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Structure of grasshopper (Orthoptera) communities in relation to ecological succession of dolomitic grasslands

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Structure of grasshopper (Orthoptera) communities in relation to ecological succession of dolomitic grasslands – Late summer grasshopper comunities were compared to each other according to some structure parameters. Grasshoppers were counted along 1 m wide transects in southwestern- and north-facing sites, and in different successional stages of dolomitic grasslands in the Buda Hills, Hungary. Community structure parameters revealed high similarity of communities related to the dolomitic succession, but showed a high dissimilarity between these sites and the north-facing site. While diversity showed a positive linear relationship with plant cover, dominance (Berger-Parker index) of species changed in a negative manner.

Introduction

The vegetation structure and its changes fundamentally influence the organization of animal communities. One of the most direct relationships between plants and animals is that connected with the food chain of organisms, the so-called phytophagy.

As the ecological succession proceeds the interactions among the living organisms become in general more heterogenous and multi-layered (Odum 1969). The vegetation cover and diversity of the plants increases (Bach 1990), and the change of vegetation architecture also considerably affects insect communities (Lawton 1983, Stinson and Brown 1983). Taxonomic and trophic diversity of insects also increase during the ecological succession (Brown and Southwood 1983), moreover, phytophagous insects themselves affect the succession of plant associations, too (Bach 1990).

In the present study I analyzed the structure of grasshopper communities in different stages of dolomitic succession. The correlation was examined between each of the three grassland associations on dolomite and the relating grasshopper communities, according to how the structure of grasshopper communities changes with increasing vegetation cover, diversity and vertical structure.

Study sites

The study was carried out in the Buda Hills (4° 35' N, 18° 90' E), on the so-called Odvas Hill, and on the Kutya Hill. the Odvas Hill is found in west and the Kutya Hill is found in northwest direction from Budapest, about 10 km and 20 km far from the town, respectively, and about 12 km far from each other. Both of them have dolomite rock. Responding to rainfall this rock quickly crumbles and breaks. As a consequence of this process the plants can hardly bind the soil, therefore, slopes are strongly eroded and quite steep. In the pioneer plant associations of these sites the soil is shallow, and the chemical-physical structure of the basic rock has the greatest influence on the soil.

The study was carried out in the following plant associations (following the categorization of Jakucs 1981):

(A) Open dolomitic grassland *(Sesseli leucospermo-Festucetum pallentis)* having a southern exposure. Plant cover is 30-70%, dominant grass species is the *Festuca pallens*.
(B) Ecotone zone between the open and the closed grasslands.
(C) Open dolomitic steppe-meadow *(Chrysopogono-Caricetum humilis)*, having a southwestern exposure. Cover of plants is 60-80%, dominant plant species is the *Carex humilis*.
(D). Closed dolomitic grassland *(Festuco pallenti-Brometum pannonici)*, having a northern exposure. The vegetation is totally closed, dominant grass is the *Bromus pannonicus*.

The study site (C) was marked out on the Kutya Hill, and the others were situated on the Odvas Hill. The edges of the sample sites followed the boundaries of the natural vegetation. The size of the study sites (A) and (B) was about 200 x 200 m, about 300 x 500 m of the site (C), and 10 x 100 m of the site (D).

Methods

Based on the instructions of Southwood (1978) a linetransect-type method was chosen for collecting data on grasshoppers. This consists of visual observation along a 1 m wide transect with the same constant speed of walking (300m/1h). All of the individuals identified by eyes along a transect were recorded. The duration of a sampling procedure at a site was 10 minutes. This procedure seemed to be sufficient for the majority of species, but in cases of a few groups identification was possible only for the genus level (*Glyptobothrus, Omocestus,* and *Euchortippus*). Data collection was made fortnightly on 4 sites from the 10th of August to the 17th of October in 1989. One visit in a week was carried out for each plots, and data were collected in the interval from 10 a.m. to 3 p.m. The Shannon-Weaver index was applied for the computation of diversity:

$$H = -\Sigma p_i \ln p_i$$

where H = diversity,
p_i = relative frequency of species i,
ln = natural logarithm.

For the comparison of insect communities referring to different plant associations the Bray-Curtis index (1957) was applied:

$$C_n = 2Jn / (A_n + B_n)$$

where C_n = Bray-Curtis index,
J_n = number of individuals of common species of two associations,
A_n = number of individuals of association A,
B_n = number of individuals of association B.

This index the gives advantage whether consideration individual number, not only the species number.

The Berger-Parker's dominance index (Berger and Parker 1972) was applied for showing of there is any dominant species in the community:

$$D = n_{max}/N$$

where D = dominance index,
n_{max} = number of individuals of the most abundant species,
N = total number of individuals.

Results

During the study period 34 Orthoptera species were found, belonging to the following families: *Acrididae* (17 species), *Tetrigidae* (3 sp.), *Oecanthidae* (1 sp.), *Ephippigeridae* (1 sp.), *Sagidae* (1 sp.), *Meconemidae* (1 sp.), Phaneropteridae (2 sp.), and *Tettigoniidae* (8 sp.) (see Appendix for detailed list of species).

The family of *Acrididae* contributes 53.1% to the total species number, and 91.6% to the total abundance. The species of the *Acrididae* family contributes relevantly to the total species number on each of the sites: open grassland (A): 95.1%, ecotone zone (B): 96.9%, steppe meadow (C): 55.5%, closed grassland (D): 90.4%. The distribution of these values is similar to the abundance ratios of the species of the *Acrididae* family: open grassland (A): 84.6%, ecotone zone (B): 80.0%, steppe meadow (C): 82.3%, closed grassland (D): 71.4%.

Table 1. Structure parameters of Orthoptera communities on the dolomitic grasslands. (A) = open grassland, (B) = ecotone zone, (C) = steppe meadow, (D) = closed grassland

	(A)	(B)	(C)	(D)
number of species	13	16	27	14
number of individuals	291	493	306	293
density (number of of individuals / visit)	36.82	61.62	36.75	35.50
Shannon-Weaver's diversity	1.057	1.369	2.259	0.902
% dominance of the most dominant genus	69	54	24	79
% dominance of the most dominant species	10	25	28	4

Community structure parameters can be seen on Table 1. The biggest species number was found on the steppe meadow (C) (27 species). On the other three sites, where the habitat was more open, species number was lower, varying between 13 and 16. The average density of grasshoppers was 47.67 individuals per transect. The lowest density was measured in the closed grassland (D) (35.50), and the highest in the ecotone zone (B) (61.62). The diversity value was greatest on the steppe meadow (C) (2.259). The calculated diversity values for sites (A), (B), and (D) were similar to each other, but these values were much lower than that of the site (C) (1.057, 1.369, and 0.902, respectively).

In each plant association *Glyptobothrus* was the dominant genus. According to the dominance values of *Glyptobothrus* (Table 1), the study sites can be ordered as:

$$(C) < (B) < (A) < (D).$$

The most dominant species (not including the *Glyptobothrus* genus) have low dominance indices in each case. In the closed grassland (D) *Rhacocleis germanica* (0.04), in the open grassland (A) *Oedipoda coerulescens* (0.10), in the ecotone zone (B) *Oe. Coerulescens* (0.25), and in the steppe meadow (C) *Stenobothrus crassipes* (0.28) were the most dominant species of the sites.

Sites can be arranged according to structure parameters in the following increasing order:

diversity	: (D) < (A) < (B) < (C)
dominance	: (C) < (B) < (A) < (D)
plant cover	: (A) < (B) < (C) < (D)

Excluding the only north-facing closed habitat (D), diversity and plant cover values changed in a similar manner, while dominance changed inversely with plant cover.

Although the grasshopper communities of the different plant associations compared with each other showed high similarity in species composition, but according to the Bray-Curtis index they were fundamentally different in terms of species abundances. The Orthoptera community of the ecotone zone (B) showed the highest similarity to the open habitat (A). Only slightly smaller values were found between the open habitat (A) and the closed grassland (D), moreover, between the ecotone (B) and the closed grassland, too. There is a relevant difference between the composition of these three communities and that of the (C) site (Table 2).

Table 2. Comparison of the study sites based on the Bray-Curtis index. (A) =open grasslands, (B) =ecotone zone, (C) =steppe meadow, (D) =closed grasslands. (++=strong similarity, +=weak similarity)

sites	(A)	(B)	(C)	(D)
(A)	X	+	+	+
(B)	0.84	X	+	+
(C)	0.36	0.31	X	+
(D)	0.74	0.74	0.41	X

Discussion

Odum (1969) summarized the changes in the ecosystems during an ecological succession. According to structure parameters of communities, such as species diversity, number of layers and spatial heterogeneity, values are higher in the mature stages than in the developmental stages.

Number of studies have pointed out that vegetation succession has strongly affected the structure of insect communities. The organization of early colonizing plant and insect communities has been debated by Simberloff (1976), and expected interactions in mature communities have been tested by Lawton and Strong (1981). Southwood et al. (1979) concluded, that in early succession, insect diversity was strongly associated with plant diversity, but in the later stages structural attributes of the vegetation (with both spatial and architectural components) became increasingly important. Hendrix et al. (1988) found that the earliest stages of succession display the dominance of phytophagous insects. In the present study the majority of *Orthoptera* species were phytophagous, mostly belonging to the family of *Acrididae*. There were detected significant differences between the pairs of the three dolomitic plant associations according to the structure parameters of grasshoppers communities.

Based on the results I stated the following: (1) The neighbouing sites showed higher similarity to each other than to the isolated sites.

(2) Although the vegetation structure of the north-facing closed grassland is much more similar to the well developed steppe meadow, the structure of its Orthoptera community is rather similar to that of the open site.

(3) The grasshopper communities of the open grasslands (open grassland, and steppe meadow) showed a high correlation to the structure of vegetation. This result agrees with the findings of Southwood et al. (1979). They reported that species richness, diversity, abundance, and life-history strategies of Heteroptera and Coleoptera taxa changed in a systematic way during the development of habitat.

In cases of the south-facing plant associations, the open grassland gradually develops to the steppe meadow. According to Odum's model of succession (Odum 1969), in these plant associations the Orthoptera communities also show developmental differences: in the steppe meadow the structure of the Orthoptera community is more complicated (higher in species number and diversity values) than that in the open grassland. Brown and Hyman (1986) revealed a similar close relationship between plants and phytophagous beetles throughout the ecological succession on sandy soil, from the bare ground through permanent pastureland to birch woodland.

In the present study the north-facing closed grassland has a different microclimate from the southern open grasslands and this is reflected in the structure of the Orthoptera community.

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Appendix

List of grasshopper species collected on dolomitic grasslands in the Buda Hills, in 1989.

Phaneropteridae

1. Leptophyes albovittata (Kollar, 1833)
2. Phaneroptera falcata (Poda, 1761)

Tettigoniidae

3. Bicolorana bicolor (Philippi, 1830)
4. Decticus verrucivorus (Linnaeus, 1758)
5. Pholidoptera aptera (Fabricius, 1793)
6. Ph. fallax (Fischer, 1853)
7. Ph. griseoaptera (De Geer, 1773)
8. Platycleis grisea (Fabricius, 1781)
9. Rhacocleis germanica (Herrich-Schaffer, 1835)
10. Tettigonia viridissima Linnaeus, 1758

Ephippigeridae

11. Ephippigera ephippiger (Fieber, 1784)

Meconemidae

12. Meconema varium (Fabricius, 1775)

Sagidae

13. Saga pedo (Pallas, 1771)

Oecanthidae

14. Oecanthus pellucens (Scopoli, 1763)

Tetrigidae

15. Tetrix bipunctata (Linnaeus, 1758)
16. T. subulata (Linnaeus, 1761)
17. T. tenuicornis (Sahlberg, 1893)

Acrididae

18. Calliptamus italicus (Linnaeus, 1758)
19. Oedipoda coerulescens (Linnaeus, 1758)
20. Euchortippus declivus (Brisout-Barneville, 1848)
21. E. pulvinatus (Fischer-Waldheim, 1846)
22. Euthystira brachyptera (Ocskay, 1826)
23. Glyptobothrus biguttulus (Linnaeus, 1758)
24. Gl. brunneus (Thunberg, 1815)
25. Gl. mollis (Charpentier, 1825)
26. Gomphocerippus rufus (Linnaeus, 1758)
27. Myrmeleotettix maculatus (Thunberg, 1815)
28. Dirshius haemorrhoidalis (Charpentier, 1825)
29. D. petraeus (Brisout-Barneville, 1855)
30. O. ventralis (Zetterstedt, 1821)
31. Stenobothrus crassipes (Charpentier, 1825)
32. S. lineatus (Panzer, 1796)
33. S. nigromaculatus (Herrich-Schaffer, 1840)

Mantidae

34. Mantis religiosa Linnaeus, 1758

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