POLSKA AKADEMIA NAUK
MUZEUM I INSTYTUT ZOOLOGII
FRAGMENTA FAUNISTICA
Tom 36 Warszawa 15 XI 1994 Nr 23

Wiesława CZECHOWSKA

Neuropterans (*Neuropteroidea: Raphidioptera, Planipennia*) of the canopy layer in pine forests

[With 2 tables in the text]

Abstract. In the years 1986-1987 a research was conducted in pine forest stands of three age classes growing in a moist forest site. The study embraced young stands (15–20 years old), medium age stands (40–60 years old) and mature stands (80–100 years old). Species composition, abundance and structure of *Neuropteroidea* communities of canopies of pines were determined in this habitat.

INTRODUCTION

Pine forests are the dominant type of forest association in the woodland areas of Central and East European lowlands. In Poland, coniferous habitats occupy an area of 5750 thousand hectares, which equals two-thirds of the total afforested area in the country. The most abundant among these habitats are pine forests (34.15%) (TRAMPLER et al. 1987).

In phytosociological terms, pine forests belong to the alliance *Dicranio-Pinion*. Two basic associations of this alliance occur in Poland: the suboceanic pine forest (*Leucobryo-Pinetum*) and the subcontinental pine forest (*Peucedano-Pinetum*). Pine *Pinus silvestris* functions as the stand-forming species in this association (MATUSZKIEWICZ 1987).

In the years 1986-1987 the Institute of Zoology of the Polish Academy of Sciences carried out a study of moist pine forest habitats, aimed at exploring the entomofauna of this habitat type and recording changes taking place in the insect communities in the course of forest stand development.

Neuropteroidea of pine forests in Poland are not well known. Certain data concerning this taxon can only be found in papers by BERNDT (1984) and CZECHOWSKA (1985).

TIME AND AREAS OF STUDIES

The study was conducted in the years 1986-1987 in Puszcza Białowieska (in the Hajnówka forest distr.), in Puszcza Biała (in the Ostrów Mazowiecka forest distr.) and in Bory Tucholskie (in the Osie forest distr). The former two forest areas are situated in the north-east of Poland, Puszcza Białowieska in the mezoregion of Wysoczyzna Bielska, Puszcza Biała in the Mazovian Lowland. Bory Tucholskie is located in north-western Poland in the Pomeranian Lake District.

The pine forest situated in Puszcza Białowieska represents the subboreal variety of the subcontinental pine forest (*Peucedano-Pinetum*) where spruce (*Picea excelsa*) is constantly present mostly in the shrub layer, but also, in smaller quantities, in mature forests. As regards deciduous tree species, birch (*Betula verrucosa*) and, sporadically, oak (*Quercus robur*) as well as hornbeam (*Carpinus betulus*) occur as constant additional species (the latter two only as saplings).

The pine forest of Puszcza Biała belongs to the "Sarmatian" variety of the subcontinental pine forest (*Peucedano-Pinetum*), characterized by a high proportion of juniper (*Juniperus communis*), particularly in older stands. Birch and, sporadically, spruce function as additional species here.

The pine forest in Bory Tucholskie belongs to the suboceanic pine forest (*Leucobryo-Pinetum*). The forest stands there consisted almost exclusively of pine with a very small proportion of birch.

The pine forests of Puszcza Biała and Bory Tucholskie are subject to systematic silvicultural practices i.e. timber harvesting for industrial purposes. New plantings are grown where old stands have been clear-cut. These vast forest areas, occupying several thousand hectares, present themselves as a mosaic of pine stands in various phases of development. The pine forest in Puszcza Białowieska occupies a much smaller area and is surrounded by a mixed forest (*Pino-Quercetum*).

The following age classes of pine stands were included in the study: young stands (15–20 years old), medium age stands (40–60 years old) and mature stands (80–100 years old). A detailed geobotanical description of the forests under study is contained in the introductory paper (MATUSZKIEWICZ et al. 1993).

METHODS AND MATERIAL

The insects were caught in pine canopies with Moericke's yellow pan traps (MOERICKE 1950). Three study sites were chosen in stands representing each age class and 5 traps hung in each site (one trap per a tree) so that there were 45 traps set altogether in each of the forest areas. The traps were emptied every fortnight from April to the end of October.

Of the total number of 3807 *Neuropteroidea* imagines collected, 1540 were caught in Bory Tucholskie, 1204 in Puszcza Białowieska and 1063 in Puszcza Biała. The following numbers of specimens were collected in each age class:

young stands – 671, medium age stands – 1555 and mature stands – 1581 individuals.

All the specimens caught belong to four *Neuropteroidea* families whose approximate shares in the material are as follows: *Raphidiidae* – 39.4%, *Coniopterygidae* – 1.7%, *Hemerobiidae* – 39.4% and *Chrysopidae* – 19.3% of the total number of individuals collected.

The abundance of a species was measured as the number of individuals caught into one trap in 24 hours.

Faunistic similarity of *Neuropteroidea* communities of the pine forest studied was calculated according to Sörensen's formula (SÖRENSEN 1948), while the degree of similarity of dominance structures was calculated after Morisita's formula modified by HORN (1966). The same formula was used in a previous paper (CZECHOWSKA 1990). The specimens were determined according to the key of ASPÖCK et al. (1980).

RESULTS

Though the pine forests studied were situated in different geographical regions of Poland, the results reveal great similarities in the species composition, abundance and dominance structures of *Neuropteroidea* communities occurring there.

Of the total of 26 *Neuropteroidea* species found in the three areas as a whole, 23 were recorded in Puszcza Białowieska and Bory Tucholskie, compared to 21 in Puszcza Biała. 18 species of *Neuropteroidea* occurred in all the three forest areas (Table I).

The following species were dominant in all the forest areas: *Raphidia xanthostigma*, *R. notata*, *Wesmaelius concinnus*, *Hemerobius stigma*, *H. nitidulus*, and *Anisochrysa prasina*. A careful analysis of dominance structures and abundance of certain species in the forests studied indicates that there exist definite tendencies in the distribution of *Neuropteroidea*.

Young stands

Twenty three neuropteran species were identified in 15–20-year-old pine stands in the three areas (Table I). From 14 to 16 species were found in a particular area, and the faunistic similarity of the communities ranged from 62% to 77% (Table II).

The average abundance of neuropterans in young stands was 0.039, the actual values ranging from 0.026 to 0.049. The abundance of *Neuropteroidea* in young stands was 2 to 5 times smaller (2.6 times on average) than in the older stands situated within the same area.

The following species had the greatest shares in the material collected in young stands: *Anisochrysa prasina* (20.5%), *Raphidia xanthostigma* (17.9%), *R. notata* (15.4%), *Hemerobius nitidulus* (12.8%), *H. stigma* (10.2%), and *Wesmaelius concinnus* (10.2%). The proportions changed a little when each forest was analysed separately (Table I). The neuropteran community of Puszcza Biała was

Table I. Abundance (n) and proportions (%) of particular species

No	Plots; age of stands / Species	Puszcza Białowieska								Puszcza			
		Young stands		Medium age stands		Mature stands		Mean		Young stands		Medium age stands	
		n	%	n	%	n	%	n	%	n	%	n	%
	Raphidiidae												
1	*Raphidia ophiopsis ophiopsis* L.	–	–	–	–	0.001	0.8	+	+	0.001	2.4	0.005	5.0
2	*Raphidia notata* Fabr.	0.004	15.4	0.008	9.4	0.004	3.1	0.005	6.3	0.009	22.0	0.016	15.8
3	*Raphidia xanthostigma* Schumm.	0.004	15.4	0.030	35.3	0.050	39.3	0.028	35.4	0.001	2.4	0.039	38.6
4	*Inocellia crassicornis* (Schumm.)	–	–	0.001	1.2	0.001	0.8	0.001	1.3	–	–	0.001	1.0
	Coniopterygidae												
5	*Coniopteryx parthenia* (Nav. et Marc.)	0.004	15.4	+	+	+	+	0.002	2.6	–	–	0.001	1.0
6	*Parasemidalis fuscipennis* (Reut.)	–	–	–	–	–	–	–	–	+	+	–	–
7	*Conwentzia pineticola* End.	+	+	+	+	–	–	+	+	–	–	–	–
	Hemerobiidae												
8	*Drepanopteryx phalaenoides* (L.)	–	–	–	–	–	–	–	–	+	+	–	–
9	*Wesmaelius conctrnus* (Steph.)	0.004	15.4	0.010	11.7	0.011	0.7	0.008	10.1	+	+	0.010	9.9
10	*Wesmaelius nervosus* (Fabr.)	–	–	+	+	0.001	0.8	+	+	–	–	–	–
11	*Wesmaelius mortoni* (McLachl.)	–	–	+	+	+	+	+	+	–	–	–	–
12	*Hemerobius humulinus* L.	–	–	0.001	1.2	0.001	0.8	0.001	1.3	0.001	2.4	–	–
13	*Hemerobius stigma* Steph.	0.003	11.5	0.015	17.6	0.010	7.9	0.009	11.4	0.005	12.2	0.014	13.8
14	*Hemerobius pini* Steph.	+	+	0.001	1.2	0.002	1.6	0.001	1.3	+	+	0.001	1.0
15	*Hemerobius fenestratus* Tjed.	+	+	+	+	+	+	+	+	–	–	–	–
16	*Hemerobius atrifrons* McLachl.	–	–	–	–	–	–	–	–	–	–	–	–
17	*Hemerobius nitidulus* Fabr.	0.001	3.8	0.001	1.2	0.002	1.6	0.001	1.3	0.009	22.0	0.006	5.9
18	*Hemerobius micans* Oliv.	+	+	+	+	–	–	+	+	–	–	–	–
19	*Sympherobius fuscescens* (Wall.)	0.001	3.8	0.001	1.2	0.001	0.8	0.001	1.3	+	+	0.001	1.0
	Chrysopidae												
20	*Nineta vittata* (Wesm.)	–	–	0.002	2.3	0.002	1.6	0.001	1.3	–	–	–	–
21	*Chrysopa perla* (L.)	–	–	+	+	–	–	+	+	0.001	2.4	+	+
22	*Chrysopa septempunctata* Wesm.	–	–	0.004	4.7	0.007	5.5	0.004	5.0	+	+	0.001	1.0
23	*Anisochrysa prasina* (Burm.)	0.005	19.2	0.010	11.8	0.025	19.6	0.013	16.5	0.014	34.1	0.005	5.0
24	*Anisochrysa ventralis* (Curt.)	–	–	+	+	0.003	2.4	0.001	1.3	–	–	–	–
25	*Chrysoperla carnea* (Steph.)	+	+	0.001	1.2	0.002	1.6	0.001	1.3	+	+	–	–
26	*Cunctochrysa albolineata* (Kill.)	+	+	+	+	0.004	3.1	0.002	2.5	+	+	0.001	1.0
	Total	0.026		0.085		0.127		0.079		0.041		0.101	

of *Neuropteroidea* in pine canopies of pine forests (+ – n < 0.001)

Biała				Bory Tucholskie								Mean					
Mature stands		Mean		Young stands		Medium age stands		Mature stands		Mean		Young stands		Medium age stands		Mature stands	
n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
0.001	1.2	0.002	2.6	–	–	0.002	1.7	0.002	2.0	0.001	1.1	+	+	0.002	2.0	0.001	1.0
0.010	12.0	0.012	15.8	0.005	10.2	0.010	8.7	0.004	4.0	0.006	6.8	0.006	15.4	0.011	10.8	0.006	5.9
0.019	22.9	0.020	26.3	0.015	30.6	0.026	22.6	0.024	23.7	0.022	25.0	0.007	17.9	0.032	31.3	0.031	30.4
0.002	2.4	0.001	1.3	–	–	–	–	+	+	+	+	–	–	0.001	1.0	0.001	1.0
0.003	3.6	0.001	1.3	–	–	0.001	0.9	0.002	2.0	0.001	1.1	0.001	2.6	0.001	1.0	0.002	2.0
–	–	+	+	–	–	–	–	+	+	+	+	+	+	–	–	+	+
0.001	1.2	+	+	–	–	–	–	–	–	–	–	+	+	+	+	+	+
–	–	+	+	–	–	–	–	+	+	+	+	+	+	–	–	+	+
0.016	19.3	0.009	11.8	0.009	18.4	0.037	32.1	0.027	26.7	0.024	27.3	0.004	10.2	0.019	18.6	0.018	17.6
+	+	+	+	+	+	–	–	+	+	+	+	+	+	+	+	+	+
–	–	–	–	+	+	0.002	1.7	+	+	0.001	1.1	+	+	0.001	1.0	+	+
0.001	1.2	0.001	1.3	+	+	0.001	0.9	0.001	1.0	0.001	1.1	+	+	0.001	1.0	0.001	1.0
0.014	16.9	0.011	14.5	0.004	8.2	0.013	11.3	0.016	15.7	0.011	12.5	0.004	10.2	0.014	13.6	0.013	12.7
–	–	+	+	+	+	+	+	+	+	+	+	0.001	2.6	0.001	1.0	0.001	1.0
–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+
–	–	–	–	–	–	–	–	+	+	+	+	–	–	–	–	+	+
0.002	2.4	0.006	7.9	0.006	12.2	0.008	7.0	0.006	5.9	0.007	8.0	0.005	12.8	0.005	4.9	0.003	2.9
–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	–	–
0.001	1.2	0.001	1.3	–	–	+	+	–	–	+	+	+	+	0.001	1.0	+	+
0.001	1.2	+	+	–	–	+	+	–	–	+	+	–	–	0.001	1.0	0.001	1.0
–	–	+	+	0.001	2.0	+	+	–	–	+	+	0.001	2.6	+	+	–	–
0.004	4.8	0.002	2.6	0.001	2.0	0.003	2.6	0.005	5.0	0.003	3.4	+	+	0.002	2.0	0.005	4.9
0.006	7.2	0.008	10.6	0.005	10.2	0.008	7.0	0.008	7.9	0.007	8.0	0.008	20.5	0.008	7.8	0.013	12.7
–	–	–	–	+	+	–	–	–	–	+	+	+	+	+	+	0.001	1.0
0.002	2.4	0.001	1.3	0.001	2.0	0.001	0.9	0.001	1.0	0.001	1.1	0.001	2.6	0.001	1.0	0.002	2.0
+	+	0.001	1.3	0.002	4.1	0.003	2.6	0.005	5.0	0.003	3.4	0.001	2.6	0.001	1.0	0.003	2.9
0.083		0.076		0.049		0.115		0.101		0.088		0.039		0.102		0.102	

characterized by rather high percentages of *A. prasina*, *R. notata* and *H. nitidulus*, while in Bory Tucholskie *R. xanthostigma* substantially exceeded the other species.

The values of the index of similarity of dominance structures of neuropteran communities from young stands oscillated between 0.51–0.78 (Table II). Greater similarity was demonstrated for the *Neuropteroidea* communities of Bory Tucholskie and Puszcza Białowieska, while the values were smaller for either of the two areas and Puszcza Biała. The difference results from a very small proportion of *Raphidia xanthostigma* in the young stands of Puszcza Biała, where the species had been replaced by *R. notata*.

Compared to the older stands, *Neuropteroidea* communities of young stands exhibited higher proportions of *Anisochrysa prasina*, *Raphidia notata*, *Hemerobius nitidulus*, and *Chrysopa perla* (Table I). The latter species was very rare in medium age stands and practically absent from mature stands.

Medium age stands

A total of 23 *Neuropteroidea* species were identified in pine canopies in medium age stands (Table I), while the number of species in a particular area ranged from 14 to 22. The degree of faunistic similarity of neuropteran communities fluctuated between 72% and 84% (Table II).

The average abundance of *Neuropteroidea* in medium age stands was 0.102 and the actual values varied from 0.085 to 0.115 in an area (Table I). The following *Neuropteroidea* species had the greatest shares in the material collected in medium age stands in all the areas: *Raphidia xanthostigma* (31.3%), *Wesmaelius concinnus* (18.6%), *Hemerobius stigma* (13.6%), *Raphidia notata* (10.8%), *Anisochrysa prasina* (7.8%), and *Hemerobius nitidulus* (4.9%).

The structural similarity of *Neuropteroidea* communities was very high in this age class of forest stand as the values ranged from 0.79 to 0.95 (Table II). A characteristic feature of these communities was above all else a substantial increase in the abundance of *Raphidia xanthostigma*. Quantitatively, this species was well ahead of the other species in Puszcza Białowieska and Puszcza Biała, while in Bory Tucholskie it was slightly less numerous than *Wesmaelius concinnus* (Table I). Several other dominant species, viz. *Raphidia notata*, *Wesmaelius concinnus* and *Hemerobius stigma* were also more abundant in medium age stands than in the young ones (Table I).

Mature stands

Altogether 24 *Neuropteroidea* species were found in mature stands (Table I). The number of species in a particular area ranged from 17 to 20, while the degree of faunistic similarity of the communities varied from 78% to 86% (Table II).

The average abundance of *Neuropteroidea* in mature stands was 0.102, the actual figures ranging from 0.083 to 0.127.

In the total material collected in mature stands, the greatest shares were those of *Raphidia xanthostigma* (30.4%), *Wesmaelius concinnus* (17.6%), *Hemerobius stigma* (12.7%), and *Anisochrysa prasina* (12.7%). Just as in medium age stands, *R. xanthostigma* was the dominant in mature stands in Puszcza Biała and Puszcza Białowieska, while *Wesmaelius concinnus* was a little more abundant in Bory Tucholskie. The shares of *Raphidia notata* and *Hemerobius nitidulus* in neuropteran communities in mature stands were much smaller than in medium age stands. The latter species was substituted by *Chrysopa septempunctata* in the dominance structure.

CONCLUSION

All the pine stands studied in a moist forest site were inhabited by the same assembly of *Neuropteroidea* species. However, the considerable differences in abundance of the communities observed in young stands and older stands indicate that the latter stands function as a refuge area for this taxon. This rings true not only for *Raphidioptera*, whose larvae dwell under the bark of old pines, but also for the families *Hemerobiidae* and *Chrysopidae*. *Hemerobius nitidulus* and *Chrysopa perla* are the only species which show a certain preference for young stands.

The most numerous families of *Neuropteroidea* in the material collected were *Raphidiidae* and *Hemerobiidae*. *Chrysopidae* and *Coniopterygidae* were less abundant. However, an earlier study conducted in mature stands of pine forests (CZECHOWSKA 1985) using the same sampling method proved that the quantitative proportions may follow a different pattern with greater shares of species of the *Chrysopidae* and *Coniopterygidae* families.

The dominant species in the pine forests studied were stenotopic and they favoured this environment because of their food and habitat requirements. A more detailed analysis of this subject will be given in the next paper.

Table II. Qualitative similarity (after the SØRENSEN formula) and similarity of dominance structure (the MORISITA index) of the communities of *Neuropteroidea* in the pine forests

	Young stands			Medium age stands			Mature stands		
	Puszcza Białowieska	Puszcza Biała	Bory Tucholskie	Puszcza Białowieska	Puszcza Biała	Bory Tucholskie	Puszcza Białowieska	Puszcza Biała	Bory Tucholskie
Puszcza Białowieska		0.66	0.78		0.95	0.82		0.80	0.79
Puszcza Biała	67		0.51	72		0.79	86		0.95
Bory Tucholskie	62	77		82	84		82	78	

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Muzeum i Instytut Zoologii PAN
Wilcza 64
00–679 Warszawa, Poland

STRESZCZENIE

[Tytuł: Siatkoskrzydłe (*Neuropteroidea*: *Raphidioptera*, *Planipennia*) warstwy koron borów świeżych]

Badania przeprowadzono w siedlisku boru świeżego na terenie Puszczy Białowieskiej, Puszczy Białej i Borów Tucholskich w drzewostanach sosnowych różnego wieku. Owady odławiano w młodnikach (15–20-letnich), drzewostanach III klasy wieku (40–60-letnich) i starodrzewiach (80–100-letnich).

Zebrany materiał obejmuje 3807 osobników reprezentujących 26 gatunków siatkoskrzydłych. W poszczególnych kompleksach borów świeżych występowało od 21 do 23 gatunków *Neuropteroidea*. Składy gatunkowe siatkoskrzydłych badanych drzewostanów sosnowych różniły się w niewielkim stopniu. W młodnikach i drzewostanach III klasy wieku stwierdzono po 23, a w starodrzewiach 24 gatunki *Neuropteroidea* (Tab. I). Stopień podobieństwa jakościowego tych faun (wg wskaźnika Sörensena) wynosił od 89 do 91%.

Średni wskaźnik liczebności siatkoskrzydłych wynosił w młodnikach 0.039, a w drzewostanach III klasy wieku i starodrzewiach po 0.102. Mimo dużo niższej liczebności zgrupowań *Neuropteroidea* w młodnikach, pod względem struktural-

nym zasadniczo niewiele różniły się one od zgrupowań ze starszych drzewostanów sosnowych.

We wszystkich badanych drzewostanach sosnowych występował ten sam zespół gatunków dominujących, składający się z *Raphidia xanthostigma*, *R. notata*, *Wesmaelius concinnus*, *Hemerobius stigma*, *H. nitidulus* i *Anisochrysa prasina*. Gatunki te, z wyjątkiem *H. nitidulus*, występowały liczebniej w starszych drzewostanach. Szczególnie wyraźny wzrost liczebności w drzewostanach III klasy wieku oraz starodrzewiach stwierdzono u *Raphidia xanthostigma*, *Wesmaelius concinnus* i *Hemerobius stigma*. W przypadku *Raphidia notata* najwięcej osobników odłowiono w drzewostanach III klasy wieku.

Redaktor pracy – dr H. Garbarczyk