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Bees (Hymenoptera: Apoidea, Apiformes) of the Drawa National Park

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ABSTRACT. We present results of our preliminary research on species diversity, dominance structure, and phenology of bees (Apiformes) in the Drawa National Park (NW Poland). In total, 118 species of Apiformes were recorded there, which accounted for 25.5% of the Polish bee fauna. The park is dominated by woodland, so major species are *Bombus lucorum* (23.6%) and *Andrena lapponica* (8.8%). Those species, on some sites, accounted for over 20% or even over 40% of the total catch.

KEY WORDS: wild bees, Apoidea, Apiformes, Drawa National Park, NW Poland, Pomerania, glacial landscape.

INTRODUCTION

The Drawa National Park (Drawieński Park Narodowy) is located in the Pomeranian Lakeland in NW Poland (Fig. 1). The park was established in 1990. It protects the most interesting ecosystems of the Polish Pomerania, which represent the most valuable – on the European scale – fragments of outwash plains formed during the last glaciation (Vistulian). This landscape is mostly composed of numerous palaeochannels and kettle holes, occupied by 13 lakes varying in depth and trophic state, and the largest of them is Lake Ostrowiec. The axis of the park is formed by the Drawa River (tributary of the Noteć) and its tributary Płociczna, forming picturesque gorges among kames (postglacial hills).

The park includes over 11 300 ha, and 84% of the total are woodlands. The majority of them were farmlands 100 years ago. The forests are mainly pure stands of Scots pine (*Pinus sylvestris*), planted at that time. However, on steep banks of rivers and lakes, natural beech and oak forests are found.

This park was established relatively recently and that is why its terrestrial fauna has been poorly studied so far (BANASZAK et al. 2004). This applies also to bees, which have not been investigated in this area.

The closest areas where pollinating insects are well-studied include the vicinity of the Noteć River valley, from Nakło to Bydgoszcz (TORKA 1913, 1933, BANASZAK 2008), as well as the Bory Tucholskie National Park (BANASZAK & WENDZONKA 2002) and the Zaborski Landscape Park (KRIGER & CIERZNIAK 2006). In the nearby town of Wałcz, bumblebees were recorded by PAWLIKOWSKI and PAJĄK (1995).

For this reason, an urgent and useful task was to initiate research on species diversity, dominance structure, and phenology of bees (Apiformes), which are the subject of this study.

Acknowledgements

We wish to express our gratitude to the Director of the Drawa NP, i.e. Tadeusz KOHUT, MSc, who enabled us to carry out this study. Special thanks are due to Krzysztof GRUCA, MSc, who systematically collected material from Moericke traps.

We dedicate this paper to our late colleague, Prof. Tomasz CIERZNIAK, who started this research, although he was never to finish it.

STUDY AREA AND METHODS

The Drawa NP and its buffer zone are located on the Drawsko Plain, which is a part of the South Pomeranian Lakeland in NW Poland. It is situated at the centre of the extensive Drawsko Forest. The park lies within the catchment area of the Drawa River (200 km long), which together with its tributary, the Płociczna (51 km long), are the major rivers of the park (Figs 1, 2). Both rivers flow across the wide belt of outwash plains, formed by sands deposited at the terminus of the glacier by meltwater flowing down to the Thorn-Eberswalde Glacial Valley (also known as the Toruń-Eberswalde Proglacial Valley). The study area is characterized by a large number of lakes, and the largest of them is Lake Ostrowiec (69.9 ha). The environmental conditions are shaped by the Atlantic climate, characterized by low annual amplitudes of temperature, and the annual mean air temperature is 7.9°C.

The park is dominated by woodland, which accounts for 84% of the park area. The forests are mostly pure stands of Scots pine (*Pinus sylvestris*). In river valleys and at lake edges, natural beech forests are still present, rarely also beech-oak forests and alder forests. Characteristic elements of the park's nature are also peatlands and isolated patches of meadows.

Field research was conducted within the park in 2004-2005, from mid-April to late September. Twelve research plots were monitored (Fig. 1), each of them for one season. The material was collected by means of Moericke traps, mounted on short poles. On each

plot, three traps were placed, i.e. white bowls, filled with a mixture of water (95%), ethyl glycol (4.8%), and a surfactant (0.2%). Every 7 days or so, the caught insects were collected, preserved, and next identified to species.

The Shannon diversity index H' (SHANNON & WEAVER 1963), and evenness index J' (PIELOU 1977) were calculated. To assess the significance of differences in H' between bee communities of individual plots, the *t* statistic was used (POOLE 1974). To estimate their similarity, the Sørensen index was calculated. Quantitative similarity of the studied communities was assessed on the basis of the Morisita-Horn index (HORN 1966).

Characteristics of research plots (Fig. 1)

Scarp (1) - steep slope near the Drawa, 30 m high, with the base eroded by the river. This site has a southern exposure, and thanks to this, xerothermic plant species occur there, e.g. *Astragalus arenarius, Sedum reflexum,* and *Epipactis atrorubens*. The area is wooded (oaks, beeches), with open sandy patches. Studied in 2004.

Moczele (2) - meadow on a slope with eastern exposure, bordering on pine forest from the west and willow thickets from the east. Studied in 2004.

Mostniki (3) - meadow on a slope with northeastern exposure, near the Drawa River (Fig. 3). Surrounded by pine forest and flood-plain vegetation found along the river. Studied in 2004.

Ostrowiec (4) - a forest settlement of 2 ha, covered by a meadow, gardens, and an avenue of Norway maple trees (*Acer platanoides*). Studied in 2004.

Cieszynka (5) - peaty meadow of 4-5 ha, surrounded by slopes that are 3-5 m high, overgrown by pine forest. Some sandy patches are dominated by xerothermic vegetation. Studied in 2004.

Pecnik (6) - fresh coniferous forest *Leucobryo-Pinetum*, 60-70% of the herb layer covered by *Vaccinium* sp. Studied in 2004.

Konotop (7) - old field, left fallow for 10-12 years, surrounded by forest (spruce, pine) (Fig. 4). Studied in 2005.

Radęcin (8) - nature reserve (since 1923), located on the right bank of the Drawa. It is a very old forest, dominated by beech (*Fagus sylvatica*) with an admixture of sessile oak (*Quercus petraea*). It is one of the most valuable forest stands in Central Europe (Fig. 5). The beech trees are aged 350 years, while oaks, 450 years. The samples were collected at a distance of 50 m west of the reserve, in forest gaps. Studied in 2005.

Czarne (9) - greatly transformed pine forest, about 80 years old, on a very fertile site. Studied in 2005.

Czarne Fen (10) - the potential plant community of this site is alder forest, but currently it is dominated by common reed (*Phragmites communis*), willow clumps, and planted pine stands of various age. The traps were mounted at the edges of peatland and forest, near willow clumps. Studied in 2005.

Piaseczno (11) - pine forest, with 90-100% of the herb layer covered by *Vaccinium myrtillus*, located 100 m away from Lake Piaseczno Duże. Potential site of acid oak forest *Calamagrostio-Quercetum*. Studied in 2005.

Rogoźnica (12) - pine forest, about 80 years old, with a very low percentage cover of *Vaccinium*. Studied in 2005.

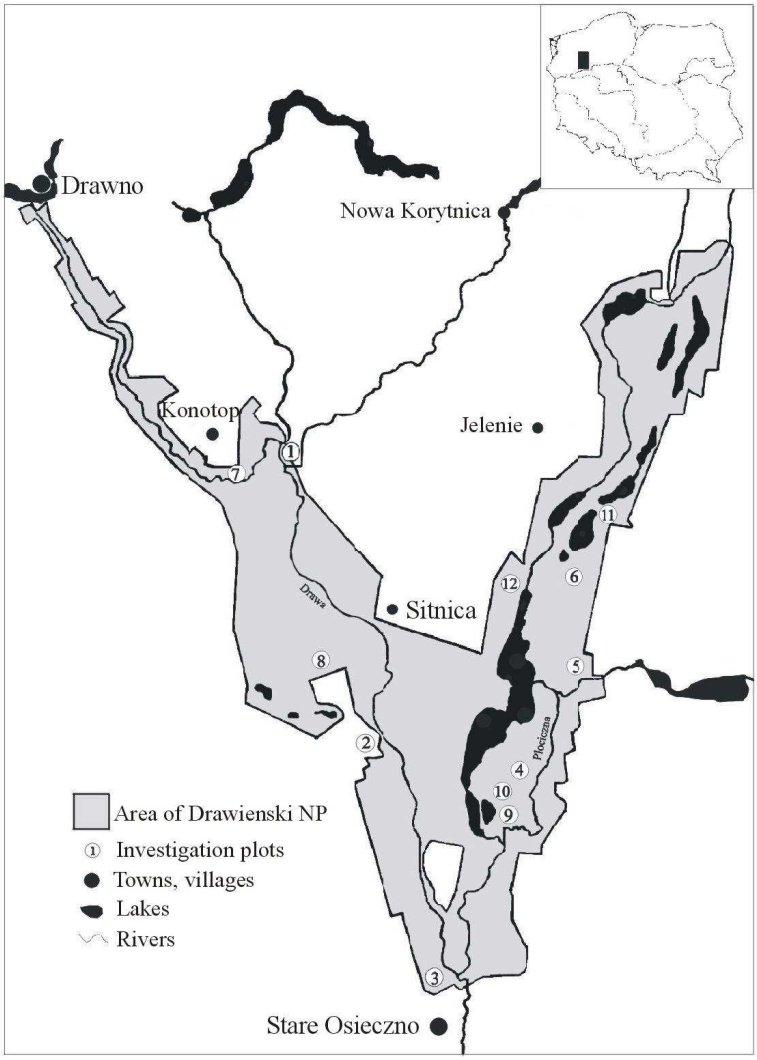

Fig. 1. Map of the Drawa National Park and location of research plots: 1 – Scarp, 2 – Moczele, 3 – Mostniki, 4 – Ostrowiec, 5 – Cieszynka, 6 – Pecnik, 7 – Konotop, 8 – Radęcin, 9 – Czarne, 10 – Czarne Fen, 11 – Piaseczno, 12 – Rogoźnica.

Fig. 2. Drawa River. (Photo by K. POLANOWSKA).

Fig. 3. Meadow – Mostniki. (Photo by A. NAWROCKA).

Fig. 4. Old field, lying fallow for 12 years – Konotop. (Photo by A. NAWROCKA).

Fig. 5. Beech forest – Radęcin. (Photo by A. NAWROCKA).

RESULTS

Species diversity and dominance structure

In total, 2884 bees (Apiformes) were caught in the Moericke traps. They belonged to 118 species of 23 genera and 7 families. The complete lists of species, and numbers of specimens caught in individual habitats, are presented in Appendix 1.

Most of the bees were members of the Apidae (mostly *Bombus*), accounting for 41.8% of the total catch, which were represented by 19 species, and Andrenidae, reaching 33.1% and represented by 30 species. The remaining bees were classified to the family Halictidae (4.8%, 31 species), Anthophoridae (5.1%, 18 species), Megachilidae (2.9%, 8 species), Colletidae (1.8%, 8 species), and Melittidae (0.4%, 4 species).

The park is dominated by coniferous forest, so dominants and subdominants are *Bombus* and *Andrena* spp. The characteristic species of the park is *Bombus lucorum* (most abundant and constant), which accounted for 23.6% of the total catch. This bumblebee dominated on 8 of the 12 studied plots, while on the others it was a subdominant (Fig. 6).

Subdominants included: *Andrena lapponica* (8.8% of the total catch), *A. haemorrhoa* (8.4%), and *A. cineraria* (3.5%). It is also noteworthy that *Evylaeus calceatus* accounted for a large proportion of the total catch (8.6%). It was found on all sites, but dominated only on the old field in Konotop. This species is characteristic of open habitats. The most abundant bumblebees were *Bombus pascuorum* (3.7%) and *B. pratorum* (3.7%).

There were 42 occasional species, represented by 1-2 individuals each, which accounted for 34.7% of the total catch. Most of them are more frequent or even common in other parts of the country, e.g. *Lasioglossum leucozonium, L. xanthopus, Evylaeus pauxillus, E. morio, E. sexstrigatus, E. villosulus, Megachile versicolor*, and *Bombus ruderarius.*

The most interesting species from the point of view of zoogeography are shortly characterized below.

Andrena lapponica - European species, recorded in Central and North Europe, and in mountains of South Europe. Associated with coniferous woodlands, reported from all parts of Poland but only in patches with *Vaccinium*.

Andrena fulva - West European species. In Poland it reaches the eastern limit of its range. Associated with trees, especially with maple. During the flowering period of maple trees it is frequent in urban areas, where it sometimes forms large colonies.

Andrena fuscipes - Central European species, typical inhabitant of forest edges. Nests on sandy sites and moors, as it often pollinates *Calluna vulgaris*, but also *Jasione montana*, *Epilobium angustifolium* and other plants (KOCOUREK 1966).

Evylaeus fratellus - eusocial species, although in Central and North Europe the nesting females are solitary. In Poland more frequent in mountains and in the north. Typical of woodlands (coniferous and mixed), it pollinates flowers of *Vaccinium* and other plants

(PESENKO et. al 2000). Recorded also in the Bory Tucholskie National Park (BANASZAK &WENDZONKA 2002). New localities:

Pecnik: 23.04.2004 - 2♀♀; 02.06.2004 - 3♀♀; 09.06.2004 - 1♀; 16.06.2004 - 2♀♀; 11.08.2004 - 1♂; 07.09.2004 - 1♀; Cieszynka: 19.05.2004 - 2♀♀; Ostrowiec: 05.05.2004 - 1♀.

Evylaeus leucopus - Euro-Siberian species. In Europe, boreo-alpine. In Poland scattered. Reported also from the Bory Tucholskie National Park. New localities:

Czarne: 24.05.2005 - 1♀; Ostrowiec: 12.05.2004 - 1♀.

Evylaeus rufitarsis - a widespread forest species, but in Poland rare. New localities:

Pecnik: 2.06.2004 - 2♀♀; 16.06.2004 - 1♀; Cieszynka: 19.05.2004 - 1♀; Piaseczno: 19.04.2005 - 2♀♀; 31.05.2005 - 2♀♀; Radęcin: 2.08.2005 - 1♀; 26.07.2005 - 1♀; Scarp: 19.05.2004 - 1♀; 29.07.2004 - 1♀.

Lasioglossum quadrinotatum - widespread in the Western Palaearctic, but in Poland infrequent, found only in the North. New localities:

Pecnik: 22.07.2004 - 1♀; 11.08.2004 - 1♀; 18.08.2004 - 1♀; Ostrowiec: 16.05.2004 - 1♀; Piaseczno: 28.06.2005 - 1♀; Radęcin: 24.05.2005 - 1♀; Rogoźnica: 28.06.2005 - 1♀.

Lasioglossum lativentre – reported from all over Europe. In Poland widespread, although infrequent; few localities in Pomerania. New localities:

Konotop: 16.06.2005 - 1♀; Czarne: 30.08.2005 - 1♀.

Lasioglossum costulatum - widespread in the Western Palaearctic, mostly in its warmer parts. Reported from all parts of Poland but infrequent; few localities in northern Poland. New locality:

Czarne Fen: 21.06.2005 - 1♀.

Osmia inermis - Europe, North America. Reported from various parts of Poland, but mostly by earlier researchers. New localities:

Moczele: 5.08.2004 - 1♀; Czarne Fen: 19.07.2005 - 1♀.

Osmia uncinata – European species, reported from different parts of Poland, but rather rarely. Associated with woodlands. Reported also from the Bory Tucholskie National Park. New localities:

Moczele: 5.05.2004 - 2♀♀; Cieszynka: 21.04.2004 - 1♀.

Bombus cryptarum - found all over Europe but we know little about it. In Poland found recently (in the 1980's). Associated with woodlands. Its food plants include *Vaccinium myrtillus* and *Calluna vulgaris.* New localities:

Czarne: 19.04.2005 - 1♀; Czarne Fen: 26.04.2005 - 1♀; Konotop: 19.04.2005 - 2♀♀; 3.05.2005 - 1♀; Piaseczno: 19.04.2005 - 1♀; Radęcin: 19.04.2005 - 1♀.

Bombus magnus - as in the case of *B. cryptarum*, recently classified as a separate species, it was earlier regarded as a variety of *B. lucorum*. Widespread in Europe and Asia to northern Mongolia and China. In Poland found as late as in the 1980's. Rare, its biology similar to that of *B. lucorum.* New localities:

Pecnik: 29.07.2004 - 1♂; Scarp: 29.07.2004 - 1♂; Czarne Fen: 12.07.2005 - 1♀.

Bombus jonellus - boreo-alpine species, rare in lowlands. It colonizes colder and more humid sites. Inhabits mainly lowland and upland forest stands and their edges, moors, mountain and alluvial meadows, fens and bogs. It emerges in late March. Associated mainly with *Vaccinium myrtillus, V. vitis-idaea, Rubus idaeus* and *Knautia.* New locality:

Konotop: 19.04.2005 – 2♀♀.

Characteristics of bee communities in the studied habitats

Table 1 shows the species diversity of bees on the 12 studied plots. In the park, 118 bee species were recorded, but on individual plots the numbers of bee species varied widely, from 14 to 65, so the respective diversity indices varied from 1.980 to 3.270. Significance of differences in Shannon index is presented in Table 2.

Coniferous woodlands. On four coniferous plots (Pecnik, Rogoźnica, Czarne, Piaseczno), 711 bees were caught, representing 52 species (43.8% of the total number of species), and accounting for 24% of the total catch. On individual plots, numbers of bee species varied from 14 (Rogoźnica), 25 (Czarne), and 28 (Piaseczno) to 32 (Pecnik). The major species was *Bombus lucorum* (Czarne, Rogoźnica) or *Andrena lapponica,* while *B. lucorum* was subdominant (Pecnik, Piaseczno) (Figs 12, 15, 17, 18).

Grasslands. On three plots (Moczele, Mostniki, Konotop) 1127 bees were caught (39.1%), belonging to 81 species (69.4%). Those sites were inhabited or visited by relatively high numbers of species: 48 (Moczele), 42 (Mostniki), and 65 (Konotop). Because of the immediate neighbourhood of forest, the dominant species were usually *Bombus lucorum* (Mostniki, Moczele) and *Andrena* spp. In Konotop, the percentage of *B. lucorum* was slightly lower, while *Evylaeus calceatus* was dominant and *Andrena haemorrhoa* was subdominant (Figs 8, 9, 13). The plot at Ostrowiec proved to be quite different, highly variable – with meadows and gardens. The major species here were: *Seladonia tumulorum* (15.3%), *Bombus lucorum* (13.6%), *Evylaeus calceatus* (12.4%) and *Osmia rufa* (11.3%) (Fig. 10).

On **xerothermic grassland** (Scarp), 42 species were found, with the dominant *Bombus lucorum* (35%). The high contributions of *Andrena* and *Bombus* are also due to the vicinity of forest (Fig. 7).

The **acid lowland beech forest** (Radęcin), with 39 bee species, was clearly dominated by bumblebees: *Bombus lucorum* (55%), and the subdominant *B. terrestris* (7%) and *B. pascuorum* (5.7%) (Fig. 14).

A high species diversity was observed in the partly **afforested fen** (Czarne Fen), with 45 bee species. *Bombus lucorum* was the dominant (36%), accompanied by much less abundant *Andrena cineraria* (8%), *A. haemorrhoa* (6.5%), and *Bombus pratorum* (4.6%) (Fig. 16).

On **peaty meadow** (Cieszynka), 32 species were found, with the dominant *Andrena lapponica* (23%), and the subdominant *Bombus lucorum* (20%) and *A. cineraria* (10%) (Fig. 11).

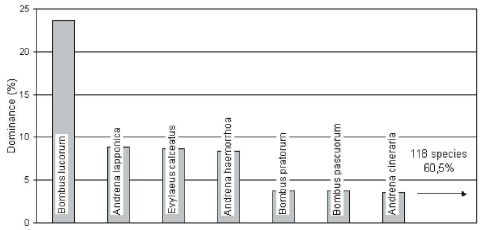

Fig. 6. Dominance structure of bees in the Drawa National Park.

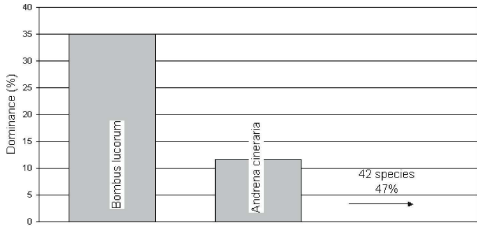

Fig. 7. Dominance structure of bees on the Scarp.

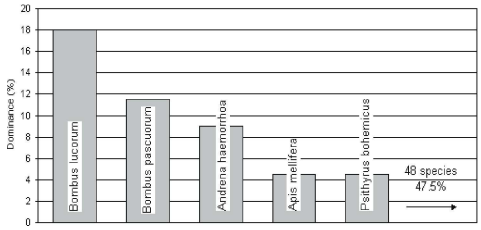

Fig. 8. Dominance structure of bees in Moczele.

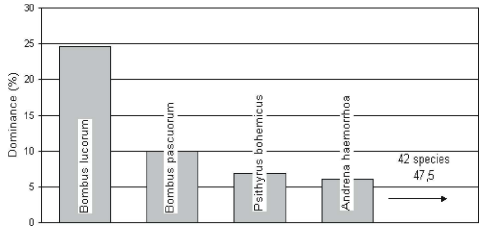

Fig. 9. Dominance structure of bees in Mostniki.

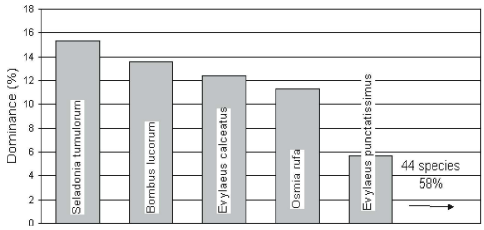

Fig. 10. Dominance structure of bees in Ostrowiec.

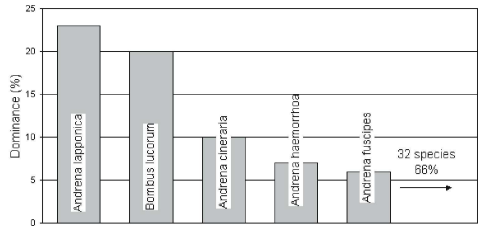

Fig. 11. Dominance structure of bees in Cieszynka.

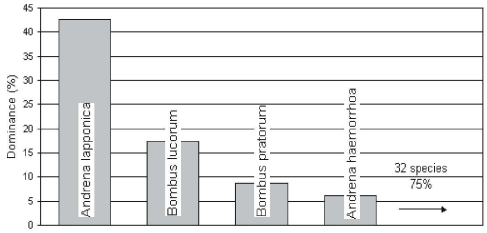

Fig. 12. Dominance structure of bees in Pecnik.

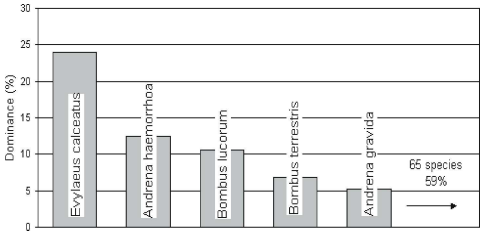

Fig. 13. Dominance structure of bees in Konotop.

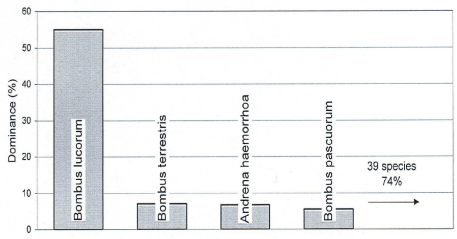

Fig. 14. Dominance structure of bees in Radęcin.

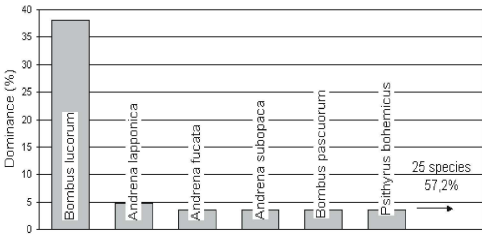

Fig. 15. Dominance structure of bees in Czarne.

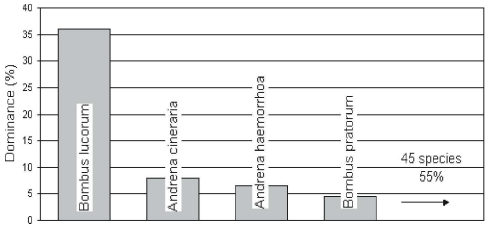

Fig. 16. Dominance structure of bees in Czarne Fen.

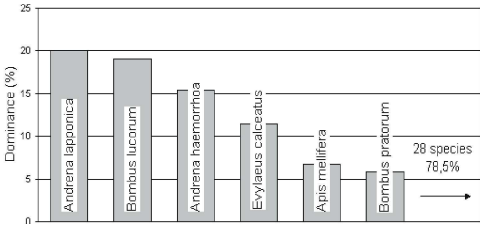

Fig. 17. Dominance structure of bees in Piaseczno.

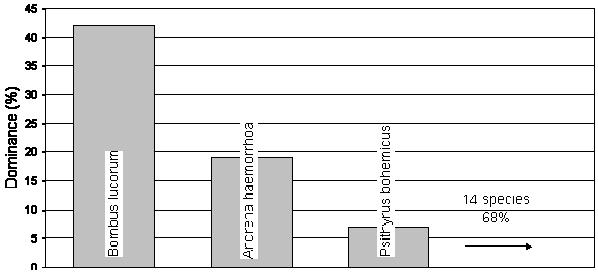

Fig. 18. Dominance structure of bees in Rogoźnica.

The majority of studied habitats, regardless of their type, are distinguished by the high dominance of *Bombus lucorum* (beside *B. pascuorum* and *B. pratorum*) as well as *Andrena laponnica* (beside several other *Andrena* spp., especially *A. haemorrhoa* or *A. cineraria*. The faunistic similarity, in extremely different habitats, is illustrated in Fig. 19 and 20.

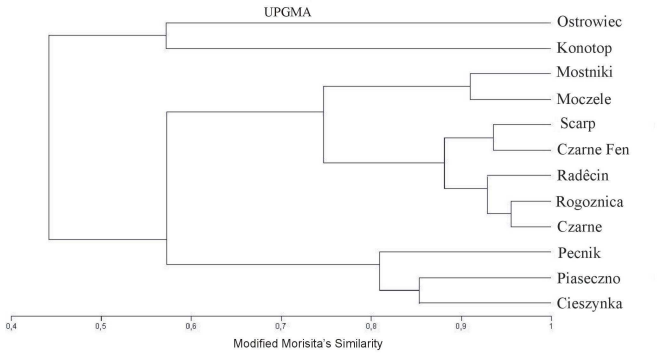

Fig. 19. Faunistic similarity (quantitative) on the studied sites, based on the Morisita-Horn index.

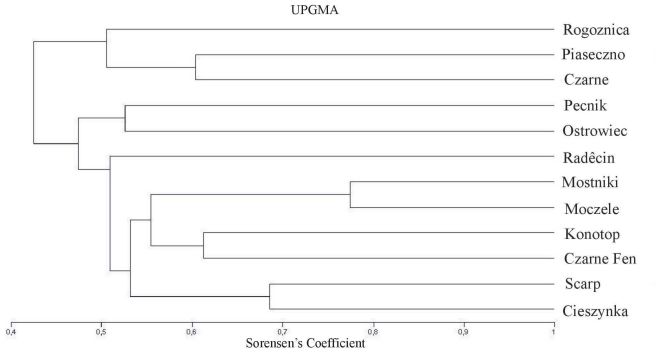

Fig. 20. Faunistic similarity (quality) on the studied sites, based on the Sørensen index.

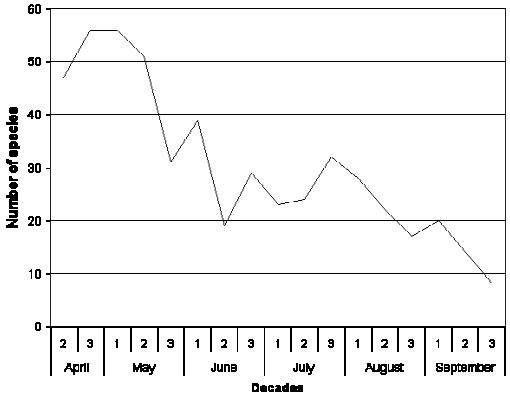

Fig. 21. Dynamics of diversity of bees in the Drawa National Park.

Table 1. Comparision of number of specimens (N), species (S), species diveristy index (H´), and evennes index (J´) of bees in the Drawa National Park.

	Cieszynka	Czarne	Czarne Fen	Konotop	Moczele	Mostniki	Ostrowiec	Pecnik	Piaseczno	Radęcin	Rogoźnica	Scarp	DPN
N	153	84	262	678	200	248	177	358	208	238	61	216	2884
S	32	25	46	67	50	43	44	33	28	39	14	42	121
H´	2.678	2.428	2.770	3.016	3.270	2.977	3.032	2.154	2.470	2.074	1.980	2.675	3.275
J´	0.773	0.754	0.723	0.717	0.836	0.792	0.801	0.616	0.741	0.566	0.750	0.716	0.683

Phenology of Apiformes

The seasonal dynamics of all bees in the Drawa NP is presented in Fig. 21. It shows that variation in bee diversity is the highest from mid-April till mid-May, when 50-55 bee species can be found in the park. Since mid-May, species numbers decreased 2-fold and remained at this level usually till early August. Typical and most common early-spring and spring species include mostly andrenids: *Andrena haemorrhoa, A. cineraria, A. lapponica, A. flavipes, A. fucata, A. fulva, A. grawida, A. fusicpes, A. helvola, A. nigroaenea, A. subopaca*, and *A. vaga.* Also cleptoparasites of some of those species are noticeable, especially *Nomada fucata, N. fulvicornis, N. moeschleri, N. panzeri*, and *N. ruficornis*. In spring, also female bumblebees can be noticed easily, e.g. *Bombus lucorum, B. pratorum, B. muscorum*, and *B. terrestris*, as well as *Osmia rufa*.

In summer, mostly halictid bees were caught, especially *Seladonia tumulorum*, *Evylaeus calceatus, E. punctatissimus, Lasioglossum subfasciatum*, and *L. sexnotatum*. Summer species include also *Colletes* spp. (especially *C. succintus*) and *Hylaeus* (especially *H. communis*).

The general curve of bee abundance is affected mostly by the flowering of spring plants, especially in mid- and late April and in early May. Later on, bee abundance declines to 100 individuals per week or even less (Fig. 22).

The dynamics of bee abundance is similar in most of the individual habitats, i.e. in coniferous forests (Figs 23, 24) and on meadows (Figs 25, 26). A peculiar site is the fen, where bees are most abundant when willows are flowering, as they are the only available and rich source of bee forage, whereas later, i.e. since early May, only single specimens were observed there (Fig. 28). The dynamics of bee abundance is completely different on the slope covered by xerothermic grassland (Scarp), where bees were most numerous in late July and early August (Fig. 29). Several peaks of bee abundance were recorded near the buildings at Ostrowiec (gardens, meadow) (Fig. 27) - dependent on many forage plant species, flowering in various periods.

Table 2. Comparision of significance of differences of the Shannon diversity idex (H´); ns - p>0,05; * - p<0,05; ** - p<0,01; *** - p<0,001.

Plots	meadow, Cieszynka	mixed coniferous forest, Czarne	fen, Czarne Fen	old field, Konotop	meadow, Moczele	meadow, Mostniki	farm buildings, Ostrowiec	fresh coniferous forest, Pecnik	mixed coniferous forest, Piaseczno	beech forest, Radęcin	fresh coniferous forest, Rogoźnica	Scarp	Total
meadow, Cieszynka	x												
mixed coniferous forest, Czarne	ns	x											
fen, Czarne Fen	ns	*	x										
old field, Konotop	**	***	**	x									
meadow, Moczele	***	***	***	*	x								
meadow, Mostniki	*	**	ns	ns	**	x							
farm buildings, Ostrowiec	**	***	*	ns	ns	ns	x						
fresh coniferous forest, Pecnik	***	ns	***	***	***	***	***	x					
mixed coniferous forest, Piaseczno	ns	ns	*	***	***	***	***	**	x				
beech forest, Radęcin	***	ns	***	***	***	***	***	ns	**	x			
fresh coniferous forest, Rogoźnica	***	*	***	***	***	***	***	ns	**	ns	x		
Scarp	ns	ns	ns	**	***	*	**	***	ns	***	***	x	
Total	***	***	***	***	ns	***	*	***	***	***	***	***	x

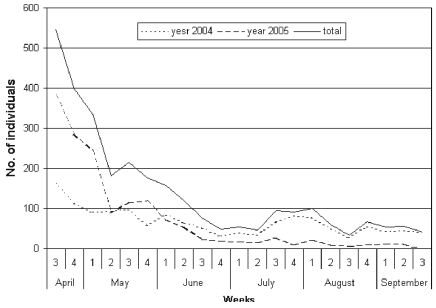

Fig. 22. Dynamics of bee abundance in the Drawa National Park.

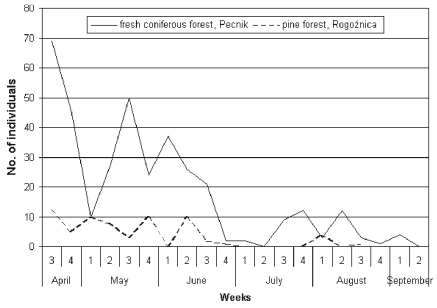

Fig. 23. Dynamics of bee abundance in fresh coniferous forests (Pecnik, Rogoźnica).

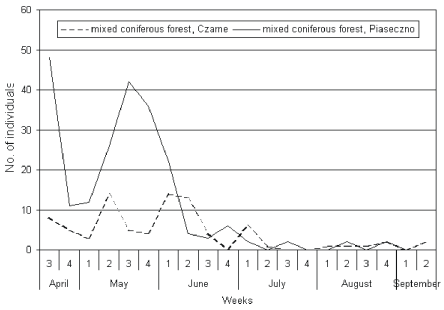

Fig. 24. Dynamics of bee abundance in mixed coniferous forests (Czarne, Piaseczno).

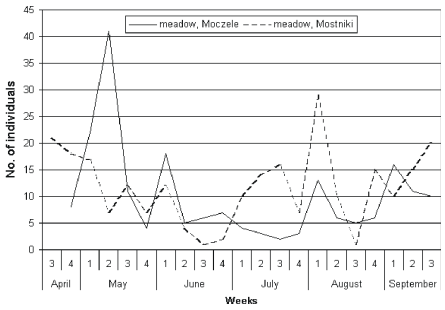

Fig. 25. Dynamics of abundance of bees in meadows (Moczele, Mostniki).

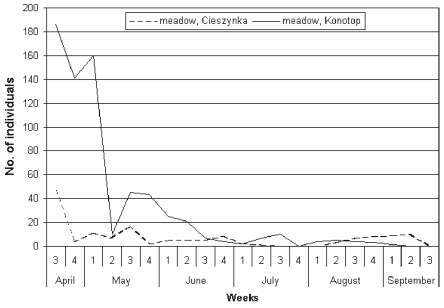

Fig. 26. Dynamics of abundance of bees in a meadow (Cieszynka) and an old field (Konotop).

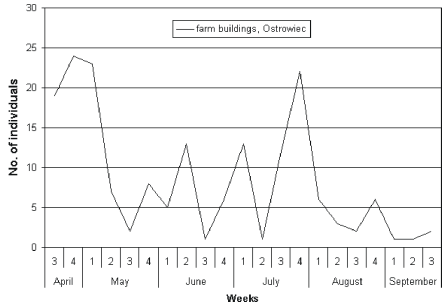

Fig. 27. Dynamics of abundance of bees in the vicinity of farm buildings (Ostrowiec).

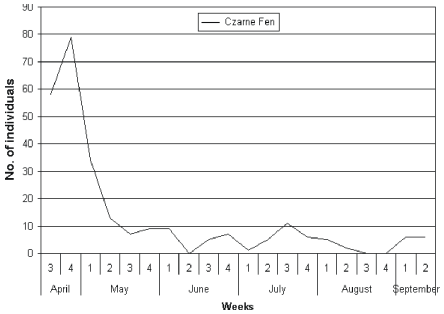

Fig. 28. Dynamics of abundance of bees in a fen (Czarne Fen).

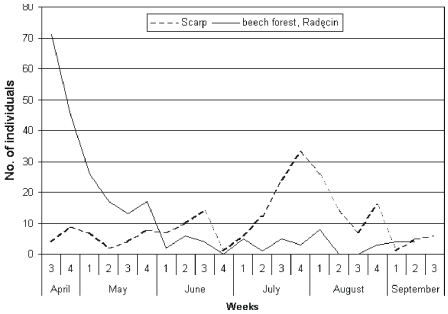

Fig. 29. Dynamics of abundance of bees on the Scarp and in a beech forest (Radęcin).

DISCUSSION

This study enabled compilation of the first list of Apiformes of the Drawa NP. Appendix 1 includes 118 species, which account for 25.5% of the Polish bee fauna. Our results can be compared with data from other parks dominated by woodlands (especially pine forests) in the Polish lowland. To date, 101 bee species were recorded in the Bory Tucholskie NP, 226 in the Wielkopolska NP, and 191 in the Wigry NP (Table 3). The number reported here certainly is not the true number of bee species in the Drawa NP, but still - for example - it is comparable with that recorded in coniferous woodlands of the Bory Tucholskie NP. Further investigations, especially searching for bees on flowers and in their favourite nesting sites, will certainly extend the list of species presented here.

Table 3. Comparison of numbers of bee species recorded in selected lowland national parks in Poland.

National Park	Area (ha)	Forest area (%)	No. of species	% of Polish fauna	Reference
Drawa NP	11342	82	121	25.5	
Bory Tucholskie NP	4798	79	101	21.1	BANASZAK & WENDZONKA 2002
Wigry NP	15085	62.7	191	40.7	BANASZAK & KRZYSZTOFIAK 1996
Wielkopolska NP	7620	58.3	226	48.2	BANASZAK 1987 BANASZAK & CIERZNIAK 1994 CIERZNIAK 2003
Kampinos NP	38544	75	180	38.2	BANASZAK & PLEWKA 1981

Because of the predominance of forests (82%) the major bee species in the Drawa NP is *Bombus lucorum* (23.6%), often accompanied by *B. protorum*, *B. pascuorum* (3.7% in total), and *Andrena* spp., mainly *A. lapponica* (8.8%), *A. haemorrhoa* (8.4%), and *A. cineraria* (3.5%). *Bombus lucorum* or *Andrena lapponica* dominated also on most of the individual plots. On some sites, *B. lucorum* exceeded 50% of the total catch, e.g. in the beech forest (Radęcin - 55%), while *A. lapponica* in coniferous forests exceeded 20%, or even 40%, e.g. in fresh pine forest *Leucobrio-Pinetum* (Pecnik - 42.7%). A similar situation was observed in the Bory Tucholskie National Park, where *Andrena lapponica* was the major species, accompanied by *B. lucorum* (BANASZAK & WENDZONKA 2002).

This study shows that the majority of bee species and individuals in the Drawa NP appear in early spring (April) and spring (May), i.e. when most of bee forage plants are flowering, mostly willows on wet sites and *Vaccinium* spp. (*V. myrtillus* or *V. vitis-idea*) in coniferous forests. A similar situation was observed in the Bory Tucholskie National Park (BANASZAK & WENDZONKA 2002). *Andrena lapponica* has also recently been classified as the most important species among the Aculeata studied in birch stands (KULA & TYRNER 2003) and spruce stands of Northern Bohemia (KULA & TYRNER 2003a).

REFERENCES

BANASZAK J. 1987. Pszczoły (Hymenoptera, Apoidea) wybranych zespołów roślinnych Wielkopolskiego Parku Narodowego. Bad. Fizjograf. Pol. Zach., C-zoologia, **35**: 5-23.

BANASZAK J. 2008. Fauna pszczół (Hymenoptera: Apoidea, Apiformes) Bydgoszczy. [In:] Fauna miast. Ochronić różnorodność biologiczną w miastach. P. INDYKIEWICZ, L. JERZAK, T. BARCZAK (eds), SAR „Pomorze", Bydgoszcz, 234-245pp.

BANASZAK J., PLEWKA T. 1981. Apoidea (Hymenoptera) Kampinoskiego Parku Narodowego. Fragm. Faun., **25**(24): 435-452, z tab.

BANASZAK J., CIERZNIAK. 1994. Spatial and temporal differentiation of bees (Apoidea) in the forests of Wielkopolski National Park, Western Poland. Acta Univ. Lodz., Fol. Zool., **2**: 3-28.

BANASZAK J., KRZYSZTOFIAK A. 1996. The natural Wild bee resources (Apoidea, Hymenoptera) of the Wigry National Park. Pol. Pismo Ent., **65**: 33-51

BANASZAK J., WENDZONKA J. 2002. Bees (Hymenoptera: Apoidea) of the Bory Tucholskie National Park (NW Poland). Pol. Pismo Ent. **71**: 327-350.

BANASZAK J., BUSZKO J., CZACHOROWSKI S., CZECHOWSKA W., HEBDA G., LIANA A., PAWŁOWSKI J., SZEPTYCKI A., TROJAN P., WĘGIEREK P. 2004. Przegląd badań inwentaryzacyjnych nad owadami w Parkach Narodowych Polski. Wiad. Entomol., 23 Supl., **2**: 5-56.

CIERZNIAK T. 2003. Changes in the bee fauna (Apoidea) of the Wielkopolski National Park over the last half century. Fragm. Faun., **46**: 151-170.

HORN H. S. 1966. Measurment of "overlap" in comparative ecological studies. Am. Nat. **100**: 419-424.

KRIGER R., CIERZNIAK T. 2006. Zmiany sukcesyjne zgrupowań pszczół (Apiformes) w borach *Leucobryo-Pinetum* w Parku Narodowym „Bory Tucholskie". [In:] J. BANASZAK, K. TOBOLSKI, (eds) Park Narodowy „Bory Tucholskie" u progu nowej dekady. Uniwersytet Kazimierza Wielkiego, Bydgoszcz, 247-267 pp.

KOCOUREK M. 1966. Prodromus der Hymenopteren der Tschechoslowakei. Pars. 9: Apoidea 1. Acta Faun. ent. Mus. nat. Pragae. 12 Suppl., 122pp.

KULA E., Tyrner P. 2003. Hymenoptera (Aculeata) in birch stands of the air-pollution area of Nortern Bohemia. Journ. Sc., **49**(4): 200-210.

KULA E., TYRNER P. 2003a. Hymenoptera (Aculeata) In birch stands of the air-pollution area of Nortern Bohemia. Journ. Sc., **49** (5): 200-207.

PAWLIKOWSKI T., PAJĄK E. 1995. Materiały do studiów nad strukturą zespołów żądłówek (Hymenoptera, Aculeata) Polski. 3. Trzmiele (Apoidea, *Bombus* Latr.) miasta Wałcz. Acta Unv. Nicolai Copernici. Biologia XLIX, Nauki Mat-Przyr., **94**: 3-17.

PESENKO YU. A., BANASZAK J., RADCHENKO V.G., CIERZNIAK T. 2000. Bees of the family Halictidae (exluding *Sphecodes*) of Poland: taxonomy, ecology, bionomics. Wydawnictwo Uczelniane Wyższej Szkoły Pedagogicznej, Bydgoszcz, 348 pp.

PIELOU E.C. 1975. Ecology diversity. A Willey-Intersci. Publ. J. Wiley a Sons. New York-London, 165 pp.

POOLE R.W. 1974: An introduction to quantitative ecology. McGraw-Hill, New York.

SHANNON C.E., WEAVER 1963. The mathematical theory of communication. Univ. Of Illinois Press, Urban, 117 pp.

TORKA V. 1913. Die Bieneu der Provinz Posen. Z. Naturw. Ver. Posen, **20**: 67-181.

TORKA V. 1933. Nachtrage zu meiner Veröffentlichung über „Die Bienen der Prowinz Posen" Deutsch. Wiss. Zeitschr. Posen, 26: 83-94.

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Appendix 1. List of species and number of individuals of Apiformes found at studied sites in Drawa National Park.

No.	Species	Cieszynka	Czarne	Czarne Fen	Konotop	Moczele	Mostniki	Ostrowite	Pecnik	Piaseczno	Radęcin	Rogoźnica	Scarp	Total
-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-
1	*Colletes cunicularius* (LINNAEUS, 1761)				3	1	2				1			7
2	*Colletes daviesanus* SMITH, 1846				1								2	3
3	*Colletes succinctus* (LINNAEUS, 1758)	2				4	3	1	2		2		2	16
4	*Hylaeus communis* NYLANDER, 1852		1		1	2	5						6	15
5	*Hylaeus confusus* NYLANDER, 1852					1	8							9
6	*Hylaeus gibbus* SAUNDERS, 1850							1						1
7	*Hylaeus gredleri* FÖRSTER, 1871												1	1
8	*Hylaeus sinuatus* (SCHENCK, 1853)							1						1
9	*Andrena alfkenella* PERKINS, 1914				1			1						2
10	*Andrena apicata* SMITH, 1847										1			1
11	*Andrena bicolor* FABRICIUS, 1775				4								2	6
12	*Andrena bimaculata* (KIRBY, 1802)			1	1									2
13	*Andrena blűthgeni* STOECK. in SCHMIED. 1930			1										1
14	*Andrena carbonaria* LINNAEUS, 1767									1				1
15	*Andrena cineraria* (FABRICIUS, 1758)	15		21	15	4	6	1	8	5	2		25	102
16	*Andrena clarkella* (KIRBY, 1802)			2	7								1	10
17	*Andrena denticulata* (KIRBY, 1802)			1										1
18	*Andrena dorsata* (KIRBY, 1802)			1	2	1	1		2	1			3	11
19	*Andrena falsifica* PERKINS, 1915							1						1

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-
20	*Andrena flavipes* PANZER, 1799				21	1	1	4						27
21	*Andrena floricola* EVERSMANN, 1852				1									1
22	*Andrena fucata* SMITH, 1847	2	3	5	11			3		2	3		3	32
23	*Andrena fulva* (MÜLLER, 1766)		1	1	15				4					21
24	*Andrena fuscipes* (KIRBY, 1802)	9		6	1	5	9					1	1	32
25	*Andrena gravida* IMHOFF, 1899	1			38		3	5					1	48
26	*Andrena haemorrhoa* (FABRICIUS, 1781)	10	11	17	85	18	15	3	22	32	16	11	2	242
27	*Andrena helvola* (LINNAEUS, 1758)			9	21	4	1	1						36
28	*Andrena jacobi* PERKINS, 1921		1		2	1		3	2	2				11
29	*Andrena lapponica* ZETTERSTEDT, 1838	35	4	8	1	5		1	153	42	2	2	1	254
30	*Andrena minutuloides* PERKINS, 1914	1			2			1				2	1	7
31	*Andrena nigroaenea* (KIRBY, 1802)	2	1	1	15				2	1	3	2	3	30
32	*Andrena nitida* (MÜLLER, 1776)				5	2	3		1	1				12
33	*Andrena praecox* (SCOPOLI, 1763)			3	1		1				1			6
34	*Andrena proxima* (KIRBY, 1802)		1	1										2
35	*Andrena subopaca* NYLANDER, 1848	2	3	2	1		5	3		2	2	1	6	27
36	*Andrena tibialis* (KIRBY, 1802)			1	1		1		1					4
37	*Andrena vaga* PANZER, 1799			4	8	6	1				1			20
38	*Andrena ventralis* IMHOFF, 1832					2					3			5
39	*Halictus quadricinctus* (FABRICIUS, 1776)				1		1							2
40	*Halictus rubicundus* (CHRIST, 1791)									1			1	2
41	*Halictus sexcinctus* (FABRICIUS, 1775)	1				2	1	1					2	7
42	*Seladonia tumulorum* (Linnaeus, 1758)				2	3		27			1		1	34
43	*Lasioglossum costulatum* (KRIECHBAUMER, 1873)			1										1
44	*Lasioglossum lativentre* (SCHENCK, 1853)		1		1									2
45	*Lasioglossum leucozonium* (SCHRANK, 1781)										1			1

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-
46	*Lasioglossum quadrinotatum* (KIRBY, 1802)							1	3	1	1	1		7
47	*Lasioglossum sexnotatum* (KIRBY, 1802)				4	1	4	4		1	1	1		16
48	*Lasioglossum subfasciatum* (IMHOFF, 1832)	1		1	8				1		3		2	16
49	*Lasioglossum xanthopus* (KIRBY,1802)				1									1
50	*Lasioglossum zonulum* (SMITH, 1848)					1	4	3	1					9
51	*Evylaeus albipes* (FABRICIUS, 1781)		1	3										4
52	*Evylaeus calceatus* (SCOPOLI, 1763)	2	2	9	162	4	11	22	6	24	3	2	2	249
53	*Evylaeus fratellus* (PÉREZ, 1903)	2						1	10					13
54	*Evylaeus leucopus* (KIRBY, 1802)		1					1						2
55	*Evylaeus minutissiumus* (KIRBY, 1802)							2	1					3
56	*Evylaeus morio* (FABRICIUS, 1793)							1					2	3
57	*Evylaeus parvulus* (SCHenck, 1853)			1				2					2	5
58	*Evylaeus pauxillus* (SCHENCK, 1853)							1						1
59	*Evylaeus punctatissimus* (SCHENCK, 1853)	1				1	1	10	5				3	21
60	*Evylaeus rufitarsis* (ZETTERSTEDT, 1838)	1							3	4	2		2	12
61	*Evylaeus sabulosus* (WARNCKE, 1986)							1						1
62	*Evylaeus semilucens* (ALFKEN, 1914)							5						5
63	*Evylaeus sexstrigatus* (SCHENCK, 1868)							1						1
64	*Evylaeus tarsatus* (SCHENCK, 1868)							1						1
65	*Evylaeus villosulus* (KIRBY, 1802)				1									1
66	*Sphecodes albilabris* (FABRICIUS, 1793)					2					1			3
67	*Sphecodes ephippius* (LINNAEUS, 1767)	1			2									3
68	*Sphecodes ferruginatus* HAGENS, 1882										1			1
69	*Sphecodes pellucidus* SMITH, 1845			1										1
70	*Melitta haemorrhoidalis* (FABRICIUS, 1775)			1	1									2
71	*Macropis europaea* WARNCKE, 1973									1				1

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-
72	*Macropis fulvipes* (FABRICIUS, 1804)				1									1
73	*Dasypoda altercator* (HARRIS)				7			1						8
74	*Chelostoma florisomne* (LINNAEUS, 1758)	1				2		2						5
75	*Chelostoma rapunculi* (LEPELETIER, 1841)				1									1
76	*Osmia inermis* (ZETTERSTEDT,1838)			1		1								2
77	*Osmia rufa* (LINNAEUS, 1758)	2		3	3	1	2	20	5		2		2	40
78	*Osmia uncinata* GERSTAECKER, 1869	1				2								3
79	*Megachile ligniseca* (KIRBY, 1802)	5	1	1	2	7	12						2	30
80	*Megachile versicolor* SMITH, 1844					1								1
81	*Coelioxys elongata* LEPELETIER,1841									1				1
82	*Anthophora plumipes* (PALLAS, 1772)					1		1						2
83	*Thyreus orbatus* (LEPELETIER, 1841)								1					1
84	*Nomada fucata* PANZER, 1798				22	5								27
85	*Nomada fabriciana* (LINNAEUS, 1767)				2	1	1		1					5
86	*Nomada ferruginata* (LINNAEUS, 1767)			2	1	2	2	1	1		1			10
87	*Nomada flava* PANZER, 1798				2		1							3
88	*Nomada flavoguttata* (KIRBY, 1802)					1	1			1			1	4
89	*Nomada flavopicta* (KIRBY, 1802)			1										1
90	*Nomada fulvicornis* FABRICIUS, 1793	2			3	7	1							13
91	*Nomada goodeniana* (KIRBY, 1802)				1								1	2
92	*Nomada lathburiana* (KIRBY, 1802)				1	2	1						1	5
93	*Nomada leucophthalama* (KIRBY, 1802)	1	2	2	3	1							1	10
94	*Nomada marshamella* (KIRBY, 1802)					1	1		1					3
95	*Nomada moeschleri* ALFKEN, 1913	1		1	3	4	2				1			12
96	*Nomada panzeri* LEPELETIER, 1841		1	2	7	4	2	2	4	2	1		1	26

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-
97	*Nomada ruficornis* (LINNAEUS, 1758)	1	1	3	8	4	2		1					20
98	*Nomada signata* JURINE, 1807				2		1							3
99	*Epeolus variegatus* (LINNAEUS, 1758)					1					1			2
100	*Bombus cryptarum* FABRICIUS, 1775		1	1	3					1	1			7
101	*Bombus hortorum* (LINNAEUS, 1761)										1			1
102	*Bombus hypnorum* (LINNAEUS, 1758)			2							1			3
103	*Bombus jonellus* (KIRBY, 1802)				2									2
104	*Bombus lapidarius* (LINNAEUS, 1758)	2			3			1	3				2	11
105	*Bombus lucorum* (LINNAEUS, 1761)	31	32	93	72	36	61	24	62	39	131	25	75	681
106	*Bombus magnus* VOGT, 1910			1					1				1	3
107	*Bombus muscorum* (LINNAEUS, 1758)										1			1
108	*Bombus pascuorum* (SCOPOLI, 1763)	4	3	8	8	23	25	3	7	6	13	2	5	107
109	*Bombus pratorum* (LINNAEUS, 1761)	6	5	12	6	1	10	6	31	12	5	6	8	108
110	*Bombus ruderarius* (MÜLLER, 1776)				1									1
111	*Bombus ruderatus* (FABRICIUS, 1775)			1										1
112	*Bombus sylvarum* (LINNAEUS, 1761)				1						1			2
113	*Bombus terrestris auct.* (nec. L. 1758)	4	1	11	46	2	6			5	17		5	97
114	*Psithyrus bohemicus* (SEIDL, 1837)	3	3	8	3	9	17	2	12	3	3	4	26	93
115	*Psithyrus campestris* (PANZER, 1801)					1	2				1		1	5
116	*Psithyrus rupestris* (FABRICIUS, 1793)								1	1			4	6
117	*Psithyrus sylvestris* LEPELETIER, 1832		1	2	1					2	1	1		8
118	*Apis mellifera* LINNAEUS, 1758	1	2	5	16	9	11			14	5		3	66
	Number of individuals	153	84	262	678	200	248	177	358	208	238	61	216	2884
	Number of species	32	25	45	65	48	42	43	32	28	39	14	42	118