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The spider fauna (Araneae) of tree canopies in the Białowieża Forest

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Abstract: Spider communities of tree-canopies in primary forest sanctuaries and forest plantations of the Białowieża Forest were sampled using insecticidal knockdown fogging. The communities showed the typical guild-, family- and species-composition of European forests with a dominance of web spiders and woodland-canopy spiders (e. g. *Diaea dorsata*, *Anyphaena accentuata*, *Paidiscura pallens*, *Keijia tincta*, *Theridion varians*). Based on 78 fogged trees, 14522 spiders (3936 adults) were sampled and sorted to 89 species from 15 families. They comprised 21% of the known species pool of the Białowieża Forest (428 species). The importance of the canopy stratum as a habitat for spiders is emphasized. Six species are new records for the Białowieża Forest. The rarely found *Dipoena nigroreticulata* Simon, 1879 (Theridiidae) was the only species with a preference for a single forest type. It was recorded from canopies of old oaks in a primary forest and might be an indicator species of old forests close to their natural condition.

Key words: canopy, insecticidal fogging, guild composition, *Theridion palmgreni*

INTRODUCTION

The Białowieża Forest is of particular interest for basic ecological research because some of the last stands of lowland primary forests of Europe can be found here (Faliński 1986, Jędrzejewska & Jędrzejewska 1998). Most ecological investigations in Europe and beyond have neglected the canopy even though it is known to harbour a diverse and abundant fauna of arthropods (Gunnarsson 1990–2004, Sterzyńska & Ślepowroński 1994, Schubert 1998, Floren & Otto 2002, Blick & Goßner 2006, Floren & Sprick in press, Floren & Schmidl in press). Furthermore, little effort has been invested in studying primary forests, which remained largely untouched by anthropogenic disturbance. This raises the question how strongly the fauna of the primary forests differs from that of cultural forests as found in various studies (Jędrzejewska & Jędrzejewski 1998, Tomiałojć 1991, Floren & Deelemann 2005).

In 2001 we started to investigate tree-specific arboreal arthropod communities in the Białowieża Forest using insecticidal knock-down fogging. One of our target taxa are spiders, an important group of predators which are regularly found in the canopy contributing between 4 and 12 % of the arboreal arthropod fauna (Floren et al. in press). In this paper we report on the faunistic results. The Białowieża Forest has already been the focus of arachnological studies (Sterzyńska & Ślepowroński 1994, Łęgowski 2001, Staręga & Kupryjanowicz 2001, Stańska et al. 2002, Łęgowski & Stańska 2003, Stańska 2003) of which only one focused on the canopy stratum. Sterzyńska & Ślepowroński (1994) sampled nine canopies of three pine forests of varying stand age using Moericke yellow pan traps. Accordingly, the 421 spider species recorded so far mainly represent lower strata of the forest while the contribution of arboreal spiders to the regional community is almost unknown. One of the aims of this work is to fill this gap and provide knowledge on the arboreal spider community of the Białowieża Forest.

In this article we make no effort analysing the differences between spider communities of primeval and managed forests. This topic will be dealt with in a separate work (Floren et al. in press.).

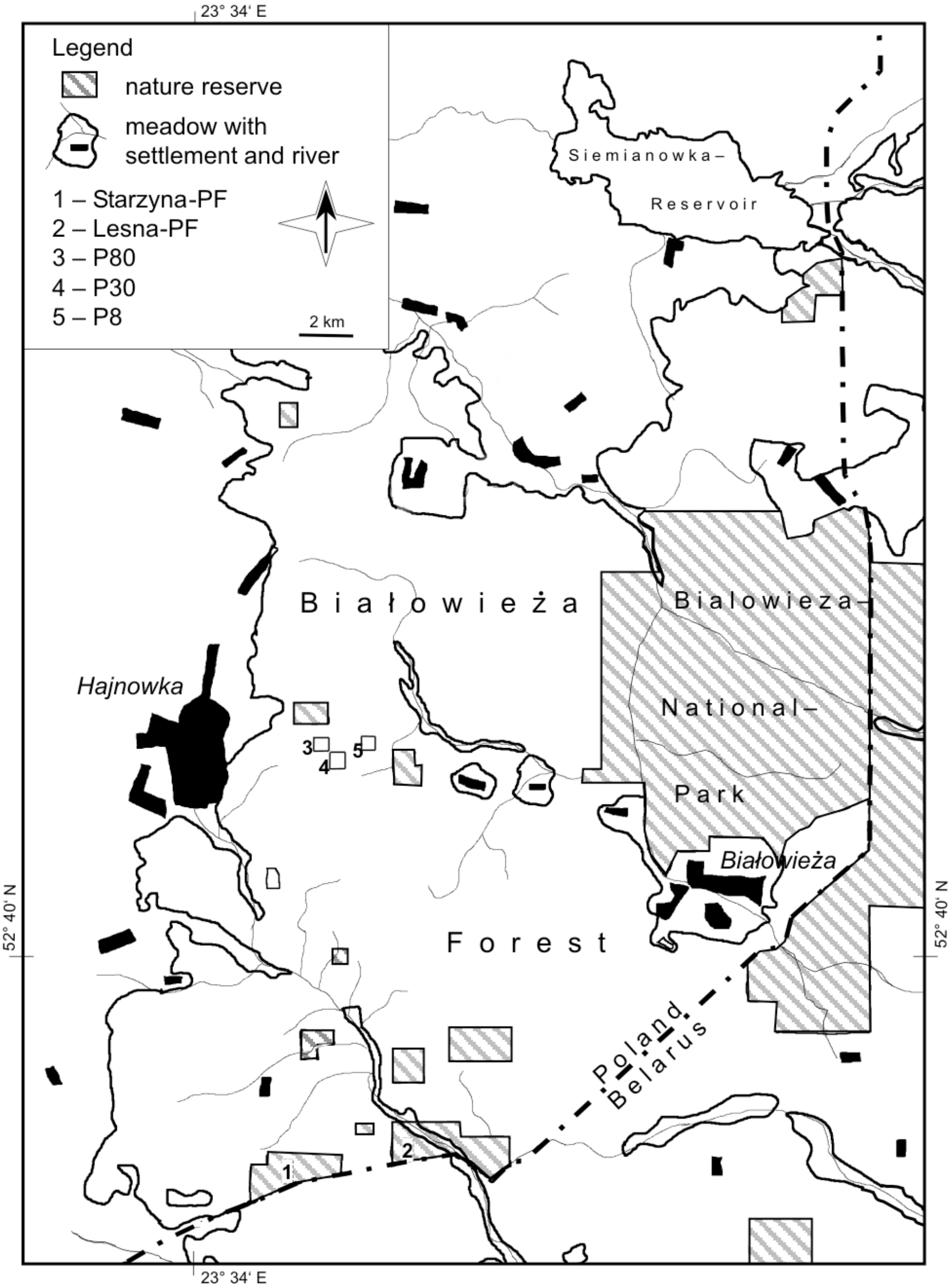

Fig. 1: Forest map and study sites.

STUDY AREA

Investigations were conducted in June and July 2001 in the Polish part of the Białowieża Forest (forest district Hajnówka). The forest extends over 1500 square kilometres across the border between Poland and Belarus (52°30'–53°N; 23°30'–24°15'E). The geological setting is comprised of fluvial sediments such as sands and clays. The vegetation-period (days of at least +5°C) extends over ca. 205 days with an average annual temperature of 6.8°C (Jędrzejewska & Jędrzejewski 1998). The usual forest formations of this transition zone between temperate und cold-temperate climates are oak-linden-hornbeam-forests (Mayer 1985). Here, spruce (*Picea abies*) is a natural part of lowland-forests and increases in dominance to the east.

About 44% of the area is covered by historically old forests, which are of natural (i.e. post-glacial) origin (Jędrzejewska & Jędrzejewski 1998). Today the remaining relicts of primary forest exist due to their century-long status as a royal hunting and leisure-district of the Białowieża Forest under the rule of both the Polish kings and Russian tsars. This prevented large-scale forest clear-cuts and extended settlements (Faliński 1986). Together with the more recent nature-conservation measures in the Białowieża Forest these conditions were responsible for the survival of Europe's largest primary woodland (Faliński 1986, Jędrzejewska & Jędrzejewski 1998).

STUDY DESIGN

All forest stands were part of the same forest-matrix (Fig. 1). The sampling included five forest-stands in the forest district Hajnówka, of which two were considered primary forests (PF) (Leśna PF: quadrants 669E, 703A; and the nature reserve Starzyna PF: quadrant 730A). The managed stands included an eight-year-old spruce plantation (P8) (quadrant 305C), a 30 year old oak plantation (P30) (quadrant 332A), and an 80 year old oak-hornbeam plantation (P80) (quadrant 303D). In total, the arthropods of 78 trees were fogged. The focus was on *Quercus robur* (L.), *Carpinus betulus* L. and *Picea abies* (L.). Details on the study-plots are presented in Table 1.

Table 1: Composition of the studied forest-plots.

Plot	Tree-age in years	Forest type	Number of sampled trees		
			Quercus robur	*Carpinus betulus*	*Picea abies*
Starzyna PF	200	mixed oak-hornbeam-spruce forest	7	2	2
Leśna PF	200–300	mixed oak-hornbeam-spruce forest	9	7	7
P80	80	mixed oak-hornbeam-spruce forest	9	9	6
P30	30	oak plantation	10	-	-
P8	8	spruce plantation	-	10	-

SAMPLING

Natural pyrethrum was used as insecticide. It is highly arthropod-specific and photochemically destroyed within a few hours while the solvent, a highly-refined mineral oil ('white-oil'), contained no other chemical additives. The fogging-machine creates a standing sound-wave which pounces the oil-insecticide-mixture (1% conc.) into droplets as small as 10 μm. Due to the small size of these droplets the resulting exhaust is a non-moistening fog which reaches into the smallest cracks and crevices on the bark and between leaves and needles. The insecticide fog is warm, resulting in a swift uplift into the canopy after ejection from the machine. Fogging was conducted between 28 June and 8 July 2001 early in the morning at sunrise when there was no wind drift. Prior to the fogging, plastic sheets were installed underneath of tree crowns to collect the arthropods falling from the canopy. These sheets covered 80% or more of the tree crown projection area. The fogging lasted for about 10 minutes. Arthropods were allowed to fall onto the sheets for 2 hours and were stored in ethanol (70 %) until determination. For further details see Floren & Linsenmair (1997) and Floren & Schmidl (2003). The spiders were counted and determined to species using the determination-keys of Wiehle (1931, 1956, 1960), Heimer & Nentwig (1991), Roberts (1993, 1995), Finch (1999) as well as Nentwig et al. (2003).

GUILD CLASSIFICATION

Although spiders are often divided into feeding guilds to assess their functionality in ecosystems no single accepted guild-concept exists so far. Uetz et al. (1999) discuss this in detail, proposing a guild concept of 6 to 8 guilds. We used this concept with the following exceptions: (1) Linyphiidae were placed within space-web builders as most species are sedentary within their webs, (2) runners and stalkers were placed within one guild (agile hunters), and (3) Philodromidae were placed within the guild "agile hunters" following Halaj et al. (1998) and Hatley & McMahon (1980) although these spiders additionally acquire prey through a sit-and-wait strategy (Haynes & Sisojević 1966). As no species of the guild sheet web-builders were recorded in this study, we distinguished four major guilds: orb-weavers, space-web weavers, agile hunters, and ambushers.

RESULTS

The collected 14522 spiders belonged to 89 species from 15 families (Table 2). Of all specimens 3936 (27 %) were in the adult stage and 10586 (73 %) were juveniles. 4012 (28 %) juveniles with recognizable habitus or species-characteristics were included in the analysis (*Anyphaena accentuata, Araneus diadematus, Hyptiotes paradoxus, Cyclosa conica, Diaea dorsata, Enoplognatha ovata, Keijia tincta, Linyphia triangularis, Paidiscura pallens*). Therefore, our analysis represents nearly 55 percent of all specimens. Eighteen species made up almost half of the community. These were mostly widespread and elsewhere abundant species (Table 3).

Table 2. Species list. Numbers represent total abundance of the species (adults + juveniles). * – new records for the Białowieża Forest. ** – after Staręga et al. (2002): VU = vulnerable, DD = data deficient.

No.	Species	Red List**	Leśna-Forest	Starzyna -Reserve	P80	P30	P8
1	2	3	4	5	6	7	8
	Mimetidae						
1	*Ero furcata* (Villers, 1789)		1	1			
	Uloboridae						
2	*Hyptiotes paradoxus* (C.L. Koch, 1834)*		1	1	24	2	3
	Theridiidae						
3	*Achaearanea lunata* (Clerck, 1757)		34	24	15	1	1
4	*Achaearanea simulans* (Thorell, 1875)		3		4	2	2
5	*Anelosimus vittatus* (C. L. Koch, 1836)*		1				
6	*Dipoena nigroreticulata* (Simon, 1879)	VU	4				
7	*Dipoena torva* (Thorell, 1875)*	VU	3				
8	*Enoplognatha ovata* (Clerck, 1757)		359	387	145	63	9
9	*Keijia tincta* (Walckenaer, 1802)		191	51	104	16	66
10	*Paidiscura pallens* (Blackwall, 1834)		669	2	15	22	
11	*Robertus arundineti* (O. P.-Cambridge, 1891)		1				
12	*Theridion mystaceum* L. Koch, 1870		24	4	6		1
13	*Theridion palmgreni* Marusik et Tsellarius, 1986*						4
14	*Theridion pinastri* L. Koch, 1872		10	6	15	5	
15	*Theridion varians* Hahn, 1833		307	5	48	44	2

1	2	3	4	5	6	7	8
	Theridiosomatidae						
16	*Theridiosoma gemmosum* (L. Koch, 1877)	VU	1				
	Linyphiidae						
17	*Araeoncus humilis* (Blackwall, 1841)		3			2	
18	*Bathyphantes gracilis* (Blackwall, 1841)		1				
19	*Ceratinella brevis* (Wider, 1834)		4			1	
20	*Diplocephalus latifrons* (O. P.-Cambridge, 1863)		1		2		
21	*Diplocephalus picinus* (Blackwall, 1841)		32			1	
22	*Diplostyla concolor* (Wider, 1834)		1				
23	*Dismodicus bifrons* (Blackwall, 1841)					1	
24	*Entelecara acuminata* (Wider, 1834)						1
25	*Entelecara congenera* (O. P.-Cambridge, 1879)		2				17
26	*Entelecara erythropus* (Westring, 1851)		1			1	
27	*Erigone atra* Blackwall, 1833		10		4		
28	*Erigone dentipalpis* (Wider, 1834)		6		1	1	
29	*Gongylidiellum murcidum* Simon, 1884		1				
30	*Gongylidium rufipes* (Linnaeus, 1758)		6				
31	*Hylyphantes graminicola* (Sundevall, 1830)		1				
32	*Hypomma cornutum* (Blackwall, 1833)		290		2		
33	*Kaestneria dorsalis* (Wider, 1834)		5				
34	*Linyphia triangularis* (Clerck, 1757) (juv.)		7		1		
35	*Maso sundevalli* (Westring, 1851)		5		2	1	
36	*Meioneta innotabilis* (O. P.-Cambridge, 1863)		8	2			11
37	*Meioneta mollis* (O. P.-Cambridge, 1871)		1				
38	*Meioneta rurestris* (C. L. Koch, 1836)		3	2	2		
39	*Microneta viaria* (Blackwall, 1841)					1	
40	*Moebelia penicillata* (Westring, 1851)		32		19	1	17
41	*Neriene emphana* (Walckenaer, 1842)		80	3	19	46	3
42	*Neriene montana* (Clerck, 1757)		20		2	2	
43	*Neriene peltata* (Wider, 1834)		86	6	5	6	1
44	*Obscuriphantes obscurus* (Blackwall, 1841)						2
45	*Oedothorax gibbosus* (Blackwall, 1841)		1				
46	*Peponocranium cf. orbiculatum* (O. P.-Cambridge, 1882)	VU			1		
47	*Pityohyphantes phrygianus* (C.L. Koch, 1836)		9	20	7		5
48	*Porrhomma pygmaeum* (Blackwall, 1834)		8			1	
49	*Tenuiphantes alacris* (Blackwall, 1853)			1			
50	*Tenuiphantes tenebricola* (Wider, 1834)		3	4	5	1	
51	*Trematocephalus cristatus* (Wider, 1834)		25	5	17	11	
52	*Walckenaeria alticeps* (Denis, 1952)		1				
53	*Walckenaeria atrotibialis* (O. P.-Cambridge, 1878)			1			
	Araneidae						
54	*Araneus cf. diadematus* Clerck, 1757		17	9	4		1
55	*Araneus nordmanni* (Thorell, 1870) (juv.)	VU	4	2	5		5
56	*Araneus sturmi* (Hahn, 1831)		2		3	3	1
57	*Araneus triguttatus* (Fabricius, 1793)		1	1		1	
58	*Araniella alpica* (L. Koch, 1869)		8		1		
59	*Araniella cucurbitina* (Clerck, 1757)		32		17	4	
60	*Araniella opisthographa* (Kulczyński, 1905)		1	2	1		
61	*Cyclosa conica* (Pallas, 1772)		55	18	49	6	29
62	*Gibbaranea gibbosa* (Walckenaer, 1802)*		1				
63	*Gibbaranea sp./ Araneus angulatus* Clerck, 1757 (juv.)		63	15	30	10	55
64	*Stroemiellus stroemi* (Thorell, 1875)		1				
	Tetragnathidae						
65	*Metellina mengei* (Blackwall, 1869)		9		1		
66	*Metellina cf. mengei* (Clerck, 1757) (juv.)		124	19	3	8	187
67	*Tetragnatha montana* Simon, 1874		93		4		
68	*Tetragnatha obtusa* C. L. Koch, 1837		199	3	30		5

1	2	3	4	5	6	7	8
	Zoridae						
69	*Zora spinimana* (Sundevall, 1833)		1			1	
	Dictynidae						
70	*Dictyna pusilla* Thorell, 1856		67		14	6	24
	Anyphaenidae						
71	*Anyphaena accentuata* (Walckenaer, 1802)		626	59	288	144	30
	Clubionidae						
72	*Clubiona caerulescens* L. Koch, 1867		1			2	
73	*Clubiona lutescens* Westring, 1851		2				
74	*Clubiona marmorata* L. Koch, 1866		8				
75	*Clubiona pallidula* (Clerck, 1757)		3				
76	*Clubiona subsultans* Thorell, 1875		1				
	Gnaphosidae						
77	*Haplodrassus soerenseni* (Strand, 1900)		1				
78	*Micaria subopaca* Westring, 1861		2		1		
	Philodromidae						
79	*Philodromus albidus* Kulczyński, 1911*	DD	9				
80	*Philodromus aureolus* (Clerck, 1757)		9	2	15	5	
81	*Philodromus collinus* C. L. Koch, 1835		93	1	28	4	2
	Thomisidae						
82	*Diaea dorsata* (Fabricius, 1777)		714	150	454	194	36
83	*Pistius truncatus* (Pallas, 1772)*		4		3	1	
84	*Xysticus audax* (Schrank, 1803)			1			
85	*Xysticus lanio* C. L. Koch, 1835		4	1	2		
	Salticidae						
86	*Ballus chalybeius* (Walckenaer, 1802)		57	1	28	59	
87	*Dendryphantes rudis* (Sundevall, 1833)		11		4		5
88	*Pseudeuophrys erratica* (Walckenaer, 1826)		1		1		
89	*Salticus zebraneus* (C.L. Koch, 1837)		2				
	Number of fogged trees		**23**	**11**	**24**	**10**	**10**

Table 3: Species collected with at least 50 individuals representing close to 50% of all spiders. Habitat after Heimer & Nentwig (1991) and Platen et al. (1999). * – as juveniles (10 adult *M. mengei*).

No.	Species	Family	Total abundance	%	Habitat
1	*Diaea dorsata*	Thomisidae	1548	21.8	canopies, forests
2	*Anyphaena accentuata*	Anyphaenidae	1147	16.1	canopies, forests
3	*Enoplognatha ovata*	Theridiidae	963	13.5	forest-edges
4	*Paidiscura pallens*	Theridiidae	708	9.9	canopies, forests
5	*Keijia tincta*	Theridiidae	428	6.0	canopies, forest-edges
6	*Theridion varians*	Theridiidae	406	5.7	canopies, forest-edges
7	*Metellina cf. mengei**	Tetragnathidae	351	4.9	forest-edges
8	*Hypomma cornutum*	Linyphiidae	292	4.1	canopies, forests
9	*Tetragnatha obtusa*	Tetragnathidae	237	3.3	canopies, forest-edges
10	*Cyclosa conica*	Araneidae	157	2.2	canopies, forests
11	*Neriene emphana*	Linyphiidae	151	2.1	forests
12	*Ballus chalybeius*	Salticidae	145	2.0	canopies, forests
13	*Philodromus collinus*	Philodromidae	128	1.8	canopies
14	*Dictyna pusilla*	Dictynidae	111	1.6	canopies
15	*Neriene peltata*	Linyphiidae	104	1.5	forests
16	*Tetragnatha montana*	Tetragnathidae	97	1.4	forests
17	*Achaearanea lunata*	Theridiidae	75	1.1	canopies, forests
18	*Moebelia penicillata*	Linyphiidae	69	1.0	canopies

FAUNISTICALLY REMARKABLE SPECIES

Currently, 422 spider-species are known from the Białowieża Forest (Sterzyńska & Ślepowroński 1994, Łęgowski 2001, Staręga & Kupryjanowicz 2001, Stańska et al. 2002, Łęgowski & Stańska 2003, Stańska 2003, Blick et al. 2006). We found six species new for the Białowieża Forest. This material contained also *Theridion palmgreni* – a species, which was published as a first record for Poland (Blick et al. 2006).

1. *Theridion palmgreni* Marusik et Tsellarius, 1986 (Theridiidae)

Material: 5 ♀: VII/8/2001, Białowieża Forest, quadrant 305C E, eight year old spruce-monoculture, *P. abies*, leg. Floren & Otto; Voucher specimens: 3 ♀ Coll. Stefan Otto; 1 ♀ Coll. T. Blick; 1 ♀ Coll. Museum Helsinki (inv. number 51.112).

The specimens were initially mistaken for *Theridion melanurum* (Otto 2004). For details on this first record in Poland and Central Europe and the species' distribution and ecology see Blick et al. (2006).

2. *Anelosimus vittatus* (C. L. Koch, 1836) (Theridiidae)

Material: 1 ♂: VI/28/2001, Białowieża Forest, Starzyna-Reserve, quadrant 730 A, oak-hornbeam primary forest, *C. betulus*, leg. Floren & Otto; Voucher specimen: Coll. Stefan Otto.

Anelosimus vittatus is distributed throughout the whole Palearctic (Platnick 2006).

This arboreal species is commonly found on trees and bushes preferring moderately xerothermic woodlands (Blick in litt., Heimer & Nentwig 1991; Platen et al. 1999). Kubcová & Schlaghamerský (2002) recorded this species from standing dead wood in the Czech Republic.

3. *Dipoena torva* (Thorell, 1875) (Theridiidae)

Material: 3 ♀: VII/2/2001, Białowieża Forest, quadrant 669 E, Leśna-Forest, oak-hornbeam primary-forest, *Q. robur*, leg. Floren & Otto; Voucher specimens: Coll. Stefan Otto.

Dipoena torva is distributed throughout the whole Palaearctic (Platnick 2006). Sterzyńska & Ślepowroński (1994) recorded this species from the Biała Forest near the Białowieża Forest.

It is a species of the higher strata and regularly recorded from tree-trunks and canopies (Simon 1997; Muster 1998; Kubcová & Schlaghamerský 2002; von Broen & Jakobitz 2004 (in Blick & Goßner 2006). The genus *Dipoena* is supposed to specialize on ants as prey (Simon 1997, Knoflach & Pfaller 2004). *D. torva* is one of the threatened spider species in Poland (status vulnerable in the Red List of Poland, Staręga et al. 2002).

4. *Hyptiotes paradoxus* (C. L. Koch, 1834) (Uloboridae)

Material: 1 juv.: VI/28/2001, Białowieża Forest, Starzyna Reserve, quadrant 730 A, oak-hornbeam primary-forest, *Q. robur*, leg. Floren & Otto; 1 juv.: VI/30/2001, Białowieża Forest, quadrant 669 E, Leśna Forest, oak-hornbeam primary forest, canopy of *Q. robur*, leg. Floren & Otto; 3 ♀, 20 juv.: VII/6/2001 and VII/5/2001, Białowieża Forest, quadrant 303 D, oak-hornbeam plantation, *P.abies* (3♀, 19 juv.) and *Q. robur* (1 juv.), leg. Floren & Otto; 2 juv.: VII/8/2001, Białowieża Forest, quadrant 332A, oak-plantation, 30-year old *Q. robur*, leg. Floren & Otto; 1 ♀, 2 juv.: VII/8/2001, Białowieża Forest, quadrant 305C E, eight year old spruce-monoculture, *P. abies*, leg. Floren & Otto; Voucher specimens: Coll. Stefan Otto.

Hyptiotes paradoxus is distributed throughout the whole Palearctic (Platnick 2006).

It is an arboreal species of coniferous forests and is regularly found in European spruce-plantations (Heimer & Nentwig 1991, Platen et al. 1999).

5. *Gibbaranea gibbosa* (Walckenaer, 1802) (Araneidae)

Material: 1 ♂: VI/30/2001, Białowieża Forest, quadrant 669 E, oak-hornbeam primary-forest, *Q. robur*, leg. Floren & Otto; Voucher specimen: Coll. Stefan Otto.

The range of *Gibbaranea gibbosa* extends from Europe southeast to Azerbaijan (Platnick 2006). The trees and bushes of forests are the typical habitats for this arboreal species (Platen et al. 1999). Vité (1953) recorded *G. gibbosa* from forest-edges and Braun (1992) found *G. gibbosa* on tree-trunks at a height of 8 m. Kubcová & Schlaghamerský (2002) recorded this species on standing dead wood in the Czech Republic.

6. *Philodromus albidus* Kulczyński, 1911 (Philodromidae)

Material: 8 ♂: VI/30/2001 (6), VI/29/2001 (1) and VII/2/2001 (1); 1 ♀: VI/29/2001, Białowieża Forest, quadrant 669 E, oak-hornbeam primary-forest, canopy of *Q. robur* (7 ♂♂) and *C. betulus* (1 ♂;1 ♀), leg. Floren & Otto; Voucher specimens: Coll. Stefan Otto.

According to Platnick (2005) *Philodromus albidus* is a species distributed throughout Western and Eastern Europe. This species is regularly recorded from tree-trunks and canopies (Platen et al. 1999, Engel 2001, Floren & Otto 2002, Kubcová & Schlaghamerský 2002). In Poland its protectoral status is not yet clear as faunistic data is 'deficient' (cf. Staręga et al. 2002).

7. *Pistius truncatus* (Pallas, 1772) (Thomisidae)

Material: 1 ♀: VII/6/2001, Białowieża Forest, quadrant 303 D, oak-hornbeam plantation, *Q. robur*, leg. Floren & Otto; 4 juv.: VI/30/2001 (3) and VII/2/2001 (1) Białowieża Forest, quadrant 669 E, oak-hornbeam primary-forest, *Q. robur*, leg. Floren & Otto; 2 juv.: VII/6/2001, Białowieża Forest, quadrant 303 D, oak-hornbeam plantation, *Q. robur*, leg. Floren & Otto; 1. juv.: VII/8/2001, Białowieża Forest, quadrant 332A, oak-plantation, 30-year old *Q. robur*, leg. Floren & Otto; Voucher specimens: Coll. Stefan Otto.

Pistius truncatus is distributed throughout the whole Palaearctic (Platnick 2006).

It is an arboreal species with preferences towards drier habitats (Heimer & Nentwig 1991; Platen et al. 1999). Its arboreal biology was confirmed by Buchar & Thaler (1995), Bauchhenß (2002) and Kubcová & Schlaghamerský (2002).

Next to the newly recorded species *Dipoena torva* and *Philodromus albidus*, four species are listed in the Red List of threatened animals of Poland (Staręga et al. 2002):

Dipoena nigroreticulata (Simon, 1879)

We recorded four females of this rarely-found species in the oak-canopies of the Leśna Primary Forest. It was only recently recorded from tree stumps in the Białowieża Forest (Stańska 2003 and pers. comm.). *D. nigroreticulata* is one of the spider species in Poland with the protected status 'vulnerable'. In Poland and Germany this species has so far only been recorded from old oaks in ancient natural forests (Dziabaszewski 1974, Finch 1999).

Theridiosoma gemmosum (L. Koch, 1877)

We recorded one female of this vulnerable-listed species from the canopy of an oak in the Leśna Primary Forest. It is listed in the checklist of the Białowieża Forest (Staręga & Kupryjanowicz 2001) and was also found by Stańska (2003). Usually this species is found in the field layer near or above water bodies (Roberts 1995, Platen et al. 1999).

Peponocranium cf. orbiculatum (O. P.-Cambridge, 1882)

We recorded one female specimen from a spruce in the 80-year-old plantation. Our specimen closely resembles other specimens of *P. orbiculatum* in general appearance and epigynal structure, but we treat our specimen as *P. cf. orbiculatum* because its vulva-structure differs slightly from those of the comparative material (from Germany) and drawings in Wiehle (1960) (Blick pers. comm.). *P. orbiculatum* was recorded from the Białowieża Forest in 10–20 years old pine crowns before by Sterzyńska & Ślepowroński (1994) and is listed in the checklist of the Białowieża Forest (Staręga & Kupryjanowicz 2001).

Araneus nordmanni (Thorell, 1870)

We found 16 juvenile specimens (including a subadult male) of this rare araneid in the Leśna and Starzyna forests as well as in P8 (determinations by N. Fritzén). 15 of the specimens come from spruce-canopies and one from an oak. *A. nordmanni* has been previously recorded in the Białowieża Forest (Staręga & Kupryjanowicz 2001) and is listed as vulnerable in the Red List.

HABITAT AND STRATUM PREFERENCES

The arboreal fauna was numerically dominated by typical silvicolous- and canopy species (Tables 3 and 4) which provided almost 60 % and 50 % respectively of all species. Species typically known from forest edges made up 22 % of the total while almost no other habitat specialists were collected. With respect to individuals, 64 % were known forest spiders and 68 % had a known canopy biology. Forest edge- and shrub-spiders made up another large segment in the canopy, providing 34 % and 28 % of all individuals respectively. In contrast, spiders of non-forest-habitats, the field-layer or the ground/soil played only minor roles in the studied communities.

Table 4: Habitat- and stratum-preferences of all identified spiders (after Platen et al. 1999)

Habitat	Species		Abundance		Stratum	Species		Abundance	
	n	%	n	%		n	%	n	%
Forest	53	60	5069	64	Canopy	44	49	5407	68
Forest edge	20	22	2663	34	Shrubs	14	15	2208	28
Open-country	8	9	38	1	Field-layer	9	10	166	2
Ubiquitous	5	6	67	1	Epi-/hypogeic	16	19	101	1
Other	1	1	1	0.01					
Uncertain	2	2	110	1	Uncertain	6	7	66	1
Total	89	100	7948	100	Total	89	100	7948	100

GUILD- AND TAXONOMIC COMPOSITION

Space-web weavers dominated in the canopy with 48 % of all specimens followed by orb-weavers (26 %), ambushers (11.1 %) and agile hunters (14.9 %) (Table 5).

Table 5: Relative family- and guild composition

Family	Guild	% of total
Araneidae	orb-web weavers	19.5
Tetragnathidae	orb-web weavers	3.8
other orb-web weavers	orb-web weavers	2.7
Theridiidae	space-web weavers	18.9
Linyphiidae	space-web weavers	7.5
other space-web weavers	space-web weavers	21.6
Anyphaenidae	agile hunters	7.9
Clubionidae	agile hunters	2.9
other agile hunters	agile hunters	4.1
Thomisidae	ambushers	11.1

Space-web weavers

This guild was represented by three families (Theridiidae, Linyphiidae, Dictynidae). Additionally we placed the 21 % of unidentifiable juveniles into this guild because juveniles of the other guilds can easily be sorted to family. The theridiid species *Enoplognatha ovata*, *Paidiscura pallens*, *Keijia tincta*, and *T. varians* were most abundant as well as the linyphiid species *Hypomma cornutum*, *Neriene emphana*, and *N. peltata* (Tab. 2). *Dictyna pusilla* was the only representative of the Dictynidae.

Orb weavers

Species of four orb-weaving families were collected (Araneidae, Tetragnathidae, Uloboridae, Theridiosomatidae). Araneidae made up the majority and about one fifth (19.5 %) of the entire community (Appendix tab.). The most abundant species were *Gibbaranea cf. omoeda/gibbosa*, (only *G. gibbosa* as adults) *Cyclosa conica*, *Araneus sturmi*, *A. triguttatus*, and *Araniella sp.*. *Tetragnatha obtusa* and *Metellina cf. mengei* (juvenile, 10 adult *M. mengei*) were abundant tetragnathid species. Juveniles of *Metellina* sp. can be identified using somatic characters (Toft 1983). Species frequently collected were *Araneus diadematus*, *A. nordmanni* (see above), *Tetragnatha montana*, *Stroemiellus stroemi*, and *Hyptiotes paradoxus*. *Theridiosoma gemmosum* (Theridiosomatidae) was an unusual record as this species usually lives in the field-layer near or above water-bodies.

Agile hunters

Species of seven families belonged to this guild (Anyphaenidae, Clubionidae, Gnaphosidae, Philodromidae, Salticidae, Zoridae, and Mimetidae). *Anyphaena accentuata* (Anyphaenidae) was the second most abundant species of the whole study (Table 3). Other abundant species were *Ballus chalybeius* (Salticidae) and *Philodromus collinus* (Philodromidae).

Ambushers

Thomisidae were the only ambushing spiders with *Diaea dorsata* being the most abundant species, accounting for almost 11% of all spiders (Table 3).

Discussion

Although the canopy stratum represents a major habitat for forest arthropods, ecological studies are normally conducted in lower strata where access and sampling is much simpler. Sampling arthropod communities of the tree crowns requires sophisticated logistical and technical means. Consequently, the number of canopy studies is comparatively small, although the canopy is inhabited by thousands of arthropods which can be expected to influence ecosystem function and many ecosystem processes (Simon 1995, Schubert 1998, see Floren & Schmidl in press). Canopy fogging makes it possible to quickly sample this fauna in a tree-specific and almost quantitative way thereby not only supplementing a faunistic survey but giving interesting quantitative information on the abundance of particular groups. First applied in tropical forest ecosystems, this method has lately become a successful tool in European canopy research too (Floren & Schmidl 2003, Horstmann & Floren 2001, Floren & Otto 2002). Recently, the growing interest in the canopy arthropod fauna has increased our knowledge on the distribution and habitat-use of rare and endangered species and their contribution to regional biodiversity (Simon 1995, Finch 1999, Floren & Schmidl 1999, Floren & Sprick in press, Schubert 1998, Goßner 2004, Junker 2005).

Spiders are a common, moderately diverse, and ecologically important group of predators in the canopy (Floren et al. in press). The 89 species collected in this study represent 21 % of the species pool of the Białowieża Forest (428 species) as reported by (Sterzyńska & Ślepowroński 1994, Łęgowski 2001, Staręga and Kupryjanowicz 2001, Stańska et al. 2002, Łęgowski & Stańska 2003, Stańska 2003). Most of the canopy spiders collected were widespread silvicolous species with a known arboreal occurrence (Tab. 2). These results are in accordance with other Central European canopy-studies (e. g. Sterzyńska & Slepowronski 1994, Simon 1995, Gutberlet 1997, Schubert 1998, Floren & Otto 2002) and underline the importance of the canopy-stratum as a habitat. This is furthermore supported by Platen et al. (1999) who, in their checklist of the spiders of Brandenburg (Germany), attributed an at least partially arboreal biology to 104 (38 %) of the 277 listed forest-species. Non-silvicolous spiders were of no larger importance for the arboreal communities. It seems probable that the recorded 'lower-strata' spiders, e.g. *Araneus diadematus*, *Achaearanea simulans*, *Porrhomma pygmaeum*, or *Erigone dentipalpis*, entered the canopies prior to or after ballooning. Possibly, these species enter canopies regularly but remain there only for short periods as abiotic conditions or competition with true canopy species prevent establishment of arboreal populations of these species.

Non-silvicolous species are known to contribute largely to the canopy communities in small fragmented woods or on isolated trees where faunal exchange with woodland habitats is reduced (Ozanne et al. 2000). According to our data, this is not the case within the deep forest matrix of Białowieża Forest.

Although most of the spiders collected in this study occur regularly in the canopy most species were also collected in lower strata (Staręga & Kupryjanowicz 2001, Stańska 2003). Therefore, the six species found for the first time are even more interesting records, *Theridion palmgreni* Marusik et Tsellarius, 1986 was a first record for Poland and Central Europe (Blick et al. 2006). These species seem to be mainly arboreal but not rare or endangered (Simon 1995, Muster 1998, Blick pers. comm.). Two of these species (*Dipoena torva*, *Philodromus albidus*), however, are listed in the Red List of Poland (Staręga et al. 2002). For *Philodromus albidus* faunistic data is still too deficient to determine its protection status while *D. torva* – classified as vulnerable – can be collected in large numbers from the canopy (Simon 1995, Blick pers. comm.). *Dipoena nigroreticulata* might be the only here recorded indicator species of old natural forests. It seems to be restricted to the canopies of old oaks in natural forests (Dziabaszewski 1974, Finch 1999). It has only recently been recorded from the Białowieża Forest by Stańska (2003) who found specimens on tree stumps. The record of the rare and vulnerable *Theridiosoma gemmosum* was surprising as this species is known to inhabit the field layer of moist habitats (Roberts 1995, Platen et al. 1999). It was collected from an oak in a wet forest near a river and probably entered the canopy accidentally during dispersal. Records of *Araneus nordmanni* in Central Europe are sparse but the species is regularly recorded in Scandinavia (Fritzén pers. comm.). It was collected mainly from spruce, corroborating the findings of Wiehle (1931).

The canopy fauna on all trees was dominated by web-spiders, paralleling the results of Stratton & Uetz (1979), Jennings et al. (1990), and Floren & Otto (2002). Guild-composition, however, varies a great deal across other studies (cf. Jennings & Dimond 1988, Mason et al. 1997, Bogya et al. 1999). This is a consequence of using different sampling methods. In studies using stem- and branch-eclectors, for example, communities were dominated by hunting spiders (up to 84 %), while web-builders were naturally represented by only 16 % to 37 % (Simon 1995, Schubert 1998). Canopy fogging, on the other hand, samples communities almost quantitatively, and is less dependent on behavioural characteristics. It is the only method known so far that gives an unbiased view on the actual composition of a community in a tree crown.

To conclude, we found a rich fauna of spiders in tree crowns of the Białowieża Forest including some faunistically remarkable species. Most of these are probably not rare or threatened species, but due to their mainly arboreal occurrence they have only rarely been recorded in species surveys. *Dipoena nigroreticulata*, however, probably qualifies as being an indicator species of natural, old-growth forests.

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STRESZCZENIE

[**Pająki (Araneae) koron drzew Puszczy Białowieskiej**]

Pająki koron drzew w pierwotnych lasach, rezerwatach i szkółkach leśnych zlokalizowanych na terenie Puszczy Białowieskiej były zbierane przy zastosowaniu naturalnego pyrethrum jako insektycydu rozpylanego na liściach i pniach drzew. Zgrupowanie pająków pokazało typową strukturę dla europejskich lasów z dominacją pająków sieciowych i pająków charakterystycznych dla koron drzew (np. *Diaea dorsata*, *Anyphaena accentuata*, *Paidiscura pallens*, *Keijia tincta*, *Theridion varians*). Z 78 drzew zebrano 14522 pająków (w tym 3936 form dojrzałych), które oznaczono do 89 gatunków z 15 rodzin. Oznaczone gatunki stanowiły 21% znanej araenofauny Puszczy Białowieskiej liczącej 428 gatunków, co podkreśla znaczenie warstwy koron drzew – dla wielu gatunków pająków stanowi ważne i sprzyjające środowisko życia. Siedem gatunków znaleziono w Puszczy Białowieskiej po raz pierwszy w Polsce. *Dipoena nigroreticulata* był jedynym gatunkiem mającym ściśle określone preferencje. Znajdowano go wyłącznie na starych dębach, w pierwotnym lesie. Dlatego, gatunek ten może być traktowany jako indykator najbardziej pierwotnych, naturalnych kompleksów leśnych.

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