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Bees of the Białowieża National Park and adjacent areas, NE Poland (Hymenoptera: Apoidea, Apiformes)

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ABSTRACT. Species composition, dominance structure, and phenology of bees (Apiformes) was studied in the Białowieża National Park, which is a part of the most extensive primeval forest on the European Plain, the Białowieża Forest (NE Poland). In total 146 species of Apiformes are reported from the park. Beside the more or less abundant honey bees, the major bee species is *Bombus lucorum*, accounting for about 30% of wild bees and as much as 71.5% of bumblebees recorded there. Among 3 other bee species dominating in a large part of Poland, *Bombus pascuorum* accounts for nearly 11% of bumblebees, while *B. terrestris* and *B. lapidarius* are accessory species in the park. This shows approximately how the bee fauna looked like in most parts of Poland and Central Europe before human activity started to change the landscape radically, starting from the Middle Ages.

KEY WORDS: wild bees, Apoidea, Apiformes, Białowieża National Park, Białowieża Forest, diversity, dominance structure, zoogeographic analysis, deciduous forest.

INTRODUCTION

Białowieża Forest (Puszcza Białowieska) is one of the best-preserved forests on the European Plain. It still has some features of ancient lowland forests (FALIŃSKI 1986). It covers about 1500 km^2 and lies at the border between Poland and Belarus. Its Polish part occupies over 620 km^2. In its central part, in 1921, the Białowieża National Park was created (BNP), which currently covers about 105 km^2.

The present knowledge of the bee fauna is not satisfactory. This applies both to the overall diversity of species and to studies of bees in major plant communities. So far, from the whole Białowieża Forest, 121 bee species have been reported, including 98 from the Polish part and 63 from the Belarusian part. The data from the Polish part of the Białowieża Forest are over 80 years old. BISCHOFF (1925) recorded 98 bee species in the part that is currently within Polish borders. Bees from the Belarusian part of the Białowieża Forest were studied by SEMAKOV (1997). A list of all known bees from the whole forest was compiled by MALCHER (2001), who added to it several species. Moreover, data on single species of bumblebees have been presented by REINIG (1937), RASMONT (1984), BANASZAK & RASMONT (1994), PAWLIKOWSKI (1994), and KRZYSZTOFIAK (2001). Entomological surveys in Polish national parks, including the Białowieża NP, were reviewed by BANASZAK et al. (2004). An analysis of the sites listed by BISCHOFF (1925) shows that he recorded 67 bee species from the current area of the park and its buffer zone (the strictly protected part of the park and on the Białowieża Glade (Polana Białowieska), where the village of Białowieża is located. This species number is relatively low and based on rather outdated data, so it appeared urgent to conduct detailed investigations in the Białowieża NP. This study increased our knowledge of species diversity both in the strictly protected part of the park and in the adjacent Białowieża Glade. In this study we paid special attention to major forest communities: mostly the fertile oak-hornbeam forests, and the less common coniferous and alluvial forests in river valleys. The application of coloured traps allowed us to analyse the phenology of bees in major forest types in this oldest lowland forest in Europe.

STUDY AREA

The Białowieża Forest (covering ca. 1500 km^2), lies at the border between East and West Europe. Since 1945 it is divided by a boundary between Poland and Belarus (Belarussian SSR in 1945-1991). Its geographic coordinates are: 23º32-55'E, 52º35-56'N.

The Polish part (ca. 620 km^2), occupies the eastern part of the Bielsk Plateau (Równina Bielska), which is part of the North Podlasie Lowland (Nizina Północnopodlaska) in Eastern Europe (KONDRACKI 1988). According to forest administration, the area lies in the Białowieża NP (10 517.27 ha) and forest districts Białowieża, Hajnówka, and Browsk (jointly 52 639.27 ha, including 12 034.22 ha of nature reserves).

The study area lies at a continental drainage divide, between the drainage basins of the Baltic and the Black Sea. The main rivers are the Narewka and Leśna Prawa (Zachodnia), and at the northern edge of the forest, the larger river Narew. Because of the low variability of land relief and small slope angle, all watercourses flow slowly, so their beds are wide, and adjacent areas are waterlogged. The southern part of the Białowieża Forest lies within the catchment area of the river Bug (FALIŃSKI 1986). Altitudes range from 134 m to 202 m. At the higher elevations, soils are mostly brown or podsolic, while in valleys and local depressions, lessivé (grey-brown podsolic), gley or peat soils prevail (FALIŃSKI 1994).

Near the study area lies a border between two geobotanical divides: the boreal Northern Divide and the Baltic Divide influenced by oceanic climate (FALIŃSKI 1986). Thus the climate is temperate, continental, but affected also by the oceanic climate. Annual mean temperature is 6.8ºC (January 4.7ºC, July 17.8ºC). Annual precipitation is on average 641 mm, but most of it is in summer. Winter is long, and permanent snow cover lasts on average over 92 days, but some winters are snowless. The growing season is short (205 days), about a month shorter than in western Poland (OLSZEWSKI 1968, 1986, FALIŃSKI 1994).

The landscape is dominated by woodland (about 96% of the study area). The other 4% are covered by fields, meadows, roads, wastelands, and running or standing waters. The major forest type is oak-hornbeam forest *Tilio-Carpinetum* (47% of woodland). Coniferous forests occupy 37%, while wet deciduous and mixed forests jointly about 14.5% of woodland. Forest stands are dominated by Norway spruce *Picea abies* (26%), Scots pine *Pinus sylvestris* (24%), black alder *Alnus glutinosa* (17%), pedunculate oak *Quercus robur* (10%), silver birch *Betula pendula*, and downy birch *Betula pubescens* (in total 11%). European ash *Fraxinus excelsior*, small-leaved lime *Tilia cordata*, Norway maple *Acer platanoides*, aspen *Populus tremula*, and elms *Ulmus* spp. are less frequent, although locally they can also be dominants, especially in the strictly protected part (54.4% of total park area). European hornbeam *Carpinus betulus*, although very common, usually forms the lower tree layer, and only rarely reaches the higher tree layer (FALIŃSKI 1984).

In comparison to other woodlands in Poland, the Białowieża Forest is composed of relatively well-preserved, natural forest stands. Nearly 40% of forest area is covered by forest stands aged over 80 years. The mean age of forest stands is 73 years in the managed part and 130 years in the strictly protected part (JĘDRZEJEWSKI & JĘDRZEJEWSKA 1995). They are characterized by a complex structure, composed of many layers, many species, and uneven aged trees.

Until the year 2001, over 11 000 species of invertebrates were reported from the Białowieża Forest, and nearly 90% of them were insects (GUTOWSKI & JAROSZEWICZ 2001). The high number of recorded species to some extent reflects the intensity of faunistic studies performed there. However, the study area is also characterized by occurrence of a large number of rare, vulnerable, and endangered species. Very many animal species are associated with dead wood, which is abundant in primeval woodlands. The large amount of dead wood is the reason why the Białowieża Forest is the major refugium of the fauna of primeval forests on the European Plain. Thanks to its large area, continuity, and well-preserved ancient forest stands, it still supports some species that have become extinct in other parts of Poland and Europe, or have only few, scattered localities. Because of the very low proportion of open habitats, which do not exceed 5% of the study area, a relatively small number of insect species associated with open habitats and anthropogenic sites are found here.

MATERIALS, METHODS, AND SAMPLING SITES

Investigations were conducted during the growing season in 2005, 2006, and 2007 within the Białowieża NP and in its direct vicinity, i.e. in open habitats of the Białowieża Glade (Fig. 1). We used Moericke traps (i.e. yellow pan traps) placed at a height of 0.5-1.0 m, depending on the height of vegetation. On each plot, the pans were spaced about 50 m apart, at sunny, sheltered sites. The caught insects were collected every 10 days. The traps were located on the following 6 sites (3 traps per site).

1. Experimental Garden of the Białowieża Geobotanical Station of Warsaw University. It is an open habitat covering ca. 1 ha, partly planted with shrubs and trees, located at the border of the Palace Park (within the Białowieża NP). Until 1972 it has been used for agriculture (arable fields and hay meadow), but later about 20% of the area was left fallow to enable natural succession, while the remaining land was planted with single shrubs and trees (*Salix* spp*., Acer platanoides, Acer pseudoplatanus, Tilia cordata, Betula pendula, Malus domestica, Picea abies, Populus tremula, Rubus* spp.). Open spaces in the garden are mown once or twice a year, so that species composition of potential bee forage plants is very rich during the year. Among over 140 herbaceous species found in the garden, the most numerous are: *Cirsium arvense*, *Crepis biennis*, *Hypochoeris radicata*, *Iris pseudacorus*, *Knautia arvensis*, *Lamium purpureum*, *Lathyrus pratensis*, *L. sylvestris*, *L. vernus*, *Leontodon hispidus*, *Lotus cornicularius*, *Medicago lupulina*, *Melampyrum nemorosum*, *Taraxacum officinale*, *Tragopogon orientalis*, *Trifolium* spp. and *Vicia* spp.

2. River valley ("Reski") (Fig. 2), deforested probably about 200 years ago, till 1973 used as a semi-natural hay meadow but later neglected. It stopped to be managed after inclusion in the Białowieża NP, and as a result the valley is being gradually overgrown by a mosaic of plant communities, with patches dominated by sedges (mostly *Carex cespitosa*, *C. appropinquata*, and *C. acutiformis*), reed *Phragmites australis*, willows (mostly *Salix cinerea*) and tall-herb communities, which are potentially an attractive source of nectar for bees. The tall-herb patches include *Caltha palustris*, *Cirsium palustre*, *C. rivulare*, *Filipendula ulmaria*, *Geum rivale*, *Lysimachia vulgaris*, *Lythrum salicaria*, *Polygonum bistorta*, etc. Moericke traps were placed near willows.

3. Meadow ("Cerkowny Wyrub") (Fig. 3) used as a hay meadow till the late 1980s, located at the edge of the strictly protected part and the Białowieża Glade. In the last 2 decades it was not mown, but it is intensively grazed by wildlife. Among grassy patches, bee forage plants are quite frequent but scattered: *Hieracium pilosella*, *Lamium* sp. *Lathyrus pratensis*, *Mentha* sp., *Taraxacum officinale*, *Trifolium* spp..

4. Oak-hornbeam forest (Fig. 4) – traps were placed in a clearing that covers 0.25 ha in section 399Ca of the strictly protected part. This gap was formed because of death of a group of trees in a mixed deciduous forest stand on a fertile potential site of oak-hornbeam forest. The canopy of the surrounding forest was dominated by *Carpinus betulus* aged about 120 years (ca. 40%) and *Tilia cordata* aged about 70 years (ca. 20%) or 35 years (10%). Less numerous were: *Picea abies* (120 years), *Quercus robur* (220 years), and *Acer platanoides* (170 years), - each accounting for ca. 10%. The herb layer included many bee-

forage plants that are common in oak-hornbeam forests: *Anemone nemorosa*, *Hepatica nobilis*, *Isopyrum thalictroides*, *Lathyrus vernus*, and *Pulmonaria obscura*. They flower in early spring, before tree leaves are fully developed. At the same time, another important source of nectar was *Acer platanoides*. Later on, when the forest floor was more shaded, some other species flowered: *Galeobdolon luteum*, *Galium odoratum*, *Glechoma hederacea*, *Ranunculus lanuginosus*, *Stellaria holostea*, *S. nemorum*, whereas in late June and early July in the canopy, *Tilia cordata*.

5. Alluvial forest – traps were placed in a gap maintained as a result of periodical flooding by the river Orłówka (section 314Di of the strictly protected part). The surrounding forest stand is composed mostly of *Alnus glutinosa* (20%), *Picea abies* (20%), and *Fraxinus excelsior* (10%) aged about 150 years, *F. excelsior* (20%) and *A. glutinosa* (10%) aged about 70 years, and *F. excelsior* aged about 50 years (20%). At the sampling site less than 10% of the area was covered by trees. In the shrub and herb layer, some bee forage plants were abundant: *Allium ursinum*, *Ficaria verna*, *Gagea lutea*, *Geranium palustre*, *Lamium maculatum*, *Padus avium*, *Ribes spicatum*, *R. nigrum*, and *Stellaria nemorum*.

6. Coniferous forest (Fig. 5) – traps were placed in a gap covering ca. 1.5 ha, which was formed in section 285Ah of the strictly protected part because of death of *Picea abies* trees 10 years ago due to a spruce bark beetle outbreak *Ips typographus* L. Only single trees are now left there, but the surrounding forest stand is still composed of *Picea abies* (30%), *Quercus robur* (20%), *Populus tremula* (10%), *Betula pendula* (10%) aged about 90 years, as well as *Pinus sylvestris* (20%) and *Q. robur* (10%) aged about 150 years. The gap has been colonized by numerous grasses, dominated by *Calamagrostis arundinacea*, and raspberry bushes *Rubus idaeus*. The site was characterized by a large amount of dead logs lying on the ground or single dead standing trees.

The trap method was supplemented on all plots by direct catching in the field (especially searching for bees on flowers and in their favourite nesting sites). In spring (late April and early May 2006) and in summer (July 2008) bees were collected mostly on the Białowieża Glade, in the village of Białowieża, and at the above-mentioned sampling sites within the Białowieża NP.

In this study, we used also a small collection of bees caught occasionally by other researchers, kept at the Białowieża Geobotanical Station, Faculty of Biology, Warsaw University (e.g. 152 specimens collected by J. GUTOWSKI, during monitoring with the use of traps in 2004, and single specimens collected by B. JAROSZEWICZ).

Representativeness of the faunistic material was assessed with the nonparametric Jackknife 2 method, proposed by BURNHAM & OVERTON (1978, 1979) and SMITH & van BELLE (1984) and the Chao 1 method (CHAO 1984, 1987). To determine if the collected samples were sufficiently homogeneous to measure species diversity by the above methods, we used COLWELL's (1997) method.

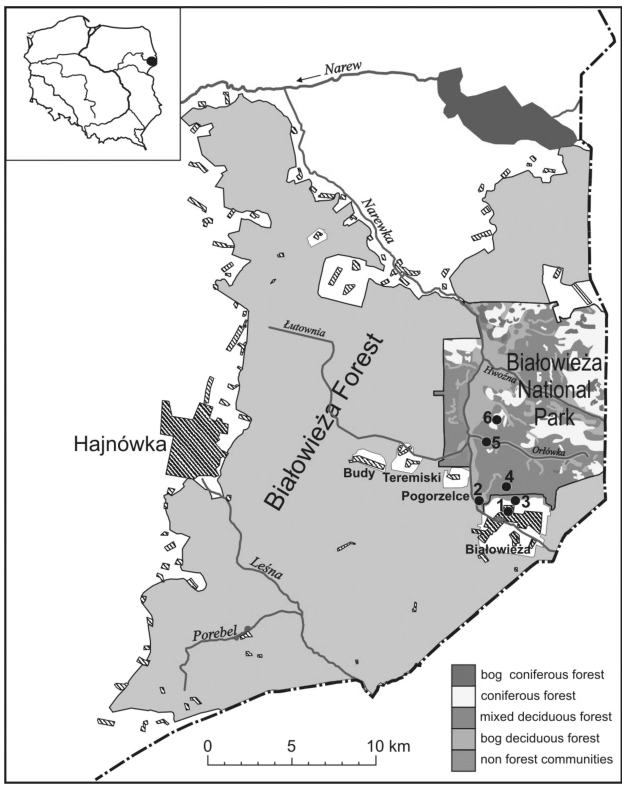

Fig. 1. Map of the Białowieża National Park and distribution of research plots: 1 – Experimental Garden, 2 – river valley "Reski", 3 – meadow "Cerkowny Wyrub", 4 – oak-hornbeam forest, 5 – alluvial forest, 6 – coniferous forest.

RESULTS

Species diversity and dominance structure

This work is based on a total catch of 6010 specimens of bees (Apiformes), including 2342 of wild bees and 3668 of *Apis mellifera*. They represented 146 bee species, which account for 31% of the Polish bee fauna. All species and numbers of specimens caught at individual research site are listed in Table 1.

The species accumulation curve for the whole spectrum of investigated habitats shows small deviation from the Coleman curve, up to about 16 samples. Above this value, the

curves are very similar and the difference does not exceed the standard error (Fig. 6). Thus the collected entomological material is sufficiently homogeneous to estimate the total number of species observed in the studied communities.

On the basis of Jackknife 2 and Chao 1, the true number of species in the study area was estimated to reach nearly 150 (Fig. 7). This suggests that we recorded about 70% of the true number of species by means of traps. Thanks to additional direct catching with a sweep net in the field, we reached a total of nearly 150 species.

The analysis of contributions of bee families (according to the traditional classification) shows that the best-represented were the Halictidae (35 species) and Andrenidae (30 species), followed by the Anthophoridae (22 species), Megachilidae (21 species), Apidae (20 species), and Colletidae (14 species). The Melittidae are poorly represented (4 species).

The collected material was dominated by honey bees (3668 individuals, i.e. 61% of the total catch), which are a variable anthropogenic factor. Because of this, further analyses (dominance structure and phenology) were made only for wild bees. The contribution of *Apis mellifera* depends on bee-keepers. Preliminary investigations revealed that the apiary closest to plot 6 (coniferous forest) was about 4 km away from it. It was a movable apiary placed in forest section 189D on a potential site of oak-hornbeam forest. Interestingly, in 2007 there were already two apiaries, one in section 189D and the other in 221AB, i.e. about 3 km from plot 6, but this did not cause any increase in bee abundance on the plot. This suggests that there are some local populations of wild honey bees. In fact, a researcher from the Mammal Research Institute in Białowieża found several wild swarms, but none of them survived longer than 1-2 years (I. RUCZYŃSKI, unpubl. data). The peak in bee abundance observed in late June and early July 2005 may be due to flowering lime trees in the protected part. Such an interpretation would be probable on the basis of plant phenology. However, this coincidence may be accidental, because bee abundance on plot 6 (coniferous forest) is much higher than in oak-hornbeam forest, where lime trees are more numerous and flower very intensively. This phenomenon is not repeated every year, and is probably associated with variation in nectar production by lime trees. It can also be due to weather conditions, which could cause intensive swarming and escape from apiaries. Then flight distance is less important, as when bee swarms get to a forest edge, they often fly above the canopy and get lost in a distance (B. JAROSZEWICZ, unpubl. data). Abundance peaks were also observed on 7 April 2007 (experimental garden) and 17 April 2007 (river valley and oak-hornbeam forest). Those dates may be associated with flowering of willows (*Salix caprea*), or Norway maples in oak-hornbeam forest. It is not surprising that in the experimental garden (an elevated and sheltered plot), willows flower slightly earlier than in oak-hornbeam forest (shade) or in the river valley (local depression and high humidity). Unfortunately, this phenomenon was not repeated in all years.

Contributions of honey bees in traps on the studied plots varied widely between years and between plots (Table 2). Honey bees in this study were caught mostly in open habitats (meadows), whereas those foraging on trees (flowers or honeydew) may not be caught in traps located at the forest floor.

Fig. 2. River valley "Reski" (Photo by I. SMERCZYŃSKI).

Fig. 3. Meadow "Cerkowny Wyrub" (Photo by I. SMERCZYŃSKI).

Fig. 4. Oak-hornbeam forest (Photo by M. ŻYWIEC).

Fig. 5. Coniferous forest (Photo by B. JAROSZEWICZ).

Among wild bees, *Bombus lucorum* was the dominant, accounting for 35% of the total catch (Fig. 9). Contributions of three other species were slightly higher than 5% each: *Evylaeus calceatus* (7%), *Andrena haemorrhoa* (6%), and *A. vaga* (6%). It must be emphasized that *B. lucorum* clearly prevailed on all plots except the Experimental Garden, where it was a subdominant. Thus the clear dominance of *Bombus lucorum* concerns various plant communities: oak-hornbeam forest (80% of total catch), alluvial forest (56%), coniferous forest (40%), meadow (27%), river valley (25%), and even the Experimental Garden (Fig. 10). It is a typical forest species, but it is not surprising in the open habitats in the Białowieża NP, because they are relatively small gaps surrounded by forest.

About half of the collected wild bees are bumblebees or cuckoo bumblebees (48.6%), while the others are solitary (51.4% of total species). As many as 82 species (56% of total species) were represented by 1-3 individuals each. Such a high number of rarely caught species can be explained by the prevalence of woodland in the study area, where open habitats are usually small enclaves. The largest among them is the Białowieża Glade. Some of those species in other conditions and places are more frequent or even abundant: *Andrena flavipes*, *A. minutula*, *A. minutuloides*, *Halictus quadricinctus*, *Lasioglossum quadrinotatum*, *Evylaeus fulvicornis*, *E. sexstrigatus*, *Anthidium manicatum*, and *Bombus lapidarius.*

The specificity of forest fauna is reflected not only in the dominance of *Bombus lucorum,* but also in the presence of other forest species: *Andrena lapponica*, *A. fuscipes*, *Evylaeus fratellus*, *E. leucopus*, and *Bombus jonellus*. Special attention should be paid to the species that are rare in Poland or change their distribution range.

Andrena fulva - West European species associated with trees, especialy with *Acer* spp. In Poland it reaches the eastern limit of its range (BANASZAK 2006). New localites: Białowieża, park, 30 Apr 2006 ♀; Białowieża, Experimental Garden, 7 May 2007 ♀, 30 Apr 2006 ♂, 1 May 2006 ♂, 7 May 2006 ♂, 27 Apr 2007 3♀♀; Białowieża NP, strict reserve "Reski", 27 May 2006 ♀, 17 May 2006 ♂; Białowieża NP, "Cerkowny Wyrub", 27 May 2006 ♀, 17 May 2007 ♀, 27 Apr 2007 3♀; Białowieża, 59 Tropinka Street, 1 May 2005 ♂.

Bombus cryptarum - In Poland recorded since 1980s. Associated with woodlands. Its food plants include *Vaccinium myrtillus* and *Calluna vulgaris*. New localities: numerous females from the strict reserve, „Reski", "Cerkowny Wyrub" and the Experimental Garden, observed in May 2006 and 2007.

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 1980s. Rare, its biology similar to that of *B. lucorum*. New localities: Białowieża NP, strict reserve, section 399, 5 Aug 2006, 1♀; section 285A, 2 ♀♀, collected by B. JAROSZEWICZ.

Bombus semenoviellus - boreal-alpine species was not known in Poland till the mid 1990s. This species, earlier reported from Lithuania, is also expansive, broadening its geographic range westwards in recent years. Since its first record near Warsaw in 1995, this bumblebee has been quickly spreading its range westwards. New locality: strict reserve,

"Reski", section 398, 7 May 2007, 2♀; "Cerkowny Wyrub" (section 399), 27 April 2007, 1♀; Białowieża Glade, 26 July 2008, 1♀.

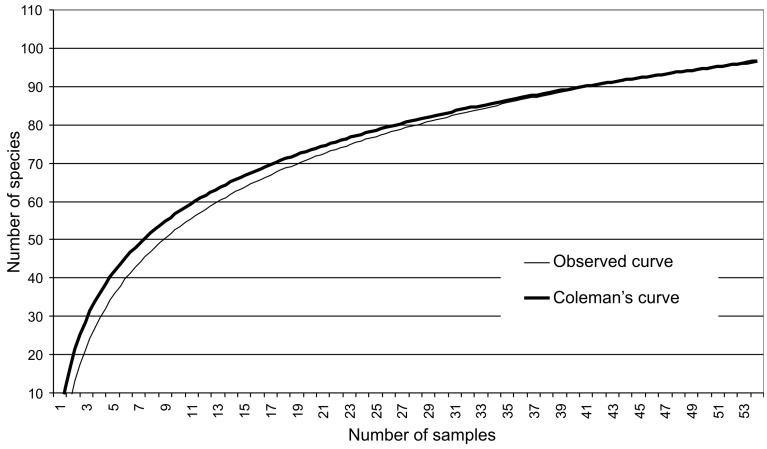

Fig. 6. Comparison of the accumulation curve with the Colemana curve.

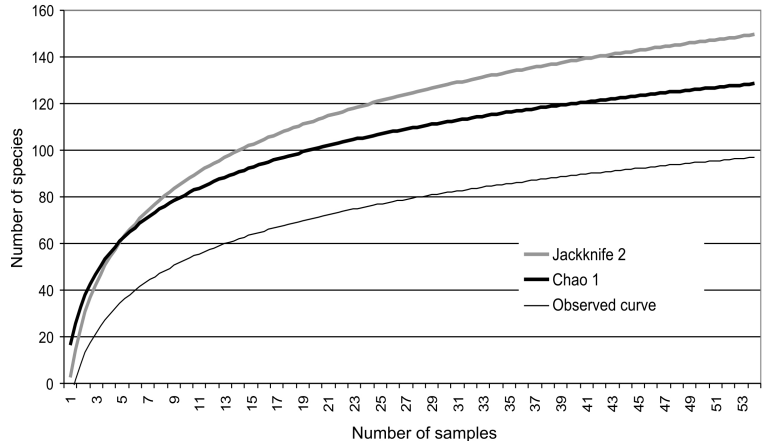

Fig. 7. Observed and estimated numbers of species of bees in the Białowieża National Park (Moericke traps) using Jacknife 2 and Chao 1 methods.

Table 1. List of species and number of indyviduals of Apiformes found at studied sites and surrounding area in Białowieża National Park (numbers of individuals caught with a entomological net are given in brackets).

No.	Species \ Investigation plot	Experimental garden	River valley („Reski")	Meadow („Cerkowny Wyrub")	Oak - hornbeam forest	Alluvial forest	Coniferous forest	Other sites	Total
-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
1	*Colletes cunicularius* (LINNAEUS, 1761)	20	9	3		1		(1)	34
2	*Colletes daviesanus* SMITH, 1846	(1)		1				(1)	3
3	*Colletes succinctus* (LINNAEUS, 1758)							(1)	1
4	*Hylaeus annularis* (KIRBY, 1802)							(1)	1
5	*Hylaeus bisinuatus*, FORSTER, 1871						(1)		1
6	*Hylaeus brevicornis* NYLANDER, 1852	1							1
7	*Hylaeus communis* NYLANDER, 1852	2(1)	3	20		11	21(5)	(9)	72
8	*Hylaeus confusus* NYLANDER, 1852	6	2	5			7(3)	(3)	26
9	*Hylaeus difformis* (EVERSMANN, 1852)						1(1)		2
10	*Hylaeus gibbus* SAUNDERS, 1850	2	1					(1)	4
11	*Hylaeus gracilicornis* (MORAWITZ, 1871)							(1)	1
12	*Hylaeus gredleri* FORSTER, 1871	2		1					3
13	*Hylaeus hyalinatus* SMITH, 1842	2							2
14	*Hylaeus pectoralis* FORSTER, 1871		1	1					2
15	*Hylaeus rinki* (GORSKI, 1852)	2					1		3
16	*Andrena apicata* SMITH, 1847	1	2	(1)				(1)	5
17	*Andrena bicolor* FABRICIUS, 1775	2					1		3
18	*Andrena chrysosceles* (KIRBY, 1802)	22	1	6	1		2		32
19	*Andrena cineraria* (LINNAEUS, 1758)		2	3		1			6
20	*Andrena clarkella* (KIRBY, 1802)	(3)	8	5			1	(1)	18
21	*Andrena denticulata* (KIRBY, 1802)	(1)							1
22	*Andrena dorsata* (KIRBY, 1802)	4(9)		2					15
23	*Andrena flavipes* PANZER, 1799	1							1
24	*Andrena fucata* SMITH, 1847	1					3	(12)	16
25	*Andrena fulva* (MULLER, 1766)	9(4)	2	6				(1)	22
26	*Andrena fuscipes* (KIRBY, 1802)						2		2
27	*Andrena gravida* IMHOFF, 1899							(1)	1
28	*Andrena haemorrhoa* (KIRBY, 1802)	39(5)	5	20	4	21	23	(30)	147
29	*Andrena helvola* (LINNAEUS, 1758)	10(1)		6	2	6	11	(15)	51
30	*Andrena humilis* IMHOFF, 1832			1					1
31	*Andrena lapponica* ZETTERSEDT, 1838							(1)	1

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
32	*Andrena minutula* (KIRBY, 1802)	1							1
33	*Andrena minutuloides* PERKINS, 1914	1							1
34	*Andrena morio* (BRULLE, 1832)					1			1
35	*Andrena nitida* (MULLER, 1776)	4	1	1					6
36	*Andrena ovatula* (KIRBY, 1802)							(1)	1
37	*Andrena pilipes* (FABRICIUS, 1781)							(1)	1
38	*Andrena praecox* (SCOPOLI, 1763)	3	1	2				(1)	7
39	*Andrena subopaca* NYLANDER, 1848	(2)			1	1	3(1)	(2)	10
40	*Andrena thoracica* (FABRICIUS, 1775)	(1)							1
41	*Andrena tibialis* KIRBY, 1802							(1)	1
42	*Andrena vaga* PANZER, 1799	9(2)	69	25		4	1		110
43	*Andrena wilkella* (KIRBY, 1802)	(1)							1
44	*Panurgus calcaratus* (SCOPOLI, 1763)	(2)						(1)	3
45	*Halictus maculatus* SMITH, 1848	1(3)					2		6
46	*Halictus quadricinctus* (FABRICIUS, 1775)						1		1
47	*Halictus rubicundus* (CHRIST, 1798)	2					1		3
48	*Halictus sexcinctus* (FABRICIUS, 1775)	3(17)	2		1		2	(7)	32
49	*Seladonia subaurata* (ROSSI, 1792)							(1)	1
50	*Seladonia tumulorum* (LINNAEUS, 1758)	10(3)					(1)	(1)	15
51	*Lasioglossum costulatum* (KREICHB., 1873)	1(1)						(1)	3
52	*Lasioglossum lativentre* (SCHENCK, 1853)	1	2	1	1		7		12
53	*Lasioglossum leucozonium* (SCHRANK, 1781)	(2)						(2)	4
54	*Lasioglossum majus* (NYLANDER, 1852)	(1)	2	2	1		6	(1)	13
55	*Lasioglossum quadrinotatum* (KIRBY, 1802)		1						1
56	*Lasioglossum sexnotatum* (KIRBY, 1802)		1		2		1		4
57	*Lasioglossum zonulum* (SMITH, 1848)	1	2	2		1	4		10
58	*Evylaeus albipes* (FABRICIUS, 1781)	12	2	1					15
59	*Evylaeus calceatus* (SCOPOLI, 1763)	48(10)	32	29	15		6	(4)	144
60	*Evylaeus fratellus* (PEREZ, 1903)						2(1)		3
61	*Evylaeus fulvicornis* (KIRBY, 1802)	(1)					(3)		4
62	*Evylaeus intermedius* (SCHENCK, 1868)							(1)	1
63	*Evylaeus laticeps* (SCHENCK, 1876)			1					1
64	*Evylaeus leucopus* (KIRBY, 1802)	1						(1)	2
65	*Evylaeus lucidulus* (SCHENCK, 1861)	(1)							1
66	*Evylaeus morio* (FABRICIUS, 1793)	6							6
67	*Evylaeus pauxillus* (SCHENCK, 1853)	2(12)						(2)	16
68	*Evylaeus sexstrigatus* (SCHENCK, 1868)		1						1
69	*Evylaeus villosulus* (KIRBY, 1802)	4	1						5
70	*Sphecodes albilabris* (FABRICIUS, 1793)							(1)	1
71	*Sphecodes ephippius* (LINNAEUS, 1767)			2		1	1	(3)	7
72	*Sphecodes geofrellus* (KIRBY, 1802)	(2)						(2)	4
73	*Sphecodes gibbus* (LINNAEUS, 1758)							(1)	1
74	*Sphecodes hyalinatus* HAGENS, 1882							(5)	5
75	*Sphecodes miniatus* HAGENS, 1882	(2)							2

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
76	*Sphecodes monilicornis* (KIRBY, 1802)	(1)						(1)	2
77	*Sphecodes puncticeps* THOMSON, 1870							(2)	2
78	*Sphecodes reticulatus* THOMSON, 1870							(1)	1
79	*Sphecodes* sp.			1					1
80	*Melitta nigricans* ALFKEN, 1905	(4)	1						5
81	*Macropis europaea* WARNCKE, 1973	2(1)	14	3			1	(3)	24
82	*Macropis fulvipes* (FABRICIOUS, 1804)			1					1
83	*Dasypoda hirtipes* (HARRIS, 1780)	13(6)	3	3		1		(1)	27
84	*Trachusa byssina* (PANZER, 1798)	(1)							1
85	*Anthidium manicatum* (LINNAEUS, 1758)	(2)							2
86	*Anthidellum strigatum* (PANZER, 1805)							(1)	1
87	*Stelis ornatula* (KLUG, 1807)	1							1
88	*Stelis punctulatissima* (KIRBY, 1802)	(1)							1
89	*Heriades crenulatus* NYLANDER, 1856			1					1
90	*Heriades truncorum* (LINNAEUS, 1758)						2	(1)	3
91	*Chelostoma campanularum* (KIRBY, 1802)							(1)	1
92	*Chelostoma distinctum* STOECKHERT, 1929		2				1		3
93	*Chelostoma florisomne* (LINNAEUS, 1758)			1	4	2	3		10
94	*Hoplitis claviventris* (THOMSON, 1872)			1					1
95	*Osmia leaiana* (KIRBY, 1802)		1				1		2
96	*Osmia rufa* (LINNAEUS, 1758)	1				2	39	(13)	55
97	*Chalicodoma ericetorum* (LEPELETIER, 1841)	(8)							8
98	*Megachile centuncularis* (LINNAEUS, 1758)	(2)		2	1				5
99	*Megachile lapponica* THOMSON, 1872						2		2
100	*Megachile ligniseca* (KIRBY, 1802)					1			1
101	*Megachile willughbiella* (KIRBY, 1802)					3			3
102	*Coelioxys alata* FORSTER, 1853		1						1
103	*Coelioxys conoidea* (ILLIGER, 1806)							(1)	1
104	*Coelioxys elongata* LEPELETIER, 1841	(1)	1						2
105	*Anthophora plumipes* (PALLAS, 1772)	(9)			1				10
106	*Tetralonia macroglossa* ILLIGER, 1806			1					1
107	*Tetralonia salicariae* (LEPELETIER, 1841)							(1)	1
108	*Ceratina cyanea* (KIRBY, 1802)	(1)							1
109	*Nomada femoralis* MORAWITZ, 1869							(1)	1
110	*Nomada ferruginata* (LINNAEUS, 1767)	2						(1)	3
111	*Nomada flava* PANZER, 1798					1			1
112	*Nomada flavoguttata* (KIRBY, 1802)						1	(1)	2
113	*Nomada flavopicta* (KIRBY, 1802)							(1)	1
114	*Nomada goodeniana* (KIRBY, 1802)							(1)	1
115	*Nomada leucophthalma* (KIRBY, 1802)	1					3	(3)	7
116	*Nomada moeschleri* ALFKEN, 1913	1					1		2
117	*Nomada ochrostoma* ZETTERSTEDT, 1838	2					3	(1)	6
118	*Nomada panzeri* LEPELETIER, 1841	1				3	9	(1)	14
119	*Nomada roberjeotiana* PANZER, 1799							(5)	5

-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
120	*Nomada ruficornis* (LINNAEUS, 1758)	5			1	3	10	(3)	22
121	*Nomada signata* JURINE, 1807	2						(1)	3
122	*Nomada striata* FABRICIUS, 1793	1							1
123	*Nomada zonata* PANZER, 1798							(1)	1
124	*Ammobates punctatus* (FABRICIUS, 1804)							(1)	1
125	*Epeolus variegatus* (LINNAEUS, 1758)							(1)	1
126	*Epeoloides coecutiens* (FABRICIUS, 1775)	(2)						(2)	4
127	*Bombus cryptarum* FABRICIUS, 1775	(3)	8	4		3	8	(1)	27
128	*Bombus hortorum* (LINNAEUS, 1761)	(4)			1	1			6
129	*Bombus hypnorum* (LINNAEUS, 1758)				(1)	2	2(1)	(1)	7
130	*Bombus jonellus* (KIRBY, 1802)		4						4
131	*Bombus lapidarius* (LINNAEUS, 1758)	(3)	1						4
132	*Bombus lucorum* (LINNAEUS 1761)	21(31)	70	64	152(1)	154	213(6)	(13)	725
133	*Bombus magnus* (VOGT, 1911)			1			2		3
134	*Bombus muscorum* (LINNAEUS, 1758)							(6)	6
135	*Bombus pascuorum* (SCOPOLI, 1763)	8(22)	8	2	2(5)	9	16(7)	(32)	111
136	*Bombus pratorum* (LINNAEUS, 1761)	1(2)	1	1	2	5	34(1)	(16)	63
137	*Bombus semenoviellus* SKORIKOV, 1910		2	1					3
138	*Bombus subterraneus* (LINNAEUS, 1758)						1	(1)	2
139	*Bombus sylvarum* (LINNAEUS, 1761)	2(15)	4						21
140	*Bombus terrestris* (LINNAEUS, 1758)		1	1		5	3		10
141	*Bombus veteranus* (FABRICIUS, 1793)	1(13)	9						23
142	*Psithyrus bohemicus* (SEIDL, 1837)			4	3	9	35	(2)	53
143	*Psithyrus campestris* (*Panzer*, 1801)					2	2		4
144	*Psithyrus rupestris* (FABRICIUS, 1793)		1			2	1		4
145	*Psithyrus sylvestris* (LEPELETIER, 1832)			2	1	23	33	(4)	63
146	*Apis mellifera* LINNAEUS, 1758	971	1420	1114	21	35	107		3668
Total		**1493**	**1705**	**1355**	**223**	**314**	**674**	**246**	**6010**
Total (without *Apis mellifera* L.)		521	285	241	203	279	567	246	2342

Table 2. Numbers of *Apis mellifera* (Moericke traps) on investigations in Białowieża National Park.

Year / Investigation plot	2005	2006	2007	Total
Experimental Garden	54	15	38	107
River valley („Reski")	11	13	11	35
Meadow („Cerkowny Wyrub")	85	319	1016	1420
Oak - hornbeam forest	154	182	778	1114
Alluwial forest	10	9	2	21
Coniferous forest	42	175	754	971
Total	356	713	2599	3668

Table 3. List of species of Apiformes in Białowieża Forest (* - REINIG 1937, ** - RASMONT 1984).

No.	Species	BNP		Adjacent areas	
		BANASZAK & JAROSZEWICZ	BISCHOFF, 1925	BANASZAK & JAROSZEWICZ	BISCHOFF, 1925
-1-	-2-	-3-	-4-	-5-	-6-
1	*Colletes cunicularius* (LINNAEUS, 1761)	+	-	+	-
2	*Colletes daviesanus* SMITH, 1846	+	-	+	-
3	*Colletes succinctus* (LINNAEUS, 1758)	-	-	+	-
4	*Hylaeus annularis* (KIRBY, 1802)	-	-	+	-
5	*Hylaeus bisinuatus*, FORSTER, 1871	+	-	-	-
6	*Hylaeus brevicornis* NYLANDER, 1852	+	-	-	-
7	*Hylaeus communis* NYLANDER, 1852	+	-	+	-
8	*Hylaeus confusus* NYLANDER, 1852	+	-	+	-
9	*Hylaeus difformis* (EVERSMANN, 1852)	+	-	-	-
10	*Hylaeus gibbus* SAUNDERS, 1850	+	-	+	-
11	*Hylaeus gracilicornis* (MORAWITZ, 1871)	-	-	+	-
12	*Hylaeus gredleri* FORSTER, 1871	+	-	-	-
13	*Hylaeus hyalinatus* SMITH, 1842	+	-	-	-
14	*Hylaeus pectoralis* FORSTER, 1871	+	-	-	-
15	*Hylaeus rinki* (GORSKI, 1852)	+	-	-	-
16	*Andrena apicata* SMITH, 1847	+	-	+	-
17	*Andrena barbilabris* (KIRBY, 1802)	-	+	-	+
18	*Andrena bicolor* FABRICIUS, 1774	+	+	-	+
19	*Andrena bimaculata* (KIRBY, 1802)	-	+	-	+
20	*Andrena chrysosceles* (KIRBY, 1802)	+	-	-	-

-1-	-2-	-3-	-4-	-5-	-6-
21	*Andrena cineraria* (LINNAEUS, 1758)	+	+	-	+
22	*Andrena clarkella* (KIRBY, 1802)	+	+	+	+
23	*Andrena denticulata* (KIRBY, 1802)	+	-	-	-
24	*Andrena dorsata* (KIRBY, 1802)	+	+	-	+
25	*Andrena flavipes* PANZER, 1799	+	+	-	-
26	*Andrena floricola* EVERSMANN, 1852	-	-	-	+
27	*Andrena fucata* SMITH, 1847	+	-	+	-
28	*Andrena fulva* (MULLER, 1766)	+	-	+	-
29	*Andrena fulvago* (CHRIST, 1791)	-	+	-	+
30	*Andrena fuscipes* (KIRBY, 1802)	+	-	-	-
31	*Andrena gravida* IMHOFF, 1899	-	-	+	-
32	*Andrena haemorrhoa* (KIRBY, 1802)	+	+	+	+
33	*Andrena helvola* (LINNAEUS, 1758)	+	-	+	-
34	*Andrena humilis* IMHOFF, 1832	+	-	-	-
35	*Andrena labiata* FABRICIUS, 1781	-	+	-	-
36	*Andrena lapponica* ZETTERSEDT, 1838	-	-	+	-
37	*Andrena minutula* (KIRBY, 1802)	+	+	-	+
38	*Andrena minutuloides* PERKINS, 1914	+	-	-	-
39	*Andrena morio* (BRULLE, 1832)	+	-	-	-
40	*Andrena nigroaenea* (KIRBY, 1802)	-	+	-	-
41	*Andrena nitida* (MULLER, 1776)	+	+	-	-
42	*Andrena ovatula* (KIRBY, 1802)	-	-	+	-
43	*Andrena pilipes* (FABRICIUS, 1781)	-	+	+	-
44	*Andrena praecox* (SCOPOLI, 1763)	+	+	+	+
45	*Andrena subopaca* NYLANDER, 1848	+	-	+	-
46	*Andrena thoracica* (FABRICIUS, 1775)	+	+	-	+
47	*Andrena tibialis* KIRBY, 1802	-	+	+	-
48	*Andrena vaga* PANZER, 1799	+	+	-	-
49	*Andrena ventralis* IMHOFF, 1832	-	+	-	+
50	*Andrena wilkella* (KIRBY, 1802)	+	+	-	-
51	*Panurgus calcaratus* (SCOPOLI, 1763)	+	+	+	+
52	*Halictus maculatus* SMITH, 1848	+	-	-	-
53	*Halictus quadricinctus* (FABRICIUS, 1775)	+	+	-	+
54	*Halictus rubicundus* (CHRIST, 1798)	+	+	-	-
55	*Halictus sexcinctus* (FABRICIUS, 1775)	+	-	+	+
56	*Seladonia subaurata* (ROSSI, 1792)	-	-	+	-
57	*Seladonia tumulorum* (LINNAEUS, 1758)	+	+	+	+
58	*Lasioglossum costulatum* (KREICHBAUMER, 1873)	+	-	+	-
59	*Lasioglossum lativentre* (SCHENCK, 1853)	+	-	-	-
60	*Lasioglossum leucozonium* (SCHRANK, 1781)	+	+	+	+
61	*Lasioglossum majus* (NYLANDER, 1852)	+	-	+	-
62	*Lasioglossum quadrinotatum* (KIRBY, 1802)	+	-	-	-
63	*Lasioglossum sexnotatum* (KIRBY, 1802)	+	+	-	+
64	*Lasioglossum zonulum* (SMITH, 1848)	+	+	-	+

-1-	-2-	-3-	-4-	-5-	-6-
65	*Evylaeus albipes* (FABRICIUS, 1781)	+	-	-	-
66	*Evylaeus calceatus* (SCOPOLI, 1763)	+	+	+	+
67	*Evylaeus fratellus* (PEREZ, 1903)	+	-	-	-
68	*Evylaeus fulvicornis* (KIRBY, 1802)	+	-	-	-
69	*Evylaeus intermedius* (SCHENCK, 1868)	-	-	+	-
70	*Evylaeus laticeps* (SCHENCK, 1876)	+	-	-	-
71	*Evylaeus leucopus* (KIRBY, 1802)	+	-	+	-
72	*Evylaeus lucidulus* (SCHENCK, 1861)	+	-	-	-
73	*Evylaeus morio* (FABRICIUS, 1793)	+	-	-	-
74	*Evylaeus pauxillus* (SCHENCK, 1853)	+	-	+	-
75	*Evylaeus sexstrigatus* (SCHENCK, 1868)	+	-	-	-
76	*Evylaeus villosulus* (KIRBY, 1802)	+	-	-	-
77	*Sphecodes albilabris* (FABRICIUS, 1793)	-	-	+	-
78	*Sphecodes ephippius* (LINNAEUS, 1767)	+	-	+	-
79	*Sphecodes geofrellus* (KIRBY, 1802)	+	-	+	-
80	*Sphecodes gibbus* (LINNAEUS, 1758)	-	-	+	-
81	*Sphecodes hyalinatus* HAGENS, 1882	-	-	+	-
82	*Sphecodes miniatus* HAGENS, 1882	+	-	-	-
83	*Sphecodes monilicornis* (KIRBY, 1802)	+	+	+	+
84	*Sphecodes puncticeps* THOMSON, 1870	-	-	+	-
85	*Sphecodes reticulatus* THOMSON, 1870	-	-	+	-
86	*Sphecodes* sp.	+	-	-	-
87	*Melitta leporina* (PANZER, 1799)	-	-	-	+
88	*Melitta nigricans* ALFKEN, 1905	+	-	-	+
89	*Macropis europaea* WARNCKE, 1973	+	-	+	+
90	*Macropis fulvipes* (FABRICIOUS, 1804)	+	-	-	-
91	*Dasypoda hirtipes* (HARRIS, 1780)	+	-	+	+
92	*Trachusa byssina* (PANZER, 1798)	+	-	-	-
93	*Anthidium manicatum* (LINNAEUS, 1758)	+	-	-	-
94	*Anthidellum strigatum* (PANZER, 1805)	-	-	+	-
95	*Stelis ornatula* (KLUG, 1807)	+	+	-	-
96	*Stelis phaeoptera* (KIRBY, 1802)	-	+	-	+
97	*Stelis punctulatissima* (KIRBY, 1802)	+	-	-	-
98	*Heriades crenulatus* NYLANDER, 1856	+	-	-	-
99	*Heriades truncorum* (LINNAEUS, 1758)	+	-	+	+
100	*Chelostoma campanularum* (KIRBY, 1802)	-	-	+	-
101	*Chelostoma distinctum* STOECKHERT, 1929	+	-	-	-
102	*Chelostoma florisomne* (LINNAEUS, 1758)	+	+	-	+
103	*Chelostoma rapunculi* (LEPELETIER, 1841)	-	-	-	+
104	*Hoplitis adunca* (PANZER, 1798)	-	+	-	+
105	*Hoplitis anthocopoides* (SCHENCK, 1853)	-	+	-	+
106	*Hoplitis claviventris* (THOMSON, 1872)	+	-	-	-
107	*Hoplitis leucomelana* (KIRBY, 1802)	-	+	-	+
108	*Osmia brevicornis* (FABRICIUS, 1798)	-	-	-	+

-1-	-2-	-3-	-4-	-5-	-6-
109	*Osmia coerulescens* (LINNAEUS, 1758)	-	-	-	+
110	*Osmia leaiana* (KIRBY, 1802)	+	-	-	+
111	*Osmia parietina* CURTIS, 1828	-	+	-	+
112	*Osmia rufa* (LINNAEUS, 1758)	+	+	+	+
113	*Chalicodoma ericetorum* (LEPELETIER, 1841)	+	-	-	+
114	*Megachile alpicola* ALFKEN, 1924	-	-	-	+
115	*Megachile centuncularis* (LINNAEUS, 1758)	+	-	-	-
116	*Megachile circumcincta* (KIRBY, 1802)	-	+	-	-
117	*Megachile lapponica* THOMSON, 1872	+	-	-	-
118	*Megachile ligniseca* (KIRBY, 1802)	+	-	-	+
119	*Megachile versicolor* SMITH, 1844	-	-	-	+
120	*Megachile willughbiella* (KIRBY, 1802)	+	+	-	+
121	*Coelioxys alata* FORSTER, 1853	+	-	-	-
122	*Coelioxys conoidea* (ILLIGER, 1806)	-	-	+	-
123	*Coelioxys elongata* LEPELETIER, 1841	+	-	-	-
124	*Coelioxys rufescens* LEPELETIER, 1825	-	-	-	+
125	*Anthophora furcata* (PANZER, 1798)	-	+	-	+
126	*Anthophora plumipes* (PALLAS, 1772)	+	+	-	+
127	*Anthophora retusa* (LINNAEUS, 1758)	-	+	-	+
128	*Eucera longicornis* (LINNAEUS, 1758)	-	+	-	+
129	*Tetralonia macroglossa* ILLIGER, 1806	+	-	-	-
130	*Tetralonia salicariae* (LEPELETIER, 1841)	-	-	+	-
131	*Ceratina cyanea* (KIRBY, 1802)	+	-	-	-
132	*Nomada femoralis* MORAWITZ, 1869	-	-	+	-
133	*Nomada ferruginata* (LINNAEUS, 1767)	+	-	+	-
134	*Nomada flava* PANZER, 1798	+	-	-	-
135	*Nomada flavoguttata* (KIRBY, 1802)	+	-	+	+
136	*Nomada flavopicta* (KIRBY, 1802)	-	-	+	-
137	*Nomada fulvicornis* FABRICIUS, 1793	-	+	-	-
138	*Nomada fuscicornis* NYLANDER, 1848	-	-	-	+
139	*Nomada goodeniana* (KIRBY, 1802)	-	-	+	-
140	*Nomada guttulata* SCHENCK, 1861	-	+	-	-
141	*Nomada leucophthalma* (KIRBY, 1802)	+	+	+	-
142	*Nomada moeschleri* ALFKEN, 1913	+	-	-	-
143	*Nomada ochrostoma* ZETTERSTEDT, 1838	+	+	+	-
144	*Nomada panzeri* LEPELETIER, 1841	+	+	+	-
145	*Nomada roberjeotiana* PANZER, 1799	-	-	+	-
146	*Nomada ruficornis* (LINNAEUS, 1758)	+	+	+	-
147	*Nomada sexfasciata* PANZER, 1799	-	+	-	+
148	*Nomada signata* JURINE, 1807	+	-	+	-
149	*Nomada striata* FABRICIUS, 1793	+	-	-	-
150	*Nomada zonata* PANZER, 1798	-	-	+	-
151	*Ammobates punctatus* (FABRICIUS, 1804)	-	-	+	-
152	*Epeoloides coecutiens* (FABRICIUS, 1775)	+	-	+	-

-1-	-2-	-3-	-4-	-5-	-6-
153	*Epeolus variegatus* (LINNAEUS, 1758)	-	-	+	-
154	*Bombus cryptarum* FABRICIUS, 1775	+	-	+	+
155	*Bombus distinguendus* MORAWITZ, 1869	-	+	-	+
156	*Bombus hortorum* (LINNAEUS, 1761)	+	+	-	+
157	*Bombus humilis* ILLIGER, 1806	-	+	-	-
158	*Bombus hypnorum* (LINNAEUS , 1758)	+	-	+	+
159	*Bombus jonellus* (KIRBY, 1802)	+	+	-	-
160	*Bombus lapidarius* (LINNAEUS, 1758)	+	+	-	+
161	*Bombus lucorum* (LINNAEUS 1761)	+	+	+	+
162	*Bombus magnus* (VOGT, 1911)	+	-	-	-
163	*Bombus muscorum* (LINNAEUS, 1758)	-	+	+	+
164	*Bombus pascuorum* (SCOPOLI, 1763)	+	-	+	-
165	*Bombus pratorum* (LINNAEUS, 1761)	+	+	+	+
166	*Bombus ruderarius* (MULLER, 1776)	-	-	-	+
167	*Bombus semenoviellus* SKORIKOV, 1910	+	-	-	-
168	*Bombus schrencki* (MORAWITZ, 1881)*	-	-	-	-
169	*Bombus subterraneus* (LINNAEUS, 1758)	+	+	+	+
170	*Bombus sylvarum* (LINNAEUS, 1761)	+	+	-	+
171	*Bombus sicheli* (RADOSZKOWSKI, 1859)*	-	-	-	-
172	*Bombus terrestris* (LINNAEUS, 1758)	+	+	-	+
173	*Bombus veteranus* (FABRICIUS, 1793)	+	-	-	-
174	*Psithyrus barbutellus* (KIRBY, 1802)	-	-	-	+
175	*Psithyrus bohemicus* (SEIDL, 1837)	+	-	+	-
176	*Psithyrus campestris* (PANZER, 1801)	+	+	-	+
177	*Psithyrus norvegicus* SCHNEIDER, 1918**	-	-	-	-
178	*Psithyrus rupestris* (FABRICIUS, 1793)	+	+	-	+
179	*Psithyrus sylvestris* (LEPELETIER, 1832)	+	-	+	-
180	*Psithyrus vestalis* (GEOFFROY in FOURCROY, 1785)	-	+	-	+
181	*Apis mellifera* LINNAEUS, 1758	+	+	+	+
	Total	119	65	73	68

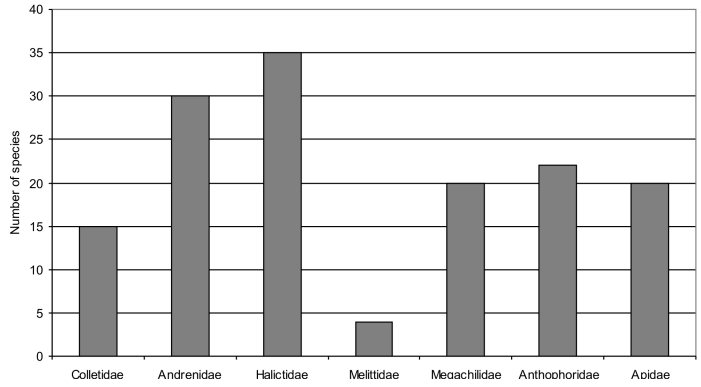

Fig. 8. Comparison of contributions of bee families among bees collected in the Białowieża National Park (traps and net).

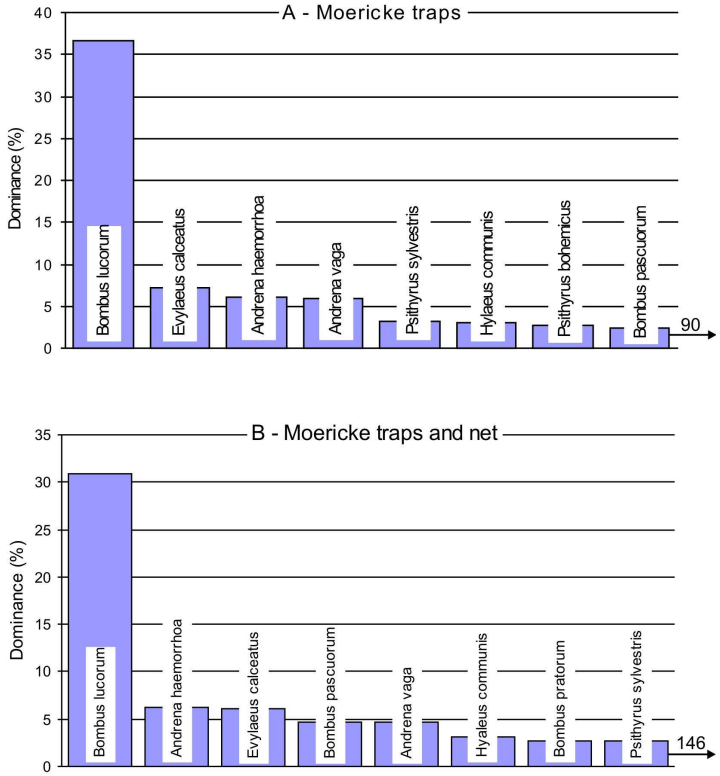

Fig. 9. Dominance structure of wild bees in the Białowieża National Park.

Characteristics of bee communities in the studied habitats

Three of the studied permanent plots (1-3) are open habitats, located near the edge of continuous forest (3) or being a meadow patch among woodland in a river valley (2) or with a large contribution of woody vegetation (1). In principle they are rich, patchy habitats, resulting from human activity, in contrast to the other three site, located in more continuous and natural forest stands (4-6).

1. The **Experimental Garden** proved to be the richest in bees, as 80 bee species were caught there in traps or with a sweep net. This is caused by a high diversity of host plants: herbs, shrubs and trees. In traps the dominant species were *Evylaeus calceatus* (16.2%) and *Andrena haemorrhoa* (12.9%), with high contributions of *Andrena chrysosceles*, *Bombus lucorum*, and *Colletes cunicularius* (Fig. 10f). This site is also most patchy, with various sites ranging from wet and shaded to open, dry and sandy. Hence this plot proved to be favourable to *Andrena haemorrhoa* (wooded sites), *Colletes cunicularius*, *Dasypoda hirtipes* or *Halictus sexcinctus.* Nests of the last mentioned species were observed between paving slabs in Sportowa Street in Białowieża (numerous males were caught there).

2. The **river valley** was characterized by a very diverse species composition, variety of sites, and a large contribution of bee forage plants. In total, 45 species of Apoidea were collected there, with the dominant *Bombus lucorum* (24.7%) and *Andrena vaga* (24.4%), and subdominant *Evylaeus calceatus* (11.3%) (Fig. 10d).

3. The **meadow** was a highly diversified habitat, bordering on oak-hornbeam forest. In total, 44 bee species were collected there, with the dominant *Bombus lucorum* (26.5%), and subdominant *Evylaeus calceatus* (12.0%) and *Andrena vaga* (10.4%) (Fig. 10e).

4. **Oak-hornbeam forest** was the most natural fragment, which is not directly affected by human activity. It is homogenous with respect to vegetation and soil. The smallest number of bee species was recorded there, in comparison with other plots: only 22 species, with *B. lucorum* as an eudominant (77.9%). *Evylaeus calceatus*, although preferring open habitats, accounts for 7.7%. *Andrena* spp. were infrequent, and only one cleptoparasitic species was collected (*Nomada ruficornis*) (Fig. 10a).

5. **Alluvial forest** formed a narrow belt of natural forest vegetation along the river Orłówka. In total, 30 bee species were found there, dominated by *B. lucorum* (55.2%!) and two other species with substantial contributions: *Andrena haemorrhoa* (7.5%) and *Psithyrus sylvestris* (8.2%) (Fig. 10b).

6. The gap in **coniferous forest** was due to a strong but natural disturbance of the forest ecosystem. It supports a large number of bees (as many as 53 species), with *Bombus lucorum* being an eudominant (39.7%). Other numerously represented species included *Osmia rufa* (7.2%), *Psithyrus bohemicus* (6.5%), *Bombus pratorum* (6.3%), and *Andrena haemorrhoa* (4.3%) (Fig. 10c).

Phenology of Apiformes

Seasonal dynamics of all bees in the Białowieża NP is presented in Fig. 11. It shows changes in the number of species active in various seasons and in their abundance. It is also noteworthy that bee abundance differed between years, but the general pattern was maintained, showing differences between spring, the transitional period in June, and summer. The largest numbers of species were recorded in both years from mid-April till late May, when the number of species in the park reached 16 (in 2006) or up to 25 (in 2007). Another peak was recorded in summer (in August), when the number of species of flying bees was about 15, but differed between years. In June the activity of bees clearly decreased. Then in the study area only several species were recorded (Fig. 11).

In early spring and spring, typical and most common species include *Andrena* species: *A. vaga, A. clarkella, A. haemorrhoa, A. helvola, A. nitida* and their cleptoparasites: *Nomada ruficornis, N. panzeri, N. ochrostoma, N. leucophthalma*, as well as *Evylaeus calceatus* and *Osmia rufa*. Active species of the transitional period (June) are chiefly *Bombus lucorum, Andrena chrysosceles, A. dorsata* and other species that are active for a long time. In summer, apart from *Bombus lucorum,* also *Hylaeus communis* as well as *Lasioglossum* spp. and *Evyleaus* spp. are abundant.

The pattern of bee abundance is similar to the pattern of bee diversity. Bees were most numerous in summer, i.e. in late July and early August, when bee abundance was on average up to 250 individuals per 10 days, but differed strongly between years, from 20 (August 2007) to 450 (in 2006).

Interesting differences between habitats were observed in the dynamics of bee diversity and abundance (Fig. 12). Their dynamics is most variable in open habitats, with most diverse bee forage plants: in the Palace Park and Experimental Garden, and in the river valley, where the curves have many peaks (Fig. 12a-b). In the other plots, the curves are simpler. One clear peak is observed there in spring (April-May) and another one in summer (early August) (Fig. 12c-f). The clear peaks of abundance in spring were due to the contribution of *Andrena vaga* (river valley in 2007) or *A. haemorrhoa* (meadow "Cerkowny Wyrub" in 2007) and *Osmia rufa* (coniferous forest in 2007).

In August the abundance peak was affected mostly by the high abundance of *B. lucorum*. For example, in early August 2006, 142 individuals were caught in oak-hornbeam forest (although next year this species was absent there in that period), 97 in alluvial forest, and 49 individuals on the meadow "Cerkowny Wyrub".

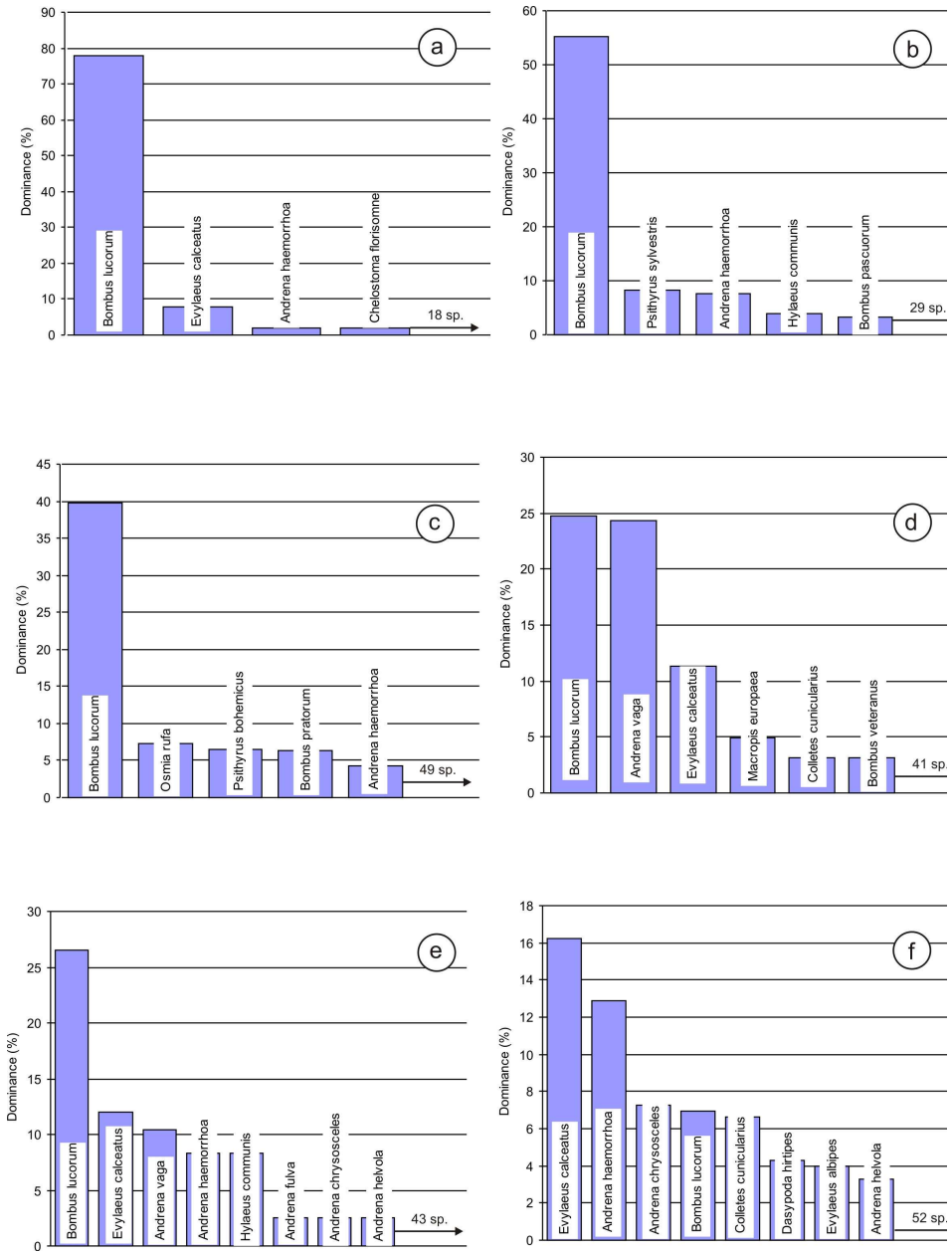

Fig. 10. Dominance structure of wild bees on research plots (Moericke traps): a – oak-hornbeam forest, b – alluvial forest, c – coniferous forest, d – river valley "Reski", e – meadow "Cerkowny Wyrub", f – Experimental Garden.

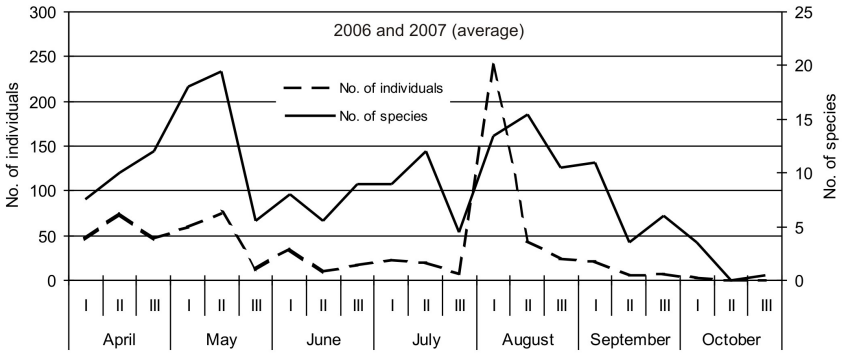

Fig. 11. Dynamics of the diversity and abundance of wild bees in the Białowieża National Park.

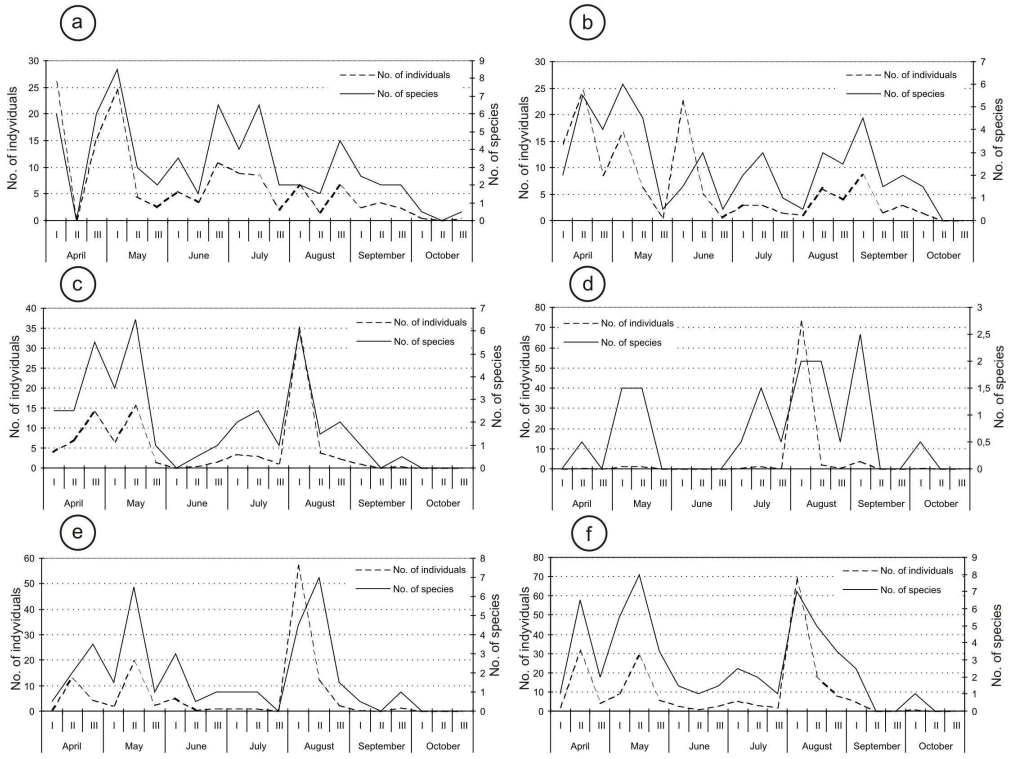

Fig. 12. Dynamics of the diversity and abundance of wild bees in the Białowieża National Park (2006-2007): a – Experimental Garden, b – river valley Reski", c – meadow "Cerkowny Wyrub", d – oak-hornbeam forest, e – alluvial forest, f – coniferous forest.

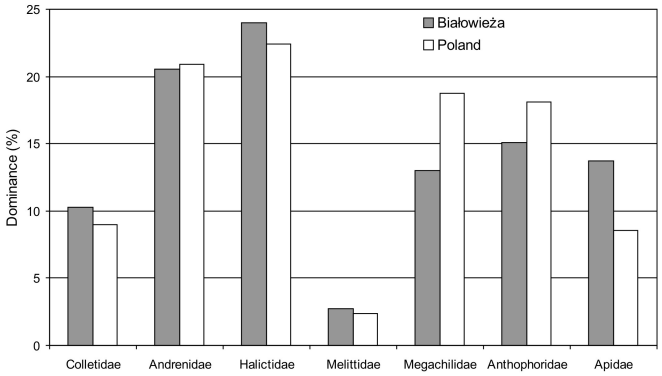

Fig. 13. Comparison of contributions of bee families among bees collected in the Białowieża National Park and Poland.

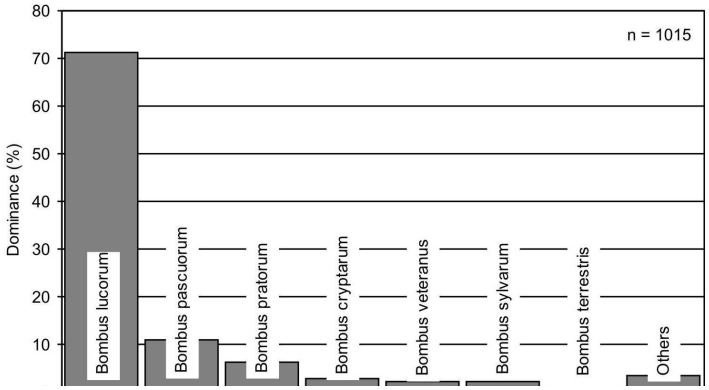

Fig. 14. Dominance structure of bumblebees in the Białowieża National Park.

DISCUSSION

Before this study, the Białowieża Forest, as the most valuable primeval fragment of European lowland forest, was insufficiently studied in respect of bee fauna. Only 64 species were known from the area that is now within the borders of the Białowieża NP, recorded 80 years ago by BISCHOFF (1925). Thanks to the present study, the number of bee species reported from the Park has increased over 2-fold. We collected 146 species of Apiformes in

the Białowieża NP and its immediate vicinity. In total, 181 bee species have been found in the Polish part of the Białowieża Forest (Table 3). This accounts for 38% of all bee species known from Poland. This certainly is not a complete list of bees inhabiting this area, but probably it is close to complete.

Knowledge of the Białowieża Forest fauna is important for at least two reasons: (1) the current fauna of the least disturbed areas reflects to some extent the past fauna of the region; and (2) consequently, it enables an assessment of changes in the fauna of other parts of Poland and Europe, where most forests are subject to management and only a small proportion of forests are protected within national parks, nature reserves, or NATURA 2000 sites.

In the relatively small study area, the total number of nearly 150 bee species is high, considering that the Białowieża NP is dominated by forest. Earlier research on other continuous woodlands in Poland shows that their bee fauna is less diverse than in open habitats (BANASZAK 1983, 2006, BANASZAK & KRZYSZTOFIAK 1996, BANASZAK & WENDZONKA 2002, BANASZAK et al. 2009, CIERZNIAK 2003a). In other Polish lowland national parks dominated by woodlands (Table 4), the number of bee species varies from 101 (Bory Tucholskie NP) to 226 (Wielkopolska NP), so the Białowieża NP is moderately rich in bee species.

Table 4. 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	References
Drawa NP	11342	82.0	121	25.5	BANASZAK et al. 2009
Bory Tucholskie NP	4798	79.0	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	75.0	180	38.2	BANASZAK & PLEWKA 1981
Białowieża NP	10517	96.0	181	38.6	BISCHOFF 1925, BANASZAK & JAROSZEWICZ

It must be stressed that the description of bee fauna presented here does not give a complete picture of its actual state at least because of: (1) a low degree of direct penetration with a sweep net, in relation to the whole area; and (2) bees were not collected in the canopy, but only at the forest floor. In contrast, research on oak-hornbeam and pine forest in the Wielkopolska National Park, revealed a considerable qualitative and quantitative variation in vertical bee distribution. That study showed that the forest floor differs from the canopy in respect of species diversity, dominance structure, and total abundance. In the herb layer of the forests, species number was twice as high as in the forest canopy. That study also proved that trees play an important role in the spectrum of bee forage plants in deciduous forests (BANASZAK & CIERZNIAK 1994). This applies mostly to honey bees, penetrating the canopy to a greater extent, for abundant nectar, pollen, and honeydew.

The question is if the fauna of the highly diversified and well-preserved natural woodland on the European Plain differs from the bee fauna of other national parks. A comparison of contributions of individual bee families in the Białowieża NP with their mean contributions to bee diversity in Poland (Fig. 13) indicates that they are not markedly different. There are no significant differences in contributions of the largest families (e.g. Andrenidae and Halictidae), and of the smallest families (e.g. Colletidae and Melittidae). Larger differences are observed among the more specialized long-tongued bees: Megachilidae, Anthophoridae, and Apidae (the last two families according to the older classification).

The Megachilidae account for 14.4% of bee species in the Białowieża Forest, but 18.8% in Poland, while the Anthophoridae for 15% and 18%, respectively. The very large difference in contribution of the Apidae (13.7% and 8.5%, respectively) probably results from the domination of woodland in the study area. The contribution of the Apidae in the past could be even greater when the honey bee was a constant component of all forests, before bee-keeping was banned in the Białowieża forest (in the late 19th century). Nowadays, *Apis mellifera* is brought to this area only occasionally. In the 17th century in the Białowieża Forest, 4500 beehives were recorded (including 1000 active ones) (BANASZAK, in print).

Table 1 shows that today the honey bee and bumblebees are the major components of the bee fauna of the Białowieża Forest. This study indicates that the honey bee is associated mostly with open habitats, but it should be remembered that the traps were located only on the forest floor, which could cause underestimation of its true abundance in the oak-hornbeam, alluvial or coniferous forest. It is common knowledge that honey bees forage on flowers of lime and other trees with honeydew, but this could be confirmed only by means of traps hanged in the canopy. In the Wielkopolska NP, *Apis mellifera* was a dominant together with *Andrena haemorrhoa* and *Bombus lucorum*, whereas at the forest floor it was recorded only sporadically (BANASZAK & CIERZNIAK 1994). Deciduous forests were always the major source of food for honey bees, also formerly in the Białowieża Forest, but the methods applied here do not reveal this.

Apart from the honey bee, also *Bombus lucorum* is an eudominant in most of the studied plant communities in the Białowieża NP. This species was most abundant in forests

(coniferous, oak-hornbeam, and alluvial), and much less abundant in open habitats, i.e. meadows (Table 1). These results confirm that this species prefers woodlands (BANASZAK 1983, 1993). This is certainly due to its strong association with plants of the family Ericaceae (ALFORD 1975), although RUSZKOWSKI (1971) listed a very large number of plant species pollinated by this species (570 species in Poland and neighbouring countries). Various coniferous forests cover as much as 37% of the Białowieża Forest. A clear dominance of *Bombus lucorum* (40% of total catch) was recorded earlier also in mixed pine-oak forest *Querceto robori-Pinetum* in the Wielkopolska NP (BANASZAK 1983), as well as in the Drawa NP, where it accounted for over 23% (BANASZAK et al. 2009). In other wooded national parks in Poland it was less abundant, although it was sometimes a subdominant, as in the Wigry NP (BANASZAK & KRZYSZTOFIAK 1996) or in the Bory Tucholskie NP (= Tuchola Forest NP) (BANASZAK & WENDZONKA 2002).

In comparison with the dominance of *B. lucorum* (which accounted for about 30.9% of the total catch of wild bees, other *Bombus* spp. had surprisingly low contributions, even the typical forest species *B. pratorum*, and the common *B. pascuorum*, which is associated with forests all over Poland. Among the 1015 individuals of all collected bumblebees in the study area, *B. lucorum* constituted 71.4%, while the generally most common in Poland *B. pascuorum* only 10.9%, *B. pratorum* 6.2%, and the reputedly typical forest species *B. sylvarum* 2.0%. Consequently, those bumblebee species in the Białowieża NP are only accessory (Fig. 14). Also cuckoo bumblebees were infrequent, e.g. *Psithyrus bohemicus* (cleptoparasite of *B. lucorum*) and *P. sylvestris* (cleptoparasite of *B. pratorum*).

Nowadays most Polish forests are managed, partly planted on former arable fields, sometimes renaturalized, while other areas are agroecosystems (about 60%) or urban ecosystems. In those areas, over hundreds of years, completely different quantitative and qualitative relationships among bees have developed. As a result of anthropogenic transformations of vegetation, *B. pascuorum* and *B. terrestris*, accessory in the Białowieża NP, are now the most common bumblebees in most of Poland.

This study, although preliminary, shows a very different picture of bee fauna in one of the last remnants of primeval lowland forest left in Europe. The current bee fauna of the Białowieża Forest, in the Middle Ages could be typical of most of Poland and other parts of the European Plain. Thus, beside honey bees, bumblebees probably dominated in the past, particularly *B. lucorum*, which in other areas has been replaced by *B. terrestris* and *B. pascuorum.*

The Białowieża Forest, as natural woodland, was never as homogeneous as the currently prevailing managed forest stands. This results from natural factors (windthrows, forest fires), as well as from human activity (livestock grazing, bee-keeping, burning of vegetation). As a result of all the above-mentioned factors, the forest stands are uneven-aged and the vegetation (not only woody) is very patchy. This has helped to preserve the diversity and abundance of bee forage plants and nesting sites.

Such forest create favourable conditions for species with various environmental and food requirements. This still applies to the Białowieża Forest, where the typical forest spe-

cies *Bombus lucorum*, as an eudominant, is accompanied by frequent species associated with open and dry habitats, e.g. *Evylaeus calceatus* and *Andrena vaga*.

The dominant forest type is oak-hornbeam forest *Tilio-Carpinetum*, which accounts for nearly half of the Białowieża Forest. Individual major oak-hornbeam communities have not been studied satisfactorily yet in respect of bee fauna, but the rough estimation can be used for comparison with similar forest communities in other parts of Poland. In the strictly protected part of the Białowieża NP, bees in oak-hornbeam forest were studied by the use of traps, as well as directly in the field, in spring and summer. In total, 22 bee species were recorded there. Considering the abundant flowering of the herb layer in April-May, dominated by anemones (*Anemone sylvestris*) and other attractive bee forage plants, such as fumewort (*Corydalis*), lungwort (*Pulmonaria*), and *Isopyrum thalictroides*, this number is relatively small, lower than in other studied forest types, i.e. alluvial and coniferous forests. However, the low number of bee species in oak-hornbeam forest is a rule, as shown by investigations conducted in other parts of Poland.

One of the best-studied oak-hornbeam forests in other parts of Poland is the reserve "Grabina im. A. WODZICZKI" in the Wielkopolska National Park. It is the most natural fragment of that park, but it lacks the primeval character that can be noticed in the Białowieża NP. That reserve is well-studied in respect of bee fauna. BANASZAK (1983, 1987) found there 11 species of Apiformes. Further research in the same reserve brought information about a total of 15 species (BANASZAK 1997), but only 13 species 10 years later (BANASZAK et al. 2003). CIERZNIAK (2003b) listed 23 bee species from various oak-hornbeam forest stands in the Wielkopolska NP. Similarly, BANASZAK (1990) reported on 19 species in oak forest in the Masovian Lowland (Nizina Mazowiecka) (nature reserve "Grabina"). Those data indicate that natural oak-hornbeam forest supports a relatively small number of bee species, up to about 20 species. Considering species composition, in oak-hornbeam forests in the Wielkopolska-Kujawy Lowland (Nizina Wielkopolsko-Kujawska) and Masovian Lowland (Nizina Mazowiecka), the dominant species of wild bees (>10% of the total catch) were: *Bombus pascuorum, B. lucorum, B. pratorum, Nomada ruficornis, Andrena helvola, A. ventralis, A. barbilabris, A. subopaca,* and *Lasioglossum fulvicorne*. The most common were *Andrena* spp. and their cleptoparasites of the genus *Nomada* spp.

SUMMARY AND CONCLUSIONS

1. Research in selected plant communities in the Białowieża National Park provided information about 146 species of Apiformes, so the list of bee species reported from this area has increased by 82 species. Thus the total number of bees recorded in the Polish part of the Białowieża Forest has reached 181 species.

2. The major species, beside the more or less abundant honey bee, is *Bombus lucorum*, which accounted for about 30% of the total catch of wild bees, and for 71.5% of bumblebees in the Białowieża NP. In contrast, among three other bumblebee species, dominating

in a large part of Poland, *B. pascuorum* accounts for nearly 11%, while *B. terrestris* and *B. lapidarius* are accessory species.

3. Honey bees accounted for 61% of the total catch. They probably come from apiaries located in the Białowieża Glade, or from those transported to the vicinity of the studied plant communities. Currently it is most frequent in open habitats (meadows), while infrequent at the floor of oak-hornbeam, alluvial or coniferous forest, but undoubtedly it can be abundant in the canopy of tress that produce nectar (lime) and honey-dew. We failed to determine what proportion of honey bees come from natural forest sites, but single wild swarms were observed in the Białowieża Forest. In the past, honey bees were a permanent, dominant component of its fauna. Till the 19th century, bee-keeping was very common in the Białowieża Forest.

4. About half of the collected wild bees are bumblebees or cuckoo bumblebees (48.6%), while the others are solitary (51.4% of total species).

5. Among solitary bees in the Białowieża Forest, the most abundant are: *Andrena haemorrhoa* (6.2%), *Evylaeus calceatus* (6.1%). *Andrena vaga* (4.7%), *Hylaeus communis* (3.0%), *Andrena helvola* (2.2%), *Osmia rufa* (2.3%), and *Andrena chrysosceles* (1.4%). These species have various environmental and food requirements, but the Białowieża NP creates favourable conditions for a wide spectrum of species, thanks to a mosaic of old and young forest and meadow communities.

6. Considering that the Białowieża Forest and particularly its parts protected as strict reserves are fragments of ancient woodland, this study shows approximately how the bee fauna looked like in Poland and part of the European Plain before human activity started to change the landscape radically, starting from the Middle Ages.

7. Extrapolating the current state of Apiformes in the Białowieża NP and generally in Poland it can be assumed that as woodlands have shrunk in Poland and the total area of agricultural landscape has increased, not only the dominance structure of bees has changed but the Polish territory has been colonized by increasing numbers of species associated with open habitats (steppes).

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