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Seasonal changes of microclimatic conditions in grasslands and its influence on orthopteran assemblages

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Abstract: We examined the microclimate of different grasslands and the relationships between the seasonal changes in the microclimatic conditions and the structural characteristics of orthopteran assemblages in the most typical grassland types of the plain, hilly and submontaneous territories of Central Europe in 2000–2005 years. According to our results: (i) The seasonal changes of humidity were characteristic of the vegetation units; (ii) The microclimatic components of grasslands with similar habitat structure could be similar independently from their ecological circumstances; (iii) The microclimatic changes influenced the structure of the orthopteran assemblages.

Key words: microclimate profiles; orthopteran assemblages; seasonal changes

Introduction

The European research on the variance in the microclimate of vegetation types has begun several decades before. Bauer & Kenyeres (2006) summed up the main results of the relevant papers in this topic from the simple measurements (Braun-Blanquet 1928, 1951; Filzer 1936) up to the present complex studies on the edge and the heterogeneity effects of the habitats to the microclimate (Matlack 1993; Chen et al. 1995; Griebeler & Gottschalk 2000; Gehlhausen et al. 2000; Gottschalk et al. 2003; Behrens & Fartmann 2004, etc.). The earlier papers focused on the microclimate variances mainly in forests, shrubby-forests and edge zone of habitats, further analyses of the temperature were more dominant in the publications (Bauer & Kenyeres 2006).

The vertical change of the humidity is a typical feature of plant associations and association groups, which can refer to ecological conditions, as naturalness, water supply, land use etc. of different grassland types (Bauer & Kenyeres 2006).

The organization of animal communities depends on the microclimatic conditions of their environment; for example some terrestrial species demand water both in their larva and imago stages (Marsh 1985; Jooisse & Verhoef 1987; Hadley et al. 1990). In the case of the animal species with quite good mobile ability the microclimate effect influences their presence and abundances on a larger scale (Shapiro & Shapiro 1973; Rees 1983). The annual dynamics of the chiefly chortobiont life mode animal assemblages, which spend the major

part of their lifetime in the medium height grasslands, are also controlled by the seasonal changes of the microclimate (Bauer & Kenyeres 2006). The Orthoptera is one of the most applicable insect taxon for modelling this phenomenon. The orthopterans usually occurring with large abundance and relatively low species number in grasslands could be sampled with quantitative methods. The earlier works on microclimatic factors demonstrated that humidity is determinant (Forsman 2001; Harz 1957) in the organization of orthopteran assemblages, but the species ontogenetic processes are chiefly controlled by the microclimatic temperature (Samways 1990; Wingerden et al. 1992; Coxwell & Bock 1995). The spatial pattern of orthopteran assemblages is ruled by not the plant associations, but by the vegetation types belong to higher coenotaxonomic level (mainly classes, see Bauer et al. 2004). This level of the vegetation units can usually be characterized by similar structure and dynamics (Joern 1982; Gallé et al. 1985; Kemp et al. 1989, 1990; Fielding & Brusven 1993).

The points of our paper were to measure the seasonal changes of microclimatic conditions and to reveal the relationships between microclimatic changes and structural features of orthopteran assemblages in the most typical grassland types of plain, hilly and submontaneous areas of Central Europe. The Transdanubian Middle Mountains situated in the western part of the Carpathian Basin and its margin areas bordering with the Hungarian Great Plain are favourable for carrying out our studies because of its biogeographical location, relief and richness in natural habitats. The

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Transdanubian Middle Mountains is one of the most important contact areas of the Atlantic and the Eastern European forest steppe vegetation types. On the basis of spread and structural characteristics of the studied grassland types (e.g., rush fen, drying fen, semi-dry grassland, hayfield, steppe grassland, rocky grassland, open sandy grassland) the sampling sites are useful to come to general conclusions in the microclimatic characteristic components of the vegetation types and in the interactions between the seasonal changes of the microclimate components and the organisation of orthopteran assemblages.

Methods

One hundred and sixty-two microclimate measurements were carried out in 84 sampling sites. We measured microclimate components: air temperature and humidity on the ground surface and at different heights: 10, 20, 30 and 120 cm in the grassland. For measurements the next equipment were applied: TESTO 615. The sampling sites were divided among the plant associations in the next proportion: rush fen: 11 sampling sites (next more: s.s.); drying fen: 6 s.s.; semi-dry grassland: 12 s.s.; hayfield: 28 s.s.; steppe grassland: 12 s.s.; rocky grassland: 11 s.s., open sandy grassland: 4 s.s.; see in details in Bauer & Kenyeres (2006) the topographical characterisation and the description of the sampled vegetation types. In each sampling site air temperature and humidity were recorded in 3–5 semi-randomly selected patches from June to September, and repeated our measures 3–4 times per sampling sites. Altogether we had 5,010 measurements of air temperature and humidity. Our samplings were carried out in clear and calm periods of the days between 10 a.m. and 4 p.m.

The samplings of the orthopteran assemblages were carried out by sweep netting in 54 study sites from the above mentioned sites four times per year [the 54 sites were divided among the vegetation types in the following manner: rush fen: 17 s.s.; drying fen: 5 s.s.; semi-dry grassland: 17 s.s.; hayfield: 9 s.s.; steppe grassland: 2 s.s.; rocky grassland: 2 s.s., open sandy grassland: 2 s.s.]. Sweep netting data were collected in three 10 × 10 m quadrates per sampling site, where the content of the net after 300 sweeps was considered one sample. Altogether 648 sweep netting samples were taken, and 4,733 specimens were caught which belonged to 41 orthopteran species.

The selected grassland types most frequently found in the Transdanubian Middle Mountains were the following:

1) Rush fens (abbreviated as RF) (Caricion davallianae Klika 1934): *Junco obtusiflori-Schoenetum nigricantis* Alorge 1921; *Caricetum davallianae* Dutoit 1924.

2) Drying fens (DF) (Molinion coeruleae Koch 1926): *Succiso-Molinietum hungaricae* /Kömlódi 1958/ Soó 1969; *Agrostio-Deschampsietum caespitosae* /Soó 1928/ Újvárosi 1947.

3) Hayfields (HF) (Arrhenatherion Koch 1926): *Pastinaco-Arrhenatheretum* /Knapp 1954/ Passarge 1964; *Anthyllido-Festucetum rubrae* /Máthé et Kovács 1960/ Soó 1971; *Cirsio cani-Festucetum pratensis* Májovsky et Ruzicková 1975.

4) Semi-dry grasslands (SD) (Bromion erecti Br.-Bl. 1936): *Bromus erectus* or *Brachypodium pinnatum* dominated semi-dry grasslands, partly with unclarified coenological status: *Brometum erecti* sl.; *Brachypodietum pinnati*

sl. on loess; *Lino tenuifolio-Brachypodietum pinnati* /Dostál 1933/ Soó 1971.

5) Steppe grasslands (SS) (*Festucion rupicolae* Soó 1940 corr. 1964): *Cleistogeni-Festucetum sulcatae* Zólyomi 1958; *Salvio nemorosae-Festucetum rupicolae* Zólyomi ex Soó 1964 and degraded types of these.

6) Rocky grasslands (RG) (*Bromo-Festucion pallentis* Zólyomi 1966): *Stipo eriocauli-Festucetum pallentis* /Zólyomi 1958/ Soó 1964; *Seseli leucospermi-Festucetum pallentis* 1936.

7) Open sandy grasslands (SG) (*Festucion vaginatae* Soó 1929): *Festucetum vaginatae* Rapaics ex Soó 1929.

The respective value of humidity data (the value measured at 120 cm was considered 0) was used for drawing the grassland's microclimate profiles and evaluating data. Choosing the height of 120 cm as a comparison level could be explained by the fact that this height is two times higher than the highest grass-level in most of the selected grassland types (e.g., drying fen ~60cm), and at this level in the grasslands the air was completely ventilated by advections. Using relative values instead of the measured ones was also motivated by eliminating the differences between the times of measuring within a day. The daily differences of the microclimate components could be found in the same grassland (Précsényi 1956; Kovács 1966), but those are usually smaller than the characteristic values of microclimate components in the different grassland types.

Classification of the sampling results (plant associations or categories) was in mutual correspondence with classification of the measured values. The curves describing the microclimate of grassland associations could be drawn on the base of averaging the sampling results. In each sampling period (June, July, August, September) relation between the curves was calculated for each grassland association (see Bauer & Kenyeres 2006). The Box-and-Whisker Plots of vegetation types were made using all the sampling results.

The relative frequency values of individual species and density of the assemblages were determined, as well as the ecological spectra and the species number per sample. The structure of orthopteran assemblages was compared with ordination methods as Standardized Principal Component Analysis (PCA) and Multidimensional Scaling (MDS). The seasonal changes were figured on the basis of density and relative frequency values of dominant and subdominant species. The Pearson Product-Moment Correlation analysis per grassland type was carried out for the microclimate data at the different grassland levels and the parameters of the orthopteran assemblages.

Our statistical analyses were performed with Statistica 6.0 (StatSoft 1995) and SYN-TAX 2000 (Podani 2001) programme packages.

Nomenclature of the plant association was used after Borhidi & Sánta (1999), nomenclature of the grasshopper species after Nagy (2003).

Results and discussion

Microclimate: Habitat capability and grassland structure

The related plant associations, so-called association groups, forming under similar ecological and biogeographical circumstances can be described by typical microclimatic conditions. Microclimate parameters usually change vertically in grasslands (Kovács 1962;

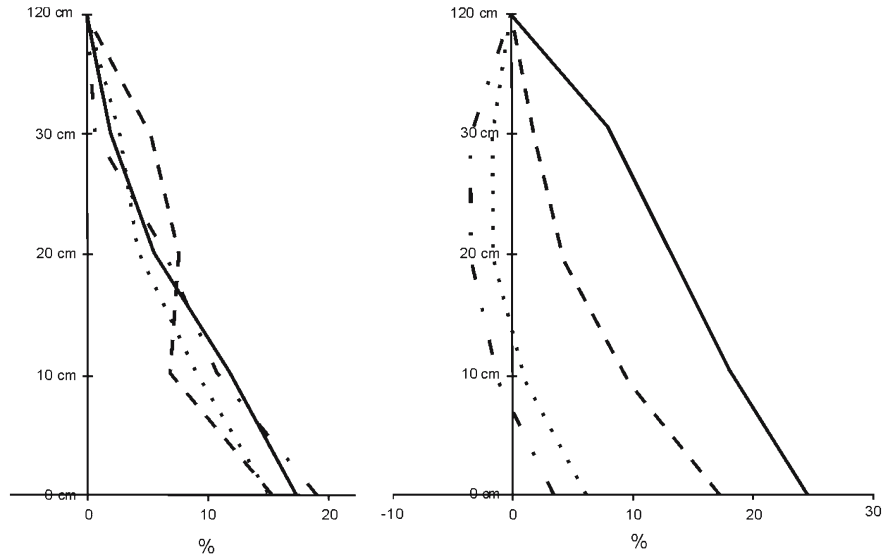


Fig. 1. Typical humidity profiles of drying fen (left) and semi-dry grassland (right). Continuous line: June, broken line: July, dotted line: August, dotted broken line: September.

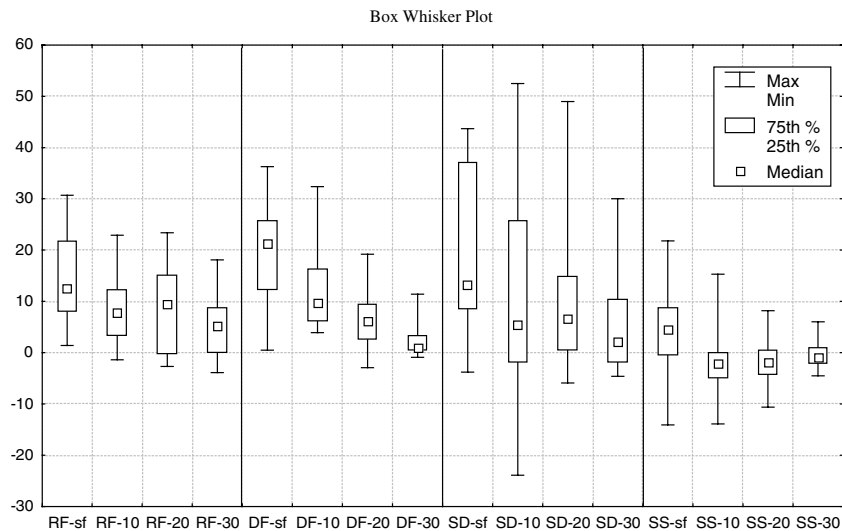


Fig. 2. The most distinctive differences in vapour content of grasslands appeared in June. BF: rush fens, DF: drying fens, SD: semi-dry grasslands, SS: steppe grasslands, sf: measured values on the ground surface, 10, 20, 30: measured values at a height of 10, 20, 30 cm in the grasslands.

Jakucs 1961, 1967, 1968; Bauer & Kenyeres 2006), however, differences could be found in the microclimate of our analysed vegetation types based on measured aspect change from June to September (Fig. 1).

The samples belonging to different groups (rush fens, drying fens, semi-dry grasslands, hayfields, steppe grasslands, rocky grasslands and open sandy grasslands) was justified in every sampling period based on the tendency in the shape of the relative humidity curves of the grasslands (Bauer & Kenyeres 2006). Slight differences in the humidity could also be observed in the sampling areas having similar grassland structure. The most distinctive differences appeared in June

(Fig. 2). Behind this phenomenon there were the most intensive plant physiological processes as blooming and crop maturation in case of the majority of plant species (Jakucs 1967). In the rest of the vegetation period decreasing differences between grassland types could be observed. The decreasing differences might be arising especially from the annual dynamics of physiological and metabolic processes, and on some sites the structural changes of vegetation caused by human activities (e.g., haymaking) (Bauer & Kenyeres 2006).

The humidity of the grassland seemed to be less influenced by the vegetation structure, and more strongly influenced by evaporation in the open dry grasslands

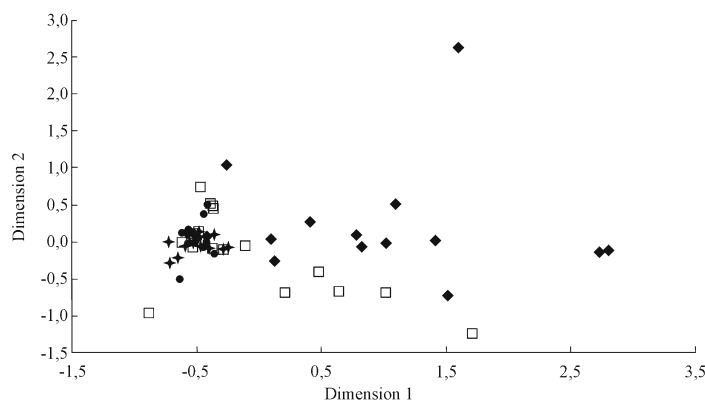


Fig. 3. Multidimensional Scaling of semi-dry grasslands' orthopteran samples. June: rhombus, July: empty square, August: circle, September: four-pointed star.

(Frank 2002; Nachabe et al. 2004). In the last case the vegetation structure and the morpho-anatomical and physiological adaptations caused the increasing influential, because of the vaporization minimization in the dry habitats. The closed steppe grasslands occurring on dry habitats are in a temporary state. This state is caused by the dry microclimate and more closed vegetation structure. Both the transpiration and the evaporation are important in forming the higher humidity values measured close to the soil surface (Bauer & Kenyeres 2006).

Similar structure – different dynamics

The microclimate profiles of closed grasslands forming in different environment conditions and dominated by broad-leaved grass species were similar, which might be the result of grassland structure. This phenomenon could be detected both in drying fens (DF) and long sward semi-dry grasslands (SD) forming in dry forest steppe environment (Fig. 1). In the case of drying fens the differences could hardly be seen during the four measuring periods (June, July, August, September). In early summer and autumn humidity values were minimally higher than measured in the driest summer months (Fig. 1, see Bauer & Kenyeres 2006). On the contrary, gradual drying after June, because of the continuous dropping of humidity could be observed in semi-dry grasslands, however, the structure of the grassland basically did not change (Fig. 1). Behind this phenomenon there could be decline of transpiration of dominant grass species, *Brachypodium pinnatum* (L.) sl. and *Bromus erectus* Huds. sl. (Gardiner & Hill 2004), and on the other hand there could be the influencing role (edge-effect) of the microclimate of habitats adjoining grasslands (forest steppe associations) (Jakucs 1968; Matlack 1993; Gehlhausen et al. 2000). In humid habitats predominated by drying fens several autumn species blossomed in the summer-end-early-autumn period. Furthermore second efflorescence was typical for many plant species which could also play a significant role. The evaporation of the wet soil surface also contributed to the maintenance of the higher humidity val-

ues of the lower height levels of the grassland.

The above-mentioned microclimatic differences could be recognized in the annual changes of the grasshopper assemblages. The assemblage-structure of orthopterans in early summer, June and July, showed significant similarity. The species composition and quantitative parameters of the orthopteran assemblages in the late summer and autumn aspect of the semidry grasslands depended on the habitat characteristic features in the ecotone zone. The microclimatic conditions of the drying fens and rush fens produced capabilities for hygrophytic species, which were represented by large densities in the assemblages during late summer and autumn (Figs 3, 4). The microclimate could be a determining ecological factor for structuring orthopteran assemblages, which might prove the edge-effect in intermittently dried up stands of drying fens of the autumn aspect (Fig. 4). The habitat structure could not be the only explanation for different and peculiar microclimate and changes of the ecological species composition of the orthopteran assemblages in semidry grasslands from early to late summer.

When the habitat changes

Item (paragraph two) showed that strong temporary change of ecological environmental factors caused microclimatic changes. Without changes of species reservoir and community structure there was a considerable difference in the fall of humidity curves in some rush fens. This phenomenon was found on fens characterized temporarily poor water supply and dried up soil surface without habitat structural changing (the drying out was caused by intermittently drying up of the springs) (Bauer & Kenyeres 2006). Differences in the humidity curves of habitat patches with proper or poor water supply emphasized the determining role of evaporation (Frank 2002). The impacting role of microclimate in natural plant associations could also be demonstrated in hayfields where we got very heterogenic samples, these fields were exposed to frequency of haymaking, oversowing, amelioration etc. (Bauer & Kenyeres 2006).

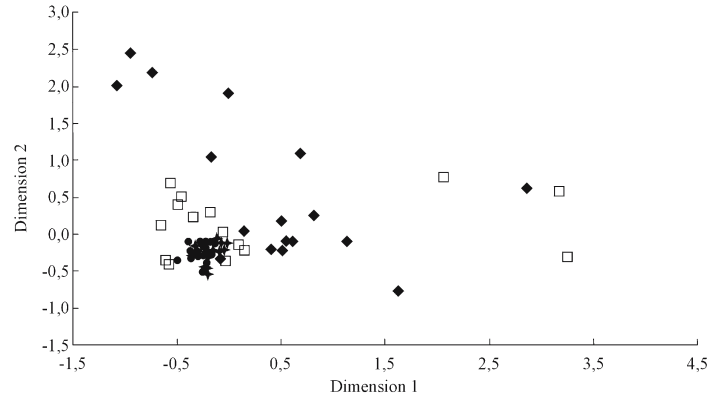


Fig. 4. Multidimensional Scaling of rush fens' orthopteran samples. June: rhombus, July: empty square, August: circle, September: four-pointed star.

Table 1. Species composition and quantity of the sampled grasshopper assemblages.

Taxon	Semi-dry grasslands (SD)				Hayfields (HF)				Drying fens (DF)				Rush fens (BF)				Σ
	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	
<i>Chorthippus biguttulus</i> (L., 1758)	1	2	2	2	12	16	2	47	0	0	0	0	0	0	0	7	91
<i>Chorthippus brunneus</i> (Thunberg, 1815)	0	8	5	3	18	3	15	59	0	0	0	1	0	2	6	13	133
<i>Chorthippus dorsatus</i> (Zetterstedt, 1821)	0	3	0	0	37	11	0	13	0	0	0	0	1	0	0	0	65
<i>Chorthippus montanus</i> (Charpentier, 1825)	16	9	5	1	649	190	29	2	1	1	0	0	47	18	0	0	968
<i>Chorthippus parallelus</i> (Zetterstedt, 1821)	48	20	9	3	800	172	51	29	3	2	0	0	85	37	6	12	1277
<i>Chrysochraon dispar</i> (Germar, 1834)	3	5	0	0	22	9	0	0	6	0	0	0	60	16	5	0	126
<i>Conocephalus discolor</i> Thunberg, 1815	0	0	0	3	0	16	0	16	0	8	12	6	6	46	22	17	152
<i>Euchortippus declivus</i> (Brisout, 1848)	0	0	0	0	505	10	2	0	0	0	0	0	0	0	0	0	517
<i>Euthystira brachyptera</i> (Ocskay, 1826)	144	73	4	6	27	8	0	21	8	5	1	0	109	91	0	0	497
<i>Leptophyes albovittata</i> (Kollar, 1833)	42	6	2	0	63	4	11	0	4	2	0	0	2	0	0	0	136
<i>Metrioptera bicolor</i> (Philippi, 1830)	73	23	6	0	41	4	0	0	0	0	0	0	3	0	0	0	150
<i>Metrioptera roeselii</i> (Hagenbach, 1822)	6	2	0	0	122	13	0	0	19	1	2	0	57	24	2	0	248
<i>Stenobothrus lineatus</i> (Panzer, 1796)	2	14	2	0	94	55	11	24	0	0	0	0	0	0	1	0	203

Other species: *Chorthippus mollis* (Charpentier, 1825) – HF: 3, 13, 0, 4; BF: 0, 0, 8, 9; *Gomphocerippus rufus* (L., 1758) – SD: 0, 7, 12, 10; *Conocephalus dorsalis* (Latreille, 1804) – HF: 0, 0, 0, 15; DF: 0, 2, 0, 0; BF: 0, 0, 0, 1; *Tettigonia viridissima* L., 1758 – SD: 2, 0, 0, 0; HF: 4, 0, 3, 0; DF: 1, 0, 0, 0; BF: 6, 2, 0, 0; *Pholidoptera fallax* (Fischer, 1853) – SD: 0, 5, 0, 0; DF: 6, 0, 0, 0; BF: 1, 2, 0, 0; *Mecostethus parapleurus* (Hagenbach, 1822) – DF: 7, 2, 2, 0; BF: 0, 2, 0, 0; *Pterolepis germanica* (Herrich-Schäffer, 1840) – SD: 1, 10, 2, 0; *Aiolopus thalassinus* (F., 1781) – BF: 0, 0, 7, 5; *Decticus verrucivorus* (L., 1785) – HF: 7, 0, 1, 0; BF: 4, 0, 0, 0; *Phaneroptera falcata* (Poda, 1761) – SD: 0, 3, 1, 1; HF: 3, 1, 2, 0; *Pholidoptera griseoaptera* (De Geer, 1773) – HF: 10, 0, 0, 0; *Stethophyma grossum* (L., 1758) – SD: 1, 0, 0, 0; HF: 0, 2, 0, 0; BF: 4, 2, 0, 0; *Ruspolia nitidula* (Scopoli, 1786) – HF: 0, 5, 0, 3; *Isophya kraussii* (Brunner v. W. 1878) – HF: 6, 0, 0, 0; *Tetrix tenuicornis* (Shalberg, 1893) – SD: 0, 3, 2, 0; BF: 1, 0, 0, 0; *Ephippigera ephippiger* (Fiebig, 1784) – SD: 3, 0, 0, 0; BF: 1, 0, 0, 0; *Phaneroptera nana* Fieber, 1853 – HF: 0, 0, 0, 3; DF: 0, 1, 0, 0; *Platycleis grisea* (F., 1781) – SD: 0, 2, 0, 0; BF: 0, 2, 0, 0; *Stenobothrus crassipes* (Charpentier, 1825) – SD: 0, 1, 2, 0; *Calliptamus italicus* (L., 1758) – SD: 0, 1, 0, 0; BF: 0, 1, 0, 0; *Tetrix bipunctata* (L., 1758) – SD: 0, 0, 2, 0; *Tetrix subulata* (L., 1758) – BF: 2, 0, 0, 0; *Chorthippus albomarginatus* (De Geer, 1773) – SD: 0, 0, 0, 1; *Oecanthus pellucens* (Scopoli, 1763) – SD: 0, 1, 0, 0; *Pezotettix giornae* (Rossi, 1794) – SD: 0, 0, 0, 1; *Pholidoptera aptera* (F., 1793) – HF: 1, 0, 0, 0; *Psophus stridulus* (L., 1758) – SD: 0, 1, 0, 0; *Stenobothrus stigmaticus* (Rambur, 1838) – HF: 1, 0, 0, 0.

Background arguments of the grasshopper-aspects' organising

PCA and MDS analyses on variable scale separated the orthopteran samples according to periods of the year and grassland types (Table 1, Figs 3, 4), the separation of early summer samples (June and July) was more typical.

The most significant correlations were found between the humidity and the structure of orthopteran assemblages in semi-dry grasslands. Significant positive correlation could be found between (1) the orthopteran species number and the soil surface temperature ($r_1 = 0.331, P_1 = 0.026$); (2) the abundance of the orthopteran

assemblages and the humidity of the grassland at soil surface ($r_2 = 0.406, P_2 = 0.006$), at height of 10 and 20 cm in the grassland ($r_3 = 0.357, P_3 = 0.016; r_4 = 0.441, P_4 = 0.002$) (3) the abundance of the orthopteran assemblages and average humidity of the grassland ($r_5 = 0.384, P_5 = 0.009$); (4) the abundance of the dominant and subdominant species and the measured vapour content of each grassland level.

In rush fens the Pearson correlation analyses showed a significant positive correlation between the abundance of orthopteran assemblages and the humidity at the soil surface ($r_{1ss} = 0.644, P_{1ss} = 0.007$), at height of 10 cm ($r_{1a} = 0.633, P_{1a} = 0.008$), at height of

20 cm ($r_{1b} = 0.600$, $P_{1b} = 0.014$), furthermore between the abundance of orthopteran assemblages and the average humidity in the grassland ($r_{1av} = 0.591$, $P_{1av} = 0.016$).

In drying fens the correlation analyses showed a significant positive correlation between (1) the orthopteran species number and average humidity in the grassland ($r_1 = 0.6200$, $P_1 = 0.014$), (2) the diversity of orthopteran assemblages and average humidity of the habitat ($r_2 = 0.6613$, $P_2 = 0.007$). A significant positive correlation was found between the orthopteran species number and the average habitat temperature ($r_3 = -0.6070$, $P_3 = 0.016$) as well as between the diversity of orthopteran assemblages and the average habitat temperature ($r_4 = -0.6492$, $P_4 = 0.009$).

The correlation analyses could not reveal significant correlations between the abundance of the orthopteran assemblages in hayfields and the vapour content and temperature of the same grassland type. However, a significant positive correlation was found between the abundances of some hygrophytic species and the humidity of the habitat [e.g., *Conocephalus discolor* Thunberg, 1815: 10 cm: $r_{cda} = 0.501$, $P_{cda} = 0.034$; 20 cm: $r_{cdb} = 0.539$, $P_{cdb} = 0.021$; *Ruspolia nitidula* (Scopoli, 1786): 10 cm: $r_{rna} = 0.507$, $P_{rna} = 0.032$; 20 cm: $r_{rnb} = 0.552$, $P_{rnb} = 0.018$].

Based on our results PCA and MDS analyses, and Pearson correlation analyses between orthopteran assemblages structure parameters and microclimate the structural changes of orthopteran assemblages within a year displayed such aspect change differences, where the change of humidity values could be in the background. Further separations of early and late summer and autumn aspects of orthopteran assemblages strongly occurred in some grassland types. Based on the character orthopteran species of semi-dry grasslands two further types of early summer aspects could be separated, the so-called *Euthystira brachyptera* (Ocskay, 1826)-type and *Chorthippus parallelus* (Zetterstedt, 1821) – *Metriopectera bicolor* (Philippi, 1830)-type. Typical autumn aspect of the orthopteran assemblages was not known in this grassland type (Fig. 3). On the contrary two autumn aspect types of orthopteran assemblages could be recognized in rush fens (RF) (Fig. 4). Rush fens dominated by *Schoenus nigricans* have a typical moss structure. In its water-supplied stocks the hygrophytic orthopteran species were dominant. On the contrary colonization of xerophytic grasshopper species could be realized in temporarily dried out, but structurally not changing grassland patches (RF), which are usually caused by droughts or low water output of springs. The above-mentioned phenomenon was strongly influenced by the presence of neighbouring dry grasslands through edge effect (2) (Fig. 4).

Early summer and late summer aspects of orthoptera assemblages in drying fens could also be differentiated based on the seasonal changes of relative-frequency values of dominant and subdominant species (Bauer & Kenyeres 2006). The early summer aspect showed significantly higher total orthopteran species

abundance, which predominated by the presence of hygrophytic and mesophytic orthopteran species. The late summer/autumn assemblage could be characterized by small hygrophytic orthopteran species number.

Microclimate vs. fenology

The effects presented in paragraph four of results might be caused by the phenological differences of the orthopteran species, but in temporarily dried stands of rush fens the xerophytic orthopteran species' presence and orthopteran assemblage formation having basically different structural features could be observed. Thereby the determining role of grassland microclimate was emphasized.

Our results in connection with hayfield stands and its orthopteran assemblages also showed that the aspect change could not explain the phenological differences alone. The change regarding the grassland microclimate's aspect in the hayfields was the result of the June/July haymaking. That was accompanied by structural and microclimate change as well and had the most drastic effect on the total number of orthopteran assemblages especially the number of grassland dwelling chortobiont species (Bauer & Kenyeres 2006). Among the orthopteran assemblage aspects of there seemed to be larger differences than in case of the rest of the grassland types (HF). The summer/autumn orthopteran assemblage aspect (August/September) of grassland (HF) with proper water supply could not be significantly separated from its early summer structure. Whereas marked changing could be found in many hayfields could characterize hygrophytic orthopteran assemblages in early summer. Xerophytic orthopteran species from dry grassland were temporarily dominant after haymaking, which caused a drastic structure and microclimate conversion. Because of haymaking the hygrophytic species escaped to neighbouring humid margin habitats and reappeared on aftercrop [see edge-effect in paragraph 2]. The dramatic change of habitat structure was the reason of special time dynamics and the aspect change of the orthopteran assemblages in these sites.

Our examinations carried out in the most typical grasslands of the plain, hilly and submontaneous territories of Central Europe revealed the seasonal changes of microclimatic features of grasslands and their effect on the structural characteristics of orthopteran assemblages. Case studies in connection with the effect of microclimate and vegetation-structure to grasshopper assemblage-organization often conducted to contradictory results (Samways 1990; Forsman 2001; Nagy & Sóllymos 2002), but it does not mean the wrong identification of factors independent of each other. In separated situations often happens that one of the factors is determinant (minimum principle, Liebig 1840). The phenomenon usually appears clearly on species level. On the contrary, on community level the effects appear in a confused and tendency-like way because of the different toleration of species originated assemblages.

References

- Bauer N. & Kenyeres Z. 2006. Data to the microclimate of some characteristic grassland associations of the Transdanubian Mountains. *Acta Bot. Hung.* **48**: 9–27.
- Bauer N., Kenyeres Z. & Kisbenedek T. 2004. A comparison of cluster analysis and diversity-ordering in community classification. *Community. Ecol.* **5**: 189–196.
- Behrens M. & Fartmann T. 2004. Die Heuschreckengemeinschaften isolierter Schieferkuppen der Medebacher Bucht (Südwestfalen/Nordhessen). *Tuexenia* **24**: 303–327.
- Borhidi A. & Sánta A. (eds) 1999. Vörös Könyv Magyarország növénytársulásairól [Red Data Book of the Hungarian Plant associations]. Természettudományi Alapítvány Kiadó, Budapest, 404 pp.
- Braun-Blanquet J. 1928. Pflanzensoziologie Grundzüge der Vegetationskunde. Biologische Studienbücher, Verlag von Julius Springer, Berlin, 330 pp.
- Braun-Blanquet J. 1951. Pflanzensoziologie II. Aufl., Springer, Wien, 631 pp.
- Chen J., Franklin J.F. & Spies T.A. 1995. Growing-season microclimate gradients from clearcut edges into old-growth douglas-fir forests. *Ecol. Appl.* **5**: 74–86.
- Coxwell C.C. & Bock C.E. 1995. Spatial variation in diurnal surface temperatures and the distribution and abundance of an alpine grasshoppers. *Oecologia* **104**: 433–439.
- Fielding D.J. & Brusven M.A. 1993. Grasshopper (Orthoptera: Acrididae) community composition and ecological disturbance on southern Idaho rangeland. *Environ. Entomol.* **22**: 71–81.
- Filzer P. 1936. Untersuchungen über das Mikroklima in niederrwüchsigen Pflanzengesellschaften. *Beih. z. Bot. Centralbl.* **55** (B): 301–346.
- Forsman A. 2001. Some like it hot: intra-population variation in the behavioral thermoregulation in colour-polymorphic pygmy grasshoppers. *Evol. Ecol.* **14**: 25–38.
- Frank A.B. 2002. Evapotranspiration from Northern Semiarid Grasslands. *Global Change Biol.* **8**: 599.
- Gallé L., Gyórfy G., Körmöczy L., Szőnyi G. & Harmat B. 1985. Különböző közösségtípusok élőhely heterogenitás indikációja homokpusztai gyepeken [Habitat heterogeneity indication of different community types on sandy grasslands]. *Természet – Tudomány – Társadalom* **1**: 230–271.
- Gardiner T. & Hill J. 2004. Feeding preferences of *Chorthippus parallelus* (Orthoptera: Acrididae). *J. Orthoptera Res.* **13**: 197–203.
- Gehlhausen S.M., Schwartz M.W. & Augspurger C.K. 2000. Vegetation and microclimatic edge effects in two mixed-mesophytic forest fragments. *Plant Ecol.* **147**: 21–35.
- Griebeler E.M. & Gottschalk E. 2000. An individual based model of the impact of suboptimal habitat on survival of the grey bush cricket, *Platypleis albopunctata* (Orthoptera: Tettigoniidae). *J. Insect Conserv.* **4**: 225–237.
- Gottschalk E., Griebeler E.M., Waltert M. & Muhlenberg M. 2003. Population dynamics in the Grey Bush Cricket *Platypleis albopunctata* (Orthoptera: Tettigoniidae). What causes interpopulation differences? *J. Insect Conserv.* **7**: 45–58.
- Hadley N.F., Knisley C.B., Schultz T.D. & Pearson D.L. 1990. Water relations of tiger beetle larvae (*Cicindela marutha*) correlations with habitat microclimate and burrowing activity. *J. Arid. Environ.* **19**: 189–197.
- Harz K. 1957. Die Geradflügler Mitteleuropas. VEB Gustav Fischer Verlag, Jena, 494 pp.
- Jakucs P. 1961. Die phytozoologischen Verhältnisse der Flauweichen-Buschwälder Südostmitteleuropas. Akadémiai Kiadó, Budapest, 313 pp.
- Jakucs P. 1967. Mikroklimatische untersuchungen im Berührungsgebiet der mediterranen und submediterranen Vegetation Albaniens. *Arch. Naturschutz. Landschaftsforsch.* **7**: 3–30.
- Jakucs P. 1968. Comparative and statistical investigations on some microclimatic elements of the biospaces of forests, shrub stands, woodland margins and open swards. *Acta Bot. Hung.* **14**: 281–314.
- Joern A. 1982. Vegetation structure and microhabitat selection in grasshoppers (Orthoptera: Acrididae). *Southwest. Nat.* **27**: 197–209.
- Joose E.N.G. & Verhoef H.A. 1987. Developments in ecophysiological research on soil invertebrates. *Adv. Ecol. Res.* **16**: 175–248.
- Kemp W.P., Kalaris T.M. & Quimby W.F. 1989. Rangeland grasshopper (Orthoptera: Acrididae) spatial variability: Macroscale population assessment. *J. Econ. Entomol.* **82**: 1270–1276.
- Kemp W.P., Harvey S.J. & O'Neill K.M. 1990. Patterns of vegetation and grasshopper community composition. *Oecologia* **83**: 299–308.
- Kovács M. 1962. Die Moortwiesen Ungarns. Akadémiai Kiadó, Budapest, 214 pp.
- Kovács M. 1966. Die Wirkung der geomorphologischen (expositionbedingten), mikroklimatischen und Bodenfaktoren auf die Entwicklung des Standortes der azidophilen Wälder im Mátra-Gebirge. *Acta Bot. Hung.* **12**: 293–324.
- Liebig J. 1840. Chemistry and its application to agriculture and physiology. Taylor and Walton, London, 352 pp.
- Marsh A.C. 1985. Microclimatic factors influencing foraging patterns and success of the thermophilic desert ant, *Ocymyrea barbiger*. *Insectes Soc.* **32**: 286–296.
- Matlack G.R. 1993. Microenvironment variation within and among forest edge sites in the Eastern United States. *Biol. Conserv.* **66**: 185–194.
- Nachabe M., Shah N., Ross M. & Vomacka J. 2004. Evapotranspiration of two vegetation covers in a shallow water table environment. *Agron. J.* **96**: 384–390.
- Nagy B. 2003. A revised check-list of Orthoptera-species of Hungary supplemented by Hungarian names of grasshopper species. *Folia Entomol. Hung.* **64**: 85–94.
- Nagy A. & Sóllymos P. 2002. Relationship between microclimate and Orthoptera assemblages in different exposures of a dolina. *Articulata* **17**: 73–84.
- Précsényi I. 1956. Mikroklima-mérések a gödöllői Száritó-pusztalegelőjén [Microclimatic measurements on Száritó-pusztalegelőjén of Gödöllő]. *Bot. Közl.* **46**: 267–274.
- Rees C.J.C. 1983. Microclimate and the flying Hemiptera fauna of a primary lowland rain forest in Sulawesi. *Special Publ. Br. Ecol. Soc.* **2**: 121–136.
- Samways M.J. 1990. Landforms and winter habitat refugia in the conservation of montane grasshoppers in southern Africa. *Conserv. Biol.* **4**: 375–382.
- Shapiro A.M. & Shapiro A.R. 1973. The ecological associations of the butterflies of Staten Islands. *J. Res. Lepid.* **12**: 65–128.
- Wingerden W.K.R.E., Kreveld A.R. & Bongers W. 1992. Analysis of species composition and abundance of grasshoppers (Orth., Acrididae) in natural and fertilized grasslands. *J. Appl. Entomol.* **113**: 138–152.

Received December 27, 2006

Accepted March 30, 2007