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The species composition and structure of scuttle fly communities (*Diptera*: *Phoridae*) in mature tree stands in pine forests at different stages of habitat degradation

Abstract. *Phoridae* were studied in pine canopies in three pine forests in Poland: Puszcza Białowieska, Puszcza Biała and Bory Tucholskie. 116 species of scuttle fly were recorded, including 2 new to science and 12 new to Poland. The phorid communities of this habitat are dominated by species of the genus *Megaselia*, that are common and have a wide distribution. The structure of phorid communities depends on the degree of habitat degradation of forests. Increase of the habitat degradation results in a decrease of number and abundance of species, especially zoophages.

Key words: *Phoridae*, pine canopies, habitat degradation

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INTRODUCTION

The *Phoridae* are one of the larger families within the *Diptera*. Many species are widely distributed and occur in different types of habitat simultaneously. Any habitat is likely to be rich in species, for these reasons *Phoridae* may provide an excellent basis on which to characterize and compare various ecosystems, and which may even make it possible to define human impact on the environment (OLECHOWICZ 1988, DISNEY 1994).

However, there have been published very few papers in which the phorid fauna of various habitats is fully characterized. These papers include studies on scuttle flies of the soils of a beech wood, a mixed forest and an oakhornbeam forest, and also of meadows, pastures and ruderal habitats (WEBER, PRESCHER 1990). Phorid communities of tree canopies have also been

the subject of some investigations but the data obtained are still rather fragmentary.

Pine forests are, in respect of size, the dominant type of forest in Poland and their value, both economic and climatic, is significant (BREYMEYER 1987). In the forest habitat the *Phoridae* are one of the most numerous groups within the fauna of tree canopies. It is therefore extremely important that phorid communities of pine forests should be studied more closely, because the acquired knowledge of this question would make it easier to understand the functioning and significance of this group in a type of forest most important in silviculture. Investigations into the fauna of pine forests were conducted by the Institute of Zoology PAS in Warsaw within the framework of the CPBP 040602 project, coordinated by Prof. A. SZUJECKI, between 1986 and 1990. They provided extensive material from this particular habitat in different regions of Poland.

It is the objective of the present paper to characterize the species composition, the structure of the communities and seasonal dynamics of the phorid fauna in pine canopies in mature stands of pine forests at various degrees of habitat degradation in different zoogeographical regions of Poland.

STUDY AREA, METHODS, MATERIAL

The material was collected in pine forests in three zoogeographic regions of Poland: Pojezierze Pomorskie (Bory Tucholskie), Nizina Mazowiecka (Puszcza Biała) and Podlasie (Puszcza Białowieska) in 1986 and 1987. The areas in which the above forest complexes are situated belong to three categories of health ranked in respect of resistance to primary and secondary pests of pine trees – from the zone of the highest degree of threat (Bory Tucholskie) to that of the lowest (Puszcza Białowieska). Detailed assumptions of the study and the distribution of the sites are presented by BAŃKOWSKA (1993).

The pine forests from Puszcza Białowieska and Puszcza Biała belong to the *Peucedano-Pinetum* type of plant association whereas those from Bory Tucholskie to the *Leucobryo-Pinetum*. The *Peucedano-Pinetum* association is richer floristically. The pine forests in Puszcza Białowieska represent a subboreal variety of the *Peucedano-Pinetum* association whereas the pine forests in Puszcza Biała are the Sarmatian variety of the same association. A detailed phytosociological description of these forests is given by MATUSZKIEWICZ, DEGÓRSKI and KOZŁOWSKA (1993).

In each site the material was collected using five yellow traps (BAŃKOWSKA, GARBARCZYK 1981) attached to top branches of trees by means of special pegs. The investigations were conducted during two seasons: from early spring to late autumn, in fortnightly periods. A total of 24,438 phorid specimens was collected and studied. Handbooks by DISNEY (1983, 1989b), LUNDBECK (1922), SCHMITZ (1938–1981) provided a basis for identifying the scuttle fly specimens to the species.

All quantitative data allowed to study the structure of communities. The following coefficients were used;

1. Index of abundance (relative) is the number of specimens caught in 10 yellow traps over 10 days

2. Assessment of similarity of species composition of individual communities was made according to the "percentage" modification of Soerensen's formula (SOERENSEN 1948):

$$So = \frac{2\ w}{a + b}\ 100$$

where a and b refer to the number of species in the communities compared and w to the number of species common to both communities.

3. Morisita's index modified by HORN (1966):

$$Mo = \frac{2 \sum_{i=1}^{s} x_i\, y_i}{\sum_{a=1}^{s} x_a^2 + \sum_{a=1}^{s} y_a^2}$$

where xi, yi – percentages of common species,
xa, ya – percentages of particular species of compared communities,
s – total number of species;
Index of dominance:

$$D = \frac{n}{N} 100$$

where n – density (trapability) of a given species,
N – density (trapability) of the community;

SPECIES COMPOSITION

13 genera of *Phoridae*, represented by at least 116 species were recorded from mature tree stands of the pine forests studied in 1986 and 1987 (Table I). Apart from these, within the genus *Megaselia* there were species identified as „A" and „B" which might be some other taxa, not mentioned here. The situation was similar in the case of species identified as *Megaselia sp.* because occasionally the taxonomic characters of some specimens could not be determined due to the condition of the material or to difficulties with identifying the females.

Altogether, there were 65 phorid species recorded from Bory Tucholskie, 67 species from Puszcza Biała and 87 species from Puszcza Białowieska (Tab. I). The material collected comprised 12 species new to the fauna of Poland and within these two species: *Megaselia durskae* and *Trucidophora* (=*Styletta*) *ewardurskae* have been described as new to science (DISNEY 1989a, 1990). The phorid communities in the three mature stands studied have a relatively similar species composition because in each of the pairs of communities compared the degree of similarity was about sixty per cent. The value of the Sorensen index of species similarity was 63.6% for Bory Tucholskie and Puszcza Biała; 64.9% for Puszcza Biała and Puszcza Białowieska, and 57.8% for Bory Tucholskie and Puszcza Białowieska.

The majority of the species dominant in the communities studied were species considered to be common and widely distributed. Imagines of

Table I. Species composition, abundance and percentage of the species comprising the phorid communities in pine mature forests in different regions of Poland (n – abundance index)

No.	Species	Type of diet	Bory Tucholskie		Puszcza Biała		Puszcza Białowieska		Mean	
			n	%	n	%	n	%	n	%
1	2	3	4	5	6	7	8	9	10	11
1	*Anevrina curvinervis* (BECKER)	–	0.004	0.03	0.000	0.00	0.008	0.04	0.004	0.03
2	*Anevrina thoracica* (MEIGEN)	–	0.000	0.00	0.040	0.39	0.013	0.06	0.018	0.11
3	*Anevrina unispinosa* (ZETTERSTEDT)	–	0.004	0.03	0.005	0.05	0.008	0.04	0.006	0.04
4	*Borophaga carinifrons* (ZETTERSTEDT)	–	0.000	0.00	0.009	0.09	0.034	0.16	0.015	0.09
5	*Borophaga femorata* (MEIGEN)	–	0.070	0.43	0.010	0.10	0.000	0.00	0.027	0.17
6	*Borophaga subsultans* (LINNAEUS)	–	0.600	3.75	0.040	0.39	0.061	0.30	0.234	1.46
7	*Conicera dauci* (MEIGEN)	–	0.008	0.05	0.000	0.00	0.004	0.02	0.004	0.03
8	*Conicera tibialis* SCHMITZ*	s	0.000	0.00	0.005	0.05	0.000	0.00	0.002	0.01
9	*Diplonevra nitidula* (MEIGEN)	z	0.000	0.00	0.000	0.00	0.013	0.06	0.004	0.03
10	*Megaselia abdita* SCHMITZ	s	0.000	0.00	0.000	0.00	0.017	0.08	0.006	0.04
11	*Megaselia aculeata* (SCHMITZ)*	–	0.000	0.00	0.009	0.09	0.000	0.00	0.003	0.02
12	*Megaselia aequalis* (WOOD)	z	0.020	0.13	0.020	0.20	0.017	0.08	0.019	0.12
13	*Megaselia affinis* (WOOD)	–	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
14	*Megaselia albicans* (WOOD)*	f	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
15	*Megaselia alticolella* (WOOD)	–	0.000	0.00	0.000	0.00	0.055	0.25	0.018	0.11
16	*Megaselia altifrons* (WOOD)	–	0.004	0.03	0.000	0.00	0.034	0.16	0.014	0.08
17	*Megaselia badia* SCHMITZ*	–	0.020	0.13	0.000	0.00	0.000	0.00	0.007	0.04
18	*Megaselia berndseni* (SCHMITZ)	f	0.000	0.00	0.005	0.05	0.100	0.46	0.035	0.22
19	*Megaselia bovista* (GIMMERTHAL)	f	0.008	0.05	0.009	0.09	0.000	0.00	0.006	0.04
20	*Megaselia brevicostalis* (WOOD)	s	0.050	0.30	0.009	0.09	0.400	1.83	0.153	0.95
21	*Megaselia campestris* (WOOD)	–	0.000	0.00	0.010	0.10	0.034	0.16	0.015	0.09
22	*Megaselia ciliata* (ZETTERSTEDT)	z	0.004	0.03	0.009	0.09	0.017	0.08	0.010	0.05
23	*Megaselia cinereifrons* (STROBL)	f	0.000	0.00	0.005	0.05	0.034	0.16	0.014	0.08
24	*Megaselia coacta* (LUNDBECK)	–	0.000	0.00	0.000	0.00	0.008	0.04	0.003	0.02
25	*Megaselia communiformis* (SCHMITZ)	–	0.000	0.00	0.040	0.39	0.000	0.00	0.014	0.08
26	*Megaselia conformis* (WOOD)	–	0.008	0.05	0.070	1.67	0.140	0.64	0.106	0.65
27	*Megaselia cothurnata* (SCHMITZ)	–	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.05
28	*Megaselia discreta* (WOOD)	f	0.000	0.00	0.000	0.00	0.013	0.06	0.004	0.03
29	*Megaselia diversa* (WOOD)	–	0.000	0.00	0.000	0.00	0.097	0.44	0.032	0.20
30	*Megaselia dubitalis* (WOOD)	–	0.360	2.25	0.170	1.67	0.008	0.04	0.179	1.12
31	*Megaselia durskae* DISNEY*	–	0.010	0.06	0.005	0.65	0.130	0.60	0.048	0.30
32	*Megaselia eisfelderae* SCHMITZ	f	0.008	0.05	0.000	0.00	0.030	0.14	0.014	0.08
33	*Megaselia elongata* (WOOD)	z	0.000	0.00	0.009	0.09	0.000	0.00	0.003	0.02

1	2	3	4	5	6	7	8	9	10	11
34	*Megaselia emarginata* (Wood)	–	0.004	0.03	0.030	0.29	0.000	0.00	0.011	0.07
35	*Megaselia errata* (Wood)	–	0.100	0.63	0.020	0.20	0.008	0.04	0.043	0.27
36	*Megaselia fenestralis* Schmitz*	–	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
37	*Megaselia flava* (Fallen)	f	0.000	0.00	0.020	0.20	0.130	0.60	0.050	0.31
38	*Megaselia frameata* Schmitz	f	0.000	0.00	0.005	0.05	0.000	0.00	0.002	0.01
39	*Megaselia giraudii* (Egger)	p	1.000	6.25	1.540	15.14	0.880	4.04	1.140	7.13
40	*Megaselia gregaria* (Wood)	–	0.020	0.14	0.050	0.49	0.008	0.04	0.026	0.15
41	*Megaselia hortensis* (Wood)	–	0.000	0.00	0.000	0.00	0.026	0.12	0.009	0.05
42	*Megaselia humeralis* (Zetterstedt)	–	0.000	0.00	0.009	0.09	0.000	0.00	0.003	0.02
43	*Megaselia ?hypopygialis* (Lundbeck)	–	0.000	0.00	0.000	0.00	0.017	0.08	0.006	0.04
44	*Megaselia insons* (Lundbeck)	–	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
45	*Megaselia intercostata* (Lundbeck)	–	0.000	0.00	0.000	0.00	0.130	0.60	0.043	0.27
46	*Megaselia involuta* (Wood)	–	0.000	0.00	0.000	0.00	0.100	0.50	0.033	0.21
47	*Megaselia lata* (Wood)	f	0.020	0.14	0.060	0.59	0.000	0.00	0.027	0.17
48	*Megaselia latifrons* (Wood)	–	0.000	0.00	0.000	0.00	0.060	0.30	0.020	0.13
49	*Megaselia longicostalis* (Wood)	–	0.020	0.14	0.060	0.59	0.020	0.09	0.033	0.21
50	*Megaselia lucifrons* (Schmitz)	–	0.020	0.14	0.000	0.00	0.013	0.06	0.011	0.07
51	*Megaselia lutea* (Meigen)	f	0.004	0.03	0.020	0.20	0.040	0.18	0.021	0.13
52	*Megaselia major* (Wood)	–	0.030	0.19	0.005	0.05	0.008	0.04	0.015	0.09
53	*Megaselia manicata* (Wood)	–	0.800	5.00	0.150	1.46	0.100	0.46	0.350	2.19
54	*Megaselia maura* (Wood)	f	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
55	*Megaselia meconicera* (Speiser)	s	2.000	12.54	1.500	14.75	1.000	4.60	1.500	9.39
56	*Megaselia meigeni* (Becker)	–	0.004	0.03	0.000	0.00	0.008	0.04	0.004	0.03
57	*Megaselia minor* (Zetterstedt)	–	0.000	0.00	0.020	0.20	0.017	0.08	0.012	0.08
58	*Megaselia nasoni* (Malloch)	z	0.000	0.00	0.000	0.00	0.030	0.14	0.010	0.05
59	*Megaselia nigriceps* (Loew)	s	0.700	4.39	0.200	1.97	0.030	0.14	0.310	1.94
60	*Megaselia palmeni* (Becker)	–	0.008	0.05	0.000	0.00	0.013	0.06	0.007	0.04
61	*Megaselia paludosa* (Wood)	z	0.000	0.00	0.000	0.00	0.026	0.12	0.090	0.05
62	*Megaselia parva* (Wood)*	–	0.000	0.00	0.020	0.20	0.004	0.02	0.008	0.05
63	*Megaselia pectoralis* (Wood)	–	0.000	0.00	0.040	0.39	0.080	0.40	0.040	0.25
64	*Megaselia picta* (Lehmann)	–	0.040	0.15	0.080	0.79	0.040	0.18	0.053	0.33
65	*Megaselia pleuralis* (Wood)	s	4.800	30.09	1.400	13.76	0.260	0.12	2.075	12.98
66	*Megaselia propinqua* (Wood)	–	0.004	0.03	0.009	0.09	0.000	0.00	0.004	0.03
67	*Megaselia protarsalis* Schmitz	–	0.000	0.00	0.000	0.00	0.008	0.04	0.003	0.02
68	*Megaselia pulicaria* (Fallen)	p	0.900	5.64	0.300	2.95	0.560	2.60	0.587	3.67
69	*Megaselia pumila* (Meigen)	–	0.004	0.03	0.030	0.29	0.017	0.08	0.170	0.11
70	*Megaselia pusilla* (Meigen)	–	0.160	1.00	0.030	0.29	0.900	4.12	0.363	2.27

1	2	3	4	5	6	7	8	9	10	11
71	*Megaselia pygmaea* (ZETTERSTEDT)	f	0.000	0.00	0.005	0.05	0.080	0.40	0.028	0.18
72	*Megasalia ?quadriseta* (SCHMITZ)	–	0.100	0.64	0.030	0.29	0.600	2.75	0.243	1.52
73	*Megaselia rubella* (SCHMITZ)	f	0.004	0.03	0.100	0.98	0.017	0.08	0.040	0.25
74	*Megaselia rudis* (WOOD)	–	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
75	*Megaselia ruficornis* (MEIGEN)	s	0.004	0.03	0.020	0.20	0.060	0.30	0.028	0.18
76	*Megaselia rufipes* (MEIGEN)	p	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
77	*Megaselia sepulchralis* (LUNDBECK)	–	0.600	3.75	0.050	0.50	0.900	4.15	0.517	3.24
78	*Megaselia serrata* (WOOD)*	–	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
79	*Megaselia sordida* (ZETTERSTEDT)	–	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
80	*Megaselia spinicincta* (WOOD)	f	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
81	*Megaselia subcarpalis* (LUNDBECK)	–	0.010	0.06	0.000	0.00	0.020	0.09	0.010	0.05
82	*Megaselia subnudipennis* (SCHMITZ)	–	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
83	*Megaselia subtumida* (WOOD)	–	0.000	0.00	0.009	0.09	0.017	0.08	0.009	0.05
84	*Megaselia superciliata* (WOOD)*	–	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
85	*Megaselia sylvatica* (WOOD)	f	0.000	0.00	0.009	0.09	0.004	0.02	0.004	0.03
86	*Megaselia tarsalis* (WOOD)	–	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
87	*Megaselia tumida* (WOOD)	–	0.000	0.00	0.005	0.05	0.000	0.00	0.002	0.01
88	*Megaselia unicolor* SCHMITZ	–	0.008	0.05	0.060	0.59	0.006	0.03	0.025	0.15
89	*Megaselia verralli* (WOOD)	–,	0.008	0.05	0.000	0.00	0.200	0.91	0.069	0.43
90	*Megaselia woodi* (LUNDBECK)	–	0.050	0.30	1.000	9.83	9.800	44.92	3.617	22.63
91	*Megaselia xanthozona* (STROBL)	–	0.000	0.00	0.000	0.00	0.020	0.09	0.007	0.04
92	*Megaselia zonata* (ZETTERSTEDT)	–	0.000	0.00	0.010	0.10	0.004	0.02	0.005	0.03
–	*Megaselia* „A"	–	0.036	0.24	0.000	0.00	0.000	0.00	0.012	0.08
–	*Megaselia* „B"	–	0.000	0.00	0.028	0.28	0.000	0.00	0.009	0.05
–	*Megaselia* sp.	–	1.600	10.00	2.300	22.60	1.700	7.40	1.867	11.68
93	*Metopina crassinervis* SCHMITZ	–	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
94	*Metopina heselhausi* SCHMITZ	–	0.008	0.05	0.000	0.00	0.017	0.08	0.005	0.05
95	*Metopina oligoneura* (MIK)	s	0.000	0.00	0.009	0.09	0.013	0.06	0.007	0.04
96	*Metopina pileata* SCHMITZ	–	0.008	0.05	0.005	0.05	0.000	0.00	0.004	0.01
97	*Phalacrotophora berolinensis* (SCHMITZ)	z	0.010	0.06	0.040	0.39	0.070	0.32	0.040	0.25
98	*Phalacrotophora fasciata* (FALLEN)	z	0.004	0.03	0.100	0.98	0.120	0.55	0.075	0.47
99	*Phora artifrons* SCHMITZ	–	0.500	3.14	0.040	0.39	0.000	0.00	0.180	1.13
100	*Phora atra* (MEIGEN)	s	0.600	3.75	0.020	0.20	0.000	0.00	0.207	1.30
101	*Phora dubia* (ZETTERSTEDT)	–	0.500	3.14	0.005	0.05	1.500	6.90	0.668	4.18
102	*Phora holosericea* SCHMITZ	z	0.000	0.00	0.080	0.79	1.000	4.60	0.360	2.25
103	*Pseudacteon formicarum* (VERRALL)	z	0.000	0.00	0.005	0.05	0.008	0.04	0.004	0.03
104	*Spiniphora maculata* (MEIGEN)	s	0.000	0.00	0.000	0.00	0.004	0.02	0.001	0.01
105	*Triphleba antricola* (SCHMITZ)	s	0.008	0.05	0.000	0.00	0.000	0.00	0.030	0.02

1	2	3	4	5	6	7	8	9	10	11
106	*Triphleba hyalinata* (MEIGEN)	s	0.004	0.03	0.009	0.09	0.000	0.00	0.040	0.03
107	*Triphleba intermedia* (MALLOCH)	–	0.100	0.05	0.000	0.00	0.000	0.00	0.003	0.02
108	*Triphleba lugubris* (MEIGEN)	p	0.004	0.03	0.020	0.20	0.013	0.06	0.012	0.08
109	*Triphleba luteifemorata* (WOOD)	–	0.004	0.03	0.020	0.20	0.008	0.04	0.010	0.05
110	*Triphleba nudipalpis* (BECKER)	p	0.000	0.00	0.009	0.09	0.004	0.02	0.004	0.03
111	*Triphleba opaca* (MEIGEN)	s	0.020	0.14	0.000	0.00	0.000	0.00	0.007	0.04
112	*Triphleba papillata* (WINGATE)	–	0.004	0.03	0.000	0.00	0.000	0.00	0.001	0.01
113	*Triphleba smithi* DISNEY	–	0.000	0.00	0.000	0.00	0.040	0.02	0.001	0.01
114	*Triphleba trinervis* (BECKER)	–	0.008	0.05	0.000	0.00	0.004	0.02	0.004	0.03
115	*Trucidiphora ewardurskae* (DISNEY)*	z	0.000	0.00	0.000	0.00	0.017	0.08	0.006	0.04
116	*Woodiphora retroversa* (WOOD)*	–	0.000	0.00	0.005	0.05	0.000	0.00	0.002	0.01
Total			16.046	100.00	10.070	100.00	21.816	100.00	16.160	100.00
Total number of species			65		67		87		73	

* – species new to the fauna of Poland
? – doubtful determination
s, f, z, p, – : type of diet (saprophages, fungivores, zoophages, polyphages, unknown biology)

Megaselia pulicaria and *M. pleuralis* feed on honeydew but they were recorded also on corpses of invertebrates. Individuals of the former species have been recorded hibernating. Larvae of the species *M. pulicaria* are polyphages, but primairly predators of spider eggs, and those of *M. pleuralis* are saprophages (DISNEY 1994). *Megaselia giraudii* is a common polyphagous saprophage. Its larvae can be found in mammalian dung, dead invertebrates, fungi, leafmines (secondary invasion), cocoons of *Symphyta*, also in caterpillars and pupae of butterflies. *M. giraudii* larvae are also known to be facultative parasites of *Orthoptera* (DISNEY 1994). *Megaselia meconicera* is another very abundant species of *Phoridae*. It has been recorded that imagines (mainly females) of this species appear in great numbers in houses, particularly in autumn and winter. *M. meconicera* individuals may hibernate during winter. Larvae of this species have been found in bat dung (DISNEY 1994). *Megaselia manicata* is a species frequently recorded on flowers; in winter it hibernates (DISNEY 1994). *Phora holosericea* larvae are predators of root aphids (YARKULOV 1972). There are virtually no data on the biology of the following species: *Megaselia woodi*, *M. sepulchralis* and *Phora dubia*. These three species and those mentioned earlier belong to species that occur in great numbers (are dominants) in mature stands of the pine forests studied.

COMMUNITY STRUCTURE

Species of the genus *Megaselia* dominated in pine canopies of the mature stands of all the pine forests studied (Fig. 1). However, the areas studied were characterized by a relatively considerable exchange of the dominants in the communities, as is clearly seen from the values of Morisita index. The highest value of this index, namely 0.74, which indicated that the dominance structures had greatly overlapped was obtained while comparing the communities from Puszcza Biała and Bory Tucholskie. In both regions, the same species belong to the group of the dominants. *M. pleuralis*, whose imagines feed on honeydew, definitely dominated in Bory Tucholskie, but in Puszcza Biała it occupied the third position in respect of its percentage share in the community. *M. giraudii* dominated in Puszcza Biała but was the third in the dominance structure in Bory Tucholskie. This species is a common polyphagous saprophage (see above). A community that differed most from those in Bory Tucholskie and Puszcza Biała was the phorid community in tree crowns of the pine forests in Puszcza Białowieska. As Morisita index shows the similarity of the dominance structure of the scuttle fly community from this region in comparison with the community in Puszcza Biała is 0.43, whereas in comparison with that in Bory Tucholskie it is 0.13. This is due to the fact that the community in Puszcza Białowieska was dominated by a different species. It was *M.woodi*, a species whose biology is still unknown. The percentage of *M. woodi* was also considerable in the community in Puszcza Biała. *M. meconicera* was a relatively abundant species recorded from the pine forests of the three regions studied. This species was the second dominant in Bory Tucholskie

and Puszcza Biała, and the third dominant in Puszcza Białowieska. It probably is polyphagous and has been recorded from many habitats; its imagines (mainly females) frequently appear in houses, especially in autumn and winter, and its larvae have been found in bat dung (DISNEY 1994). *M. pulicaria*, whose larvae are polyphages, but primarily predators of spider eggs, had a considerable percentage in the phorid communities in Bory Tucholskie and Puszcza Biała. In the community in Puszcza Białowieska there were three more species whose position in the dominance structure was significant. They were: yet another species, with unknown biology, of the genus *Megaselia: M. sepulchralis*, and two species of the genus *Phora: Ph. dubia* and *Ph. holosericea*. The biology of the former is not known; the latter is a predator of root aphids (YARKULOV 1972).

The phorid communities of pine canopies in the forests in Bory Tucholskie and Puszcza Biała also demonstrated a greater similarity in respect of the percentage of the dominants. The lowest, a merely 0.5% difference between the share of the dominant and of the subdominant was recorded for the community in Puszcza Biała. This particular difference reached 20% in Bory Tucholskie and even 40% in Puszcza Białowieska. The most diverse distribution of the abundance among the particular species was recorded in communities from Puszcza Białowieska, and the least diverse in those from Puszcza Biała.

The biology of species of the phorid family is poorly known. In the case of the material studied the available literature data on the life history of individuals cover merely 44 species (about 40%) and, moreover, these data are incomplete. It is known, however, that imagines of some *Phoridae* visit flowers very frequently, but their primary source of sugar is honeydew. They also feed on the protein-rich meals. The larvae have a considerably varied diet. Depending on the type of their diet phorid larvae have been divided into four trophic groups (Table II, Fig. 2).

The saprophage group contained 13 species and its mean share in abundance, in comparison with the other groups, was as much as 62.6%. This

Table II. Percentage of the trophic elements in the phorid fauna of the pine forests (S – number of species)

Stand	Bory Tucholskie		Puszcza Biała		Puszcza Białowieska		Total	
Trophic group	S	%	S	%	S	%	S	%
saprophages	9	39.1	9	30.1	8	24.3	13	29.5
fungivores	6	26.1	10	33.3	11	33.3	15	34.1
zoophages	4	17.4	7	23.3	10	30.3	11	25.0
polyphages	4	17.4	4	13.3	4	12.1	5	11.4

group included not only the typical saprophage species but also those species whose larvae are necrophages or coprophages or which are found in nests (DISNEY 1994). The following species belonged here: *Conicera tibialis*, *Megaselia abdita*, *M. brevicostalis*, *M. meconicera*, *M. nigriceps*, *M. pleuralis*, *M.*

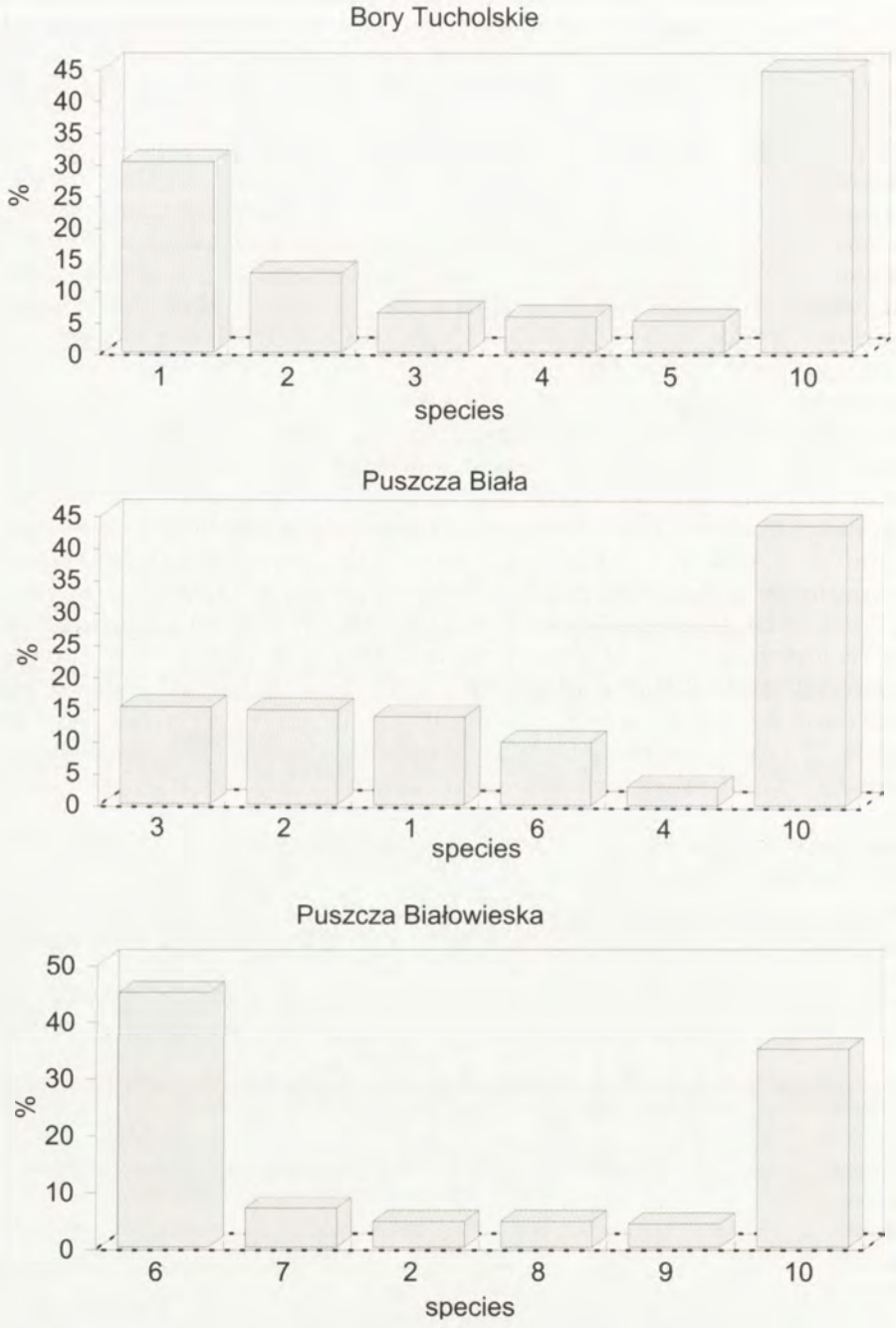

Fig. 1. Dominance structure of the phorid communities in pine canopies in the mature tree stands of the three forests studied: 1 – *Megaselia pleuralis*, 2 – *Megaselia meconicera*, 3 – *Megaselia giraudii*, 4 – *Megaselia pulicaria*, 5 – *Megaselia manicata*, 6 – *Megaselia woodi*, 7 - *Phora dubia*, 8 – *Phora holosericea*, 9 – *Megaselia sepulchralis*, 10 – Other species

ruficornis, *Metopina oligoneura*, *Phora atra*, *Spiniphora maculata*, *Triphleba antricola*, *T. hyalinata* and *T. opaca*.

The group of fungivores comprised the highest number of species, namely 15, but it was the least abundant in the forests studied and, on average, it made merely 3.8% of the total abundance of individuals belonging to the species whose biology was known. The species included into this group were those associated with fungi mycetophages and mycetophiles (DISNEY 1994). All the species in this group belonged to the genus *Megaselia: M. albicans*, *M. berndseni*, *M. bovista*, *M. cinereifrons*, *M. discreta*, *M. eisfelderae*, *M. flava*, *M frameata*, *M. lata*, *M. lutea*, *M. maura*, *M. pygmaea*, *M. rubella*, *M. spinicincta*, and *M. sylvatica*.

The group of zoophages comprised 11 species whose larvae are either predators or parasitoids. On average their abundance share was 8.1%. The following species belonged here: *Megaselia aequalis*, *M. ciliata*, *M. nasoni*, *M. elongata*, *M. paludosa*, *Diplonevra nitidula*, *Phalacrotophora berolinensis*, *Ph. fasciata*, *Phora holosericea* and *Pseudacteon formicarum*. The species *Trucidophora ewardurskae* was also included into the group under discussion because the structure of the ovipositor in the female of this species is typical of parasitoids.

The group of polyphages comprised only five species of scuttle fly; three species of the genus *Megaselia* and two species of the genus *Triphleba*. However, their individuals made up 25.5% of the abundance of species with a known diet. *Megaselia giraudii* and *M. rufipes* are polyphagous saprophage species (see above). *Megaselia rufipes* may be a parasite of *Coleoptera* too (DURSKA, unpublished data). To this group belong also polymorphous *Megaselia pulicaria*, *Triphleba lugubris* and *T. nudipalpis*.

It is true that the above list was based only on knowledge of the diet of barely 40% of the phorid species but, nevertheless, it comprised most of the dominant species. On this basis it can be noticed that there is a clear tendency of changes in the trophic structure in scuttle fly communities depending on the gradient of threat to forests by secondary pests. As the degree of threat increases from Puszcza Białowieska through Puszcza Biała to Bory Tucholskie the percentage of zoophagous *Phoridae* decreases but the percentage of saprophages clearly increased (Fig. 2). The abundance of zoophages (1.16) in Puszcza Białowieska was five times higer than in Bory Tucholskie (0.23). But the abundance of saprophages in Bory Tucholskie (5.58) in comparison to their abundance in Puszcza Białowieska (1.51) increased over three times.Thus the data present a different view of the trophic structure of the communities of the pine forests in particular regions. The most even distribution of the trophic elements was recorded for the phorid communities from Puszcza Białowieska, and the most distinct feature there was a considerable proportion of zoophages, namely 26.8% of the total number of individuals, whereas in Puszcza Biała that proportion was only 5.3% and in Bory Tucholskie merely 0.7%. The differences between the percentages of fungivores and polyphages were not so great; the proportion of the former ranged from 0.5% in Bory Tucholskie to 10.2% in Puszcza Białowieska and of the latter from

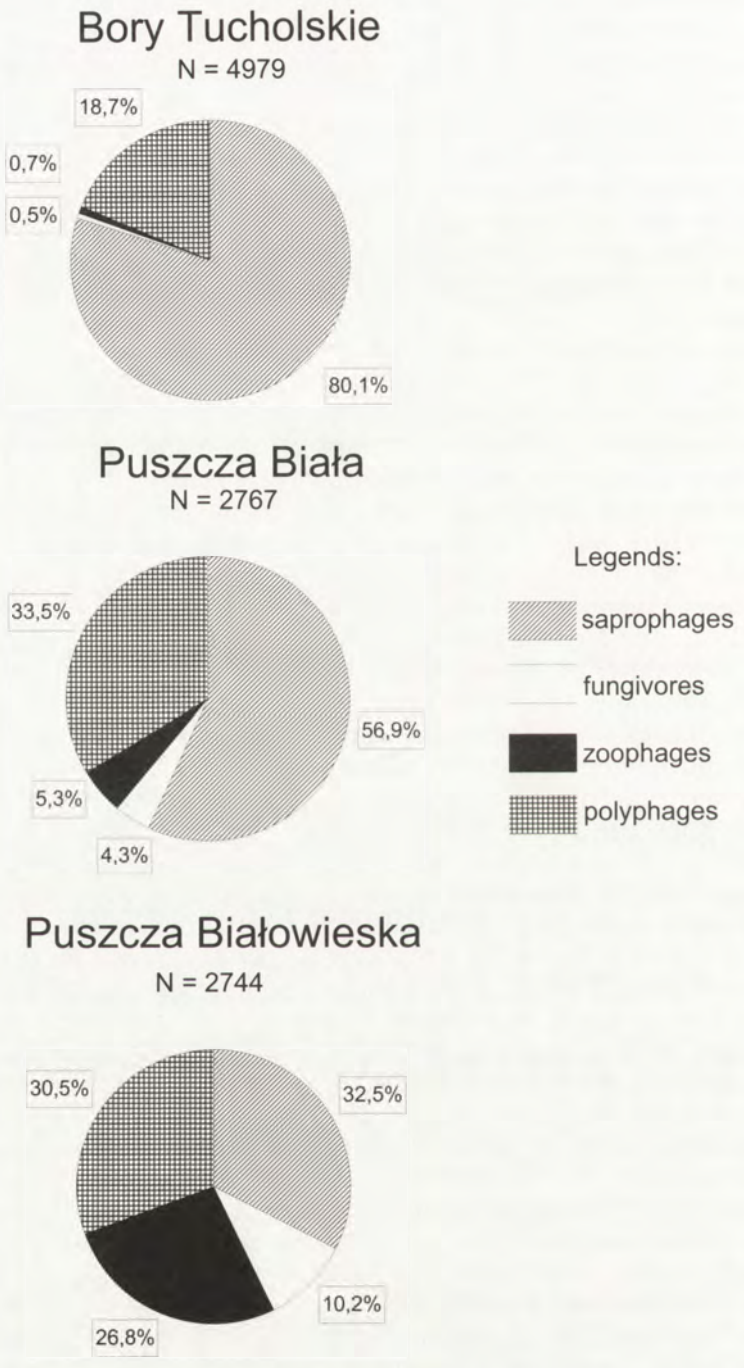

Fig. 2. Trophic structure of the communities of *Phoridae* in the mature stands of the pine forests (based on abundance)

18.7% in Bory Tucholskie to 33.5% in Puszcza Biała. The group of saprophages was the most abundant in all the phorid communities everywhere; it comprised 32.5% individuals in Puszcza Białowieska and 80.1% in Bory Tucholskie.

SEASONAL DYNAMICS

Changes in the species composition and the abundance of particular species in the phorid communities were recorded both in 1986 and in 1987. Their course was similar in both seasons. Therefore their mean numbers of species and their mean abundances for two years have been used to describe the seasonal changes. However, there were differences in the course of the

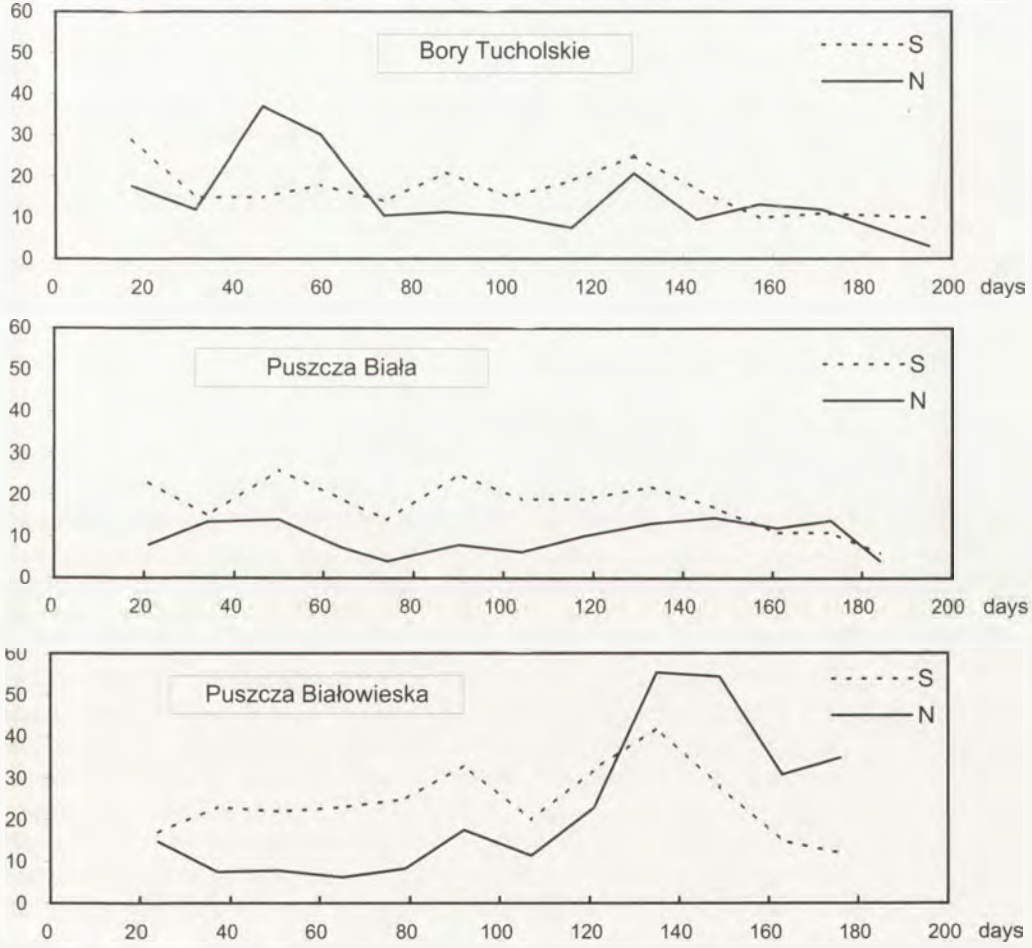

Fig. 3. Changes in the abundance and in the number of the species of *Phoridae* in pine canopies of the mature tree stands of the forests studied from May to November (mean data from 1986 and 1987 together); S – number of species, N – abundance

changes in the number of species and in the abundance of scuttle flies in each of the three regions studied.

The most clear changes both in the number and in the abundance of phorid species were recorded for the mature stand in Puszcza Białowieska. Within the abundance fluctuations there were three phenological peaks of the abundance of *Phoridae* (Fig. 3). The first and lowest peak occurred in May. At that time the maximal abundance was recorded for two species of the genus *Phora: Ph. dubia* and *Ph. holosericea*, which occupied high positions in the dominance structure of the phorid communities in the forests of Puszcza Białowieska. The second abundance peak was in the latter half of July. Five species: *Megaselia brevicostalis, M. meconicera, M. pusilla, Phora dubia* and *Ph. holosericea* dominated at that time. Three of these were significant dominants in the scuttle fly community in the mature stand in Puszcza Białowieska. The third and highest abundance peak of the phorids occurred at the turn of August and September. That was the time when the greatest number of species was recorded, namely 42 species. The abundance of the scuttle fly community increased because there had occurred an overlapping of the phenologies of the species of the genus *Megaselia: M. brevicostalis, M. conformis, M. diversa, M. giraudii, M. involuta, M. longicostalis, M. manicata, M. meconicera, M. nasoni, M. pleuralis, M. pulicaria, M. pusilla, M. quadriseta, M. sepulchralis, M. verralli* and *M. woodi*. A rapid increase in the abundance of the last of the above species, the superdominant *M. woodi*, exerted the greatest impact on the abundance of the community during the third phenological peak of the *Phoridae*. During autumn the abundance of the scuttle flies remained at a very high level during the two study seasons, and towards the end of October it reached 34.87% (Fig. 3). That was the highest abundance of phorids recorded from pine forests in the three regions.

The changes in the number and the abundance of the phorid species recorded for pine canopies in Bory Tucholskie were a little milder. The spring abundance peak, the first and lowest, occurred at the turn of April and May. The greatest number of species, namely 29, was recorded just then. The most abundant species were as follows: *Borophaga subsultans* and three species from the dominant group: *Megaselia manicata, M. meconicera* and *M. pulicaria*. The second, and the highest, abundance peak was recorded at the beginning of June. At that time, the increase in the abundance of the community was mainly influenced by an increase in the abundance of *Megaselia pleuralis*, a Holarctic species that was eudominant at the sites studied in Bory Tucholskie. Here, as in Puszcza Białowieska, the third abundance peak occurred at the turn of August and September. The number of phorid species reached 25. During that time the dominant species belonged to the genus *Megaselia: M. giraudii, M. meconicera, M. pulicaria* and *M. nigriceps*. The first three species dominated in the mature forest under discussion. In the case of all the above mentioned species first there was a rapid increase in abundance and then a decrease (Fig. 3).

The mildest changes in the number of species and the abundance were recorded from the mature tree stand in Puszcza Biała. The first, and the highest, peak of the abundance of scuttle flies occurred in June. At that time the

number of species reached 26 and thus was the highest. The most numerous were *Megaselia giraudii*, *M. meconicera* and *M. pleuralis*, species from the group of the dominants, and also *Phalacrotophora fasciata*, a parasitoid of ladybird pupae. In the case of the species *M. pleuralis* there was recorded a rapid increase and then a decrease in its abundance, just as in the mature forest in Bory Tucholskie during the same period. The second abundance peak, slightly lower than the first, occurred in the latter half of September. 17 species of *Phoridae* were recorded at that time. The dominant species belonged to the genus *Megaselia: M. giraudii* (dominant), *M. meconicera* (subdominant) and *M. woodi*. First a rapid increase and then a decrease in the abundance of the species were recorded. The abundance of the species *M. woodi* had the greatest impact on the abundance of the scuttle fly community at that time. The third increase in the abundance of *Phoridae* was recorded in the second half of October, and this was only slightly lower than the second peak. In the course of this peak the number of species dropped to eleven (Fig. 3). The species *Megaselia woodi* was the superdominant at that time. A rapid increase in the abundance of this species was followed by a decrease.

During both study seasons it was recorded that the majority of species belonging to the genus *Megaselia* and dominating in the three mature stands generally reached the highest peaks of abundance increase in autumn. These species included the following: *M. meconicera* (in Puszcza Biała the higher peak was in spring), *M. giraudii*, *M. pulicaria* (in Puszcza Biała the higher peak was in spring), *M. manicata* and *M. woodi*. In the case of the species *Megaselia pleuralis* in Bory Tucholskie and Puszcza Biała there was recorded an exceptionally high increase in the abundance of this species in spring. In Puszcza Białowieska, on the other hand, only 12 individuals of this species were collected at the turn of August and September. Such a rapid abundance increase taking place at that particular time has also been recorded by other scientists working on the Phorid family. (DISNEY, COLUSON, BUTTERFIELD 1981, DISNEY 1987).

It is supposed that the increase in abundance is connected with a rapid reproduction of fungivore species, because it is a time when mushrooms begin to sprout in great masses. Two species: *Phora dubia* and *Phora holosericea* belonging to the dominant group had the highest increase in their abundance in spring. Individuals of species of the genus *Anevrina* (*A. curvinervis*, *A. thoracica*, *A. unispinosa*) were found in samples from spring till early summer. Individuals of the species *A. thoracica* were collected for the longest time, even as late as September. Out of the species of the genus *Borophaga* the species *B. subsultans* occurred throughout both study seasons. The abundance peak of this species was recorded from Bory Tucholskie in spring and from Puszcza Białowieska in autumn, but no increase in its abundance was recorded from Puszcza Biała. The species *B. femorata* occurred in Bory Tucholskie from April till May and in Puszcza Biała it was found in samples only in September. The presence of the species *B. carinifrons* in samples was recorded in Puszcza Biała in September and in Puszcza Białowieska in August. The genus *Conicera* was represented by two species. The species *C. dauci* was found in sam-

ples from Bory Tucholskie from May till July but in Puszcza Białowieska it was recorded only in September. The species *C. tibialis* was represented by just two individuals caught in Puszcza Biała in September. In the case of the genus *Triphleba* the greatest number of species was recorded from Bory Tucholskie and the lowest from Puszcza Biała. The occurrence of the species *T. intermedia*, *T. luteifemorata* and *T. opaca* was recorded in early spring. The presence of *T. luteifemorata* and the other species of the genus *Thriphleba* was recorded from the latter half of July till November. Individuals belonging to five species of the genus *Metopina* were found in samples collected in July, August and September. The species *M. oligoneura*, represented by two individuals, was recorded in spring samples in May. Two species of the genus *Phalacrotophora: Ph. berolinensis* and *Ph. fasciata* were recorded in May and June. Individuals belonging to species of the genus *Phora* appeared in samples from April till September. All the species of this genus had a spring increase in the abundance peak.

SUMMARY

The phorid communities in pine canopies in mature tree stands of the forests in the three regions of Poland were characterized by a similar species composition overlapping in about 60%. The most abundant species common to the three mature tree stands comprised mainly species of the genus *Megaselia: M. giraudii, M. manicata, M. meconicera, M. pleuralis, M. pulicaria, M. sepulchralis* and *M. woodi*. All these species belong to those that are common in various ecosystems.

The scuttle fly communities in the mature stands in Bory Tucholskie and in Puszcza Biała were characterized, in spite of a clear difference in abundance, by a great similarity of the dominance structures. However, they were different from the scuttle fly communities of the mature stands in Puszcza Białowieska, and the evidence of this is found in the values of Morisita index. There are at least two reasons for the most distinct character of the structure of the phorid communities. One is the presence of the other dominants of the genus *Megaselia*. The high positions of the second and fourth dominants were occupied by two species of the genus *Phora*, i.e. *Ph. dubia* and *Ph. holosericea*. Of these, *Ph. dubia* was present, although in low abundances, in the forests of the other regions, whereas *Ph. holoserica* was never recorded from Bory Tucholskie, and in Puszcza Biała its abundance was sixfold lower than that in Puszcza Białowieska. The other reason why the dominance structure of the phorid community in Puszcza Białowieska was different arose from a significantly higher percentage of the first dominant. *M. woodi*, the dominant, did occur in the other two communities, but in Puszcza Biała it was a dominant of the fourth position and in Bory Tucholskie it did not belong to the group of dominants at all. The abundance peak of this species was recorded in September. That held true both for Puszcza Białowieska and Puszcza Biała, although in the latter the occurrence of this species was less intensive. During

both study seasons (1986 and 1987), the changes in the abundance of the phorid communities in the mature tree stands of the three forests studied took place during similar periods. It was recorded that both the increase and the decrease in abundance had occurred at almost the same time and had been connected with an increase and decrease in the number of species (Fig. 3). A very distinct increase in the abundance of *Phoridae* in pine canopies in the mature stands was recorded at the turn of August and September during both study seasons, probably connected with a rapid reproduction of fungivore species. The species *Megaselia woodi*, the eudominant from Puszcza Białowieska was the one to reach the highest abundance. The life history of this species may also be connected with fungi (MALLOCH 1906). Nevertheless, the present studies show that the highest abundance of phorids was in Puszcza Białowieska and the lowest in Puszcza Biała (Table I). The differences in the abundance and number of scuttle fly species occurring in the habitats studied may have been due to the impact of habitat conditions on the communities studied. Bory Tucholskie (N=65, the lowest number of species) are situated in a zone where the primary and secondary pests of the pine pose the greatest threat. Puszcza Białowieska (N=87, the highest number of species) is in a zone where the threat is the lowest. There exists an interdependence between the occurrence of the *Phoridae* and the degree of the habitat degradation. In the present studies neither a lower number of species nor a decrease in the total abundance resulting from it were the only manifestations of such an interdependence. It was also evident in the fact that particular species had clearly decreased their abundance. *Megaselia woodi* provides the best example here because this species was the most abundant in Puszcza Białowieska, but in Puszcza Biała it did not fall into the position of the first dominant for its abundance was lower there, and in Bory Tucholskie it was merely an accessory species. *M. berndseni*, *M. campestris*, *M. flava* and *M. ruficornis* were less abundant species but they reacted in a similar way. Moreover, it follows from an analysis of the trophic structure of the phorid communities that the communities from Puszcza Białowieska were clearly different from the others. It must be born in mind, however, that in the larvae of the *Phoridae* there is an extraordinary variety of trophic types and that polyphagy is common. These facts imply that when the biology of scuttle flies has been studied in more detail, many species now known as saprophages may turn out to be zoophages and the same may apply to fungivores (DISNEY 1979, 1994). Nevertheless, the considerable percentage of zoophage scuttle flies in Puszcza Białowieska and the gradual decrease in their percentage in the forests from regions of increasing degradation suggest that there is interdependence between the trophic structure of the phorid communities and the condition of their habitat. This was most evident in Bory Tucholskie where the forest habitat studied was the most degraded and there were disturbances in the form of frequent pest outbreaks in the ecological system. There the zoophage phorids had been virtually eliminated from the community which consisted mainly of saprophages (Fig. 2). It is therefore justified to conclude that as the pine forests are more and more degraded the reaction of the phorid communities was manifested mainly by a decrease in the num-

ber of species, by a decrease in the abundance of species remaining within a given community and by a change in the feeding structure which resulted in a lower percentage of zoophages.

Phorid fauna from pine canopies unlike that of broad-leaved trees of European forests (DISNEY 1994, BUCK 1994) is much richer. Data obtained from some oak trees near Oxford (England) cover merely 16 species reprezented by several hundred specimens in all (DISNEY 1994). The phorid communities of terrestrial habitats (mainly broad-leaved trees) in the vicinity of Darmstadt (Germany) were also rather poor in species (26) (BUCK 1994). The above briefly comparison indicates that, irrespective of the stages of habitat degradation, pine conopies in mature tree stands are very rich in *Phoridae*.

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STRESZCZENIE

[Tytuł: Skład gatunkowy i struktura zgrupowań zadrowatych (*Diptera: Phoridae*) starodrzewów borów świeżych o różnym stopniu degradacji środowiska]

W koronach sosen starodrzewów borów świeżych trzech regionów Polski: Puszczy Białowieskiej, Puszczy Białej i Borów Tucholskich, reprezentujących trzy strefy zdrowotności lasów zebrano i oznaczono do gatunku 24,5 tys. zadrowatych (*Phoridae, Diptera*). Stwierdzono występowanie 116 gatunków, w tym 12 nowych dla Polski (wśród nich 2 nowe dla nauki).

Zgrupowania *Phoridae* poszczególnych regionów wykazują podobieństwo składu gatunkowego na poziomie ok. 60%. Tworzą je przede wszystkim gatunki z rodzaju *Megaselia*, pospolite, o szerokim zasięgu. W Puszczy Białowieskiej głównym dominantem jest *M. woodi*, w Puszczy Białej – *M. giraudii*, natomiast w Borach Tucholskich – *M. pleuralis*.

W borach świeżych badanych regionów szczyty liczebności zadrowatych występują w podobnych terminach. Największy z nich stwierdzono na przełomie sierpnia i września w Puszczy Białowieskiej.

W miarę stopnia odkształcenia boru świeżego od stanu naturalnego zaobserwowano spadek liczby gatunków zadrowatych. Najwięcej gatunków znaleziono w Puszczy Białowieskiej (87), mniej w Puszczy Białej (67) i najmniej w Borach Tucholskich (65). W tym gradiencie zmian środowiska niektóre gatunki (*M. giraudii, M. berndseni, M. campestris, M. flava* i *M. ruficornis*) zmniejszają też swoją liczebność. Najwyraźniejszą reakcję na degradację borów świeżych zaobserwowano jednak w strukturze fagicznej zgrupowań *Phoridae*. Liczebność zoofagów spada od 26.8% w Puszczy Białowieskiej do 0.7% w Borach Tucholskich głównie na korzyść saprofagów zwiększających odpowiednio swój udział z 32.5% do 80.1%.

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