

THE ANTECEDENTS OF THE TISZA RESEARCH

K. Bába

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Abstract. Regular and coordinated research work on the Tisza valley started in 1955, but there were several initiations in the previous decades in the framework of the 'Great Hungarian Plain Research Concept'. This paper gives a brief summary of these antecedents, and comprises a short literature on Tisza research.

K. Bába, Department of Biology, Gy. Juhász Teacher Training College, Szeged, Hungary

At a regular meeting of the Biological Society of Szeged in 1954 Prof. Gábor Kolosváry warned that the issue of launching the Tisza Research program could not be the subject of further debate and hesitation. The Principal Hydrological Committee of the Hungarian Academy of Sciences set up a Tisza Committee in 1955. Following two consecutive scientific expeditions on the river in 1956 and 1957, a one-day Tisza conference was held on 30 November 1957. Gábor Uherkovich considers that day the beginning of the Tisza Research, although the actual research work started in 1955 already and the Tisza Research Committee had its first assembly on 10 January 1958. In the period between 1954 and 1958 the committee's main tasks were organization preparations for studies, raising funds and finding appropriate personnel. Thus it is quite understandable that the beginnings of this research program could be treated superficially - merely by listing the names of persons involved - in a lecture on the history and perspectives of the Tisza Research given by Gábor Kolosváry in 1957. In this paper, the antecedents will be discussed in brief.

The idea of a Tisza Research program emerged from the major concept of the Great Hungarian Plain Research. The principal initiator of the latter was the Hungarian Geographic Society. Lajos Lóczy and Jenő Cholnoky gave a program and established the Great Hungarian Plain Committee at two successive meetings held at Kecskemét and Szeged in 1907 and 1909, respectively. The city of Szeged continued to be the centre of the planning and organization of the Great Hungarian Plain Research in the future as well. The program received a renewed impetus when the University of Kolozsvár was moved to Szeged in 1921. In addition to this, Béla Farkas emphasized the need for a better understanding of the life of the

Tisza river in 1922, and Zoltán Szilády urged on an institutional Tisza research in his work titled "The Fauna of the Great Hungarian Plain" published in 1925. The Great Hungarian Plain Research Committee was set up at Szeged in 1927 and their program was published in the Journal "Föld és Ember". However, this committee was not a long-lived one. In 1940 the Ferenc József University was moved back to Kolozsvár, thus no central organization remained for the co-ordination and financing of the Great Hungarian Plain studies. When the New University of Szeged was founded on 11 November 1940, it was included into its program, that special emphasis should be laid on science and on the study of the Great Hungarian Plain and the river Tisza, areas quite neglected until then.

The Great Hungarian Plain Research Committee was re-established by Károly Kogutovicz. Its financial basis - 43 000 pengő (the currency of Hungary at that time) - was donated by the Hemp Processing Factory of Szeged. In the meantime, Zoltán Szilády repeatedly called for the zoological exploration of the Tisza in his paper "The standardization of zoological studies" published in 1941.

Due to personal conflicts the committee work resumed in 1943 only, when the Ministry of Religion and Public Education appointed Lajos Bartucz to be the director of the Great Hungarian Plain Research Institute. He founded a state-organized institute and requested plans from numerous experts all over the country. The plans were discussed in committees of professionals and were prepared for publication in two volumes. It is not known, if these documents still exist today, as only one volume was printed in the first Yearbook of the Great Hungarian Plain Research Institute in 1946.

Perhaps it was the result of Szilády's appeal, or the product of personal motivations, that several comprehensive works dealing with the Tisza and its tributaries were published between 1925 and 1943. The most important among these were the monographs on mollusks in the environs of Szeged and on the Great Hungarian Plain written by Rotarides and Czóglér, on the fluvial mollusks of the Maros and Tisza rivers by the same authors, on the fishery in the Tisza valley by Kolosváry, on the vertebrates of Szeged by Béla Farkas, on the limnology of dig-out pits along the Tisza by László Varga, on precipitation properties of the Tisza by Hajósi, on the protists of the Tisza by Jolán Stiller, József Gelei and Béla Párducz, on the life of riparian spiders along the Tisza by Kolosváry, on the floodplain beetle fauna of the river Maros by Erdős, on the plankton of the rivers Tisza and Maros by Károly Wellich, on the mollusks in the Tisza by Andor Horváth, and on the plankton of the Tisza by János Megyeri. In 1942 István Szalay published his work titled "Contributions to the knowledge of the phytoplankton of the Körös rivers".

In his 1943 paper "Few notes on the zoological investigation of the Great Hungarian Plain" Béla Farkas was the first to assign the task of collecting and studying the terrestrial fauna of the Great Hungarian Plain and the Tisza for the University's Animal Taxonomy Department. He emphasized that in addition to the pure scientific interest, national concerns also give grounds for a comprehensive study of the river Tisza, as fishery plays a considerable role in the country's economy. In his program he considered hydrographical and hydrobiological studies especially important. Investigations on water current, spring-floods, water temperature, suspended load and river-bed properties, and their relevance to parasitological conditions, public health and agriculture were also felt to be crucial. He expressed the need for a Tisza Biological Research Institute as well. The commitment of his institute to the exploration of the Tisza is best shown by several publications of the personnel. Among these he mentioned the 1938 paper by Károly Wellich titled "On the periodic changes of the plankton in the Tisza" and the work by Géza Zilahi Sebess on the biology of the Californian scale insect. Two of his own results were cited. One was the discovery of the dwarf catfish in the river. The other was finding an association between the occurrence of swift trout in the Tisza and the exemption of the fish from the fluke *Distomum micheri*. This was because the water chemistry in the lower Tisza reaches kills the vermin, as he explained. Responding to the call by Lajos

Bartucz in 1943, several plans appeared for the scientific study of the Great Hungarian Plain and the Tisza. Ambrus Ábrahám dealt with the zoological tasks, honorary lecturer József Szentiványi outlined the complete Great Hungarian Plain Research, while Bálint Zólyomi - also honorary lecturer staying at Szeged then - made plans for the phytogeographical and palynological studies. Several comprehensive treatises were published as well. Among geologists, István Mihácz and Mária Faragó discussed the freshwater limestone and the suspended and dissolved load of the Tisza. The heath-moths of the Great Hungarian Plain were treated by Szentiványi, while Miksa Szalai worked on the rivers fish fauna. Here it should be noted, that in his plan Szentiványi emphasized the importance of seasonal investigations and the need for increasing the number of protected areas.

The first Tisza study scheme truly independent of the Great Hungarian Plain Research was prepared by Dr. Adorján Kesselyák in 1945. This was printed in the Yearbook of the Great Hungarian Plain Research Institute in 1946. The Hungarian Academy of Sciences approved the plan in 1950 and commissioned Kesselyák to the biological study of the Tisza. He was donated by a barge for his work.

Between 1945 and 1950 a short treatise was published by Margit Szabados (1949) titled "The hydrobiological study of surface waters of Carpato-Ukraine". In 1952 Dr. János Megyeri submitted a proposal to the Academy for investigations on the lower crayfish in the Tisza at Szeged.

Rezső Soó, member of the Academy, organized a Geobotanical Symposium in 1950, where the vegetation mapping of the Tisza between Szolnok and Szeged and a detailed survey of gallery forests were decided. This work was accomplished by Lajos Timár, and the resulting vegetation map (at the scale of 1:25 000) is held at the Botany Department of the University.

Before discussing Kesselyák's plan, which was probably the starting point of the later Tisza Research plan, a short biography of Adorján Kesselyák will be given. He was born in 1906. From 1929 he worked as the assistant of Lajos Méhely, then continued his studies in the Hesse and Schellenberg Institutes in Berlin between 1929 and 1931. From 1934 he was the assistant of professor Dudich, then he became an honorary lecturer in 1938. In 1939 he worked at the Zoological Research Station in Naples. In 1940 he was elected the head of the Zoology Department of the Teacher Training College at Szeged. For six months in 1945 he was also the head of the Animal Taxonomy Department of the University at Szeged. Between 1948 and 1949

he was appointed by the state to organize the new Zoological Department of the Bólyai University at Kolozsvár. He died of a heart attack in 1950 on the bank of the Tisza when he had just finished an 11-hours-long course given for correspondence students. His main research interest was terrestrial

and aquatic hog louses. He has discovered the occurrence of *Cardilophora caspia* in the Tisza.

Kesselyák's plan is shown and compared with the later Tisza Research program in Tables 1 and 2. His proposal can be divided into two main parts. The first one aims at exploring the region's hydrography

Table 1.

<p>A. Kesselyák's plan for a Tisza treatise</p> <p>I. Description of the catchment area research Geological, hydrographical, climatic and soil properties</p> <p>II. Hydrographical studies Landscape description, photo and painting documentation, Geographical description, history and river course changes, fluvial and eolic sediments, drainage of inland waters, irrigation history, shipping and trading.</p> <p>III. Hydrological studies statistical analysis of water level changes, speed of water current, suspended load, ability to work and utilizable energy, the origin of inorganic material (K, P, N), water chemistry of the river and the tributaries, temperature and light conditions, characteristics of ice formation and drift.</p>	<p>Published treatises</p> <p>The Hydrological Atlas of Hungary 7. The Tisza. 1958. Microclimate studies by M. Andó.</p> <p>Kolosváry, G. Photographic documentation and slide collection</p> <p>Mike, K.1991. Paleohydrology of Hungary and the history of surface waters.</p> <p>Lászlóffy, V.1982. Water regulations and water management in the Tisza and its tributaries (prepared with the participation of 76 researchers and 9 institutes)</p> <p>Andó, M.1994. The hydrological, geographical, geological and environmental components of the water level fluctuations in the Tisza.</p>
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Table 2.

<p>A. Kesselyák's plan for a Tisza treatise</p> <p>I. Description of the catchment area flora and fauna genesis in the catchment area, the relict marine fauna,</p> <p>IV. Potamobiology (the Tisza as a biological individual) studies on the turnover of matter (producers, consumers and decomposers) from taxonomical, ecological and genetical viewpoints.</p> <p>Subthemes: A/ producer plants: bacteria, algae and fungi B/ fauna of the Tisza (predicts the importance of vertebrates) B1/ relict marine fauna (from the Ponto-Caspian river system) B2/ dispersal and migration of river fauna B3/ the fish in the Tisza and their economical relevance B4/ the ethnography of fishing in the Tisza C/ decomposers in the Tisza (saprobionts and mineralization) D/ public health relations of the Tisza: pollution, self-purification, pathogene bacteria and parasites E/ communities of organisms in the Tisza (plankton, nekton, river bottom, oxbows, temporary water courses, springs and the tributaries. F/ matter turnover in the Tisza</p>	<p>The Tisza Research program</p> <p>I. The complex study of the Tisza's aquatic and riparian biota II. The protection of humans and their natural environment</p> <p>I.1. Studies on the algae of the Tisza 2. Limnological survey of the river, the flood area, oxbows, and the tributaries Seasonal plankton monitoring, model oxbow lake study 3. Investigations on the Tiscian fauna: river bank, digout holes, flood area, river bottom. 4. Microclimate studies Economical relevance: water saprobity, meadow- and forest management.</p> <p>II.1. The hydrological, botanical, zoological, geographical and microclimatological survey of the Tisza II. barrage system 2. Study of the Tisza Landscape Protection Area (Mártély-Sasér) 3. Study of the planned Tisza III. barrage system (Csongrád) 4. Influence of pesticides Economical relevance: landscape reconstruction, recreation, biological protection of dikes</p> <p>Organizations involved: three local Water Conservancy Directorates, the National Public Health Institute and the Principal Environmental Protection Authority for the Lower-Tisza Region.</p> <p>International relations: Collaboration with scientists from Carpatho-Ukraine, Rumania and the former Jugoslavia.</p>
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and hydrology. This includes the study of the geological, hydrographical, climatic and soil properties, as well as the historical circumstances and the influence of the river on shipping and trade. He also felt important the description of landscapes, thus Gábor Kolosváry prepared a six-volume photographic documentation and a slide collection on this.

The Tisza Research program was never granted with the opportunity of extending the Tisza Research Station. It originally worked with two scientists, later this was reduced to one, and finally the station was closed. Thus research areas having economical relevance became the tasks of other state organizations like the local Water Conservancy Directorates, the Public Health Institute and the principal environmental protection authorities. These state institutes were much better financed and employed a greater staff of professionals. Between 1958 and 1991 these organizations published several comprehensive works on the abiotic factors listed in Kesselyák's plan for the entire length of the Tisza. Mihály Andó's treatise appeared in 1994.

Concerning the river's potamobiological study, several new research areas opened up mostly from the seventies. Investigations became restricted to the Middle- and Lower Tisza Reaches as a result of the prevailing major landscape development plans of economical motivation. This area practically included the Tisza II. and the planned Tisza III. barrages, and two Landscape Protection Areas. In Kesselyák's plan, economical considerations were restricted to fishery and public health relations only. Later these were extended to water saprobity, meadow and forest management, recreation, landscape reconstruction, the biological protection of dikes and the effects of pesticide application. Most recently a need is emerging for the reconstruction of oxbow lakes along the Tisza to compensate for the ever increasing human influence in the river's full course.

Some fields received less attention than it was planned in Kesselyák's proposal, like the flora- and fauna genesis in the catchment area, the relict marine fauna, the influence of the Ponto-Caspian river-system, the microscopic fungi of the Tisza, and the general issues of matter turnover in the Tisza. At the same time, the Tisza Research became an international project with the involvement of neighbouring countries.

Comprehensive treatises dealing with several groups of organisms were published for the entire length or for certain reaches of the Tisza. The first was Zicsi's 1965 compilation on the Lumbricidae, and then on the Bryozoa and Opilionidae fauna. This

was followed by Gábor Uherkovich's 1971 book titled "Microscopic floating plants in the Tisza". László Gallé's 1976-77 synopsis on the lichen coenoses of Hungary also belongs to this group. These were followed in 1974-78 by papers on the plankton algae of the Main Eastern Canal, and on the algae of the rivers in Northern Hungary. Based on studies conducted in 1979, publications appeared in 1981 on the diatom and bacterium flora, the physical and chemical properties of the riverbed sediment, and on the mollusks of the Tisza and its tributaries. Synopses of the same sort were prepared for certain parts of the river as well dealing the following groups: bacteria, diatoms, Zooflagellata, Rhizopoda, Ciliata, Rotatoria, Entomostraca, Platyhelminthes, Lumbricidae, aquatic Oligochaeta, Polychaeta, Chironomidae, Orthoptera, Formicidae, wild bees, aquatic snails and mammals. For other animal groups (e.g. Rotatoria, Pisces, amphibians, reptiles, birds and terrestrial snails) comprehensive works were issued for the entire course of the river. Among these, birds and terrestrial snails have been already included in Kesselyák's plan under the headline of studies on fauna dispersal along the river.

More than one thousand publications appeared as results of the Tisza Research in the period between 1954 and 1995. Thus the literature cited below is far from being complete as it intends to illustrate the main trends only. Papers and treatises issued between 1957 and 1972 are listed in the references of the works by G. Kolosváry, G. Uherkovich and M. Marián.

As the above discussion reflected, 45 years of preparation between 1909 and 1954 had to precede the start of the regular Tisza Research. While the Great Hungarian Plain Research program had not realized, the Tisza Research was successfully launched. Another 40 years has elapsed since the start of the regular research. Perhaps it was due to financial problems, that the highly awaited comprehensive Tisza treatise has not been published yet. Thus we have only "snapshots" of an ever and more and more rapidly changing river and its valley.

This summary is closed with a quotation from István Széchenyi, which was the motto of the Great Hungarian Plain Research: "The past is out of our power, but we rule the future, do we. Let us to do so!"

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**FOISSNER, W., BERGER, H. AND KOHMANN, F. (1994):
TAXONOMISCHE UND ÖKOLOGISCHE REVISION DER CILIATEN
DES SAPROBIENSYSTEMS III: HYMENOSTOMATA,
PROTOSTOMATIDA, NASSULIDA. - INFORMATIONSDERICHTE
DES BAYER. LANDESAMTES FÜR WASSERWIRTSCHAFT 1/94, PP.
548.**

The 3rd volume of Foissner and collaborators is of 548 pages. It falls into four main chapters, literature and index, and was published in 1994 in a high standard similar to the former volumes.

Writers applied the structure known from the former books that after the introduction the first main chapter contains those general acknowledgements connected with the research of Ciliata (e.g. methods, ecological know-hows, statistical analyses etc.). Present volume introduces a saprobiological system as a base of biological water analysis, the possibility of application of Ciliata, and also the Pantle-Buck and Zelinka-Marvan indexes, are discussed.

Informations are given on the arrangements of water qualities of a river and on some cenological parameters such as abundance, dominance, frequency, constancy and presence. In the first three chapters are summarized these applied methods which are generally known by researchers of saprobiological water qualification. There is only one sentence perhaps, which I would argue about: "daß die Ciliaten in der Oligosaprobie und Betamesosaprobie nur eine geringe Rolle spielen". It is a fact, that the quantity of the degradable organic matter which can be utilized as food is less than in the more polluted, loaded sections, therefore consumers have smaller abundance but a betamesosaprob environment is rich in species and this richness betrays good water quality.

Nowadays, when the environment protection look for solution of more and more problems we cannot say, that Ciliata have no importance in this ecological dimension. The diversity of the living world of a river can be a measure and a start to solve water quality problems.

Species of the volume are members of the Hymenostomata subclass, as well as of Prostomatida and Nassulida orders. It was important already to publish such a new - documented book of these taxa, because this group of Ciliata includes such important indicator species as Colpidium, Paramecium, Frontonia, Coleps etc., as well as the small and hardly determinable Scuticociliata species.

The number of treated species is 72. The introduction of species is done on the usually cautious way, by which we can almost get acquainted with the history of the development of protozoological researches. From the early drawings to REM it was really a long and hard way, but results proved it being worth.

This, already 3rd volume can be perused by beginners and advanced protozoologists as well. The book is in German.

Subscription: Bayerisches Landesamt für Wasserwirtschaft, Lazarettstr. 67, D-80636 München.

M. Cs. Bereczky

RELATIONSHIP BETWEEN VEGETATION AND SOIL ON THE NORTHEASTERN SLOPE OF THE FEHÉR-SZIRT (WHITE CLIFF) OF KESZTÖLC

K. Penksza, A. Barczy, B. M. Benyovszky, B. M. Mösel, V. Birkenheuer and T. Szabó

Penksza, K., Barczy, A., Benyovszky, B. M., Mösel, B. M., Birkenheuer, V. and Szabó, T. (1995): Relationship between vegetation and soil on the northeastern slope of the Fehér-szirt (White cliff) of Keszölc. - Tiscia 29, 3-10.

Abstract. In 1993-1994, the forest vegetation of the northeastern slope of the Fehér-szirt (White Cliff) near Keszölc, Hungary, has been investigated by transect method. Along a 400 m transect, phytosociological relevés were taken in 20×20 m adjacent plots through the *Mercuriali-Tilietum* Zólyomi et Jakucs 1958, *Quercus petraeae-Carpinetum* Soó et Pócs (1931) 1957 and the *Melitti-Fagetum* Soó 1962. Along the transect studied specific soil parameters were analyzed: moisture content, bulk density, humus content, pH (H₂O and KCl), lime content (CaCO₃), nutrient regime (N,P,K), texture, 'sticky point according to Arany' (K_A) and hygroscopy. According to the phytosociological data, no clear-cut border can be drawn between the associations. Changes in the vegetation correlate with the physical properties of the soil: more mesophilous beech forest on the Humic Cambisol formed from loess with a higher water capacity and the hornbeam-oak forest on Chromic Cambisol formed from sandy parent material with a lower water capacity.

Keywords: Soil, vegetation, transect.

K. Penksza, Department of Botany and Plant Physiology, Agricultural University of Gödöllő, A. Barczy, Department of Soil Sciences and Agricultural Chemistry, Agricultural University of Gödöllő, B. M. Benyovszky, Department of Grassland Management, Agricultural University of Gödöllő, B. M. Mösel, Abt. Geobotanik, Inst. f. Landw. Botanik Universität Bonn, V. Birkenheuer, T. Szabó, Institute of Environmental and Landscape Management, Agricultural University of Gödöllő,

Introduction

The transect-method is very suitable for the investigation of two adjacent associations with continuous transitions without a clear line of demarcation (Van der Valk and Danis, 1976; Katona and Tóthmérész, 1984; Mészáros et al., 1981; Molnár, 1989; Tóthmérész, 1993). By that method, gradual changes in species composition of the vegetation due to specific ecological factors - i.e. altitudinal or humidity gradients - can be described (Whittaker, 1956; Whittaker and Niering, 1963; Auerbach and Shmida, 1993). Although these authors have used similar methods to investigate complete mountains, the transect method is useful for smaller areas as well. The present investigations

will examine the relationship between soil parameters and remarkable transitions of the White Cliff forest vegetation where the segregation of different associations are blurred (Kovács, 1964; Marrs and Proctor, 1979). These investigations will supplement previous studies on the relationship between soil and vegetation of the White Cliff of Keszölc by Kovács-Láng (1966, 1971) and Draskovits and Kovács-Láng (1968) which dealt with the rocky grasslands of the steep SW facing slope.

This study is directed to the question whether any relationship exists between soil and vegetation characteristics in adjacent forest associations where segregation borders are blurred.

Methods

The investigated area is the smaller part of the westernmost section (Kétágú-hegy) of the Pilis Mountains in Hungary (Bulla, 1962). Soil studies and vegetation analysis were carried out on its northeastern facing slope on 14 October 1993, 25 March, 28 April and 6 June 1994 (Fig. 1).

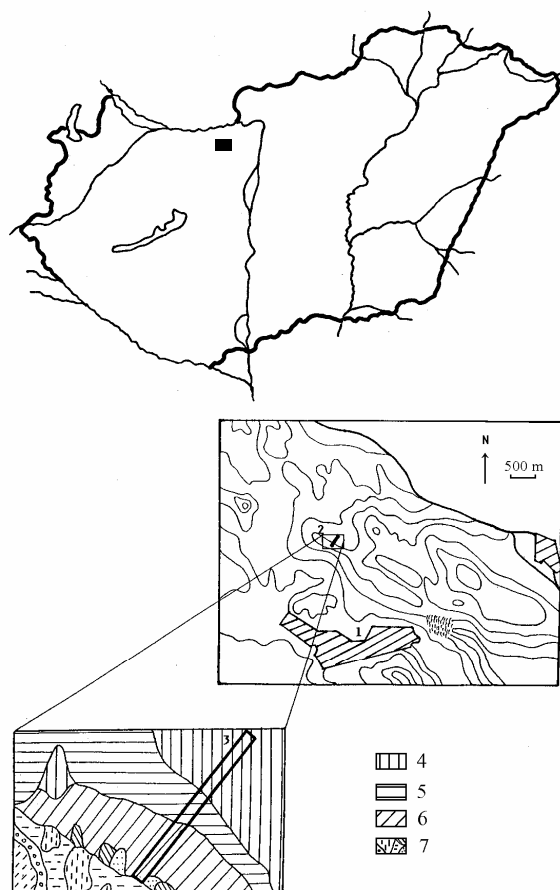


Figure 1. The investigated area. 1: Kesztlőc, 2: Fehér-szirt (White Cliff), 3: transect, 4: Melitti-Fagetum, 5: *Quercus petraea*-*Carpinetum* 6: *Mercuriali-Tilietum* 7: Grasslands and shrubforests complex

Close to the peak of the Fehér-szirt (White cliff) the *Orno-Quercetum* Horánszky, Jakucs et Zólyomi 1958 or the *Mercuriali-Tilietum* Zólyomi et Jakucs 1958 are found followed by *Quercus petraea*-*Carpinetum* Soó et Pócs (1931) 1957 and *Melitti-Fagetum* Soó 1962 on the lower slopes (Penksza, 1993).

On the northeastern slope of the hill it is noticeable that between 250 and 350 m asl. the *Melitti-Fagetum* is connected with the *Quercus petraea*-*Carpinetum* zone.

The phytosociological relevés were taken along a 400 m long transect consisting of 20 × 20 m adjacent plots (Whittaker, 1967; Krebb, 1983). The transect was placed across *Mercuriali-Tilietum*, *Quercus petraea*-*Carpinetum* and *Melitti-Fagetum*. Each species was documented by its cover percentage. The phytosociological table shows the mean cover of relevés in three dates.

The syntaxonomical ranks and nomenclature of the species are after Simon (1992). Mean W values were calculated according to Borhidi (1993). The syntaxonomical nomenclature is after Soó (1980), that of the soils is in accordance with Stefanovits (1956, 1961, 1992) and the FAO standards.

First the soils of the area were sampled using the Pürckhauer-sampler technique (Benzler et al., 1982), by which a 2-3 cm in diameter and 1 m long soil core was taken. This method is suitable for separating the genetic soil types, choosing the most characteristic sampling plots and a previous investigation of the selected plots. Apart from this, information on the thickness of the surface soil was obtained on the spot, too. Soil cores were taken in the phytosociological plots, more cores were taken in the contact zone between different soil types. These profiles were pre-investigated in the field, and the different layers were sampled for further analysis. Physical and chemical properties of soil samples were examined according to the prevalent standard (Buzás, 1988, 1993). The investigations included the following parameters: moisture content, bulk density, humus content, pH (H₂O and KCl), lime content (CaCO₃), nutrient regime (N,P,K), texture, 'sticky point' (according to Arany, K_A), hygroscoy.

Results

Table 1 contains the coverage values of the occurring species in the phytosociological relevés. The species are enumerated by cenological groups.

Fig. 2 shows species (including their cover values), which are restricted to certain associations. *Quercetea pubescentis-petraea* species which are characteristic species of the shrub forest and the xerophytic oak forest were found only in the first 6 plots and have higher cover-percentage only in the first 3 plots. *Geranium lucidum*, characteristic species of the *Mercuriali-Tilietum* association could only be found in relevés no. 3-5, probably the most typical strip of the association. *Tilia platyphyllos*, which is a characteristic tree species of the *Mercuriali-Tilietum* occurred in the hornbeam-oak forest (*Quercus petraea*-*Carpinetum*), as well. The other *Tilia* species, *Tilia cordata* which is

Table 1. Coverage values of occurring species in percentage

Relevés (no.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A																				
Querco-Fagetea species																				
Fraxinus excelsior	10	10	20	10	15	20		15	10	5										
Quercus petraea	20	15	10		20	5	10	30	10	5	5	10					10	5	10	
Acer campestre		5			15	15										15				
Tilia cordata									10		30	15	20	35	30	5	25	15	10	25
Acer platanoides												15							20	
Carpinion-Betuli species																				
Carpinus betulus						5	5			10	30	40								
Fagion medio-europaeum species																				
Tilia platyphyllos	30	30	25	40	30	25		5	10	40										
Quercetea pubescenti-petraeae species																				
Quercus pubescens	5												10							
Quercetalia pubescentis species																				
Quercus cerris	5					3		10	15											
Ceraso-Quercetum pubescentis species																				
Cerasus mahaleb	10	5																		
Fagetalia species																				
Fagus sylvatica		5											60	40	40	60	45	40	60	50
B																				
Quercetea pubescenti-petraeae species																				
Cornus mas	50	30	40	40	30	25	20	20		5										
Fagion medio-europaeum species																				
Tilia platyphyllos	10	10	10	15	10	5		10	30	10	10									
Querco-Fagetea species																				
Sorbus torminalis						3														
Staphylea pinnata					10			5	10	5	10	5	10	10	5	2	3	1	3	3
Lonicera xylosteum									5				5	3		3				
Acer platanoides									2		2	3		3		3	3	2		2
Tilia cordata								15	10	20	30	10		10	5	5	10			
Fraxinus excelsior							30	10	5	5	5									
Acer campestre							10	3						3						
Viburnum lantana														2						
Prunion spinosea species																				
Crataegus monogyna		5						5		5										
Fagetalia species																				
Fagus sylvatica													5							
Acer pseudo-platanus												5	2							
Ulmus glabra										5	5	5	2							
Sambucetalia species																				
Sambucus nigra													2							
Carpinion-Betuli species																				
Carpinus betulus							10										3	5		5
C																				
Querco-Fagetea species																				
Ficaria verna	5	1		12	18	12	15	15	15		2	2	2			5	2		3	20
Geum urbanum	3	1	1		2	1		1	1											
Veronica hederifolia	17	20	12	15	22	12	35	3	3		5									
Moehringia trinervia	15	15	10	9	4	4			2		2	2	2	5	2	3				
Alliaria petiolata	8	6	13	8	4	4	3	5	1	5	5	1	3		4	4	3	2	4	2
Geranium robertianum	8	11	8	13	12	18	12	16	10	23	33	16	4	1						
Cystopteris fragilis			3		5	2														
Bromus benekenii		7	10	4	7	2	6	5		1		2	2	2		2	2	5		5
Viola odorata	5	2	5	5	5		5	5	5	1								2		1
Lilium marthagon					1										1	2				1
Melica uniflora	10	32	27	35	15	5	30	25	22	5	5	5	3	5	5	5	5	5	3	5
Veratrum nigrum				11	2	2	1	1	5	1				1						
Poa nemoralis		7	5		4	1		1							2					
Galium schultzeii					5			2	3	3		5		1						

Table 1. Continued.

Relevés (no.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<i>Dactylis polygama</i>	27	7	9	10						3			3				1			
<i>Veronica chamaedrys</i>			2											3						
<i>Galium mollugo</i>	5																			
<i>Lapsana communis</i>	3																			
<i>Viola sylvestris</i>									2	2	2	2			4	4	3	2	5	
<i>Heracleum sphondylium</i>							1		2			3	2		3		3			
<i>Viola alba</i>														10	1	1	1	1	2	
<i>Melica nutans</i>													3	3	1				7	
<i>Campanula rapunculoides</i>													5	10	5				2	
<i>Lathyrus niger</i>																1				
<i>Brachypodium sylvaticum</i>															2					
<i>Mycelis muralis</i>													2							
<i>Scrophularia nodosa</i>									1								2	2		1
<i>Clematis vitalba</i>														1						
Fagetalia species																				
<i>Lamium maculatum</i>	15	13	13	9	30	30	12	20	8	33	31	16	2		10		5	10	5	13
<i>Mercurialis perennis</i>	13	5	15	5	9	9	12	5	8	5	2	3	23	22	13	8	4	22	20	20
<i>Corydalis cava</i>	2	4	4	3	12	3	7	17	22	3	12	15	1		3	5	5	12	7	15
<i>Corydalis solida</i>	10	7	4	3	7	3	15	7	5	12	7	5	1		3		2	4	4	4
<i>Isopyrum thalictroides</i>			1			1												1		
<i>Glechoma hirsuta</i>		12	15	13	15	13													10	20
<i>Gagea lutea</i>	3	8	15	12	6	5	8	5												
<i>Galanthus nivalis</i>	8	21	22	22	22	4	8	8	5	3				3			2	3	4	3
<i>Anemone ranunculoides</i>	3	3	3	4	2	2	3	3	5	2	5				3	5	5	3	3	5
<i>Hedera helix</i>	5	5	5		3			5	3	2	3	3	5	5	3	3	2		2	2
<i>Pulmonaria officinalis</i>			5	5										6	6	6	6	4	4	2
<i>Aconitum vulparia</i>			3																	
<i>Viola mirabilis</i>	5	5											1	1	2				3	
<i>Galium odoratum</i>					4			2		5	5	5	15	8	16	10	10	5	10	10
<i>Polygonatum multiflorum</i>		2	1				1	5	3	2	2	2	3			5	3	1	1	3
<i>Campanula trachelium</i>			1	1										1						
<i>Dentaria bulbifera</i>							5	5	5	4	8	7	10	8	13	18	10	4	12	8
<i>Asarum europaeum</i>							1				3	6	15	26	13	12	8	8	8	5
<i>Galeobdolon luteum</i>										13	12	15	5		5		13	13	8	12
<i>Arum maculatum</i>								3	4	3										
<i>Stachys sylvatica</i>												5							2	5
<i>Hordelymus europaeus</i>										2	5							2		3
<i>Lathyrus vernus</i>										2	3			3	5					
<i>Symphytum tuberosum</i>															3			5		
<i>Ranunculus auricomus</i>																				
Alliarion petiolatae species																				
<i>Chelidonium majus</i>	9		2	8	5	5	1													
<i>Chaerophyllum temulum</i>			12	12	18	42	30	5	5	7	30				6					
Quercetum pubescenti-petraeae species																				
<i>Cardaminopsis arenosa</i>	18	4	15	4		4														
<i>Arabis turrita</i>	10	5	5	1	2															
<i>Sedum maximum</i>	5																			
<i>Valeriana officinalis</i>	4																			
<i>Silene vulgaris</i>	3																			
<i>Pulmonaria mollissima</i>							3	1			3	7	6							
<i>Heracleum sphondylium</i>				1																
Seslerio-Festucion pallentis species																				
<i>Asplenium ruta-muraria</i>	5		5		5	2														
Fagion medio-europaeum species																				
<i>Geranium lucidum</i>	18		5	1	14															
Asplenio-Festucion pallentis species																				
<i>Polipodium vulgare</i>	9		15	1																
Quercetum petraeae-cerris species																				
<i>Campanula persicifolia</i>		5	5	1																
Festucetalia valesiatae species																				
<i>Carduus collinus</i>	5		2																	

Table 1. Continued.

Relevés (no.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Chenopodietea species																				
Melandrium album		3							2	2										
Stellaria media			20	5	5															
Ballota nigra		3	3	5																
Arctium lappa															2					
Bilderdikia convolvulus		2	2																	
Cirsium arvense									3	2										
Calystegietalia species																				
Galium aparine					5	5	12	15	20	10	10	6			5	4	8	28	8	18
Urtica dioica																				1
Quercetalia pubescentis species																				
Chrysanthemum corymbosum			2																	
Orno-Cotinetalia species																				
Oryzopsis virescens																				
Melittis melissophyllum								1					1	1	1	2				
Festuco-Brometea species																				
Muscari neglectum		2																		
Carpinion betuli species																				
Carex pilosa								3	4	5	10	25	33	18	23	13	15	13	25	
Stellaria holostea		8	10	12	4			11	5	7	10	8	7		17		7	8	5	6
Pino-Quercetalia species																				
Hieracium sylvaticum																				
Convallario-Quercetum roboris species																				
Convallaria majalis															10	4				
Arrhenatheretea species																				
Dactylis glomerata															1					

characteristic of beech forests (*Melitti-Fagetum*), was also found in the *Quercus petraeae-Carpinetum*, but missed in the *Mercuriali-Tilietum* association. *Chelidonium majus* and *Chaerophyllum temulum* as *Alliarion petiolatae* species could be found as natural components of the association owing to the high N content of the soil. *Carpinus betulus* occurred in relevés N° 6-12, its cover is around 50% in relevés N° 10-12. Regarding the cover percentage, as well there is an approximately 60 m long strip that can be considered as “proper” hornbeam-oak forest. The other recorded *Carpinion* species, *Carex pilosa* is not strictly bound to the *Quercus petraeae-Carpinetum* association. It was found in the *Melitti-Fagetum* as well, but it attained only low cover values. *Gagea lutea*, a *Fagetalia* element is typical of the *Mercuriali-Tilietum*. *Fagus sylvatica* itself is the only *Fagetalia* species with a clear-cut border, *Asarum europaeum* and *Galium odoratum*, *Fagetalia* species likewise, occurred in the *Quercus petraeae-Carpinetum*, as well.

Fig. 2 also shows the mean W-values of each plot. These values show a gradual increase from 4.2 to approximately 5. This increase is effected by former deep roads crossing that loess area establishing a certain soil solidification. The relevés

no. 13-16 show decreasing values, caused by a slight increase in the number of the species of the herb layer, which are usually attached in xerophytic associations (characterized by lower W-values).

Soil sampling also remarked the diversity of the bedrock. The Triassic Dachstein limestone was uplifted to the surface in the form of standing columns close to the peak, and Lithic Leptosol is formed on it with a thin solum. Further down these soils are replaced by 30-40 cm deep black Rendzic Leptosol. From where the sandy parent material from the Pleistocene age appears Mollic Cambisols formed from sand and sandy loess make the surface more diversified.

Towards the hollow the parent material of these soils change into loess which has not been destroyed by erosion, younger than the sand but originates also from the Pleistocene. Humic Cambisols formed on the sandy parent material can be separated and are referred to as Haplic Luvisol. These brown forest soils were characterized by even, thick layers under both the beech and oak forests, so degradation caused by erosion and deposit accumulation (and thickening of the solum by this) are out of the question. Other signs of erosion (e.g. gravel bands) have not been found either.

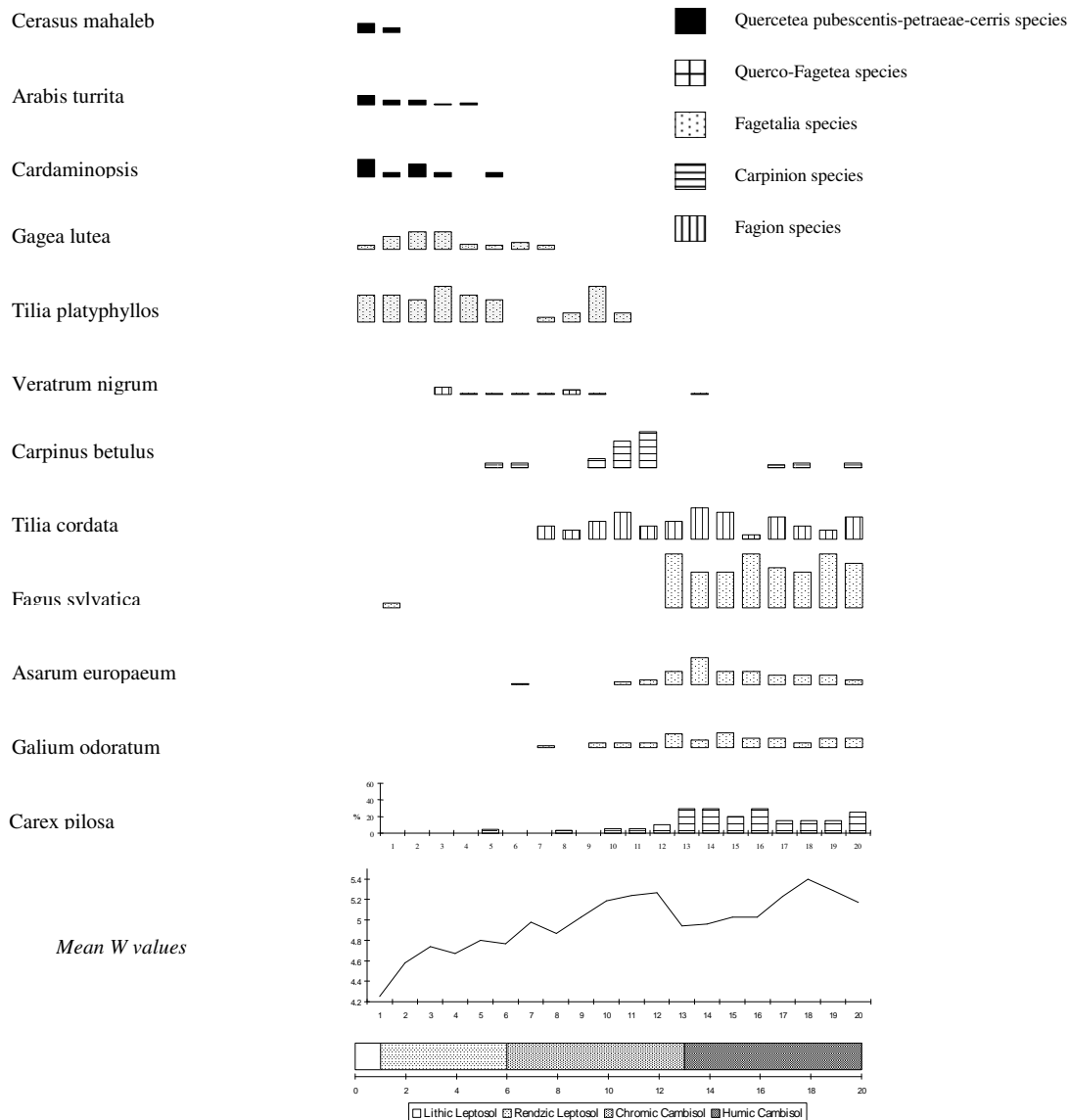


Figure 2. The distribution of selected species (%)

The pedological analysis was carried out in the laboratory to elucidate any reasons for the vegetation changes. Lithic Leptosols, Rendzic Leptosols and Haplic Luvisols differ significantly in several parameters. These changes accorded with the genetic types of the soils. Brown forest soils differed also significantly from other types of soils, but the properties of the two varieties (Humic Cambisol and Chromic Cambisol) sampled under beech and oak forests were very similar to each other, and most properties did not show significant differences (Table 2). The physical properties of these latter soils differed at the highest significance level. A clay fraction appears in the 'B' horizon due to the clay

formation processes which are characteristic of the forest soils. The physical type of the 'C' horizon was in accordance with the parent material. As it is shown in table there can be significant differences between the physical types of soils (depending on the parent material) although their conditions of formation and the soil genetic processes were the same. As a result the largest difference between the varieties could be detected in the texture, hygroscopy and K_A (Table 3). It should be noted that the changes in soil types and vegetation correspond to each other and that the two types of the Humic Cambisols also changed at the border of the beech and the oak forests (see Fig. 2).

Table 2. Soil properties in the forest soil profiles by genetic horizons. K_A is the 'sticky point' according to Arany.

	Humic Cambisol			Chromic Cambisol		
	0-30 cm	30-100 cm	100-130 cm	0-30 cm	30-100 cm	100-130 cm
Humus (%)	3.31	1.15	0.71	3.42	0.97	0.64
pH (H ₂ O)	6.4	6.8	7.3	6.1	6.7	6.9
CaCO ₃ (%)	0.52	0.76	19.70	0.38	0.10	1.06
K _A	40	44	36	34	33	30
NO ₃ -N+NH ₄ (ppm)	26	11	5	24	8	4
P ₂ O ₅ (ppm)	30	25	27	28	21	26
K ₂ O (ppm)	104	138	113	100	121	81

Table 3. Results regarding the physical types of the forest soils by genetic horizons. K_A is the 'sticky point' according to Arany, hy₁ is hygroscopy.

	Humic Cambisol			Chromic Cambisol		
	0-30 cm	30-100 cm	100-130 cm	0-30 cm	30-100 cm	100-130 cm
K _A	40	44	36	34	33	30
hy ₁	3.7	4.2	2.1	3.3	3.2	1.4
Particle size (%)						
0.01 mm <	52	42	51	66	63	61
0.01-0.001 mm	31	46	39	26	24	28
0.001 mm >	17	12	10	8	13	11

Discussion

Phytosociological results indicate that the three zones considered as associations are primarily marked by tree species. Although the species in the herb layer which are characteristic of the associations have the maximum cover within their typical zone, they also occur with lower cover in the adjacent associations. Mean W-values are characteristic and are parallel to the phytosociological results because more mesophilous associations show higher W-values.

Phytosociological results and mean W-values also correspond to the results of the soil analysis, so the changes in the soil are reflected by the changes in the vegetation. In the region close to the peak where the *Mercuriali-Tilietum* was found, Lithic Leptosol and Rendzic Leptosol were formed. Appearance of the *Quercus petraeae-Carpinetum* is paralleled to brown forest soils. The brown forest soils of the hornbeam-oak forest and the beech forest (*Melitti-Fagetum*) differ. Beneath the hornbeam-oak forest Chromic Cambisol, beneath the beech forest Humic Cambisol can be found. The Hungarian nomenclature considers these soil types as one because of their similar properties. However, as shown in this study, there are some differences between these soils due to which they provide suitable conditions for different types of vegetation. Changes in the vegetation are in close relationship with the physical properties of the soil (texture, which determines the water regime of

the soils), since these are the most varied of the soil parameters examined. The loamy physical type (of the soil formed beneath the beech forest from loess) can support an association with higher water demand. In the strip of the hornbeam-oak forest The Chromic Cambisol formed from sandy parent material (sand or sandy loam physical type) provide growth conditions for a slightly more xerophilous association.

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OVERVIEW OF THE FLORA AND VEGETATION OF THE HUNGARIAN BODROGKÖZ

Z. Tuba

Tuba, Z. (1995): Overview of the flora and vegetation of the Hungarian Bodrogeköz. - Tiscia 29, 11-17.

Abstract. This paper presents an overview of the flora and vegetation of Bodrogeköz, Hungary. A brief introduction to the physical geography of the region is followed by a floristic account, a brief summary of the bryophyte flora and a list of protected, rare and/or endangered vascular species of the region. Of the flowering plants the mountain woodland herbaceous species, which very rarely occur in the Hungarian Plain, are of special interest. The list of protected or locally important plants contains species which are not under protection in Hungary, but are enlisted in the Red Data Book of the International Union for Conservation of Nature (IUCN). The abundant occurrence of *Trapa natans*, *Salvia natans*, *Marsilea quadrifolia* and *Stratiotes aloides* makes Bodrogeköz a conservation area of international importance. The flora listing is followed by the description of the associations with an emphasis on the woodland formations.

Key words: *Samicum*, *flora*, *bryophytes*, *vascular plants*, *protected plants*, *plant communities*, *woodland formations*.

Z. Tuba, Plant Physiological Section, Department of Botany and Plant Physiology, Agricultural University of Gödöllő, H-2103 Gödöllő, Hungary.

Introduction

This paper is an overview of the flora and vegetation of the Bodrogeköz, Hungary. There is a dearth of vegetation data from the Bodrogeköz. Those published are either restricted to two localities, Bodrogekzug (at Tokaj) and Long-erdő, or are of short notes (Chyzer, 1905; Margittai, 1927; Kiss, 1939; Simon, 1950; Dévai, 1971, 1972-73, 1975; Fintha, 1994).

The history of botanical research in the Bodrogeköz will be dealt with in a separate paper because of the outstanding botanical interest of the Long-erdő and because the Bodrogeköz area as a whole has never been dealt with on its own merit. Three of the botanists, Antal Egey, who first reported the existence of the Long-erdő; Hargitai (1938), who first described the plant communities of the Long-erdő; and Bodrogeközy (1962, 1990), who reported the non-wooded vegetation formations in the Bodrogekzug, need mentioning here.

The description of the physical geography of the area is followed by a floristic account. First, a brief

summary of the bryophyte flora is presented then rare or endangered species or species of outstanding botanical interest are discussed. This is followed by the description of plant communities of which the woodland formations are discussed in detail. Except for the Long-erdő the woodland formations of the region were exclusively investigated by the author of the present paper. Observations of the importance for conservation are also presented. Separate papers will discuss the vegetation of the Bodrogeköz in detail.

The geomorphology, climate, soils and hydrography of the Bodrogeköz

The area called Bodrogeköz (Fig. 1) is the alluvial plain of the rivers Bodrog and Tisza (Borsy, 1969). The plain is covered by Holocene alluvial sand, silt, and clay. The areas near to the banks of the river are mostly sandy as opposed to the central areas which are on deposits of finer particle size with Pleistocene sand islands at Tiszakarád, Cigánd, Révleányvár and Zemplénagárd.

The climate is moderately warm and dry with cold winters (Péczeley, 1969). Summers are warm with cooler temperatures in the north-east. Average mean monthly temperature in July is 19.5 (W) - 21 (NE) °C, and -3.5 °C in January. Winter is cold, the number of winter days is high (35-40). Snow lies for 29-35 days. The growing season starts in late spring. Predominant wind direction is northeast to southwest. Total annual precipitation is 550-600 mm with June as the wettest month (65-75 mm) and January as the driest one (18-35 mm). The second peak in precipitation in the autumn is negligible. In early spring, the Bodrogköz is one of the driest areas in Hungary. Average annual water deficit is 75-100 mm.

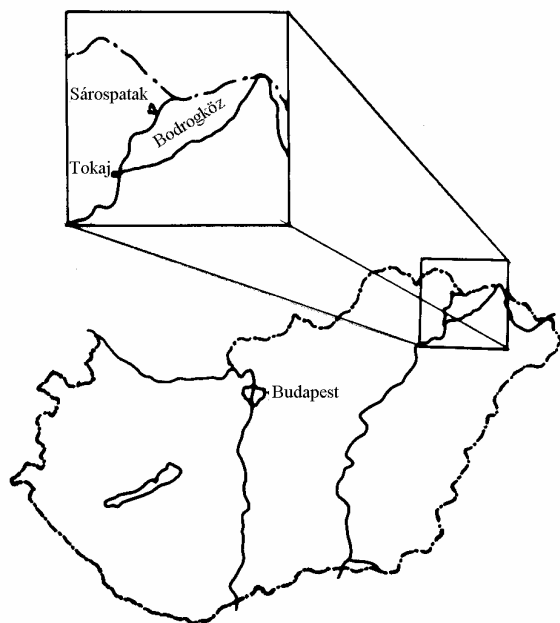


Fig. 1. Situation of the Hungarian Bodrogköz.

The young soils of the alluvial plain are low in humus content and contain no calcium carbonate (acidic) (Stefanovits, 1969). Their physical structure, both macro and micro, and their water conductivity are poor. The soil profiles have iron pans with mobile iron salts. The pH in surface samples is 6.0-6.5; in the subsurface it is about 7.0. The subsoil is often gley, clay and below 1 m depth calcium carbonate may precipitate (Stefanovits, 1969). The central low lying depression of the Bodrogköz has no direct connection with the bordering rivers and differs considerably from the areas affected by regular flooding by the rivers Tisza and Bodrog. Backwaters of the two rivers are characteristic of the area. The water table is 3 m on average which may

drop to 6 m on the alluvial plain. Areas such as Cigánd and Ricse are affected by partial waterlogging causing high salinity of calcium hydrogen carbonate and sodium hydrogen carbonate type.

The flora of the Bodrogköz

The plant geographical classification places the Bodrogköz in the Samicum (North Hungarian Plain) of the Pannonicum (Simon, 1969). The flora is predominantly of European species (Simon, 1969).

Cryptogamic species

No data other than that on the mosses has been collected so far.

Liverworts and mosses

The bryophyte flora of the Bodrogköz has been enumerated by Tuba and Kis (1995) and Kis and Tuba (1995) following the very limited data (restricted altogether to three species) by Boros (1968). Kis and Tuba (1996) listed more than 60 species of which eleven had rarely been reported from the Great Plain:

- Brachythecium glareosum* (Spruce) B.S.G.
- Brachythecium mildeanum* (Schimp.) Schimp.
- Bryum caespiticium* Hedw.
- Campylium polygamum* (B.S.G.) C. Jens.
- Dicranum scoparium* Hedw.
- Homalia trichomanoides* (Hedw.) B.S.G.
- Metzgeria furcata* (L.) Dum. var. *ulvula* Nees
- Orthodicranum montanum* (Hedw.) Loeske
- Pterygynandrum filiforme* (Timm.) Hedw.
- Riccia huebeneriana* Lindenb.
- Riccia rhenana* Lorbeer in. K. Müll.

Nomenclature follows Orbán (1991).

Vascular plants

A list of protected (Csapody, 1982), rare or plant geographically interesting species is given below. Other species of interest are woodland forbs which occur there; they will be listed together with the woodland communities. Species which require protection for their local or nation-wide status are being studied and a report on them will be published later.

- Achillea ochroleuca* (*Kitaibeliana* Soó) Ehrl.
- Acorus calamus* L.
- Agrimonia odorata* (Gouan) Mill.
- Alchemilla vulgaris* L.

Anacharis canadensis (Rich.) Planchon
Aster amellus L.
Chrysanthemum serotinum L. *
Cicuta virosa L.
Epipactis helleborine (L.) Cr.
Fritillaria meleagris L. (observed in 1977) * *
Gentiana pneumonanthe L. *
Iris sibirica L. *
Marsilea quadrifolia L. *
Nymphoides peltata Ktze. *
Pulsatilla hungarica Soó (observed in 1968)
Silaum silaus (L.) Schinz et Thell.
Sparganium emersum Rehman
Thalictrum flavum L.
Veronica longifolia L.
Wolffia arrhiza L.

where * - potentially endangered; ** - endangered (Németh, 1990). Nomenclature follows Soó (1973).

The waterweeds such as *Trapa natans*, *Salvinia natans*, *Marsilea quadrifolia*, *Stratiotes aloides* deserve highlighting because although not protected these species are listed in Red Data Book of the International Union for Conservation of Nature (IUCN) (see Németh, 1990). This and their abundance in the Bodrogeköz makes them of outstanding conservation value internationally. Their protection can only be ensured by designating their habitat a nature reserve which will also serve to protect the wildlife of the area.

Wetland areas feature prominently in international conservation projects such as for example the Wetland Conservation Program (e.g. Maltby et al., 1992). The Bodrogeköz area should receive much greater attention from local, national and international conservation authorities to recognize its importance for world heritage.

Plant communities

The broad scale of hydrological variation over the area has resulted in a variety of communities.

Aquatic communities

These occur abundantly in the backwaters of the Bodrog (natural and man-made) and in lakes (e.g. Kis-Nádas tó, Nagy-Nádas tó, Kapitány-tó, ó-Bodrog, Füzesér, Törökér, etc.).

Floating aquatic communities

Lemno-Utricularietum

This is the most common aquatic community in the Bodrogeköz. All three Hungarian *Lemna* spp. are

represented in places sometimes with abundant *Utricularia vulgaris* growth.

Salvinio-Spirodeletum

This community is characterized by the abundant presence of *Salvinia natans* with *Spirodela polyrrhiza* in some places.

Marsilea quadrifolia occurs in several places in the Bodrogeköz as part of the rooting aquatic communities.

Hydrochari-Stratiotetum

Both *Hydrocharis morsus-ranae* and *Stratiotes aloides* are abundant in the Bodrogeköz.

Wolffio-Lemnetum

Local and in some places in the southern Bodrogeköz (Bodrogzug) increasing (spreading from the Tiszadob region).

Large pondweed communities

Myriophyllo-Potametum (submerged pondweed community)

with *potametosum natantis*;

potametosum crispum;

potametosum amphibium;

potametosum lucentis sub-associations.

Very characteristic of the area is the sub-association dominated by *Potamogeton lucens*. This species only occurs in and along the river Tisza and its community is called *Potametum lucentis* Bodrogeközy 1962 (Hueck 1931).

Nymphaeetum albo-luteae (rooting floating pondweeds)

In the backwaters of the river Bodrog this community often occurs without *Nuphar lutea*. *Hippuris vulgaris* is also present at several localities.

Nymphoidetum peltatae

Rare, mostly with *Trapa natans* forming a transition to the *Trapetum natantis* community.

Trapetum natantis

A very characteristic community which can be a kilometer in extent.

The account of *Magnocaricion* and *Agrostion albae* (tall *Carex* and wet meadow) communities follows to Bodrogeközy (1962, 1990) with additional data from my personal observations.

Reedbeds (Phragmition)

Sparganio-Sagittarietum, and

Scirpo-Phragmitetum.

Several sub-associations of the two communities occur in shallow water in lakes and backwaters. Frequent facies are *typhosum latifoliae* et *angustifoliae* and *sparganiosum*. It is noteworthy that the northern Eurasian *Cicuta virosa* also occurs in places.

Rorippo-Oenanthemum aquaticae
Glycerietum maximae
Pure stands of the above are rare.

Sparganio-Glycerietum fluitantis
The *glycerietosum fluitantis* and *agrostetosum stoloniferae* sub-associations of the above community occur in several places.

Small sedge communities (Nanocyperion)
Eleocharito acicularis-Schoenoplectetum supini
This community is most abundant on muddy stretches of river banks, backwaters and waterlogged areas.

Tall sedge communities (Magnocaricion)
These occur in the lake shore zone on the shore edge of reedbeds, or in some cases directly succeed the submerged aquatic zone.

Caricetum gracilis
Three sub-associations of this community occur: *caricetosum vulpinae* with several fen species; *bolboschoenetosum maritimae*; and *caricetosum vesicariae*, a typical tall sedge formation of the Bodrogeköz. This latter forms a transition to the *Caricetum acutiformis-ripariae* community.

Caricetum acutiformis-ripariae
Occurs abundantly in the Bodrogeköz.

Caricetum elatae
This community is nationally rare and occurs in the northern parts of the Bodrogeköz.

Caricetum inflato-vesicariae
A remnant of the old fen sedge vegetation.

Wet meadow communities (Agrostion albae)

Alopecuretum pratensis
The *agrostetosum albae* and *normale* sub-associations (facies *potentillosum reptantis*; *ranunculosum reptantis*; *trifoliosum reptantis*; and *poetosum reptantis*) grow over large open areas.

Lolio-Alopecuretum

Lolio-Potentilletum

These communities occur on pastures affected by seasonal flooding.

Salicetum cinereae fragments occur frequently as remnants of the earlier fen vegetation.

Weed communities

They are rich and varied. Several communities described at more southerly localities along the banks and seasonally flooded plains of the river Tisza (Timár, 1950) are present in the Bodrogeköz. There are some communities of interesting species composition which occur mainly along the river Bodrog. Recently, the abundant spread of *Asclepias syriaca*, *Ambrosia elatior*, and *Echinochloa crus-galli* has been noted.

River bank willow carr (Salicetum triandrae)

These occur on or near to river banks. Their canopy height is about 1-4 m; canopy dominants are *Salix triandra*, *S. viminalis*, and *S. alba*. Characteristic climbers are *Calystegia sepium* and *Echinocystis lobata*. The herb layer is mostly of *Rubus caesius*, *Phragmites communis*, *Lycopus europaeus* and *Rorippa austriaca*. *Solidago gigantea* is more frequent by the river Bodrog than along the Tisza. In places, a transitional form into the open willow-poplar gallery forest is apparent.

Willow-poplar gallery forest (Salicetum albae-fragilis)

The species composition of the above forest type in the Bodrogeköz is that of the *Salicetum albae-fragilis tibiscense* regional variant of the *Salicetum albae-fragilis hungaricum* Soó association. This is the most common community in the Bodrogeköz. It is usually found within a band 10-100 m wide flanking the river banks. The most extensive stands are at the confluence of the Bodrog and Tisza, and along the two rivers.

The soil is mostly compacted silt, or muddy sand which becomes periodically flooded. The average canopy cover is 50-75% which may reach 80-85% in older stands. Average tree height is 12-15 m. The shrub layer is about 1-5 m in height and its cover may vary between 2-30%. Natural regeneration of the trees is negligible. The ground cover is dense (80-100%) with an average height of 20-80 cm.

In some localities *Populus nigra* dominates the canopy (*P. nigra* consociation) with *Lycopus exaltatus* as the differential species. *Vitis riparia* is always present in great abundance while there is no

Glycyrrhiza echinata, *Oenanthe banatica* and *Cornus sanguinea* are also absent in this community sometimes. This latter is in contrast with the open willow-poplar gallery forests in Szatmár-Bereg. The following facies occur: *Rubus caesius* (most frequent); *Echinocystis lobata*; *Lysimachia nummularia*; and *L. vulgaris*. This community usually forms an open canopy with thin undergrowth, which is unfavourable for vegetation succession.

The percentage distribution of the flora elements is: Eurasian 62.4%; European and adventive 9.4% each; and continental 6.2%. The hemicryptophyte life form is the most frequent followed by the phanerophyte.

Ash-elm forests (*Fraxino pannonicae-Ulmetum*)

Ash-elm forests occur on higher ground in the Bodrogeköz. The average canopy cover is 70-80% or more. The dominant species in the canopy are *Quercus robur*, and to a lesser extent *Ulmus laevis* and *Populus nigra*. Trees in the upper canopy are 10-15 m high; the lower canopy is formed by *Ulmus* and *Quercus*. In the north-eastern parts of the Bodrogeköz *Fraxinus angustifolia* ssp. *pannonica* is frequent also. The shrub layer sometimes also consists of a taller and a lower layer with *Quercus robur*, *Crataegus oxycantha*, *Ulmus laevis*, *Cornus sanguinea*, *Euonymus europaeus*, *Corylus avellana*, *Ligustrum vulgare*; at the edges of the woodlands *Prunus spinosa* and *Rosa canina* as the most frequent species. The average cover of the shrub layer is 20% and its height is 1-5 m. At the edges, the climber *Vitis riparia* is characteristic.

The 20-40 cm tall herb layer covers about 30% of the forest floor with large patches completely devoid of ground cover. Characteristic facies are: *Rubus caesius* and *Convallaria majalis* with the former prevailing in most stands indicating wet soil conditions.

The ash-elm forests of the Ricse region are of outstanding importance. They have two sub-associations: *circaeetosum* and *asperuletosum*. The facies in the wet *circaeetosum* sub-association are: *Circaea lutetiana*, *Stachys silvatica*, and *Cephalaria pilosa*; in the mesic *asperuletosum*: *Asperula odorata*, *Aegopodium podagraria*, and *Viola mirabilis*. Where the stands are more open *Brachypodium silvaticum* occurs in great abundance (*Brachypodium silvaticum* facies; *brachypodietosum* sub-association). The *Urtica dioica* facies is of secondary origin. Although *Cornus sanguinea* occurs persistently it does not form a sub-association in the Bodrogeköz, nor in the Northern Great Plain (Simon,

1957). In northern north-eastern regions *Fraxinus angustifolia* ssp. *pannonica* forms a consociation where it dominates the canopy.

The percentage distribution of the flora elements is: Eurasian 34%; European 21%; sub-Mediterranean (Euro-Mediterranean) 12%; and cosmopolitan and adventive 2%. The most common life forms are phanerophyte and hemicryptophyte.

The area these communities cover today is only a fraction of that in earlier days which is evident from the examination of historic maps (Kiséry, 1935; Hanusz, 1980). The cause of the reduction of the oak forests was mainly felling. More recently the oak gallery forests have been replaced by subsidized hybrid poplar plantations and some of the native willow-poplar forests were clear-felled. For the existing oak forests the rise in the water table following construction of the dams on the Tisza are causing noticeable changes in the species composition of the ground flora. The ground flora is generally impoverished and species characteristic in the willow-poplar forests and in the tall sedge communities are appearing apparent in older oak stands (*Lysimachia vulgaris*, *Lycopus europaeus*, *Scutellaria galericulata*, *Carex riparia*, *C. gracilis*, *Euphorbia palustris*). These changes certainly differ between topographies of stands; it is for example more noticeable in low lying oak woods at Bodrogekertesztúr than in the stands on higher ground at Bodrogolaszi. The effects are more pronounced in the spring when spring geophytes are becoming rare or absent even from the oak woods. Altogether the changes in the hydroecology of the area are causing a shift in species composition and species with higher tolerance to high water table are replacing the original oak gallery forest species. Such is the case for the lily of valley (*Convallaria majalis*), for example, which is giving way to *Rubus* and in places to *Carex* spp.; *Cornus sanguinea* is also being unfavourably affected.

The non-forested areas in the periodically inundated areas of the river valleys were covered by pastures and wet meadows about twenty years ago; today tall sedge communities grow there. The *Convallaria*-type oak forests, though classified together with the ash-elm forest, have a special character and they are similar to the oak forests at Sajólád (Ujvárosi, 1941) and Tiszadob (personal observation). This type therefore should receive special attention. It is suggested that these forests should be left unmanaged and bands of a mix of native species should be planted around them as buffer areas. Also, the native willow-poplar stands should be left to nature to work its succession there.

Noteworthy species in the oak forests are: *Epipactis helleborine* and in clearings *Gentiana pneumonanthe* in great numbers. In the open forest edges *Chrysanthemum leucanthemum* grows. This species also occurs at the edges of willow-poplar forests.

Hornbeam-oak mixed woodlands (Quercus petraeae-Carpinetum)

Their best example in the Bodrogeköz is the Long-erdő near to the confluence of the river Ronyva and the Bodrog (Hargitai, 1938). In other locations in the north and north-east (Ricsé, Révleányvár) there are some remnant small stands which are however rather degraded.

The original area of the Long-erdő was much bigger than that at present day which cover the area between Vajdacska and Végardó at Sárospatak (Kiséry, 1935; Hanusz, 1980). This forest is outstandingly unique in its species composition. The forest which lies at 90-95 m a.s.l. has a large number of hornbeam and also some beech trees. They probably represent a periglacial beech forest relict which could survive in the relatively cool climate there. The forest is a mosaic of few hornbeam-beech (at Nagykökényes erdő), some hornbeam-oak, and numerous and larger oak (*Quercus robur*) patches.

The ground flora is similar to the sub-montane hornbeam-oak forests with a number of montane species such as *Carex pilosa*, *Majanthemum bifolium*, *Circaea lutetiana*, *Galeopsis speciosa*, *Aegopodium podagraria*, *Heracleum sphondylium*, *Asperula odorata*, *Dentaria bulbifera*, *Ranunculus cassubicus*, *Sanicula europea*, *Euphorbia amygdaloides*, and *Campanula trachelium*. Some of these species also occur in the ash-elm forests in the north-east Bodrogeköz. The forest at Long-erdő gives way to alder and willow at lower elevation and the above species disappear there. Recently some of the forests were clear-felled!

Alder fens

They are relatively few in the Bodrogeköz. In the north east (Zemplénagárd), the *Carex acutiformis-C. riparia* type occurs. Another type is the mesophile alder fen with a ground flora largely similar to that in the ash-elm forests. Some stands have been dying recently.

Oak woodlands

A number of transitional types of the dry to wet oak woods on sand occur, mostly in small and degraded overgrazed groves.

Robinia plantations

Their types range from the dry to the wet and occur all over the area.

Sandy meadow grasslands

This vegetation type occurs on sand hills, non-cultivated sand patches (e.g. Budahomok, Dámoc). The stands are mostly degraded and of secondary origin. *Festuca vaginata*, the dominant species of the characteristic *Festuco-Corynephorum* on acid sand, only survives in few locations (Simon, 1969). Some characteristic species of these stands are: *Pulsatilla hungarica*, *Helichrysum arenarium*, *Achillea ochroleuca*, *Chondrilla juncea*, *Gypsophila paniculata*, *Sedum sexangulare*, the moss *Tortula ruralis*, and the lichens *Cladonia convoluta* and *C. magyarica*.

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INTERSPECIFIC ASSOCIATIONS IN DIFFERENT SUCCESSIONAL STAGES OF THE VEGETATION IN A HUNGARIAN SANDY AREA

K. Margóczy

Margóczy, K. (1995): Interspecific associations in different successional stages of the vegetation in a Hungarian sandy area. - Tiscia 29, 19-26.

Abstract. Intraspecific associations were studied in seven plant communities in a Hungarian sandy area. Aim of present study was to reveal the differences of species coexistence structures in the vegetation of different successional stages.

The frequency and intensity of pairwise interspecific associations positively correlated with the species number. It was proved, that the higher association value was not only a statistical consequence of higher species number in the species rich stands, but it referred to the organization degree of studied communities, because the species association values of the real, field samples were considerable higher than that of the spatially randomized reference of the same data.

The value of the community level measure 'associatum' and sum of the pairwise associations show similar rank of the studied stands. Both measures were spatial scale dependent.

Combination of principal coordinate analysis and plexus diagram method indicated two coalitions in the species rich communities, such as closed grassland and shrubby habitat: an assemblage with higher species number and a second one with lower species number.

Keywords: interspecific association, associatum, information theory statistics, spatial scale dependence, succession, sandy vegetation

K. Margóczy, Department of Ecology, JATE University, Szeged, Pf. 659, H-6701 Hungary

Introduction

The frequency and intensity of interspecific spatial associations belong to the most widely used measures of coexistence and interaction in plant communities. Usually a strong positive association can be obtained between species belonging to the same community (Greig-Smith, 1983).

Association analysis is especially useful to gain insight into the mechanisms of successional processes. Recently, the role and importance of interspecific association in succession were studied by several authors. Kikvidze (1992) demonstrated, that the selection of species composition is going on through the 'sieve' of interspecific relations during succession of alpine-subnival vegetation patches.

No consistent trend was found in changes of the frequency of significant associations when several stages of old-field succession were compared (Leps and Burianek, 1990).

The proportion, number, and level of significance of interspecific associations declined in

ten old fields during 31 years of succession (Myster and Pickett, 1992). Moderate cattle grazing decreased the number of both positive and negative associations in a grassland community (Matus and Tóthmérész, 1990).

The above-mentioned studies dealt with pairwise associations of species. Studying ecological coalitions, that is organization between population and community level, has central importance in understanding species coexistence in plant communities. Matejka (1992) specified two units in this organization level - microcoenosis (a spatial unit), and structural group of species (similar to the notion of coalition). Vegetation should be viewed as a mosaic of species combinations, rather than separate species patterns (Bartha, 1992).

The plant communities representing different successional stages form a landscape-level mosaic-like pattern on sandy areas of the Hungarian Plain. Possible successional sequences of them were described by Hargitai (1940), Zsolt (1943) and Magyar (1960). Recently Fekete (1992) published a

new concept of primary succession of sandy vegetation which differs from the traditional interpretation of the Hungarian phytosociologists.

Interspecific association of species was used for examining ecological specialization in a grassland community called *Festucetum vaginatae* (Rapaics, 23) Soó 29 by Précsényi et al. (1980), but the change of interspecific association relations during succession of this type of vegetation have not been analyzed.

The aim of present study was to investigate the change of species coexistence structure and interspecific association relations as a function of succession within sand vegetation.

Précsényi (1981) and Margóczy (1993) demonstrated species diversity changes during succession of sandy vegetation. The higher the species number, evidently, the higher the frequency of possible pairwise association of species, if the relative frequency of species is balanced. In this study I investigated, whether the increase of intensity and frequency of pairwise association during succession is just a result of higher species number, or this increase refers to other elements of complexity of the studied communities.

Study area and methods

Site description

The field studies were carried out in a nature reserve situated in the southern Hungary, between the rivers Danube and Tisza near the village of Kéleshalom. The study site is a complex of wind-formed sand dunes. Several successional stages of sand vegetation ranging from bare sand to poplar forest occur at the site. For the present purposes 7 plots were selected, which represent the following stages:

Plot 1: **sparse, pioneer vegetation** with some plant species typical of the *Festucetum vaginatae*; the bare surface within the plot may derive from an abandoned small sand-mine.

Plot 2: **open perennial grassland** with 30-40 % of plant coverage, predominated by *Festuca vaginata* (*Festucetum vaginatae danubiale*);. The moss and lichen layer was also considerable.

Plot 3: similar to Plot 2, but predominated by *Stipa borysthena* (*Festucetum vaginatae danubiale stipetosum borysthena*).

Plot 4: open perennial grassland predominated by species of the *Festucetum vaginatae*. **Populus**

alba forms a shrub storey here. (50 cm in height, about 25 % in cover).

Plot 5: **closed grassland** with some xero-mesophilous and mesophilous species besides the drought-tolerant ones.

Plot 6: **shrubby habitat** (50-60 % cover) of *Crataegus monogyna*, *Juniperus communis*, *Berberis vulgaris* and *Ligustrum vulgare*.

Plot 7: closed **poplar (*Populus alba*) forest** with admixed *Robinia pseudoacacia* trees; *Crataegus monogyna* and *Juniperus communis* make a sparse shrub layer.

The areas of the study plots were about 400 m². The vegetation of these plots was studied by Margóczy (1993) using multivariate analysis. Ant assemblages and epigeic fauna of the same study sites were studied by Járdán et al. (1993).

Field sampling

We used a modified version of the sampling procedure developed by Szollát and Bartha (1991). Long transects of 200 contiguous small plots, each sized 20 x 20 cm, were sampled in each stand. The 40 m long transect was folded 4-5 times, resulting a zigzag line "netting" the whole plot. The presence of species rooting in the subplots was recorded. In the shrubby habitat and in the poplar forest only the herb layer was sampled. The presence of lichen and moss species was recorded and analyzed with the higher plants.

Data analysis

Pairwise associations of species were computed from the 2 x 2 contingency tables of each species pair. Zarr (1984) recommend to use G test for analyzing contingency table data, where

$$G = 2[m \log m + a \log a + b \log b + c \log c + d \log d - (a+c) \log (a+c) - (b+d) \log (b+d) - (a+b) \log (a+b) - (c+d) \log (c+d)]$$

a, b, c, and d correspond to the notations of a 2x2 contingency table, m=a+b+c+d is sample size.

The same formula was used to define pairwise association of species by Juhász-Nagy and Podani (1983) as one of the functions of information theory method for the study of spatial processes and succession. In their paper, the formula of pairwise association is as follows

$$mI(A,B) = G/2$$

Table 1. Frequency values of the species in the 200 20x20 cm subplots per study plot. Data of 22 rare species, whose pooled frequency values were below 10 (i.e. 5 %) are not indicated. The used nomenclature is after Simon (1992).

SPECIES	STUDY PLOTS							CODE
	1	2	3	4	5	6	7	
Achillea pannonica	0	0	0	11	72	0	0	ACHI
Alyssum tortuosum	30	1	5	0	0	39	0	ALYS
Asclepias syriaca	16	0	0	0	0	0	0	ASCL
Asperula cynanchyca	0	0	0	0	27	0	0	ASPE
Berberis vulgaris	0	0	0	0	26	0	27	BERB
Botriochloa ischemum	0	0	9	0	0	9	0	BOTR
Bromus sterilis	0	0	0	0	0	0	36	BROM
Calamagrostis epigeios	0	0	0	16	4	0	0	CALAM
Camptothecium lutescens	0	0	0	0	54	0	0	CAMT
Carex flacca	0	0	0	0	0	0	72	CAFL
Carex liparicarpos	12	24	34	58	119	77	127	CARE
Cladonia magyarica	0	33	0	14	0	0	0	CLMA
Cladonia rangiformis	0	0	0	8	56	0	0	CLRA
Cladonia convoluta	0	59	8	1	0	4	0	CLCO
Cladonia furcata	0	39	58	1	0	2	0	CLFU
Cornus sanguinea	0	0	0	0	19	0	10	CORN
Crataegus monogyna	1	0	0	0	9	0	36	CRAT
Cynodon dactylon	0	0	14	0	0	0	2	CYNO
Cynoglossum officinale	0	0	0	0	0	32	0	CYOF
Equisetum ramosissimum	0	0	0	26	0	0	0	EQUI
Erigeron canadensis	1	13	0	0	0	4	0	ERIG
Erysimum diffusum	0	4	5	3	0	7	0	ERYS
Euphorbia cyparissias	0	2	0	6	23	0	0	EUPH
Euphorbia seguieriana	59	12	29	2	9	10	0	EUPH
Falcaria vulgaris	0	0	0	0	14	0	0	FALC
Festuca wagneri	0	0	0	73	18	0	0	FEWA
Festuca vaginata	124	109	68	22	45	167	5	FEVA
Fumana procumbens	17	5	70	0	0	3	0	FUMA
Galium verum	0	0	0	94	37	0	4	GAVE
Holoschoenus romanus	0	0	0	42	0	0	0	HOLO
Kochia laniflora	0	30	66	9	0	4	0	KOCH
Koeleria glauca	12	13	36	2	4	0	0	KOEL
Ligustrum vulgare	0	0	0	0	24	0	55	LIGU
Minuartia glomerata	0	4	0	0	0	8	0	MIGL
Minuartia verna	5	28	8	1	2	0	0	MINU
Pimpinella saxifraga	0	0	0	0	0	0	10	PIMP
Pleurochaete squarrosa	0	36	0	37	7	0	0	PLEU
Poa angustifolia	0	0	0	43	51	0	12	POAN
Polygonum arenarium	0	7	5	12	0	50	0	POAR
Populus alba	0	0	0	33	0	0	0	POPU
Potentilla arenaria	0	37	18	16	23	76	0	POTE
Prunus spinosa	0	0	0	0	0	2	27	PRUN
Scabiosa ochroleuca	0	0	0	0	21	55	0	SCAB
Sedum hillebrandtii	0	3	11	0	0	0	0	SEDU
Stipa borysthénica	23	132	105	61	51	98	0	STBO
Stipa capillata	0	0	0	0	64	0	0	STCA
Syntrichia ruralis	5	70	16	34	22	0	0	SYNT
Taraxacum officinale	0	0	0	0	1	5	4	TARA
Teucrium chamaedrys	0	47	0	0	113	26	48	TEUC
Thesium arvense	0	0	0	0	4	6	0	THES
Thymus pannonicus	15	46	45	0	52	101	0	THYM
Torilis japonica	0	0	0	0	0	0	16	TORI
Viola rupestris	0	0	0	0	0	32	5	VIOL
SPECIES NUMBER	16	24	21	19	35	35	28	

The higher this value the greater is the information obtained on species B by determining the score for species A and vice versa. The pairwise association values [mI(A,B)] were computed for each 7 site

separately, by the program INPRO3 of the program package SYN-TAX III. (Podani, 1988).

The significant positive pairwise association values were indicated by edges in the principal

coordinate analysis (PCoA) scattergram of species computed by the program PRINCOOR from SYN-TAX III., Jaccard similarity was used as the resemblance measure. Since G is approximately distributed as χ^2 , and the degree of freedom is 1 in the case of 2 x 2 contingency table (Zarr, 1984) $\chi^2=3.841$ ($P=10\%$) was used as an arbitrary threshold for connecting species by edges. Combination of association analysis, and PCoA is very similar to the plexus graph method used by Matus and Tóthmérész (1991). This method was used to reveal the coalition structure of the studied communities.

Associatum is an other important function of the information theory method (Juhász-Nagy, 1976). It is a community level measure that refers not only to the pairwise interspecific association relations, but it is a quantitative expression of the spatial dependence of the realized species combinations. Description of the method and formula of associatum are given in Juhász-Nagy and Podani 1983.

Since the size of the sample plots influences the probability of finding a given species combination (Juhász-Nagy and Podani, 1983; Szollát and Bartha, 1991) the sum of positive pairwise association values and associatum of each study site were computed at 15 different sampling unit sizes. The different plot sizes were obtained by combining 2, 3, 4, 6, 8, 10, 14, 18, 22, 26, 30, 34, 38, and 50 20x20 cm subplots by the program Spat-Proc (Horváth, unpublished).

The same data analysis was performed on random data matrices, and the results were compared with the real, field situation. Original matrices, containing the species presence data in the subplots were rearranged in order to gain random reference. The presence of species in the subplots was spatially randomized, without any change of the original species numbers and frequencies in the complete data set. The spatial dependence of species association measures counted from real and random data is displayed on the Fig. 4 in the case of an open grassland (Plot 2) and the closed grassland (Plot 5).

The species association measures were plotted against species number in the case of field data and their random reference. The used spatial scale was that where the departure from random reference was considerable at both measures (plot size 20x160 cm).

The Shannon diversity values of the 7 study sites were computed from the frequency values of species in the 200 subplots, species number is shown in Table 1.

Results

Diversity and species associations

Altogether 53 species were detected in the 7

study sites. The frequency data of species are presented in Table 1. Data of 22 rare species, pooled frequency values of which were below 10 (i.e. below 1%) are not indicated.

The diversity values of the study sites are shown in Fig. 1. Diversity and species number is high in the closed grassland (plot 5.) and in the shrubby habitat (Plot 6), low in bare sand (Plot 1) and in the open grassland with small poplar trees (Plot 4). (Fig. 1.)

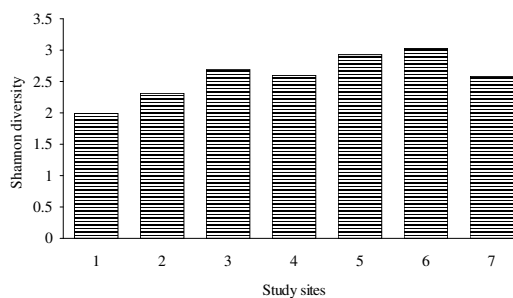


Fig. 1. Shannon diversity values of the study sites computed from the species frequencies given in Table 1.

The rank order of the sample sites is rather similar according to the sum of positive pairwise associations, associatum (maximal values), species number and diversity (Table 2), indicating the positive correlation between these measures. The question is, whether the frequency and intensity of species association is only a statistical consequence of species number, or it also refers to the complexity of the studied communities as well.

Table 2. The rank order of the sample sites according to the species number, diversity, maximal values of the sum of positive pairwise associations and associatum.

Species number	1 < 4 < 3 < 2 < 7 < 6 < 5
Diversity	1 < 2 < 7 < 4 < 3 < 5 < 6
Sum of positive pairwise associations	1 < 3 < 2 < 4 < 7 < 6 < 5
Associatum	1 < 4 < 3 < 2 < 7 < 5 < 6

The sum of positive associations showed spatial scale dependence (Fig. 2). They reach maximal values at relatively large plot sizes, between 360x20 and 1000x20 cm. These values are considerably higher than the association values found for the 20x20 cm plot size, but the rank of the studied stands is rather similar. Three categories can be differentiated in both cases: Low, Medium and High intensity association levels. The sparse, pioneer vegetation of the Plot 1. represents the Low association level category, the two open grasslands (Plots 2 and 3) the Medium one, the closed grassland and shrubby habitat (Plots 5 and 6) the High association level category. The relative difference

between the maximal association intensity and the value found for the 20x20 cm spatial scale is higher in the case of the open grassland with small poplar trees (Plot 4) and the forest grass layer (Plot 7). Therefore Plot 4 belongs to the Low level association category at 20x20 cm sample size, but to the Medium level category regarding the maximal values. The Plot 7 belongs to the Medium level association category at 20x20 cm sample size, but to the High level category regarding the maximal values (Fig. 2).

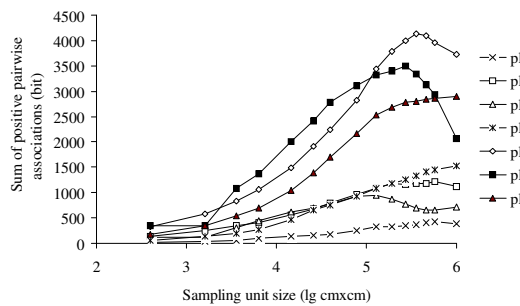


Fig. 2. Spatial scale dependence of the sum of positive pairwise species associations.

The associatum showed spatial scale dependence as well (Fig. 3.). The rank of the study sites on the basis of associatum values were rather similar, than in the case of pairwise associations both at 20x20 cm sampling unit size and at maximal values.

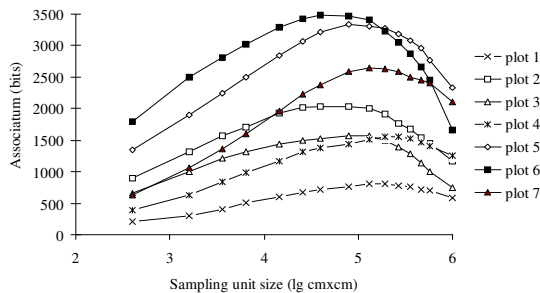


Fig. 3. Spatial scale dependence of associatum.

Departure from the random reference

The spatial dependence of the departure was displayed in the case of an open grassland (Plot 2) and the closed grassland (Plot 5) (Fig. 4). Difference between the sum of positive pairwise associations, and associatum values of the real and random data were considerable high at larger spatial scales.

A positive correlation was found when the species association measures were plotted against the species number (Fig. 5). The increase of species association frequency and intensity with species number was much more intensive in the case of field

data than that of their random reference.

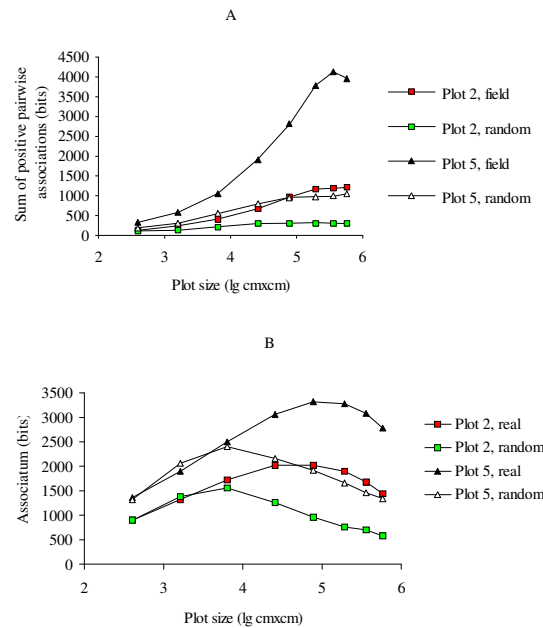


Fig. 4. Spatial scale dependence of the sum of positive pairwise associations (A) and associatum (B) in real, field situation, and in the spatially randomized case.

Ordination of species and possible coalition structure

In the study site of pioneer, sparse grassland (Plot 1) no intensive positive association developed between the frequent species. This community is very simple and undeveloped, represents the pioneer stage of sandy succession. Only two pairs of species are associated in the open grassland with small poplar trees (Plot 4). So, plexus graphs of these two study sites are not shown.

The frequency of associations is higher in the two open grassland study sites (Plot 2 and 3), and the coalition structure is rather similar (Figs. 6 and 7). Two separate coalitions exist, one with four members and an other with three members in both stands. A parallel feature is, that PARM (a lichen species) is a central member in the three-member group, and the other member (THYM in Plot 2, and POTE in Plot 3) has similar growing form. Clonal growth along the soil surface is characteristic on both species. The KOCH is a member of the four-member coalition, but it is difficult to find out any possible assembly rule, for the other three members has rather different character in Plot 2 and 3. The dominant perennial grasses (FEVA and STBO) are close to each other in the graph, but do not belong to any coalition, perhaps because of their high frequency (they are present in almost every subplots).

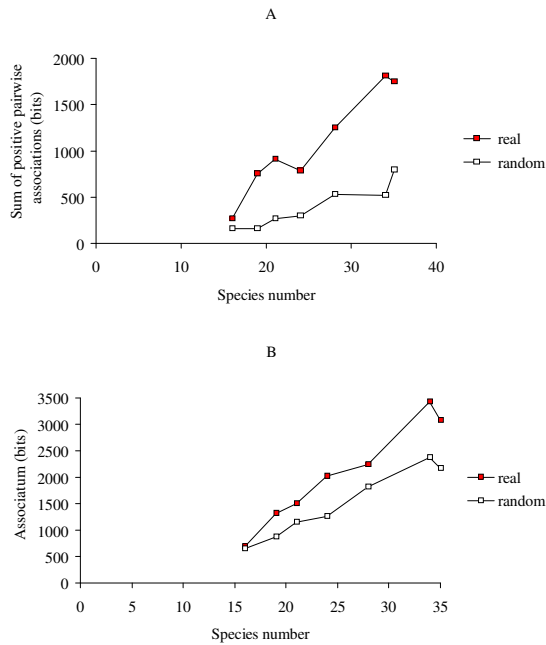


Fig. 5. Connection between the species number and the sum of positive pairwise associations (A), and associatum (B), computed from the real, field data matrices and from their spatially randomized references.

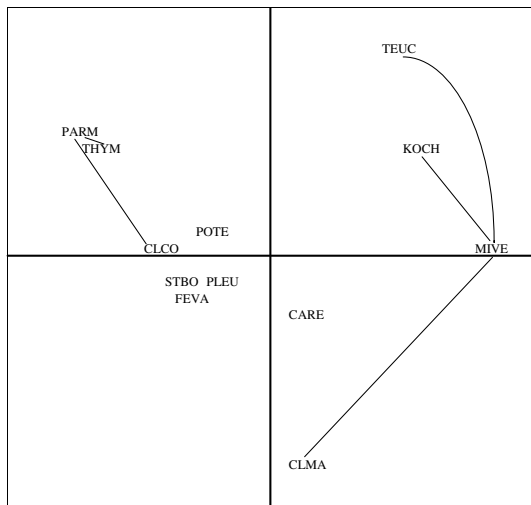


Fig. 6. Plexus graph of the species of Plot 2. The species are arranged according to the first two axis of the PCoA, Czekanowski similarity was used as the resemblance measure, plot size: 20x160 cm. The significant positive pairwise association values are indicated by edges. The species below 5% frequency value are not shown. Species names belonging to the abbreviations are given in Table 1.

In the closed grassland (Plot 5) and in the shrubby habitat (Plot 6) there are more significant associations (Figs. 8 and 9). Two coalitions can be separated in both plots: a dominant one containing

more species, and a subordinated coalition with fewer members. The dominant coalition in Plot 5 include 9 species with rather mesophilous and generalist character. The subordinated coalition is represented here by *Stipa borysthena*, two *Festuca* species and a moss (*Syntrichia ruralis*). These species belong to the open sand grassland community (*Festucetum vaginatae*) which has a drought tolerant character.

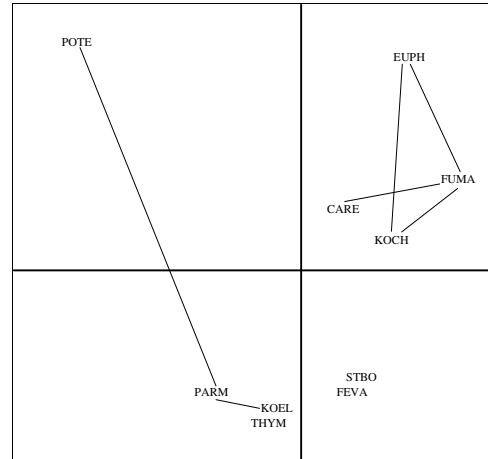


Fig. 7. Plexus graph of the species of Plot 3. (Details are given at Fig. 6).

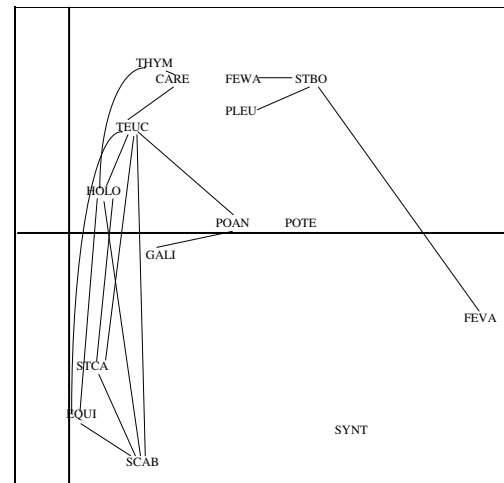


Fig. 8. Plexus graph of the species of Plot 5. (Details are given at Fig. 6).

In Plot 6 (shrubby habitat) the dominant coalition is built from eight closely connected species. The subordinated coalition consist of two grass species (POAN and FEVA), one herb (ASPE) and CARE which is one of the most frequent species in the study sites.

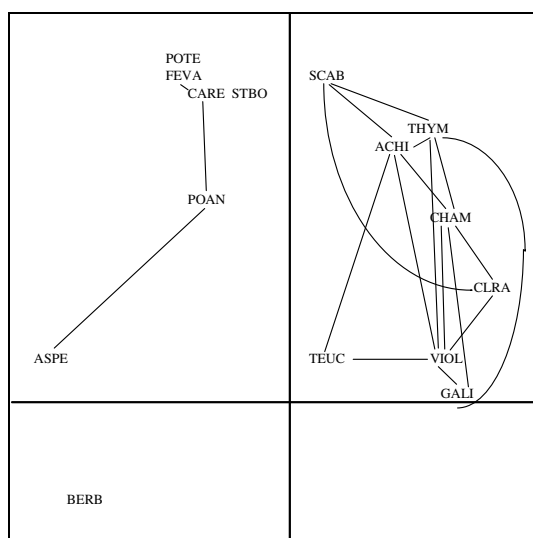


Fig. 9. Plexus graph of the species of Plot 6. (Details are given at Fig. 6).

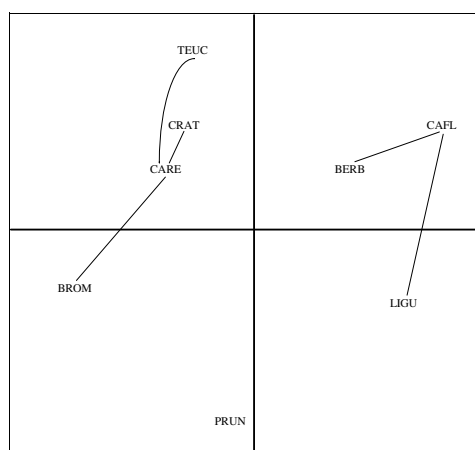


Fig. 10. Plexus graph of the species of Plot 7. (Details are given at Fig. 6).

In the understorey vegetation of the poplar forest two small coalitions can be found, similar to the open grassland sites (Fig. 10).

Discussion

Species association and succession

The three distinguished association level category (Low, Medium and High) correspond with three successional steps. The same three category of these study sites were established using diversity ordering (Margóczy, 1993).

Leps and Buriánek (1990) found no consistent trend, Myster and Pickett (1992) described a decline in the changes of the frequency of significant

associations with the successional age of the old field. Bartha (1992) pointed out that using a careful scaling procedure and large samples higher number of species combination can be detected even in the case of relatively simple, undeveloped early successional plant assemblages. In present study the sample size is smaller than recommended by Bartha (1992), but the associatum values even at plot size 20x20 cm show differences of the studied vegetation types, and determine a possible successional order of them (Fig. 3). This is because our study sites represent different successional stages of a highly natural vegetation, and it is not an oldfield, studied by Leps and Buriánek (1990) and Myster and Pickett (1992), or not weed community, studied by Bartha.

Species association frequency and intensity as a measure of community organization degree

Departure from the random reference was very low in the above mentioned small spatial scale, but at larger scale (plot size 20x160 cm) it was considerable (Fig. 4). The higher the species number, the larger the difference between the real and random values (Fig. 5), indicating, that the detected increase of species association intensity and frequency is not a trivial statistical phenomenon, but refers to the organization degree of the studied communities. So only the sparse, pioneer vegetation of Plot 1 can be regard as randomly organized. The co-occurrence of plant populations is restricted by assembly rules (Wilson, 1991) in the other five study sites. Although we tried to choose spatially homogenous patches for the study, it cannot be excluded, that a certain degree of soil micro- heterogeneity influenced the spatial organization of the vegetation.

Spatial dependence of the detectability of species associations

Careful spatial scaling is recommended to reveal all of the relevant species combinations (Bartha, 1992; Szolláth and Bartha, 1991). In this work we found that the rank of the studied stands did not change considerably when regarding the maximal value at appropriate spatial scale and the value at 20x20 cm sampling unit size. The same was found both in the case of pairwise associations or associatum (Figs. 2 and 3). Only the Plots 4 and 7 has different character in this respect. The detectability of species associations is more spatial dependent here, than in the other five study plots. The association intensity is low at low spatial scale, but the maximal value is relatively high. Further analysis will be required to reveal the reason of this phenomenon. Presumably these study plots represent

not a single, intact community, but a complex of several transitional or disturbed patches.

Species coalition structure

In the plots of Low level association category (Plot 1 and 4) no coalitions were revealed on the basis of pairwise associations. Two coalitions were found in the other 5 study plots. In the plots of Medium level association category the species number of the coalitions was low and equal. The species number of the coalitions was 9 and 3 in the closed grassland (Plot 5), and it was 8 and 4 in the shrubby habitat (Plot 6). The latter species coalition structure is rather similar to that of found by Seffer and Stanova (1993) in an acidophilous sand dune, where 10 species formed a larger coalition and other three species a smaller one. The size of the coalitions revealed by plexus-graph method was very similar in the study of Matus and Tóthmérész (1990) as well: 10 and 3 in an undisturbed sand grassland, and 8 and 2 in the grazed part of it. These results suggests, that in sand grassland communities plant populations are grouped generally in two separate coalitions, one of it with higher species number, and the other with low species number. Present study does not provide any suggestion about the nature of the assembly rules forming such coalition structure. Population level approach is necessary to find them.

The coalitions in Plot 5 can be differentiated according to the drought tolerance character of the members. This is in good agreement with the result of Körmöczy and Balogh (1990) that drought tolerance is important driving force of the spatial distribution of species in different communities of sand vegetation.

Acknowledgments

This investigation was carried out on the study sites selected by László Gallé, and joins to his project about community organization during succession on sand. The work was supported by the OTKA I/3 1607 grant.

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REVIEW OF AQUATIC VEGETATION OF THE REGIONAL PARK "STARI BEGEJ"

B. Butorac

Butorac, B. (1995): Review of aquatic vegetation of the regional park "Stari Begej". - Tiscia 29, 27-32.

Abstract. Within the Regional Park "Stari Begej" the following macrophyte associations have been recorded: *Nymphaeetum albo-luteae* Nowinski 1928, *Hydrochari-Nymphoidetum peltatae* Slavnić 1956 and *Trapetum natantis* Müller et Görs 1960. These associations were first mentioned in this area by Gigov and Gyôrfy in 1960. The authors also distinguished the *Myriophyllo-Potametum* Soó 1934 community, which is no longer present in the waters of this protected area.

Preliminary studies of aquatic vegetation showed that in this habitat the association *Wolffietum arrhizae* Myaw. et Tx. 1960 (*Lemnetea* class) developed. The following new associations were found in the region: *Salvinio-Spirodeletum polyrrhizae* Slavnić 1956, *Lemnetum trisulcae* Soó 1927, and *Lemno-Utricularietum vulgaris* Soó (1928) 1938.

Key words: aquatic community, floating vegetation, submerged vegetation.

B. Butorac, Institute of Nature Protection of the Republic of Serbia, Department in Novi Sad, Petrovaradinska tvrđava 3, Novi Sad, Yugoslavia.

Introduction

The Regional Park Stari Begej is located in Vojvodina - in the north-eastern part of Yugoslavia, at the estuary of river Begej into the river Tisza, and is a remnant of the floodplain between the two rivers. The seven parts reported in Butorac and Stojšić (1991-1992) are characterized by a mosaic-like vegetation of swamps, marshes, flooded and periodically flooded forests.

The heterogeneous flora and vegetation of this protected area are hardly known. The only data on the vegetation are from 1960 published by Gigov and Gyôrfy. They surveyed the aquatic, swamp and flooded-forest vegetation of dried-up Carska Bara, Vojtina Mlaka and Mala Bara. Therefore only certain parts of the Regional Park were investigated from floristic, phytogeographic or phytocenological point of view, and other parts were not visited. Some supplements were given to the knowledge of aquatic vegetation of this protected area by Butorac and Stojšić (1991-1992). The authors reported about the first discovery of *Wolffietum arrhizae* association, the stands of the smallest flowering plant on some parts of the protected area which are occasionally flooded by the river Begej.

In the past, when the human influence was

significantly smaller, the whole area was exposed to floods because of its low terrain (72-74 m a.s.l.), and the characteristics of the vegetation are just due to those conditions. Regulation of the riverbed at the beginning of this century reduced the flooded areas. Some twenty years ago the extended flood-prevention works resulted in even more drastic changes in the landscape. The typical habitat was changed by canalization of a part of river Begej which was cut off at the 15th km and directed to a newly excavated riverbed (i.e. canal). The old riverbed of the Begej, which is about 10 km in length, was surrounded with an embankment, and separated from the river Begej alive (Ham, 1975). Thanks to the controlled water regime, the inundation of the low terrain from the old riverbed has been reduced and less frequent, having an important influence on the recent vegetation.

Material and Methods

Phytocenological relevés were taken in the protected area in 1990, 1991 and 1992 according to the method of Braun-Blanquet (1964). Collected plants were determined after Jávorka (1925), Jávorka and Csapody (1934) and Josifović (1970-1986). Syntaxonomic status of the species was given from

Soó (1964-1980). Associations and subassociations were identified according to the first literature descriptions. Syntaxonomic status of associations and subassociations was determined from Soó (1973) and Parabućski et al. (1986).

Results and discussion

The following syntaxa of aquatic vegetation of marshes, flooded areas and the old riverbed of Begej could be distinguished according to Soó (1973) and Parabućski et al. (1986):

Class: *Lemnetea* W. Koch et Tx. 1954
 Order: *Lemnetalia* W. Koch et Tx. 1954
 Alliance: *Lemnion minoris* W. Koch et Tx. 1954
 Ass.: *Wolffietum arrhizae* Myawaki et Tx. 1960
 Ass.: *Salvinio-Spirodeletum polyrrhizae* Slavnić 1956
 Ass.: *Lemnetum trisulcae* Soó 1927, Knapp et Stoffers 1962, Trinajstić 1964
 Alliance: *Hydrocharition* Rübél 1933
 Ass.: *Lemno-Utricularietum vulgaris* Soó (1928) 1938

Class: *Potametea* Tx. et Prsg 1942
 Order: *Potametalia* W. Koch 1926
 Alliance: *Nymphaeion* Oberd. 1956 emend. Neuhausl 1959
 Ass.: *Nymphaetum albo-luteae* Nowinski 1928 (syn.: *Myriophyllo-Nupharetum* W. Koch 1926)
 Subass.: *nymphaetosum* (Timár) Kárpáti
 Subass.: *nupharetosum* (Timár) Kárpáti
 Ass.: *Hydrochari-Nymphoidetum peltatae* Slavnić 1956
 Ass.: *Trapetum natantis* Müller et Görs 1960

In the Regional Park "Stari Begej", three associations of the alliance *Lemnion minoris* were recorded (see Table 1).

1. *Wolffietum arrhizae*

This association developed on four localities between the embankment and the old riverbed of Begej, south of Vojtina Mlaka (cf. Butorac and Stojšić, 1991-1992). This paper reported for the first time on the floating stands of the smallest macrophytes in this region. Poor floristic composition and the cenological characteristics reflected on a specific water regime of the habitat. In

Table 1. Phytosociological relevés from *Lemnion minoris* and *Hydrocharition* communities.

	1	2	3	4	5	6	7	8	9	10	11	12
Association character species and <i>Lemnion minoris</i> W. Koch et Tx. 1954 ex Oberd. 1957 and <i>Hydrocharition</i> Rübél 1933												
<i>Wolffia arrhiza</i> (L.) Wimm *	5.4	5.4	5.5	-	-	-	-	-	-	-	-	-
<i>Salvinia natans</i> (L.) All. **	-	-	-	3.2	2.2	2.2	3.2	-	+	-	-	-
<i>Spirodela polyrrhiza</i> (L.) Schleid. **	+1	1.1	+1	+1	2.1	2.2	3.1	+1	-	-	-	-
<i>Lemna trisulca</i> L. ***	4.4	4.2	4.4	1.2	-	-	-	5.5	5.5	2.2	2.1	2.1
<i>Lemna minor</i> L. ****	3.3	2.1	1.1	5.1	1.1	2.1	2.1	1.1	2.1	2.1	3.1	3.1
<i>Utricularia vulgaris</i> L. ****	-	-	-	-	-	-	-	-	-	5.5	4.4	4.4
<i>Lemnetalia</i> W. Koch et Tx. 1954 and <i>Lemnetea</i> W. Koch et Tx. 1954												
<i>Hydrocharis morsus-ranae</i> L.	-	-	-	4.2	1.1	2.1	1.1	-	+1	-	-	-
<i>Myriophyllum spicatum</i> L.	-	-	-	2.2	-	1.1	1.1	-	-	-	-	-
<i>Ceratophyllum demersum</i> L.	-	-	-	4.2	-	+	-	-	-	-	-	-
<i>Najas marina</i> L.	+1	-	+1	-	-	-	-	-	-	-	-	-
<i>Nuphar luteum</i> Sm.	-	-	-	-	-	-	1.1	-	-	-	-	-
<i>Trapa natans</i> (agg.)	-	-	-	-	-	+1	-	-	-	-	-	-
Accessory species												
<i>Phragmites communis</i> Trin.	-	-	-	+1	1.1	1.1	-	-	-	-	-	+1
<i>Typha latifolia</i> L.	-	2.1	-	-	-	-	-	+	-	-	-	-
<i>Polygonum amphibium</i> L.	-	-	-	+1	-	-	-	-	-	1.1	-	-
<i>Glyceria aquatica</i> Presl.	-	-	-	-	1.1	-	-	-	-	-	-	-

Legend

Lemnion minoris W. Koch et Tx. 1954 ex Oberd. 1957
 **Wolffietum arrhizae* Miyawaki et J.Tx. 1960 = 1,2,3
 ***Salvinio-Spirodeletum polyrrhizae* Slavnić 1956 = 4,5,6,7
 ****Lemnetum trisulcae* Soó 1927 = 8,9
Hydrocharition Rübél 1933
 *****Lemno-Utricularietum vulgaris* Soó 1928 = 10,11,12

Sites
 Stari Begej = 1,2,3,4,8,9
 Kanal = 5
 Carska bara = 6,10,11,12
 Perleska bara = 7

accordance with periodical drying up in the warmest months (particularly during the last few years), the ecological conditions have changed in the habitats, and became similar to those in the most shallow, warm, still waters of Vojvodina. These alterations caused a somewhat different structural appearance of *Wolffietum arrhizae*, when compared to the stands near village Bokros and other areas in Hungary (Szalma et al., 1985; Fintha, 1984). *Utricularia vulgaris* and *Stratiotes aloides* were not recorded together with *Wolffia arrhiza*, similarly to the situation on some Hungarian areas (Fintha, 1984).

2. *Salvinio-Spirodeletum polyrrhizae*

Slow or no water flow in certain periods of year, lukewarm, eutrophic water (Branković, 1992) and other changed parameters of water regime conditioned visible exuberant growth of the character species of this associations: *Salvinia natans* and *Spirodela polyrrhiza*, corresponding to the results of some other authors (Slavnić, 1956; Topić, 1989; Stojanović, 1990). Well-developed stands of *Salvinio-Spirodeletum polyrrhizae* association were found near the bank of the old riverbed of Begej, as well as in the canals that supply the surrounding pools with water. Recently they are, however, muddy and covered by vegetation. Particularly large number and coverage of the edificator species of this association was noticed at widened bends of those lateral canals, as well as near the bank of the old riverbed of Begej. At those places the speed of water decreased and the water is more shallow, but still deep enough to develop certain differences in floristic composition of the stands.

This association becomes the most apparent in August. *Salvinia natans*, *Spirodela polyrrhiza* and *Lemna minor* have a huge importance in the stands of *Salvinio-Spirodeletum polyrrhizae* association. According to the data from Slavnić (1956), Stojanović et al. (1990), Rauš et al. (1978, 1980) and Szalma (1987-1988) it is a heliophytic floating community, which forms a thick green "carpet" on the water surface. Investigations in the Regional Park "Stari Begej" showed, however, that submerged forms are also included in the floristic composition of this association, species from the genera *Myriophyllum* and *Ceratophyllum*. The total coverage is increased by dense populations of *Hydrocharis morsus-ranae*.

3. *Lemnetum trisulcae*

This association of the submerged duckweed has a relatively limited extension in the Regional Park "Stray Begej". It only developed in fragments at some places along the old riverbed of Begej, from

Vojtina Mlaka to Perleska Bara. These terrains are occasionally flooded, sometimes even up to the roots of old willow trees at the embankment, which is the western border of the Regional Park. The stands of this monoculture association develop in the shade of willow trees, and are of submerged-hydrophytic character as it was recorded by Rauš et al. (1978) and Topić (1989). The latter author points out that submerged layers are at the depth from a few cm to several dm. The dominant species of this association is the pseudofloating *Lemna trisulca*, i.e. this scyophytic species (Landolt, 1977) occurs totally submerged in the water but close to the surface, giving the impression of a floating vegetation (Janković, 1972; Janković et al., 1987, 1988). This species influences the physiological processes of the plants in the deeper water layers, reducing there the light intensity.

4. *Lemno-Utricularietum vulgaris*

This association is the only one from the alliance *Hydrocharition* (Table 1.), and located in only one part - Carska Bara. The duckweed - bladder-wort community is the final successional stage of the smallest aquatic vascular plants. It is similar to *Salvinio-Spirodeletum polyrrhizae* association, and there is no distinct ecological or spatial boundary between them.

The character species distinguishing this associations from those mentioned above are *Utricularia vulgaris* and the species of the genus *Lemna*. *Utricularia vulgaris* is an insectivorous species, and since withdraws from the aquatic habitats of Vojvodina, it is on the list of "Red Data Book of Serbia".

Water depth, eutrophicity, light and temperature regime are the most important background factors in development and survival of its floristic composition and cenological structure.

5. *Nymphaeetum albo-luteae*

It is an important association of the Strict Nature Reserve "Carska Bara", and its another locality was found in the old riverbed of Begej, close to village Perlez. This association is the main character of aquatic vegetation of Perleska Bara. Waterlily community is the association of the largest aquatic macrophytes, occurring in the Carska Bara as a more or less wide belt, and is in direct contact with the stands of hydro-helophytic vegetation at the bank zone. The main structural and physiognomic characteristics of this species poor association are given by white and yellow water-lilies, *Nymphaea alba* and *Nuphar luteum*. They contribute to the beauty of the scenery, and are protected

representatives of the pool-swamp ecosystems. These are differential species of the subassociations: *nymphaetosum* and *nupharetosum*. Third species of this community is the water chestnut, *Trapa natans* agg. (i.e. *Trapa longicarpa* M. Jank. 1954 ssp. *perlongicornis* M. Jank. 1986 var. *cornata* (Nath.) Glck. 1936), but its density and dispersion are low. The water layers below these floating forms are filled with dense populations of only one species, *Ceratophyllum demersum*.

Restricted stands of this association have somewhat more complex structure in the old riverbed of Begej, with an important contribution of *Hydrocharis morsus-ranae*, *Salvinia natans*, and the presence of *Myriophyllum spicatum* was also established (Table 2).

Ecology of *Nymphaetum albo-luteae* association is greatly influenced by two character species characterized by strong and often very long rhizomes (trunks), laid horizontally on the bottom, by which these hydrophytes spread quickly and smoothly. They occupy the water surface by large floating leaves, and the bottom is largely muddied by their dead parts.

6. *Hydrochari-Nymphoidetum peltatae*

The stands of frogbit-fringed water-lily association are adapted to very shallow, well-illuminated, slow, warm waters, such as Vojtina Mlaka is. They were found in the vegetation of Carska Bara in certain years only, when water level was extremely low, with high temperature and illumination. This association can not be developed in deeper, cooler water of the old riverbed of Begej with at least occasional waterflow.

The habitats suitable for its optimum development are also characterized by high organic production, with enormous layer of mud on the bottom. These conditions indicate a very strong eutrophication. In the last years, high emergent plants such as reed (*Phragmites communis*), bulrush (*Typha latifolia* and *Typha angustifolia*), sweet-grass (*Glyceria maxima*), bur-reed (*Sparganium ramosum*) have been expanding closer and closer to the center of the water of Carska Bara.

The basic aspect of *Hydrochari-Nymphoidetum peltatae* is given by the character species of the association: *Nymphoides flava* (syn: *Nymphoides peltata*). *Hydrocharis morsus-ranae* and some other floating macrophytes, which are the character species of the alliance, order and class, play an important role in floristic composition and physiognomy.

Table 2. Phytosociological relevés from *Nymphaeion* and *Potametalia* communities.

	1	2	3	4	5	6	7	8	9	10	11	12
Association character species and Nymphaeion Oberd. 1956 emend Neuhausl 1959												
<i>Nymphaea alba</i> L. *	4.1	4.4	4.4	4.4	-	-	-	-	-	-	-	-
<i>Nuphar luteum</i> Sm. *	-	-	1.1	2.2	3.3	3.5	-	-	-	-	-	-
<i>Nymphoides flava</i> Hill.	-	-	-	-	-	-	5.5	5.5	4.4	-	-	-
<i>Hydrocharis morsus-ranae</i> L. **	1.2	2.2	1.1	1.1	1.1	1.2	2.2	2.2	3.2	1.2	3.1	-
<i>Trapa natans</i> (agg.) ***	1.1	-	1.1	-	+1	2.2	1.1	1.1	1.2	3.2	3.4	4.2
Potametalia W. Koch 1926 and Potametea Tx. et Prsg. 1942												
<i>Ceratophyllum demersum</i> L.	3.2	-	3.2	2.2	-	-	1.1	1.1	2.2	3.3	3.3	4.5
<i>Myriophyllum spicatum</i> L.	-	1.1	3.2	1.1	-	3.1	-	-	-	3.3	-	+1
<i>Najas marina</i> L.	-	-	-	-	-	1.1	-	-	-	-	2.1	2.2
<i>Potamogeton crispus</i> L.	+1	+1	-	1.1	-	-	-	+1	-	-	-	-
<i>Ranunculus circinatus</i> Sibth.	-	-	-	+1	-	-	-	1.1	-	-	-	-
Accessory species												
<i>Salvinia natans</i> (L.) All.	2.2	2.1	-	1.1	-	2.2	+	-	-	1.2	3.2	-
<i>Spirodela polyrrhiza</i> (L.) Sch.	1.1	-	-	1.1	-	1.1	-	-	-	1.1	-	-
<i>Lemna minor</i> L.	+1	-	-	-	1.1	-	+1	-	+1	-	-	-
<i>Lemna trisulca</i> L.	-	-	-	-	-	2.2	-	-	-	-	-	2.2
<i>Rorippa amphibia</i> (L.) Bess.	-	-	-	-	-	-	-	1.1	-	-	-	-

Legend:

- * *Nymphaeetum albo-luteae* Nowinski 1928 = 1,2,3,4,5,6
- ** *Hydrochari-Nymphoidetum peltatae* Slavnić 1956 = 7,8,9
- *** *Trapetum natantis* Müller et Görs 1960 = 10,11,12

Sites

- Carska Bara = 1,3,6,12
- Stari Begej = 2,10,11
- Perleska bara = 4,5
- Vojtina Mlaka = 7,8,9

7. *Trapa natantis*

This association is the dominant floating community in Carska Bara. Its edifier and often the only species is the water chestnut (*Trapa natans*), the species aggregate. On the basis of fruit morphology, we can state that this taxon is *Trapa longicarpa* M. Jank. 1954 ssp. *perlongicornis* M. Jank. 1986 var. *cornata* (Nath.) Glck. 1936 (Janković in Josifović, 1986) which is often present in the water-lily community.

The monotonous and compact stands cover entirely the area of Carska Bara so that often one can not see open water surface. The shallow water, thick mud layer and densely interlaced rhizomes, submerged leaves make boat passage impossible. Lack of waves and moves of already shallow water, with decomposition of organic remnants, contribute to the increase of water temperature, which also favours sprouting and spreading of water chestnut. Here it should be emphasized that, according to the literature, the fruits of the relict and protected genus *Trapa* are resistant to low temperature, so it can survive for some time even in frozen state.

The monotonous scenery is brightened up by the stands of water-lily at fringes and the autumn aspect, when floating rosettes of the water chestnut appear like a spotted carpet on the water surface. Under this layer, dense submerged mass of the horn wort (*Ceratophyllum demersum*) appears, which decrease the possibilities of shipping.

Stands of *Trapa natantis* association were found in the slow water of river Stari Begej. Their structure is different, and have lower number and coverage of the basic edifier species. From the floating coenobionts, the participation of *Salvinia natans* and *Hydrocharis morsus-ranae* is significant, and sometimes *Spirodela polyrrhiza* occurs. Because of deeper and cooler water, the scyphylic *Ceratophyllum demersum*, important by its coverage, and *Najas marina*, on an open sandy bottom, were found in the old riverbed of the Begej. Presence of latter species was not fully expected, because the stands of this association are typical for shallow and warm water with muddy bottom.

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NEW FEATURES OF MULTI-PATTERN 1.10: ROBUST NONLINEAR SMOOTHING

B. Tóthmérész and Zs. Erdei

Tóthmérész, B. and Erdei, Zs. (1995): New Features of MULTI-PATTERN 1.10: Robust Nonlinear Smoothing. - Tiscia 29, 33-36.

Abstract. New features of the MULTI-PATTERN program package, to analyse the spatial structure of multispecies point patterns, are discussed. Robust nonlinear smoothers are included in the package to improve the estimation of the maximum area of a community and the curve of spatial statistics. Eight robust nonlinear smoothers are mentioned and their performances are discussed. For spatial series analyses the smoothings related to the locally weighted robust regression are performed exceptionally well.

Keywords: robust nonlinear smoothing, maximum area, spatial series analyses, multispecies spatial point patterns.

B. Tóthmérész, Zs. Erdei, Ecological Institute, Kossuth L. University, Debrecen, POB 71, H-4010
Fax: (36) 52 431-148, E-mail: tothmerb@tigris.klte.hu and zserdei@tigris.klte.hu

Introduction

It was Juhász-Nagy who proposed the indirect spatial series analysis to study the spatial pattern of communities (Juhász-Nagy, 1967, 1976). He developed a systematic, quite formal theory. From technical point of view, spatial series analyses are based on the graphing of a spatial statistics against the plot size (Bartha, 1992; Juhász-Nagy and Podani, 1993; Podani et al., 1993). This is the so-called spatial series curve. Juhász-Nagy preferred such spatial statistics which were based on the presence-absence pattern of communities (Juhász-Nagy, 1984, 1993). During the interpretation of results the characteristics of the spatial series curve is vital; especially the global maximum and the local maxima are important. The main difficulty with the indirect spatial series analysis is that it requires huge sample size. Even with large sample sizes the oscillation of spatial series curve may be significant (Tóthmérész and Erdei, 1993; Tóthmérész, 1994b).

In this paper robust smoothings are used to identify the maximum area of spatial statistics for multispecies communities. Robust nonlinear smoothers are ideal tools to smooth heavily oscillating sequences and let us see regularities with the elimination of "random noise." Tóthmérész (1994a) proposed to use robust nonlinear smoothers

to improve the estimation of spatial series curves and especially to estimate the maximum area. For small and medium sample sizes these techniques are reducing heavily the variance of the estimation of maximum area (Tóthmérész, 1994c); this was the basic motivation to include these methods into the MULTI-PATTERN program package (Erdei and Tóthmérész, 1993).

Methods

There are three groups of nonlinear smoothers in the new release of MULTI-PATTERN (Fig. 1). The first one includes composed running median smoothers. 3RSSH and 4253H are included. These are standard running median smoothers of the statistical literature (Velleman and Hoaglin, 1981; Tukey, 1977). Robust locally weighted regression (LOWE, Cleveland, 1978, 1979, 1981) and a special version of it (RANK-LOWE) proposed by Tóthmérész (1994c) comprise the second group. In the case of RANK-LOWE smoothing the steps of the spatial series analysis are considered to be equally scaled. We can also say that just the rank-order of the plot sizes is used and the actual size of the plot is not used during the computations. Finally, there is a third group of smoothers included in the package. These are based on the composition of a running median

smoothers and the robust locally weighted regression. These were also proposed and assessed by Tóthmérész (1994c).

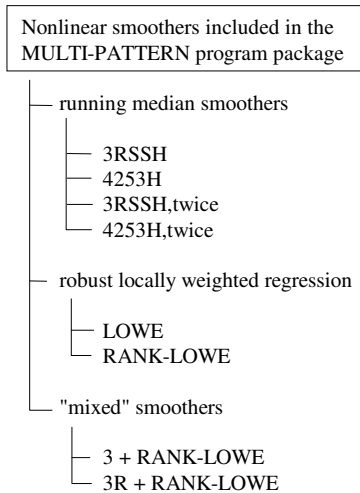


Figure 1. Three diagram of the nonlinear smoothers included in the package.

How to use the new options

The new "Smoothing REsult files" option is included in the "Edit" menu. This is the last item in the pull down menu (Fig. 2). With a click on the left

button of the mouse to the option, the screen of the nonlinear smoothers appears (Fig. 3). You can smooth spatial series curves. This means that you have to have a "*.RES" file which contains the result of a direct or indirect spatial series analysis if you would like to use the nonlinear smoothers. The first step is to choose a file which contains the result of a spatial series analysis. With a click on the "Input file" button you receive a list of "*.RES" files of the directory and thus, you can choose a file to be smoothed or you can change the directory to find a file. The result of the smoothing is written into another file. Thus, you have to define the file name clicking on the "Output file" button and typing the file name. Then you have to choose one of the nonlinear smoothers by clicking to the name of the smoothers. Your choice is indicated by a "(●)" sign. In the case which is demonstrated in Fig. 3 we have chosen the RANK-LOWE smoother. Finally, when everything is all right, you have to click on the "Smooth" button or on the "Cancel" button if you decided not to smooth et al. The program shows the progression of the calculation and informs you when it is ready. Then you can use the "View" option of the program to draw the smoothed spatial series curves.

For 3RSSH and 4253H smoothers there is a possibility for twice-ing using the "Twice" button. This procedure is based on the smoothing and adding of the rough to the smoothed series (Tukey,

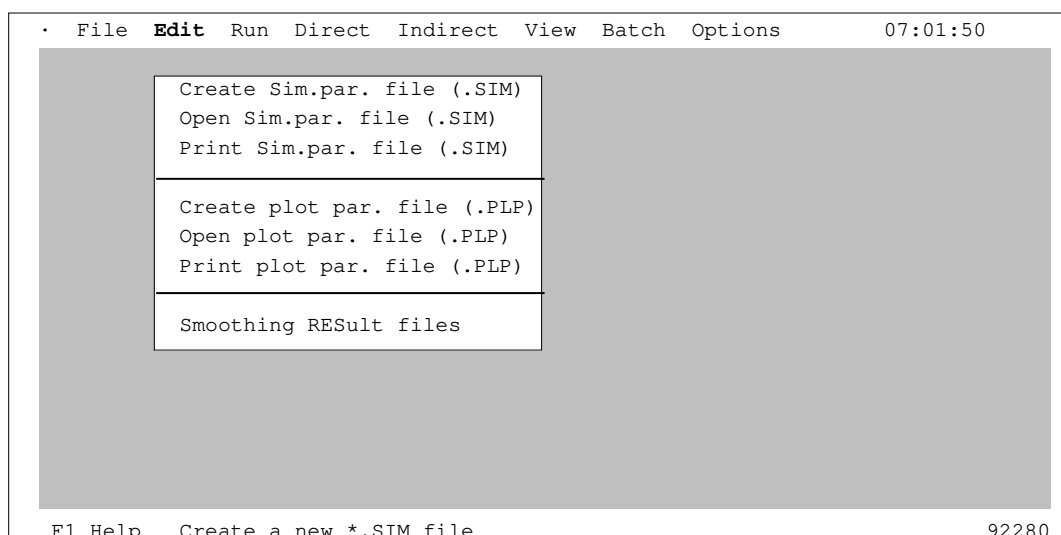


Figure 2. The "Smoothing REsult files" option is included in the "Edit" menu.

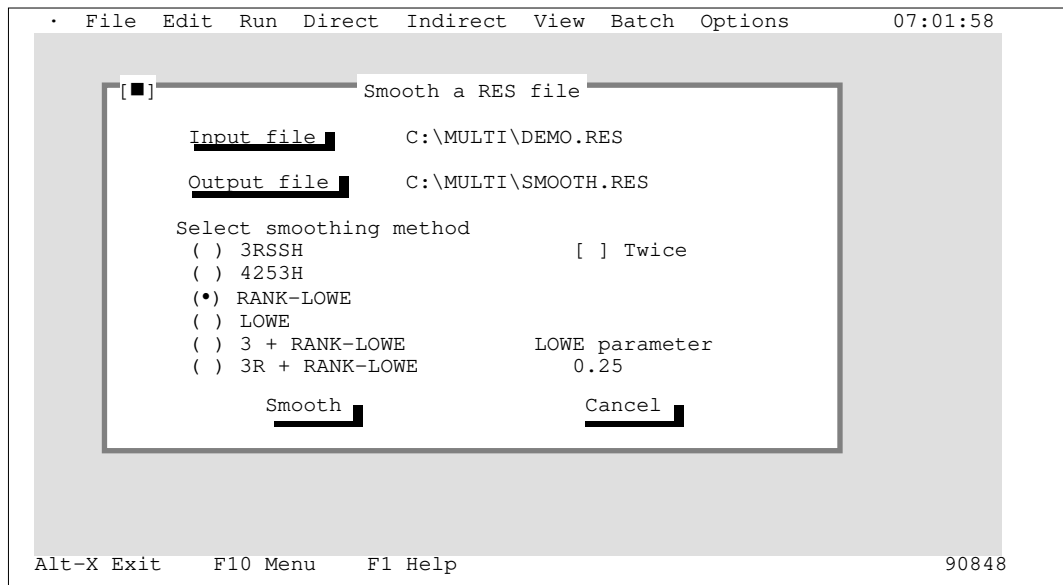


Figure 3. The screen of the nonlinear smoothers in the package.

1977). This may prevent the elimination of some of the trends or fluctuations that are really present in the data sequence.

Discussion

There is a rather elementary solution to "eliminate" the oscillation of the spatial series curve. Simply to choose a large step size for the spatial series analysis as it is demonstrated by the Fig. 4. In this case the curve looks smooth enough for moderate plot sizes. For small step sizes the oscillation is too heavy even for large sample sizes. Large step size, however, prevents the correct identification of the maximum area. Decreasing the step size, we have to cope with the oscillation. The problem of oscillation was also reported by Tóthmérész and Erdei (1992).

Figs. 5. and 6. show the spatial series curve of a 4-species completely spatially random community using the diversity of species combinations as a spatial statistics and the smoothed versions of the curve. The number of sample plots were 100 for each step of the spatial series analysis. The 4253H is not a drastic smoother; it does not eliminate the oscillation of the curve just the high peaks and low valleys (Fig. 5). The 3R+RANK-LOWE produces a very smooth curve which eliminates almost all the oscillations (Fig. 6).

Robust nonlinear smoothers are very powerful in extracting regularities from data sequences. Therefore these are ideal tools to improve the *TISCIA 29*

estimation of the maximum area and especially to improve the quality of indirect spatial series curves. Our experience with these smoothers shows that the 3RSSH and 4253H smoothers are moderately effective in smoothing. They do not eliminate the

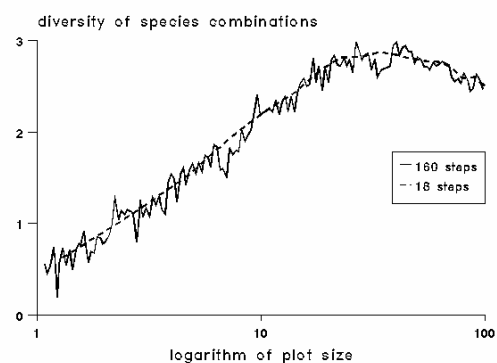


Figure 4. Spatial series analysis of a 4-species community using the diversity of species combinations as a spatial statistics. One of the spatial series curve is produced by large steps while the other is calculated by small steps between the plot sizes. The sample size was 1000 plots for each plot size.

oscillations as heavily as the LOWE techniques. Therefore, these can be used to eliminate the heavy peaks and valleys and still there are some mild oscillations in the series. These techniques proved not very effective in reducing the variance of the estimation of the maximum area (Tóthmérész,

1994b). There was almost no effect of twice-ing in the studied cases.

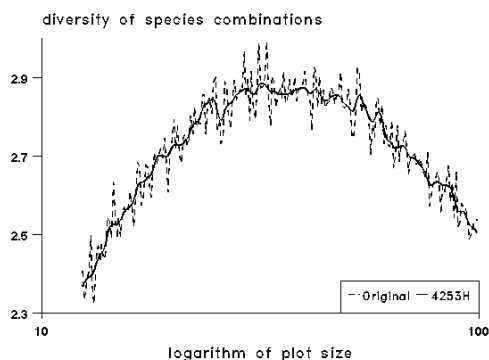


Figure 5. Spatial series analysis of a 4-species community using the diversity of species combinations as a spatial statistics. The sample size was 100 plots for each plot size. The spatial series curve is smoothed by the 4255H smoother.

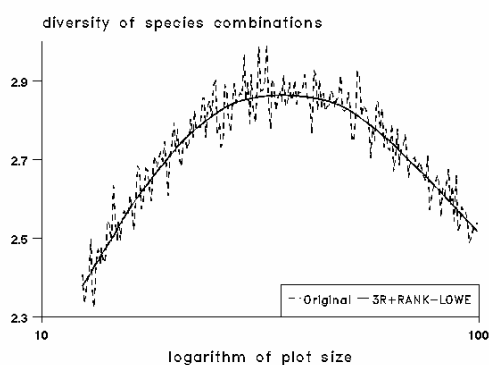


Figure 6. Spatial series analysis of a 4-species community using the diversity of species combinations as a spatial statistics. The sample size was 100 plots for each plot size. The spatial series curve is smoothed by the 3R+RANK-LOWE smoother.

A dramatic improvement was produced by the LOWE and RANK-LOWE techniques. The smoothed curves are without oscillation and the variance of the estimation of the maximum area are heavily reduced even for relatively small number of sample plots. In the case of LOWE the computing time is much longer and this is usually less effective in reducing the variance of the estimation than the RANK-LOWE. Therefore, the favourite choice is probably the RANK-LOWE smoother. The 3+RANK-LOWE and 3R+RANK-LOWE techniques eliminate the extremely high peaks and very low valleys by 3 and 3R smoothing and then they perform a RANK-LOWE smoothing. These smoothers are designed especially robust against "peculiar" values and also to produce very smooth spatial series curves

without oscillations. These techniques are designed to incorporate the beneficial features of both the running median smoothers and the RANK-LOWE.

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SPATIAL AND TEMPORAL VARIATION OF THE LEAFHOPPER (CICADINA) ASSEMBLAGES ASSOCIATED WITH *HIERACIUM PILOSELLA* IN HUNGARY

M. Sárospataki and Gy. Györffy

Sárospataki, M. and Györffy, Gy. (1995): *Spatial and temporal variation of the leafhopper (Cicadina) assemblages associated with Hieracium pilosella in Hungary.* - *Tiscia* 29, 37-40.

Abstract. We studied the structure of the leafhopper assemblages associated with *Hieracium pilosella* at different sites of Hungary in 1992-1994. A total of 225 individuals of 24 species were collected during the three years. The high variance of species number between sites and years indicated a large number of accidental or tourist species. The local species abundance was positively correlated with the regional distribution. One species (*Eupterix notata*) was very abundant at one site but was not regionally widespread. The regional distribution of the species did not show bimodality predicted by the core and satellite species hypothesis.

Key words: insect-plant relationship, local abundance, regional distribution.

M. Sárospataki, Department of Zoology and Ecology, Gödöllő University of Agricultural Sciences, Gödöllő, Hungary; Gy. Györffy, Department of Ecology, József Attila University, H-6701 Szeged, P.O.Box 659, Hungary

Introduction

The study of the local and regional variations in assemblage structure can bring us closer to find out what are the most important factors affecting this structure.

The study of the herbivore assemblages associated with a plant species has produced an extensive literature since the first attempts to use insects as biological control agents of weeds. Most of these studies were faunistical, producing lists of species associated with the given plant species (Goeden, 1971, 1976; Goeden and Ricker, 1974, 1976; Batra, 1984; Batra et al., 1986; Kingsolver et al., 1984). There are few papers examining the structure of an insect assemblage of a plant species and comparing the local and regional variations in this structure (Lawton, 1976; Gaston and Lawton, 1989; Basset and Kitching, 1991; Briese et al., 1994).

We studied the leafhopper assemblages associated with *Hieracium pilosella* in order to find out the spatial and temporal variation in different parts of Hungary.

Material and Methods

Hieracium pilosella is a widespread plant species in the dry open grasslands in Europe. It is distinguished from the other *Hieracium* species by its large solitary pale yellow capitula and dense stellate pubescence on stolons and on the underside of leaves. In Hungary, *H. pilosella* occurs especially in hilly - low mountainous regions. It has a good ability of vegetative reproduction, and usually forms dense mats.

Seven sites at different parts of the low mountain and hill regions of Hungary were selected for regular sampling visits (Fig. 1.). Four of them (J; H; R; S) were grazed or used as hay meadows the remaining three were natural or seminatural grasslands with different degrees of human disturbance. *Hieracium pilosella* formed dense mats at each sites. The sampling sites were visited weekly in the flowering season (late April and May), and fortnightly afterwards until the end of September in 1992-1994. The insects were collected by hand picking from 100 randomly selected rosettes at each sites and on each sampling occasion.

The ANOVA was made by using Minitab 8.2 program package (General Linear Modeling).

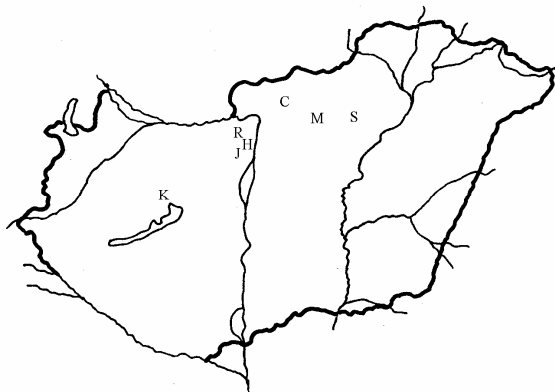


Fig. 1. : The map of the regular sampling sites. K) Kádárta (Bakony mountains); J) Julianna major (Budai mountains); H) Hármashatárhegy (Budai mountains); R) Budapest-RADELKIS (Budai mountains); C) Romhány (Cserhát mountains); M) Recsk (Mátra mountains); S) Síkfőkút (Bükk mountains).

Results

A total of 225 individuals of 24 leafhopper species were collected during the three years (Table 1). Both the species and individual numbers varied widely between sites (Figs. 2-3.). The sites differ significantly both in the numbers of species and individuals (ANOVA $p=0.015$ and 0.018 respectively). The species number varied less widely between years than between sites, however the species turnover between years were very high at all sites (Table 1.).

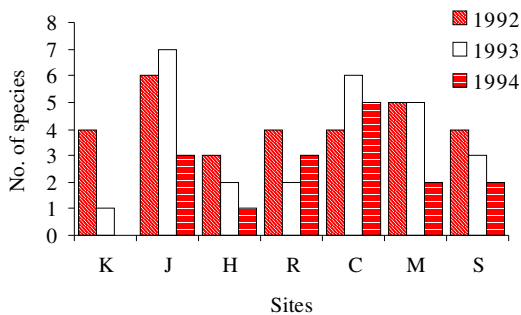


Fig. 2.: The number of species collected at different sites in the different years. For the explanation of the letters in X axis see Fig. 1.

The local species abundance was positively correlated with the regional distribution (Fig. 4.). However, *Eupteryx notata* Curtis was very abundant

at "J" site in 1992 (48 individuals) but was collected from only 3 sites so had a moderately large regional distribution. The regional distribution of species is shown in the Fig 5. A large number of species was found only at one site, while only one species, *Aphrodes makarovi* was found at all the seven sites.

Discussion

The total species number was much higher than those of similar surveys of other herbaceous plant species (Goeden, 1971, 1976; Batra, 1984; Batra et al., 1986). The high variance in species and individual numbers between sites suggests a large regional variance in the structure of the assemblages. It seems from the high species turnover between years that there are a large number of accidental species, which are only occasional visitors on *Hieracium* patches.

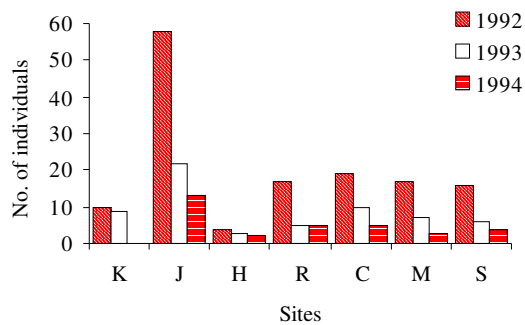


Fig. 3.: The number of individuals collected at different sites in the different years. For the explanation of the letters in X axis see Fig 1.

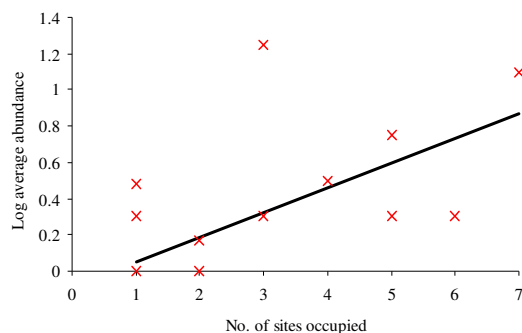


Fig. 4.: Relationship between regional distribution and average local abundance of leafhopper species ($Y=0.112 \cdot X - 0.027$; $R^2=0.3959$; $p=0.001$)

The positive correlation between local abundance and regional distribution has been demonstrated for a number of taxa (Bock and Ricklefs, 1983; Cornell, 1985; Gaston and Lawton, 1989; Maurer, 1990; Hanski et al., 1993; Gallé, 1986). We also found this positive correlation. The large number of *Eupteryx notata* in 1992 at "J" site seems to be exceptional, because *Hieracium pilosella* is only an occasional host of this species (Payne, 1981).



Fig. 5.: Distribution of species across the sampling sites.

The core and satellite species hypothesis (Hanski, 1982a,b) predicts a bimodal distribution of species across the sites, where the two modes of the histogram represent the satellite species with very small, and the core species with very large regional distribution. However, Nee et al. (1991) argued that this bimodality in the regional distribution can be a sampling or a measurement scale artefact in a number of cases. Similarly to the results of Gaston and Lawton (1989) on bracken herbivores we did not find the bimodality in our data. We found only the mode of the satellite species, and this mode can be explained by the presence of the large number of accidental species, which species do not represent genuine members of the community (Nee et al., 1991). Although *H. pilosella* occurs in a large number of different plant communities, the presence of *H. pilosella* may be not a principal component in the habitat selection of polyphagous leafhoppers found on this plant. In this case these species do not have similar habitat selection and this can be the reason of the lack of bimodality (Hanski, 1982a).

Table 1.: The list of species collected on *H. pilosella* at seven different sites in Hungary during 1992-1994. (l): only larve were found (list of other abbreviations as on Fig. 1.)

Species/Sites	K.	J.	H.	R.	C.	M.	S.	Σ
Agallia ribauti Ossiannilsson, 1938	0	6	0	8	6	3	5	28
Aphrodes makarovi Zachvatkin, 1948	16	27	2	6	14	10	6	81
Arocephalus lanquidus Flor, 1861	1	0	0	0	0	0	0	1
Artianus interstitialis Germar, 1821	0	1	0	0	0	0	0	1
Delphacidae sp.	0	1	0	0	0	0	1	2
Dictyophara europaea (Linnaeus, 1767)	0	0	0	1	0	0	0	1
Dictyophara pannonica (Germar, 1830) (l)	0	0	0	0	1	0	0	1
Diplocolenus sp. (l)	0	0	0	0	0	1	0	1
Doratura stylata (Boheman, 1847)	1	3	1	0	3	2	0	10
Emelyanoviana mollicula (Boheman, 1845)	0	0	0	0	0	1	0	1
Eupteryx notata Curtis, 1837	0	49	0	0	1	0	2	52
Euscelis incisus Kirschbaum, 1858	0	1	0	1	0	0	0	2
Goniagnathus brevis (H.-S., 1835)	0	1	1	3	1	3	3	12
Graphocraerus ventralis (Fallén, 1806) (l)	0	0	0	0	2	1	0	3
Jassargus sp.	0	2	0	0	0	0	0	2
Lepyronia coleoptrata (Linnaeus, 1758)	0	0	0	0	1	0	0	1
Macrosteles sp.	0	0	3	0	0	0	0	3
Mendrausus pauxillus (Fieber, 1869)	0	0	1	0	0	0	0	1
Mocuellus collinus (Boheman, 1850)	0	1	0	0	0	0	0	1
Neoliturus fenestratus (H.-S., 1834)	0	0	0	5	1	2	4	12
Philaenus spumarius (Linnaeus, 1758)	0	0	0	0	1	0	0	1
Psammotettix sp.	0	1	0	0	0	0	0	1
Turrutus socialis (Flor, 1861)	1	0	0	0	0	0	0	1
Ulopa trivialis Germar, 1821 (l)	0	0	0	0	3	1	2	6
Total No. of species	4	11	5	6	11	9	7	24
Average No. of species/year	1.7	5.3	2	3	5	4	3	12.3
Number of individuals	19	93	8	24	34	24	23	225
Average No. of individuals/year	6.3	31	2.7	8	11.3	8	7.7	75
Mean species turnover	2	6.5	3.5	3	5.5	5.5	3	14

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ECOLOGICAL CHARACTERISTICS OF BEE COMMUNITIES ON A SANDY GRASSLAND

M. Sárospataki and J. P. Fazekas

Sárospataki, M. and Fazekas, J. P. (1995): Ecological characteristics of bee communities on a sandy grassland. - Tiscia 29, 41-46.

Abstract. The Apoidea community on a sandy grassland in the Kiskunság National Park, Central Hungary consisted of 96 Apoidea species, and the diversity calculated for single traps by the Shannon-Wiener function was high ($H = 2.25 - 4.19$).

Only the dominant species showed seasonal (*Lasioglossum calceatum*, *Nomioides minutissima* and *Seladonia semitectus*) or spatial (*Andrena taraxaci* and *A. florivaga*) segregation.

Results from both the cluster analysis and the principal component analysis indicated that the spatial patterns of the Apoidea populations and the plant patches did not match.

An interpretation of the PCA results showed that the first principal component was correlated with the value of plant cover but explained only 18% of variance; this indicated that several additional components influenced the distribution of bees, however the plant cover seems to be the most important factor.

Key words: Apoidea, community structure, insect-plant relationships, temporal and spatial distribution.

M. Sárospataki, J. P. Fazekas, Department of Zoology and Ecology, University of Agricultural Sciences, Gödöllő, Hungary

Introduction

The diverse group of Apoidea has an important role in ecological communities by pollinating plants. A substantial amount of research deals with bee foraging patterns and the relationship between a chosen plant species and its pollinators (Kevan and Baker, 1984; Johnson, 1984; Waser, 1986; Dukas, 1987). However, studies on bumble bees (Pyke, 1980; Lundberg and Ranta, 1980; Mjelde, 1983) and on the honey bee (Menzel, 1985) dominate the literature. Few studies examined the community structure of bee populations living on one site (Mackay and Knerer, 1979; Ginsberg, 1983).

We studied the Apoidea community on a sandy grassland in the Kiskunság National Park, Central Hungary. Besides the spatial and seasonal distribution of the most abundant bee populations, we examined the relationship between the Apoidea group as a whole and the plant communities by means of multivariate analyses. To the best of our knowledge, there is no previous example of the application of these methods to study of entire

Apoidea communities.

Materials and Methods

Study area

The study area was on a sandy grassland with sand hills and grooves in the Kiskunság National Park, Central Hungary. The average annual rainfall in this region is 500 mm, which falls mostly in spring; the summer is very dry and hot.

2.4 ha of the area was fenced off in 1976 to study secondary succession. The plant association on the sand hills of drier soil was *Festucetum vaginatae*. This is a species-rich grass association with low vegetation cover (64%). The predominant species were e.g. *Alcanna tinctoria*, *Gypsophila arenaria*, *Fumana procumbens* and *Stipa sabulosa*. In the grooves, where the soil humidity was higher, *Molinio-Salicetum rosmarinifoliae* association developed with high plant cover. The predominant species were *Potentilla arenaria*, *Carex stenophylla* and *Holoschoenus vulgaris*. About half of the study area was covered with *Potentillo-Festucetum*

pseudovinae association characteristic of the surrounding pasture. This association is a transition in the succession from the heavily grazed area to the natural or seminatural grass associations. These three associations were noticeably distributed with several transitions among each other. The detailed description of the study area and the exact place of the traps can be found in Györfy and Karsai (1991). A total of 130 plant species were identified on the study site (Gallé et al., 1987).

Parts of the study area were experimentally manipulated:

1) two blocks, 60 m² each, were regularly watered from 1982, from June to August. In the year of our observations, this amounted to 135 mm.

2) a 300 m² area was fertilized in 1977;

3) the topsoil was removed from a 600 m² area in 1982 (further called "bared" area);

Sampling procedures

The bees were sampled by 60 white pan traps with a diameter of 20 cm. They were placed on the soil surface and filled with ethylene-glycol. The traps were emptied fortnightly from April to October, 1985. The material was kept in ethyl-alcohol until identification.

Each plant species, and its respective cover percentage was recorded within a 1 m-radius circle surrounding the traps.

Evaluation methods

The dispersion of bee populations was estimated by the variance/mean ratio ($I = S^2/x$). The diversity values of single traps were calculated by the Shannon-Wiener index.

The traps were grouped by cluster analysis based on the cover of each plant species and also on the number of individuals of bee species. We used the Czekanowski similarity index and the group average linkage procedure (Podani, 1980; Pielou, 1984). The two dendrograms were compared to each other visually, because the differences between them were evident at first view.

Principal component analysis (PCA, centralized-standardized) was applied on the number of individuals of each bee species caught by single traps in the experimental year (Manly, 1986). This analysis was carried out in order to determine the main factors influencing the distribution of the bee community.

Results and Discussion

Community description

1517 individuals of 96 Apoidea species were collected, which suggested a species-rich

assemblage. Kratochwill (1988) found 128 species in a dry mountain grassland in a two years period. Tschardtke (1983, 1984) recorded only 33 and 15 species on a bog and on a xerothermic slope, respectively. Mackay and Knerer (1979) caught 141 Apoidea species in an old field, but that study area was much larger and more diverse than ours.

The diversity values calculated for single traps by the Shannon-Wiener function were high ($H = 2.25 - 4.19$). Similarly high values were given for other areas (Mackay and Knerer, 1979; Tschardtke, 1984; Kratochwill, 1988), however these are summarized diversities, not single trap values. The highest values in our area were obtained from the traps on the "bared" area ($H = 3.38 - 4.19$), the highest number of species (a total of 66) was also caught there. This was because of two probable reasons:

a) there were more insect-pollinated plants on this area than on the grassland because, after the manipulation, many dicotyledonous weeds grew in this area (Gallé et al., 1987). These were attractive for the bees (Lindley, 1958; Banaszak, 1983).

b) More than 80% of individuals belonged to soil-nesting species. The "bared" area has probably attracted these species because of its low plant cover. However, in terms of species numbers there were no more soil-nesting species than in the traps of other areas with higher plant cover.

The most numerous species were: *Andrena taraxaci*, *Apis mellifera*, *Lasioglossum calceatum* and *Seladonia semitectus* (table 1.). These are xero- and/or thermophile species, except the honey bee, *A. mellifera*, which is an ubiquitous species (Schmiedecknecht, 1930; Móczár, 1967).

On a dry mountain grassland, Kratochwill (1983) found that the highest percentage of individuals (40.7%) belonged to the family Apidae, followed by Halictidae (36.9%) and Megachilidae (13.2%); Andrenidae was only the 4th (8.2%). In our study, most individuals (40.8%) belonged to Andrenidae followed by Halictidae (32.2%) and Apidae (19.9%). Andrenidae are mostly "spring native bees" (Ginsberg, 1983). The study area has enough rainfall only in the spring and early summer; the rest of the summer months are very dry. These weather conditions are suitable mostly for spring native bees, and this is the probable reason for the high percentage of Andrenidae in the catches.

Seasonal dynamics and distribution

Ginsberg (1983) distinguished four groups of bees according to their seasonal dynamics: spring native bees, early summer native bees, late summer native bees and honey bees. We also detected a temporal partitioning of this sort, but the "late

summer" group consisted of a few animals only. Mostly bumble bees belong to this group (Ginsberg, 1983). We observed fairly large number of bumble bees active at this time on the study area but they were under-represented in our traps. The "spring native bees" group included the most species (mainly *Andrena* spp.) and individuals (see above).

Table 1. - The abundance and the dispersion index of the abundant species

Species	Number of individuals	Variance/mean ratio ($I=S^2/x$)
<i>Nomioides minutissima</i> Rossi	59	9.05
<i>Andrena taraxaci</i> Gir.	213	4.61
<i>Andrena labiata</i> F.	56	3.56
<i>Apis mellifera</i> L.	207	2.46
<i>Seladonia semitectus</i> Mor.	116	2.24
<i>Andrena subopaca</i> Nil.	69	2.06
<i>Lasioglossum calceatum</i> Scop.	180	2.01
<i>Andrena tibialis</i> K.	37	1.93
<i>Andrena fucata</i> Smith	38	1.93
<i>Lasioglossum euboense</i> Strand	20	1.90
<i>Andrena florivaga</i> Ev.	85	1.78
<i>Megabombus ruderarius</i> Müll.	13	1.42
<i>Lasioglossum limbellum</i> Mor.	27	1.39
<i>Osmia atrocoerulea</i> Spin.	17	1.33
* <i>Andrena carbonaria</i> L.	16	1.25
<i>Osmia melanogastra</i> Spin.	10	1.25
<i>Bombus terrestris</i> L.	24	1.20
<i>Megachile argentata</i> F.	11	1.20
<i>Andrena flavipes</i> Pz.	29	1.16
<i>Megabombus humilis</i> Ill.	25	1.08
<i>Andrena barbilabris</i> K.	14	1.07
<i>Tetralonia macroglossa</i> Ill.	10	1.05
<i>Sphecodes pellucidus</i> Smith	13	0.98
<i>Colletes fodiens</i> Gy.	12	0.98
<i>Seladonia confusus</i> Bl.	26	0.96
<i>Megachile maritima</i> K.	10	0.85
<i>Andrena varians</i> K.	17	0.85
Other species (69)	163	

* Below the line the distribution of the species did not differ significantly from random ($p < 0.1$)

In North America, *Apis mellifera* compete with native bees in the spring and may depress the foraging population of certain wild bees on large flower clusters (Ginsberg, 1983). In our study, especially in the early spring samples, such depression was not observed. Other species (e.g. *Andrena taraxaci*) had much higher numbers in the traps than the honey bee. This difference may be due to the introduced status of the honey bee in North America. However, the honey bee is a specialist on

high densities of flowers and the grass associations of the study area had no large high density flower clusters. The lack of these clusters could be the cause for the lack of such depression.

The three dominant Halictid species showed temporal segregation during the season (Fig. 1).

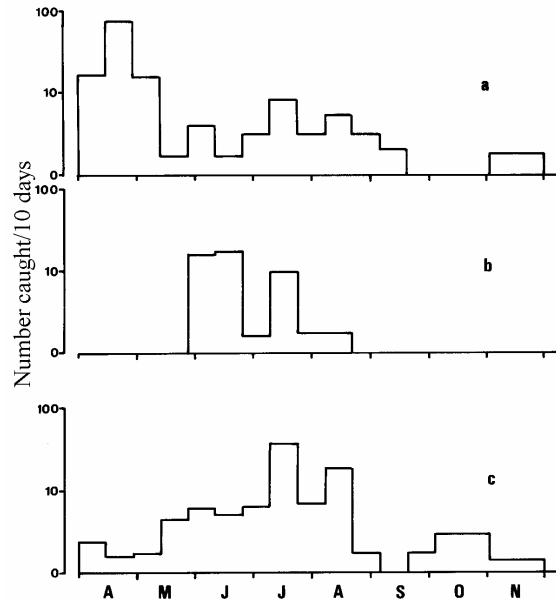


Fig. 1. Seasonal activity of the three dominant halictid species. a: *Lasioglossum calceatum*; b: *Nomioides minutissima*; c: *Seladonia semitectus*

Evaluating the dispersion of the species, we found that the most aggregated species were: *Nomioides minutissima*, *Andrena taraxaci* and *Andrena labiata* (Table 1). All the more abundant species were aggregated; no aggregation could be detected for the rarer species.

We compared the spatial distribution of the dominant bee species among the different areas. The highest relative abundance was on the "bared" and the fertilized areas. A few temporally overlapping species were spatially segregated. For example *Andrena taraxaci* and *A. florivaga* were abundant during the same period, but the first species was collected mainly on the "bared", while the second one on the fertilized area (Fig. 2). Such segregation was also observed between *A. fucata* and *A. tibialis* and between *A. subopaca* and *A. labiata*. *Andrena* species did not show consistency in their flower preferences (Schmidecknecht, 1930), therefore the differences in their spatial segregation could not be evaluated in this connection.

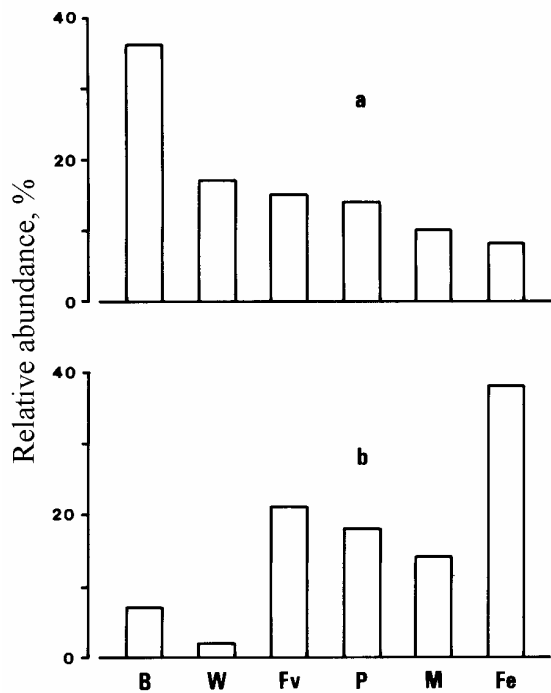


Fig. 2. The relative abundance of two *Andrena* species on the different areas. a: *Andrena taraxaci*; b: *Andrena florivaga*; B: "bared" area; W: watered area; Fv: *Festucetum vaginatae*; P: *Potentillo-Festucetum pseudovinae*; M: *Molinio-Salicetum rosmarinifoliae*; Fe: fertilized area

Multivariate analysis

Cluster analysis was carried out on the plant cover data. The resulting dendrogram (Fig. 3) showed that the traps formed groups according to the associations as expected. The classification of the

traps based on the data of bee species caught (number of individuals/species/trap) did not result in the same dendrogram (Fig. 4); plant and bee clusters did not correspond to each other. The distribution of Apoidea populations did not follow the mosaic-like pattern of plant associations. On the one hand this can be because the vegetation patches probably are "fine-grained" for the bees because the daily flight range includes numerous, diverse patches. However, host-specific bees distinguish on the basis of vegetation type (which is related to species composition). This could be examined by analyzing host-specific bees separately from broadly polyphagous species. On the other hand, the multivariate analyses were carried out on the total year catch, so the seasonal differences in the flowering phenology could disappear. Unfortunately, our data on the host-specific species and on separated seasonal samples are not sufficient to perform such a more detailed analysis.

Principal component analysis was also carried out on the number of individuals of Apoidea species. The first principal component accounted for only 18% of the variance in the data, which indicated that several components influenced the distribution of the bees. In the factorial plane of first and second PCA axis, the points representing the different plant associations did not segregate from each other (Fig. 5). The fertilized area showed a light segregation, however with only three traps, this could not be reliably tested. The points representing the "bared" area with low plant cover stood apart from the other points along the first axis. Plant cover was negatively correlated with the values of the first axis ($r = 0.63$,

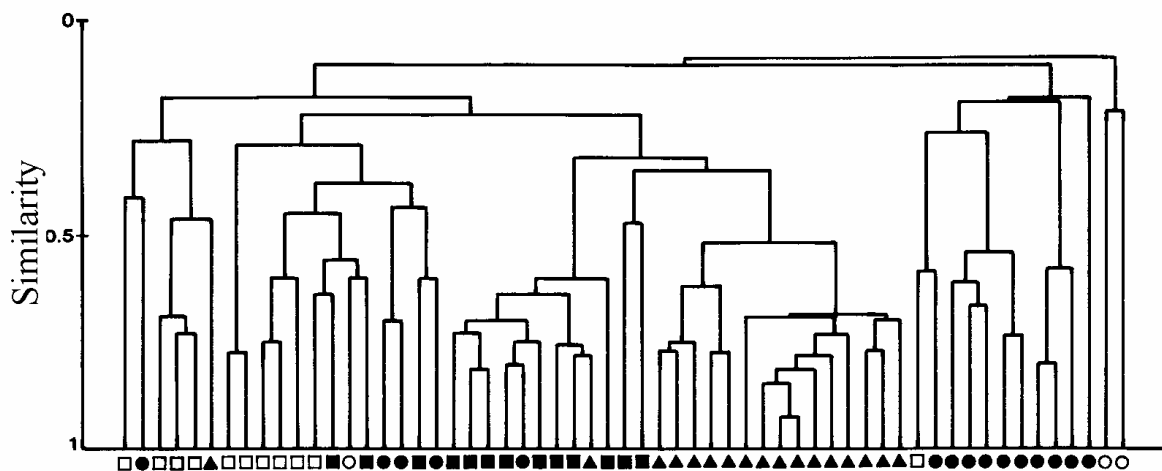


Fig. 3. The dendrogram of the cluster analysis of the traps based on the data of plant cover surrounding the traps. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; ○: fertilized area; □: "bared" area

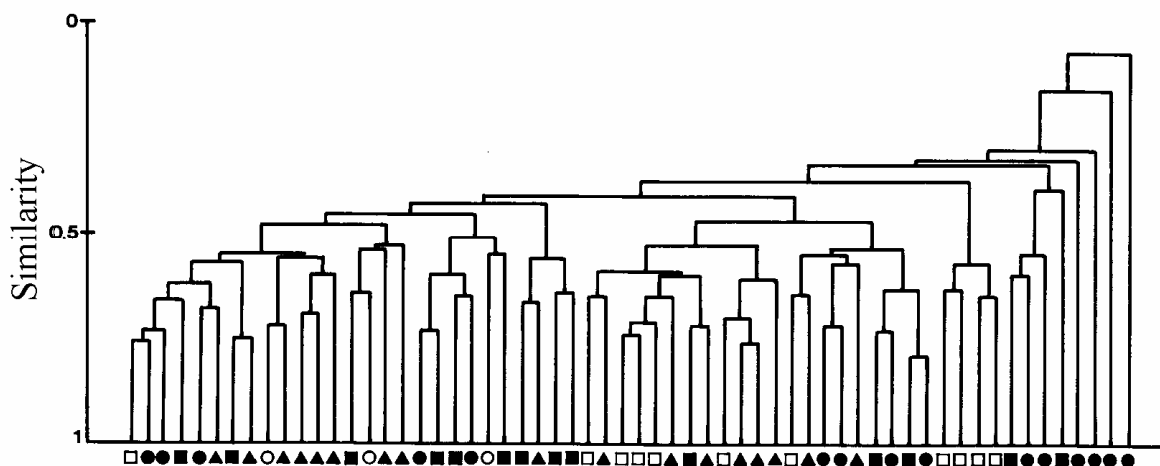


Fig. 4. The dendrogram of the cluster analysis of the traps based on the data of bee species caught. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; ○: fertilized area; □: "bared" area

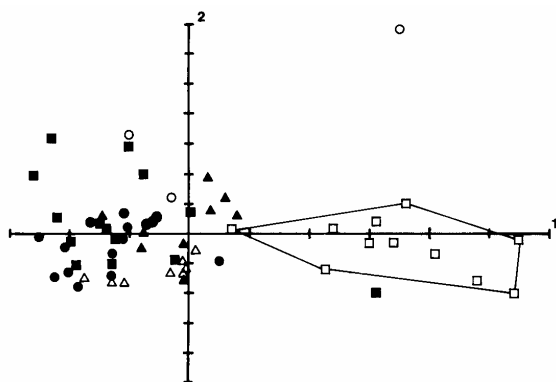


Fig. 5. PCA scatter diagram of the traps based on the data of bee species caught. Axis 1 and 2. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; △: watered area; ○: fertilized area; □: "bared" area

$p < 0.01$), therefore the first principal component could be interpreted as the value of plant cover. Plant cover was also negatively correlated with the total number of Apoidea species ($r = 0.58$, $p < 0.01$). This result seems to support hypothesis b) explaining the high abundance on the bared area. However, considering the bee species individually, only two species showed the same significant relationship with plant cover: *Lasioglossum limbellum* ($r = 0.6$, $p < 0.01$) and *Nomioides minutissima* ($r = 0.49$, $p < 0.01$).

In the factorial plane of third and fourth PCA axes the points did not form groups according to the associations (Fig. 6). However, the points of the watered area were separated from *Festucetum vaginatae* along the fourth axis, in spite of the fact that the watered area was originally covered with this

association. Therefore we think the fourth principal component can be correlated with the water content of the soil. Unfortunately, we do not have data to test this hypothesis.

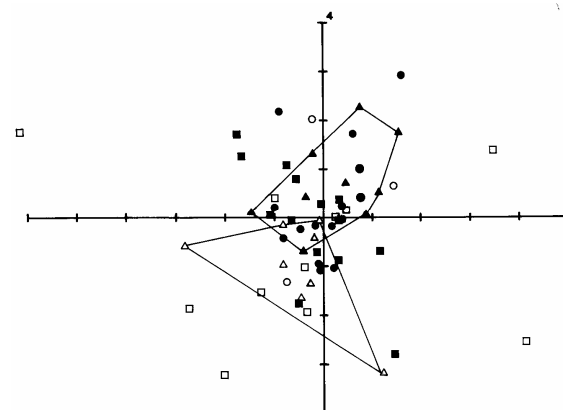


Fig. 6. PCA scatter diagram of the traps based on the data of bee species caught. Axis 3 and 4. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; △: watered area; ○: fertilized area; □: "bared" area

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During the period of the study we were B. Sc. fellows at the Department of Zoology, József Attila University, Szeged. We thank Dr. I. Kincsek for her help in the botanical studies, Dr. L. Tanács for his help in the identification of bees, Dr. L. Körmöczi for the use of his computer programs and giving pieces of advice, Dr. L. Gallé, Gy. Györffy and G. L. Lövei for their helpful comments and advice during the study and the preparation of the manuscript.

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COMPOSITION OF ORTHOPTERA ASSEMBLAGES IN GRASSLAND HABITATS AT LOWER-TISZA FLOOD PLAIN

K. Krausz, J. Pápai and L. Gallé

Krausz, K., Pápai, J. and Gallé, L.(1995): Composition of Orthoptera assemblages in grassland habitats at Lower-Tisza flood plain. - Tiscia 29, 47-52.

Abstract. The Orthoptera assemblages of continuous grassland strips on dike sides of rivers Tisza and Maros were compared with habitat islands of different distances from river flood plains. The species composition in habitat islands within 2-300 m distance is similar to the corresponding nearest dike-side meadow, whereas that of the assemblages sampled in a meadow of about 3 km from the river, differ from Tisza region. A multivariate statistical analysis shows that the differences between local Orthoptera assemblages are brought about by the distance of their habitats, while the influence of plant species composition and vegetation architecture is weaker within the range of the studied habitats.

Keywords: Orthoptera assemblages, dike sides of rivers Tisza and Maros, habitat islands, ecological corridors, Hungary

K. Krausz, J. Pápai, L. Gallé, Department of Ecology, JATE University, H-6701 Szeged, Pf. 659, Hungary

Introduction

The degradation of flora and fauna and the decline of ecological diversity as a result of the fragmentation and isolation of natural habitats are among the main, world-wide problems of nature conservation. Therefore, these phenomena have drawn the ecologists' attention to different topics of landscape ecology, e.g., habitat fragmentation, isolation (see Wilson and Willis, 1975; Diamond and May, 1976 as the first papers in this field) and the significance of stripe-like habitats, so called "ecological corridors" (Simberloff and Cox, 1987; Noss, 1987). The changes in agricultural management and the expansion of various human activities led to the disappearance of large natural areas and the isolation of the remaining fragments in the Great Hungarian Plain. The study of the possible role of "ecological corridors" is therefore a relevant field of conservation biology (cf. Gallé et al., 1995). River Tisza and other rivers in the Great Hungarian Plain were regulated in the last century. As a result of this regulation, the original flood plains are divided into two parts by dikes, i.e., "flood areas", which are regularly flooded, mostly in the spring, and "protected flood plains", without direct influence of

flooding. The dikes, running along the river, are covered by grasslands and thus form continuous grassland-strip habitats, which are assumed to be "ecological corridors" .

The Orthoptera fauna of the Great Hungarian Plain has been studied from faunistical, zoosociological and various ecological aspects (Nagy, 1943, 1953, 1958, 1991; Gausz, 1969, 1970a, b; Gallé and Gausz, 1968; Gallé et al., 1995; Szelényi et al., 1974; Rácz, 1986). We know, however, much less of the similarities and differences between the Orthoptera faunas of the river flood plains and the neighbouring ecological islands. There are also gaps in the knowledge of the role of isolation and habitat corridors in structuring of Orthoptera assemblages.

We address the following main questions in this paper: (1) Do Orthoptera assemblages of the dike grasslands by the rivers and that of habitat islands in the protected flood plain differ in their density and species composition? (2) Is there any difference between the diversity of Orthoptera of the corridor-like grassland habitats along the river and of the isolated ones? (3) Whether the habitat structure or the distance of similar habitats has a stronger effect on the structure of the Orthoptera assemblages? (4)

Can the Orthoptera fauna be divided into correlated groups, called coalitions hereafter on the basis of their species local distribution?

Material and methods

Study sites

Orthoptera populations were sampled from June to September 1994 in seven habitats in the southern part of the Great Hungarian Plain. Four sampling plots were established on the dike meadow of the rivers Tisza and Maros and three in the nearby grasslands ("habitat islands") (Fig. 1).

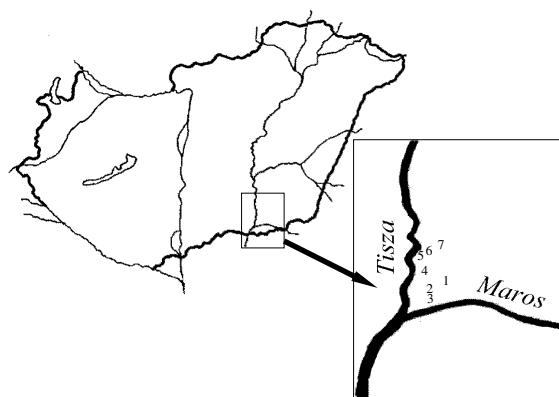


Fig. 1. Position of study sites by rivers Tisza and Maros. 1 = M1; 2 = M2; 3 = M3; 4 = T1; 5 = T2; 6 = T3; 7 = T4.

Two out of four on the dikes of both rivers, one of them was exposed to the flood area (referred to as "inner side" hereafter), the other one to the protected flood plain ("outer side") in both sites. The aspect of Maros dike sides were of NW-SE, while the dike sides of River Tisza had E-W aspect. The vegetation of dikes grasslands was described by Bodrogek (1966) in details. According to a spring survey, Borhidi's (1993) "naturalness value" of vegetation, is the highest at the outer side dike grassland of River Maros, and it is the lowest at the inner dike side of the same river (Margóczy et al., 1995). The plant species richness and the Shannon-Wiener diversity are the highest at the inner dike side of River Tisza. During summer, the vegetation of the outer dike side was less diverse, while the vegetation of the inner dike side of River Tisza became less dry. On the inner side dike grassland of River Maros (referred to as M3 hereafter), *Alopecurus pratensis* L., *Achillea millefolium* L., *Geranium dissectum* Jusl. were present with greatest coverage, and on the outer side of the dike (M2), *Festuca rupicola* Heuff., *Arrhenatherum elatius* L., *Bromus commutatus* Schrad., *Poa angustifolia* L., *Achillea millefolium* L., *Vicia hirsuta* S. F. Gray were predominant. The inner

side dike grassland of Tisza (T2) was predominated by *Arrhenatherum elatius* L., *Poa angustifolia*, and to a lesser degree by *Alopecurus pratensis*, while on the outer side (T3), *Alopecurus pratensis*, *Glycyrrhiza echinata* were predominant. The dike meadows were regularly moved.

The remaining three sampling plots were more or less isolated grassland habitats in the protected flood plain, outside of the dikes. One of them (M1) was a small grassland (400 m²) with rather weedy vegetation and about 0.5 km from the nearest sampling plot on the dike of River Maros. Its vegetation shows the lowest naturalness and diversity values (Margóczy et al., 1995). The number of plant-species was low, *Agropyron repens*, *Alopecurus pratensis* could be found in the greatest coverage, and *Artemisia vulgaris* L., *Ballota nigra* L. were present, as well. This plot was bordered by a small forest and a road.

The second plot (T1) was a large grazed meadow, about 3 km distance from the River Tisza. Its vegetation was more natural and diverse. Here *Carex melanostachya* Willd., *Poa angustifolia*, *Potentilla reptans* L. and *Carex praecox* Schreb., were the predominant plant species. The last one (T4) was a dry grassland in the area of an abandoned farmland situated about 200 m from the dike of River Tisza. This plot was surrounded by alfalfa plantation. The predominant plants were: *Agropyron repens*, *Alopecurus pratensis*, *Poa angustifolia*, *Lathyrus tuberosus* L. The two sets of plots (by the River Tisza and River Maros respectively) were about 60 km from each other (Fig. 1).

Each sample plot was characterized by the relative coverage of plant species (estimated in quadrates of 2x2 m size), the vegetation architecture (i.e. the total coverage of vegetation heights 0-5, 5-10, 10-15, 15-20, 20-30, 30-50, 50-100, 100-150 cm), the orientation and the slope of the dike sides, the size of the plot and the composition of grassland fauna were collected in the same way as the grasshoppers.

Methods of sampling and evaluation

We sampled Orthoptera populations with sweep nets from 10 quadrates of 4x4 m size. The area of quadrates were carefully swept with the nets (by about 45 sweeps) three times. On the basis of the last catches we suppose that the Orthoptera individuals were completely collected from the area of the sample units. The sampling was repeated five times during the growing season between 25th June and 25th September, 1994.

The diversity of the Orthoptera fauna is given by the conventionally used diversity indices

(Shannon-Wiener, Simpson-Yule and Brillouin) and the diversity ordering (Tóthmérész, 1993a, b). The similarities and differences of the Orthoptera assemblages and their seasonal shifts are characterized by their pattern and its transformation in PCoA factor space, which was computed with Czekanowski's similarity coefficient (Tóthmérész, 1993a). We employed correlation analysis between the geographical distance of the sampled habitats and their Euclidean distance computed on the basis of the composition of the Orthoptera assemblages in order to establish the role of topographical distance in the differentiation of Orthoptera species composition of different habitats.

We attempted to classify Orthoptera species into correlated groups (referred to as coalitions hereafter) on the basis of their spacio-temporal distribution by employing cluster analysis with Czekanowski similarity indices and weighted average algorithm.

Results

Species composition and density

A total of 24 species were collected from the sampling plots (Table 1). The total cumulative densities (i.e. the seasonal sum of the estimated densities) vary from 2.8 and 12.7 ind./m². The greatest densities were found in the dike grasslands

of River Tisza (12.7 and 10.8 respectively), and the lowest ones in the different habitats by River Maros (2.8-3.8 ind./m²).

The habitats along the two rivers are more or less separated in the PCoA scattergram set up on the basis of their Orthoptera assemblages (Fig. 2) with the exception of the grazed meadow situated 3 km from the flood area of the River Tisza. The seasonal trends of the assemblages of Tisza habitats are more complicated than that of the River Maros. The latter show, however, the greater seasonal shifts in the PCoA factor space. Much clearer picture is yielded when the scattergram is set up on the basis of the cumulative density values of the populations (Fig. 3): the separation of the habitats belonging to the two rivers is clear and the special position of the grazed meadow mentioned above is well seen.

Diversities

The species diversities of the assemblages changed between 2.12 and 3.02 (Shannon-Wiener function), the smallest was observed at the abandoned farmland (T4) and the highest was at the Tisza inner dike side (T2). No significant diversity difference was found between the dike and "island" habitats. No clear diversity differences were observed on the basis of diversity ordering curves either (Fig. 4).

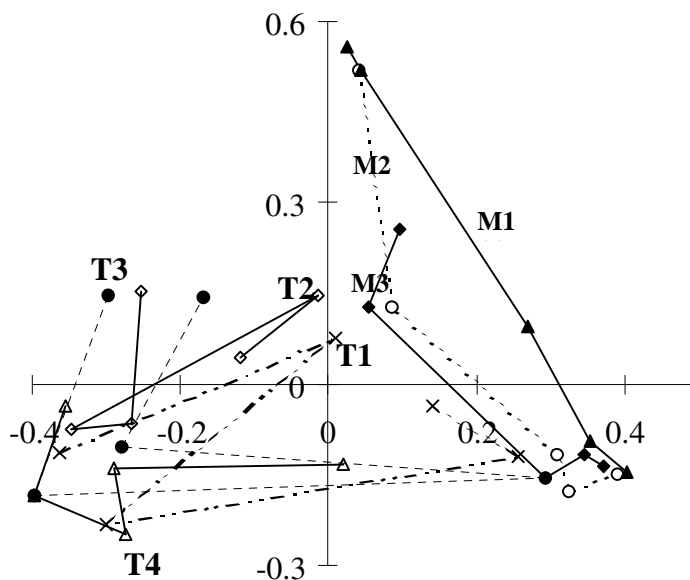


Figure 2. The PCoA scattergram set up on the basis of the relationships of the Orthoptera assemblages and their seasonal shifts in the studied habitats. The abbreviation of the plots is shown in Table 1. Samples were taken three-weekly from June to September, 1994. The first and the last sampling period is indicated by a circle.

Table 1. The composition and the cumulative population densities of Orthoptera assemblages. M1 = weedy grassland 0.5 km apart from Maros dike sample plots; M2 = Maros dike grassland of NW exposure; M3 = Maros dike grassland of SE exposure; T1 = grazed meadow 3 km from the dike of Tisza; T2 = Tisza dike grassland of NNE exposure; T3 = Tisza dike grassland of SSW exposure; T4 = abandoned farmland 200 apart from the Tisza dike sample plots. The figures in the table are the seasonal mean of the densities/m².

Species	M 1	M 2	M 3	T1	T 2	T 3	T 4
1.Tetrix nutans Sahlb.	0	0	0	0	0.01	0.01	0
2.Tetrix subulata L.	0	0	0	0.03	0.05	0.01	0
3.Calliptamus italicus L.	0	0.02	0.01	0.01	1.10	0.54	1.72
4.Pezotettix giornae Rossi.	1.22	0.98	0.94	0.06	2.1	2.27	0.92
5.Aiolopus thalassinus Fabr.	0	0.02	0.09	0.07	0.29	0.03	0
6.Dociostaurus brevicolis Evers.	0	0	0.01	0	0.13	0.12	0
7.Omocestus ventralis Zett.	0.45	0.29	0.72	0.21	0.52	0.51	0.10
8.Glyptobothrus brunneus Thunbg.	1.00	0.05	0.01	0.06	0.33	0.19	0.08
9.Chortippus albomarginatus Beg.	0.32	0.39	0.19	2.49	3.55	4.22	5.30
1.Chortippus parallelus Zett.	0.06	0.07	0	1.94	1.54	0.31	0
11.Euchortippus declivus Bris.	0.86	1.00	0.48	1.41	1.56	2.31	2.34
12.Gryllus campestris L.	0	0	0	1.06	0	0.01	0.14
13.Oecanthus pellucens Scop.	0.01	0.03	0	0	0	0	0.01
14.Phaneroptera nana Fieb.	0.05	0	0.06	0	0.02	0	0
15.Leptophyes albovittata Koll.	0.04	0	0.02	0	0	0.05	0.02
16.Conocephalus dorsalis Latr.	0.10	0	0	0	0.02	0	0
17.Conocephalus discolor Fabr.	0	0.01	0.01	0.16	0.16	0.03	0
18. Ruspolia nitidula Scop.	0	0	0	0	0.02	0	0
19.Tettigonia viridissima L.	0.02	0	0	0	0	0	0
20.Gampsocleis glabra Herbst.	0	0	0	0	0	0.01	0
21.Decticus verrucivorus L.	0	0	0	0	0	0	0
22.Tesselana vittata Charp.	0	0.02	0.01	0	0.09	0.01	0
23.Roeseliana roeseli Hgb.	0.10	0	0	0.07	1.14	0.18	0.19
24.Bicolorana bicolor Phil.	0	0	0	0	0	0	0.19

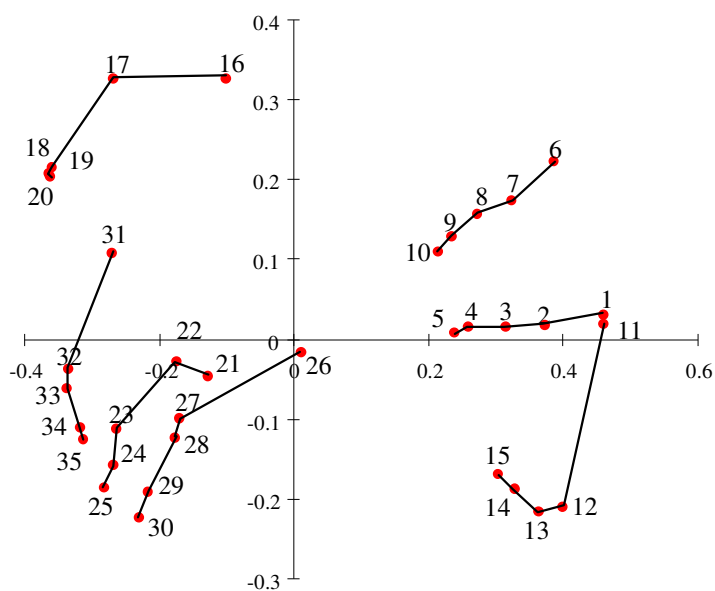


Figure 3. The PCoA scattergram of the cumulative density values of the Orthoptera populations in five consecutive sampling dates. 1-5: M 1, 6-10: M 2, 11-15: M3, 16-20: T 1, 21-25: T 2, 26-30: T 3, 31-35: T 4. The increasing figures within each site indicate the temporal sequence of sampling.

Habitat structure versus habitat distance

In order to answer the third question, a correlation analysis was carried out between the geographical distance classes of the studied habitats and the Euclidean distances of the Orthoptera assemblages of the corresponding habitats in the PCoA factor space. The correlation coefficient was $r = 0.73$, $p < 0.001$. A similar analysis between the habitat structural characteristics and the composition of the Orthoptera assemblages resulted in a non-significant correlation ($r = 0.22$).

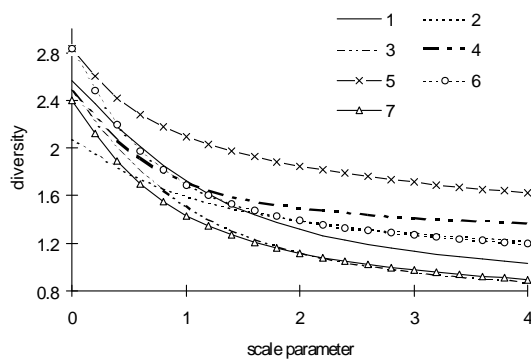


Fig. 4. The species diversities of the Orthoptera assemblages on the basis of diversity ordering curves. 1 = M1, 2 = M2, 3 = M3, 4 = T1, 5 = T 2, 6 = T3, 7 = T4

Existence of coalitions

A cluster analysis of the Orthoptera species (Fig. 5) on the basis of their occurrence rates shows that there are very few correlative groups among the sampled species. Only the pairs *Phaneroptera nana-Conocephalus dorsalis*, *Aiolopus thalassimus-Chortippus brunneus* show close association. The high co-occurrence rates of those species, which were rare in the samples could be the result of random coincidence. The coexistence rate of the species *P. giornae* and *E. declivus* can be explained by the fact that they are common at all study sites. Therefore, none of these groups or pairs of species can be regarded as real coalitions.

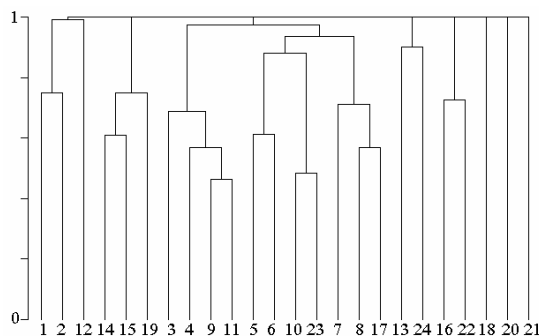


Figure 5. The cluster analysis of the Orthoptera species on the basis of their occurrence rates. For the figures of species see Table 1.

Discussion

It cannot be proved that the sets of Orthoptera populations we have studied in this paper formed real ecological communities. On the basis of the general concepts and conventions, we can define an ecological community as a set of coexistent populations, which interact in some ways, or at least they are arranged into such structural units (e.g. guilds), which indicate the presence of interactions. Neither direct interactions, nor species coalitions could be established in this study, therefore, these Orthoptera faunulae were considered only as species assemblages. The species composition of these assemblages is similar to those that were described by Gausz (1967, 1968) from the Middle and Lower Tisza districts. The Orthoptera fauna of River Maros district is not well known. Kis (1970) described the occurrence of two rare subspecies of *Isophya modestior* (*I. modestior modestior* and *I. modestior stysi*) from Bánát and Transsylvanian and N-Hungary part of this River. We could not find any of these taxa in the present study. *Isophya costata* Br. was also detected from the Dike-side of the Tisza at Mártély and one other female of *Isophya modesta* Friv. (or *costata*) was caught at the "inner side" of the dike at Klárafalva (Nagy 1981).

The relation great species richness of the dike-sides is probably due to the moderate disturbances and the special, stripe-like shape of these grassland habitats, which promotes the migration and recolonization of populations, and therefore compensates the stronger disturbances and extinction.

The third question addressed above refers to the relations between the geographical distance of the habitats and the similarities in their Orthoptera assemblages. Mabelis et al. (1994) studied this problem on several Orthoptera populations, Kindwall and Ahlen (1992) investigated this problem on the metapopulation of *Bicolorana bicolor* and they emphasized the importance of the distance for the presence of *B. bicolor* in habitat islands. It was given that this species can cover about 100 m distance and 0.5 hectare was established as the minimum habitat size for this species. Nagy (1992) consider the *Bicolorana bicolor* as "vagrant" species in the case of holopterous form, which might be more effective in colonization process. In the present study, we found this species in a grassland habitat of about 200 m far from the nearest dike, in which it was not present.

Timár (1953), Gausz (1967), Gallé (1967) and Gallé et al. (1995) emphasized the importance of dike-sides habitats in the migration of plant and animal species. Gausz (1967) described that the

stripe-like shape of dikes promotes the distribution of two Mediterranean species, *Pezotettix giornae* and *Phaneroptera quadripunctata* (= *Ph. nana*) to the North. In our sample plots *Pezotettix giornae* was a frequent species, with especially high densities on the dike-sides. We found *Phaneroptera nana* to be much rarer.

According to Rácz (1994) the structure of vegetation and the microclimate are the main factors in structuring Orthoptera assemblages. In this study, however, we found the distance between habitats to be a more important factor than the structural characteristics of the habitats.

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RIVER VALLEYS: ARE THEY ECOLOGICAL CORRIDORS?

L. Gallé, K. Margóczy, É. Kovács, Gy. Györffy, L. Körmöczy and L. Németh

Gallé, L., Margóczy, K., Kovács, É., Györffy, Gy., Körmöczy, L. and Németh, L. (1995): River valleys: Are they ecological corridors? - Tiscia 29, 53-58.

Abstract. "Ecological corridor" became a buzzword in ecology and nature conservation especially during the last five-six years when the ideas "econet" and "ecological network" have been widely spread. The importance and disadvantages of habitat strips ("corridors") are well known in the biogeography and the ecology of habitat islands. The flood plains of River Tisza and the tributaries are complexes of habitat zones, which have a significant role in the distribution of fauna and floral elements. The migration and distribution along habitat strips or a complex of them are not sufficient conditions for an ecological corridor, because the later assumes the existence of "core areas" (i.e., source and target areas of migration and distribution), too. It is demonstrated in this paper that the "ecological corridor" function is object-specific and the relevance of the river flood plains in the nature conservation is more than that of simple "ecological corridor": besides promoting the distribution of fauna and flora, they act as core areas, too.

Key words: habitat strips, river valleys, migration, distribution, higher plants, birds, insects.

L. Gallé, K. Margóczy, É. Kovács, Gy. Györffy, L. Körmöczy, L. Németh, Department of Ecology, József Attila University, Szeged, Pf 659 H-6701 Hungary.

Introduction

The term "ecological corridor" has become one of the most fashionable buzzwords in conservation biology and nature conservation, especially in relation to the use of the concepts "econet" and "ecological network" (e.g., Ribaut, 1995; Council of Europe, 1995a, 1995b). It is often used as a key word or slogan to promote the action-oriented activities and the utilization of financial sources for research and conservation. In this paper, our main aim is to investigate, whether the valley of River Tisza - which is often stated *a priori* as an ecological corridor, - meets the criteria of "ecological corridors".

Definitions, advantages and disadvantages of corridors

"Ecological corridor" is hardly regarded to be scientific term. It was introduced as landscape corridor more than thirty years ago (see Lewis, 1964). It is mainly used in the conservation practice, in the politics dealing with nature conservation, and

in the conservation biology for such habitat strips that promote migration of fauna and floral elements. Some recent definitions of ecological corridors and related term are as follows:

"Migration corridors: The main directions for intensive geodynamic and bio-informational exchange, based on flow and migration channels" (Kavaliuskus, 1995).

"Ecological corridors: Within areas of moderate or low ecological value, natural corridors... (omission by the recent authors) are defined as the landscape units, which are hazardous for other uses such as agriculture, forestry or settlements" (Troumbis, 1995).

"Ecological corridors ("landscape connections"): Important landscape bands, e.g. river valleys and forest reaches, that connect a nature area" (Brandt, 1995).

"Ecological corridors comprise landscape structures and artificial provisions that contribute to migration between core areas" (van Zandelhoff and Lammers, 1995).

"Ecological corridors: (a) zones, which are

thought to facilitate the movement of species between core areas and nature development areas; (b) (landscape elements which have) landscape structure and land use, and suitable environmental conditions comparable with those of sites that have to be connected” (DeBlust et al., 1995).

Main categories in ECONET concept: biocenters, biocorridors, potential biocorridors or interactive elements (Doms et al., 1995).

It is clear from the above definitions that although there is a multiple usage of this term, it is common in the majority of the definitions that ecological corridors are habitat strips, which promote the exchange of flora and fauna elements by migration between quasi-natural habitats ("core areas", see Fig. 1A). The promotion of migration by a longitudinal habitat or habitat complex (Fig. 1B) without core areas is not sufficient criteria for ecological corridors.

It is often disregarded that the term "ecological corridor" is plural, similarly to the environment, niche and other basic terms of ecology. Clearly the same habitat strip does not act as a corridor for birds, plants, beetles, ants, etc. at the same time and at the same scale. Therefore it is senseless to speak of ecological corridors *per se*, without a reference ecological object (e.g., a population).

The advantages and disadvantages of ecological corridors are known for at least one decade (see Simberloff and Cox, 1987; Noss, 1987). When this term is employed as a campaign slogan, however, for political or science-political aims, the scientific reasoning is disregarded. In popular or semi-popular texts, even if they appear in the context of landscape ecology, only the advantages of corridors are emphasized. Such misinformation has probably contributed to the suggestions to protect and establish ecological corridors without any critical assessment of the particular circumstances, e.g., if they promote the migration and distribution of protected species or only introduced weeds. The plural character of the ecological corridors is also neglected in the Sofia Conference: "We call for promotion of nature protection, both inside and outside protected areas, by implementing the European Ecological Network, a physical network of core areas linked by corridors and supported by buffer zones, thus facilitating the dispersal and migration of species" (Ministerial Conference, 1995).

River Tisza valley as an ecological corridor

By the above mentioned definitions, the ecological corridors should meet the following

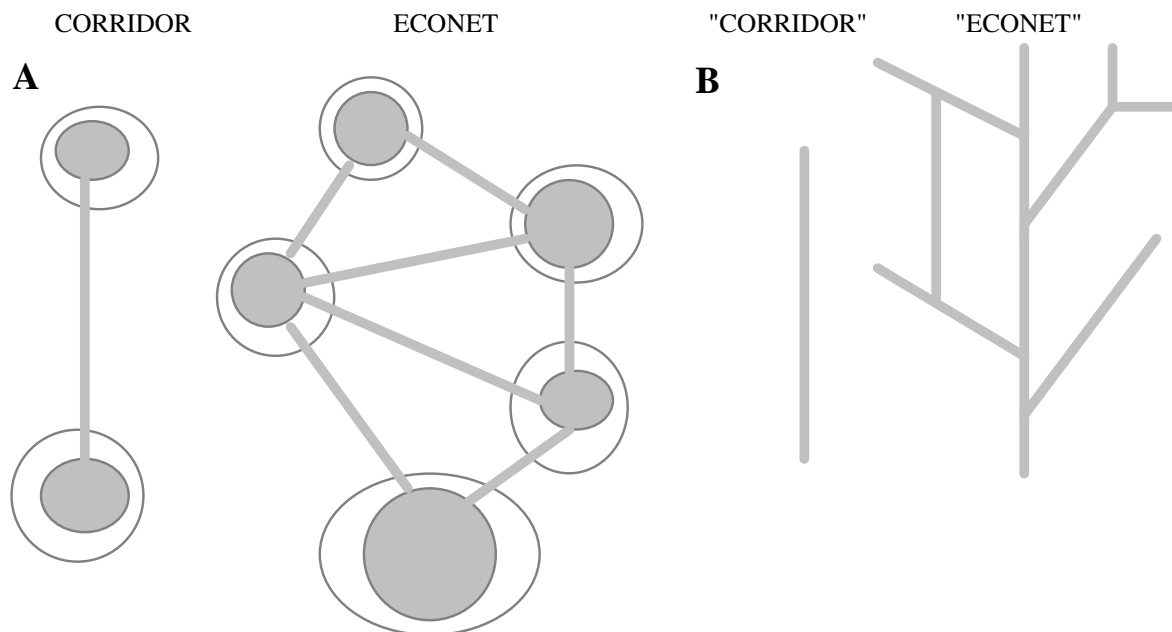


Fig. 1. The basic question of this paper if river valleys are "real ecological corridors" linking core areas, that are supported by buffer zones (A), or simple routes without core areas (B).

criteria (Gallé et al., 1995): (1) they should promote the migration and/or the distribution of particular population(s); (2) they should connect natural or quasi-natural core areas by this function; and (3) they should contribute to the dispersion of those species that are valuable from conservation points of views.

The possible migration and dispersal route function of the Tisza Valley is in the focus of interest of the biologists working in this region, because since the time when the river was regulated, the valley has formed a landscape strip consisting of such habitats that differ from the neighboring ones. The importance of River Tisza in the distribution and migration of water fauna and flora is obvious, therefore we do not discuss it here. The role of this river valley in the migration and overwintering of the birds is also well known from the black stork (*Ciconia nigra* L.) to the bullfinch (*Pyrrhulla pyrrhulla* L.) (e.g., Molnár, 1995). The most apparent example for the distribution of terrestrial birds along the River Tisza is the case of olivaceous warbler (*Hippolais pallida elaeica* Lindl.). This species found unsaturated communities and therefore unutilized resources in the bushy willow forest vegetation by the river beds (*Salicetum triandrae* plant community) and the olivaceous warbler's distribution could be followed in these habitat strips from year to year (Bankovics, 1975, 1977, 1995). From among the insects, the best classical examples were given by Erdős (1935), who studied the role of River Maros (one of the tributaries of River Tisza) in the dispersion of beetle fauna. He described a lot of beetle species that had not been known from the southern Hungarian Plain before and supposed that these species' distribution was supported by the river floods. Their presence, however, is not an evidence of the successful colonization and persistence. In some cases, Erdős (1935) discussed the possibilities of survivorship and he found it very probable in some species originated from the mountain beetle fauna (e.g., *Thonobius longipennis* Heer, *Bledius dissimilis* Er., *Patrobus atrorufus* Ström). Gausz (1967) studied the dispersal of southern, mainly Mediterranean, grasshopper and locust species to the North along River Tisza Valley. He found unequivocal evidences for the role of Tisza valley in distributing *Pezotettix giornaie* Rossi, and *Phaneroptera quadripunctata* Br. W. Gallé (1967) likewise found that some "southern" elements of the ant fauna (e.g., *Messor structor* Latr, *Plagiolepis* species) spread along the dikes, whereas the

mountain species were found in those moist habitats of the flood area, which are not intensively influenced by the inundation. The influence of River Tisza Valley on the distribution of other invertebrate groups is given by Kolosváry (1967, harvestmen) and Bába (1995, mollusks). On plants, Újvárosi (1940) and Timár (1950, 1953), citing also Lányi's (1914, 1916) previous studies, provided good examples. Timár (1953) also referred to the role of Tisza valley in the distribution of weeds.

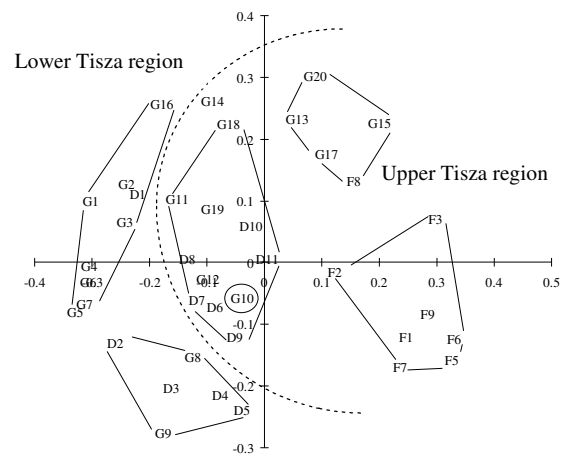


Fig. 2. PCoA scattergram of sampled habitats according to their vegetation. Capitals indicate different types of habitat: G=grasslands, D=Tisza-dikes, F=forests. The sample sites belonging to the same cluster in hierarchical cluster analysis are outlined by edges.

These, above mentioned studies provided evidences on the level of populations that the flood area and the river dikes work as migration routes for several terrestrial plants and animals. Community-level information can be gained from the differences and similarities of the community composition between the upper and lower Tisza district (Margóczy et al., 1995). High community-level similarities presumably indicate a homogenizing effect and therefore an ecological corridor function by the river valley habitats. We compared the composition of the vegetation, the leafhopper (Auchenorrhyncha) and the ant (Formicoidea) assemblages of habitat sets at the upper (vicinity of Tiszadob and Kesznyéten) and a lower Tisza district (Szeged district) by PCoA ordination, employing Czekanowski similarity algorithm. The upper and lower Tisza sites as well as

the dikes and the grasslands in the protected flood plain are clearly separated in their plant and leafhopper assemblages (Figs. 2 and 3). The sampled habitats joined into five main groups according to their vegetation. These groups can be distinguished not only by their geographical position (upper and lower Tisza district), but by their naturalness values, too. The leafhopper assemblages of the dikes are similar to that of grasslands with strongly disturbed vegetation. We found no differences between the upper and lower Tisza region in the PCoA ordination space of ant assemblages (Fig. 4), therefore, a homogenizing effect by the river valley can be assumed. The smaller scale dissimilarities are mainly brought about by the habitat quality, which is indicated by the ants in a manner differing from both vegetation and the leafhoppers assemblages.

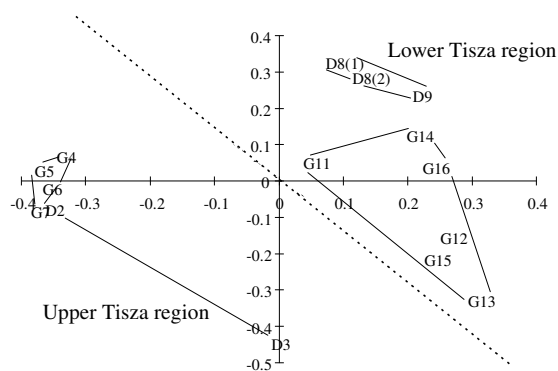


Fig. 3. PCoA scattergram of sampled habitats according to their leafhopper assemblage. For legends see Fig. 2.

The migration and dispersal are not sufficient conditions to regard Tisza Valley as an ecological corridor, because there should be natural or "core" areas, between which the migration and dispersal take place. This is a crucial problem, because in the majority of cases, no core areas can be identified, only larger regions, e.g., North Hungarian Central Range, the Hungarian Great Plain or even the Danube flood plain are mentioned. It is not possible to outline the conservation value of the flood plains as ecological corridors from these general statements. The studies of the habitat islands by the river valley (Gallé, 1990a, 1990b; Gallé et al., 1989, 1992) revealed that the flood area of River Tisza, especially the dike-side grasslands, flood plain meadows and forests, biologically communicate with the habitat

islands outside the protected flood area. This is, however, not an ecological corridor function simply, because in this case River Tisza Valley is a species pool or one of the "core areas". The natural values (i.e. plant and animal populations, ecological communities) of River Tisza have been documented in details during the forty years of Tisza research (see the back volumes of Tiscia). Therefore it can be stated that the Tisza Valley is a complex of habitat zones, and contains valuable natural biota. The stripe-like character of the habitats promotes the distribution of species. The corridor function of River Tisza Valley is only secondary, its main relevance is that it works as a species and propagula pool for the nearby ecological islands at least in some animal populations. In the case of plants, which have more restricted distribution ability, the capacity of the narrow dike-sides (width is 40-50 m at most) to produce propagula is probably insufficient for recolonization of ecological islands.

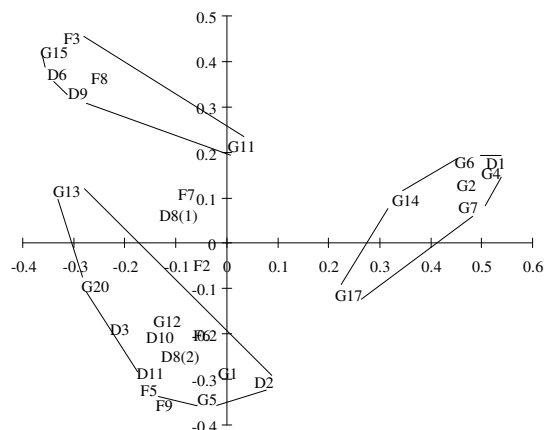


Fig. 4. PCoA scattergram of sampled habitats according to their ant assemblage. For legends see Fig. 2.

To maintain both core area and corridor functions, it is necessary that natural and semi-natural habitats should form continuous strips and should have large areas, at least in those regions, where the protected flood area is wide enough. This latter criterion is necessary to protect species with larger area demands (e.g., eagles, falcons, other raptors, herons, black stork etc.). We suggest to maintain continuous strips of bushy willow forests (*Salicetum triandrae*) strips by the river bed, willow-poplar

forests (*Salicetum albae-fragilis*), hard-wood forests (*Fraxino pannonicae-Ulmetum*), meadows in the protected flood area (*Alopecurus pratensis* and *Typhoides arundinacea* dominated plant communities), dike-side grasslands (*Alopecuretum pratensis*, *Cynodonti-Poetum angustifoliae* and *Salvio-Festucetum rupicolae* plant communities in the majority of cases) and the plant belt along the dike roads (*Schlerochloo-Polygonetum avicularis*). Some habitat types, however, contribute to the spread of induced, habitat-strange species. Among others, *Amorpha fruticosa* L., *Acer negundo* L., *Fraxinus pensylvanica* Marsh. plant species are spreading in the planted forests of introduced poplar and willow species. These zones should be interrupted and replaced by natural forests.

Since the flood plains in the Hungarian Great Plain are not only corridors but core areas, too, it is necessary to establish buffer zones, which support both functions of the protected flood area. The minimal width of the buffer zone is 150-200 m. Buffer zones have a similar character, as the habitats inside the flood area as a rule. In some cases, however, they can be of different type, if they are in some biological connections with the flood area, e.g., saline lakes are the foraging habitats of herons breeding in the flood area.

The habitat islands outside the flood area (see Krausz et al., 1995) could be supported by stepping stones (small habitat patches promoting migration) and transversal ecological corridors, i.e., habitat strips between the virtual islands and the flood area. These corridors are usually stripes of grasslands along road, forest strips and marshy areas along tributaries of River Tisza etc. The maintenance of these strips can support the ecological communication between the flood area and the habitats outside.

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