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Raphidioptera and *Neuroptera* (*Neuropterida*) of the canopy in montane, upland and lowland fir forests of *Abies alba* MILL. in Poland[1]

Abstract: The paper presents an analysis of *Raphidioptera* and *Neuroptera* material collected during 1993 and 1994 in fir canopies in the following forest types: montane (Beskid Sądecki), upland (Góry Świętokrzyskie) and lowland (Wysoczyzna Łódzka). The species composition, abundance, dominance structure and ecological traits of the communities, and their phenology are discussed. The fauna was compared with that of other forests (moist pine, mixed and linden-oak-hornbeam) occurring in lowland and upland regions of the country. Of the 44 species recorded, *Coniopteryx pygmaea* END. (=*C. parthenia* NAVÁS et MARCET) and *Conwentzia pineticola* (END.) were the most abundant. The presence of the montane species *Puncha ratzeburgi* BRAU., *Hemerobius contumax* TJED., *Sympherobius pellucidus* (WALK.), *Nothochrysa capitata* (FABR.), *Nineta pallida* (SCHN.) and *Peyerimhoffina gracilis* (SCHN.) was a characteristic feature of the fir forest fauna when compared with that of the other woodlands. Two of these species, *H. contumax* and *S. pellucidus*, were the most constant and abundant. *Dichochrysa abdominalis* (BRAU.), was a species new to the fauna of Poland.

Key words: *Raphidioptera* and *Neuroptera*, fir forest, *Abies alba* MILL., canopy, fauna, ecology, Poland

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INTRODUCTION

Silver fir (*Abies alba* MILL.) is a European montane tree species growing at 400–2100 m a.s.l. Its ranges fragmentarily from the Carpathians to the Pyrenees, reaching Calabria in the south (38°N) and central Poland in the north (52°N) (Fig. 1). In Poland, *A. alba* finds the north-eastern range limit of its natural range. It crosses Nizina Śląska (Silesian Lowland), the northern part of Wyżyny Środkowe (Central Uplands), Nizina Mazowiecko-Podlaska (Mazovian-Podlasie Lowland), Roztocze (Roztocze Upland)

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and Bieszczady Zachodnie (Western Bieszczady Mts) (Fig. 2). The northernmost, isolated sites of this species are in Puszcza Białowieska (Białowieża Forest) in Poland and in Normandy in France (BORATYŃSKI 1983).

In Poland, at present the fir woodlands take up to about 3% of the total, the distribution being highly patchy. The main centre of *A. alba* distribution in Poland lies in the Carpathians, especially in the mountains of Beskid Niski, Bekid Sądecki and Bieszczady. In the uplands, fir frequently occurs only in Góry Świętokrzyskie (Świętokrzyskie Mts) and in Roztocze Środkowe (Central Roztocze Upland). In lowland Poland, fir is fairly rare. The few sites at which fir finds favourable conditions include Puszcza Kozienicka (Kozienice Forest) and some forest reserves in Wysoczyzna Łódzka (Łódź Eminence) (BORATYŃSKI 1983).

The species *A. alba* is characterised by considerable ecological tolerance, which is shown by its presence in various forest associations. Its optimum environmental conditions lie in the mountains, in the lower forest zone, where it grows together with beech (*Fagus sylvatica*) and spruce (*Picea alba*). Beech-fir (*Dentario glandulosae-Fagetum*) and fir-spruce forests (*Abieti-Piceetum montanum*) are associations characteristic of this zone. A mixed fir forest, *Abietetum polonicum*, is a forest association endemic to Poland. The range of this community is restricted to uplands and Pogórze Karpackie (Carpathian Foothills). In the lowlands, the linden-oak-hornbeam forest (*Tilio-Carpinetum*) forms an association, where fir is occasionally the dominant component (WOJTERSKI 1983).

Fig. 1. Range of *Abies alba* MILL. (from BORATYŃSKI 1983).

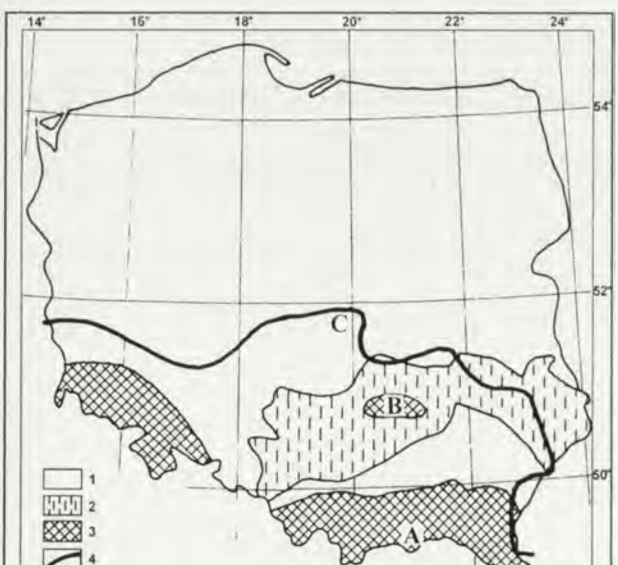

Fig. 2. Situation of the study areas: A – Beskid Sądecki Mts, B – Świętokrzyskie Mts, C – Wysoczyzna Łódzka; 1 – lowlands, 2 – uplands, 3 – mountains, 4 – limit of natural range *Abies alba* MILL. (from SZAFER 1977).

The proportion of fir in European woodlands has been decreasing for about 200 years. This has been brought about by many unfavourable, natural and man-induced, factors. Excessive exploitation and a decrease in the biological resistance of fir have contributed to the regress of the species. Fir is sensitive to industrial pollution and to adverse weather conditions. Weakened trees are invaded by various primary and secondary pests (BERNADZKI 1983, GĄDEK 1993).

Of phytophages feeding in fir canopies, lepidopterans and aphids pose the greatest threat. In Poland, the most serious damage is caused by *Choristoneura murinana* HBN., *Epinotia nigricana* H.-S. and *Zeiraphera rufimitrana* H.-S. (*Tortricidae, Microlepidoptera*). Of the dozen or so aphid species living on *A. alba*, economically the most important are representatives of the genus *Adelges* VALLOT, subgenus *Dreyfusia* BÖRN., which migrate from spruce to fir or reproduce parthenogenetically on fir all year round (BLACKMAN & EASTOP 1994). In Poland, the abundance of *Adelges* (*Dreyfusia*) *nordmanniane* (EKSTEIN) (= *nuesslini* C.B.) on fir keeps growing; the increase is alarming because this species damages needles and young shoots (GĄDEK 1993).

OBJECTIVES

The fact that, in Poland, fir woodlands are decreasing justifies research into their entomofauna both in the cognitive and practical aspects. Threat to fir means that a whole complex of insects associated with this tree species is endangered, a complex still unknown in many respects. Neuropterids are one of the least studied groups. In Poland, there are 100 neuropterid species recorded, most of which live in forest, mainly in the tree canopies and shrubs. These predatory insects feed on various small arthropods, especially phytophages. As their prey they prefer different developmental stages of *Hemiptera* (*Aphidinea, Coccinea, Auchenorrhyncha, Aleyrodoidea, Psylloidea*), *Thysanoptera, Psocoptera, Lepidoptera* (*Tortricidae, Pyralidae, Noctuidae, Pieridae*), *Coleoptera* and *Acari* (KILLINGTON 1936, PRINCIPI & CANARD 1984, NEW 1986, STELZL 1991, BOZSIK 2000). Food selection, i.e. preference of phytophages from a definite species of tree, shrub or herb, is very common in neuropterids. Trophic relations between particular neuropterid species and their prey, and also their habitat requirements, are expressed as associations with particular types of vegetation.

Papers describing quantitative relations of the *Neuropterida* of well defined habitat and (or) a tree species are not numerous (RESSL 1971 a, b, 1974, GEPP 1973, BERNDT 1984, CZECHOWSKA 1985, 1986, 1990, 1994, 1995, 1997, BARNARD et al. 1986, SAURE & KIELHORN 1993, MONSERRAT & MARÍN 1992, 1994, 1996, WERSTAK 1994, SCHUBERT & GRUPPE 1999).

In the literature on neuropterids, species collected on *Abies* are mentioned by ASPÖCK et al. (1980, 1991) as well as in numerous faunistic studies, e.g. by EGLIN 1940, EGLIN-DEDERDING 1955, ZELENÝ 1963, RESSL 1971a, b, 1974, GEPP 1977, 1989, POPOV 1981, PANTALEONI 1990, CANARD & VANNIER 1992, MONSERRAT & MARÍN 1994, 1996 (see also the reference lists in ASPÖCK et al. 1980, 1991, 2001). However, there is no comprehensive description of the neuropterid fauna in particular forest associations with *A. alba*.

The aims of the present study were:

- to characterise and compare the neuropterid communities of the canopies of fir in montane, upland and lowland forests in respect of species composition, dominance structure and abundance;
- to describe the seasonal dynamics of neuropterids in fir canopies;
- to characterise the ecological profile of neuropterids of fir canopies;
- to compare the neuropterid faunas of fir forests and of other lowland–upland woodlands;
- to determine the role and impact of neuropterids in maintaining the ecological equilibrium in forest associations containing fir.

STUDY AREA

The material was collected during 1993 and 1994 in Beskid Sądecki, Góry Świętokrzyskie and Wysoczyzna Łódzka[2]. These regions, situated within the natural range of fir, differ in respect of the climatic conditions, the proportion of fir in woodlands, and the health of the tree species.

Beskid Sądecki. A mountain range in the western part of Carpathians (Fig. 2). Mean temperature in January: –5.24°C, in July: +16.32°C, mean annual precipitation 922 mm. Fir covers about 35% of the woodland area of this region and is very healthy[3]. The material was collected in forests at 700–800 m a.s.l., in forest district Kopciowa. In the phytosociological respect, these forests belong to the association of Carpathian beech (*Dentario glandulosae-Fagetum*). Captures were made in three plots with 9 traps each (see "Methods and material") during two seasons.

Plot I. Divisions 1c and 2a, 95–100-year old stand mainly consisting of fir with some spruce (*Picea alba*), southern exposition.

Plot II. Division 17, 55–75-year old stand with predominant fir, spruce fairly numerous at places, and some larch (*Larix decidua*) and pine (*Pinus sylvestris*) here and there, southern exposition.

Plot III. Divisions 18f and 19f, 125-year old fir growth, eastern exposition.

Góry Świętokrzyskie. An ancient mountain range in Wyżyna Małopolska (Małopolska Upland) (Fig. 2). Mean temperature in January: –4.10°C, in July: +18.20°C, mean annual precipitation 639 mm. Fir still constitutes about 20% of the tree stand, but its health is poor. Due to unfavourable weather conditions (hurricanes, drought, frost) and air pollution, the natural resistance of the species is being deteriorated and fir forest becomes susceptible to attacks by insect and fungal pests. Between 1948 and 1991, more or less devastating outbreaks of tortricid lepidopterans took place (GĄDEK 1993). As a result, the originally dense tree stands have become thinner, and the canopy shape has become abnormal.

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[2] Collected by Dr. Janusz Sawoniewicz, who conducted studies on *Ichneumonidae* of fir canopies in the frame of the grant No 66339 91 02 from the State Committee for Scientific Research.

[3] Climatic date and the proportion of fir in woodlands of a given region are after TRAMPLER *et al.* 1990.

The material was collected at 300–450 m a.s.l. in mixed fir forest (*Abietetum polonicum*). In this association, occasionally there also occur the following species: *Fagus sylvatica, Quercus robur, Q. sessilis, Populus tremula, Alnus glutinosa, Betula verrucosa, Pinus sylvestris* and *Picea abies* (GŁAZEK 1985). Recently, beech has been increasing its proportion in tree stands of this association in Góry Świętokrzyskie. Nine traps were set in each of the following three plots. The material from plots II and III was collected during both seasons, that from Plot I only in 1993.

Plot I. Division 38b near the village of Wola Szczygiełkowa, 75–125-year old fir stand, northern exposition.

Plot II. Divisions 203a and 204a on the southern slope of Łysa Góra (Łysa Mt.) near the village of Trzcianka, 80-year old fir stand.

Plot III. Division 196y and 197g at the foot of the eastern slope of Łysa Góra near Nowa Słupia, 50–80-year old tree stand.

Wysoczyzna Łódzka. A region in Niż Środkowopolski (lowland area of central Poland), 100–200 m. a.s.l. (Fig. 2). Mean temperature in January: –3.50°C, in July: +18.57°C, mean annual precipitation 542 mm. Forest dominated by pine (*Pinus sylvestris*): nearly 80% of woodland; the proportion of fir is merely 0.2% but the species is healthy. The material was collected at six plots. Plots I–V represented a linden-oak-hornbeam forest (*Tilio-Carpinetum*), Plot VI was a fir forest of the *Galio-Abietion* subaliance. Traps were set in larger concentrations of fir.

Plot I. Uroczysko Doliska, division 82d, about 80-year old fir stand; 9 traps throughout both seasons.

Plot II. Uroczysko Zimna Woda, division 129d, about 60-year old fir stand with some pine (*Pinus sylvestris*) and oak (*Quercus* sp.); 3 traps in 1993.

Plot III. Uroczysko Zimna Woda, division 140f, about 60-year old stand with pine dominating and fir an additional component; 3 traps in 1993.

Plot IV. Uroczysko Doliska, division 85a, about 80-year old pine-fir stand; 3 traps throughout both seasons.

Plot V. Uroczysko Zacywilki, division 53f, about 50-year old fir stand; 3 traps throughout both seasons.

Plot VI. Łaznów Reserve (Brzeziny Forestry Insprectorate), division 333c, 95–130-year old fir stand; 9 traps in 1993.

For more details of the study area see NOWAKOWSKA (1996).

METHODS AND MATERIAL

Insects were collected in yellow plastic bowls (height 6 cm, ø 18 cm) filled with water with a conservant (ethanediol $C_2H_6O_2$) and a detergent lessening the surface tension. Traps, attached to fir canopies at 10– 20 m, were emptied every two weeks from the beginning of May through October. For details of the method see SAWONIEWICZ (1996).

Altogether, 5,710 neuropterid adults were collected, including 152 individuals of *Raphidioptera* and 5548 of *Neuroptera*. The relative abundance of particular species and of particular communities is expressed using an index which reflects the number of individuals captured in one trap during 100 days.

The frequency (F) of a given species was evaluated by the percentage of the sites at which it was recorded against the total number of the study sites. The degree of frequency was determined using Tischler's scale (TROJAN 1975), in which species with 100–76% frequency are considered as constant, 75–51% as relatively constant, 50–26% as accessory, and below 25% as accidental.

An analysis of the dominance structure of the communities yielded four classes of species: eudominants (>15%), dominants (5.1–15%), subdominants (1.1–5%), and accessory species (<1.0%). The similarity of species composition (So) of the communities compared was determined using SØRENSEN's (1948) similarity coefficient. The similarity of dominance structure (Mo) was determined by Morisita's index as modified by HORN (1966).

RESULTS

Species composition, structure and abundance

The material comprised 44 species of both *Raphidioptera* and *Neuroptera* (=*Planipennia*). *Raphidioptera* were represented by the families *Raphidiidae* (5 species) and *Inocelliidae* (1 species); *Neuroptera* by *Hemerobiidae* (18 species), *Chrysopidae* (14 species) and *Coniopterygidae* (6 species). The abundances and proportions of the above taxa in the neuropterid communities from particular regions are given in Table I. The material was quantitatively dominated by *Neuroptera* individuals, and within these by representatives of the family *Coniopterygidae*. They were especially numerous in the montane forests in which their proportions in the communities reached 73%. *Chrysopidae*, on the other hand, showed about 2–3 times higher percentages in the communities from upland or lowland forests than in montane stands. The proportions of *Raphidioptera*, generally small, were relatively high in the lower regions. The most similar proportions were those of *Hemerobiidae*, ranging between 16 and 24% everywhere. The characteristics of the neuropterid communities in the fir forests of the regions studied are given below.

Table I. Number of species (N), index of abundance (n) and proportions (%) of particular taxa of *Neuropterida* in the material collected in fir canopies in the forests of the different regions studied.

Geographical zones	Mountains			Uplands			Lowlands			Total		
Regions	Beskid Sądecki			Góry Świętokrzyskie			Wysoczyzna Łódzka					
Taxa	N	n	%	N	n	%	N	n	%	N	n	%
Raphidioptera	**2**	**0.09**	**0.30**	**4**	**0.52**	**2.47**	**6**	**2.22**	**7.46**	**6**	**0.94**	**3.53**
Raphidiidae	2	0.09	0.30	3	0.49	2.34	5	2.20	7.39	5	0.93	3.47
Inocelliidae	-	-	-	1	0.03	0.13	1	0.02	0.07	1	0.02	0.06
Neuroptera	**26**	**29.19**	**99.70**	**32**	**20.51**	**97.53**	**30**	**27.56**	**92.54**	**38**	**25.75**	**96.47**
Coniopterygidae	3	21.42	73.16	4	9.10	43.28	6	16.58	55.67	6	15.70	58.81
Hemerobiidae	14	4.59	15.68	14	4.99	23.73	12	5.32	17.86	18	4.96	18.60
Chrysopidae	9	3.18	10.86	14	6.42	30.52	12	5.66	19.01	14	5.09	19.06
Total	**28**	**29.28**	**100.00**	**36**	**21.03**	**100.00**	**36**	**29.78**	**100.00**	**44**	**26.69**	**100.00**

Beskid Sądecki. A total of 28 species was recorded, with 21 or 22 species at each particular plot. The abundance index of the communities ranged between 22.2 and 36.9, mean 29.3. The communities from particular plots had very similar species compositions (16 shared species) and dominance structures. An extremely high proportion (ca 70%) of *Coniopteryx pygmaea* (syn. *C. parthenia* NAVÁS et MARCET) was characteristic (Table II, Fig. 3). *Hemerobius contumax* was the dominant. A large group of subdominants included *Wesmaelius concinnus, W. quadrifasciatus., Hemerobius stigma, Sympherobius pellucidus, Nothochrysa capitata, Chrysopa pallens* and *Peyerimhoffina gracilis*. Within the group of 19 accessory species, *Parasemidalis fuscipennis, Hemerobius humulinus, Nineta flava* and *Cunctochrysa albolineata* were the most abundant.

Table II. Number of individuals (S), index of abundance (n) and proportions (%) of particular species of *Neuropterida* in the forests of Beskid Sądecki.

	Plots	I			II			III			Total		
No	Species	S	n	%	S	n	%	S	n	%	S	n	%
1	*Phaeostigma notata*	1	0.04	0.14	3	0.11	0.30	1	0.04	0.18	5	0.06	0.22
2	*Puncha ratzeburgi*	1	0.04	0.14	1	0.04	0.11	–	–	–	2	0.03	0.09
3	*Coniopteryx pygmaea*	561	20.23	70.41	771	27.42	74.31	422	15.68	70.66	1754	21.11	72.10
4	*Parasemidalis fuscipennis*	9	0.33	1.15	2	0.07	0.19	9	0.34	1.53	20	0.25	0.84
5	*Conwentzia pineticola*	4	0.14	0.49	1	0.04	0.11	–	–	–	5	0.06	0.20
6	*Drepanepteryx algida*	–	–	–	–	–	–	1	0.04	0.18	1	0.01	0.05
7	*Wesmaelius concinnus*	9	0.33	1.15	13	0.47	1.27	6	0.23	1.04	28	0.34	1.17
8	*Wesmaelius quadrifasciatus*	5	0.18	0.63	15	0.54	1.46	18	0.69	3.11	38	0.47	1.61
9	*Wesmaelius subnebulosus*	–	–	–	–	–	–	1	0.04	0.18	1	0.01	0.05
10	*Wesmaelius mortoni*	2	0.08	0.28	–	–	–	–	–	–	2	0.03	0.09
11	*Hemerobius humulinus*	3	0.11	0.38	11	0.40	1.08	3	0.11	0.50	17	0.21	0.71
12	*Hemerobius stigma*	20	0.73	2.54	24	0.86	2.33	12	0.46	2.07	56	0.68	2.33
13	*Hemerobius pini*	2	0.07	0.24	1	0.04	0.11	1	0.04	0.18	4	0.05	0.17
14	*Hemerobius contumax*	48	1.70	5.92	89	3.14	8.51	34	1.28	5.77	171	2.04	6.97
15	*Hemerobius atrifrons*	5	0.19	0.66	2	0.07	0.19	1	0.04	0.18	8	0.10	0.34
16	*Hemerobius nitidulus*	1	0.04	0.14	–	–	–	1	0.04	0.18	2	0.03	0.09
17	*Hemerobius micans*	–	–	–	–	–	–	2	0.08	0.36	2	0.03	0.09
18	*Sympherobius fuscescens*	–	–	–	1	0.04	0.11	–	–	–	1	0.01	0.05
19	*Sympherobius pellucidus*	10	0.36	1.25	24	0.84	2.28	14	0.53	2.39	48	0.58	1.97
20	*Nothochrysa capitata*	41	1.49	5.19	31	1.10	2.98	26	1.00	4.51	98	1.20	4.09
21	*Nineta flava*	11	0.40	1.39	7	0.25	0.68	4	0.16	0.72	22	0.27	0.92
22	*Nineta vittata*	–	–	–	3	0.11	0.30	1	0.04	0.18	4	0.05	0.17
23	*Nineta pallida*	–	–	–	3	0.11	0.30	1	0.04	0.18	4	0.05	0.17
24	*Chrysopa pallens*	30	1.10	3.83	15	0.54	1.46	13	0.51	2.30	58	0.72	2.45
25	*Dichochrysa ventralis*	1	0.04	0.14	–	–	–	–	–	–	1	0.01	0.05
26	*Peyerimhoffina gracilis*	20	0.72	2.51	18	0.64	1.73	17	0.64	2.88	55	0.67	2.28
27	*Chrysoperla carnea s.l.*	1	0.04	0.14	–	–	–	–	–	–	1	0.01	0.05
28	*Cunctochrysa albolineata*	10	0.37	1.29	2	0.07	0.19	4	0.16	0.72	16	0.20	0.68
	Total	795	28.73	100.00	1037	36.90	100.00	592	22.19	100.00	2424	29.28	100.00
	Number of species	22			21			22			28		

Góry Świętokrzyskie. A total of 36 species was recorded, with 12 to 32 species at each particular plot. The abundance index of the communities ranged between 10.0 and 28.5, mean 21.0 (Table III).

Table III. Number of individuals (S), index of abundance (n) and proportions (%) of particular species of *Neuropterida* in the forests of Góry Świętokrzyskie.

No	Plots	I			II			III			Total		
	Species	S	n	%	S	n	%	S	n	%	S	n	%
1	*Phaeostigma notata*	3	0.23	2.30	2	0.07	0.28	16	0.64	2.25	21	0.31	1.47
2	*Dichrostigma flavipes*	–	–	–	–	–	–	12	0.50	1.76	12	0.17	0.81
3	*Puncha ratzeburgi*	–	–	–	–	–	–	1	0.04	0.14	1	0.01	0.05
4	*Inocellia crassicornis*	–	–	–	1	0.04	0.16	1	0.04	0.14	2	0.03	0.14
5	*Coniopteryx tineiformis*	–	–	–	6	0.24	0.97	5	0.22	0.77	11	0.15	0.71
6	*Coniopteryx pygmaea*	54	4.09	40.90	69	2.68	10.85	74	3.04	10.69	197	3.27	15.55
7	*Parasemidalis fuscipennis*	15	1.14	11.40	12	0.45	1.82	6	0.24	0.84	33	0.61	2.90
8	*Conwentzia pineticola*	26	1.97	19.70	111	4.03	16.32	233	9.20	32.34	370	5.07	24.10
9	*Drepanepteryx phalaenoides*	–	–	–	5	0.20	0.81	3	0.13	0.46	8	0.11	0.52
10	*Drepanepteryx algida*	–	–	–	1	0.04	0.16	2	0.09	0.32	3	0.04	0.19
11	*Wesmaelius concinnus*	–	–	–	3	0.12	0.49	4	0.18	0.63	7	0.10	0.48
12	*Wesmaelius quadrifasciatus*	–	–	–	4	0.16	0.65	5	0.22	0.77	9	0.13	0.62
13	*Wesmaelius nervosus*	–	–	–	1	0.04	0.16	–	–	–	1	0.01	0.05
14	*Wesmaelius ravus*	–	–	–	–	–	–	1	0.04	0.14	1	0.01	0.05
15	*Hemerobius humulinus*	1	0.08	0.80	8	0.32	1.30	3	0.13	0.46	12	0.18	0.86
16	*Hemerobius stigma*	–	–	–	50	1.98	8.02	18	0.78	2.74	68	0.92	4.37
17	*Hemerobius pini*	–	–	–	1	0.04	0.16	–	–	–	1	0.01	0.05
18	*Hemerobius contumax*	2	0.15	1.50	58	2.28	9.23	51	2.17	7.63	111	1.53	7.28
19	*Hemerobius atrifrons*	–	–	–	3	0.12	0.49	6	0.26	0.91	9	0.13	0.62
20	*Hemerobius nitidulus*	–	–	–	1	0.04	0.16	–	–	–	1	0.01	0.05
21	*Hemerobius micans*	–	–	–	1	0.04	0.16	1	0.05	0.18	2	0.03	0.14
22	*Sympherobius pellucidus*	4	0.30	3.00	95	3.61	14.62	34	1.43	5.03	133	1.78	8.46
23	*Nothochrysa fulviceps*	–	–	–	–	–	–	3	0.13	0.46	3	0.04	0.19
24	*Nothochrysa capitata*	11	0.83	8.30	21	0.83	3.36	23	0.97	3.41	55	0.88	4.18
25	*Nineta flava*	–	–	–	25	0.99	4.01	17	0.72	2.53	42	0.57	2.71
26	*Nineta vittata*	–	–	–	5	0.20	0.81	–	–	–	5	0.07	0.33
27	*Nineta pallida*	2	0.15	1.50	1	0.04	0.16	6	0.26	0.91	9	0.15	0.71
28	*Chrysotropia ciliata*	–	–	–	11	0.43	1.74	1	0.04	0.14	12	0.16	0.76
29	*Chrysopa pallens*	–	–	–	8	0.32	1.30	10	0.43	1.51	18	0.25	1.19
30	*Dichochrysa flavifrons*	–	–	–	1	0.04	0.16	7	0.30	1.05	8	0.11	0.52
31	*Dichochrysa prasina*	–	–	–	5	0.20	0.81	6	0.26	0.91	11	0.15	0.71
32	*Dichochrysa abdominalis*	1	0.08	0.80	40	1.57	6.36	59	2.52	8.86	100	1.39	6.61
33	*Dichochrysa ventralis*	1	0.08	0.80	20	0.80	3.24	10	0.41	1.44	31	0.43	2.04
34	*Peyerimhoffina gracilis*	12	0.91	9.00	–	–	–	5	0.21	0.74	17	0.37	1.76
35	*Chrysoperla carnea s.l.*	–	–	–	7	0.28	1.13	20	0.87	3.06	27	0.38	1.81
36	*Cunctochrysa albolineata*	–	–	–	63	2.49	10.09	45	1.93	6.78	108	1.47	7.00
	Total	132	10.01	100.00	639	24.69	100.00	688	28.45	100.00	1459	21.03	100.00
	Number of species	12			31			32			36		

The communities from plots II and III, situated on the southern and eastern slope of Łysa Góra, respectively, had a rich species composition and high abundance indices. Conwentzia pineticola was the eudominant, *Coniopteryx pygmaea, Hemerobius contumax, Sympherobius pellucidus, Dichochrysa abdominalis* and *Cunctochrysa albolineata* were dominants. The community from Plot I was the least abundant and showed the poorest species composition. This may have been due to the situation of the plot on the northern, therefore colder, slope of Łysa Góra. Moreover, a shorter (one season) collecting period may have been another factor of some impact.

The community from Plot I also differed from those from the other two plots in higher proportions of *Coniopteryx pygmaea, Parasemidalis fuscipennis, Nothochrysa capitata* and *Peyerimhoffina gracilis* (Table III). In the entire material collected in this region, *Conwentzia pineticola* and *Coniopteryx pygmaea* were the most abundantly represented species. *Sympherobius pellucidus, Dichochrysa abdominalis, Hemerobius contumax* and *Cunctochrysa albolineata*, which made the group of dominants, had fairly high proportions, too (6.6–8.5%). The group of subdominants was very numerous and it included *Phaeostigma notata, Parasemidalis fuscipennis, Hemerobius stigma, Nothochrysa capitata, Nineta flava, Chrysopa pallens, Dichochrysa ventralis, Peyerimhoffina gracilis* and *Chrysoperla carnea s.l.* The accessory component consisted of 21 species; of these, *Dichrostigma flavipes, Coniopteryx tineiformis, Hemerobius humulinus, Nineta pallida, Chrysotropia ciliata* and *Dichochrysa prasina* were the most abundant.

In comparison with the neuropterid fauna of the forests in Beskid Sądecki, that of the fir forests in this region was characterised by a greater species richness. The proportion and abundance of *Coniopteryx pygmaea* were considerably lower at the expense of such species as *Conwentzia pineticola, Sympherobius pellucidus, Cunctochrysa albolineata* (Tables II, III, V; Fig. 3). Of the species unrecorded from the woodlands of Beskid Sądecki but present there, *Dichochrysa abdominalis* stood out because of its considerable abundance.

Wysoczyzna Łódzka. A total of 36 species were recorded; from 14 to 27 at each particular plot. The abundance of the communities was generally high, the index values ranged between 18.8 and 38.7, mean 29.8 (Table IV). *Coniopteryx pygmaea* was the eudominant (39–69.4%) at almost all plots (except Plot IV). Other species with high proportions were: *Conwentzia pineticola, Hemerobius stigma, Dichrostigma flavipes, Dichochrysa prasina, Sympherobius pellucidus, Chrysoperla carnea s.l., Hemerobius contumax, Dichochrysa abdominalis, Parasemidalis fuscipennis, Peyerimhoffina gracilis, Phaeostigma notata* and *Cunctochrysa albolineata*. In the dominance structures of particular communities, they generally occupied the positions of dominants or subdominants. A different situation was only observed at Plot IV (in the forest patch studied, fir co-occurred with pine), where *Hemerobius stigma* was the eudominant. Of the 22 accessory species, *Hemerobius humulinus, Dichochrysa flavifrons* and *Dichochrysa ventralis* were fairly numerous.

When the neuropterid fauna of the fir forests in Góry Świętokrzyskie was compared with that of Wysoczyzna Łódzka, it showed much higher abundance and proportion of *Coniopteryx pygmaea*, and a higher abundance of *Dichrostigma flavipes, Hemerobius stigma, Dichochrysa prasina* and *Chrysoperla carnea s.l.* However, the abundances and percentages of *Conwentzia pineticola, Hemerobius contumax, Sympherobius pellucidus, Nothochrysa capitata* and *Dichochrysa abdominalis* were lower (Tables III, IV, V; Fig. 3).

Table IV. Number of individuals (S), index of abundance (n) and proportions (%) of particular species of *Neuropterida* in the forests of Wysoczyzna Łódzka.

	Plots	I			II			III			IV			V			VI			Total		
No	Species	S	n	%	S	n	%	S	n	%	S	n	%	S	n	%	S	n	%	S	n	%
1	*Phaeostigma notata*	5	0.23	0.79	3	0.62	2.26	–	–	–	2	0.24	0.62	17	1.93	5.88	6	0.40	2.13	33	0.57	1.91
2	*Dichrostigma flavipes*	23	0.95	3.28	15	3.09	11.28	17	3.62	11.32	13	1.56	4.04	–	–	–	4	0.26	1.38	72	1.58	5.31
3	*Xanthostigma xanthostigma*	–	–	–	–	–	–	–	–	–	1	0.12	0.31	–	–	–	–	–	–	1	0.02	0.07
4	*Raphidia ophiopsis ophiopsis*	–	–	–	–	–	–	–	–	–	–	–	–	1	0.11	0.33	–	–	–	1	0.02	0.07
5	*Puncha ratzeburgi*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.07	0.37	1	0.01	0.03
6	*Inocellia crassicornis*	–	–	–	–	–	–	–	–	–	1	0.12	0.31	–	–	–	–	–	–	1	0.02	0.07
7	*Coniopteryx tineiformis*	–	–	–	–	–	–	1	0.21	0.66	–	–	–	–	–	–	–	–	–	1	0.04	0.13
8	*Coniopteryx pygmaea*	262	11.70	40.39	53	10.90	39.80	104	22.17	69.35	36	4.30	11.15	115	12.95	39.43	186	12.30	65.46	756	12.39	41.61
9	*Parasemidalis fuscipennis*	4	0.14	0.48	2	0.41	1.50	3	0.64	2.00	3	0.37	0.96	1	0.11	0.33	32	2.12	11.28	45	0.63	2.12
10	*Semidalis aleyrodiformis*	7	0.25	0.86	-	-	-	2	0.43	1.35	-	-	-	-	-	-	-	-	-	9	0.11	0.37
11	*Conwentzia psociformis*	1	0.04	0.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.01	0.03
12	*Conwentzia pineticola*	49	1.75	6.04	28	5.76	21.03	7	1.49	4.65	12	1.46	3.79	85	9.62	29.29	5	0.33	1.76	186	3.40	11.42
13	*Drepanepteryx phalaenoides*	-	-	-	-	-	-	-	-	-	-	-	-	3	0.33	1.00	-	-	-	3	0.06	0.20
14	*Wesmaelius concinnus*	5	0.24	0.83	-	-	-	-	-	-	13	1.54	3.99	10	1.08	3.29	1	0.07	0.37	29	0.49	1.64
15	*Wesmaelius quadrifasciatus*	-	-	-	-	-	-	-	-	-	5	0.59	1.53	-	-	-	-	-	-	5	0.10	0.33
16	*Hemerobius humulinus*	11	0.52	1.79	1	0.21	0.77	-	-	-	4	0.48	1.24	2	0.23	0.70	-	-	-	18	0.24	0.81
17	*Hemerobius stigma*	18	0.87	3.00	-	-	-	1	0.21	0.66	66	7.81	20.25	14	1.52	4.63	4	0.26	1.38	103	1.78	5.98
18	*Hemerobius pini*	1	0.05	0.17	1	0.21	0.77	-	-	-	2	0.24	0.62	-	-	-	-	-	-	4	0.08	0.27
19	*Hemerobius contumax*	33	1.45	5.01	2	0.41	1.50	2	0.43	1.35	18	2.14	5.55	8	0.87	2.65	12	0.79	4.20	75	1.02	3.43
20	*Hemerobius atrifrons*	-	-	-	-	-	-	-	-	-	4	0.48	1.24	-	-	-	-	-	-	4	0.08	0.27
21	*Hemerobius nitidulus*	1	0.05	0.17	-	-	-	-	-	-	1	0.12	0.31	-	-	-	-	-	-	2	0.03	0.10
22	*Hemerobius micans*	1	0.05	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.01	0.03
23	*Sympherobius elegans*	-	-	-	1	0.21	0.77	–	–	–	1	0.12	0.31	–	–	–	–	–	–	2	0.06	0.20
24	*Sympherobius pellucidus*	56	2.65	9.15	9	1.85	6.75	1	0.21	0.66	19	2.26	5.86	9	0.99	3.01	4	0.26	1.38	98	1.37	4.60
25	*Nothochrysa capitata*	5	0.26	0.90	–	–	–	–	–	–	–	–	–	2	0.22	0.67	3	0.20	1.06	10	0.11	0.37
26	*Nineta flava*	11	0.56	1.93	–	–	–	–	–	–	2	0.24	0.62	–	–	–	–	–	–	13	0.13	0.44
27	*Nineta vittata*	1	0.05	0.17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.01	0.03
28	*Nineta pallida*	4	0.16	0.55	–	–	–	–	–	–	3	0.36	0.93	1	0.11	0.33	2	0.13	0.69	10	0.13	0.44
29	*Chrysopa pallens*	8	0.41	1.42	1	0.21	0.77	–	–	–	2	0.24	0.62	1	0.11	0.33	–	–	–	12	0.16	0.54
30	*Dichochrysa flavifrons*	2	0.09	0.31	1	0.21	0.77	3	0.64	2.00	4	0.48	1.24	2	0.23	0.70	1	0.07	0.37	13	0.29	0.97
31	*Dichochrysa prasina*	49	2.38	8.22	3	0.62	2.26	2	0.43	1.35	44	5.23	13.56	4	0.44	1.34	1	0.07	0.37	103	1.56	5.24
32	*Dichochrysa abdominalis*	20	0.97	3.34	–	–	–	2	0.43	1.35	25	2.97	7.70	3	0.33	1.00	–	–	–	50	0.75	2.52
33	*Dichochrysa ventralis*	6	0.24	0.83	1	0.21	0.77	1	0.21	0.66	5	0.60	1.56	–	–	–	–	–	–	13	0.21	0.71
34	*Peyerimhoffina gracilis*	5	0.19	0.66	2	0.41	1.50	4	0.85	2.66	1	0.12	0.31	5	0.46	1.40	21	1.39	7.40	38	0.57	1.91
35	*Chrysoperla carnea s.l.*	46	2.34	8.08	9	1.85	6.75	–	–	–	25	2.96	7.67	8	0.87	2.65	–	–	–	88	1.34	4.50
36	*Cunctochrysa albolineata*	8	0.38	1.31	1	0.21	0.77	–	–	–	12	1.42	3.68	3	0.33	1.00	1	0.07	0.37	25	0.40	1.34
	Total	642	28.97	100.00	133	27.39	100.00	150	31.97	100.00	324	38.57	100.00	294	32.84	100.00	284	18.79	100.00	1827	29.78	100.00
	Number of species	27			17			14			27			20			16			36		

The neuropterid faunas of montane, upland and lowland fir forests had some specific regional features as well as certain things in common. Northwards, the species composition and structure of the communities changed because of the different habitat conditions. The species community of a typical montane woodland was the poorest (28 species), with a subsequent increase in species richness by 16 species more northerly and towards lowlands.

Of the 44 species recorded, 24 occurred in all three regions (Table V). The neuropterid faunas of the upland and lowland forests had the most similar species compositions, with 31 species shared (So=86%). A medium rate of similarity was recorded for the faunas of the upland and montane forests, with 25 species in common (So=78%), the lowest, yet not at all much so, in the faunas of the montane and lowland forests, with 24 shared species (So=75%). The mean pairwise similarity of the faunas compared was 80%. This indicates high similarity of the species compositions of neuropterids inhabiting the fir forests.

The dominance structure of the neuropterid communities from particular regions had one feature in common, i.e. presence of one or two species of the family *Coniopterygidae* as eudominants. The differences were in the sequence of species at the farther positions in the community.

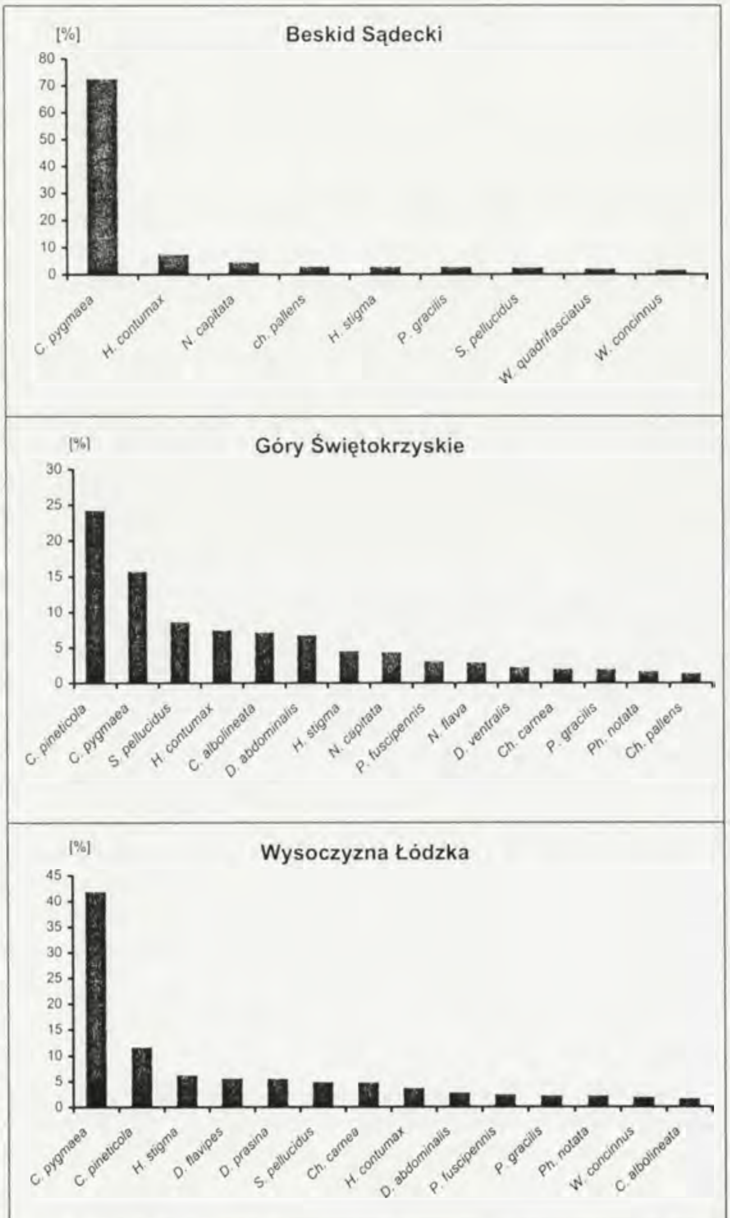

Fig 3. Mean dominance structures of *Neuropterida* communities in fir forests from particular regions.

Coniopteryx pygmaea predominated in all montane forests, whereas either *Coniopteryx pygmaea* or *Conwentzia pineticola* in the upland and/or lowland ones. *Coniopteryx pygmaea, Conwentzia pineticola, Hemerobius contumax, Sympherobius pellucidus* and *Hemerobius stigma* were the most abundantly represented lacewings in the entire material (>4%, each), also being species shared in the three regions (Table V).

A comparison of the mean dominance structure of neuropterids from particular regions showed that the communities from the montane and lowland forests were the most similar in this respect (Mo=0.83). A little lower similarity was recorded for the structures of the communities from the lowland and upland forests (Mo=0.70), whereas the similarity of the structures of those from the montane and upland forests was very low (Mo=0.39). The mean value of the Mo index for all pairs of the regions compared was 0.64.

The species with the highest frequency of occurrence in the fir forests were as follows: *Coniopteryx pygmaea, Parasemidalis fuscipennis, Hemerobius contumax, Sympherobius pellucidus* (F=100%), *Phaeostigma notata, Conwentzia pineticola, Peyerimhoffina gracilis* (F=92%), *Hemerobius humulinus, H. stigma* and *Cunctochrysa albolineata* (F=83%). The fairly constant ones were: *Wesmaelius concinnus, Nothochrysa capitata, Nineta pallida, Chrysopa pallens* (F=75%), *Dichochrysa flavifrons, D. prasina, D. ventralis* (F=67%), *Hemerobius pini, Nineta flava, Dichochrysa abdominalis* and *Chrysoperla carnea s.l.* (F=58%).

Frequency is a measure of the presence of a given species in the habitat, independent of abundance. Species with the highest abundances generally are also the most common ones, yet this is not always the case. Noteworthy is the high frequency of a relatively little abundant *Parasemidalis fuscipennis* which, in this respect, precedes a much more abundant *Conwentzia pineticola* (Table V).

Phenology

Neuropterid adults fell into the traps throughout the season (from May through October) (Table VI). In the course of the seasonal dynamics, there were two abundance peaks, one in spring and the other in summer. The spring peak (May–June) was related to the emergence of *Raphidioptera* and of the first generation of bivoltine species of the families *Coniopterygidae* and *Hemerobiidae*. The summer peak (July–August) was associated with the emergence of univoltine species (mostly *Chrysopidae*, some *Hemerobiidae*) and the second generation of bivoltine species. Towards the end of August, the number of individuals and species captured decreased rapidly. *Coniopteryx pygmaea, Conwentzia pineticola, Parasemidalis fuscipennis, Hemerobius humulinus, H. stigma, H. contumax, Sympherobius pellucidus, Peyerimhoffina gracilis* and *Chrysoperla carnea* were the longest to be collected during the season (from May to September or even October). Great abundance fluctuations during particular seasons were recorded for most species, *Conwentzia pineticola* first of all. The lowest differences in this respect were reported for *Coniopteryx pygmaea, Hemerobius contumax* and *Sympherobius pellucidus*.

Table V. Index of abundance (n), proportions (%) and frequency (F) of particular *Neuropterida* species recorded in fir canopies of the forests of the different regions studied.

No	Geographical zones	Mountains		Uplands		Lowlands		Total		F
	Regions	Beskid Sądecki		Góry Świętokrzyskie		Wysoczyzna Łódzka				
	Species	n	%	n	%	n	%	n	%	(%)
	Raphidioptera									
1	*Phaeostigma notata* (FABR.)	0.06	0.20	0.31	1.47	0.57	1.91	0.313	1.17	92
2	*Dichrostigma flavipes* (STEIN)	–	–	0.17	0.81	1.58	5.31	0.583	2.18	50
3	*Xanthostigma xanthostigma* (SCHUMM.)	–	–	–	–	0.02	0.07	0.007	0.03	8
4	*Raphidia ophiopsis ophiopsis* L.	–	–	–	–	0.02	0.07	0.007	0.03	8
5	*Puncha ratzeburgi* (BRAU.)	0.03	0.09	0.01	0.05	0.01	0.03	0.017	0.06	33
6	*Inocellia crassicornis* (SCHUMM.)	–	–	0.03	0.14	0.02	0.07	0.016	0.06	25
	Neuroptera									
7	*Coniopteryx tineiformis* CURT.	–	–	0.15	0.71	0.04	0.13	0.063	0.24	25
8	*Coniopteryx pygmaea* END.	21.11	72.10	3.27	15.55	12.39	41.61	12.256	45.92	100
9	*Parasemidalis fuscipennis* (REUT.)	0.25	0.84	0.61	2.90	0.63	2.12	0.497	1.86	100
10	*Semidalis aleyrodiformis* (STEPH.)	–	–	–	–	0.11	0.37	0.037	0.14	17
11	*Conwentzia psociformis* (CURT.)	–	–	–	–	0.01	0.03	0.003	0.01	8
12	*Conwentzia pineticola* END.	0.06	0.20	5.07	24.10	3.40	11.42	2.843	10.65	92
13	*Drepanepteryx phalaenoides* L.	–	–	0.11	0.52	0.06	0.20	0.057	0.21	25
14	*Drepanepteryx algida* (ERICHS.)	0.01	0.05	0.04	0.19	–	–	0.017	0.06	25
15	*Wesmaelius concinnus* (STEPH.)	0.34	1.17	0.10	0.48	0.49	1.64	0.309	1.16	75
16	*Wesmaelius quadrifasciatus* (REUT.)	0.47	1.61	0.13	0.62	0.10	0.33	0.232	0.87	50
17	*Wesmaelius nervosus* (FABR.)	–	–	0.01	0.05	–	–	0.003	0.01	8
18	*Wesmaelius subnebulosus* (STEPH.)	0.01	0.05	–	–	–	–	0.003	0.01	8
19	*Wesmaelius ravus* (WITHYCOMBE)	–	–	0.01	0.05	–	–	0.003	0.01	8
20	*Wesmaelius mortoni* (MCLACHL.)	0.03	0.09	–	–	–	–	0.010	0.04	8
21	*Hemerobius humulinus* L.	0.21	0.71	0.18	0.86	0.24	0.81	0.209	0.78	83
22	*Hemerobius stigma* STEPH.	0.68	2.33	0.92	4.37	1.78	5.98	1.127	4.22	83
23	*Hemerobius pini* STEPH.	0.05	0.17	0.01	0.05	0.08	0.27	0.047	0.18	58
24	*Hemerobius contumax* TJED.	2.04	6.97	1.53	7.28	1.02	3.43	1.530	5.73	100
25	*Hemerobius atrifron* MCLACHL.	0.10	0.34	0.13	0.62	0.08	0.27	0.102	0.38	50
26	*Hemerobius nitidulus* FABR.	0.03	0.09	0.01	0.05	0.03	0.10	0.023	0.09	42
27	*Hemerobius micans* OLIV.	0.03	0.09	0.03	0.14	0.01	0.03	0.023	0.09	33
28	*Sympherobius elegans* (STEPH.)	–	–	–	–	0.06	0.20	0.020	0.07	17
29	*Sympherobius fuscescens* (WALL.)	0.01	0.05	–	–	–	–	0.003	0.01	8
30	*Sympherobius pellucidus* (WALK.)	0.58	1.97	1.78	8.46	1.37	4.60	1.244	4.66	100
31	*Nothochrysa fulviceps* (STEPH.)	–	–	0.04	0.19	–	–	0.013	0.05	8
32	*Nothochrysa capitata* (FABR.)	1.20	4.09	0.88	4.18	0.11	0.37	0.730	2.74	75
33	*Nineta flava* (SCOP.)	0.27	0.92	0.57	2.71	0.13	0.44	0.323	1.22	58
34	*Nineta vittata* (WESM.)	0.05	0.17	0.07	0.33	0.01	0.03	0.043	0.16	33
35	*Nineta pallida* (SCHN.)	0.05	0.17	0.15	0.71	0.13	0.44	0.110	0.41	75
36	*Chrysotropia ciliata* (WESM.)	–	–	0.16	0.76	–	–	0.053	0.20	17
37	*Chrysopa pallens* (RAMB.)	0.72	2.45	0.25	1.19	0.16	0.54	0.377	1.41	75
38	*Dichochrysa flavifrons* (BRAU.)	–	–	0.11	0.52	0.29	0.97	0.133	0.50	67
39	*Dichochrysa prasina* (BURM.)	–	–	0.15	0.71	1.56	5.24	0.570	2.14	67
40	*Dichochrysa abdominalis* (BRAU.)	–	–	1.39	6.61	0.75	2.52	0.713	2.67	58
41	*Dichochrysa ventralis* (CURT.)	0.01	0.05	0.43	2.04	0.21	0.71	0.217	0.81	67
42	*Peyerimhoffina gracilis* (SCHN.)	0.67	2.28	0.37	1.76	0.57	1.91	0.537	2.01	92
43	*Chrysoperla carnea* (STEPH.) *s.l.*	0.01	0.05	0.38	1.81	1.34	4.50	0.577	2.16	58
44	*Cunctochrysa albolineata* (KILL.)	0.20	0.68	1.47	7.00	0.40	1.34	0.690	2.58	83
	Total	29.28	100.00	21.03	100.00	29.78	100.00	26.69	100.00	
	Number of species	28		36		36		44		

Table VI. Number of *Neuropterida* individuals caught in fir canopies of the forests studied in particular months and years (from May to October).

No	Years / Months / Species	1993							1994							Total						
		V	VI	VII	VIII	IX	X	Total	V	VI	VII	VIII	IX	X	Total	V	VI	VII	VIII	IX	X	Total
1	*Phaeostigma notata*	38	11	3	1			53	1	2	3				6	39	13	6	1			59
2	*Dichrostigma flavipes*	54	8	1				63	1	12	7	1			21	55	20	8	1			84
3	*Xanthostigma xanthostigma*							0	1						1	1						1
4	*Raphidia ophiopsis ophiopsis*							0			1				1			1				1
5	*Puncha ratzeburgi*		2	1	1			4							0		2	1	1			4
6	*Inocellia crassicornis*	2						2		1					1	2	1					3
7	*Coniopteryx tineiformis*				1			1	8	2		1			11	8	2		2			12
8	*Coniopteryx pygmaea*	542	64	64	436	51	2	1159	235	1168	52	76	16	1	1548	777	1232	116	512	67	3	2707
9	*Parasemidalis fuscipennis*	30	7	20	18	1		76	4	4	14				22	34	11	34	18	1		98
10	*Semidalis aleyrodiformis*				7	2		9							0				7	2		9
11	*Conwentzia psociformis*				1			1							0				1			1
12	*Conwentzia pineticola*	39	52	261	171	12	1	536	21	4					25	60	56	261	171	12	1	561
13	*Drepanepteryx phalaenoides*							0			1	8	1	1	11			1	8	1	1	11
14	*Drepanepteryx algida*							0					4		4					4		4
15	*Wesmaelius concinnus*		2					2	1	4	32	25			62	1	6	32	25			64
16	*Wesmaelius quadrifasciatus*		1	1	2		1	5	1	2	12	32			47	1	3	13	34		1	52
17	*Wesmaelius nervosus*							0				1			1				1			1
18	*Wesmaelius subnebulosus*							0			1				1			1				1
19	*Wesmaelius ravus*		1					1							0		1					1
20	*Wesmaelius mortoni*							0				2			2				2			2
21	*Hemerobius humulinus*	4	2	1	3	1		11	1		3	27	4	1	36	5	2	4	30	5	1	47
22	*Hemerobius stigma*	2	2	5	6	2		17	4	19	112	75			210	6	21	117	81	2		227
23	*Hemerobius pini*		1	2				3		2	1	3			6		3	3	3			9
24	*Hemerobius contumax*	9	19	24	55	17		124	45	37	30	75	41	5	233	54	56	54	130	58	5	357
25	*Hemerobius atrifrons*				1			1		6	6	6	2		20		6	6	7	2		21
26	*Hemerobius nitidulus*							0	1		2	2			5	1		2	2			5
27	*Hemerobius micans*							0	1	1	2			1	5	1	1	2			1	5

No	Years / Months / Species	1993							1994							Total						
		V	VI	VII	VIII	IX	X	Total	V	VI	VII	VIII	IX	X	Total	V	VI	VII	VIII	IX	X	Total
28	*Sympherobius elegans*			2				2							0			2				2
29	*Sympherobius fuscescens*		1					1							0		1					1
30	*Sympherobius pellucidus*	16	20	25	49	3		113	28	64	42	23	8	1	166	44	84	67	72	11	1	279
31	*Nothochrysa fulviceps*							0			2	1			3			2	1			3
32	*Nothochrysa capitata*		4	24	11			39		6	57	61			124		10	81	72			163
33	*Nineta flava*			4	1			5		1	33	38			72		1	37	39			77
34	*Nineta vittata*		1					1				9			9		1		9			10
35	*Nineta pallida*			1	4	4	1	10			1	6	6		13			2	10	10	1	23
36	*Chrysotropia ciliata*	3		1	1			5			3	4			7	3		4	5			12
37	*Chrysopa pallens*			3	2			5		2	22	59			83		2	25	61			88
38	*Dichochrysa flavifrons*			5	5	1		11			4	6			10			9	11	1		21
39	*Dichochrysa prasina*		2	16	8			26			74	15			89		2	90	23			115
40	*Dichochrysa abdominalis*			15	8	1		24			54	72			126			69	80	1		150
41	*Dichochrysa ventralis*		4	8	2			14			23	7			30		4	31	9			44
42	*Peyerimhoffina gracilis*	7	4	16	17	11	15	70	3	4	7	15	9	2	40	10	8	23	32	20	17	110
43	*Chrysoperla carnea s. l.*	5		3		4	2	14			10	76	16		102	5		13	76	20	2	116
44	*Cunctochrysa albolineata*		1	9	3			13		1	59	76			136		2	68	79			149
	Total	751	209	515	814	110	22	2421	356	1342	670	802	107	12	3289	1107	1551	1185	1616	217	34	5710
	Number of species	13	21	25	25	13	6	34	16	20	30	29	10	7	38	19	27	33	35	16	11	44

Ecological characteristics

The neuropterids from the fir forests studied differed in their habitat preferences as well as in the range of their ecological amplitude (Table VII). Over half of them (25) were poly-, oligo- or stenotopic forms associated with coniferous woodland (Table VIII). The total proportion of their individuals was nearly 95% of the mean abundance of the communities in the montane woodlands, 81% in the upland forests, and 85% in the lowland ones. Of polytopes, *Coniopteryx pygmaea* was the most numerous. Among the species with a lower ecological amplitude, there were a lot of *Conwentzia pineticola*, *Hemerobius contumax* and *Sympherobius pellucidus*, followed by *Nothochrysa capitata* and *Dichochrysa abdominalis*. In the montane-upland-lowland transect, the abundance indices of these species took on different values (Table V). As the distance from the mountains increased the abundances of *Hemerobius contumax* and *Nothochrysa capitata* decreased, quite unlike that of *Conwentzia pineticola;* the latter species reached a higher abundance in the upland and lowland forests. *Sympherobius pellucidus* occurred in all the regions, but it was most numerous in Góry Świętokrzyskie, under the conditions of piedmont climate.

Dichochrysa abdominalis and *D. prasina* are closely related species which have only recently been separated (HÖLZEL 1998). During the present studies, neither was recorded in the mountains, but they co-occurred in the two other regions; *Dichochrysa abdominalis* was more abundant in Góry Świętokrzyskie while *D. prasina* in Wysoczyzna Łódzka. To date, *D. abdominalis* has only been recorded from a few European countries and its ecological requirements are poorly known. According to HÖLZEL & WIESER (1999), the species prefers *Picea* sp. in not too dry habitats. However, the species has also been observed abundant on oak, *Quercus pubescens* (DUELLI 1989). The present data show that, in comparison with *Dichochrysa prasina*, *D. abdominalis* prefers cooler and more humid habitats.

Neuropterids ecologically associated with deciduous woodland but collected in the fir forests (13 such species were recorded) constituted less than 8% of the mean abundance of the communities. *Cunctochrysa albolineata*, *Dichochrysa prasina* and *Nineta flava*, the most abundant of these species, occurred in all the regions, but the greatest numbers of individuals were collected in Góry Świętokrzyskie and Wysoczyzna Łódzka where fir co-occurs with deciduous trees.

Chrysoperla carnea s.l., an eurytope with a very wide range of ecological amplitude, was barely present in Beskid Sądecki but its relatively high proportion was recorded from the forests in Wysoczyzna Łódzka where fir co-occurs with oak (*Quercus* sp.).

Fir forests are first of all populated by neuropterid species whose thermal requirements are moderate and whose tolerance of high humidity is quite good. The proportion of more thermophilous species, which was low in the mountains, kept increasing in the other regions. The abundance of *Phaeostigma notata*, *Conwentzia pineticola*, *Parasemidalis fuscipennis*, *Hemerobius stigma* and *Sympherobius pellucidus* in the upland and lowland forests was higher than that in the montane ones. Xerophilous neuropterids occurred in the forests only sporadically. Of the species whose presumed habitat optimum lies in pine forest, individual *Xanthostigma xanthostigma*, *Raphidia ophiopsis*

ophiopsis, *Inocellia crassicornis* and *Hemerobius nitidulus* were found while only *Wesmaelius concinnus* and *Hemerobius stigma* were collected on fir more frequently.

Table VII. Ecological classification of *Neuropterida* species recorded in the forests studied.

No	Species	Ecological element[4]
1	*Phaeostigma notata* (FABR.)	Polytope of coniferous forests
2	*Dichrostigma flavipes* (STEIN)	Oligotope of dry coniferous forests and dry grasslands
3	*Xanthostigma xanthostigma* (SCHUMM.)	Stenotope of dry pine forests
4	*Raphidia ophiopsis ophiopsis* L.	Stenotope of dry pine forests
5	*Puncha ratzeburgi* (BRAU.)	Stenotope of dry coniferous forests
6	*Inocellia crassicornis* (SCHUMM.)	Stenotope of dry pine forests
7	*Coniopteryx tineiformis* CURT.	Oligotope of warm deciduous forests
8	*Coniopteryx pygmaea* END.	Polytope of coniferous forests
9	*Parasemidalis fuscipennis* (REUT.)	Oligotope of warm coniferous forests
10	*Semidalis aleyrodiformis* (STEPH.)	Oligotope of warm deciduous forests
11	*Conwentzia psociformis* (CURT.)	Oligotope of warm deciduous forests
12	*Conwentzia pineticola* END.	Oligotope of warm coniferous forest
13	*Drepanepteryx phalaenoides* L.	Polytope of deciduous and coniferous forests
14	*Drepanepteryx algida* (ERICHS.)	Stenotope of cold coniferous forests
15	*Wesmaelius concinnus* (STEPH.)	Oligotope of warm coniferous forests
16	*Wesmaelius quadrifasciatus* (REUT.)	Stenotope of cold coniferous forests
17	*Wesmaelius nervosus* (FABR.)	Polytope of deciduous and coniferous forests
18	*Wesmaelius subnebulosus* (STEPH.)	Oligotope of warm deciduous forests
19	*Wesmaelius ravus* (WITHYCOMBE)	Stenotope of dry coniferous forests
20	*Wesmaelius mortoni* (MCLACHL.)	Stenotope of dry coniferous forests
21	*Hemerobius humulinus* L.	Polytope of deciduous and coniferous forests
22	*Hemerobius stigma* STEPH.	Polytope of coniferous forests
23	*Hemerobius pini* STEPH.	Stenotope of cold coniferous forests
24	*Hemerobius contumax* TJED.	Stenotope of humid coniferous forests
25	*Hemerobius atrifrons* MCLACHL.	Stenotope of cold coniferous forests
26	*Hemerobius nitidulus* FABR.	Stenotope of dry pine forests
27	*Hemerobius micans* OLIV.	Polytope of deciduous forests
28	*Sympherobius elegans* (STEPH.)	Oligotope warm deciduous forests
29	*Sympherobius fuscescens* (WALL.)	Stenotope of dry coniferous forests
30	*Sympherobius pellucidus* (WALK.)	Stenotope of humid coniferous forests
31	*Nothochrysa fulviceps* (STEPH.)	Stenotope of humid deciduous forests
32	*Nothochrysa capitata* (FABR.)	Stenotope of humid coniferous forests
33	*Nineta flava* (SCOP.)	Polytope of deciduous forests
34	*Nineta vittata* (WESM.)	Polytope of deciduous forests
35	*Nineta pallida* (SCHN.)	Stenotope of humid coniferous forests
36	*Chrysotropia ciliata* (WESM.)	Stenotope of humid deciduous forests
37	*Chrysopa pallens* (RAMB.)	Polytope of deciduous and coniferous forests
38	*Dichochrysa flavifrons* (BRAU.)	Oligotope of warm deciduous forests
39	*Dichochrysa prasina* (BURM.)	Oligotope of warm deciduous forest
40	*Dichochrysa abdominalis* (BRAU.)	Oligotope of humid coniferous forests?
41	*Dichochrysa ventralis* (CURT.)	Polytope of deciduous and coniferous forests
42	*Peyerimhoffina gracilis* (SCHN.)	Stenotope humid coniferous forests
43	*Chrysoperla carnea* (STEPH.) *s.l.*	Eurytope (ubiquitous species)
44	*Cunctochrysa albolineata* (KILL.)	Oligotope of humid deciduous forests

[4] Almost all of the mentioned species to more or less extent enters mixed deciduous-coniferous forests.

Table VIII. Proportions of particular ecological elements in the *Neuropterida* communities in fir canopies of the forests studied (N – number of species, n – index of abundance, % – proportions).

Geographical zones	Mountains				Uplands				Lowlands				Total			
Regions	Beskid Sądecki				Góry Świętokrzyskie				Wysoczyzna Łódzka							
Elements	N	%	n	%	N	%	n	%	N	%	n	%	N	%	n	%
Polytopes of coniferous forests	3	10.7	21.85	74.6	3	8.3	4.50	21.4	3	8.3	14.74	49.4	3	6.8	13.70	51.3
Oligotopes of coniferous forests	3	10.7	0.65	2.2	5	13.9	7.34	34.9	5	13.9	6.85	23.0	5	11.4	4.94	18.5
Stenotopes of coniferous forests	13	46.5	5.27	18.0	13	36.1	5.08	24.1	13	36.1	3.56	12.0	17	38.6	4.63	17.3
Polytopes of deciduous forests	3	10.7	0.35	1.2	3	8.3	0.67	3.2	3	8.3	0.15	0.5	3	6.8	0.39	1.5
Oligotopes of deciduous forests	2	7.1	0.21	0.7	4	11.1	1.88	8.9	7	19.5	2.47	8.3	8	18.2	1.52	5.7
Stenotopes of deciduous forests	–	–	–	–	2	5.6	0.20	1.0	–	–	–	–	2	4.6	0.07	0.3
Polytopes of deciduous and coniferous forests	3	10.7	0.94	3.2	5	13.9	0.98	4.7	4	11.1	0.67	2.3	5	11.4	0.86	3.2
Eurytopes (=ubiquists)	1	3.6	0.01	0.1	1	2.8	0.38	1.8	1	2.8	1.34	4.5	1	2.3	0.58	2.2

Specificity of the neuropterid fauna of fir forest

A. alba is a montane tree species with a highly limited and fragmented range. The question therefore arises whether the neuropterid fauna of forest associations with fir differs in any particular way from that of firless forest of lowland-upland Poland. In order to answer this question, a comparison was made between the neuropterids of fir forest and of the forest associations characteristic of lowland-upland Poland, i.e. moist pine, mixed and linden-oak-hornbeam forest (after CZECHOWSKA 1997).

As the results show (Tables IX, X), the neuropterid fauna of fir forest was the most similar to that of moist pine woodland. However, this similarity applies to the species composition (28 shared species, So=75%) more than to the dominance structure (Mo=0.57). The presence of *Coniopteryx pygmaea* in the group of dominants was a significant shared feature in the structure of the faunas of pine woodland and fir forest. Significant differences in the structures compared apply to the percentage of *Raphidioptera*, whose proportion in fir forest was minimal (3.5%), whereas in pine woodland it reached nearly 25% (Table IX).

The presence of montane species (*Puncha ratzeburgi, Hemerobius contumax, Sympherobius pellucidus, Nothochrysa capitata, Nineta pallida* and *Peyerimhoffina gracilis*) was a peculiar trait of the fir forest fauna. The proportion of their individuals in the entire material was 15.6%, and in the material from particular regions it ranged from 11 to 23% (Tables II, III, IV, V). *Hemerobius contumax* and *Sympherobius pellucidus* showed the greatest shares (ca 5–6%) and the greatest frequency (F=100%) in all fir forests combined (Table V). *Nothochrysa capitata* and *Peyerimhoffina gracilis*, too, were characterised by great constancy (75–92%) and considerable share (ca 2–3%). Of the other two species, *Nineta pallida* (75%) was more constant than *Puncha ratzeburgi* (33%), but in respect of proportion (<1%) both species represented an accessory element in the fauna of fir canopies.

All of these montane species have a small range with the centre in Central Europe. The distribution of their sites is largely in line with that of the mountain ranges; only in the northern parts of their territory do they occur in lowlands. In the west of Europe, these species do not occur beyond the Pyrenees, and in the east beyond the Carpathians. The northernmost records of some of them are in the British Isles and in the south of Norway, Sweden and Finland. In the south of Europe, they reach the southernmost parts of Greece and Italy. Outside Europe, isolated records of some of these species lie in the Caucasus, in the mountains of Asia Minor and in north-eastern Africa (ASPÖCK et al. 1980, 2001). Within their range, these insects are mostly captured on conifers (*Picea*, *Abies*, *Pinus*), but some on deciduous trees as well.

Table IX. Occurrence of particular species of *Neuropterida* in fir forest, moist pine forest (*Peucedano-Pinetum* and *Leucobryo-Pinetum*), mixed pine forest (*Querco roboris-Pinetum*) and linden-oak-hornbeam forest (*Tilio-Carpinetum*); n – index of abundance, % – proportions, + – < 0. 01, * – date by CZECHOWSKA (1997)).

No	Forest types	Fir forest		Moist pine forest*		Mixed pine forest*		Linden-oak-hornbeam forest*	
	Species	n	%	n	%	n	%	n	%
1	*Phaeostigma notata* (FABRICIUS, 1781)	0.31	1.2	0.50	3.50	1.42	3.5	0.16	0.4
2	*Phaeostigma major* (BURMEISTER, 1839)	–	–	–	–	–	–	0.04	0.1
3	*Dichrostigma flavipes* (STEIN, 1863)	0.58	2.2	0.10	0.69	–	–	–	–
4	*Xanthostigma xanthostigma* (SCHUMMEL, 1832)	0.01	0.0	2.41	16.66	0.35	0.9	+	+
5	*Raphidia ophiopsis ophiopsis* LINNAEUS, 1758	0.01	0.0	0.39	2.70	0.05	0.1	–	–
6	*Puncha ratzeburgi* (BRAUER, 1876)	0.02	0.1	–	–	–	–	–	–
7	*Inocellia crassicornis* (SCHUMMEL, 1832)	0.02	0.1	0.19	1.31	0.02	0.1	–	–
8	*Aleuropteryx loewii* KLAPALEK, 1894			0.07	0.48	0.04	0.1	–	–
9	*Coniopteryx tineiformis* CURTIS, 1834	0.06	0.2	–	–	–	–	0.14	0.4
10	*Coniopteryx borealis* TJEDER, 1930	–	–	–	–	–	–	0.02	0.1
11	*Coniopteryx pygmaea* ENDERLEIN, 1906	12.26	45.92	2.77	19.14	2.01	4.9	0.02	0.1
12	*Coniopteryx haematica* MCLACHLAN, 1868	–	–	–	–	–	–	0.05	0.1
13	*Parasemidalis fuscipennis* (REUTER, 1894)	0.50	1.86	0.37	2.56	0.09	0.2	–	–
14	*Semidalis aleyrodiformis* (STEPHENS, 1836)	0.04	0.14	–	–	0.06	0.1	0.02	0.1
15	*Conwentzia psociformis* (CURTIS, 1834)	+	+	–	–	0.04	0.1	0.05	0.1
16	*Conwentzia pineticola* ENDERLEIN, 1905	2.84	10.65	0.09	0.62	0.16	0.4	–	–
17	*Drepanepteryx phalaenoides* (LINNAEUS, 1758)	0.06	0.21	+	+	0.06	0.1	0.04	0.1
18	*Drepanepteryx algida* (ERICHSON, 1851)	0.02	0.07	–	–	–	–	–	–
19	*Wesmaelius concinnus* (STEPHENS, 1836)	0.31	1.16	2.65	18.30	0.27	0.7	0.04	0.1
20	*Wesmaelius quadrifasciatus* (REUTER, 1894)	0.23	0.87	–	–	–	–	0.08	0.2
21	*Wesmaelius nervosus* (FABRICIUS, 1793)	+	+	0.02	0.14	0.08	0.2	0.04	0.1
22	*Wesmaelius subnebulosus* (STEPHENS, 1836)	+	+	–	–	–	–	–	–
23	*Wesmaelius ravus* (WITHYCOMBE, 1923)	+	+	–	–	–	–	–	–
24	*Wesmaelius mortoni* MCLACHLAN, 1899)	0.01	0.04	0.01	0.07	0.04	0.1	–	–
25	*Hemerobius humulinus* LINNAEUS, 1758)	0.21	0.78	0.41	2.80	0.97	2.4	1.04	2.8
26	*Hemerobius stigma* STEPHENS, 1836	1.13	4.22	1.22	8.43	0.51	1.3	–	–

Table IX (continued).

No	Species	n	%	n	%	n	%	n	%
27	*Hemerobius pini* STEPHENS, 1836	0.05	0.18	0.03	0.21	0.04	0.1	–	–
28	*Hemerobius contumax* TJEDER,1932	1.53	5.73	–	–	–	–	–	–
29	*Hemerobius fenestratus* TJEDER, 1932	–	–	0.01	0.07	–	–	–	–
30	*Hemerobius atrifrons* MCLACHLAN 1868	0.10	0.38	+	+	–	–	0.07	0.2
31	*Hemerobius nitidulus* FABRICIUS 1777	0.02	0.09	0.65	4.49	0.39	1	–	–
32	*Hemerobius micans* OLIVIER, 1792	0.02	0.08	0.02	0.14	0.1	0.2	0.16	0.4
33	*Hemerobius marginatus* STEPHENS, 1836	–	–	–	–	–	–	+	+
34	*Sympherobius pygmaeus* (RAMBUR, 1842)	–	–	–	–	0.04	0.1	–	–
35	*Sympherobius elegans* (STEPHENS,1836)	0.02	0.07	–	–	0.02	0.1	–	–
36	*Sympherobius fuscescens* (WALLENGREN, 1863)	+	+	0.02	0.14	0.06	0.1	–	–
37	*Sympherobius pellucidus* (WALKER, 1853)	1.24	4.66	–	–	–	–	–	–
38	*Sympherobius klapaleki* ZELENY, 1963	–	–	–	–	–	–	0.16	0.4
39	*Nothochrysa fulviceps* (STEPHENS, 1836)	0.01	0.05	–	–	–	–	–	–
40	*Nothochrysa capitata* (FABRICIUS, 1793)	0.73	2.74	0.04	0.28	–	–	–	–
41	*Nineta flava* (SCOPOLI, 1763)	0.32	1.22	0.07	0.48	0.1	0.2	7.4	19.8
42	*Nineta vittata* (WESMAEL, 1841)	0.04	0.16	0.04	0.28	0.63	1.6	0.83	2.2
43	*Nineta inpunctata* (REUTER,1894)	–	–	–	–	–	–	0.04	0.1
44	*Nineta pallida* (SCHNEIDER, 1846)	0.11	0.41	–	–	–	–	–	–
45	*Chrysotropia ciliata* (WESMAEL, 1841)	0.05	0.20	0.02	0.17	0.73	1.8	10.6	28.5
46	*Chrysopa perla* (LINNAEUS, 1758)	–	–	0.01	0.07	–	–	0.02	0.1
47	*Chrysopa dorsalis* BURMEISTER, 1839	–	–	–	–	0.04	0.1	–	–
48	*Chrysopa pallens* (RAMBUR, 1838)	0.38	1.41	0.35	2.42	1.15	2.8	0.87	2.3
49	*Dichochrysa flavifrons* (BRAUER, 1850)	0.13	0.50	–	–	–	–	–	–
50	*Dichochrysa prasina* (BURMEISTER, 1839)	0.57	2.14	1.25	8.61	24	58.9	5.46	14.6
51	*Dichochrysa abdominalis* (BRAUER, 1856)	0.71	2.67	?	?	?	?	?	?
52	*Dichochrysa ventralis* (CURTIS, 1834)	0.22	0.81	0.06	0.41	0.46	1.1	0.16	0.4
53	*Peyerimhoffina gracilis* (SCHNEIDER, 1851)	0.54	2.01	–	–	–	–	–	–
54	*Chrysoperla carnea* (STEPHENS, 1836) *s.l.*	0.58	2.16	0.52	3.59	6.6	16.2	9.24	24.7
55	*Cunctochrysa albolineata* (KILLINGTON, 1935)	0.69	2.59	0.18	1.24	0.21	0.5	0.6	1.6
	Index of total abundance	26.37	100.00	14.47	100.00	40.74	100.00	37.39	100.00
	Number of species	44		31		31		28	

Table X. Similarities of species composition (%) and similarity of dominance structures between the communities of *Neuropterida* from the particular types of forests.

Forest types	Fir forest	Moist pine forest	Mixed pine forest	Linden-oak-hornbeam forest	Sørensen index
Fir forest		75	69	53	
Moist pine forest	0.57		84	61	
Mixed pine forest	0.18	0.29		61	
Linden-oak-hornbeam forest	0.08	0.15	0.45		
Morisita index					

The material also contained the following boreo-montane species: *Drepanepteryx algida, Wesmaelius quadrifasciatus* and *Hemerobius atrifrons*. These occurred most frequently on trees of the genus *Larix*.

Role and importance of neuropterids

Nearly 86% of the species recorded from fir canopies, and 97% of the individuals, belonged to the order *Neuroptera*. Dominant were small species of the families *Coniopterygidae* and *Hemerobiidae* living on conifers and usually producing two generations per season. Due to their short developmental cycle and trophic scale limited to phytophages of conifers, these species may be very effective bioregulators of phytophages of fir. Various developmental stages of *Hemiptera* and *Acari* are their preferred prey. The abundance of lacewings trophically associated with entomofauna of conifers in the forest associations varied. The highest abundance was recorded in the montane fir forests with some other conifers (spruce, pine, larch). The species also reached a high abundance in the lowland forests where fir co-occurred with pine.

A lower abundance of neuropterids associated with conifers was recorded in the fir forests in Góry Świętokrzyskie. Due to a considerable loss of fir, habitats with originally dense stands of *Abietetum polonicum* have undergone changes favourable for beech. As a result of the presence of beech, and of other deciduous trees, the neuropterid communities in fir canopies here, in comparison with that of a typical montane fir forest, had a higher proportion of individuals of more polyphagous species, both those living on conifers and those associated with deciduous trees; the proportion of forms preferring, or even exclusively associated with, entomofauna of deciduous trees was higher. Moreover, the percentage of univoltine species of the family *Chrysopidae* was higher while that of bivoltine species of the families *Coniopterygidae* and *Hemerobiidae* lower (Table I, V). Bearing in mind the fact that the ecological equilibrium in the fir forests of this region is greatly disturbed and that the health of fir is poor, the low abundance of trophically specialised predators is an unfavourable phenomenon. According to Sawoniewicz (pers. comm.), fir twigs which were clipped in order to determine the abundance of tortricid larvae[5] were thickly coated with aphids. Very abundant aphid populations mean that the species has too few natural enemies. This may lead to further deterioration of the fir tree stands.

CONCLUSIONS

An analysis of the material collected on *A. alba* in montane, upland and lowland forests provided evidence of variability of the neuropterid fauna brought about by regional and local habitat conditions. Climate is the basic factor affecting the differentiation of flora and fauna. When exceeding the mountainous areas, fir enters a zone of warmer and drier climate with less precipitation. Climatic changes and the

[5] Even during SAWONIEWICZ's (1996) studies, the abundance of tortricid caterpillars was already minimal. This means that the state of the neuropterid communities presented in this paper applies to a post-outbreak period.

consequent changes in species compositions of forest associations with fir were reflected in the composition, species richness and structure of the neuropterid communities. The greatest stability of the species composition and quantitative structures was recorded for the neuropterid communities from the montane fir forests. The least stable in this respect were the communities from the lowland forests in which particular patches of associations with fir covered small areas and the microclimate was very unstable.

In spite of the species range of fir being fragmented into larger or smaller patches, the neuropterid faunas of the fir forests studied in different regions showed significant common features. Their core was made up by *Coniopteryx pygmaea* and *Conwentzia pineticola*, both species with a wide geographic distribution and a great ecological amplitude. The presence of *Puncha ratzeburgi, Hemerobius contumax, Sympherobius pellucidus, Nothochrysa capitata, Nineta pallida* and *Peyrimhoffina gracilis* was a characteristic feature of the fauna of the fir forests. These species are typical of montane coniferous forest, and in Poland they have never been recorded beyond the natural range of fir. Apart from the above-mentioned species, those rare in Poland and in Europe included *Parasemidalis fuscipennis, Drepanepteryx algida, Wesmaelius ravus, W. mortoni* and *Nothochrysa fulviceps*. Among these, only *P. fuscipennis* stood out in respect of the great frequency in fir canopies in the forests studied. *Dichochrysa abdominalis* is a species new to the fauna of Poland. It has hitherto been recorded in a few countries only, e.g. Italy, Austria, Switzerland and Germany, and its ecological preferences still poorly known. Special studies on the distribution of this species in Poland are to be carried out.

Fir declining poses threat to the existence of neuropterid species with small ranges, species which, in respect of habitat requirements, are associated with fir forest. On the basis of the great abundance and occurrence constancy of *Hemerobius contumax* and *Sympherobius pellucidus* in *A. alba* canopies, it seems justified to recognise them as species chiefly associated with this habitat and thus the most threatened.

The results of the study as well as literature data (ASPÖCK et al. 1980, 1991, 2001) concerning the occurrences of *Puncha ratzeburgi, Hemerobius contumax, Sympherobius pellucidus, Nothochrysa capitata, Nineta pallida, Peyerimhoffina gracilis* and *Parasemidalis fuscipennis* indicate that the distribution of these species, at least in some parts of their ranges, may be associated with the distribution of *A. alba* and other species of this genus. However, the link can prove to be not too close, as these species may also occur on trees of the genera *Picea* and *Pinus*. Nevertheless, their records in boreal regions, beyond the range of *A. alba*, lie under the climatic conditions similar to those in fir forest.

The present results may serve as the basis for considering *Hemerobius contumax* and *Sympherobius pellucidus* as species indicatory for Central European fir forest. *Parasemidalis fuscipennis* has already been declared an indicatory species (GEPP 1999).

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STRESZCZENIE

[Tytuł: *Raphidioptera* i *Neuroptera* (*Neuropterida*) w górskich, wyżynnych i nizinnych lasach Polski w warstwie koron jodły *Abies alba* MILL.]

Jodła (*Abies alba* MILL.) jest europejskim drzewem górskim, które w Polsce osiąga północno-wschodnią granicę swego naturalnego zasięgu (Fig. 1, 2). Udział jodły w całkowitej powierzchni leśnej kraju wynosi niecałe 3%, a jej centrum występowania znajduje się w Karpatach.

W opracowaniu przedstawiono charakterystykę owadów siatkoskrzydłych (*Neuropterida*) występujących w lasach jodłowych. Omówiono skład gatunkowy, liczebność, strukturę dominacyjną, profil ekologiczny zgrupowań, fenologię oraz znaczenie i rolę siatkoskrzydłych. Faunę *Neuropteridea* lasów jodłowych porównano z fauną innych lasów (borów sosnowych świeżych, mieszanych i grądów) występujących w nizinnych i wyżynnych regionach kraju.

Siatkoskrzydłe (5720 imagines) zostały zebrane w latach 1993 i 1994 w lasach Beskidu Sądeckiego, Gór Świętkorzyskich i Wysoczyzny Łódzkiej. Wymienione regiony, położone na różnych wysokościach w odmiennych warunkach klimatycznych, tworzą transekt pozwalający prześledzić zmiany następujące w faunie siatkoskrzydłych w miarę posuwania się jodły na północ.

Analiza materiału zebranego na *Abies alba* w lasach górskich, wyżynnych i nizinnych wykazała zmienność fauny *Neuropterida*, uwarunkowaną regionalnymi i lokalnymi warunkami siedliskowymi. Wykraczając poza obszary górskie, jodła wchodzi w strefę klimatu cieplejszego i suchszego, z mniejszą ilością opadów. Zmiany w warunkach klimatycznych i idące w ślad za tym składu gatunkowego zbiorowisk leśnych z udziałem jodły znajdowały odzwierciedlenie w składzie, bogactwie gatunkowym i strukturze zgrupowań siatkoskrzydłych.

Zebrane siatkoskrzydłe należały do dwóch rzędów i pięciu rodzin (Tab. I). Wśród 44 gatunków wykazanych ogółem, 24 występowały we wszystkich trzech regionach (Tab. II, III, IV, V). Średnie podobieństwo faun (wg wzoru Sørensena) z poszczególnych regionów było wysokie wynosiło bowiem 80%. Najbardziej zbliżone składy gatunkowe miały *Neuropterida* z lasów wyżynnych i nizinnych (So=86%), stosunkowo najmniej podobne były nuropterofauny lasów górskich i nizinnych (So=75%). Wspólną cechą struktury zgrupowań siatkoskrzydłych z poszczególnych regionów była obecność jednego lub dwu gatunków z rodziny *Coniopterygidae* na pozycjach eudominantów. Różnice dotyczyły kolejności gatunków na dalszych pozycjach w zgrupowaniu. W lasach górskich wszędzie przeważał *Coniopteryx pygmaea*, natomiast w wyżynnych i nizinnych dominowały wymiennie *Coniopteryx pygmaea i Conventzia pineticola*. Sieciarkami naliczniej reprezentowanymi w całości materiału a zarazem wspólnymi dla wszystkich trzech regionów były *Coniopteryx pygmaea*, *Conventzia pineticola*, *Hemerobius contumax* i *Sympherobius pellucidus*. Wskaźnik podobieństwa struktur dominacyjnych (wg wzoru Morisity) siatkoskrzydłych z lasów poszczególnych regionów wynosił średnio 0,64. Najbardziej podobne do siebie pod tym względem były zgrupowania z lasów górskich i nizinnych (Mo=0,83) a następnie nizinnych i wyżynnych

(Mo=0,70). Bardzo małe podobieństwo istniało natomiast między strukturą ilościową neuropterofauny lasów jodłowych górskich i wyżynnych (Mo=0,39).

Pod względem ekologicznym, trzon fauny siatkoskrzydłych we wszystkich badanych lasach, stanowiły gatunki żyjące na drzewach iglastych, wilgociolubne lub o dużej tolerancji względem wilgotności środowiska. Marginesowy udział miały formy kserofilne. Ich udział, bardzo niski w lasach górskich, wzrastał nieco w lasach wyżynnych i nizinnych (Tab. VII, VIII).

Fauna badanych lasów jodłych pod względem składu gatunkowego okazała się w dużym stopniu podobna do fauny lasów z nizinnych i wyżnnych regionów kraju (Tab. IX, X), w szczególności do fauny borów sosnowych (28 gatunków wspólnych, So=75%). Rysem charakterystycznym fauny siatkoskrzydłych lasów jodłowych była obecność rzadkich gatunków górskich (*Puncha ratzeburgi, Hemerobius contumax, Sympherobius pellucidus, Nothochrysa capitata, Nineta pallida, Peyerimhoffina gracilis*), które w kraju nie zostały wykazane poza granicą naturalnego występowania jodły, a więc poza 52° szerokości północnej. Wszystkie te gatunki charakteryzują się małymi zasięgami, z centrum występowania w Europie Środkowej. Za gatunki wskaźnikowe dla lasów jodłowych uznano *H. contumax* i *S. pellucidus*, z uwagi na ich wysoką stałość występowania (100%) i znaczący udział ilościowy wynoszący odpowiednio ok. 6 i 5% całości zebranego materiału.

Lasy jodłowe były zasiedlane głównie przez gatunki z rzędu *Neuroptera*, których podstawowym pożywieniem są różne stadia rozwojowe pluskwiaków (*Hemiptera*), szczególnie mszyc. Wysoka liczebność siatkoskrzydłych, stwierdzona w większości badanych lasów, wskazuje, iż owady te mogą być ważnym ogniwem odpowiedzialnym za ograniczanie liczebności tych fitofagów jodły.