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Spatial Pattern of True Bugs (Heteroptera) in Heterogeneous Grassland – Preliminary Results

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The present study was carried out at a dune slack meadow near Mórahalom town in the Southern part of the Great Hungarian Plain. The area of the grassland is approximately 840,000 m^2. The vegetation is mosaic-like in accordance with the variable microrelief and water content. The lower part of the grassland consists of various types of saltmarshes and wet meadows and at the upper microrelief, Pannonic sand steppe patches occur. True bug assemblages were sampled at 16 patches using 5×50 sweeps at each sampling site. The sampling was repeated three times in both 2007 and 2008. The area, the perimeter, the shape index of the sampled patches as well as the diversity of the surrounding patches were assessed as "landscape parameters". The plant species number and diversity of the sampled patches were estimated from the data of 5 × 5 m coenological quadrats. Altogether 66,087 adult individuals belonging to 153 species were collected. The ordination methods showed that the true bug assemblages of the sampling patches differ from each other in accordance with the vegetation type. These assemblages differed in their species composition and diversity as well as in their assemblage structure. The results suggested that the vegetation type based on plant species composition determined the true bug assemblages.

Keywords: Heteroptera assemblages, diversity, habitat heterogeneity.

European countries are dominated by agricultural landscapes. The increased farming intensity in the last decades caused a decrease of species richness (Marshall and Moonen, 2002) due to the destruction (Tscharntke and Kruess, 1999) and fragmentation (Steffan-Dewenter and Tscharntke, 2000) of the natural habitats. Considering the differential habitat use of arthropods only a mosaic of different habitats can provide high species richness (Duelli and Obrist, 2003). Therefore the natural remnants of heterogeneous grasslands and the patterns and processes taking place in these remnants have an important role in the conservation of arthropod diversity in an agricultural landscape.

This study was carried out in the Kiskunság region which is situated in the middle part of the Hungarian Great Plain. The region consists mainly of agricultural fields and forest plantations, but some remnants of the original natural habitats also occur. During

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the last two decades, 99% of the steppe grasslands, 56% of the alkali vegetation and 55% of the fen vegetation was destroyed by human activities in the Kiskunság (Biró et al., 2008). In the southern Kiskunság the natural vegetation (sand steppes, fen and marsh meadows and alkali vegetation) survived in the dune slack meadows as these grasslands could not be used for anything else than hay-meadow or pasture because of the high water level during the spring (Margóczi et al., 2007). The species rich vegetation is mosaic-like in accordance with the variable microrelief and water content and has a high natural value (Aradi et al., 2006).

True bugs are an ecologically very divers group including both herbivorous and predaceous species with different degree of food specialization and both adults and nymphs live at the same habitat (Dolling, 1991). Furthermore, the true bug diversity correlates with the total insect diversity (Duelli and Obrist, 1998) and they respond sensitively to habitat changes (Torma and Körmöczi, 2009). True bugs are an ideal group to study the patterns and processes in heterogeneous grasslands.

The aims of present study were to reveal a) whether distinct true bug assemblages exist at the various vegetational patches of heterogeneous grassland; b) whether these assemblages differ in their species richness, diversity and assemblage structure; c) which factors influenced the species composition and the structure of these assemblages.

Materials and Methods

Study site and sampling

The studied dune slack meadow called Csipak-semlyék is situated near Mórahalom town. The area of the grassland is approximately 840,000 m^2. The lower part of the grassland consists of various types of alkali vegetation (e.g. *Juncus gerardii* meadows, *Lepidium-Puccinellia limosa* hollows, *Festuca pseudovina* swards) as well as reedland patches, and wet meadows (searing *Molinia* swards and marsh meadows often with mixed characteristics). At the upper microrelief, Pannonic sand steppe vegetation occurs (Aradi et al., 2006).

True bugs were sampled at 16 sites using 5×50 sweeps at each one. The sampling was repeated three times (May, June, July) in both 2007 and 2008. According to the digital vegetation map of the grassland, the area and the perimeter of the sampled patches were computed using Arc View Gis 3.3 software. The shape index and the diversity of the surrounding patches were calculated, too. These parameters were used as "landscape parameters". The plant species number and the plant diversity of the sampled patches were estimated from the data of 5×5 m coenological quadrats. The average water requirement of the plants observed in a coenological quadrat was used as the humidity of a sampled patch. The data set of water requirements of plant species was due to the Hungarian Flora Database 1.2 (Horváth et al., 1995). The vegetation type of a patch was determined by the plant species composition. The categories of vegetation types followed the Hungarian habitat classification manual (Bölöni et al., 2007). Three patches of both Pannonic sand steppes (PSS), *Juncus gerardii* meadows (JGM) and *Lepidium-Puccinellia limosa* hollows (LPH) as well as 7 patches of wet meadows (WM) were studied. At one of the LPH sites *Lepidium crassifolium* occurred in very small stands and *Festuca pseudovina* was a dominant plant species, too. In spite of these differences it was categorised as LPH.

The nomenclature of true bugs faollows Kondorosy (1999).

Data analysis

The data of the different sampling periods were pooled because the temporal patterns were not studied. The data set of the two years also were pooled for the analyses as they strongly correlated (Mantel test: $r = 0.81$; $p < 0.001$).

Correspondence analysis (CA) was used to show the natural grouping of true bug species and sampling sites. Canonical correspondence analysis (CCA) was applied to reveal the factors influenced the true bug assamblages. Abundance data of true bugs were logarithmically transformed. The marginal and partial effects of the variables were calculated. Marginal effects denoted the variability explained by a variable without considering other variables, whereas partial effects denoted the variability explained by a given variable after removing the confounding effect of one or more other variables. Marginal and conditional effects were tested for significance by Monte Carlo permutation tests with 1,000 permutations.

The difference between true bug assamblages was tested by the PERMANOVA using Bray-Curtis similarity index. The test based on 10,000 permutations.

Rényi's diversity ordering was applied to compare the species diversity of true bug assamblages.

Kruskall-Wallis test was used to compare the number of species per samples between the different true bug assemblages.

We used the R (R Development Core Team, 2007) and SPSS 11.5 softwares for the analyses.

Results

Altogether 66,087 adult individuals belonging to 153 species were collected.

The scatter plot of the ordination *(Fig. 1)* showed that the true bug species as well as the sampling sites grouped in accordance with the vegetation influenced by salinity (axis 1) and humidity (axis 2).

According to the CCA *(Table 1)* the number and diversity of plant species, the humidity and the type of the vegetation had significant influence on the true bug assemblages, however they effects overlapped highly. On the basis of the partial CCA, the vegetation type affected the true bug assamblages, principally *(Table 1)* and the diversity of plant species had also a significant partial effect.

The Mantel test showed a strong relationship between the distribution of plant and true bug species ($r = 0.64$, $p < 0.001$).

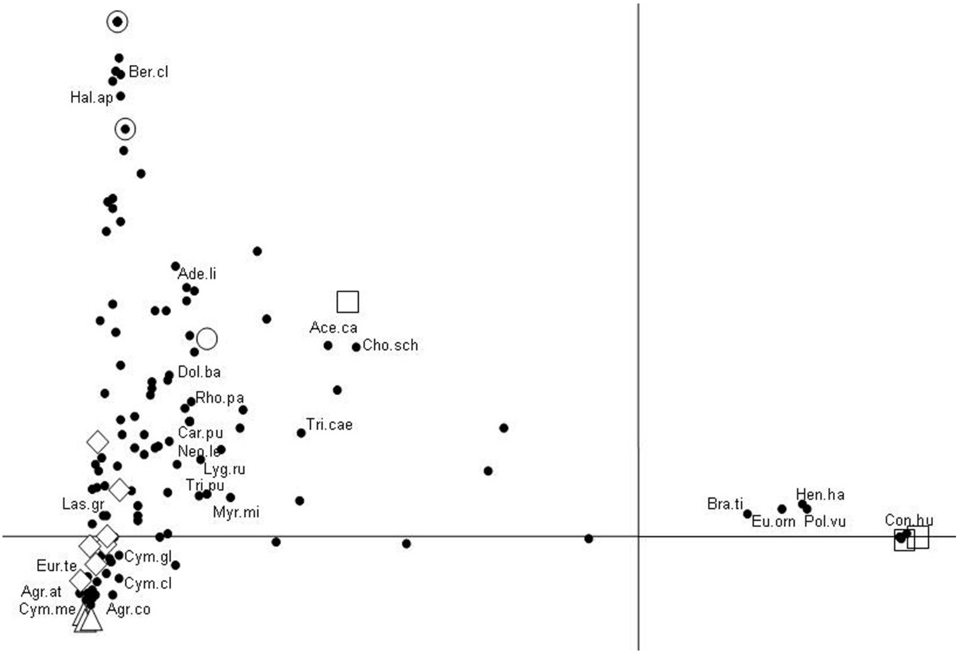

Fig. 1. The scatter plot of the CA based on the total data set shows the separation of sampling sites and true bug species along the first two axes. True bug species are marked with field black circles; the frequent species (above 1%) are marked with the first three letters of the genera name and the first two letters of the species name. The sites belonged to the different vegetational types are marked with the following symbols: PPS sites with empty circles, JGM sites with triangles, WM sites with diamonds and LPH sites with squares

Table 1

The results of canonical correspondence analyses (CCA) show the impact of factors influenced the true bug assemblages. Significance of parameters was tested by Monte-Carlo procedure with 1000 permutations

	Explained inertia (%)	
Total	76.68**	
	Marginal effect	Partial effect
Area	ns	
Perimeter	ns	
Diversity of surrounding patches	ns	
Number of plant species	22.04**	ns
Diversity of plants	24.09**	14.70*
Vegetation type	54.45**	40.07*
Humidity	29.89**	ns

Levels of significance: *p < 0.05, **p < 0.01, ***p < 0.001; ns: non-significant

The true bug assemblages belonged to the various vegetation types differed significantly according to PERMANOVA (pseudo F=3.556; $p < 0.001$; based on 10,000 permutations). These assemblage did not differ in their species number (Kruskall-Wallis test: Chi-Square: 6.812; df: 4; p=0.148) but differed in their species diversity according to the Rényi's diversity ordering *(Fig. 2)*. The highest species diversity occurred at Pannonic sand steppe patches. Very low diversity was observed at JG and LP patches.

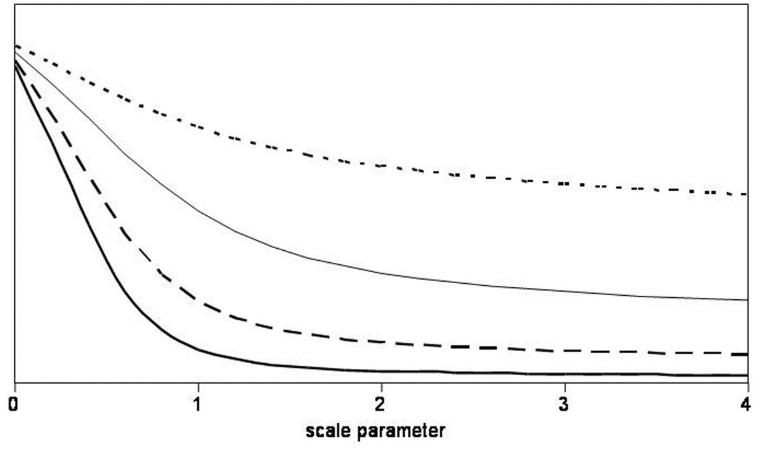

Fig. 2. The Rényi's diversity profiles show differences between the diversity of true bug assamblages belonging to the various habitats. The diversity profiles of true bug assemblages are marked with dotted line at PPS, with broken line at JGM, with solid line at WM and with thick solid line at LPH

The most frequent species were *Conostethus hungaricus* E. Wagner, 1941 (92.43%) and *Henestaris halophilus* (Burmeister, 1835) (2.60%) at LPH habitat. *Agramma confusum* Puton, 1879 and *Agramma atricapillum* (Spinola, 1837) were the dominant species at both JGM (75.38% and 12.88%) and WG (44.63% and 11.56%) habitats. However, at WG sites there were some subdominant species, additionally [e.g. *Lasiacantha gracilis* (Herrich-Schäffer, 1838), *Eurygaster testudinaria* (Geoffroy, 1785) and *Cymus* spp.]. At PSS habitat, *Halticus apterus* (Linnaus, 1761), *Sciocoris microphtalmus* Flor, 1860 and *Berytinus clavipes* (Fabricius, 1775) were the most abundant species with a frequency of 13.90%, 9.67% and 8.02%, respectively.

Discussion

The fine scale pattern of true bugs was studied in a heterogeneous grassland.

The results of ordination methods and PERMANOVA showed that distinct true bug assemblages exist at the various vegetational patches of the grassland. These true bug assemblages differed in their species composition and diversity as well as in their assemblage structure. Two species were extremely abundant; *C. hungaricus* at *Lepidium-Puccinellia* *limosa* hollows, and *A. confusum* at *Juncus gerardii* meadows. The lowest diversity was observed at these patches in this manner. Similar high abundance of *C. hungaricus,* approximately 80–100 individuals per sweeps, was also reported by Szücs (1961) at saline grasslands in the Kiskunság. The high abundance of this species presumably was due to the high density of its host plant *Lepidium crassifolium* in accordance with the resource concentration hypothesis (Root, 1973) which suggested that specialist herbivores are more likely to find and remain on their host plants if these plants are concentrated in dense, pure stands. It was confirmed by the fact that at the LPH site where *L. crassifolium* occurred in very small stands, *C. hungaricus* was not a frequent species.

According to present study, "landscape parameters" (e.g. area, perimeter, shape index, the diversity of surrounding patches) had no impact on the species composition of true bug assemblages at such a small scale. Contrarily, vegetation type, plant diversity, plant species richness and humidity had significant impacts, however their effects overlapped highly. The impact of various vegetation properties, e.g. vegetation species composition (Sanderson et al., 1995), vegetation structure and flower abundance (Zurbrügg and Frank, 2006), plant diversity or plant species richness (Frank and Künzle, 2006), vegetation height and density (Bröring and Wiegleb, 2005) on true bug assemblages is well known. Some paper emphasized the importance of plant species richness and diversity (e.g. Greatorex-Davies et al., 1994; Frank and Künzle, 2006) but Di Giulio et al. (2001) found that the bug fauna is affected more strongly by the texture and the microclimate conditions in the grasslands than by plant species richness. Considering the result of partial CCA it seemed that in a heterogeneous grassland, the species composition of true bug assemblages associated primarily with the vegetation type as it was suggested by Sanderson et al. (1995). It was confirmed by the Mantel test which also showed high correlation between the distribution of plant and Heteroptera species.

However, it is problematic that various feeder groups (e.g. plant feeders, predators, etc.) presumably are not influenced by the same factors. Di Giulio et al. (2001) suggested that in the case of zoophagous and polyphagous herbivore species, the plant species richness might play a less important role than the textural diversity of the habitat. The impacts of various factors may differ between the degrees of feeding specialization, e.g. specialist and generalist herbivores, too (Jonsen and Fahrig, 1997). Finally, there are great seasonal differences in the abundance of several true bug species (e.g. Musolin and Saulich, 1999; Saulich and Musolin, 2007) thus the investigation of temporal patterns is also important to obtain a clear insight into the organization of true bug assemblages.

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