ECOLOGICAL CHARACTERISTICS OF BEE COMMUNITIES ON A SANDY GRASSLAND

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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 sptial 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.

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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. A*lcanna 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 Györffy 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 m^2 each, were regularly watered from 1982, from June to August. In the year of our observations, this amounted to 135 mm.

2) a 300 m^2 area was fertilized in 1977;

3) the topsoil was removed from a 600 m^2 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. Tscharntke (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; Tscharntke, 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).

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

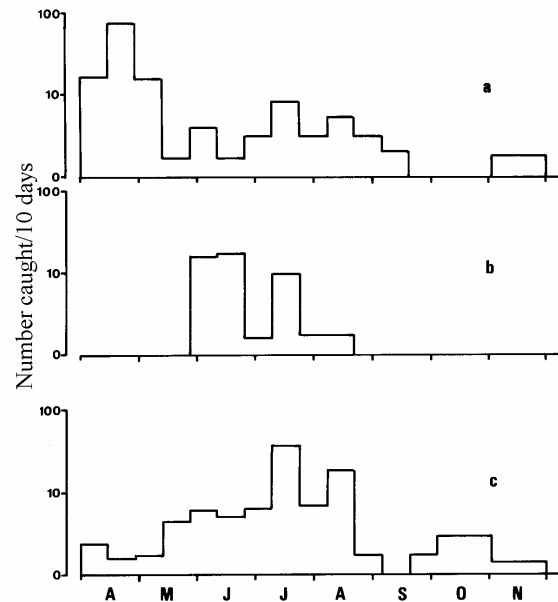The three dominant Halictid species showed temporal segregation during the season (Fig. 1).

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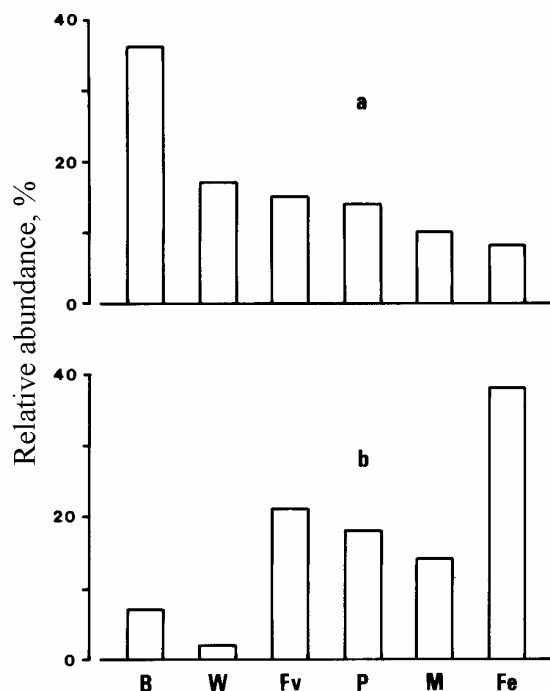
Fig. 2. The relative abundance of two Andrena species on the different areas. a: *Andrena taraxaci*; b: *Andrena florivaga*; B: "bared" area; W: watered area; Fv: *Festucetum vaginatae*; P: *Potentillo-Festucetum pseudovinae*; M: *Molinio-Salicetum rosmarinifoliae*; Fe: fertilized area

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,
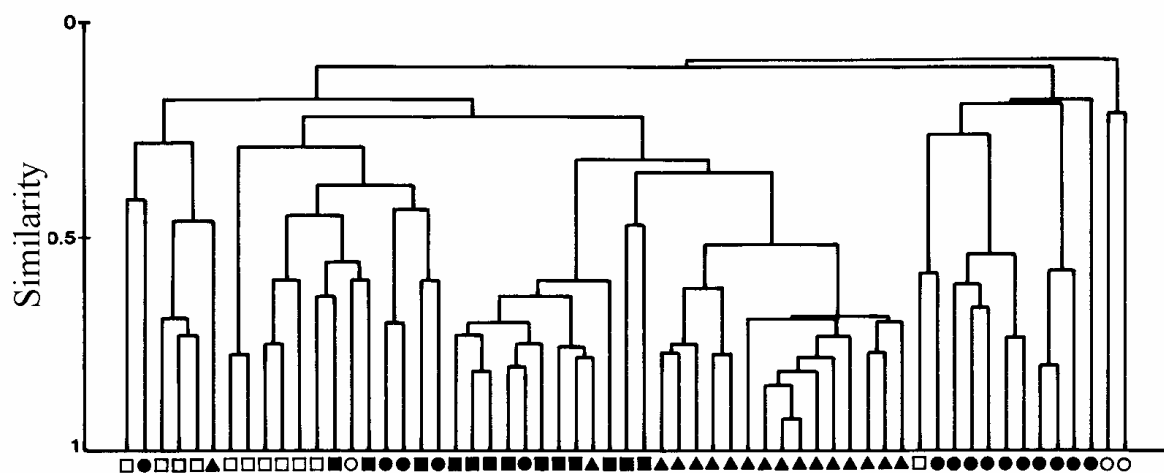

Fig. 3. The dendrogram of the cluster analysis of the traps based on the data of plant cover surrounding the traps. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; ○: fertilized area; □: "bared" area
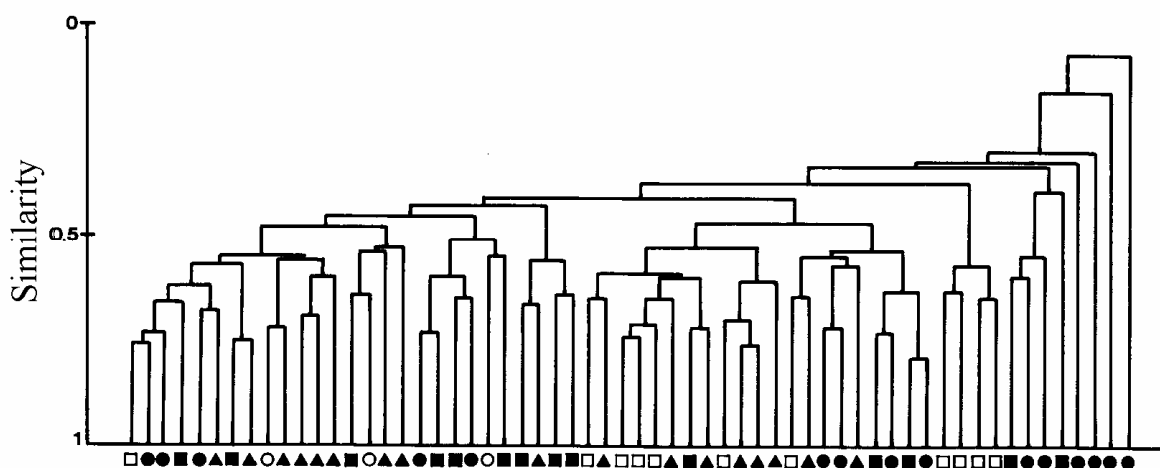
Fig. 4. The dendrogram of the cluster analysis of the traps based on the data of bee species caught. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; ○: fertilized area; □: "bared" area
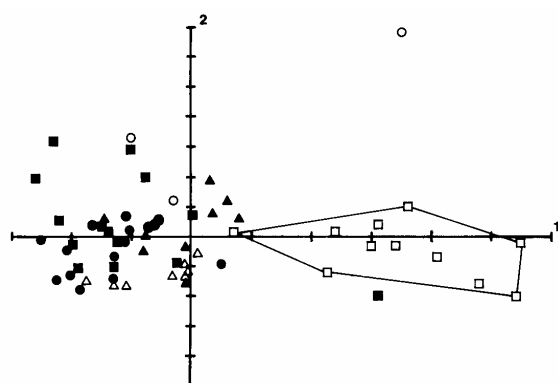

Fig. 5. PCA scatter diagram of the traps based on the data of bee species caught. Axis 1 and 2. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; △: watered area; ○: fertilized area; □: "bared" area

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.
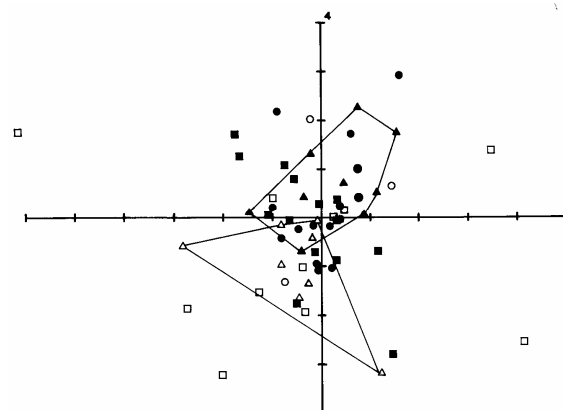

Fig. 6. PCA scatter diagram of the traps based on the data of bee species caught. Axis 3 and 4. ▲: *Festucetum vaginatae*; ●: *Molinio-Salicetum rosmarinifoliae*; ■: *Potentillo-Festucetum pseudovinae*; △: watered area; ○: fertilized area; □: "bared" area

Acknowledgement

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