BUMBLEBEES AND CUCKOO-BUMBLEBEES (*Apiformes*: *Bombini*) OF UNDERGROWTH AND GRASSLAND – HERBS FOREST ENVIRONMENTS IN THE TERRITORY OF THE ŚWIĘTOKRZYSKI NATIONAL PARK

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S u m m a r y

In the years 2001 and 2002, from April till the end of September, bumblebees and cuckoo-bumblebees (*Bombini*) were studied on 13 sites in the Świętokrzyski National Park. The study aimed at presenting the dynamics of the community structure of these insects in anthropogenically differentiated forest communities of the Park. In total, 11 species of bumblebees (*Bombus* Latr.) and five species of cuckoo-bumblebees (*Psithyrus* Lep.) were recorded in the study area. *Bombus pascuorum* (Scop.), *B. lucorum* (L.), *B. pratorum* (L.), *Ps. bohemicus* (Seidl.), *Ps. campestris* (Pz.) and *Ps. rupestris* (F.) were the most frequently recorded species. Those were also the dominating species in the study area. The average density of insects was the highest in *Bombini* communities of semi-natural and segetal habitats, and the evenness index J' reached the highest parameters (0.4) in the assemblage of *Bombini* communities of segetal habitats. The species and quantitative similarity of the structure of insects' communities decreased starting from natural environments, through semi-natural towards segetal and ruderal environments.

Keywords: bumblebees, cuckoo-bumblebees, *Bombini*, assemblage structure, plant communities, the Świętokrzyski National Park.

INTRODUCTION

In the Polish climate, bumblebees (along with honeybees) are the most important pollinators of flowering plants. Bumblebees are legally protected in Poland due to their natural and economic significance and numerous threats coming from man.

For over one hundred years, research on this group of insects has been carried out in open areas, where bumblebees can find rich food resources and suitable habitats for nesting and overwintering. Forest areas were considered as not very attractive for bumblebees and thus they were studied there only occasionally, mostly along forest fringes and in forest clearings. Only in the 1980s were studies on this group of insects undertaken in forest environments. They were carried out mainly in northern and northeastern Poland (e.g. Banaszak 1987, 1990; Banaszak and Cierzniak 1994; Krzysztofiak 2001; Pawlikowski 1985, 1990, 1991, 1992).

Of particular significance are studies on bumblebee communities from natural habitats subject to anthropogenic transformations (Pawlikowski 1991, 1992, 1993, 2000). Data on the number and community structure of these insects in different habitat types, especially in central Poland, are still very incomplete. In the Świętokrzyskie Mountains, research on bumblebees (in-

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cluding their nest parasites) began in the 1930s. The research was carried out mostly by Drogoszewski (1932), Kończyk (1965), Čmak and Szczypciak-Bąk (1987), Ruszkowski et al. (1989), Bąk (2002, 2003), Dylewska and Bąk (2005).

The aim of this paper was to present the dynamics of structure of *Bombini* communities in anthropogenically differentiated plant communities and associations of forest habitats in the territory of the Świętokrzyski National Park.

The study area

The Świętokrzyski National Park, together with the buffer zone, covers the central part of the Świętokrzyskie Mountains, with the highest mountain range called Łysogóry. It is one of the oldest ranges in Europe and stretches from north-west to south-east over an area of ca. 15 km. The highest peaks of Łysogóry are Mt Łysica (612 m above sea level) and Mt Łysa Góra (595 m above sea level). According to Kondracki (2002), the Park is located within the Małopolska Upland and is included in the mezoregion of the Świętokrzyskie Mountains. The Świętokrzyski National Park was established on 1 April 1950 and covers an area of 7626.45 ha; the buffer zone around the Park covers 20 786.07 ha.

The climate of the Świętokrzyskie Mountains has several features characteristic of submontane climates. Thermal conditions depend here on elevation above sea level and slope exposure. The average temperature in the highest parts of Łysogóry is 5.7°C (Mt Święty Krzyż), whereas in valleys (surroundings of the Bodzentyn town) it reaches 7.8°C. Precipitation in the highest parts of Łysogóry varies on average from 800 to 850 mm. More severe thermal conditions are also characterized by ca. 2 weeks shorter vegetation season, shorter summer (54 days) and longer winter (119 days) as compared with surrounding areas. Westerly and northwesterly winds predominate in the Park.

Soils in the Park developed on Palaeozoic sandstone, of which a significant characteristic is an abundant occurrence of rocky and skeleton soils (Strzemski 1967). A considerable part of the Park's area is covered by forests (7188 ha – 96.2%). The most important forest-forming species in the studied area are: fir (63%), pine (21%) and beech (11%). Of lesser importance for the composition of forest stands are: spruce, oak, birch, sycamore, larch and others.

Altogether 13 study sites were set in different plant communities (Table 1). For all studied sites a list of flowering plants was prepared (according to Mirek et al. 1995).

Site No. 1. A four-year-old fallow land with segetal and meadow plant species; located on the eastern slope of Mt Góra Miejska, with a slope inclination of 30°. Brown soils developed from loess. Vegetation cover – ca. 80%. The following are the most common plant species: *Equisetum arvense*, *Achillea millefolium*, *Hypericum perforatum*, *Artemisia vulgaris*, *Solidago virgaurea*, *Trifolium pratense*, *T. repens*, *Vicia cracca*, *Lysimachia vulgaris*.

Site No. 2. A ruderal site that developed on industrial soils, very heavily transformed, situated on the south-eastern slope; slope inclination of 4°. Herbaceous vegetation cover – ca. 70%. The most common are meadow and segetal species: *Trifolium repens*, *Achillea millefolium*, *Leontodon autumnalis*, *Chamomilla suaveolens*, *Ranunculus repens*, *Potentila anserina*, *Lamium purpureum*, *Senecio vulgaris*.

Site No. 3. A wet meadow in the Wilkowska Valley, some affinity with herbaceous meadows, a high share of grasses and sedges (the association *Cirsietum rivularis* from the class *Molinio-Arrhenatheretea*), situated in the neighbourhood of a forest. Fertile humus soils of high humidity. Herbaceous vegetation

cover – ca. 100%. The most common plant species are: *Cirsium rivulare*, *Caltha palustris*, *Myosotis palustris*, *Ranunculus acris*, *R. repens*, *Lotus uliginosus*, *Lysimachia vulgaris* and others.

Site No. 4. An ecotonal community at the transitory zone between an oak-hornbeam-lime forest and a meadow. Wet brown soils developed from loess. The forest zone with the domination of *Alnus glutinosa* and *Tilia cordata*; canopy density – ca. 20%, herb layer – ca. 80%. The following species occur there: *Veronica chamaedrys*, *Lysimachia vulgaris*, *L. nummularia*, *Hypericum maculatum*, *Trifolium repens* and others.

Site No. 5. A herbaceous meadow with xerothermic species, extensively cultivated. Eastern slope with inclination of 3°. Brown, slightly alkaline soils developed from loess. Density of herbaceous vegetation – 100%. The most frequently occurring species: *Centaurea phrygia*, *Bettonica officinalis*, *Hypericum maculatum*, *Potentilla erecta*, *Veronica chamaedrys*, *Leontodon hispidus*, *Lotus uliginosus*.

Site No. 6. Overgrowing meadow ecotone at the transition zone with the oak-hornbeam-lime forest. Eastern slope with inclination of 3°. Brown, slightly alkaline soils. Density of shrubs and trees – 50%. *Populus tremula*, *Acer pseudoplatanus* and *Betula pendula* occur there. Very dense herb layer (100%) with *Rubus* sp., *Centaurea phrygia*, *Hypericum maculatum*, *Potentilla erecta*, *Veronica chamaedrys* and others.

Site No. 7. A community of a raised peat bog, situated on peat soils built of raised peats; heavily waterlogged. The area is surrounded by pine forests of high air humidity. A shrub layer poorly developed with dominating *Pinus sylvestris* and *Betula pubescens*. The herb layer is very dense, dominated by common cottongrass and sheathed cottonsedge (*Eriophorum angustifolium* and *E. vaginatum*).

Site No. 8. A community of midfield thickets, called "thorny thickets". A southern slope with an inclination of 5°. Arable, parched soils developed from loess. Density of shrub and herb layers – 60%. The following species occur most frequently: *Rosa canina*, *Betula pendula*, *Solidago virgaurea, Hypericum perforatum*, *Achillea millefolium*, *Rubus hirtus* and others.

Site No. 9. Fir-tree woods (*Abietetum polonicum*) situated on the northern slope with inclination of 10°. Clayey and silty soils; sinkholes and rock outcrops in the substrate. Density of the tree stand - 60%, with the domination of *Abies alba* and *Pinus sylvestris*. In the rather dense undergrowth (40%) *Abies alba* occur and more seldom *Populus tremula* and *Sorbus aucuparia*. The herb layer (30% cover) with rare occurrence of *Vaccinium myrtillus*, *Rubus hirtus* and *Majanthemum bifolium*.

Site No. 10. A shady community of fresh coniferous forest *Leucobryo-Pinetum*, situated on poor podzol soils. The tree layer is composed of *Pinus sylvestris*, *Quercus robur* and *Q. petraea*. The undergrowth, of ca. 20% cover, consists of *Frangula alnus*, *Quercus robur* and *Sorbus aucuparia*. The compact herb layer (70% cover) is composed mostly of coniferous forest species: *Rubus hirtus* and *Vaccinium myrtillus.*

Site No. 11. Mixed coniferous forest (*Querco roboris Pinetum*) with ca. 70--year-old tree stands. The southern slope with inclination of 3°. Parched brown soils developed from loess. The highest layer of trees is built of *Quercus robur* and *Pinus sylvestris*, and in the beneath-canopy layer *Populus tremula*, *Quercus robur* and *Frangula alnus* occur. The shrub layer is dominated by *Corylus avellana* and *Sorbus aucuparia*. The herb layer is rather loose and heavily shaded, with occurring *Potentilla erecta*, *Vaccinium myrtillus*, *Melampyrum pratense*.

Site No. 12. The association of riverine forest *Fraxino-Alnetum* situated on rich hu-

mus soils of high humidity. Beneath the uppermost tree layer, moderately dense (70% cover), composed mainly of *Alnus glutinosa* and *Pinus sylvestris*, the undergrowth develops of 40% cover. The herb layer (80% cover) is composed of hygrophilous and shade-loving species: *Cirsium rivulare*, *Lythrum salicaria*, *Lysimachia vulgaris*, *Scutellaria galericulata*, *Caltha palustris* and others.

Site No. 13. Oak-hornbeam-lime forest (*Tilio cordatae-Carpinetum betuli*) with some affinity to mixed coniferous forest. The north-western slope of 3° inclination. Parched brown soils developed from loess. The forest dominated by *Pinus sylvestris*, *Larix* sp., *Quercus robur*, *Q. petraea* and *Fagus sylvatica* (the canopy cover - 40%). In the undergrowth: *Frangula alnus* and *Euonymus* sp. The herb layer, poorly compact, with plants: *Galeobdolon luteum*, *Viola reichenbachiana*, *Vaccinium myrtillus*, *Galium schultezii* and others.

MATERIAL AND METHODS

During the years 2001-2002, from April till the end of September, observations and live catching (only for determination checks) of bumblebees and cuckoo-bumblebees were carried out every two weeks on selected 13 study sites in natural, seminatural and synanthropic plant communities of forest environments (Table 1, Fig. 1).

At each study site, quantitative samples were collected applying the modified random walk method (Pawlikowski 1992). This method consists of counting (identifiable in field conditions) and catching insects with an entomological net during 30 min. within the zone of 1 m wide and 200 m long on flowers up to 2.5 m high, in nutritionally attractive vegetation patches. A sample was constituted by a number of counted and caught insects in conditions favourable to flights, i.e. between

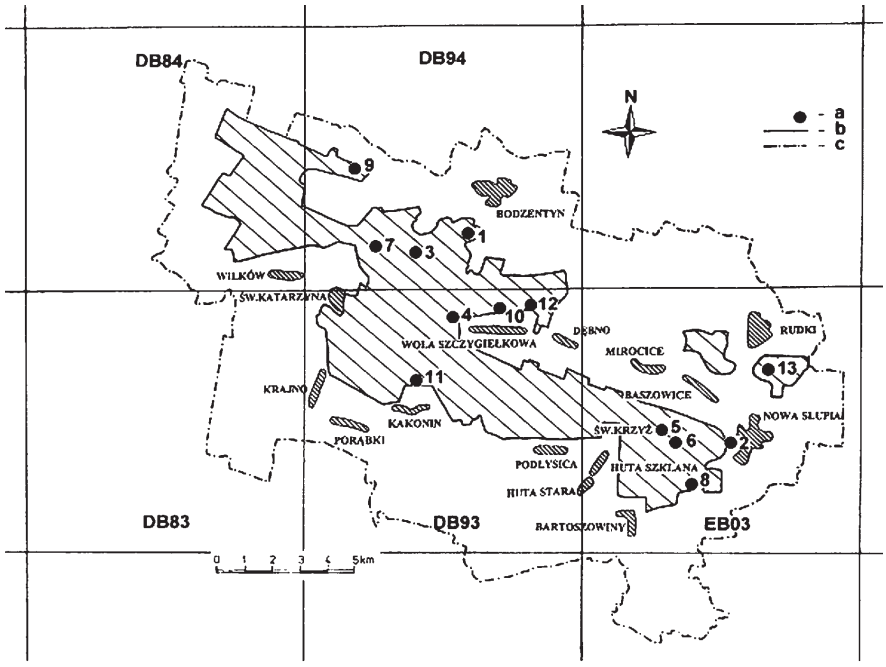

Fig. 1. Location of the research stands in the Świętokrzyski National Park on the background of the UTM grid system: a – stands (numbers according to Table 1); b – borders of the National Park; c – borders of the National Park's protection zone.

Table 1

A list of research stands and their characteristics in the area of the Świętokrzyski National Park.

Stand [UTM]	Environment characteristics	
	Syntaxonomy	Transformation stage
Nr 1 – Miejska Góra [DB 94]	Segetal habitat	3
Nr 2 – Nowa Słupia [EB 03]	Ruderal habitat	4
Nr 3 – Podgórze [DB 94]	Wet meadow related to the *Cirsietum rivularis* community form the *Molionio-Arrhenatheretea* class	2
Nr 4 – Wola Szczygiełkowa [DB 93]	Ecotone of a wet deciduous forest and a meadow community	2
Nr 5 – Bielnik [EB 03]	Meadow with herbaceous plants and some xerothermic species	2
Nr 6 – Bielnik 2 [EB 03]	Ecotone of a meadow with herbaceous plants and a deciduous forest	2
Nr 7 – Mokry Bór [DB 94]	Raised peat bog	1
Nr 8 – Trzcianka [EB 03]	Shrubs in meadows („thorny thickets”)	2
Nr 9 – Psary-Podłazy [DB 94]	*Abietetum polonicum* community	1
Nr 10 – Wola Szczygiełkowa 2 [DB 93]	Pine tree community - *Leucobryo-Pinetum*, similar to a mixed forest	1
Nr 11 – Kakonin [DB 93]	Mixed forest *Querco roboris-Pinetum*	1
Nr 12 – Plecionki [DB 93]	Mixed riverine forest *Fraxino-Alnetum*	1
Nr 13 – Góra Chełmowa [EB 03]	Dry decidus forest *Tilio cordatae-Carpinetum betuli*, similar to a mixed forest	1

Transformation stages of plant communities and associations:
1 – natural association (forests with tree stands corresponding to soil types, peat bogs);
2 – seminatural associations (forests with planted tree stands, meadows with low-intensity use, shrubs “thorny thickets”, ecotones);
3 – synanthropic associations of segetal characters (arable fields):
4 – synanthropic associations of ruderal characters with most transformed habitats (parking places, rubbish dumps).

10:00 a.m. and 16:00 p.m., with no or only a light wind and temperature of 19-25°C. Additionally, the “search out” method was applied to complete the species list in the studied environment. All samples were used in order to analyse the structure of bumblebee communities.

In total, 788 bumblebees and cuckoo--bumblebees were recorded in the study area. They were included in the description

Table 2

A list of *Bombini* species caught (ni) in the Świętokrzyski National Park in 2001-2002; n – number of samples.

	Species	Stands														%
		1	2	3	4	5	6	7	8	9	10	11	12	13		
		n=22	n=15	n=22	n=18	n=27	n=14	n=14	n=20	n=20	n=17	n=21	n=20	n=13		
1	*Bombus hortorum* (L.)	3	-	-	-	3	-	-	1	1	-	2	1	1	12	1.52
2	*Bombus humilis* (Ill.)	1	-	-	-	-	-	-	-	-	-	-	-	-	1	0.13
3	*Bombus hypnorum* (L.)	-	1	1	-	1	1	1	-	-	1	1	1	-	8	0.99
4	*Bombus lapidarius* (L.)	18	-	6	-	9	1	1	3	2	2	-	1	2	45	5.71
5	*Bombus lucorum* (L.)	4	4	12	4	43	6	13	14	2	7	4	3	5	121	15.36
6	*Bombus pascuorum* (Scop.)	12	5	19	11	19	-	3	31	13	5	3	18	6	145	18.4
7	*Bombus pratorum* (L.)	6	-	13	1	42	3	2	-	4	2	1	7	-	81	10.28
8	*Bombus ruderarius* (Mull.)	4	-	4	-	2	-	-	2	1	-	-	-	-	13	1.65
9	*Bombus ruderatus* (F.)	1	2	-	-	1	-	-	-	1	-	-	-	-	5	0.63
10	*Bombus sylvarum* (L.)	8	-	-	-	-	-	-	-	-	-	-	-	-	8	0.99
11	*Bombus terrestris* (L.)	2	2	-	-	6	-	6	4	1	-	2	2	1	26	3.3
12	*Psithyrus bohemicus* (Seidl.)	3	15	11	4	55	4	7	7	3	14	1	5	1	130	16.5
13	*Psithyrus campestris* (Pz.)	2	3	1	1	43	-	1	6	7	4	24	2	1	95	12.06
14	*Psithyrus norvegicus* (Sp-S.)	-	-	2	2	25	-	1	1	-	-	1	2	-	34	4.31
15	*Psithyrus rupestris* (F.)	9	3	1	2	31	1	1	5	4	-	4	-	-	61	7.74
16	*Psithyrus sylvestris* (Lep.)	-	-	-	-	2	-	-	-	-	-	-	1	-	3	0.38
	Total [n_i]	73	35	70	25	282	16	36	74	39	35	43	43	17	788	

of communities. In the community structure, the following indices were determined: the number of species (S), domination for each species (D), avarage trappability, i.e. a number of individuals caught during 30 min. per 200 m^2, general species diversity (H') expressed by the Shannon-Weaver coefficient (1963) and potential species diversity (evenness of distribution – J') (Pielou 1966) where $\mathbf{J'=H'/\log_2 S}$. The Marczewski-Steinhaus (1959) index was used for qualitative comparison of community structures: **MS = w/(a+b–w)**, where w – a number of common species in compared communities, a – a number of species in the first compared community, b – a number of species in the next compared community. Additionally, the Renkonen index of qualitative and quantitative similarity (1938) was applied: $\mathbf{Re = D_{min}}$, where D_{min} – a value of minimum domination for a species from compared communities.

RESULTS AND DISCUSSION

In the studied sites situated within the Świętokrzyski National Park, 16 *Bomibini* species were recorded, including 11 species of bumblebees and 5 species of cuckoo-bumblebees. This constitutes respectively 37.9% and 50% of species recorded in Poland (Table 2).

Among species of bumblebees, the following were the most frequently caught:

Table 3

Domination (in %) of *Bombini* caught in the Świętokrzyski National Park in 2001-2002.

	Species	Stands													$\overline{D}$
		1	2	3	4	5	6	7	8	9	10	11	12	13	
1	*Bombus hortorum* (L.)	4.11	-	-	-	1.06	-	-	1.35	2.56	-	4.65	2.33	5.88	3.13
2	*Bombus humilis* (Ill.)	1.37	-	-	-	-	-	-	-	-	-	-	-	-	1.37
3	*Bombus hypnorum* (L.)	-	2.86	1.43	-	0.35	6.25	2.78	-	-	2.86	2.33	2.33	-	2.65
4	*Bombus lapidarius* (L.)	24.66	-	8.57	-	3.19	6.25	2.78	4.05	5.13	5.71	-	2.33	11.76	7.44
5	*Bombus lucorum* (L.)	5.48	11.43	17.14	16.0	15.25	37.5	36.11	18.92	5.13	20.0	9.3	6.98	29.41	17.59
6	*Bombus pascuorum* (Scop.)	16.44	14.29	27.14	44.0	6.74	-	8.33	41.89	33.33	14.29	6.98	41.86	35.29	24.22
7	*Bombus pratorum* (L.)	8.22	-	18.57	4.0	14.89	18.75	5.55	-	10.26	5.71	2.33	16.28	-	10.46
8	*Bombus ruderarius* (Mull.)	5.48	-	5.71	-	0.71	-	-	2.7	2.56	-	-	-	-	3.43
9	*Bombus ruderatus* (F.)	1.37	5.71	-	-	0.35	-	-	-	2.56	-	-	-	-	2.5
10	*Bombus sylvarum* (L.)	10.96	-	-	-	-	-	-	-	-	-	-	-	-	10.96
11	*Bombus terrestris* (L.)	2.74	5.71	-	-	2.13	-	16.7	5.41	2.56	-	4.65	4.65	5.88	5.6
12	*Psithyrus bohemicus* (Seidl.)	4.11	42.86	15.71	16.0	19.5	25.0	19.4	9.46	7.69	40.0	2.33	11.63	5.88	16.89
13	*Psithyrus campestris* (Pz.)	2.74	8.57	1.43	4.0	15.25	-	2.78	8.11	17.95	11.43	55.81	4.65	5.88	11.55
14	*Psithyrus norvegicus* (Sp-S.)	-	-	2.86	8.0	8.87	-	2.78	1.35	-	-	2.33	4.65	-	4.41
15	*Psithyrus rupestris* (F.)	12.33	8.57	1.43	8.0	10.9	6.25	2.78	6.76	10.2	-	9.3	-	-	7.65
16	*Psithyrus sylvestris* (Lep.)	-	-	-	-	0.71	-	-	-	-	-	-	2.33	-	1.52

$\overline{D}$ – middle domination (%).

Bombus pascuorum (Scop.) (18.5% of the total number of specimens), *B. lucorum* (L.) – (16.1%) and *B. pratorum* (L.) – (10.2%). The following were the most frequent species from among parasites: *Psithyrus bohemicus* (Seidl) – (16.5%), *Ps. campestris* (Pz.) – (12.1%) and *Ps. rupestris* (F.) – (7.74%). All the above mentioned species dominated in the study area and altogether constituted ca. 73% of the total number of studied insects. *B. lucorum* and *Ps. bohemicus* were recorded at every study site during both vegetation seasons. Whereas *Bombus humilis* (Ill.), *B. ruderatus* (F.) and *Psithyrus sylvestris* (Lep.) (Table 2) occurred rarely.

When analysing the domination structure of caught species, it was ascertained that the highest number of dominants (8 species) was recorded in the natural environment (ZN), 6 dominating species were recorded in the semi-natural environment (ZP), 4 species in the segetal environment (ZS) and 3 species in the ruderal environment (ZR) (Table 3).

The species number ratio in selected environments ZN:ZP:ZS:ZR was as follows: 14:14:13:8, which can be simplified to 5:5:4:3 (Table 2). It was observed that the number of species decreased together with anthropogenization of the environment. Natural and semi-natural *Bombini* communities have the highest comparable number of species.

The average abundance (trapability) varied from 0.8 to 10.8 individuals caught during 30 minutes per 200 m^2. It was found that the highest values occurred in communities of semi-natural and segetal environments, and the lowest in assemblages of

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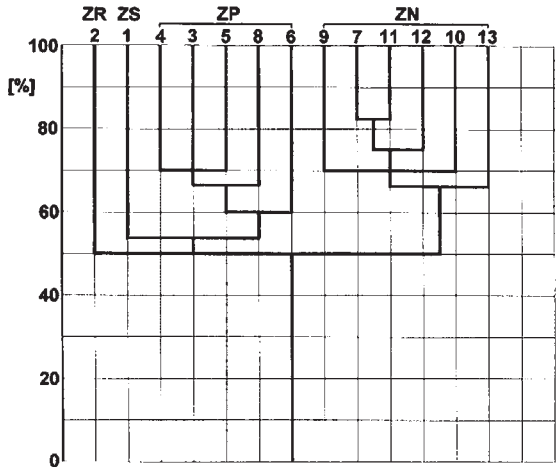

Fig. 2. Species similarity (according to the Marczewski-Stainhaus index) of *Bombini* community structures in different environments: natural (ZN), seminatural (ZP), segetal (ZS) and ruderal (ZR) in the area of the Świętokrzyski National Park (stand numbers according to Table 1).

Table 4

Structure of *Bombini* communities in Świętokrzyski National Park in 2001-2002.

Parameters	Stands												
	1	2	3	4	5	6	7	8	9	10	11	12	13
S	13	8	10	7	14	6	10	10	10	7	10	11	7
A	3.04	0.84	3.5	1.05	10.8	0.8	1.8	3.45	2.19	1.75	1.98	1.79	0.85
H'	0.31	0.37	0.36	0.37	0.23	0.46	0.38	0.31	0.34	0.39	0.29	0.31	0.43
J'	0.39	0.16	0.14	0.15	0.06	0.22	0.29	0.11	0.12	0.21	0.1	0.11	0.2

S – numbers of species,
A – mean number of individuals caught per 30 min. in 200 m^2,
H' – species diversity on the basis of Shannon & Weaver's (1963) formula,
J' – evenness on the basis of Pielou's (1966) formula.

natural and ruderal environments (Table 4).

The qualitative and quantitative characteristics of the structure of bumblebee assemblages were described with coefficients of general species diversity (H') and evenness (J'). The general species diversity varied from 0.23 to 0.46. Low values of this index reflect low stability of the studied environments, with bumblebee assemblages from natural and semi-natural environments with the most stable structure (Table 4). The evenness index (J') reached the highest values for bumblebee assemblages in segetal environments (0.4). In other environments, the index varied from 0.1 to 0.3 (Table 4).

In the analysis of the species similarity of the structure of *Bombini* communities (based on the MS index), distinct groups were distinguished based on the transfor-

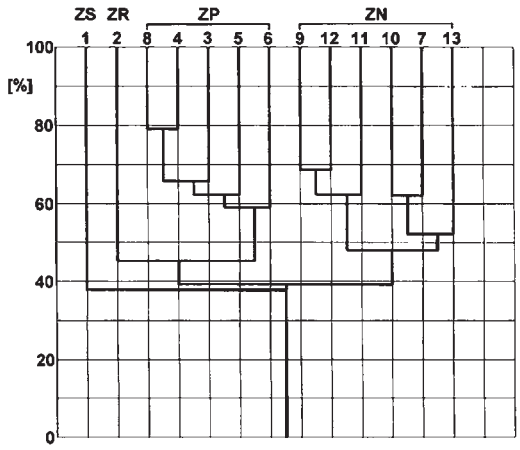

Fig. 3. Quantity similarity (according to Renkonen index) of *Bombini* community structures in the area of the Świętokrzyski National Park. Environment types as in Fig. 2; stand numbers as in Table 1.

mation degree of forest environments. Their similarity decreased starting from assemblages of natural environments, through communities of semi-natural, to communities of segetal and ruderal environments. Similarity values oscillated within the range of 50-80% (Fig. 2).

On the other hand, the analysis of the quantitative similarity of community structures (based on the Re index) revealed a decrease of values starting from communities of natural and semi-natural to communities of segetal and ruderal environments. However in this case, higher fluctuations of similarity values were observed – 40-80% (Fig. 3).

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TRZMIELOWATE (*Apiformes*: *Bombini*) PODSZYCIA I MURAWOWO-ZIOŁOROŚLOWYCH ŚRODOWISK LEŚNYCH NA OBSZARZE ŚWIĘTOKRZYSKIEGO PARKU NARODOWEGO

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S t r e s z c z e n i e

W latach 2001-2002 prowadzono badania, dotyczące zespołów trzmieli (*Bombus* Latr.) i trzmielców (*Psithyrus* Lep.) na wybranych 13 powierzchniach badawczych: w naturalnych (ZN), półnaturalnych (ZP), segetalnych (ZS) i ruderalnych (ZR) zbiorowiskach roślinnych Świętokrzyskiego Parku Narodowego (tab. 1, ryc. 1).

Zebrane owady charakteryzowano za pomocą wskaźników: liczby gatunków (S), dominacji (D), średniej łowności (A), czyli liczby osobników złowionych w ciągu 30 minut na 200 m^2, ogólnego zróżnicowania gatunkowego (H') i równomierności rozkładu (J'). Do jakościowego porównania struktury zespołów posłużono się wskaźnikiem Marczewskiego-Steinhausa (MS), a podobieństwo jakościowo-ilościowe zespołów badano za pomocą wskaźnika Renkonena (Re).

W wyniku badań stwierdzono występowanie 11 gatunków trzmieli i 5 gatunków trzmielców - ich pasożytów gniazdowych. Ogółem odnotowano 788 osobników (tab. 2). Spośród trzmieli najczęściej odławianymi gatunkami były: *Bombus pascuorum* (Scop.), *B. lucorum* (L.) i *B. pratorum* (L.). Spośród pasożytów najliczniej wystąpiły: *Psithyrus bohemicus* (Seidl.), *Ps. campestris* (Pz.) i *Ps. rupestris* (F.). Były to gatunki dominujące na badanym terenie. Nielicznie wystąpiły 3 gatunki: *B. humilis* (Ill.), *B. ruderatus* (F.) i *Ps. sylvestris* (Lep.) (tab. 3). Stosunek liczby gatunków w wyodrębnionych środowiskach ZN:ZP:ZS:ZR kształtował się jak 14:14:13:8, co można było uprościć do 5:5:4:3. Zauważono, że liczba gatunków zmniejszała się w miarę stopnia antropogenizacji środowiska (tab. 2). Średnia liczebność (łowność) wynosiła od 0,8 do 10,8 osobnika. Najwyższe jej wartości wystąpiły w zespołach środowisk półnaturalnych i segetalnych. Ogólne zróżnicowanie gatunkowe, wyrażone współczynnikiem Shannona--Weavera wahało się w zakresie 0,23-0,46. Najbardziej zrównoważoną strukturę wykazywały zespoły trzmielowatych w środowisku naturalnym i półnaturalnym. Wartość wskaźnika równocenności (J') osiągnęła najwyższe parametry w środowisku segetalnym (tab. 4). Podobieństwo gatunkowe (w oparciu o wskaźnik MS) i podobieństwo ilościowe (w oparciu o wskaźnik Re), wykazywało spadek wartości począwszy od zespołów naturalnych, poprzez zespoły półnaturalne, do zespołów środowisk segetalnych i ruderalnych (ryc. 2, ryc. 3).

Słowa kluczowe: trzmiele, trzmielce, *Bombini*, struktura zespołów, zbiorowiska roślinne, Świętokrzyski Park Narodowy.