Natrongewässern. — Acta Biol. Szeged. 9, 207-218.
- Molnár, B. and Mucsi, M. (1966): A Kardoskúti-Fehértó vízföldtani viszonyai (Hydrogeological studies of the Fehértó at Kardoskút). — Hidrológiai Közöny 46, 413-420.

- Molnár, Zs. and Biró, M. (1995): Botanical and landscape historical survey and evaluation of the Kardoskút Nature Reserve. — Report, Nature Conservation Directorate of Körös-Maros, Szarvas.
- Nagy, I. and Szigeti, J. (1984): Hódmezővásárhely története I (History of Hódmezővásárhely). — Hódmezővásárhely.
- Nagy, Sz. (1993): Jelentés a Kardoskút Természetvédelmi Terület és a csatlakozó területek, mint Európai jelentőségű madárelőhely állapotáról (Report on the status of the Kardoskút Nature Reserve and neighbouring areas, as bird habitats of European importance). — MME, Manuscript.
- Olasz, E. (1959): Elpusztult 11-16. századi falvak Kardoskút, Tótkomlós és Békéssámszon környékén (11-16th century destroyed villages near Kardoskút, Tótkomlós and Békéssámszon). — Szántó-Kovács János Múzeum Évkönyve, Orosháza 1, 31-39.
- Pálfai, I. (1991): Kétszáz év nagy aszályai a Tisza-völgyben (1791-1990) (Droughts in the Tisza-valley in the last 200 years). — Széchenyi és a Tisza-völgy rendezése, Magyar Hidrológiai Társaság, Budapest.
- Peterken, G. and Game, M. (1981): Historical factors affecting the number and distribution of vascular plant species in the woodlands of central Lincolnshire. — J. Ecol. 72, 155-182.
- Ráth, I. (1994): Kritikus vízháztartási helyzet a Duna-Tisza közti hátságban (Critical hydrological situation in the area between the Danube and Tisza). — Ö.K.O. 5, 29-36.
- Soó, R. (1964-80): Synopsis Systematico-Geobotanica Florae Vegetationesque Hungariae I-VII. — Akadémiai Kiadó, Budapest.
- Soó, R. and Máthé, I. (1938): A Tiszántúl flórája (Flora of the Tiszántúl). — Debrecen.
- Sterbetz, I. (1966): Data to the mammalian and fish fauna of the Kardoskút-Reservation. — Vertebrata Hungarica 8, 135-138.
- Sterbetz, I. (1974): A Kardoskúti Természetvédelmi Terület madárvilága 1952-1973 időközében. — Aquila 80-81, 91-120.
- Sterbetz, I. (1977): Einfluss der Veränderungen der Agrarumwelt auf die Tierwelt des Naturschutzgebietes Kardoskút. — Aquila 84, 65-81.
- Sterbetz, I. (1992): A Vásárhelyi-pusztán fészkelő széki lile populáció (*Charadrius alexandrinus* L., 1758) elsoványodásának vizsgálata (Gradual disappearance of population of *Charadrius alexandrinus* L., 1758 from the Vásárhelyi-pusztá). — Állattani Közlemények 78, 89-93.
- Szenti, T. (1983): Újabb levéltári adatok a Vásárhelyi-pusztáról (New documentary evidence to the history of the Vásárhelyi-pusztá). — Békés megyei Múzeumok Közleményei 7, 279-295.
- Szeremlei, S. (1907): Hód-Mező-Vásárhely története I (History of Hód-Mező-Vásárhely). — Hódmezővásárhely.
- Zólyomi, B. (1931): A kultúra hatása a vegetációra a Hanság medencéjében (Effect of human culture on the vegetation of the Hanság-basin). — A debreceni Tisza István Tudományos Társaság orvos-természettudományi osztályának munkáiból 4, 120-126.

*Maps, aerial photographs and archives consulted*

- 1st (1784), 2nd (1861-66) and 3rd (1884) Military Survey, Museum of War History, Budapest
- 5th Military Survey Map (1: 25 000 — 1970, 1: 10 000 — 1983), Institute of Geodesy and Remote Sensing, Budapest
- Black and white aerial photographs from 1950, 1953, 1964, 1981, 1989 and 1991, Cartographic Institute of the Ministry of Defence, Budapest.
- Black and white aerial photograph from 1976, Institute of Geodesy and Remote Sensing, Budapest
- Colour aerial photograph from 1995, at the author.
- ATIVIZIG: Soil water monitoring database, Szeged.

## CHANGES OF ZOOCOENOTIC STRUCTURE IN LOWER REACH OF RIVER TISZA

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*Pujin, V., Djukić, N., Maletin, S., Miljanović, B. and Ivanc, A. (1996): Changes of zoocoenotic structure in lower reach of river Tisza. - TISCIA 30, 35-38.*

**Abstract.** Hydrotechnical constructions on rivers Danube (Hydroelectric plant Djerdap I and II) and Tisza (Dam Novi Bečej), as well as general industrial development in the Tisza valley caused deterioration of physico-chemical quality of water of river Tisza. The slowing down of its flow and increased inflow of waste water led to a decrease in dissolved oxygen concentration and affected the structure of zoocoenosis. The number of zooplankton species characteristic of smooth waters and tolerant to oxygen depletion increased. These conditions affected, as well, both the composition of bottom fauna and ichthyofauna. Analysis of Oligochaeta community has indicated a sharp reduction in the number of species and decrease in the numbers. The abundance of sterlet and predator fish species has been decreasing as well as phytophils. A slow decrease in carp population occurred despite a permanent stocking with fingerlings. Special changes appear in fish community in relation to introduced species, especially Prussian carp. The decrease in dissolved oxygen concentration below biological minimum caused fish dying in recent years.

*Keywords: zooplankton, Oligochaeta, ichthyofauna, hydroecosystem, degradation*

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### Introduction

The long-term investigations of the lower Tisza river have resulted in awareness of various changes of its physical and chemical properties concurrently affecting its zoocoenoses structure (Pujin and Rajković 1979, Djukić and Stanojević 1981, Kojčić *et al.* 1988, 1989, Pujin 1987, 1989, Djukić *et al.*, 1993). Since fish kills and death of other organisms have been reported frequently so far, the aim of the paper was to document structural changes of zoocoenoses in the lower Tisza caused primarily by anthropogenic influence.

### Material and methods

Investigations included the composition and dynamics of zooplankton, oligochaeta fauna, and ichthyofauna during the period 1990-1994. Sampling

was done by use of standard techniques (planctonic nets, Ekman-Birge dredge, electro-fishing, and fishing nets) and standard methods (Felföldy 1980, American Standard Methods 1985).

### Results and discussion

In the investigated period the qualitative composition of the zooplankton was as follows (Table 1.).

The analysis shows a total of 88 zooplankton species with an expected dominance of Rotatoria (Table 2.). Variations of the species numbers were associated with year, seasons, and locality resembling to some extent already published results (Ratajac 1979, Pujin 1989, 1992). Those investigations reported on changes caused by building a dam on the Tisza and hydroelectric power plant Djerdap I on the Danube that resulted in a slower water flow as well as an increased influence of waste waters.

Table 1. Qualitative composition of zooplankton of the lower Tisza in 1990-1994.

Species	1990	1991	1992	1993	1994	Species	1990	1991	1992	1993	1994
Protozoa						<i>K. quadrata</i>	+	+	+	+	+
<i>Actinosphaerium eichhorni</i>	+	+	-	-	-	<i>K. testudo</i>	+	+	-	-	-
<i>Arcella vulgaris</i>	+	+	-	-	-	<i>K. valga</i>	+	+	-	-	-
<i>Aspidisca costata</i>	+	+	+	+	+	<i>K. valga monospina</i>	+	+	-	-	-
<i>Carchesium polypinum</i>	+	+	+	+	+	<i>Lecane bulla</i>	+	+	-	+	-
<i>Chilodonella cucullus</i>	+	+	+	+	+	<i>L. luna</i>	+	+	-	-	-
<i>Colpidium colpoda</i>	+	+	+	+	+	<i>L. lunaris</i>	+	+	-	-	-
<i>Dileptus anser</i>	+	-	-	-	-	<i>Lepadella ovalis</i>	+	+	+	+	+
<i>Epistylis plicatilis</i>	-	+	+	+	+	<i>Liliferotrocha subtilis</i>	+	+	-	-	-
<i>Paramecium aurelia</i>	+	+	+	+	+	<i>Mytilina mucronata</i>	+	+	-	-	-
<i>P. bursaria</i>	+	-	-	-	-	<i>Notholca squamula</i>	+	+	+	-	-
<i>P. caudatum</i>	+	+	+	+	+	<i>Polyarthra dolichoptera</i>	+	+	+	+	+
<i>P. trichium</i>	-	+	+	+	+	<i>P. vulgaris</i>	+	+	-	-	+
<i>Tintinnidium fluviatile</i>	+	+	-	-	-	<i>Pompholyx complanata</i>	+	+	+	+	+
<i>Tintinnopsis lacustris</i>	+	+	+	+	-	<i>Rotaria neptunia</i>	-	-	+	+	+
<i>Tokophrya quadripartita</i>	+	-	+	-	-	<i>R. neptunoidea</i>	-	-	+	+	+
<i>Vorticella campanulata</i>	+	+	+	+	+	<i>R. rotatoria</i>	+	+	+	+	+
<i>V. convallaria</i>	+	-	-	-	-	<i>Synchaeta oblonga</i>	+	+	-	+	-
<i>V. microstoma</i>	+	+	+	+	+	<i>S. pectinata</i>	+	+	-	-	-
Rotatoria						<i>Trichotria tetractis</i>	+	+	-	-	-
<i>Anureopsis fissa</i>	+	+	+	-	-	<i>Trichocerca capucina</i>	+	+	-	-	+
<i>Asplanchna brightwelli</i>	+	+	+	+	+	<i>T. dixon-nuttalli</i>	+	+	-	-	-
<i>A. girodi</i>	+	-	-	-	+	<i>T. similis</i>	+	+	-	-	-
<i>A. priodonta</i>	+	+	+	+	+	<i>T. weberi</i>	+	+	-	-	-
<i>Brachionus angularis</i>	+	+	+	+	+	Cladocera					
<i>B. budapestinensis</i>	+	+	+	+	+	<i>Alona quadrangularis</i>	+	-	+	-	-
<i>B. calyciflorus</i>	+	+	+	+	+	<i>Bosmina longirostris</i>	+	+	+	+	+
<i>B. calyciflorus f. anureiformis</i>	+	+	+	+	+	<i>Ceriodaphnia quadrangula</i>	+	-	+	-	-
<i>B. calyciflorus f. amphicerus</i>	+	+	+	+	+	<i>Chydorus sphaericus</i>	+	+	+	+	+
<i>B. diversicornis</i>	+	+	+	-	-	<i>Daphnia longispina</i>	+	+	+	-	-
<i>B. falcatus</i>	+	+	-	-	-	<i>D. magna</i>	-	+	+	+	+
<i>B. forficula</i>	-	+	-	-	-	<i>Diaphanosoma brachyurum</i>	+	-	-	-	-
<i>B. leydigi</i>	+	+	+	+	+	<i>Graptoleberis testudinaria.</i>	+	-	-	-	-
<i>B. urceolaris</i>	+	+	+	+	+	<i>Moina micrura</i>	+	-	-	-	-
<i>B. urceolaris var. rubens</i>	+	+	-	+	+	<i>Macrothrix laticornis</i>	+	-	-	-	-
<i>Cephalodella cetellina</i>	+	+	-	-	-	<i>Scapholeberis kingi</i>	-	+	-	-	-
<i>C. gibba</i>	+	+	-	-	-	Copepoda					
<i>Colurella coluris</i>	+	+	-	-	-	<i>Acanthocyclops robustus</i>	+	+	+	+	+
<i>Dissotrocha aculeata</i>	+	+	-	-	-	<i>A. vernalis</i>	+	+	+	+	+
<i>Epiphanes senta</i>	+	+	+	+	+	<i>Cyclops vicinus</i>	+	+	+	-	-
<i>Euchlanis dilatata</i>	+	+	-	-	-	<i>Diacyclops bicuspidatus</i>	+	-	-	-	-
<i>Filinia longiseta</i>	+	+	+	+	+	<i>Eucyclops serrulatus</i>	+	-	-	-	-
<i>F. opoliensis</i>	+	+	-	-	-	<i>E. speratus</i>	+	+	-	-	-
<i>Keratella cochlearis</i>	+	+	+	+	+	<i>Eudiaptomus gracilis</i>	+	+	-	-	-
<i>K. cochlearis var. tecta</i>	+	+	+	+	-	<i>Mesocyclops leuckarti</i>	+	+	+	+	+
<i>K. paludosa</i>	+	+	-	-	-	<i>Thermocyclops crasus</i>	+	+	+	+	+

Table 2. The number of zooplankton species according to analyzed groups.

Groups	1990	1991	1992	1993	1994	Total
Protozoa	16	14	12	10	10	18
Rotatoria	46	47	25	20	21	50
Cladocera	9	7	5	4	4	11
Copepoda	9	7	5	4	4	9
Total	80	73	48	37	38	88

Zooplankton composition, in the period under consideration, showed the occurrence of species characteristic of slower streams and more tolerant of alterations in oxygen status (Kojčić *et al.* 1988, 1989,

Pujin 1987, 1989). The influence of water impound upon the structure of zoocenoses was also reported for certain Danube sections (Pujin 1990, Gulyas 1994). Such a water control has resulted in an



increased threat of waste waters and, concurrently, significantly changing the zooplankton composition in the Tisza river.

Significant qualitative and quantitative changes were found in the Oligochaeta fauna of the littoral zone of the Tisza river. Oligochaeta was found in all the analyzed samples where they dominated when compared with other hydrobionts. Our earlier investigations of the qualitative composition of the Oligochaeta community in the period 1974 to 1984 showed the occurrence of 16 species from the two families (Djukić and Kilibarda 1985, Djukić *et al.* 1993). In the period 1990-1994 however, only 13 species belonging to two families were recorded (Table 3). In the whole period under consideration dominant species were *Limnodrilus hoffmeisteri* and *Branchiura sowerbyi*, the indicators of organic load and slower streams.

Table 3. Qualitative composition of Oligochaeta community.

Species	Period		
	1974-1984	1985-1990	1990-1994
Naididae			
<i>Dero digitata</i>	+	+	+
<i>D.obtusa</i>	+	+	+
<i>Nais communis</i>	+	+	-
<i>N.elinguis</i>	-	+	+
<i>Paranis litoralis</i>	+	+	-
<i>Uncinaiis uncinata</i>	+	+	-
<i>Stilaria lacustris</i>	-	+	-
<i>Chaetogaster sp.</i>	-	-	+
Tubificidae			
<i>Branchiura sowerbyi</i>	+	+	+
<i>Limnodrilus claparedeanus</i>	+	+	+
<i>L.hoffmeisteri</i>	+	+	+
<i>L.helveticus</i>	+	-	-
<i>L.udekemanus</i>	+	+	+
<i>Peloscoclex velutinus</i>	+	+	+
<i>Potamothrix hammoniensis</i>	+	+	+
<i>P.moldaviensis</i>	-	+	+
<i>Psamoricoides barbatus</i>	+	+	+
<i>Iliodrilus perieri</i>	+	-	-
<i>Isochaeta michaelseni</i>	+	-	-
<i>Tubifex montanus</i>	-	+	-
<i>T.tubifex</i>	+	+	+

Not only a reduced number of species, but also quantitative analysis have indicated a sharp decrease in the Oligochaeta numbers when compared with former periods. Mean annual numbers for period 1991 to 1994 ranged from 260 to 1,272 ind/m<sup>2</sup>, while maximum was ten times as low as the average annual numbers in 1990 (Fig. 1). The phenomenon is associated with changes in the environment, representing a consequence of building dams which slow streams and increase matter deposits.

A quantitative analysis of the fish community including total catch data during the investigation period shows uniform annual values amounting approx. 100,000 kg/year. The highest percentage of the fish community belongs to lithophilous species (*Acipenser ruthenus*, *Barbus barbus*, and certain Abramidinae and Percidae), as well as *Carrasius auratus gibelio* with values exceeding 50% at certain sections. Qualitative analysis of the ichthyofauna structure shows certain changes when compared with the investigated period 1984 to 1988, primarily reflected by the reduction of numbers of certain phytophilous species such as *Esox lucius*, the majority of Cyprinidae, and certain Percidae possibly due to a constant reduction of the flood zone and low water level (Maletin *et al.* 1990). Also, a significant reduction of phytophils, as well as certain drop in numbers of *A. ruthenus* and *Silurus glanis* was reported (Djukić *et al.* 1994). The percentage of *C. carpio* in total catch was found to be 20%, decreasing slowly, despite a permanent stocking. It should be emphasized that these changes are less evident at the Tisza II section (from the river mouth to the dam near Novi Bečej) due to a greater stability of water level and larger flood zone.

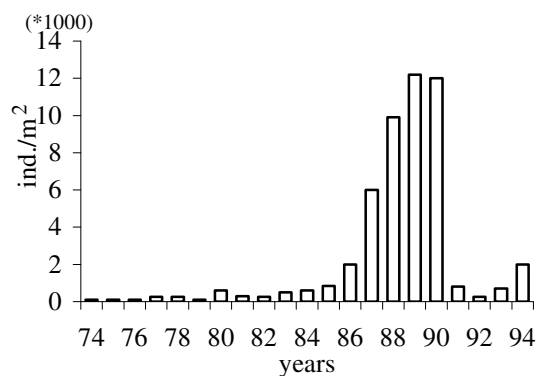


Fig. 1. Mean annual abundances of Oligochaeta community in river Tisza.

Both qualitative and quantitative changes in the fish community inhabiting the Yugoslavian portion of the Tisza are even greater when compared with the period 1974-1983. The average annual catch was app. 120,000 kg twenty years ago with significant mass percentages of *S. glanis* (27.49), *E. lucius* (13.42), *A. ruthenus* (10.28), and *Stizostedion lucioperca* (6.27). At the same time percentage of *C. auratus gibelio* amounted only app. 7% (Budakov *et al.* 1985, Table 4). In the past twenty years significant changes in sex structure, namely a constant increase in male percentage, was recorded in the population of Prussian carp.

Table 4. Structure of total catch in lower Tisza river (in %)

Period	<i>A. ruthenus</i>	<i>S. glanis</i>	<i>S. lucioperca</i>	<i>C. carpoi</i>	<i>E. lucius</i>	<i>C. auratus</i>	Other	Total
74-80	10.28	27.49	6.27	18.50	13.42	7.39	16.65	100
81-83	4.20	10.60	7.00	7.53	5.13	22.70	42.94	100
84-88	4.00	6.12	3.84	10.63	4.28	40.71	30.42	100
90-94	3.68	2.88	3.64	8.15	1.39	50.61	29.65	100

The majority of other introduced species showed a slow (*Ctenopharyngodon idella*, *Hypophthalmichthys molitrix* and *H. nobilis*), or a more rapid increase in their numbers (*Pseudorasbora parva*) during the investigated period. An exception was *Ictalurus nebulosus* characterized by locally dependent stagnation or slow decrease in population numbers.

From the biological and ecological aspects, such a distinct degradation of zooplankton structure, Oligochaeta community, and ichthyofauna, of the lower Tisza river is obviously due to an intensive influence of a complex of anthropogenic factors slowing streams and contributing to the water pollution. A culmination of the negative effect of the total spectrum of the abiotic and biotic factors upon the investigated zoocenoses is recorded during summer (most frequently in August) when fish kill was regularly recorded in the past four years.

## References

- Budakov, Lj., Maletin, S. and Kostić, D. (1985): Der Einfluss der Stauanlage auf die Fischfauna im unteren Theisslauf. — 25. Arbeitstagung der IAD, Bratislava, 371-375.
- Djukić, N. and Stanojević, M. (1981): Der Einfluss der physikalisch-chemischen Eigenschaften auf die Oligochaetenfauna der Flüsse Theiss, Stari Begej und Plovní Begej. — 22. Arbeitstagung der IAD, Basel, 161-164.
- Djukić, N. and Kilibarda, P. (1985): Oligochaeta-Fauna in unteren Theisslauf in der periode 1974-1984. — 25. Arbeitstagung der IAD, Bratislava, 287-290.
- Djukić, N., Maletin, S. and Miljanović, B. (1993): Oligochaeta composition as indicator of eutrophication in lower stream of river Tisza. — *Tiscia* 27, 49-52.
- Djukić, N., Maletin, S., Pujin, V., Kojčić, K. and Miljanović, B. (1994): Ecological assessment of water quality of the Tisza by physico-chemical and biological parameters. — *Tiscia* 28, 37-40.
- Felföldy, L. (1980): *Vizügyi Hidrobiológia*. 18 Kötet, Hírnár határozó. — Körny. és ter. fejlesztési Minisztérium, Budapest.
- Gulyás, P. (1994): Veränderungen des Rotatoria und Crustacea Planktons an der Donaustrecke zwischen Rajka und Komárom infolge der in der Slowakei stattgefundenen Umleitung des Stromes. — *Limnologische Berichte Donau* 1994, 1, 49-52.
- Kojčić, K., Stanojević, M., Pujin, V., Djukić, N., Maletin, S., Bugarski, R., Berković, M. and Kilibarda, P. (1988): Uticaj hidroloških uslova na neke fizičko-hemijske i saprobiološke karakteristike reke Tise (Impact of some hydrological conditions on some physico-chemical and saprobiological characteristics of river Tisza). — "Zaštita voda '88", Dojran, 314-326.
- Kojčić, K., Pujin, V. and Bugarski, R. (1989): Changes of some physico-chemical and saprobic characteristics in the lower course of the Theiss in the period 1980-1986. — *Tiscia* 23, 21-28.
- Maletin, S., Djukić, N. and Kostić, D. (1990): Analyse der Fischbestände in der Donau und in der Theiss in der Vojvodina und ihr gegenseitiger Einfluss. — *Limnol. Berichte der 28. tagung der IAD, Varna*, 323-330.
- Pujin, V. (1987): Zooplankton-Zoobenthoszusammensetzung und Dynamik in Donaueinzugsgebiet unter dem Einfluss von Stauanlagen. — 25. Arbeitstagung der IAD, 124-137.
- Pujin, V. (1989): Developments in the composition of biocenosis in the lower Tisza river (Yugoslavia) caused hydrological changes. — *Tiscia* 23, 43-49.
- Pujin, V. (1990): Changes in the composition of the Danube river basin biocenosis resulting from anthropogenic influences. — *Wat. Sci. Techn.* 22, 13-30.
- Pujin, V. (1992): Comparative data on the composition of Zooplankton in the part of the river Danube and the Tisza river in Vojvodina (Yugoslavia). — *Tiscia* 26, 49-57.
- Pujin, V. and Rajković, D. (1979): Die Rotatoria im unteren Lauf der Theiss. — 21. Arbeitstagung der IAD, Novi Sad, 321-327.
- Pujin, V., Kojčić, K. and Bugarski, R. (1990): Vergleich einiger hydrobiologischer und chemischer Wassereigenschaften der jugoslawischen Donau- und Theissabschnitte. — *Limnologische Berichte*, 28. Arbeitstagung der IAD, Varna, 256-259.
- Ratajac, R. (1979): Populationsdynamik einiger Copepoda-Arten in der Theiss in der SAP Vojvodina. — 21. Arbeitstagung der IAD, Novi Sad, 329-336.
- Standard Methods for the Examination of Water and Wastewater. 16th Edition (1985). Washington DC.

## SEASONAL DYNAMICS OF *TRIOPS CANCRIFORMIS* (BOSC, 1801) (CRUSTACEA, BRANCHIOPODA) IN THE BANAT PROVINCE IN YUGOSLAVIA

B. Petrov and D. M. Cvetković

*Petrov, B. and Cvetković, D. M. (1996): Seasonal dynamics of Triops cancriformis (Bosc, 1801) (Crustacea, Branchiopoda) in the Banat province in Yugoslavia. — Tiscia 30, 39-43.*

**Abstract.** At the territory of Banat province, in the southern part of the Pannonian Plain, about 100 kilometers north of Belgrade, the appearance and seasonal dynamics of a bisexual population of *Triops cancriformis* over the period 1991-1995 was observed.

A population of *T. cancriformis* appears regularly, i. e. every year when ephemeral ponds are formed. Hatching takes place between the beginning of March and the beginning of April when average temperature varies between 7 and 10 °C. Sexual maturity is reached after one month. A life span of two months is registered.

During one year, several generations may appear at one month intervals, i. e. when sexual maturity of a previous one is reached. Up to three generations may be present simultaneously. Males are present during the whole season. They make 15-40 % of the population.

*Key words:* Crustacea, Branchiopoda, bisexual population of *Triops cancriformis*, ephemeral ponds

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### Introduction

Marinček (1961) registered, for the first time in Yugoslavia, presence of *Triops cancriformis* (Bosc 1801) near the village Ečka close to Zrenjanin (Banat province). Later, this species was discovered in many other localities in the Pannonian Plain and in the easternmost part of the limnological area of the Dinaric West Balkan (according to Illies 1978). In the material collected only females were present (Marinček and Petrov 1994).

During our investigations of Branchiopod fauna in 1991, at the territory of Banat province, about 100 kilometers north of Belgrade, in the vicinity of the village Melenci, a rich fauna of these shrimps and among them a species *Triops cancriformis*, was discovered. Males of *Triops cancriformis* were found for the first time in Yugoslavia (Petrov and Cvetković 1995). Since it has been the only finding of a bisexual population in Yugoslavia up till now, the appearance and seasonal dynamics of this species during the period 1991 - 1995 was observed.

### Material and methods

Material was collected from ephemeral ponds on a pasture ground. In late winter, ponds were formed by snow melting while later on they were drained or refilled by rain falls.

The area was observed at two week intervals from the beginning of February up to the beginning of August. Depending on the rain fall, the number and size of ponds varied considerably. The number of ponds was between 3 and 46, but after heavy rains almost all the area was covered with water and ponds were fused (sometimes completely). The volume of ponds varied between 88 and 0.03 m<sup>3</sup> (most frequently less than 5 m<sup>3</sup>) and their depth did not exceed 50 cm, most frequently being 5 - 20 cm.

The presence of a species was established by intensive sampling. Samples were taken with a hand net mesh size 1 mm. Because of the small size of ponds and the restricted number of individuals in them, only a few specimens of different size were always taken from each pond and fixed in 70% ethyl-

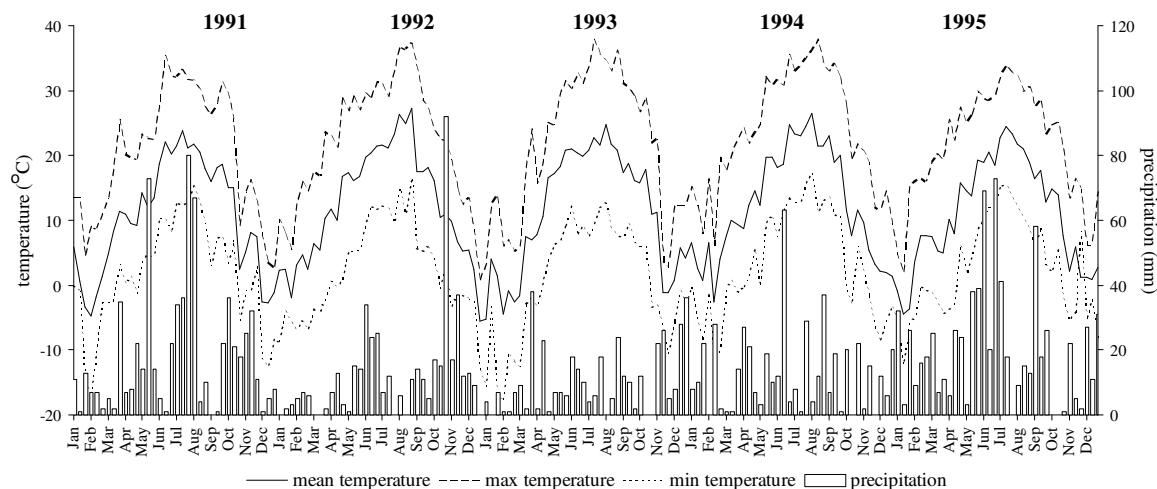


Fig. 1. Annual fluctuation of temperature and rain fall in 1991 - 1995 (mean, maximum and minimum temperatures, and precipitation amount for decades are shown)

alcohol. Carapace length was measured in order to establish the size of an animal .

Official records of temperature and rain fall for this period were used.

## Results

In 1991, from the beginning of the year until the end of March the amount of rain fall was very small (Fig. 1). The last 10 days of March were characterized by considerable increase of precipitation. This caused a formation of numerous ephemeral ponds and a hatching of *Triops cancriformis* at the beginning of April. At this time the average temperature for the decade was 10.9 °C and the minimum temperature 0.1 °C. Only young individuals were collected on April 13th (Fig. 2), and from May 12th, sexually differentiated specimens were found. Up to the beginning of June a high amount of precipitation was maintained. A rapid decrease of rain fall in June, followed by increase of temperature (maximum temperature up to 35.5 °C) caused drying of ponds to the middle of June, and consequently a disappearance of *Triops*. Average temperature for the decade was 22.1 °C and the maximum was 32.4 °C. During its whole life span *Triops* grew rapidly; maximum length of carapace attained was 3.2 cm.

Since the climatic conditions were favourable the second generation appeared in May and the third one in June. In the second generation the growth was faster than in the first one. Individuals of the third generation did not reach sexual maturity because soon after their appearance ponds were dried up.

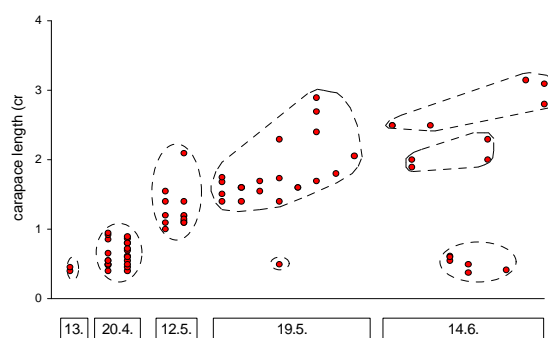


Fig. 2. Carapace length of *Triops cancriformis* of different age in 1991. (Specimens of individual generations grouped together. Individuals from different ponds are in separate columns)

In 1991, males appeared simultaneously with females. They were present during the whole season and their proportion was 16-40 % of the population.

From the end of June to the beginning of August the amount of precipitation was very high again, but the ponds were not formed because of high temperature (average above 21 °C, and the maximum up to 29.7 °C) and extremely desiccated soil.

The whole 1992 was very dry and warm so that the ephemeral ponds were not formed, and *T. cancriformis* could not develop.

The year 1993 was similar, but with somewhat more rain fall at the end of March and in the mid-April. During that period ephemeral ponds were formed. Their number and distribution was similar to those in 1991, but because of higher temperature and considerably lower precipitation from the end of April, these ponds lasted only for one month. *T. can-*

*criformis* appeared by the mid-April, but it could not reach a sexual maturity. At the time of hatching, average and minimum temperatures were similar to those in 1991 (10.7 °C and 0.6 °C respectively), while at the time of disappearance of *T. cancriformis* average temperature was only 17.2 °C and maximum was 24.7 °C.

The year 1994 was characterized by higher amount of rain fall and also with higher temperature in January and February compared to previous years. This caused an early formation of ponds but to much less extent than in previous years, and earlier appearance of *T. cancriformis*. Hatching took place in the second half of March when average temperature was about 10 °C and a minimum one 0.7 °C. The development was faster because of a higher temperature in the period after hatching; adult specimens were present as early as the middle of April. It is interesting that in the period of maturation the temperature dropped twice beneath zero (-1.2 and -0.4 °C). As the amount of precipitation was very low from the end of February, and the temperature increased rapidly, the ponds were dried out by the middle of May when the population of *Triops* disappeared. At this time average and maximum temperatures were 19.8 °C and 32.2 °C respectively.

In 1995 climatic conditions were especially favourable; extremely high amount of precipitation and its timing, together with favourable temperature, caused a formation of ponds and their drying for several times, what made the appearance of several generations of *T. cancriformis* possible.

High amount of precipitation in January caused an early formation of ponds (at the beginning of February) in a much higher number than in previous years, but hatching did not take place until the beginning of March. At the time of hatching average temperature was 7.5 °C and the minimum -1 °C. Young individuals were collected for the first time on March 17th (Fig. 3). As in the previous year, temperature dropped several times below zero (up to -2.9 °C) over the period from hatching to sexual maturity.

Because of a considerably low precipitation at the end of March and the beginning of April, and an increase of temperature most ponds were dried out. In a few that remained, sexually differentiated specimens were found at April 15th. During the period of sexual maturation a relatively slow growth was observed. Having attained sexual maturity, the growth became considerably faster so that in mid-May, when the last individual of this generation was found, carapace reached 3.2 cm in length.

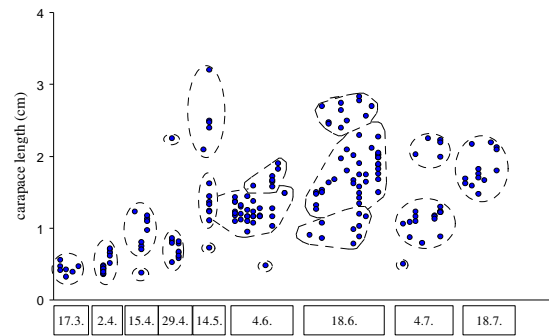


Fig. 3. Carapace length of *Triops cancriformis* of different age in 1995. (Specimens of individual generations grouped together. Individuals from different ponds are in separate columns)

In the middle of April the increase of rain fall caused a new formation of ponds, but to a much less amount than earlier. Most of newly formed ponds lasted for only a month when they went dry again.

At the time when ponds refilled, a second generation of *T. cancriformis* appeared. This generation reached sexual maturity by mid-May, and disappeared by mid-June. A growth of the specimens was, in contrast to the first generation, uniform during the whole life time, but a maximum size they reached was smaller (carapace length about 2.8 cm).

About in the middle of May a third generation appeared. This generation reached sexual maturity somewhat earlier (at the beginning of June) and disappeared by the beginning of July. The growth of this generation was uniform, like the previous one, and with a similar rate, but a maximum body size attained was smaller (carapace length about 2.3 cm).

From the end of May to the middle of July unusually high amount of precipitation caused a formation of numerous ponds for the third time during that year. The number of ponds and their distribution was at the beginning similar to that after second formation of ponds, but in mid-July almost all the area investigated was covered with water. The ponds lasted by the beginning of August.

At about the time when ponds refilled for third time, a new, fourth generation of *T. cancriformis* appeared. This generation reached sexual maturity by the middle of June and was present in the ponds until they dried out at the end of July. The growth of this generation, like two previous ones, was uniform. Maximum carapace size attained was about 2.2 cm.

Finally, at the beginning of July a fifth generation appeared; it lasted until the drying of ponds. At the time when a population of *T. cancriformis* finally disappeared the average temperature was about 23.3 °C and a maximum temperature attained 32.7 °C.

In September the amount of precipitation was high again, but the ponds were not formed because of high temperature (average temperature was 16.4 °C, maximum one 27.5 °C) and extremely desiccated soil.

As in 1991, season males were present during the whole; they appeared in each generation and made 15-38 % of the population. By the beginning of June they were considerably less frequent than later on (Fig. 4).

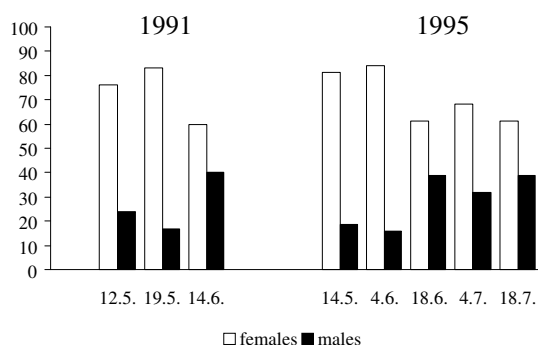


Fig. 4. Fluctuation of sex ratio in the population during the season

It is interesting to mention that *Triops cancriformis* was never present in all the ponds formed, although they were very close to each other, sometimes less than 1 m apart. *Triops cancriformis* was found in 8 - 39% of ponds (an example is given in Fig. 5). When ponds were fused it was restricted to certain areas.

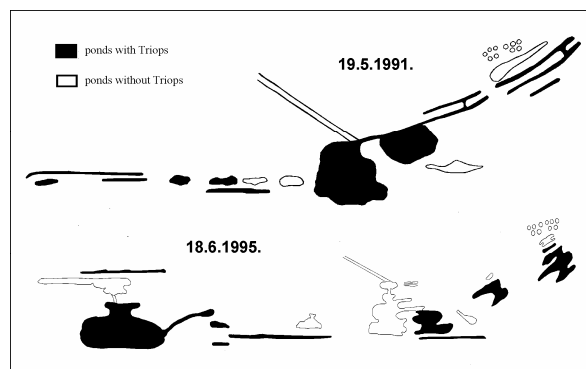


Fig. 5. Spatial distribution of *Triops cancriformis*

## Discussion

Due to a periodical fusion of individual ponds in the area studied, and high possibility of transferring eggs from one pond to another, it may be assumed that the individuals of *Triops cancriformis* inhabiting different ephemeral ponds make a single population.

A population of *Triops cancriformis* appears with large individual numbers and regularly, i. e. every year when ephemeral ponds are formed. This is opposite to Hempel-Zawitkowska's (1967) observation in Poland where this species seldom occurs in small water bodies, and with a small abundance. Although regularly present, *T. cancriformis* is never found in all the ponds formed. At the beginning of the season (in early spring) its distribution is sporadic. Later on it is present in more and more ponds, but never in all of them.

Hatching takes place between the beginning of March and the beginning of April when the average air temperature varies from 7 to 10 °C, and a minimum one is usually between 4 and 6 °C, but sometimes also about zero. Since the investigated ponds are very shallow, there is a little difference in temperature between the water and the air. This means that temperatures at which hatching takes place in our population are much below the level of temperature (12-25 °C) established by Gaschott (1928) and Hempel-Zawitkowska (1967) at which eggs of *T. cancriformis* may hatch. Furthermore, after hatching, larvae and young individuals can endure even lower temperatures (up to -2.9 °C). This is in accordance with Gaschott (1928) who states that *T. cancriformis* can tolerate temperatures between 0 and 41 °C.

Eggs of the population investigated may hatch with or without previous drying. In the later case hatching usually follows after heavy rain fall. This causes a change of osmotic pressure what is probably a stimulus for hatching. The time of the appearance of *T. cancriformis* and its distribution in individual ponds during the season confirms the existence of all three types of eggs that Hempel-Zawitkowska (1967) has established in the parthenogenetic population of this species, i. e. eggs which may hatch in the same year without drying, eggs which will hatch next year after drying and eggs which hatch only after several times of repeated drying and irrigation.

Sexual maturity is reached after one month. The first sexually differentiated individuals may be found between the middle of April and the beginning of May. Individuals of our population need much more time to attain sexual maturity than those from a parthenogenetic population from Poland (about 12 days; Hempel-Zawitkowska 1967) or France (10 days; Nourisson and Aguesse 1962).

An individual life span of about 2 months and a 5 months life span of a population is established during our investigations. From the literature it may be concluded that the life span of a population of *T. cancriformis* varies considerably, e. g. it is 12-29 days (Hempel-Zawitkowska 1967) or about 3.5 months (Grasser 1933) or 4 months (Čuvachin 1929).

Ramult (1938) found that the population always died shortly after attaining maximal development, and Hempel-Zawitkowska (1967) stated that most of the populations observed died suddenly before the drainage of the pond. During our investigations we have not noticed such cases; on the contrary, our population was present in the pond up to their desiccation.

Hempel-Zawitkowska (1967) investigated the effects of temperature and drying on the hatching of larvae of *T. cancriformis* and found that eggs may hatch without previous drying, but she did not found the second generation in the same season. She supposed that some unknown factors exist which cause an inhibition of egg development, or that metanauplii are eaten by adult individuals. We have found that several generations (up to 5) may appear during one year. New generations appear at one month intervals; this is a time when sexual maturity of previous generation is reached. Since up to three generations may be present in the same pond at a time, it is obvious that the parental generation does not affect the new one.

The growth rate of succeeding generations is faster and more uniform than that of the first one, and sexual maturity is reached earlier (after 25 and 20 days) probably because of more favourable conditions (higher temperatures in the first place). A time necessary for reaching sexual maturity in the youngest generation is closer to that in the parthenogenetic populations from Poland and France. A maximum size of individuals attained is smaller in every succeeding generation, and a life span is somewhat shorter.

The investigated area was inhabited with bisexual population of *T. cancriformis*. The presence of males was established whenever ponds were maintained long enough to reach sexual maturity. Males appeared simultaneously with females; they were present in the population during the whole period and in all generations. Males made 15-40 % of the population. At the beginning of the season (up to the end of May) they were less frequent, while later on they were twice as abundant. An increase of temperature could be the reason of this, since it is known that within the species of *T. cancriformis* bisexuality is normal in the southern part of its range, while in more northerly regions males become less frequent and they are totally absent in the extreme north of the range (Longhurst 1955, Hempel-Zawitkowska 1967). The frequency of males varied considerably in individual ponds at the same time probably due to local conditions. On July 6th in one pond, as many as 77 % of males were present.

## Conclusions

On the basis of our five years investigations it may be concluded that a bisexual population of *Triops cancriformis* appears regularly with large individual numbers in the vicinity of the village Melence, in the Banat province. This species is never present in all the ponds formed.

Hatching takes place when the average temperature reaches 7-10 °C, and the minimum one 4-6°C. Larvae and young individuals can endure even lower temperatures. Eggs may hatch with or without previous drying. Three types of eggs are produced.

Sexual maturity is reached after one month. Individual life span is about 2 months, and life span of a population is 5 months.

If the climatic conditions are favourable during one year, several generations may appear. Up to three generations may be present at a time. The growth rate of succeeding generations is faster, but a maximum size of individuals and a life span is shorter in every succeeding generation.

Males appear regularly and in all generations. The frequency of males increases during the season.

## Acknowledgements

This research was supported by the National Scientific Research Found of Serbia (grant number 03E34).

## References

- Čuvachin, V. (1929): Zur Biologie des *Apus cancriformis* Schaeff. — Bull. Stat. Biol. Bolchevo 3, 74-102.
- Gaschott, O. (1928): Beobachtung und Versuche an *Triops cancriformis* (Bosc). — Zool. Anz. 75, 267-280.
- Grasser, J. (1933): Die exkretorischen Organe von *Triops (Apus) cancriformis* Bosc. — Zeitschr. Wiss. Zool. 144, 317-362.
- Hempel-Zawitkowska, J. (1967): Natural history of *Triops cancriformis* (Bosc). — Zoologica Poloniae 17, 173-239.
- Illies, J. (1978): Limnofauna Europea, 2. Auflage. — Gustav Fisher Verlag, 532 pp.
- Longhurst, A. (1955): A review of Notostraca. — Bull. Brit. Mus. Nat. Hist. Zool. 3, 1-57.
- Marinček, M. (1961): Some Euphyllopods (Euphyllopoda) of the Pannonian Plain. — Zbornik za prirodne nauke Matice srpske 20, 160-163.
- Marinček, M. and Petrov, B. (1994): Zoogeographic investigation of Anostraca, Notostraca and Conchostraca (Crustacea) in Serbia. — Bios 2, 137-142.
- Nourisson, M. and Aguesse, P. (1962): Cycle annuel des Phyllopes d'une mare temporaire de Camargue. — Bull. Soc. Zool. France 86, 6, 754-762.
- Petrov, B. and Cvetković D. (1995): A first record of males of *Triops cancriformis* (Bosc, 1801) (Crustacea, Branchiopoda) from Yugoslavia. — Arch. Biol. Sci. 47, 3-4 (in press).
- Ramult, M. (1938): Observations on the appearance of Euphyllopods in the vicinity of Krakow. — Spr. Kom. Fizjogr. PAU 73, 261-274.

## SEASONAL DYNAMICS, PARASITIZATION AND COLOUR POLYMORPHISM OF THE PEA APHID, *ACYRTHOSIPHON PISUM* (HARRIS) (APHIDIDAE, HOMOPTERA) ON ALFALFA IN THE SOUTH PART OF THE PANNONIAN AREA

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*Tomanović, Ž., Brajković, M., Krunić, M. and Stanisavljević, Lj. (1996): Seasonal dynamics, parasitization and colour polymorphism of the pea aphid, Acyrthosiphon pisum (Harris) (Aphididae, Homoptera) on alfalfa in the south part of the Pannonian area. — Tiscia 30, 45-48.*

**Abstract.** Over the period 1992 to 1994, individuals of the pea aphid, *Acyrthosiphon pisum* were collected in the localities Kovilovo and Surčin near Belgrade, in order to analyze its seasonal dynamics, colour polymorphism and parasitization. Samples of pea aphid were collected by sweeping inside the field, and every sample contained ten subsamples.

Aphid parasites were obtained by rearing aphids. We found that parasite spectrum of the pea aphid in Yugoslavia includes four species: *Aphidius ervi*, *A. eadyi*, *A. picipes* and *Praon barbatum*. Dominant species was *A. ervi*.

We have also observed the influence of parasitization on the seasonal dynamics of the pea aphid. The greater the autumn parasitization of the pea aphid population, the greater the number of emerged parasites next spring which also means the greater the parasitization of the pea aphid population. If the autumn parasitization is low, the next spring parasitization of the population is also low.

Colour polymorphism is an important self-regulating mechanism of pea aphid population. We found that neither of the four parasite species showed preference to any colour form of pea aphids.

*Key words:* pea aphid, parasitoid, population density, colour forms.

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### Introduction

The first faunistic investigations of aphids on alfalfa were carried out by Tanasijević (1966) in Pannonian area of Federal Republic of Yugoslavia. He pointed out that during a vegetation period three aphid species lived on alfalfa: *Acyrthosiphon pisum* (Har.), *Therioaphis trifolii* (Mon.) and *Aphis craccivora* Koch. It was also found that *A. pisum* was more abundant than the two other species, and appeared on alfalfa during the whole vegetation period.

Among the most significant natural enemies of the pea aphid are their primary parasites belonging to the family Aphidiidae (Hymenoptera) (Starý 1962, 1972, 1974a, b, Starý *et al.* 1980, Hozak 1968, Jia-Hua Chen *et al.* 1990).

Green, red and yellow forms of the pea aphid are known. In North America only green form has been recorded (Harper *et al.* 1978), while in Europe in addition to the most abundant green form, there are also red and somewhat less frequent yellow ones. Individuals of the green form have the highest reproductive capacity. Relationships between these forms are various depending on many factors (Honek 1982).

The main goal of this paper was to observe the seasonal dynamics of the pea aphid and to estimate the influence of primary parasites on it.

### Material and methods

Samples for analysis of seasonal dynamics were taken in the period 1992 to 1994, in the localities



Kovilovo and Surčin near Belgrade on a 50 ha of alfalfa fields. Samples were taken during the whole alfalfa season in 1992 and 1993 in the Kovilovo site, but in the whole season in 1993 and spring in 1994 in the Surčin site.

Sweep net of 30 cm in diameter was used for collecting samples. Sweepings were carried out inside the field, 100 m far from the field margin to avoid edge effect. Each sample consisted of ten subsamples (two rows of 5) 20 m apart. Each subsample consisted of ten strokes of the net (Hozak 1968, Starý 1970, Maiteki *et al.* 1986). Pea aphids were put into plastic bottles closed by gauze and were counted immediately in the field.

Primary parasites were obtained by rearing the collected pea aphids from which parasites emerged after a week or two. The percentage of population parasitization was given by the rate of mummified aphids (emerged and non-emerged) to the total number of aphids. We used Starý's (1974a, b) and Tobias's (1986) keys to determine the primary parasites.

In the Kovilovo site in 1992, coloured forms were separated immediately in the field and were reared in plastic bottles to obtain parasites and determine their preference for colour forms. Statistical test of colour preference was performed with *t*-test. *t*-values were calculated with the following formula:

$$t = \frac{x_1 - x_2}{Sx_1 - Sx_2}$$

where  $x_1$  and  $x_2$  are the mean values of primary parasites preferring red and green forms, respectively, and  $Sx_1 - Sx_2$  is the standard error of difference of arithmetical means in basic set. Degree of freedom was 12, and the critical values of *t*-test are  $t_{0.05}=2.179$  and  $t_{0.01}=3.055$ .

## Results and discussion

### Parasite spectrum and relative number of parasites

In 1992 in the studied localities, 374 parasites were obtained by rearing the pea aphid. The most frequent species was *Aphidius ervi* Hal. (62.8%), somewhat less frequent was *Praon barbatum* Mack. (26.6%), while *Aphidius eadyi* Starý and *A. picipes* Nees were relatively rare in the parasite spectrum of the pea aphid (8.3% and 2.7%, respectively; Table 1). In 1993, 94 parasites were obtained by rearing, 47.9% of which belonged to *A. ervi*, 33.0% to *A. eadyi*, 14.9% to *P. barbatum* and 4.2% to *A. picipes*. In 1994, the 78 reared parasites consisted of 87.2% *Aphidius ervi*, 9.0% *A. eadyi* and 3.8% *Praon barba-*

*tum*. *A. picipes* was not observed in the first months of that year.

*Aphidius ervi* was the most frequent in the parasite spectrum of the pea aphid (Table 1) which may mean that it is the best adapted species in the localities investigated.

Table 1. Number of the pea aphid parasitoids in the years studied.

	<i>A. ervi</i>		<i>A. eadyi</i>		<i>A. picipes</i>		<i>P. barbatum</i>	
	%	Σ	%	Σ	%	Σ	%	Σ
1992	62.8	235	8.3	31	2.7	10	26.2	98
1993	47.9	45	33.0	31	4.2	4	14.9	14
1994	87.2	68	9.0	7	0	0	3.8	3

### Seasonal dynamics and parasitization of the pea aphid

The first aphids (fundatrices) were collected on 19th April at Kovilovo site in 1992 which means that they emerged at the end of March or at the beginning of April. There were several maximum values of population abundance in that year (Fig. 1). At the beginning of May the population density of the pea aphid rose gradually, but that trend was temporarily stopped by harvesting of alfalfa. By the end of June the population reached its maximum size (2003 individuals per 200 sweepings), whereas under the influence of sweeping and climatic factors (temperature, humidity) it later temporarily fell. In late July the abundance of the population rose up to 1368 individuals per 200 sweepings. In August the population abundance fell again to several tens of individuals, and in September it rose to 461.

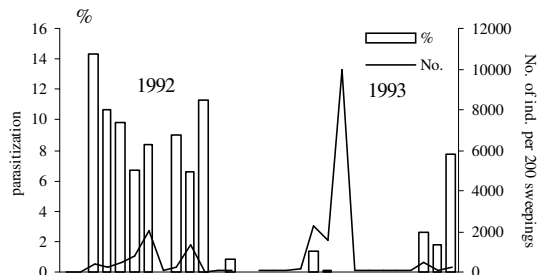


Fig. 1. Seasonal dynamics and rate of parasitization of the pea aphid at the Kovilovo site. Sampling dates in 1992: 19-Apr, 23-Apr, 10-May, 31-May, 08-Jun, 14-Jun, 21-Jun, 09-Jul, 15-Jul, 26-Jul, 16-Aug, 22-Aug, 13-Sep; those in 1993: 13-Apr, 19-Apr, 25-Apr, 02-May, 10-May, 28-May, 05-Jun, 03-Jul, 15-Jul, 13-Aug, 04-Sep, 14-Sep, 24-Sep, 14-Oct, 28-Oct

The first aphid parasites were gathered by sweeping on 19th April, while the parasitization of the aphid population was recorded at the beginning of May (14.3%; Fig. 1). Later in the season, the parasitization rate decreased gradually, since the parasite population could not follow the population

growth of pea aphid due to their lower reproductive capacity. This spring parasitization (14.3% in early May), however, is very significant, as it did not allow the rapid increase of the pea aphid population at the Kovilovo site in 1992. At the end of the season at the same site, the percentage of parasitization was very low, 0.8% on 13th September. Such a low autumn parasitization of the pea aphid population meant that only a small number of parasites would appear in the following spring, so that next spring (in 1993) the parasitization was hardly recorded (Fig. 1). That was one of the most important reasons for very quick growth of the pea aphid population next spring. On 5th June, 1993 over 10,000 individuals were recorded. At the end of the season a slight increase of parasitization was observed, the maximum parasitization rate was recorded on 28th October (7.7%). Similar situation was observed at the Surčin site in 1993 (Fig. 2). Spring parasitization was extremely low while the pea aphid population grew rapidly reaching the number of 6549 individuals in mid-May. It was only the end of the season when the parasitization increased gradually reaching its maximum value on 30th October (5.1%). The autumn increase in 1993, which was a few times larger than in the autumn 1992, implied that the parasitization would play more significant role in spring 1994 than did in spring 1993. In 1994 at the Surčin site the parasitization was recorded as early as the end of April (9.7%; Fig. 2), while the maximum number of pea aphids (612) was recorded on 23th May.

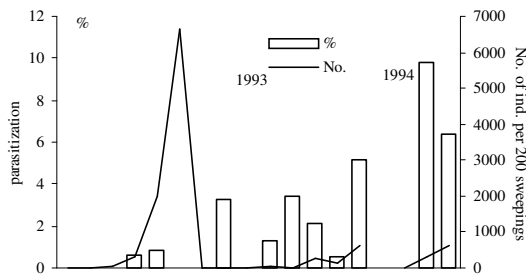


Fig.2. Seasonal dynamics and rate of parasitization of the pea aphid at the Surčin site. Sampling dates in 1993: 15-Apr, 20-Apr, 26-Apr, 03-May, 11-May, 17-May, 12-Jun, 19-Jun, 16-Jul, 28-Jul, 07-Sep, 23-Sep, 10-Oct, 30-Oct; those in 1994: 15-Apr, 28-Apr, 23-May.

Hence, parasitization as a population regulating factor is the most important in spring when the abundance of pea aphid is relatively low and the parasite activity is the most effective, since the number of aphids is reduced at the very beginning and hinders their growth later. The spring parasitization of the pea aphid population depends on its autumn

parasitization in the previous year. The greater the autumn parasitization, the greater the number of emerged pea aphid parasites in spring which also means the greater the number of parasitized pea aphids.

#### Seasonal dynamics of colour forms

At the Kovilovo site in the middle of April, 1992, the first collected samples of pea aphid were green and they belonged to fundatrix generation (Fig. 3). Red forms were first recorded at the beginning of May reaching the rate of 46%. In 1992 when the population density was relatively low, the percentage of red form was relatively high during that year ( $47.3 \pm 8.4\%$ ). Next year the population size was relatively high, and the number of red forms gradually rose during the year. Similarly at the Surčin site in 1993, at large population size of pea aphids the percentage of red forms was relatively low (Fig. 4).

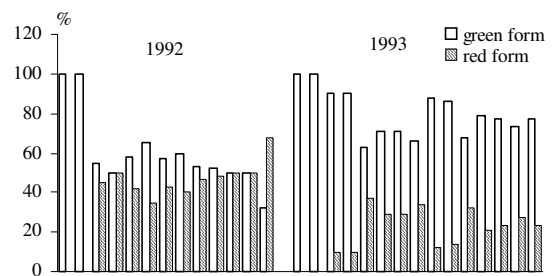


Fig. 3. Seasonal dynamics of colour forms of the pea aphid at the Kovilovo site. Sampling dates are the same as on Fig. 1.

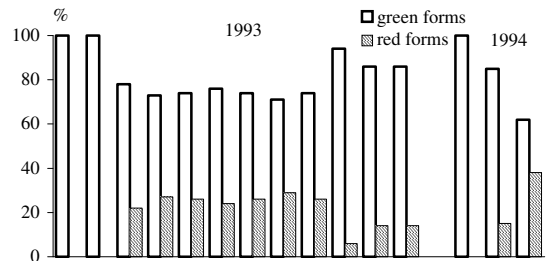


Fig. 4. Seasonal dynamics of colour forms of the pea aphid at the Surčin site. Sampling dates are the same as on Fig. 2.

In our opinion, colour polymorphism is an important self-regulatory mechanism of pea aphid population as population maintains its size near optimal level favouring red forms which have lower fecundity than the green forms. But in years when the number of pea aphids is relatively high (1993) the percentage of red forms should be relatively low.

### Parasitization of colour forms

One of the factors that may influence the relationship between colour forms of pea aphids is the parasitization. The green form is generally more parasitized (Table 2) which is understandable as it is more frequent than the red form. Using *t*-test, we pointed out that there was no preference of *A. ervi* ( $t=0.537$ ), *A. picipes* ( $t=0.787$ ), *A. eadyi* ( $t=0.194$ ) and *P. barbatum* ( $t=0.444$ ) to any colour forms.

Table 2. Preference of pea aphid parasitoids to different colour forms in the Kovilovo site (1992).

date	<i>A. ervi</i>		<i>A. eadyi</i>		<i>A. picipes</i>		<i>P. barbatum</i>	
	green	red	green	red	green	red	green	red
10.5.	15	19	-	1	-	1	7	5
31.5.	10	10	-	-	-	-	3	1
8.6.	7	5	2	-	3	-	4	5
14.6.	6	6	1	2	-	-	9	8
21.6.	61	31	4	3	2	2	4	6
15.7.	3	1	-	-	-	-	3	4
26.7.	18	16	-	-	1	-	17	11

### References

Harper, A. M., Miska, J. P., Manglitz, G. R., Irwin, B. J. and Armbrust, E. J. (1978): The literature of Arthropods associated with alfalfa. III A bibliography of the pea aphid, *A. pisum* (Harris) (Homoptera: Aphididae). — Special publication 50, Agricultural Experiment Station, College of Agriculture, University of Illinois at Urbana, Champaign, 89 pp.

Honek, A. (1982): Colour polymorphism in *Acyrtosiphon pisum* in Bohemia (Homoptera, Aphididae). — Acta Ent. Bohemoslov. 79, 406-411.

Hozak, A. (1968): The pea aphid, *Acyrtosiphon pisum* (Harris) and its parasites on alfalfa in Czechoslovakia. — Acta Univ. Carolinae, Biologica 1968, 371-415.

Jia-Hua Chen, D., Gonzalez, E.E. and Luhman, J. (1990): A new species of *Aphidius* (Hymenoptera) attacking the pea aphid, *Acyrtosiphon pisum*. — Entomophaga 35, 509-514.

Maiteki, G. A., Lamb, R. J. and Ali-Khan, S. T. (1986): Seasonal abundance of the pea aphid, *Acyrtosiphon pisum* (Homoptera: Aphididae), in Manitoba field peas. — Can. Ent. 118, 601-607.

Starý, P. (1962): Hymenopterous parasites of the pea aphid, *Acyrtosiphon onobrychis* (Boyere) in Czechoslovakia. — Folia Zool. Brno 11, 265-278.

Starý, P. (1970): Biology of aphid parasites (Hymenoptera, Aphidiidae) with respect to integrated control. — Junk, The Hague, Series entomologica 6, 643 pp.

Starý, P. (1972): Relative abundance of parasite species as an area-dependent phenomenon and its possible significance in biological control (Hymenoptera, Aphidiidae). — Boll. Lab. Ent. Agr. Portici 30, 19-27.

Starý, P. (1974a): Taxonomy, origin, distribution and host-range of *Aphidius* species (Hymenoptera, Aphidiidae) in relation to biological control of the pea aphid in Europe and North America. — Z. Angew. Ent. 77, 141-171.

Starý, P. (1974b): Population dynamics, parasitization, control and prognosis of the pea aphid (*Acyrtosiphon pisum* Harris) in Czechoslovakia. — Trans. Czechoslov. Acad. Sci., Ser. Math. Nat. Sci. 84, 123 pp.

Starý, P., Gonzalez, D. and Hall, J. C. (1980): *Aphidius eadyi* n. sp. (Hymenoptera, Aphidiidae), a widely distributed parasitoid of the pea aphid, *Acyrtosiphon pisum* (Harris) in the Palearctic. — Ent. Scand. 11, 473-480.

Tanasijevic, N. (1966): Prilog poznavanja vasiju na biljkama porodice leptirnjaca (Papilionaceae). — Agrohem. Beo. 1, 89-12.

Tobias, V. I. (1986): Sem. Aphidiidae — Aphidiidi v G. S. Medvedev, opredelitel nasekomih evropejskoj casti SSSR. — Prepcantokrilie 3, 232-283.

## SPECIES COMPOSITION OF JUVENILE (0+) FISH ASSEMBLAGES IN THE SZIGETKÖZ FLOODPLAIN OF THE DANUBE

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*Guti, G. (1996): Species composition of juvenile (0+) fish assemblages in the Szigetköz floodplain of the Danube. — Tiscia 30, 49-54.*

**Abstract.** Samples of juvenile fishes were collected with a point abundance sampling strategy using electroshocker at 27 sites in the Szigetköz floodplain in late summer 1992. Species composition of assemblages was examined and related with the habitat types (parapotamon, plesiopotamon) by principal component analysis. From the 27 species recorded the juveniles of 21 species were found. The distribution of juvenile fishes was correlated with the general flowing conditions of the backwaters and their actual connectivity with the main channel.

*Keywords:* parapotamon, plesiopotamon, backwater, electrofishing, point abundance sampling, principal component analysis

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### Introduction

The enormous variability of the braided hydro-system in the Szigetköz floodplain made possible the development of diverse potamic biocenoses unique in Europe. Szigetköz is the geographical unit of the alluvial cone of the Little Danubian Plain on the right side of the Danube. Its borders are clearly marked by a 59 km section of the main river and the 129 km Mosoni Danube, a meandering arm.

In the second half of the 19th century the extensive regulation of the Szigetköz became necessary because of navigational problems and damages caused by inundation. The flood protection dikes divided the original floodplain into two ecologically distinct areas: the old floodplain is protected from floods by dikes, the active floodplain is situated between the dikes and the main channel of the Danube. It had an area of only 6 % of the former floodplain. The rolling and suspended alluvial sediment having been deposited on the former floodplain accumulated on the narrow active floodplain, and this process accelerated the aggradation of the main channel and the silting up of the side arms (Guti 1993). A new extensive regulation of the Szigetköz started in the 1960's. Since the 1980's, the intensive gravel extractions from the main channel have resulted in the deepening of the river bed, and the side arm systems

were fed by surface water directly from the Danube during only 20 % of the year. The construction of the Gabčíkovo River Barrage has exacerbated the situation. Since the end of 1992, its implementation, the diversion of the Danube's discharge away from the floodplain, has threatened the region's environment (Daubner 1981, Holčík *et al.* 1981, Holčík 1991, Guti 1993).

Despite numerous regulation hitherto made, there is a wide spectrum of aquatic habitats in the Little Danubian Plain (Bastl 1991). In general, owing to the great diversity of floodplain habitats, the number of fish species, the density of their populations, the ecological production and the fishery catch in the sections of rivers bordered by floodplains are very high. Adjacent reaches, which do not have such an extensive diversity of habitats, have lower value (Holčík *et al.* 1989).

Before the operation of the Gabčíkovo River Barrage, the side arms of the active floodplains in the Little Danubian Plain were connected with the main channel of the Danube and they played a prominent role in the reproduction of fish, especially for open substratum spawning phytophils, phytolithophils and lithophils (Holčík *et al.* 1981, Holčík 1991). The spatial distribution of juvenile fish is related to the reproductive potential of floodplain habitats, and so it provides essential information for any future

floodplain restoration attempts. The juveniles of nearly all species remain in their spawning ground and use it as a nursery area, and the density of juveniles tends to stabilize towards the end of the spawning season in late summer and early autumn (Copp 1989, Penáz *et al.* 1991). The present study aimed to describe the species composition of juvenile (0+) fish assemblages in the active floodplain of the Szigetköz before the hydrological changes caused by the Gabčíkovo River Barrage.

## Methods

The classical methods for the examination of the natural fish assemblages are based on the qualitative estimation of the composition of the temporary assemblages, i.e. the De Lury method applying the data of cumulative fish catches efforts or the mark and recapture Petersen method (Ricker 1975). These methods produce reasonable data first of all on streams and small rivers. The spatial and temporal distribution of fish assemblages in large rivers is quite heterogeneous. As a result, classical population density estimation methods would require huge samples to avoid miscalculations, but it is not realistic (Persat and Oliver 1991). A new approach to the study of riverine fish assemblages was the point abundance sampling method and strategy (Nelva *et al.* 1979). It was basically a high number of small samples instead of several large ones, which provides better statistical data for indicating the presence of populations with patchy distribution and a description of the spatial structure of the assemblages. At the end of the 1980's Copp and Penáz (1988) developed a new version of the point abundance sampling for the investigation juvenile fish assemblages by some technical changes, and it was a purposeful complement of the research programme of fluvial ecosystems in the Rhone river (Penáz *et al.* 1991).

Our study was implemented in 27 sampling sites in the active floodplain of the Szigetköz between rkm 1817 and 1840. The investigated sites were subdivided into parapotamic and plesiopotamic type of habitats (Roux *et al.* 1982, Amoros *et al.* 1987). At each sites, sampling was carried out with point abundance sampling strategy at 20-40 sampling points at a distance of approximately 10 m-s from each other in a random distribution. Fish were collected with a battery-powered electroshocker of a low output (80 W). A special anode of 10 cm developed for the catching of juvenile fish was used. A rubber boat was needed to reach the sampling points. The anode was put fast at a depth of 50 cm and the shocked fish were collected with a 1 mm mesh size

dipnet of 35 cm in diameter. Small fish specimens were preserved in a 4 % formaldehyde solution.

From the material recorded, a data matrix of sampling points by fish species was created and the mean number of fish per sample, the index of aggregation (Southwood 1984) and the frequency distribution were calculated for each species. For the typological analysis of sampling sites (habitats), another matrix was derived from the data set. The numerous point samples taken from one site were summed and the resulting matrix contained the abundance of the fish species at each sampling site. This sites by species matrix was converted to absence/presence and then submitted to centered and normalized principal component analysis (Copp 1989).

## Results

Samples were taken at 27 sampling sites in the active floodplain of the Szigetköz between August 4 and 19, 1992. Seven sites were plesiopotamic, the others parapotamic (Table 1). In the sampling period the water level of the Danube was very low and the side-arms were fed only by groundwater. Slow, local flow was observable at the narrow and shallow sections of some parapotamic side arms. Most of the plesiopotamic habitats were completely disconnected to other side arms.

During the survey, 5923 individual fish were caught in 730 samples from the 27 sampling sites. The standard length of the fish varied between 12 and 353 mm. From the 27 species recorded the juveniles (0+) of 21 species were found (Table 2). Altogether 4849 fry were collected, which was 82 % of the total number. There were six species *Carassius carassius*, *Cobitis taenia*, *Lota lota*, *Stizostedion lucioperca*, *Gymnocephalus schraetzer* and *Gymnocephalus baloni*, which were represented only by 1+ or older individuals.

The juveniles of *Rutilus rutilus* were the commonest. It was followed by *Alburnus alburnus*, *Blicca bjoerkna*, *Rhodeus sericeus amarus*, etc. (Fig. 1). The average individual number per sample was low with the exception of roach, which were represented by more than four individuals in a sample as an average. The aggregation index was the highest again with roach. It was high with *A. alburnus*, *R. sericeus*, *Leuciscus leuciscus* and *Barbus barbus* as well indicating the common occurrence of this species in groups.

The ordination resulting from the PCA of the 27 sampling sites by 21 fish species matrix (Fig. 2a) distinguished the slow flowing and stagnant sites, with most of the variance being accounted by PC1,

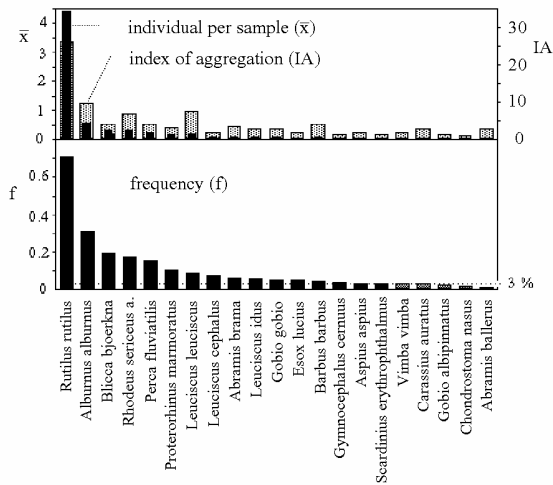


Fig. 1. The mean number of individuals per samples ( $\bar{x}$ ), the index of aggregation (IA) and the frequency of occurrence (f) of 0+ fish species collected in the Szigetköz floodplain, in August 1992.

as well as the species-poor and species-rich sites (PC2). The first two component of the analysis

accounted for 34 % of the variation. The species richness of the sites is indicated with a square size relative to the numbers of species sampled. The presentation of the PC1×PC2 ordination by the habitat types (Fig. 2b) demonstrated that stagnant plesiotamom type habitats (Sites: 2, 5, 6, 8, 10, 23, 24) are ordinated to the lower right, whereas the parapotamic habitats are ordinated from the left side to the upper right, which indicates their greater variance. The sampling sites where slow flow was observable (Sites: 3, 7, 15, 17, 20) are ordinated to the left side. In the stagnant sites, the grain size of the deposited mineral sediments referred to the slope gradient of the channel and the current velocities during inundation, therefore these sites were subdivided into two groups according to the dominant bed materials. Stagnant parapotamic sites where the bottom was composed of gravel (Site: 4, 9, 12, 13, 16, 21) are ordinated to the lower central, while the sites where the bottom consisted of sand and silt (Sites: 1, 11, 14, 18, 19, 22, 25, 26, 27) are ordinated to the upper right.

According to the groups of the sampling sites, the frequency distributions of juvenile fish species

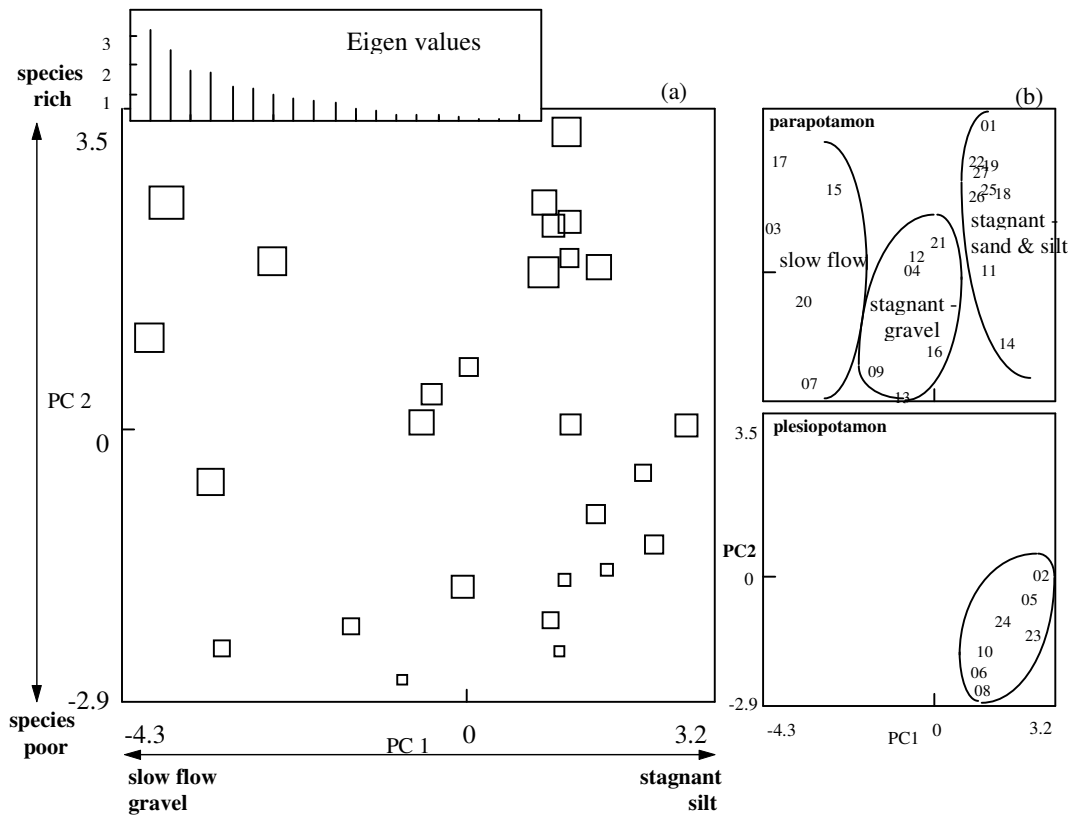


Fig. 2. Ordination of the Sites by Species matrix. In (a), the size of squares relative to the number of species collected. In (b), the same ordination is presented according to the habitat character.

were calculated (Fig. 3). Rheophilic fishes occurred in the parapotamic side arms, however three of them, *Leuciscus cephalus*, *Gobio gobio* and *Aspius aspius* were collected from plesiopotamic waters, too. Eurytopic and limnophilic species were present both in parapotamic and plesiopotamic habitats, though *Abramis brama* was not found in plesiopotamon type of water.

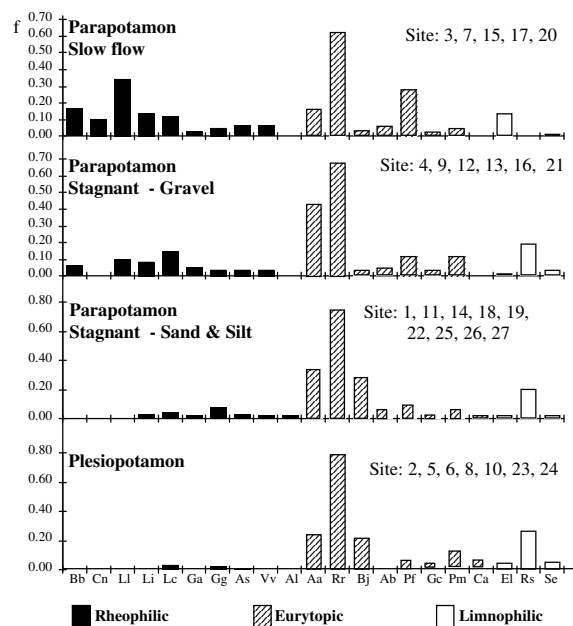


Fig. 3. Frequency of occurrence (f) of 0+ fish species in the habitat types subdivided according to the PCA ordination of the sampling sites in Fig. 2.

In the samples, 48 % of the species were rheophilic, 38 % of the species were eurytopic and 14 % of the species were limnophilic. PCA ordination of the fish species as defined by sampling sites (Fig. 4) presented the rheophilic, eurytopic and limnophilic fishes, however ecological groups were not distinguished sharply. Rheophilic species are ordinated to the lower left, some of them were in the upper centre. Limnophilic species are ordinated to the lower right. The three most frequently encountered species (*R. rutilus*, *A. alburnus* and *B. bjoerkna*) were eurytopic, which are ordinated to the central zone.

### Discussion

Before the operation of the Gabčíkovo River Barrage, at the end of 1980's, and at the beginning of 1990's most side arms were parapotamic and plesiopotamic in the active floodplain in the Szigetköz. Parapotamic side arms are permanently connected

with the main channel at their downstream ends. Their flow, which is fed by both surface and groundwater may reverse due to water level fluctuations in the main channel of the river. Macrophytes are scarce but phytoplankton is rich and abundant. The fish fauna is rather diversified and the ichthyomass is moderate. Plesiopotamic backwaters are permanent or temporary stagnant formerly side arms. They are sometimes fed by groundwater. Their size changes according to the hydrological conditions. Macrophytes grow densely, phytoplankton is very abundant, algal blooms frequently occur. The fish fauna is mildly diversified and ichthyomass varies from very low to very high (Holčík *et al.* 1989).

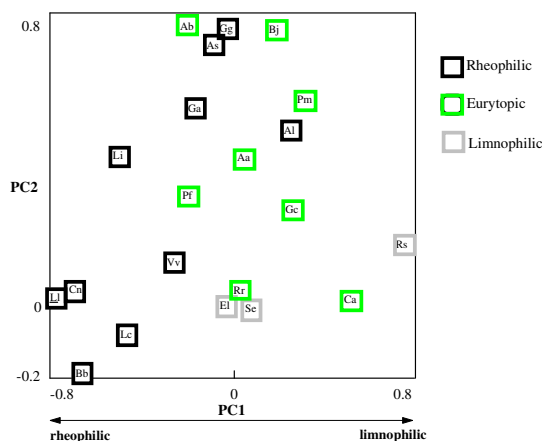


Fig. 4. The PCA of the fish species (see Table 2) as defined by the stations, from the Sites by Species matrix.

Over the sampling period, in August 1992, the backwaters were not fed by surface water in the Szigetköz, and as a consequence the current velocity decreased in the side arms and water temperature was higher than in the main channel. According to the deposition of the suspended sediment turbidity declined, primary production increased, the dissolved oxygen was higher and its daily fluctuation was more extreme. The hydrochemical and hydrobiological changes were more pronounced in more disconnected side arms (Tevanné Bartalis 1987). In stagnant backwaters there was a considerable vertical and diurnal thermal and dissolved oxygen stratification.

The species composition of juvenile fish assemblages and their distribution were related to the general flowing conditions of the sampling sites studied in the Szigetköz. The species richness of the assemblages were different in the parapotamic and plesiopotamic backwaters, the juveniles collected represented 21 and 13 species, respectively. In the subdi

Table 1: List of the sampling sites in the active floodplain of the Szigetköz. Habitat: para = parapotamon, plesio = plesiopotamon, \* = slow flow, Sampl.: number of samples per site; F. ind. = number of collected juvenile fish per site; F. sp. = number of juvenile fish species.

Code	Site	Habitat	Date	Sampl.	F. ind.	F. sp.
1	Szigeti arm	para	Aug.12	20	194	13
2	Jegenyés arm	plesio	Aug.12	10	95	10
3	Kecölcés weir	para*	Aug.04	30	171	13
4	Csákányi arm I.	para	Aug.04	30	135	11
5	Csákányi backwater	plesio	Aug.07	30	118	7
6	Muki oxbow	plesio	Aug.12	10	88	7
7	Doborgazi canal weir	para*	Aug.06	20	48	7
8	Schisler oxbow	plesio	Aug.07	30	38	4
9	Csákányi arm II.	para	Aug.05	30	46	7
10	Akali arm	plesio	Aug.06	30	75	5
11	Kerekesciglés arm I.	para	Aug.11	30	209	9
12	Kerekesciglés arm II.	para	Aug.11	20	105	9
13	Bodaki arm I. (Kőhíd)	para	Aug.11	30	21	4
14	Bodaki arm II.	para	Aug.05	30	44	5
15	Gombócos weir	para*	Aug.17	25	235	13
16	Újszigeti arm	para	Aug.17	35	200	10
17	Halrekesztő weir	para*	Aug.17	40	238	15
18	Halrekesztő arm	para	Aug.15	30	348	11
19	Morva arm	para	Aug.15	20	207	10
20	Szürke weir	para*	Aug.19	30	364	12
21	Öntési arm	para	Aug.19	30	124	8
22	Pókmacskási arm	para	Aug.19	30	303	11
23	Pókmacskási oxbow	plesio	Aug.19	30	146	8
24	Ásványi backwater	plesio	Aug.16	20	248	8
25	Béka arm	para	Aug.16	30	452	
26	Szilfási arm I.	para	Aug.18	30	275	14
27	Szilfási arm II.	para	Aug.18	30	322	10

Table 2: Species recorded in juvenile fish assemblages in 1992 in the active floodplain of the Szigetköz, with indication of their ecological groups (Schiemer and Spinder 1989) and their occurrence (+) in parapotamic and plesiopotamic habitats.

Code	Species	Ecol. group	Parap.	Plesiop.
Bb	<i>Barbus barbus</i>	rheophilic	+	-
Cn	<i>Chondrostoma nasus</i>	rheophilic	+	-
Ll	<i>Leuciscus leuciscus</i>	rheophilic	+	-
Li	<i>Leuciscus idus</i>	rheophilic	+	-
Lc	<i>Leuciscus cephalus</i>	rheophilic	+	+
Ga	<i>Gobio albipinnatus</i>	rheophilic	+	-
Gg	<i>Gobio gobio</i>	rheophilic	+	+
As	<i>Aspius aspius</i>	rheophilic	+	+
Vv	<i>Vimba vimba</i>	rheophilic	+	-
Al	<i>Abramis ballerus</i>	rheophilic	+	-
Aa	<i>Alburnus alburnus</i>	eurytopic	+	+
Rr	<i>Rutilus rutilus</i>	eurytopic	+	+
Bj	<i>Blicca bjoerkna</i>	eurytopic	+	+
Ab	<i>Abramis brama</i>	eurytopic	+	-
Pf	<i>Perca fluviatilis</i>	eurytopic	+	+
Gc	<i>Gymnocephalus cernuus</i>	eurytopic	+	+
Pm	<i>Proterorhinus marmoratus</i>	eurytopic	+	+
Ca	<i>Carassius auratus</i>	eurytopic	+	+
El	<i>Esox lucius</i>	limnophilic	+	+
Rs	<i>Rhodeus sericeus amarus</i>	limnophilic	+	+
Se	<i>Scardinius erythrophthalmus</i>	limnophilic	+	+



visions of the parapotamon type arms, the number of the species was same, but the composition of the assemblages was slightly dissimilar. Great differences were detected in terms of the nursery capacity of the parapotamic habitats in the French section of the Rhone river. Such aspects the actual degree of connectivity with the main channel, and the intensity of groundwater alimentation appeared to be especially decisive. The increasing intensity of primary production considerably deteriorated the nursery of juveniles (Penáz *et al.* 1991). According to these experiences, a decreasing tendency of abundance of rheophilic species appeared in the habitats in the direction from slow flowing parapotamon towards stagnant parapotamon with sand and silt composed bottom in the Szigetköz.

Owing to the low input of water in the floodplain, the distribution of rheophilic fish was limited and the occurrence of limnophilic species were relatively wide-spread. Juveniles of rheophilic species clumped in the slow flowing habitats, mainly below the cross weirs, which may function as refuges for them, during the low discharge period in late summer.

#### Acknowledgement

This study was supported by the National Scientific Research Foundation (OTKA grant number F-5341).

#### References

- Amoros, C., Roux, A. L., Reygrobellet, J. L., Bravard, J. P. and Pautou, G. (1987): A method for applied ecological studies of fluvial hydrosystems. — *Regulated Rivers 1*, 17-36.
- Bastl, I. (1991): The impact of the Gabčíkovo River Barrage System on fishery management. In: Penáz, M. (ed.): *Biological monitoring of large rivers*. — Brno, 79-81 pp.
- Copp, G. H. (1989): The habitat diversity and fish reproductive function of floodplain ecosystems. — *Env. Biol. Fish.* 26, 1-27.
- Copp, G. H. and Penáz, M. (1988): Ecology of fish spawning and nursery zones in the flood plain, using a new sampling approach. — *Hydrobiologia 169*, 209-224.
- Copp, G. H., Guti, G., Rovny, B. and Černý, J. (1994): Hierarchical analysis of habitat use by 0+ juvenile fish in Hungarian/Slovak flood plain of the Danube. — *Env. Biol. Fish.* 40, 329-348.
- Daubner, I. (1981): Dunai vízlépcsők építésének biológiai aspektusai. — *MTA Biol. Oszt. Közl.* 24, 57-65.
- Guti, G. (1993): Fisheries ecology of the Danube in the Szigetköz floodplain. — *Opusc. Zool. Budapest.* 26, 67-75.
- Holčík, J. (1991): Fish communities in the Slovak section of the Danube river in relation to construction of the Gabčíkovo River Barrage System. In: Penáz, M. (ed.): *Biological monitoring of large rivers*. — Brno, 86-89 pp.
- Holčík, J., Bastl, I., Ertl, M. and Vranovsky, M. (1981): Hydrobiology and ichthyology of the Czechoslovak Danube in relation to predicted changes after the construction of the Gabčíkovo-Nagymaros River Barrage System. — *Práce Lab. Rybár. Hydrobiol.* 3, 19-158.
- Holčík, J., Banarescu, P. and Evans, D. (1989): General introduction to fishes. In: Holčík, J. (ed.): *The freshwater fishes of Europe*. — AULA-Verlag, Wiesbaden, 18-147 pp.
- Nelva, A., Persat, H. and Chessel, D. (1979): Une nouvelle methode d'etude des peuplements ichthyologiques dans les grands cours d'eau par echantillonnage ponctuel d'abondance. — *C. R. Acad. Sc. Paris.* 289, 1295-1298.
- Penáz, M., Oliver, J. M., Carrel, G., Pont, D. and Roux, A. L. (1991): A synchronic study of juvenile fish assemblages in the French section of the Rhone River. — *Acta Sc. Nat. Brno* 25, 1-36.
- Persat, H. and Oliver, J. M. (1991): The point abundance sampling, a fishing strategy for large rivers: Short presentation of the concept, its appliance and some results. In: Penáz, M. (ed.): *Biological monitoring of large rivers*. — Brno, 104-113pp.
- Ricker, W. E. (1975): Computation and interpretation of biological statistics of fish populations. — *Bull. Fish. Res. Board Can.* 191, 1-382.
- Roux, A. L. *et al.* (1982): Cartographie polythematique appliquee a la gestion, cologique des eaux. — CNRS, Paris, 1-113.
- Schiemer, F. and Spindler, T. (1989): Endangered fish species of the Danube river in Austria. - *Regulated Rivers 4*, 397-407.
- Southwood, T. R. E. (1984): *Ökológiai módszerek (Ecological methods)*. — Mezőgazd. Kiadó, Budapest, 314 pp.
- Tevanné Bartalis, É. (1987): A Duna szigetközi szakaszának és hullámtéri vizeinek biológiai vízminősége. (Biological water qualification of Szigetköz section and the floodplain of river Danube). In: Dvihally, Zs. (ed.) *A kisalföldi Dunaszakasz ökológiája*. — VEAB 42-77 pp.

## 30 YEARS OF THE ECOLOGICAL JOURNAL TISCIA

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*Körmöczi, L. (1996): 30 years of the ecological journal Tiscia. — Tiscia 30, 55-64.*

**Abstract.** Tiscia, an ecological journal, succeeded the 30th volume. A short history of three decades is reported. Major changes and preferences are also summarized, and the content of the previous 29 volumes is listed.

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1996 is a jubilee in the history of journal Tiscia, since it reached the 30th volume. It was founded in 1965 as the official platform for the Tisza Research Committee and for the research activity. Founders and members of the first editorial board were the professors and qualified researchers of József Attila University, Szeged. The starting editorial board consisted of three persons: editor in chief was Prof. Gábor Kolosváry, the initiator and promoter of both Tisza research activity and journal Tiscia, technical editors were György Bodrogeközy (for 25 years) and Andor Horváth.

Tiscia has been published as an annual periodical nearly continuously from 1965, and only in 1970 and 1991 were short breaks in this continuity.

The first 29 volumes contain 440 articles, titles of which are listed below. Number of authors is 231. Most of the authors were professors or students of JATE University, but many of them were secondary school teachers in cities along the river Tisza, or were working in water conservancy authorities.

From 1979, Tiscia became international, since the list of authors was completed with Ukrainian, Romanian and Yugoslavian researchers, covering the whole range of river Tisza. Next larger step of changes in the character of the journal was in 1991. Until that year Tiscia accepted exclusively papers dealing with the life of the river Tisza or the Tisza valley. It resulted that over 85% of the contributions (371 items) dealt with the river Tisza, Tisza valley, backwaters and tributaries of Tisza. Only 5 % of the papers were written on plants or animals of other regions or on theoretical and methodological problems as a consequence of the change in the editorial board. In 1991 the scope of Tiscia was widened in relation to the territory but limited to rather ecological

studies. In that year also the format of the volumes altered, only the original logo was kept.

Publications were very diverse in some respect. There were typical preferences, but there occurred rarities. Language of Tiscia is typically English: great majority of the articles was published in English, proportion of the 345 papers compared to the total number is 78%. 69 papers (16%) were written in German, mainly in the several first years of the journal. Only one volume was published in Hungarian, but with English summary. From that year (11th volume in 1976) the articles appeared with Hungarian, Russian and Yugoslavian summaries (or also with English summary if written in Hungarian or Russian). In the course of the 29 years, only one paper was in French (Fig. 1).

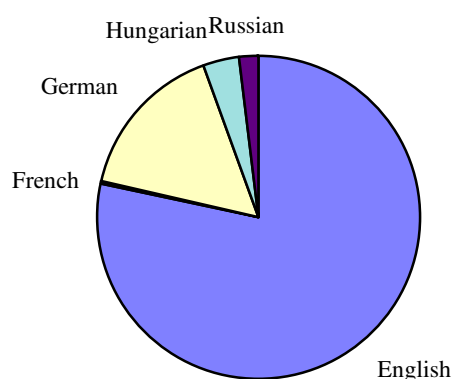


Fig. 1 Distribution of languages in the 440 papers of the 30 volumes.

As for the subject of the papers, we can see again some preferred issues, but the diversity is much larger (Fig. 2). Nearly one third of the papers were faunistic, because most of the researchers were zoologists, at the next two places of the rank order we can find ecology and floristics. Larger number of ecological papers was due to the modification of the scope of latest volumes. Very surprising the relatively low number of articles on plant communities. This should be because Szeged was not a very strong centre for phytocenologists, only few botanists of the University belonged to this group. Also surprising that the number of zoocenological investigations is not proportional with the actual development of zoocenology compared to the phytocenology, much more papers could have been expected on plant communities.

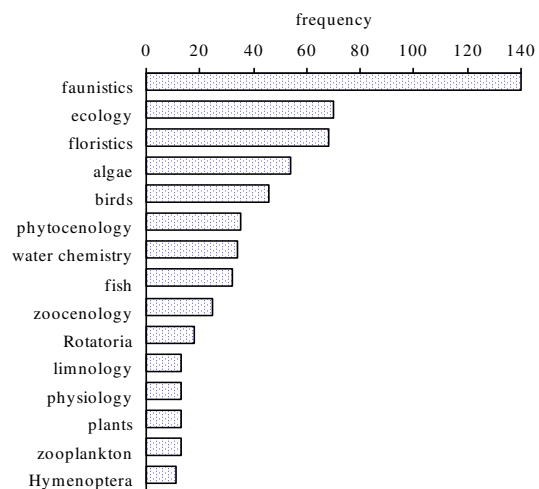


Fig. 2. Frequency distribution of preferred subjects in the publications. Only those key words are listed frequency of which exceeds 10.

### List of publications

Ádamosi, M., Végvári, P., Bancsi, I., Hamar, J., B. Tóth, M., Ferencz, M. and Szitó, A. (1978): Limnological investigations in the longitudinal section of the river Tisza. — *Tiscia 13*, 99-140.

Albert, A. and Wollemann, M. (1986): Spectrogram and oscillogram comparative analysis of night heron (*Nycticorax nycticorax* L.) advertising call. — *Tiscia 21*, 123-127.

Andó, M. (1969): Climatic and microclimatic peculiarities of the Tisza and its inundation area. — *Tiscia 5*, 15-36.

Andó, M. and Vágás, I. (1973): The great flood in the Tisza basin in 1970. — *Tiscia 8*, 9-32.

Avasi, Z. (1987): Flood as ecological perturbation of epigeic animal communities II. The effect of flood on ground beetle assemblages (Coleoptera: Carabidae). — *Tiscia 22*, 99-107.

Avram, S. (1968): Contribution a l'étude des opilionides de la zone inondable de la Tisa entre les kilometres fluviaux 698-744. Avec la description d'une nouvelle espece: *Leiobunum tisciae*. — *Tiscia 4*, 111-125.

B. Tóth, M. (1976): Hydrochemical conditions of the river Tisza 2. Seasonal dynamism of the oxygen household and nitrogen-phosphorus forms. — *Tiscia 11*, 27-33.

B. Tóth, M. (1976): Hydrochemical conditions of an experimental area in the region of the Kisköre river barrage. — *Tiscia 11*, 105-110.

B. Tóth, M. (1981): Bacteriological study of the sediment in the Tisza and its tributaries. — *Tiscia 16*, 55-64.

B. Tóth, M. and Hamar, J. (1976): The part of water vegetation in eutrophication in an experimental area at the Kisköre river barrage. — *Tiscia 11*, 115-118.

B. Tóth, M. and Végvári, P. (1976): Preliminary investigations of the experimental area in the interest of protecting the water quality of the future Kisköre reservoir. — *Tiscia 11*, 99-103.

Bába, K. (1965): Einige Daten zur Zönose der Muscheln. — *Tiscia 1*, 63-64.

Bába, K. (1967): Malakozöologische Zonenuntersuchungen im toten Tiszaarm bei Szikra. — *Tiscia 3*, 41-55.

Bába, K. (1969): Zöologische Untersuchungen der an der Flussbettkante der Tisza und inhrer Nebenflüsse lebenden

Schneken. — *Tiscia 5*, 107-119.

Bába, K. (1971): Malacocoenoses of backwaters of the Upper Tisza with various vegetation. — *Tiscia 6*, 88-94.

Bába, K. (1974): Mollusca communities in the Tisza bed in the region of Szeged. — *Tiscia 9*, 99-104.

Bába, K. (1980): A history and present-day situation of the investigation of the recent land snails in the Great Hungarian Plain. — *Tiscia 15*, 93-102.

Bába, K. (1982): Comparative faunistic and ecological investigations into the land-mollusks of the Körtevényes reservation area. — *Tiscia 17*, 174-190.

Bába, K. (1983): History of the investigation of the terrestrial snails of the Great Hungarian Plain and its present situation II. — *Tiscia 18*, 85-97.

Bába, K. (1983): Effect of the regions of the Tisza valley on the malaco-fauna. — *Tiscia 18*, 99-104.

Bába, K. (1989): Zoogeographical conditions of snails living on grass-associations of two Hungarian lowland regions. — *Tiscia 24*, 59-67.

Bába, K. (1995): The antecedents of the Tisza Research. — *Tiscia 29*, 59-65.

Bába, K. and B. Tóth, M. (1981): The mollusca fauna of the Tisza and its tributaries. — *Tiscia 16*, 169-181.

Bagi, I. (1985): Studies on the vegetation dynamics of Nanocyperion communities I. Characteristic indicator values and classification and ordination of stands. — *Tiscia 20*, 29-43.

Bagi, I. (1987): Studies on the vegetation dynamics of Nanocyperion communities III. Zonation and succession. — *Tiscia 22*, 31-45.

Bagi, I. (1987): Studies on the vegetation dynamics of Nanocyperion communities IV. Diversity and succession. — *Tiscia 22*, 47-54.

Bagi, I. (1988): Cenological relations of mud vegetation of a hypertrophic lake in the Tiszaalpar basin. — *Tiscia 23*, 3-12.

Bagi, I. (1994): Measures of association and correlation between two coexistent forms of *Carex serotina* Mérat: pattern and distribution of dominance. — *Tiscia 28*, 15-19.

Bagi, I. and Bodrogekőzy, Gy. (1984): Seasonal dynamics of the succession series at the Körös flood-plain leading to the association of the *Echinochloa-Heleochloetum alopecuroides*

- (Rapcs. 27) Bodrk. 82. — Tiscia 19, 113-135.
- Bagi, I. and Körmöczy, L. (1986): Studies on the vegetation dynamics of Nanocyperion communities II. Classification and ordination of species. — Tiscia 21, 13-24.
- Banarescu, P. (1972): Zur Kenntnis der Fischfauna des Theissbeckens. — Tiscia 7, 69-77.
- Bancsi, I. (1976): Zooplankton investigations in an experimental area at the Kisköre river barrage. — Tiscia 11, 59-65.
- Bancsi, I. (1976): Results of the zooplankton investigation of the bay at Abádszalók. — Tiscia 11, 93-98.
- Bancsi, I. (1976): Zooplankton investigations in the dammed river Tisza reaches. — Tiscia 11, 119-124.
- Bancsi, I. (1977): Diurnal water-chemical investigations in an experimental area at the Kisköre water barrage. — Tiscia 12, 3-10.
- Bancsi, I. (1980): The Rotatoria fauna of the flood-plain of the Bodrog at Sárospatak. — Tiscia 15, 61-92.
- Bancsi, I., Hamar, J., Végvári, P. and B. Tóth, M. (1978): Limnological characteristics of the Tisza stretch at Kisköre dam in 1975. — Tiscia 13, 83-95.
- Bancsi, I. and Hamar, J. (1981): Data on the Rotatoria and Zooflagellata fauna of the sediment in the Tisza and its tributaries. — Tiscia 16, 155-159.
- Bancsi, I., Szitó, A. and Végvári, P. (1981): General remarks on studies of sediment in the Tisza during 1979. — Tiscia 16, 5-12.
- Bankovics, A. (1974): Spreading and habits of *Hippolois pallida elaeica* (Lind.) along the Tisza. — Tiscia 9, 105-113.
- Bankovics, A. (1975): Data on the comparative ecology of the scrub warbler (*Hippolois pallida elaeica* (Lind.)) and its spreading along the Tisza in the years 1973 to 1974. — Tiscia 10, 81-83.
- Beliczay, I. (1977): Reconstruction of the nature conservation district Mártély. — Tiscia 12, 77-84.
- Berezky, M. Cs. (1994): Book review. — Tiscia 28, 73.
- Beretzky, P., Cizmazia, Gy., Gallé, L., Gausz, J., Homonnay, S., Kolosváry, G., Molnár, Gy., Nagy, J. and Schäfer, L. (1966): Neue Beiträge zur Kenntnis der Tierwelt des oberen Tiszatales. — Tiscia 2, 67-81.
- Bodrogközy, Gy. (1965): Die Vegetation des Theiss-wellenraumes II. Vegetationsanalyse und Standortökologie der Wasser- und Sumpfpflanzenzönosen im Raum von Tiszafüred. — Tiscia 1, 5-31.
- Bodrogközy, Gy. (1966): Die Vegetation des Theiss-wellenraumes III. Auf der Schutzdammstrecke zu Szeged durchgeführten fitozöologischen Analysen und ihre praktische Bewertung. — Tiscia 2, 47-66.
- Bodrogközy, Gy. (1967): Vegetation of the Tisza inundation area IV. Examination results of the Magnocaricion associations from the area of Alpár. — Tiscia 3, 27-39.
- Bodrogközy, Gy. (1968): Results of investigation of an experiment aiming at the development of biological defence and productivity of grass associations on the Tisza dam, in the environment of Szeged. — Tiscia 4, 37-52.
- Bodrogközy, Gy. (1972): Life of the Tisza Research. Conference on the Tisza Research '71. — Tiscia 7, 93-102.
- Bodrogközy, Gy. (1973): From the life of the association. Tisza Research Conference '72. — Tiscia 8, 97-104.
- Bodrogközy, Gy. (1974): Research into the life of the Tisza. Conference on Tisza Research in 1973. — Tiscia 9, 159-168.
- Bodrogközy, Gy. (1975): Research into the life of the Tisza. Conference on Tisza Research in 1974. — Tiscia 10, 89-101.
- Bodrogközy, Gy. (1975): Research into the life of the Tisza. Conference on Tisza Research in 1975. — Tiscia 10, 103-112.
- Bodrogközy, Gy. (1977): Research into the life of the Tisza. Conference on Tisza Research in 1976. — Tiscia 12, 149-154.
- Bodrogközy, Gy. (1978): From the life of the Tisza-research working committee. Tisza-research conference VIII. — Tiscia 13, 175-190.
- Bodrogközy, Gy. (1978): From the life of the Tisza-research working committee. Tisza-research conference XI. — Tiscia 13, 191-214.
- Bodrogközy, Gy. (1979): Professor Dr. Imre Horváth (1926-1979). — Tiscia 14, 3-5.
- Bodrogközy, Gy. (1979): From the life of the Tisza-research Working Committee. Tisza-research conference X (1979). — Tiscia 14, 229-238.
- Bodrogközy, Gy. (1980): Dr. László Gallé, sr. (1908-1980). — Tiscia 15, 3-5.
- Bodrogközy, Gy. (1980): From the life of the Tisza-research working committee. Tisza research conference XI (1980). — Tiscia 15, 139-149.
- Bodrogközy, Gy. (1982): Objectives and results of complex investigations in the landscape protection district of Mártély (Hungary). — Tiscia 17, 3-13.
- Bodrogközy, Gy. (1982): Ten-year changes in community structure, soil and hydroecological conditions of the vegetation in the protection area at Mártély (S. Hungary). — Tiscia 17, 89-130.
- Bodrogközy, Gy. (1983): From the life of Tisza-research working committee. Tisza-research conference XII (1981). — Tiscia 18, 135-146.
- Bodrogközy, Gy. (1984): Hydroecology of the grass-associations found at the dams along the Upper-Tisza. — Tiscia 19, 89-111.
- Bodrogközy, Gy. (1984): From the life of the Tisza-research working committee, which has become international. Tisza-Research Conference XIV (1983). — Tiscia 19, 211-219.
- Bodrogközy, Gy. (1985): Hydroecology of the plant communities at the middle Tisza-valley I. *Agropyro-Rumicion*. — Tiscia 20, 55-97.
- Bodrogközy, Gy. (1985): From the life of the Tisza-research working committee, which has become international. Tisza-research conference XV (1984). — Tiscia 20, 145-147.
- Bodrogközy, Gy. (1987): From the life of Tisza-research working committee, which has become international. Tisza-research conference XVII (1986). — Tiscia 22, 129-141.
- Bodrogközy, Gy. (1989): From the life of Tisza-research working committee. Tisza research conference XIX (1988). — Tiscia 24, 131-141.
- Bodrogközy, Gy. (1990): Hydroecological relations of littoral marsh meadow associations at Bodrogzug. — Tiscia 25, 31-57.
- Bodrogközy, Gy. (1990): Tisza-research conference XX (1989). — Tiscia 25, 87-92.
- Bodrogközy, Gy. and Horváth, I. (1974): Study of the indicator role of plant populations of marsh-meadow along the Tisza in the water-household of the environment in the district of Kisköre. — Tiscia 9, 43-51.
- Bodrogközy, Gy. and Horváth, I. (1977): Connections between stand pattern and the organic-matter production in the marshlands of the inundation area at Körtvélyes. — Tiscia 12, 65-70.
- Bodrogközy, Gy. and Horváth, I. (1979): Effect of lasting floods on the species composition and organic-matter production of the marshy meadow-lands in the floodplains of the Tisza. — Tiscia 14, 81-88.
- Bozicic, B. (1985): Investigation of mosquito fauna (Diptera, Culicidae) in Potisje. — Tiscia 20, 111-116.
- Brankovic, D. (1993): Preliminary data about the phytoplankton community and saprobiological characteristics of river Stari Begej. — Tiscia 27, 57-60.
- Brankovic, D. and Budakov, L. (1994): Phytoplankton community and saprobiological characteristics of Lake Ludas during the spring season. — Tiscia 28, 21-24.
- Budakov, L. (1988): Fecundity of *Esox lucius* L. in the Tisza river. — Tiscia 23, 107-114.
- Budakov, L. (1993): Characteristics of feeding and growth of pike perch and pike in the protected part of river Begej. — Tiscia 27, 53-56.

- Budakov, L., Brankovic, D. and Gajin, S. (1994): Comparative investigation between phytoplankton and the intestinal content of carp. — *Tiscia* 28, 47-51.
- Budakov, L. and Maletin, S. (1984): Dynamics of longitudinal growth and body mass of *Esox lucius* L., *Blicca bjoerkna* L., and *Carassius auratus gibelio* Bloch in the Tisza. — *Tiscia* 19, 173-178.
- Bugyi, I., Csizmazia, Gy., Gorzó, Gy., Havranek, L. and Kolosváry, G. (1965): Weitere Untersuchungen über die Entwicklung der Fauna des Tisza-ales. — *Tiscia* 1, 81-92.
- Butorac, B. (1995): Review of aquatic vegetation of the regional park "Stari Begej". — *Tiscia* 29, 27-32.
- Butorac, B. and Stojšic, V. (1992): The results of preliminary investigations of aquatic vegetation in the regional park "Stari Begej". — *Tiscia* 26, 29-36.
- Butorac, B., Stojanovic, S. and Stojšic, V. (1992): Specificities in the vegetation of unprotected band of river Tisza. — *Tiscia* 26, 37-41.
- Cs. Bereczky, M. (1995): Book review. — *Tiscia* 29, 67.
- Csépai, F. (1980): Hygienic investigation of the Tisza-water, and the drinking-water made of that with the modified *Daphnia* test. — *Tiscia* 15, 19-25.
- Csépai, F. (1984): Summarizing evaluation of the results of the *Daphnia* test carried out at the Tisza-section and major district waters at Szolnok county (1977-1983). — *Tiscia* 19, 17-20.
- Csépai, F. (1989): Comprehensive evaluation of the results of the *Daphnia* test carried out at the Tisza-section and major district waters in Szolnok county (1977-87). — *Tiscia* 24, 35-41.
- Csépai, F. and Wajjandt, J. (1988): Heavy metal content in the branchiae of some Tisza-river fish. — *Tiscia* 23, 97-105.
- Csizmazia, Gy. (1966): Eine interessante, kolonienbildende Rotatoria aus der Tisza. — *Tiscia* 2, 97-98.
- Csizmazia, Gy. (1966): Beiträge zur Fledermaus-fauna des ungarischen Tisza-ales. — *Tiscia* 2, 127-130.
- Csizmazia, Gy. (1969): Investigation of brown rats (*Rattus norvegicus norvegicus* Berkenhout 1769) living in the Tisza dams, with a view to flood prevention. — *Tiscia* 5, 121-127.
- Csizmazia, Gy. (1982): Die Wirkung des Hochwassers der Theiss auf die Population der Maulwürfe (*Talpa europaea* Linné 1758) im Inundationsraum bei Körtvélyes (Ungarn). — *Tiscia* 17, 219-224.
- Csizmazia, Gy. (1982): A report on the results of the Tisza-research work in 1980. — *Tiscia* 17, 225-228.
- Csizmazia, Gy. (1984): Summary of the results in Tisza-research obtained during the year 1982. — *Tiscia* 19, 221-226.
- Csizmazia, Gy., Homonnay, S., Kolosváry, G. and Nógrádi, S. (1966): Neuere Daten zur Fauna des Tisza-ales. — *Tiscia* 2, 83-88.
- Csoknya, M. (1973): Experimental investigation of the respiration of nymphs of *Palingenia longicauda* Oliv. (Ephemeroptera). — *Tiscia* 8, 47-51.
- Csoknya, M. and Ferencz, M. (1972): A study of *Palingenia longicauda* Oliv. in the zoobenthos of the Tisza and Maros (Ephemeroptera). — *Tiscia* 7, 47-57.
- Csoknya, M. and Ferencz, M. (1975): Data to the horizontal and vertical distribution of the zoobenthic fauna of the Tisza region at Szeged. — *Tiscia* 10, 45-50.
- Csoknya, M. and Halasy, K. (1974): Data on the distribution of mayfly larvae (Ephemeroptera). — *Tiscia* 9, 71-75.
- Csoknya, M. and Halasy, K. (1975): Experiments for determining the oxygen consumption of nymphs of *Palingenia longicauda* (Ephemeroptera). — *Tiscia* 10, 51-54.
- Csongor, Gy. (1980): Zoltán Jósza (1914-1980). — *Tiscia* 15, 7-8.
- Djukic, N. (1988): Eutrophication of the dead Theiss indicated by Oligochaeta. — *Tiscia* 23, 61-64.
- Djukic, N. and Maletin, S. (1989): *Limnodrilus hoffmeisteri* Claparede, 1862 as a dominant species in the Tisza dear-arm (Curug-Biserno Ostrvo) Oligochaeta community. — *Tiscia* 24, 43-47.
- Djukic, N., Maletin, S. and Miljanovic, B. (1993): Oligochaeta community as indicator of eutrophication in lower stream of river Tisza. — *Tiscia* 27, 49-52.
- Djukic, N., Maletin, S., Pujin, V., Ivanc, A., Kojcic, K. and Miljanovic, B. (1994): Ecological assessment of water quality of the Tisza by physico-chemical and biological parameters. — *Tiscia* 28, 37-40.
- Dobler, E. (1987): Seasonal changes of phytoplankton in the backwater Bokros. — *Tiscia* 22, 3-12.
- Dobler, E. and Kovács, K. (1981): On the diatoms, chlorophyll-a and phaeophytin-a in sediments of the Tisza and its tributaries. — *Tiscia* 16, 93-111.
- Dobler, E. and Kovács, K. (1982): Biological water quality in the Mártély and Körtvélyes backwaters of the Tisza from 1976 to 1980, with special regard to phytoplankton changes. — *Tiscia* 17, 67-88.
- Dobler, E. and Kovács, K. (1984): Results of the preliminary investigations on the alga communities in the backwater of the Tisza at Alpár. — *Tiscia* 19, 59-68.
- Dobler, E. and Schmidt, A. (1980): Weitere vergleichende Beiträge zur Kenntnis limnologischer Verhältnisse der Donau und Theiss. — *Tiscia* 15, 45-51.
- Dosztál, I. (1974): Comparative study of the water-bug (Hydrocorisae) populations of a dead-arm of the Tisza and some sodic waters. — *Tiscia* 9, 77-82.
- Dózsa, J. (1990): From the life of Tisza-research working committee, which has become international. Dr. István Kiss 1910-1990. — *Tiscia* 25, 83-86.
- Dukic, N. and Stanojevic, M. (1983): Physikalisch-chemikalische Eigenschaften und die Oligochaetenfauna der Theiss. — *Tiscia* 18, 59-63.
- Erdei, M. (1979): Nutrition-biological investigation into the red fox population living in the flood plain of the Tisza-Maros. — *Tiscia* 14, 217-224.
- Erdei, Zs. and Tóthmérész, B. (1993): MULTI-PATTERN 1.00. Program package to analyze and simulate community-wide patterns. — *Tiscia* 27, 45-48.
- Erdei, Zs., Tóthmérész, B. and Erdei, A. (1994): Linear algorithm to calculate indirect spatial statistics for completely random multi-species communities. — *Tiscia* 28, 67-72.
- Estók, B. (1980): Sediment investigations carried out in the longitudinal section of the Tisza and in the mouth of its major tributaries for establishing the presence of faecalindicator bacteria. — *Tiscia* 15, 27-34.
- Estók, B. (1981): Faecal indicator bacteria of the sediment in the Tisza and the mouths of its greatest tributaries. — *Tiscia* 16, 75-82.
- Estók, B. and Andrik, P. (1977): The bacteriological investigation of the Tisza in the stretch between Cigánd and Kisköre in 1975. — *Tiscia* 12, 11-15.
- Estók, B. and Milinki, E. (1989): Changes in the quality of water in Laskó stream and the storage lake built on it at Egerszalók. — *Tiscia* 24, 11-22.
- F. Kemenes, K. and M. Horváth, M. (1979): Investigation into the water quality of the Tisza from Csongrád till Tiszasziget. — *Tiscia* 14, 7-17.
- Farkas, Á. (1977): Pisces fauna of the Tisza dead-arm at Körtvélyes. — *Tiscia* 12, 101-108.
- Farkas, Á. (1982): Ichthyological relations of Körtvélyes dead channel in Mártély landscape protection area. — *Tiscia* 17, 191-197.
- Farkas, Á. (1989): Changes in the fish population of the intermitently closed Tisza-dead-arm. — *Tiscia* 24, 69-77.
- Fekete, E. (1984): Study on the heavy metals having effect on the water biocenoses in the backwaters at Alpár and Lakitelek. — *Tiscia* 19, 3-15.
- Ferencz, M. (1965): Beiträge zur Fischfauna der Tisza. — *Tiscia* 1, 67-68.
- Ferencz, M. (1968): Vorstudium über die vertikale Verteilung des

- Zoobenthos der Theiss. — *Tiscia* 4, 53-58.
- Ferencz, M. (1969): Occurrence of *Hypania invalida* (Grube) in the Tisza (Annelida, Polychaeta). — *Tiscia* 5, 69-71.
- Ferencz, M. (1974): Data on the horizontal and vertical distributions of the zoobenthos of the Tisza. — *Tiscia* 9, 65-69.
- Ferencz, M. (1981): Studies on the zoobenthos in the longitudinal section of the Tisza: Oligochaeta, Polychaeta fauna. — *Tiscia* 16, 161-168.
- Fintha, I. (1979): Revision of the home distribution of *Wolffia arrhiza* (L.). — *Tiscia* 14, 71-79.
- Fodor, I. (1984): The floristic and geobotanical relations of the Black Tisza-valley. — *Tiscia* 19, 151-156.
- Fodor, S. S. and Jancó, L. I. (1986): *Helianthus decapetalus* L. in the Tisza river basin. — *Tiscia* 21, 39-44.
- Fodor, S. S., Komendar, V. I., Sherban, M. I. and Duninski, T. T. (1983): On the upper flow of the river Tisza. — *Tiscia* 18, 53-57.
- From the life of the co-operative: a conference on the subject of Tisza-research. — *Tiscia* 6, 129-143.
- From the life of Tisza-research working committee, which has become international. Dr. Dániel Gál. — *Tiscia* 23, 131-132.
- Fügedi, K. and Fekete, E. (1980): Heavy-metal investigation into the water- and bottom-sediment samples of the river Tisza. — *Tiscia* 15, 9-17.
- Fügedi, K. and M. Horváth, M. (1982): Water quality in Körtvélyes backwater. — *Tiscia* 17, 15-27.
- Gajin, S., Gantar, M., Matavulj, M., Obrecht, Z. and Erbeznik, M. (1988): The dominant bacteri flora in the water of the river Tisza and the Mrtva Tisza (Yugoslavia). — *Tiscia* 23, 37-42.
- Gajin, S., Gantar, M., Matavulj, M., Petrovic, O., Obrecht, Z., Radnovic, D. and Budakov, L. (1992): Microbiological indicators of the water quality of Backwater Tisza with special reference to the oligotrophic microflora. — *Tiscia* 26, 43-48.
- Gajin, S., Petrovic, O., Gantar, M. and Matavulj, M. (1986): Microbiological examination of the Carska bara swamp water. — *Tiscia* 21, 45-53.
- Gajin, S., Petrovic, O., Matavulj, M., Gantar, M. and Radnovic, D. (1990): Vertretung der erdöl- und phenolabbauenden Bakterien im Theisswasser. — *Tiscia* 25, 15-19.
- Gál, D. (1971): Die Rhizopodenfauna der ungarischen Strecke der Theiss und des Mündungsteiles ihrer Nebenflüsse. — *Tiscia* 6, 31-40.
- Gál, D. (1972): Dr. Andor Horváth (1913-1972). — *Tiscia* 7, 3-4.
- Gál, D. (1972): Rhizopodenfauna der Theissstrecke über der im Bau begriffenen II. Theissstufe. — *Tiscia* 7, 29-35.
- Gál, D. (1981): Studies on the benthic Testacea fauna in the longitudinal section of the Tisza. — *Tiscia* 16, 131-140.
- Gál, D. (1982): Quantitative und qualitative saisonmäßige Veränderung des Zooplanktons im Altwasser der Theiss bei Körtvélyes im Zeitraum von 1971 bis 1976. — *Tiscia* 17, 131-142.
- Gál, D. (1986): Die saisonalen Veränderungen des Zooplanktons im Altwasser der Theiss bei Tiszaalpár während der Jahre 1981-83. — *Tiscia* 21, 55-67.
- Gallé, L., sen. (1965): Über das Vorkommen der *Parmelietum conspersae criscicum* Flechten-assoziaton in der ungarischen Tiefebene. — *Tiscia* 1, 33-39.
- Gallé, L., sen. (1966): Lichen associations from the inundation areas of Tisza in Hungary and Yugoslavia. — *Tiscia* 2, 25-40.
- Gallé, L., sen. (1966): Lichen flora of the forty years old Botanical Garden in Szeged. — *Tiscia* 2, 41-46.
- Gallé, L., sen. (1967): Lichens of the arboretum at Tiszakürt and its surroundings. — *Tiscia* 3, 21-26.
- Gallé, L., sen. (1968): Die quantitativen Relationen der Epiphyton- und Epixyl-flechtenarten an den Überschwemmungsgebieten der Theiss. — *Tiscia* 4, 21-35.
- Gallé, L., sen. (1973): Die Flechtenvegetation der Eschenbaumstämme längs der Theiss. — *Tiscia* 8, 41-42.
- Gallé, L. (1966): Ecological and zoocenological investigation of the Formicoidea fauna of the flood area of the Tisza river. — *Tiscia* 2, 113-118.
- Gallé, L. (1967): Ecological and zoocenological conditions of the Formicidae fauna at Tiszakürt. — *Tiscia* 3, 67-73.
- Gallé, L. (1969): Myrmecological investigations in the environs of Kisköre. — *Tiscia* 5, 87-95.
- Gallé, L. (1972): Formicidae populations of the ecosystems in the environs of Tiszafüred. — *Tiscia* 7, 59-68.
- Gallé, L. (1975): Factors stabilizing the ant populations (Hymenoptera: Formicidae) in the grass associations of the Tisza basin. — *Tiscia* 10, 61-66.
- Gallé, L. and Gausz, J. (1968): Data for knowledge of the entomology of the Upper-Tisza district. (Orthoptera and Formicoidea). — *Tiscia* 4, 83-101.
- Gallé, L., Györfy, Gy. and Hornung, E. (1982): Flood as an ecological perturbation of epigeic animal communities. I. Some preliminary hypotheses on the application of catastrophe theory by evaluating some Mártély-Körtvélyes data. — *Tiscia* 17, 155-162.
- Gallé, L., Margóczy, K., Kovács, Györfy, Gy., Körmöczy, L. and Németh, L. (1995): River valleys: Are they ecological corridors?. — *Tiscia* 29, 53-58.
- Garovnikov, B. and Popovic, E. (1985): Ormithofauna of Carska bara swamp. — *Tiscia* 20, 127-133.
- Gaskó, B. (1982): Cerambycid beetles developing on the willow, *Salix alba* in Körtvélyes. — *Tiscia* 17, 143-154.
- Gausz, J. (1969): Faunistical and ecological investigations of Orthoptera in the region of the Middle-Tisza (Kisköre). — *Tiscia* 5, 55-68.
- Gausz, J. (1971): Ecological and coenological investigations of Orthoptera in the environs of Poroszló. — *Tiscia* 6, 57-66.
- Gausz, J. (1971): Faunistical and ecological observations on the Orthoptera fauna of the Hungarian Plain. — *Tiscia* 6, 67-80.
- Gorzó, Gy. (1965): An explanation of the capacity of orientation of birds. — *Tiscia* 1, 109-110.
- Györi, Z. and Végvári, P. (1981): Physical and chemical conditions in the sediment of the Tisza and its tributaries. — *Tiscia* 16, 13-43.
- Gyovai, F. (1989): Demographic analysis of the moor frog (*Rana arvalis wolterstorffi* Fejérváry 1919) population in *Fraxino pannonicae-Alnetum* of the Tisza basin. — *Tiscia* 24, 107-121.
- Guti, G. (1996): Species composition of juvenile (0+) fish assemblages in the Szigetköz floodplain of the Danube. — *Tiscia* 30, 49-54.
- Hamar, J. (1971): Effect of the waste-water of sugar-works on natural history of the river Zagyva. — *Tiscia* 6, 109-128.
- Hamar, J. (1973): Data on the knowledge of zooflagellata of the river Tisza. — *Tiscia* 8, 33-40.
- Hamar, J. (1976): Data to the bacteriological and algological conditions of the region of Kisköre river barrage. — *Tiscia* 11, 41-44.
- Hamar, J. (1976): About the algae of the Kisköre river barrage and environs. — *Tiscia* 11, 45-58.
- Hamar, J., Bancsi, I., B. Tóth, M. and Végvári, P. (1976): Data to the hydrobiology of the middle and lower Tisza river region. — *Tiscia* 11, 67-75.
- Hamar, J. (1976): Bacteriological and algological investigation of the bay at Abádszalók (Kisköre reservoir). — *Tiscia* 11, 85-92.
- Hamar, J. (1976): Investigation of bacterio- and phytoplankton in the experimental area of Abádszalók at the Kisköre river barrage. — *Tiscia* 11, 111-114.
- Hamar, J. (1977): Data on knowledge of the blue-green alga *Anabaenopsis raciborskii* Wolosz. — *Tiscia* 12, 17-20.
- Hamar, J. (1977): Data on the summer algal flora of dead-arms in the vicinity of Tiszafüred. — *Tiscia* 12, 21-36.
- Hamar, J. (1979): Zooflagellates from the water storage area of Kisköre (Hungary). — *Tiscia* 14, 139-145.
- Hamar, J. (1979): Some new zooflagellates from Hungary. — *Tiscia* 14, 147-162.

- Hamar, J. and Bancsi, I. (1976): Diurnal plankton investigation in an experimental area, in the reach of the Kisköre river barrage. — *Tiscia 11*, 125-128.
- Hamar, J. and Borbély, Gy. (1981): Assessment of the heterotrophic activity of sediment and water in the Tisza and its tributaries. — *Tiscia 16*, 83-92.
- Harka, Á. (1972): Data of the fish population in the living Tisza. — *Tiscia 7*, 79-85.
- Harka, Á. (1974): Study of the fish population in the region of the second series of locks on the Tisza (1970-1973). — *Tiscia 9*, 125-143.
- Harka, Á. (1975): Investigations of the relation between body length and body weight of the pike-perch (*Lucioperca lucioperca* L.) in the Tisza stretch at Tiszafüred. — *Tiscia 10*, 77-80.
- Harka, Á. (1977): Growth of pike-perch (*Lucioperca lucioperca* L.) in the Tisza stretch at Tiszafüred. — *Tiscia 12*, 109-115.
- Harka, Á. (1980): Relation between body weight and body length of the wels or wallers (*Silurus glanis* L.) in the Tisza reaches at Tiszafüred. — *Tiscia 15*, 103-106.
- Harka, Á. (1983): Growth of pike (*Esox lucius* L.) in the section of the Tisza river at Tiszafüred. — *Tiscia 18*, 105-114.
- Harka, Á. (1984): New member in the fish fauna of the river Tisza: the balon stickleback (*Gimmocephalus baloni* Holcik et Hensel 1974). — *Tiscia 19*, 179-182.
- Harka, Á. (1985): Ichthyological and piscatorial problems at the Kisköre water basin. — *Tiscia 20*, 117-126.
- Harka, Á. (1989): Growth of carp (*Cyprinus carpio* L.) in the Kisköre storage lake. — *Tiscia 24*, 79-86.
- Harka, Á. (1990): Growth of different forms of carp (*Cyprinus carpio* L.) in Kisköre storage-lake. — *Tiscia 25*, 59-64.
- Harka, Á. (1992): Changes in the growth of pike perch (*Stizostedion lucioperca*) in the area of Lake-Tisza. — *Tiscia 26*, 9-12.
- Harka, Á. and Pintér, K. (1990): Systematic status of Hungarian bullhead pout: *Ictalurus nebulosus pannonicus* ssp. n. — *Tiscia 25*, 65-73.
- Havranek, L. and Molnár, H. (1965): Preliminary report on the Arachnoidea-fauna of the Tisza-valley. — *Tiscia 1*, 93-107.
- Hegedűs, M., Fodré, Zs. and Zsigó, M. (1980): Hygienic bacteriological investigations in the Tisza reaches between Csongrád and Szeged (1975-1978). — *Tiscia 15*, 35-44.
- Hegedűs, M., Fodré, Zs. and Dobler, E. (1990): Bacteriological quality of the fresh waters in the region of the lower Tisza in the period 1977-1986. — *Tiscia 25*, 21-29.
- Hegedűs, M. and Kajáry, I. (1985): Water quality of the Tisza river and the Alpár backwater. — *Tiscia 20*, 3-12.
- Hegedűs, M., Kiss, P. and Berényi, L. (1979): Salmonellae in the surface waters of Csongrád county. — *Tiscia 14*, 25-39.
- Hegedűs, M., Lévai, I., Fodré, Zs. and Zsigó, M. (1983): Communal hygienic and bacteriological conditions of the river-bank baths along surface waters in Csongrád county. — *Tiscia 18*, 13-21.
- Hegedűs, M. and Zsigó, M. (1981): Changes in the *Clostridium* count of the sediment in the longitudinal section of the Tisza. — *Tiscia 16*, 65-73.
- Hegedűs, M. and Zsigó, M. (1982): Hygienic bacteriological investigations of the backwaters at Mártély and Körtvélyes. — *Tiscia 17*, 29-49.
- Homonnay, S., Iharos, G., Kolosváry, G., Sterbetz, I. and Vasvári, M. (1965): Zoologische Ergebnisse der Tiszaforschungen aus dem Jahre 1962. — *Tiscia 1*, 71-80.
- Horváth, A. (1966): About the mollusks of Tisza before the river control. — *Tiscia 2*, 99-102.
- Horváth, A. (1969): Prof. Dr. Gabriel Kolosváry. — *Tiscia 5*, 3-13.
- Horváth, A. (1972): Aquatic mollusca fauna of the flood area and dead arms of the Tisza. — *Tiscia 7*, 37-46.
- Horváth, I. (1974): In memoriam Prof. Péter Beretz. — *Tiscia 9*, 5-6.
- Horváth, I. (1978): Dr. Rezső Vámos (1913-1977). — *Tiscia 13*, 3-5.
- Horváth, I., Bodrogekőzy, Gy. and Marián, M. (1973): Results and tasks of the fifteen years old Tisza Research. — *Tiscia 8*, 3-8.
- Horváth, I. and Margóczy, K. (1979): Region reconstruction of the Tisza dead-arm at Lakitelek on the basis of the ecological investigations performed in Töserdő. — *Tiscia 14*, 89-104.
- Ilosvay, Gy. (1977): Effect of urbanization on the herpetofauna of a settlement at the Tisza (Szeged). — *Tiscia 12*, 123-130.
- Ivanc, A., Maletin, S., Djukic, N. and Miljanovic, B. (1994): Ecophysiological interpretation of hematology of different Percidae species in the River Tisza. — *Tiscia 28*, 53-56.
- Janisch, M. (1973): Occurrence of the ringed snake of peculiar shape and designs along the Upper Tisza. — *Tiscia 8*, 95.
- Járdán, Cs., Gallé, L. and Margóczy, K. (1993): Ant assemblage composition in a successional Hungarian sand dune area. — *Tiscia 27*, 9-15.
- Jósa, Z. (1974): Effect of town waste-water on the development of Ciliata plankton in the Szolnok section of the Tisza. — *Tiscia 9*, 53-63.
- Jósa, Z. (1981): Studies on the Ciliata fauna of sediment samples from the Hungarian reach of the Tisza. — *Tiscia 16*, 141-154.
- Kamarás, G. (1969): Data to the autumn mushroom flora in the inundation area of the Tisza in the neighbourhood of Szeged. — *Tiscia 5*, 49-53.
- Karabasil, D. and Bukurov, D. (1994): A contribution to the study of the cause and distribution of Minamata disease in the lower course of the River Tisza. — *Tiscia 28*, 57-62.
- Károlyi, Z. (1978): The history of water management in the central Tisza region. — *Tiscia 13*, 7-25.
- Katona, S. (1976): Some results of the chemical investigations of the river Tisza in 1974. — *Tiscia 11*, 34-39.
- Keresztes, T. and M. Horváth, M. (1977): Investigation into the 2,4-D accumulation of water-plants. — *Tiscia 12*, 71-76.
- Keve, A. (1973): Rolle der Theiss und ihre Nebenflüsse im Zug der Vögel der Ostkarpaten. — *Tiscia 8*, 61-64.
- Keve, A. and Sage, B. L. (1966): Ornithological observations near the rivers Bodrog and Tisza. — *Tiscia 3*, 91-92.
- Kiss, B. J. and Sterbetz, I. (1973): Comparative data of the nutrition of grebes (Podicipidae) at the Tisza. — *Tiscia 8*, 65-70.
- Kiss, I. (1975): Mass-production occurrence of the *Botrydium* species in the inundation areas of the Tisza and Maros in the environs of Szeged. — *Tiscia 10*, 39-44.
- Kiss, I. (1977): Investigation of the water blooms of *Eudorina elegans* in the dead-arm of the river Tisza at the community Mártély. — *Tiscia 12*, 37-47.
- Kiss, I. (1977): Variability of *Scenedesmus ecornis* (Ralfs) Chod. in the dead-arm of the river Tisza at Körtvélyes. — *Tiscia 12*, 49-56.
- Kiss, I. (1978): Algological investigations in the dead-Tisza at Lakitelek-Töserdő. — *Tiscia 13*, 27-47.
- Kiss, I. (1978): Occurrence of *Synura uella* Ehr. var. *tiszaensis* n. var. in the dead arm of the river Tisza near Lakitelek. — *Tiscia 13*, 49-54.
- Kiss, I. (1979): Algological investigations in the dead arm of the river Tisza at Tiszaalpár and Tiszaug. — *Tiscia 14*, 41-61.
- Kiss, I. (1979): Seltene *Strombomonas*-arten aus den toten Armen der Tisza (Theiss) am mittleren und oberen Flusslauf. — *Tiscia 14*, 63-70.
- Kiss, I. (1982): The algal flora and its seasonal aspects in the Körtvélyes and Mártély backwaters of the Tisza. — *Tiscia 17*, 51-65.
- Kiss, I. (1983): *Microcystis* type planococcus state of *Anabaena* in the temporarily alkalized Tisza river. — *Tiscia 18*, 23-31.
- Kiss, I. (1983): The role of seasonal, edaphic and biotic factors in the development of phytoplankton communities in the Cibakháza backwater of the Tisza. — *Tiscia 18*, 33-46.
- Kiss, I. (1984): Algological investigations in the waters of the Tisza basin at Alpár. — *Tiscia 19*, 49-58.

- Kiss, I. (1985): The development of striking algal mass productions at the Alpár-basin region of the Tisza-valley. — *Tiscia* 20, 13-28.
- Kiss, J., K. Fügedi, K. and H. Mészáros, M. (1983): Effect of irrigation water polluted with different chemicals on cultivated plants II. Effect of motor-oil and sodium-salt of 2,4-D. — *Tiscia* 18, 9-12.
- Kiss, I., Marián, M. and Horváth, I. (1978): Effect of the antropogeneous pollution on the Tisza and its tributaries. — *Tiscia* 13, 163-168.
- Kiss Keve, T. (1974): Effect of the turbidity of the water on the development of algal associations in the Tisza. — *Tiscia* 9, 9-24.
- Kiss Keve, T. (1983): Characteristic phytoplankton communities in the dammed up section of the Tisza river and the Eastern main canal. — *Tiscia* 18, 47-52.
- Kiss Keve, T. (1984): Relationship between the chemical oxygen demand, suspended matter content and algal count in the Eastern main canal (Hungary). — *Tiscia* 19, 39-48.
- Kiss Keve, T. and Szabó, A. (1975): Longitudinal profile investigation in the Tisza and eastern main Channel I. Quantitative changes in phytoplankton. — *Tiscia* 10, 3-14.
- Kojcic, K., Pujin, V. and Bugarski, R. (1988): Changes of some physico-chemical and saprobiologic characteristics in the lower course of Theiss in the period 1980-1986. — *Tiscia* 23, 21-28.
- Kolosváry, G. (1965): Opilioniden aus dem nördlichen Tiszatal. — *Tiscia* 1, 111-113.
- Kolosváry, G. (1966): Die Opilioniden des Reservates "Sasér" bei der Theiss. — *Tiscia* 2, 119.
- Kolosváry, G. (1966): Über Ökologie der Weberknechte der Inundationsräume der Theiss. — *Tiscia* 2, 121-125.
- Kolosváry, G. and Homonnay, S. (1967): Weitere zoologische Beobachtungen im nördlichen Tiszatal. — *Tiscia* 3, 75-81.
- Kolosváry, G. (1968): Über die Bryozoen der oberen Theiss vom 716. bis 740. Fluss-kilometer. — *Tiscia* 4, 79-81.
- Kolosváry, G. (1968): Über die 16 jährige Geschichte unserer zoologischen Inundationsgebietforschungen im Theisstal. — *Tiscia* 4, 139-145.
- Kolosváry, G. (1969): Opilioniden der oberen und mittleren Tisza-gegend. — *Tiscia* 5, 79-81.
- Komendar, V. I. (1984): Phytocenological characteristics of the White-Tisza Valley. — *Tiscia* 19, 137-149.
- Komendar, V. I. and Szabados, V. I. (1986): On ecology and some biological features of *Leucojum aestivum* L. in flooded oaklands of Transcarpathia. — *Tiscia* 21, 31-38.
- Komendar, V. I. and Fodor, I. (1980): Aquatic plants of middle range of river Tisza and its tributaries. — *Tiscia* 15, 53-59.
- Komendar, V. I. and Fodor, S. S. (1987): Studies on the upper timber line of different forest types in the Carpathians. — *Tiscia* 22, 55-60.
- Kostic, D. and Maletin, S. (1988): Arrangement and number of radial channels on the scales of prussian carp (*Carassius auratus gibelio* Bloch) from the dead Theiss — Biserno Ostrvo. — *Tiscia* 23, 115-122.
- Kovács, A. and Maletin, S. (1986): Tisza water, as irrigation water, polluted with various compounds. — *Tiscia* 21, 25-29.
- Kovács, K. (1986): Seasonal composition, biomass and primary productivity of the phytoplankton in Lakitelek backwater during 1980 and 1983. — *Tiscia* 21, 3-12.
- Kovács, K. and Dobler, E. (1984): Studies on the qualitative and quantitative composition and the seasonal changes of phytoplankton at three sampling areas of the dead Tisza at Lakitelek. — *Tiscia* 19, 69-78.
- Kovács, S. T. (1982): Data to the knowledge of Lepidoptera fauna at Mártély-Körtvélyes environment protection area. I. — *Tiscia* 17, 163-173.
- Kovács, S. T. (1984): The phenological and ecological relations of the *Acentria nivea* Olivier, 1971 (Lepidoptera: Acentropidae) in the backwaters at Mártély-Körtvélyes. — *Tiscia* 19, 165-172.
- Kovács, S. T. (1986): Data to the knowledge on the Lepidoptera fauna at Bodrogzug. — *Tiscia* 21, 89-94.
- Kozma, A. and Tölgyesi, Gy. (1979): Plant associations of flood plains along the middle Tisza and their agricultural utilization. — *Tiscia* 14, 105-122.
- Körmöczy, L. (1996): 30 years of the ecological journal *Tiscia*. — *Tiscia* 30, 55-64.
- Krausz, K., Pápai, J. and Gallé, L. (1995): Composition of Orthoptera assemblages in grassland habitats at Lower-Tisza flood plain. — *Tiscia* 29, 47-52.
- Kricsfalusi, V. V. and Komendar, V. I. (1985): Ecological and biological features, ways of protection and regeneration of the natural area of *Narcissus angustifolius* Curt. in the basin of the Tisza river. — *Tiscia* 20, 99-110.
- Kricsfalusi, V. V., Komendar, V. I., Mező-Kricsfalusi, G. N., Szabados, V. I., Feszénka, S. S. and Sumszkaja, N. V. (1987): Study of reproduction biology of some rare plant species in the upper Tisza valley. — *Tiscia* 22, 61-73.
- Lantos, G. (1986): Data to the Amphipoda and Isopoda fauna of Töserdő and its environs in the Tisza valley I. Amphipoda, Asellota (Crustacea, Peracarida). — *Tiscia* 21, 81-87.
- László, F. and Berta, E. (1981): Heavy metals in sediment samples taken along the longitudinal section of the Tisza. — *Tiscia* 16, 45-54.
- Legány, A. (1966): Vergleichende ornithologische Untersuchungen an drei Altwässern entlang der Tisza. — *Tiscia* 3, 93-103.
- Legány, A. (1966): Ein Beitrag zur Säugetierfauna des mittleren Tiszatales im oberen Pleistozän. — *Tiscia* 3, 105.
- Legány, A. (1971): Data to the ornithological conditions of the inundationarea Tiszafüred-Kisköre. — *Tiscia* 6, 41-55.
- Legány, A. (1974): Ornithological investigations in some biotops of the Upper-Tisza inundation area. — *Tiscia* 9, 115-124.
- Legány, A. (1978): Data on the bird stock of the flood-plain at Tiszafüred. — *Tiscia* 13, 157-161.
- Legány, A. (1980): The comparative ornithological investigation into the flood-plain meadow at Tiszalök and Rakamaz. — *Tiscia* 15, 107-118.
- Legány, A. (1983): The ornithological investigation on the forests of "Tiszadob flood basin" nature conservation area. — *Tiscia* 18, 125-133.
- Legány, A. (1986): Ornithological investigations at the area of the Kisköre water basin (Tisza II). — *Tiscia* 21, 105-116.
- Legány, A. (1989): Method for assessment of different territories from the nature conservation point of view. — *Tiscia* 24, 123-129.
- Legány, A., Kónya, J. and Vértes, I. (1977): Data on the avifauna of the Tisza region in Szatmár-Bereg. — *Tiscia* 12, 131-139.
- Lövei, G. (1979): The autumn migration of the blackcap (*Silvia atricapilla* L.) in the Danube-bend. — *Tiscia* 14, 197-207.
- M. Horváth, M. and F. Kemenes, K. (1979): Water investigations of the Triple-Körös. — *Tiscia* 14, 19-23.
- Magyar, L. (1982): Feeding ecological investigations in the district of the nature conservation-area Mártély-Körtvélyes. — *Tiscia* 17, 199-206.
- Maletin, S. and Budakov, L. (1983): Growth of some species of fishes in the Tisza river. — *Tiscia* 18, 115-119.
- Maletin, S. and Budakov, L. (1986): Growth and fecundity of *Carassius auratus gibelio* Bloch, 1783 in Mrtva Tisza. — *Tiscia* 21, 95-104.
- Maletin, S., Dukic, N. and Kostic, D. (1989): The growth and fecundity of *Lepomis gibbosus* (Pisces: Centrarchidae) in the Tisza dead-arm (Curug-Biserno Ostrvo). — *Tiscia* 24, 95-101.
- Maletin, S., Djukic, N. and Kostic, D. (1992): Fecundity of phytophil fish species in "Backwater Tisza" (Biser Island). — *Tiscia* 26, 13-24.



- Maletin, S., Djukic, N. and Miljanovic, B. (1992): Heavy metal content in fish from "Backwater Tisza" (Biser Island). — *Tiscia* 26, 25-28.
- Maletin, S., Djukic, N., Stojanovic, S., Ivanc, A., Zderic, M., Matic, A., Andric, B., Radak, L. and Miljanovic, B. (1994): Meliorative effect of grass carp (*Ctenopharyngodon idella*) in controlling aquatic macrophytes in the Tisza valley. — *Tiscia* 28, 41-45.
- Maletin, S. and Kostic, D. (1988): The growth of silver carp (*Hypophthalmichthys molitrix* Val.) in the dead Theiss. — *Tiscia* 23, 123-129.
- Maletin, S. and Kostic, D. (1989): Fish growth rate in the Tisza dead-arm (Curug-Biserno Ostrvo) depending on the type of nutrition. — *Tiscia* 24, 87-93.
- Malik, E. (1989): Inclusions in the liver cells of silver carp (*Hypophthalmichthys molitrix* Val.) from the Kisköre storage-lake. — *Tiscia* 24, 103-106.
- Mandrik, V. J. and Pavlina, E. I. (1987): Morphological properties of some *Rosa canina* L. populations in the upper Tisza valley. — *Tiscia* 22, 75-81.
- Margóczy, K. (1993): Comparative analysis of successional stages of sandy vegetation — a case study. — *Tiscia* 27, 3-8.
- Margóczy, K. (1995): Interspecific associations in different successional stages of the vegetation in a Hungarian sandy area. — *Tiscia* 29, 19-26.
- Marián, M. (1967): Zoologische Aufklärungsreise im Mündungsgebiet der Tisza. (Herpetologische und ornitologische Beobachtungen). — *Tiscia* 3, 83-90.
- Marián, M. (1968): Uferschwalbenkolonien (*Riparia riparia* L.) bei den Mittel- und Unterläufen der Tisza. (Die Uferschwalben des Theisstales I.). — *Tiscia* 4, 127-138.
- Marián, M. (1972): *Tisciana Hungarica* 1957-1969. — *Tiscia* 7, 89-92.
- Marián, M. (1974): Prof. Péter Beretzk (1894-1973). — *Tiscia* 9, 3-5.
- Marián, M. (1974): From the publications of Dr. Péter Beretzk. — *Tiscia* 9, 6-8.
- Marián, M. (1974): *Tisciana Hungarica* Series 1970-1972. — *Tiscia* 9, 157.
- Marián, M. (1975): The part of flood in the formation of the avifauna in the flood area of the Tisza. — *Tiscia* 10, 85-88.
- Marián, M. (1977): Effect of floods on the Amphibia-Reptilia fauna living in the flood-plain of the Tisza and their regeneration. — *Tiscia* 12, 117-121.
- Marián, M. (1977): On the activity of the Tisza-research working committee in 1976. — *Tiscia* 12, 145-147.
- Marián, M. (1978): On the activity of the Tisza-research working committee in 1977. — *Tiscia* 13, 169-174.
- Marián, M. (1979): Work-conference on evaluating the work on the area of the Kisköre reservoir and its environment. — *Tiscia* 14, 225-228.
- Marián, M. (1980): Report of the activity of the Tisza-research working committee in 1979. — *Tiscia* 15, 151-153.
- Marián, M., Bankovics, A., Bogdán, I. and Lőrincz, I. (1978): Some ecological characteristics of the bird stock of Töserdő. — *Tiscia* 13, 141-149.
- Marián, M. and Puskás, L. (1973): Quantitative Untersuchung der Singvogelpopulation (Passeriformes) des Überschwemmungsgebietes der Theiss (Tisza). — *Tiscia* 8, 71-77.
- Marián, M. and Puskás, L. (1982): Ecological and quantitative relations of the bird community in the holm Körtvélyes. — *Tiscia* 17, 207-218.
- Maróti, P. (1971): About the oribatid fauna of the Tisza basin (Oribatida, Acari). — *Tiscia* 6, 81-88.
- Matavulj, M., Gajin, S., Erbeznic, M., Bokorov, M. and Petrovic, O. (1988): Phosphatase activity of water as a parameter of the river Tisza water monitoring. — *Tiscia* 23, 29-36.
- Mező-Kricsfalusi, G. N., Kricsfalusi, V. V. and Komendar, V. I. (1989): Studies on the population biology of *Ornithogalum umbellatum* L. (Liliaceae) for elaboration strategy of the species survive in Transcarpathia. — *Tiscia* 24, 3-10.
- Mihály, A. V. and Komendar, V. I. (1993): The state of population of *Crocus banaticus* J. Gay in the Transcarpathian region of the Tisza valley. — *Tiscia* 27, 61-63.
- Mikes, M. (1988): Tisza-research conference XVIII (1987). — *Tiscia* 23, 133-139.
- Mikes, M. and Habijan-Mikes, V. (1985): Coenotic relations of small mammals along the river Tisza. — *Tiscia* 20, 135-143.
- Molnár, Gy. (1980): Investigation into the nest colonies and nesting behaviour of the starling (*Sturnus vulgaris* L.) in the flood plain of the Tisza. — *Tiscia* 15, 119-124.
- Molnár, Gy. (1984): Niche studies in the stock of starling (*Sturnus v. vulgaris* L. 1758). — *Tiscia* 19, 183-194.
- Molnár, Gy. (1986): Data to the phenology of starling (*Sturnus v. vulgaris* L. 1758). — *Tiscia* 21, 117-122.
- Molnár, Gy. (1990): On food composition of four heron species. — *Tiscia* 25, 75-82.
- Molnár, Zs. (1996): Vegetation history of the Kardoskút area (SE. Hungary) II.: The lake Fehér-tó in the last 200 years. — *Tiscia* 30, 27-34.
- Molnár, Zs. and Biró, M. (1996): Vegetation history of the Kardoskút area (S.E. Hungary) I.: Regional versus local history, ancient versus recent habitats. — *Tiscia* 30, 15-25.
- Nagy, I. (1976): Management of water-supplies in the Tisza river basin. — *Tiscia* 11, 3-9.
- Nemes, I. (1971): Bird-coenological investigations in the inundation area of the Maros. — *Tiscia* 6, 95-100.
- Nosek, J. N. and Bereczky, M. Cs. (1994): The effect of some environmental factors on Protozoa populations of the River Danube. — *Tiscia* 28, 29-36.
- Obradovic, M. (1971): Verbreitung der Arten *Plantago schwarzenbergiana* Schur., *Vicia biennis* L. und *Astragalus contortuplicatus* L. in der Vojvodina. — *Tiscia* 6, 25-29.
- Obradovic, M. and Budak, V. (1979): Research into flora of the southern part of the Tisa basin. — *Tiscia* 14, 123-130.
- Obradovic, M., Bózsza, P. and Budak, V. (1983): Some flora features of the southern portion of the Tisza river region. — *Tiscia* 18, 64-69.
- Papp, J. (1965): Der Wurmlattich (*Helminthia echioides* Gärt.) auf den Tonböden der Wiesen im Tiszagebiet. — *Tiscia* 1, 41-45.
- Papp, J. (1965): Das Arboretum in Tiszakürt. — *Tiscia* 1, 47-54.
- Parabucski, S., Stojanovic, S., Butorac, B., Vuckovic, M., Pekanic, V., Crncevic, S. and Bózsza, P. (1988): Vegetation of the lower Tisza river. — *Tiscia* 23, 13-19.
- Paraschivescu, D. (1993): Ecological studies on ants and their commensal insects. — *Tiscia* 27, 29-31.
- Pécsi, T. and Kiss, K. (1969): Occurrence and distribution of *Urnatella gracilis* Leidy (Kamptozoa) in the Eastern Main Canal (Hungary). — *Tiscia* 5, 83-86.
- Penksza, K., Barczy, A., Benyovszky, B. M., Möseler, B. M., Birkenheuer, V. and Szabó, T. (1995): Relationship between vegetation and soil on the northeastern slope of the Fehérszirt (White cliff) of Kesztölc. — *Tiscia* 29, 3-10.
- Petrov, I. Z. (1993): Some remarks on the foraging strategy in *Cataglyphis aenescens* Nyl. (Hymenoptera, Formicidae). — *Tiscia* 27, 23-28.
- Petrov, B. and Cvetković, D. M. (1996): Seasonal dynamics of *Triops cancriformis* (Bosc, 1801) (Crustacea, Branchiopoda) in the Banat province in Yugoslavia. — *Tiscia* 30, 39-43.
- Popovic, E. and Mikes, M. (1988): Infestation of tailless amphibians of genus *Rana* by trematodes in the valley of the Tisza river (Yugoslavia). — *Tiscia* 23, 77-85.
- Popovic, E., Simic, S. and Tallósi, B. (1992): Food analysis of some *Rana* species in the habitat of Carska bara (YU). — *Tiscia* 26, 1-3.
- Pujin, V. (1988): Developments in the composition of biocenosis

- in the lower Tisza river (Yugoslavia), caused by hydrological changes. — *Tiscia* 23, 43-49.
- Pujin, V. (1992): Comparative data on the composition of zooplankton in the part of the river Danube and river Tisza in Vojvodina (Yugoslavia). — *Tiscia* 26, 49-57.
- Pujin, V., Djukić, N., Maletin, S., Miljanović, B. and Ivanc, A. (1996): Changes of zoocenotic structure in lower reach of river Tisza. — *Tiscia* 30, 35-38.
- Pujin, V. and Maletin, S. (1987): Diet of prussian carp (*Carassius auratus gibelio* Bloch) in the Carska bara. — *Tiscia* 22, 93-98.
- Pujin, V., Ratajac, R. and Djukic, N. (1984): Zusammensetzung und Dynamik des Zooplanktons und der Bodenfauna des unteren Theisslauf. — *Tiscia* 19, 79-87.
- Pujin, V., Ratajac, R. and Djukic, N. (1986): Ein Beitrag zur limnologischen Untersuchungen der Carska bara. — *Tiscia* 21, 69-80.
- Pujin, V., Ratajac, R., Djukic, N., Svircev, Z. and Kilibarda, P. (1987): Saisonmässige Variationen der Zusammensetzung des Planktons und der Bodenbesiedlung in der Carska Bara (Jugoslawien). — *Tiscia* 22, 83-91.
- Pujin, V. and Ratajac, R. (1988): Structure and dynamics of zooplankton in the dead Theiss. — *Tiscia* 23, 51-59.
- Pujin, V. and Stanojevic, M. (1979): Hidrobiologiske Untersuchungen des unteren Theisslauf. — *Tiscia* 14, 131-138.
- Ratajac, R. (1989): The composition and the dynamics in population of the dominant Crustacea species in Mrtva Tisza. — *Tiscia* 24, 49-57.
- Ratajac, R. (1992): The structure and dynamics of Cladocera in the Yugoslavian section of the river Tisza. — *Tiscia* 26, 59-61.
- Sárosataki, M. and Györfy, Gy. (1995): Spatial and temporal variation of the leafhopper (Cicadina) assemblages associated with *Hieracium pilosella* in Hungary. — *Tiscia* 29, 37-40.
- Sárosataki, M. and Fazekas, J. P. (1995): Ecological characteristics of bee communities on a sandy grassland. — *Tiscia* 29, 41-46.
- Schmidt, E. (1973): Zur Ökologie des Sprosses (*Luscinia luscinia* L.) in der Theiss-auen bei Tiszatelek, nach seiner Ankunft im Frühling. — *Tiscia* 8, 79-81.
- Schmidt, A. (1992): A second discovery of *Scenedesmus grahneisii* (Heynig) Fott in Hungary. — *Tiscia* 26, 63-65.
- Schmidt, E. and Sipos, G. (1971): Kleinsäugerfaunistische Angaben aus dem Hernádbecken auf Grund der Gewölluntersuchungen der Schleiareulen (*Tyto alba* (Scop.)). — *Tiscia* 6, 101-108.
- Sey, O. (1966): Contributions to knowledge of the internal parasites of muskrat (*Ondatra zibethica* L., 1766) living along the river Tisza. — *Tiscia* 2, 89-95.
- Sey, O. (1968): Trematodes from birds living along the Tisza. — *Tiscia* 4, 59-68.
- Sey, O. (1968): Cestodes from birds living along the Tisza. — *Tiscia* 4, 69-78.
- Simic, S., Tallósi, B. and Popovic, E. (1992): Seasonal changes in feeding of *Rana ridibunda* Pallas (Amphibia: Anura) from Backwater Tisza. — *Tiscia* 26, 5-7.
- Simic, S. and Vujic, A. (1987): The syrphid fauna (Diptera) of the Tisza basin in Yugoslavia. — *Tiscia* 22, 121-127.
- Sterbetz, I. (1969): Moulting ecological problems of wild-ducks in the Tisza basin. — *Tiscia* 5, 73-78.
- Sterbetz, I. (1972): Occurrence of pygmy cormorants in the Tisza flood areas at Csongrád-Hódmezővásárhely. — *Tiscia* 7, 87-88.
- Sterbetz, I. (1977): The rook (*Corvus frugilegus* L., 1758) in the nesting community of the herony at Sasér. — *Tiscia* 12, 141-144.
- Sterbetz, I. (1978): Circulation in materials, induced by the colony of the rooks (*Corvus frugilegus* L., 1758) at Sasér, in the period of reproduction. — *Tiscia* 13, 151-155.
- Sterbetz, I. (1980): The food basis of rooks (*Corvus frugilegus* L., 1758) wintering in the nature reserve at Mártély and Sasér. — *Tiscia* 15, 125-129.
- Sterbetz, I. (1983): Wintery alimentation of wintering mallard masses on the reach of Tisza at Szentcsanak-Hódmezővásárhely between 1971-1980. — *Tiscia* 18, 121-123.
- Sterbetz, I. (1984): Kcalory demand of the heron colonies in the Hungarian Tisza-valley. — *Tiscia* 19, 195-199.
- Sterbetz, I. (1984): The migrant mollusc (*Dreissena polymorpha* Pall.) as the aliment of natatorial birds at the Tisza-valley. — *Tiscia* 19, 201-204.
- Szabados, M. (1965): *Uroglena hungarica* nov. spec. Szabados. — *Tiscia* 1, 55-57.
- Szabados, M. (1966): Data to the knowledge of the microorganisms of the Jugoslav reaches of Tisza and the "Danube-Tisza canal". — *Tiscia* 2, 3-11.
- Szabados, M. (1966): Das Leben der Tisza. Protisten: Flagellaten. — *Tiscia* 2, 13-24.
- Szabó, A. and Kiss Keve, T. (1977): Summer longitudinal section investigations in the Tisza and the Eastern main channel II. Quantitative changes in the zooplankton. — *Tiscia* 12, 85-91.
- Szabó, J. (1974): Quantitative and qualitative characterization of the avifauna of the Maros-side (1965-1967). — *Tiscia* 9, 145-155.
- Szalma, E. and Bodrogekőzy, Gy. (1985): Phytocenology of *Wolffietum arrhizae* Miyaw. et J. Tx. 60. Element content of its species components as well as sediment- and water samples. — *Tiscia* 20, 45-53.
- Szalma, E. and Lévai, O. (1987): Seasonal dynamics and structural changes in the cenoses belonging to the Phragmitetea association class at lake Sulymos. — *Tiscia* 22, 13-29.
- Széll, J., K. Balogh, I. and H. Mészáros, M. (1983): Effect of irrigation water polluted with different chemicals on cultivated plants I. Weed killing effect of chlorbromuron and that of herbicides mixtures on species Gramineae. — *Tiscia* 18, 3-8.
- Szépfolusi, J. (1971): Water-chemical investigations in the Csongrád-Szeged reaches of the Tisza. — *Tiscia* 6, 3-18.
- Szitó, A. (1973): Data on the *Chironomus* fauna of the flood area of the Tisza at Tiszafüred-Kisköre. — *Tiscia* 8, 43-45.
- Szitó, A. (1974): Quantitative and qualitative study of Chironomida larvae on the section of the Tisza between Tiszafüred and Kisköre. — *Tiscia* 9, 83-85.
- Szitó, A. (1978): Benthos investigations in the Tisza stretch between Tiszafüred-Kisköre. — *Tiscia* 13, 97-98.
- Szitó, A. (1981): Environmental factors influencing the abundance of chironomid larvae. — *Tiscia* 16, 191-203.
- Szitó, A. and Botos, M. (1988): Macrozoobenthos in the river Tisza and its influents. — *Tiscia* 23, 65-75.
- Szitta, T. (1979): Data on the small-mammalia fauna of Tiszakarád and its environs. — *Tiscia* 14, 209-216.
- Tallósi, B. and Sekulic, R. (1988): The Carabidae (Coleoptera) fauna on the sodic soils of the Tisza valley (Yugoslavia). — *Tiscia* 23, 87-95.
- Tanács, L. (1975): The Apoidea (Hymenoptera) of the Tisza-dam. — *Tiscia* 10, 55-60.
- Tanács, L. (1979): Regeneration of the Apoidea insect fauna in the flood area, as a function of the ecological conditions. — *Tiscia* 14, 175-185.
- Tanács, L. (1979): Protected areas of the flood plain of the lower-Tisza region, their Apoidea insect population and the connections of these with nutritive plants. — *Tiscia* 14, 187-196.
- Tanács, L. (1987): The trend of the composition of the wild-bee population on anthropogenic effects in the biotopes of the Kisköre storage-tank region at the Tisza-valley. — *Tiscia* 22, 109-119.
- Tomanović, Ž., Brajković, M., Krnić, M. and Stanisavljević, Lj. (1996): Seasonal dynamics, parasitization and colour polymorphism of the pea aphid, *Acyrtosiphon pisum* (Harris) (Aphididae, Homoptera) on alfalfa in the south part

- of the Pannonian area. — *Tiscia* 30, 45-48.
- Tóth, L. (1973): Investigation of composition of the fish population in backwaters belonging to the area of water-basin II of the Tisza. — *Tiscia* 8, 53-59.
- Tóth, S. (1966): Ein Beitrag zur Libellen-fauna des Tisza-ales. — *Tiscia* 2, 103-106.
- Tóth, S. (1966): Neue Angaben zur Dipterafauna des Theiss-ales. — *Tiscia* 2, 107-114.
- Tóth, S. (1969): Data to the Trypetidae fauna of the Tisza-valley (Diptera). — *Tiscia* 5, 97-105.
- Tóth, S. (1974): Odonata fauna of the area of the second series of locks on the Tisza. — *Tiscia* 9, 87-97.
- Tóth, S. (1975): Tabanidae fauna in the area of the Tisza II River Barrage. — *Tiscia* 10, 67-76.
- Tóth, S. (1977): Quantitative and qualitative investigations into the Culicidae-fauna of the Tisza-basin. — *Tiscia* 12, 93-99.
- Tóth, S. (1979): Preliminary investigation into the Syrphidae fauna of the Tisza-valley. — *Tiscia* 14, 163-174.
- Tóthmérész, B. (1993): DivOrd 1.50: A Program for Diversity Ordering. — *Tiscia* 27, 33-44.
- Tóthmérész, B. (1994): DivOrd 1.60. Diversity ordering: finite and infinite samples. — *Tiscia* 28, 63-65.
- Tóthmérész, B. and Erdei, Zs. (1995): New features of MULTIPATTERN 1.10: robust nonlinear smoothing. — *Tiscia* 29, 33-36.
- Tölgyesi, Gy. (1983): Element composition of plants on the inundation areas of the river Tisza between Tivadar and Tiszaszalka. — *Tiscia* 18, 77-84.
- Tölgyesi, Gy. and Kozma, A. (1983): Taxonomic and ecological comments relating macro- and micro-element concentrations in plant species of inundation area. — *Tiscia* 18, 71-75.
- Tölgyesi, Gy. and Kozma, A. (1984): Mineral substances of aquatic and terrestrial vegetation in the storage tank at Kisköre. — *Tiscia* 19, 157-163.
- Tuba, Z. (1995): Overview of the flora and vegetation of the Hungarian Bodrogköz. — *Tiscia* 29, 11-17.
- Uherkovich, Á. (1967): Die Tagfalter des Tisza-ales. — *Tiscia* 3, 57-65.
- Uherkovich, Á. (1968): Beiträge zur Verbreitung der Tagfalter im Tisza-tal. — *Tiscia* 4, 103-109.
- Uherkovich, Á. (1973): Neuere Beiträge zur Kenntnis der Grossschmetterlinge des Theiss-ales, mit besonderer Rücksicht auf die Umgebung von Tiszafüred. — *Tiscia* 8, 83-93.
- Uherkovich, G. (1966): Theiss-forschung 1957-1966. — *Tiscia* 2, 131-141.
- Uherkovich, G. (1967): Neue und seltenere Algen aus der Theiss (Tisza) und zwei Altwässer der Theiss. — *Tiscia* 3, 3-11.
- Uherkovich, G. (1967): Über das Sommerplankton des Altwassers von Mártély. — *Tiscia* 3, 13-20.
- Uherkovich, G. (1968): Limnologische Forschungen in den Einzugsgebieten der Flüsse Sajó und Bodrog. — *Tiscia* 4, 3-10.
- Uherkovich, G. (1968): Über verschiedene Typen der Algenmassenvermehrung in der Tisza (Theiss). — *Tiscia* 4, 11-20.
- Uherkovich, G. (1969): Über das Phytoseston der eutrophierten Theiss (Tisza) I. Beobachtungen im Juli 1968. — *Tiscia* 5, 37-47.
- Uherkovich, G. (1971): Über das Phytoseston der eutrophierten Theiss (Tisza) II. Zur Frage der Indikatoralgen für den eutrophierten Flusszustand. — *Tiscia* 6, 19-24.
- Uherkovich, G. (1972): Taxonomische und ökologische Übersicht der Chrysophyten-organismen der Theiss. — *Tiscia* 7, 13-28.
- Uherkovich, G. (1975): Taxonomisch-ökologische Übersicht der Chlorophyten-, Rhodophyten-, Schizomycophyten- und Mycophyten-organismen der Theiss (Tisza) und ihrer Nebengewässer. — *Tiscia* 10, 15-37.
- Uherkovich, G. (1978): Beiträge zur Kenntnis über das Vorkommen der *Scenedesmus*-arten in Ungarn III. Daten aus Südgarn. — *Tiscia* 13, 55-70.
- Vámos, R. (1974): Questions of the utilization of the dead-arms of the Tisza for fishing purposes. Problems caused by pollution. — *Tiscia* 9, 25-41.
- Vámos, R. and Tasnádi, R. (1972): Die ökologischen Faktoren des durch H<sub>2</sub>S und Ammoniak bedingten Fischsterbens. — *Tiscia* 7, 5-12.
- Váncsa, A. L. (1977): Tychoplanktonical algal associations of the Sajó. — *Tiscia* 12, 57-64.
- Váncsa, A. L. (1978): Results of the algological investigation of the Sajó bed stretch below Miskolc in 1976. — *Tiscia* 13, 71-81.
- Váncsa, A. L. (1981): Qualitative and quantitative studies on the "non-diatom" algae of sediment samples collected in the longitudinal section of the Tisza. — *Tiscia* 16, 113-130.
- Váncsa, A. L. (1984): Biological water quality of the Tisza between Tokaj and Tiszafüred (on the basis of studies carried out between the period 1971-1980). — *Tiscia* 19, 21-38.
- Vásárhelyi, I. (1965): Fische von Sárszög. — *Tiscia* 1, 65-66.
- Vásárhelyi, I. (1965): Amphibien von Sárszög. — *Tiscia* 1, 69.
- Végvári, P. (1976): Factors, natural fundamentals, and artificial effects determining the hydroecological state of the river Tisza. — *Tiscia* 11, 11-16.
- Végvári, P. (1976): Water motion in the river Tisza and its connection with the suspended matter content in 1974. — *Tiscia* 11, 17-20.
- Végvári, P. (1976): Hydrochemical conditions of the river Tisza 1. Mineral content and ion-dynamism on the basis of the investigations in 1973 and 1974. — *Tiscia* 11, 21-25.
- Végvári, P., Hamar, J., Bancsi, I. and B. Tóth, M. (1976): Hydroecological investigations in the bay of the future Kisköre reservoir at Abádszalók. — *Tiscia* 11, 77-83.
- Virágh, K. (1994): Spatial aspects of vegetation dynamics induced by herbicide disturbances in a Hungarian loess grassland community. — *Tiscia* 28, 3-13.
- Virágh, K. and Bartha, S. (1996): The effect of current dynamical state of a loess steppe community on its responses to disturbances. — *Tiscia* 30, 3-13.
- Vuckovic, M., Stojanovic, S., Stankovic, Z., Zderic, M., Kilibarda, P., Radak, L. and Radulovic, S. (1994): Quantitative presence of macrophytes in basic channel network of hydrosystem Danube-Tisza-Danube. — *Tiscia* 28, 25-28.
- Waijandt, J. (1989): Influence of the waste-water of Szolnok on the water quality of the Tisza river. — *Tiscia* 24, 23-34.
- Waijandt, J. (1990): Water quality of the Tisza river at Szolnok in the period 1970-1988. — *Tiscia* 25, 3-13.
- Wollemann, M. (1980): Spectrogram analysis of the night heron (*Nycticorax nycticorax* L.) calls at the heronry of Labodár. — *Tiscia* 15, 131-137.
- Wollemann, M. (1984): Spectrogram analysis of different calls at the heronry of Labodár. — *Tiscia* 19, 205-210.
- Woyciechowski, M. (1993): Ants (Hymenoptera, Formicidae) of the glades in the Tatra Mts. (the Carpathians). — *Tiscia* 27, 17-22.
- Zicsi, A. (1965): Beiträge zur Lumbriciden des Tisza-ales. — *Tiscia* 1, 59-62.
- Zsuga, K. (1981): Benthic Entomostraca fauna of the Tisza and its tributaries. — *Tiscia* 16, 183-190.