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**The structure of weevil communities (*Coleoptera*, *Curculionidae*)
of selected Polish pine forests**

[With 10 tables and 19 figures in the text]

Abstract. This paper describes communities of weevils belonging to the families: *Attelabidae*, *Rhinomaceridae*, *Apionidae*, and *Curculionidae*, inhabiting pine forests situated within four forest areas in Poland, namely, the subcontinental pine forests (*Peucedano-Pinetum*) of Puszcza Białowieska and Puszcza Biała and the suboceanic pine forests (*Leucobryo-Pinetum*) of Bory Tucholskie and Rostocze National Park.

INTRODUCTION

The beetles of the weevil family inhabit various biotopes, including xerothermal greens, meadow associations, agrocenoses, coniferous and deciduous forests, wooded areas in towns and others. Some weevil species are regarded as the most dangerous pests among beetles. They are particularly dangerous to monocultures where they can cause extensive damage if they appear in large numbers. The damage done to agricultural and forest crops, forest stands and wooded areas may sometimes be important in economic terms. In most cases the damage is physiological. By eating leaves and gnawing at shoots, weevils reduce the assimilating surface of plants, and by feeding on inflorescence, setting seeds or fruit, they diminish crop yield. Being physiological pests, weevils are classified as the so-called primary and secondary pests. A few are technical timber vermins.

Most papers concerned with the *Curculionidae* fauna of forest environments in Poland describe linden-oak-hornbeam forests (CHOLEWICKA 1981, CMOLUCH et al. 1990, KNUTELSKI 1988, KUŚKA 1982, PETRYSZAK 1988). A couple of papers are devoted to weevils inhabiting pine forest habitats. Some of them deal with other plant association types as well (CMOLUCH 1961, CMOLUCH, ŁĘTOWSKI 1987, PETRYSZAK 1982, STACHOWIAK 1991) and describe pine forest weevil communities only fragmentarily. Still other studies analyse the weevil fauna inhabiting

selected plant species characteristic of pine forests, but fail to examine the habitat where the plants grow (CMOLUCH, KOWALIK 1963, STACHOWIAK 1984). There are also papers describing pine forest weevil communities inhabiting the forest areas which were the subject of this study, i.e. Puszcza Białowieska, Puszcza Biała and Roztocze National Park. Such papers do not usually go beyond describing the species composition (TENENBAUM 1913, GOTWALD 1968, KARPIŃSKI 1958) and the structure of dominance (CMOLUCH, ŁĘTOWSKI 1987). Only a few are concerned with issues of forest fauna ecology (SZUJECKI 1959).

The aim of this study was to describe weevil communities inhabiting pine forests within the territory of Poland. To fulfil the tasks, the researchers analysed the species composition, seasonal variations in the abundance and dominance structure of *Curculionidae*. The study objectives were also accomplished by describing the weevils studied in ecological terms as well as comparing the structures of communities inhabiting the various areas studied.

THE AREAS OF STUDY

The study was carried out in four pine forest areas in Poland: the subcontinental pine forests (*Peucedano-Pinetum*) in Puszcza Białowieska and Puszcza Biała, and the suboceanic pine forests (*Leucobryo-Pinetum*) in Bory Tucholskie and Roztocze National Park (Fig. 1).

Quantitative research was performed in mature stands (80–150 years old). In each forest area, the quantitative research was carried out in 12 stands. In order to collect as great a number of weevil species occurring in this habitat type as possible, the specimens were also caught in middle age and young stands.

A geobotanical description of the stands has been provided by a team of phytosociologists (MATUSZKIEWICZ et al. 1993).

MATERIAL AND METHODS

The catches were conducted in the vegetational season from April to October in the years 1986 and 1987. About 7.500 specimens of weevils were collected. The specimens were collected by means of various quantitative methods. A different sampling method was used in each forest layer in mature stands.

In the canopy layer, weevils were caught using Moericke's pitfall traps. Five traps (yellow bowls) were hung high up in canopies of pines (*Pinus sylvestris* L.) in each stand. The insects were collected every fortnight.

In the herb layer, specimens were caught with a sweeping net. 10 samples were taken at each stand twice a month. 25 sweeps made one sample.

Additional sampling methods were also used. They served to provide exhaustive information about the species composition of weevil communities in the forest areas studied. The methods included Barber's pitfall traps used for collecting specimens from the soil surface and species active at night, picking the beetles from soil siftings, Moericke's traps located on the soil surface and "stalking" (collecting insects from under stones and bark and wood dust).

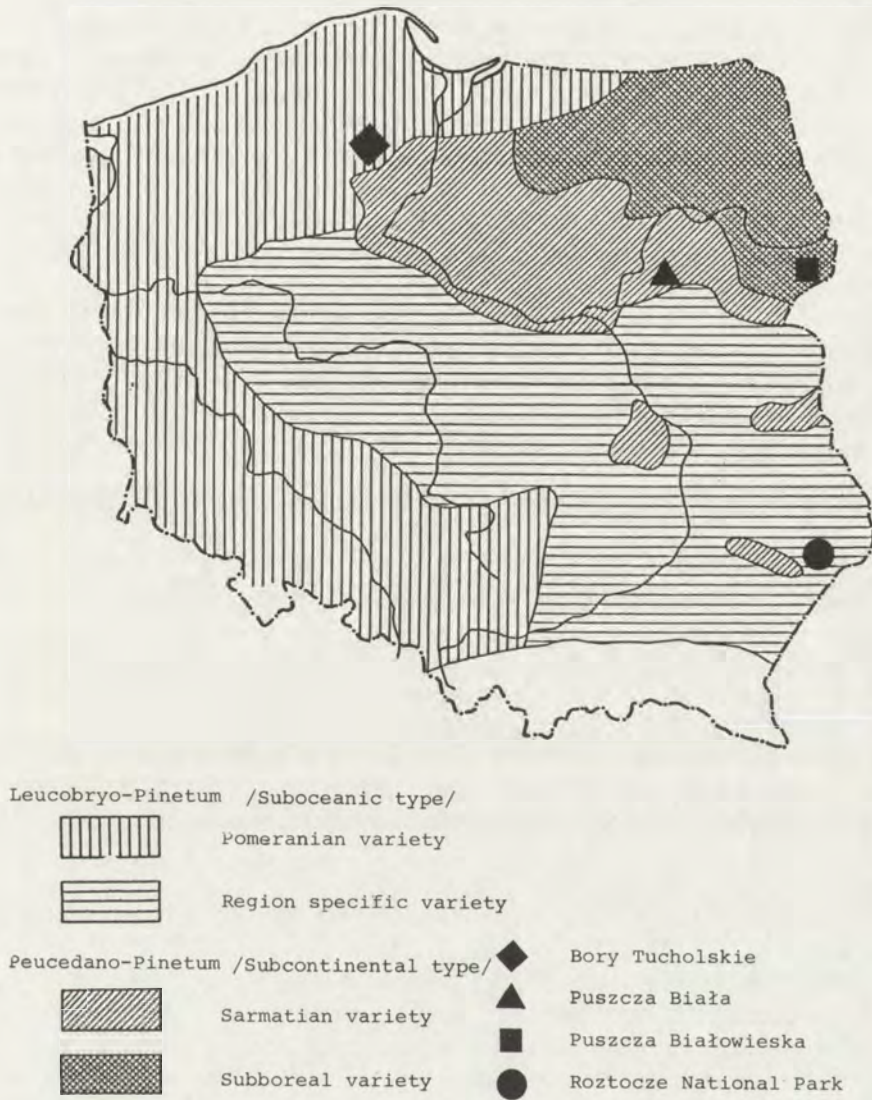


Fig. 1. The location of study areas with the regional differentiation of the pine forest (regional differentiation by Matuszkiewicz 1987).

The material analysed embraces the *Curculionidae* family sensu lato. The following families were identified in the material analysed: *Attelabidae*, *Rhinomacreridae*, *Apionidae* and *Curculionidae*.

The abundance of each species was expressed by means of a relative abundance index (n), which was first calculated separately for each sampling method. In the canopy layer, the index was equivalent to the number of weevil specimens caught into 10 Moericke's traps over 10 days, while in the herb layer

it corresponded to the number of weevils collected in 25 sweeps. In order to determine the abundance of weevil communities in pine forests, a conversion factor was used so that the abundance indices calculated for Moericke's traps and sweeping nets could be summed. The value of the conversion factor – 5.0 – was calculated as a ratio of the number of weevils caught into Moericke's traps situated on the soil surface and the number of specimens collected with sweeping nets in the same area and over the same length of time. The value is the same both in the case of the most abundant species and the total of weevil individuals collected.

In order to determine species richness of weevil communities in the mature stands of the coniferous forests studied, the following indices of species diversity were employed: 1. Menhinick's diversity index, 2. Simpson's index and 3. Shannon and Weaver's index (ODUM 1977). Because the results obtained with each of the three indices were similar, the species diversity of weevils is described

according to the results obtained with Shannon and Weaver's index (\bar{H}):

$$\bar{H} = - \sum_{i=1}^s \frac{n_i}{N} \log \frac{n_i}{n}$$

where:

N – abundance index of all the species

n_i – abundance index of each species

In order to measure the degree of similarity of species composition between weevil communities in the forest areas studied, a similarity coefficient (TROJAN 1975), or Jaccard's (J_a) and Sørensen's (S_o) figure, was used:

$$J_o = \frac{2a}{b+c}$$

where:

a – the number of species found in both areas

b – the number of species in the first forest area

c – the number of species in the second forest area

In order to determine the similarity of dominance structures of weevil communities inhabiting two areas compared, Morisita's formula (1959), modified by Horn (1966) was used:

$$S = \frac{2 \sum_{i=1}^n x_i y_i}{\sum_{i=1}^n x_a^2 + \sum_{i=1}^n y_a^2}$$

where:

x_i, y_i – the percentage of species abundance common for two complexes

x_a, y_a – the percentage of species abundance in the particular complex.

The criteria for a zoogeographical classification and the resulting classification of weevils was based on papers by PETRYSAK (1980), DIECKMANN (1954), HOFFMANN (1954), O'BRIEN, WIMBER (1982) and KOSTROWICKI (1953).

DESCRIPTION OF CURCULIONIDAE COMMUNITIES

The following 16 species were considered common to all the forest areas studied (Tab. 1): *Rhinomacer attelaboides*, *Doydirhynchus austriacus*, *Deporaus betulae*, *Apion simile*, *A. vitens*, *A. fulvipes*, *Brachyderes incarus*, *Strophosoma capitatum*, *Hyllobius abietis*, *Anthonomus phyllocola*, *Brachonyx pineti*, *Curculio pyrrhoceras*, *Magdalis linearis*, *M. phlegmatica*, *Ceutorhynchus erisimi* and *C. floralis*. These species account for about 14% of the total number of specimens.

Some of the species which occurred in all the forests studied were also the most abundant ones. These are: *R. attelaboides*, *D. austriacus*, *Apion simile*, *A. fulvipes*, *S. capitatum*, *H. abietis*, *A. phyllocola*, *B. pineti*, *M. linearis* and *M. phlegmatica*. *Attelabus nitens*, *Apion curtirostre*, *Apion marchicum*, *Ottiorhynchus scaber*, *Phyllobius arborator* and *Hyllobius pinastri* were also abundant in the research material, but were not identified in all the pine forest areas studied.

The Curculionidae community of pine forests is characterized by the occurrence of species associated with plants typical of this association. The species most abundant in the material are those whose biology is connected with pine or other coniferous tree species as well as with herb species characteristically occurring in this forest association. Apart from weevils which feed on plants typical of pine forests, polyphagous species form another abundant group. Like other insects, these species are found in all forest layers. Since they are phytophages, their spatial distribution depends on the presence of the plants which serve as their food supplies. In order to determine the structure of Curculionidae family in the pine forest habitat, one should, therefore, analyse layer after layer. The weevil species identified in pine forests have been divided into 11 biotic groups. Some of them are associated with the various stratocenoses, some treat pine forests as a wintering area, while others can only be found there by chance. From among the species which develop in different forest layers, first biotic group has been formed that consists of species which are associated with the canopies of coniferous trees both as larvae and as imagines. Consisting of 13 species, the group includes weevils that develop in inflorescence, that mine or gnaw at coniferous needles as well as those whose larvae develop in branches, under the bark or in young shoots. *Rhinomacer attelaboides*, *Doydirhynchus austriacus*, *Anthonomus phyllocola*, *Brachonyx pineti*, *Magdalis linearis* and *M. phlegmatica* were found in all the forests studied. It should be stressed that *R. attelaboides*, *A. phyllocola* and *B. pineti* have high abundance indices. The dominant species in this forest layer was *Rhinomacer attelaboides* whose larva develops in male inflorescence of pine, while the pupation takes place in the soil. Either the larva or the pupa use pine forests as wintering areas. Like *Magdalis linearis* and *M. phlegmatica*, *R. attelaboides* is seldom found in the herb layer. The larvae of the species of the genus *Magdalis* are wood-eaters that feed in branches and trunks of dead or decaying trees, less often in healthy ones. The

Table I. Abundance of the various species of *Curculionidae* found in four pine forests in Poland.

No	Species	Forest complex		Puszczka Białowieska		Roztocze N. Park		Puszczka Biała		Bory Tucholskie		Average in complexes	
		n	%	n	%	n	%	n	%	n	%		
1	2	3	4	5	6	7	8	9	10	11	12		
1	<i>Rhinomacer attelaboides</i> F.	3.87	16.36	4.65	20.04	11.77	57.09	1.43	18.65	5.431	28.90		
2	<i>Doydirhynchus austriacus</i> (OIV.)	0.30	1.25	1.38	5.96	0.19	0.92	0.10	1.36	0.493	2.62		
3	<i>Pselaphorhynchites longiceps</i> (THOMS.)	0.01	0.04							0.003	0.01		
4	<i>Pselaphorhynchites nanus</i> (PAYK.)	0.08	0.34			0		0.01	0.11	0.022	0.12		
5	<i>Pselaphorhynchites tomentosus</i> (GYLL.)	0.04	0.18							0.010	0.06		
6	<i>Caenorhinus germanicus</i> (HERBST)	0.01	0.04	+						0.003	0.01		
7	<i>Byctiscus betulae</i> (L.)	0.01	0.04			0				0.003	0.01		
8	<i>Byctiscus populi</i> (L.)	0.01	0.04							0.003	0.01		
9	<i>Deporaus betulae</i> (L.)	0.14	0.58	0.12	0.52	0.06	0.31	0.02	0.23	0.085	0.45		
10	<i>Deporaus mannerheimii</i> (HUMM.)	0											
11	<i>Attelabus nitens</i> (SCOP.)	0.43	1.84					0.02	0.23	0.113	0.60		
12	<i>Apoderus coryli</i> (L.)	0.02	0.08	=						0.005	0.03		
13	<i>Apion cruentatum</i> WALT.					0.03	0.12			0.006	0.03		
14	<i>Apion haematodes</i> KIRBY			0.01	0.02	0.06	0.29	0.02	0.21	0.020	0.11		
15	<i>Apion rubens</i> STEPH.	0.02	0.09	0.02	0.07					0.009	0.05		
16	<i>Apion rubiginosum</i> GRILL	0.06	0.26			0.10	0.49	0.01	0.11	0.043	0.23		
17	<i>Apion curtirostre</i> GERM.	0.03	0.13	0.05	0.22	0.35	1.70			0.109	0.58		
18	<i>Apion marchicum</i> HERBST	0.06	0.26	0.01	0.05	0.41	1.97			0.120	0.64		
19	<i>Apion breuirostre</i> HERBST			0.01	0.05	#				0.003	0.01		
20	<i>Apion simum</i> GERM.					0.03	0.16			0.008	0.05		
21	<i>Apion corniculatum</i> GERM.					0.01	0.04			0.002	0.01		
22	<i>Apion elongatum</i> DESBR.	0.06	0.26			0.05	0.25			0.028	0.15		
23	<i>Apion vicinum</i> KIRBY					0							
24	<i>Apion austriacum</i> WAGN.							0					
25	<i>Apion jaffense</i> DESBR.			0.01	0.02					0.001	0.01		
26	<i>Apion vorax</i> HERBST					0							
27	<i>Apion simile</i> KIRBY	0.62	2.62	0.04	0.15	0.15	0.74	0.03	0.33	0.208	1.11		
28	<i>Apion erui</i> KIRBY			0.01	0.02					0.001	0.01		

1	2	3	4	5	6	7	8	9	10	11	12
29	<i>Aption viciae</i> (PAYK.)			0.02	0.07					0.004	0.02
30	<i>Aption cracca</i> (L.)			0.02	0.07	0.01	0.04	0.02	0.21	0.010	0.05
31	<i>Aption dimidiatum</i> DESBR.			0.01	0.02					0.001	0.01
32	<i>Aption utrens</i> HERBST	0.19	0.78	0.01	0.05	0.10	0.49	0.05	0.63	0.087	0.46
33	<i>Aption apricans</i> HERBST	0.07	0.31	0.01	0.05					0.021	0.11
34	<i>Aption fulvipes</i> (GEOFR.)	0.23	0.95	0.54	2.31	0.15	0.72	0.07	0.96	0.246	1.31
35	<i>Nanophyes marmoratus</i> (GOEZE)	0.01	0.04							0.003	0.01
36	<i>Ottiorhynchus ligustici</i> (L.)			#							
37	<i>Ottiorhynchus raucus</i> (F.)	#		#							
38	<i>Ottiorhynchus scaber</i> (L.)	0.01	0.04	#						0.003	0.01
39	<i>Ottiorhynchus ovatus</i> (L.)	0		#		#					
40	<i>Phyllobius viridicollis</i> (F.)	0.01	0.04							0.003	0.01
41	<i>Phyllobius arborator</i> (HERBST)	0.50	2.11	0.07	0.29					0.142	0.75
42	<i>Phyllobius argentatus</i> (L.)	0.02	0.09					0		0.005	0.03
43	<i>Phyllobius pyri</i> (L.)					0.02	0.10			0.005	0.03
45	<i>Trachyphloeus artstatus</i> (GYLL.)	#									
44	<i>Trachyphloeus bifoveolatus</i> (BECK.)			0.01	0.02	0.01	0.04			0.003	0.02
46	<i>Polydrusus pallidus</i> (GYLL.)	0				0.13	0.65	0.04	0.56	0.044	0.24
47	<i>Polydrusus cervinus</i> (L.)					0.02	0.08			0.004	0.02
48	<i>Polydrusus confluens</i> STEPH.	0.03	0.13							0.008	0.04
49	<i>Polydrusus pilosus</i> GREDL.	0.03	0.13							0.008	0.04
50	<i>Polydrusus mollis</i> (STRØM)					=					0.00
51	<i>Brachyderes incanus</i> (L.)	0.02	0.08	#		0.11	0.55	0.02	0.21	0.037	0.20
52	<i>Strophosoma capitatum</i> (DEG.)	8.57	36.24	2.03	8.76	2.37	11.51	1.71	22.23	3.672	19.54
53	<i>Strophosoma fulvicorne</i> (WALT.)							0.17	2.21	0.042	0.23
54	<i>Sitona griseus</i> (F.)	0.01	0.04					0.02	0.21	0.007	0.04
55	<i>Sitona crinitus</i> (HERBST)	0.01	0.04	0.01	0.02			0.02	0.23	0.008	0.04
56	<i>Sitona humeralis</i> STEPH.			0.03	0.13	#		0		0.008	0.04
57	<i>Sitona leptidus</i> GYLL.							0			
58	<i>Sitona lineatus</i> (L.)	0.08	0.34	0.03	0.13			0.01	0.11	0.030	0.16
59	<i>Sitona puncticollis</i> STEPH.	0.01	0.04							0.003	0.01
60	<i>Sitona sulcifrons</i> (THUNB.)			0.02	0.09					0.005	0.03
61	<i>Contioleonus hollbergii</i> (FAHR.)					#		#			

1	2	3	4	5	6	7	8	9	10	11	12
62	<i>Dryophthorus corticalis</i> (PAYK.)	=									
63	<i>Cossonus paralleleptedus</i> (HERBST)	0.01	0.04							0.003	0.01
64	<i>Tanysphyrus lemnae</i> (PAYK.)	0.01	0.04			0.01	0.04			0.005	0.03
65	<i>Grypus equiseti</i> (F.)			#							
66	<i>Tychius pictrostris</i> (F.)			0.04	0.15	0.02	0.08	0.01	0.11	0.015	0.08
67	<i>Sibinia pellucens</i> (SCOP.)							▲			
68	<i>Sibinia potentillae</i> GERM.					0.03	0.14			0.007	0.04
69	<i>Anthonomus rubi</i> (HERBST)	0.06	0.26							0.016	0.08
70	<i>Anthonomus phyllocola</i> (HERBST)	1.87	7.92	10.92	47.06	0.35	1.71	0.30	3.91	3.362	17.89
71	<i>Brachonyx pineti</i> (PAYK.)	4.20	17.75	1.65	7.12	2.52	12.20	2.62	34.12	2.746	14.62
72	<i>Curculio rubidus</i> GYLL.	0.07	0.31							0.018	0.10
73	<i>Curculio pyrrhoceras</i> MARSH.	0.19	0.78	0.03	0.13	0.02	0.08	0.06	0.84	0.074	0.40
74	<i>Pissodes notatus</i> (F.)					0					
75	<i>Pissodes pini</i> (L.)			#		0.02	0.10			0.005	0.03
76	<i>Pissodes piniphilus</i> (HERBST)					0					
77	<i>Magdalis exarata</i> (Bris.)	0.02	0.08							0.005	0.03
78	<i>Magdalis phlegmatica</i> (HERBST)	0.06	0.25	0.36	1.55	0.06	0.31	0.21	2.72	0.173	0.92
79	<i>Magdalis nitida</i> (GYLL.)	0.02	0.08					0		0.005	0.03
80	<i>Magdalis linearis</i> (GYLL.)	0.43	1.80	0.46	1.99	0.91	4.41	0.51	6.67	0.577	3.07
81	<i>Magdalis frontalis</i> (GYLL.)					0		0			
82	<i>Magdalis violacea</i> (L.)	0.06	0.25							0.015	0.08
83	<i>Magdalis duplicata</i> GERM.	0.08	0.34			0.01	0.04	0.06	0.78	0.037	0.20
84	<i>Hylobius abietis</i> (L.)	0.02	0.08	+, #		0.42	2.03	0.06	0.78	0.125	0.66
85	<i>Hylobius pini</i> (GYLL.)	0.03	0.13	+, #		#				0.008	0.04
86	<i>Hylobius transversotattatus</i> (GOEZE)	0.01	0.04							0.003	0.01
87	<i>Plinthus tischeri</i> GERM.			#							
88	<i>Hypera zoilus</i> (SCOP.)	0									
89	<i>Hypera rumicis</i> (L.)			0.01	0.02			▲		0.001	0.01
90	<i>Hypera nigritrostris</i> (F.)	0		0.01	0.05	0.02	0.10			0.008	0.04
91	<i>Hypera arator</i> (L.)					0.02	0.10			0.005	0.03
92	<i>Hypera postica</i> (GYLL.)							0			
93	<i>Pelenomus quadricorniger</i> (COLONN.)	0				0					
94	<i>Rhinoncus bruchoides</i> (HERBST)	0				#					

1	2	3	4	5	6	7	8	9	10	11	12
95	<i>Rhinoncus castor</i> (F.)	O				0.06	0.29	O		0.015	0.08
96	<i>Rutidosoma globulus</i> (HERBST)	0.03	0.13							0.008	0.04
97	<i>Coeliodes rubicundus</i> (HERBST)	0.24	1.01							0.060	0.32
98	<i>Coeliodes erythroleucus</i> (GMEL.)	0.01	0.04							0.003	0.01
99	<i>Micrelus erice</i> (GYLL.)	0.01	0.04							0.003	0.01
100	<i>Ceutorhynchus pleurostigma</i> (MARSH.)	O		0.04	0.15					0.009	0.05
101	<i>Ceutorhynchus assimilis</i> (PAYK.)	O		0.04	0.15			O		0.009	0.05
102	<i>Ceutorhynchus contractus</i> (MARSH.)	0.01	0.04					O		0.003	0.01
103	<i>Ceutorhynchus erysimi</i> (F.)	0.04	0.17	0.02	0.07	0.01	0.04	0.02	0.21	0.020	0.11
104	<i>Ceutorhynchus sulcicollis</i> (PAYK.)			0.03	0.13					0.008	0.04
105	<i>Ceutorhynchus punctiger</i> GYLL.	0.02	0.08							0.005	0.03
106	<i>Ceutorhynchus angulosus</i> (BOH.)			0.01	0.02					0.001	0.01
107	<i>Ceutorhynchus floralis</i> (PAYK.)	0.02	0.09	0.16	0.70	O		0.08	1.10	0.067	0.36
108	<i>Trichostrocalus barnevillei</i> (GRENIER)					O					
109	<i>Gymnaetron antirrhini</i> (PAYK.)	0.01	0.04							0.003	0.01
110	<i>Anoplus plantaris</i> (NAEZ.)	0.07	0.30			O		O		0.018	0.09
111	<i>Rhynchaenus quercus</i> (L.)	0.01	0.04							0.003	0.01
112	<i>Rhynchaenus avellanae</i> (DONOV.)	0.05	0.22							0.013	0.07
113	<i>Rhynchaenus fagi</i> (L.)			0.36	1.55					0.090	0.48
114	<i>Rhynchaenus rusici</i> (HERBST)	0.39	1.63			0.01	0.04			0.098	0.52
115	<i>Rhynchaenus stigma</i> (GERM.)	O				O					
116	<i>Rhamphus pulicarius</i> (HERBST)	0.02	0.08	0.01	0.02			O		0.006	0.03
	Total	23.66	100.00	23.21	100.00	20.62	100.00	7.67	100.00	18.789	100.00

n – abundance index (data from Moericke's traps and sweeping net)

▲ – litter sifting

= – "stalking"

+ – Moericke's traps put on the ground

– Barber pitfall traps

O – species found only in young and middle age pine forest

* – value of abundance index are lower than in reality because these species were trapped in Barber pitfall traps in high abundant.

weevils occurring abundantly in this forest layer: *Anthonomus phyllocola* and *Brachonyx pineti*, are found in large numbers not only in tree crowns but in the lower layers of the forest as well. The larva of *B. pineti* feeds on the parenchyma of young pine needles (ŚLIWA, PILAWA 1976), while *A. phyllocola* is, like *R. attelaboides*, a species that develops in male inflorescence of pine (*Pinus sylvestris*) or spruce (*Picea abies*). In the two latter cases, the pupation takes place in the larva's feeding ground. The imago hibernates in the soil or under fallen leaves. In the herb layer, *B. pineti* was most caught in the greatest numbers in autumn – at the beginning of October (Fig. 2), i.e. before hibernation. On the other hand, the highest abundances of *A. phyllocola* were recorded at the end of May (Fig. 3). *Doydirhinchus austriacus* has a biology similar to *R. attelaboides*. Even though the former species was less abundant than the latter, it was likewise registered in all the forest areas.

25 species that constitute the second biotic group are associated with canopies of deciduous trees and bushes forming the undergrowth in the forests studied. The larvae of these weevils gnaw at young shoots, mine leaves, twist them into cones, and eat inflorescence, flowers or fruit. Although the group has the greatest number of species, its abundance is not high. *Deporaus betulae* ought to be considered a species characteristic of the canopies of undergrowth-forming trees since it occurred in all the forest areas studied. The larva of this species develops in a leaf twisted into a cone by the egg-laying female. The species feeds mostly on birch (*Betula* sp.) trees and its pupation occurs in the soil. Fruit of birch are food to the larvae of *Apion simile*, which eat the seeds and causes fruit hypertrophy. The imago feeds on leaves. It is the imago that hibernates. This species is characteristic of all the forests studied. It was collected predominantly in the herb layer and the canopy layer, only a few specimens were collected from the soil surface. *Attelabus nitens* develops on oak trees, a species characteristic of the pine forest. Having laid an egg, the female twists a leaf into a cone. The larva hibernates inside the cone on the soil surface. Another weevil species included into this biotic group is *Curculio pyrrhoceras*. This species, too, is associated with oak trees (*Quercus* sp.). The larvae develop in hymenopteran excrescences caused by *Dryophanta folii* L. (*Cynipidae*) on the leaves of various species of oak. Registered in the canopies and the herb layer, this species is not characterized by high abundance indices, but it occurs in all the forest areas.

The third biotic group embraces 10 species associated with above-ground parts of herbaceous plants of the herb layer. The species in this group gnaw at or mine leaves, cause galls, and feed on stalks, flowers or fruit of herbaceous plants. This biotic group of weevils is not abundant either in the number of species or individuals. One species worth mentioning here is *Apion curtirostre*, which lives on various sorrel species (*Rumex* sp.), the larva developing inside the stalks.

The subsequent three biotic groups consist of species whose larvae feed on roots while the imagines are associated with above-ground parts of plants. The 4 weevil species whose larvae develop on the roots of coniferous trees and the imagines feed on the above-ground parts of these plants form the fourth biotic group. *Hylobius abietis* was recorded in high abundances in all the forest areas

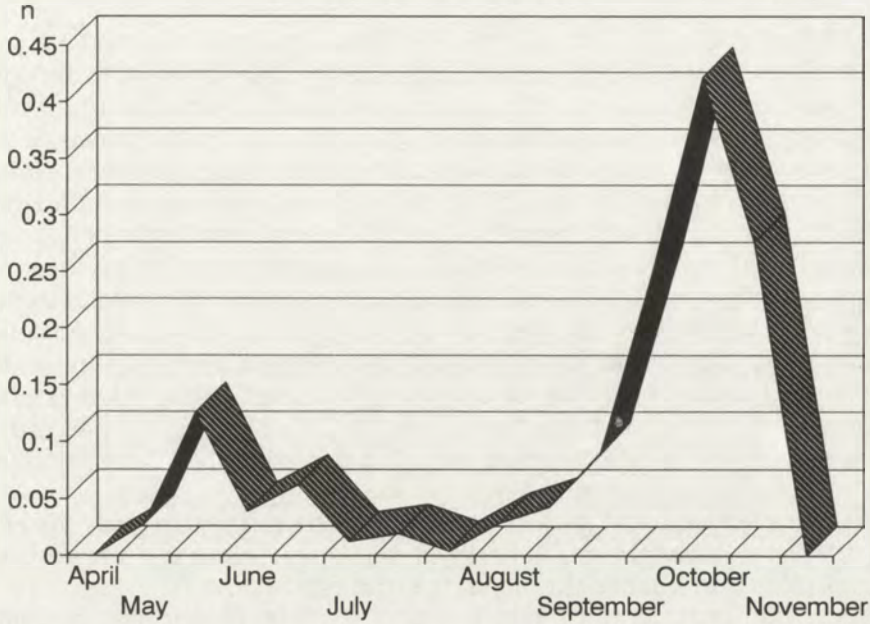


Fig. 2. Seasonal abundance variations of *Brachonyx pineti* in the pine forests herb layer. n – abundance index for the sweeping net.

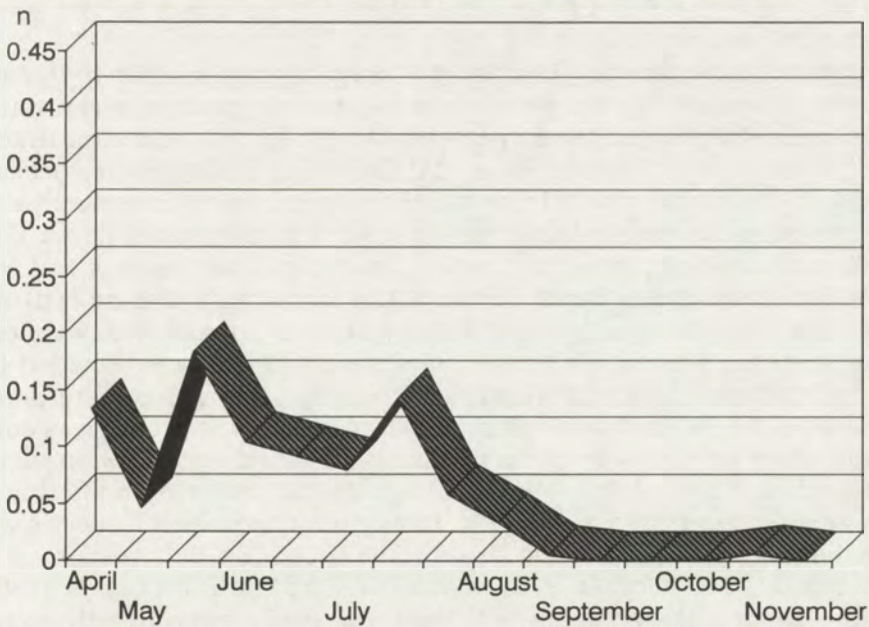


Fig. 3. Seasonal abundance variations of *Anthonomus phyllocola* in the pine forests herb layer. n – abundance index for the sweeping net.

under study. Dominant in his biotic group, this species is known to be a pest to pine cultures. Its larvae develop in decaying roots, feeding on the pulp and xylem, while the adult form cuts through trunks or gnaws at the bark of young saplings (2–5 years old) and is considered a pest (FRYDRYCHEWICZ 1937). The adult forms of this beetle were identified in all vegetation layers. The larvae of *Hylobius pinastri* drive corridors under the bark of the trunk and roots of pines and spruce trees. Like *H. abietis*, the development cycle of this species lasts for 2 years. It was recorded less frequently than *H. abietis*, being most abundant on the surface of the soil and in the herb layer. *Brachyderes tricarvus* is another species included into this biotic group that was registered in every layer of the forest association studied. Its larvae develop on the roots and feed on their bark. The imago feeds on needles by making incisions and causing resin leakages. Sometimes the beetles attack the bark. This species is a well-known pest not only to pine but to other European coniferous trees as well. It was recorded in every forest area, but its abundance indices are low.

The fifth biotic group is one of the least numerous with only three not abundant species. Their larvae develop on the roots, while the imago lives in canopies of trees and bushes that form the undergrowth.

The sixth quite numerous biotic group, including 11 species, consists of weevils whose larvae develop on the roots of herbaceous species, while the imagines feed on the above-ground parts of these plants. The monophagous *Apion marchicum* which causes galls on the roots of *Rumex acetosella*, a plant commonly found in the areas studied, was only identified in the herb layer. The species was not recorded in Bory Tucholskie. It occurred in the greatest abundances in Puszcza Biała.

The seventh biotic group consists of 7 polyphagous species that usually develop on roots, while the imagines are found in all vegetation layers. *Strophosoma capitatum* was the dominant species in this group caught in large numbers in all vegetation layers. Both the larva and the imago of this beetle species are polyphagous, the imago, which feeds mostly on trees, being considered a pest. The species often causes serious damage to young cultures of beech (*Fagus sylvatica*), oak and pine. Its larvae feed on the roots of herbaceous and woody plants. When appearing in large numbers, the larvae may also be considered pests to annual and bi-annual herbaceous plants. *S. capitatum* is wingless so its locomotive ability is rather limited. In spite of that, it was recorded in all vegetation layers. It is a common species, abundant in various plant associations. *Phyllobius arborator*, another species from this biotic group, was considerably abundant only in two coniferous forest areas: Puszcza Białowieska and Bory Tucholskie. This species, which feeds on deciduous trees and herbaceous plants, was recorded in all forest layers. *Otiorhynchus scaber* is a species which was registered in the same forest areas as *P. arborator*. It is polyphage that develops mostly on coniferous trees, willow (*Salix* sp.), hazel (*Corylus avellana*) and various herbaceous plant species. The larvae feed predominantly on roots, while the adult forms are mostly found on leaves and in moss. As the other species in this genus, it leads a nocturnal life.

Species that develop in decayed wood formed a separate eighth biotic group consisting of two species only.

That a species is assigned to a particular biotic group does not mean, however, that it is exclusively associated with a specific vegetation layer. Although weevils are not known to be good flyers, they are frequently found in layers or environments where they neither develop nor can find their host plants. Nearly all species spend winter in the soil or on its surface mostly as imagines and only rarely as larvae, pupas or eggs. The location of the wintering grounds often makes them migrate to a different layer within one environments or even to a different environment. This statement can be strengthened by the fact that 27 of the weevil species identified in the course of our study (23% of the total number of species) fed on plants growing outside the pine forests in the areas studied. Some of these were found in high abundances in the areas, while others, such as *Aption fulvipes*, *A. virens*, *Ceutorhynchus erisimi* and *C. floralis*, are species common to all the coniferous forests studied. They were identified both in the canopies and in the herb layer. They should be classified into the ninth biotic group composed of 19 species that migrate to this habitat to hibernate. Their larvae develop in the above-ground parts (stalks, petioles, flowers and fruit) of various species of the family *Cruciferae* (WIECH 1987, WIECH, WNUK 1987), which is not characteristic of pine forests. Since plants belonging to this family did not occur in the areas studied, these weevils must be considered species that migrate to forest habitats in order to hibernate (STEIN 1970). The abundance index of *A. virens* increases in September and October (Fig. 4), while in the other months

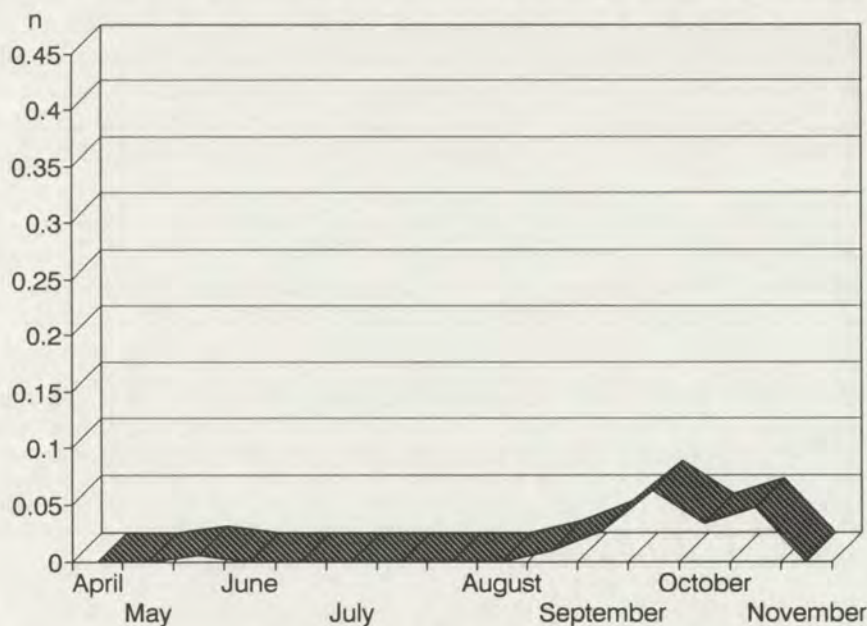


Fig. 4. Seasonal abundance variations of *Aption virens* in the pine forests herb layer. n - abundance index for the sweeping net.

the species was registered only sporadically in the study sites. The species of the genus *Ceutorhynchus*, which hibernate as imagines, choose hideouts located far away from cultivated fields, chiefly forest edges and field woodlands (MICZULSKI 1963).

Moreover, a number of the species identified in the study, most of them belonging to the genus *Hypera*, cannot find their host plants in pine forests, nor do they hibernate there. These species had migrated to this habitat by chance. They have been classified as a separate tenth biotic group. The species were found in the pine forests in spring when they look for feeding grounds particularly vigorously (OPRYCHAŁOWA 1957). To the eleventh biotic group belong weevils with unknown development.

Of the 11 biotic groups distinguished, the one most abundant in species is that composed of weevils which live in the crowns of undergrowth-forming deciduous trees both as larvae and as imagines (Tab. II). Nearly all the species from this biotic group occurred in Puszcza Białowieska. Their share in the community is also the greatest in that region.

Table II. Number of species for the weevils in various biotic groups in four pine forests complexes in Poland

Biotic group	Puszcza Białowieska		Roztocze N. Park		Puszcza Biała		Bory Tucholskie		All forest complexes	
	N	%	N	%	N	%	N	%	N	%
1	9	11.69	7	13.46	9	16.07	9	20.93	13	11.21
2	24	31.17	7	13.46	8	14.29	6	13.95	25	21.55
3	6	7.79	6	11.54	3	5.36	3	6.98	10	8.62
4	4	5.19	3	5.77	4	7.14	3	6.98	4	3.45
5	2	2.60			2	3.57	1	2.33	3	2.59
6	6	7.79	6	11.54	5	8.93	6	13.95	11	9.48
7	4	5.19	3	5.77	5	8.93	2	4.65	7	6.03
8	2	2.60							2	1.72
9	9	11.69	13	25.00	10	17.86	8	18.60	19	16.38
10	5	6.49	1	1.92	4	7.14	2	4.65	8	6.90
11	6	7.79	6	11.54	6	10.71	3	6.98	14	12.07
Total	77	100.00	52	100.00	56	100.00	43	100.00	116	100.00

N – number of species. Biotic group: 1. Larvae and imagines are living in coniferous canopy layer, 2. Larvae and imagines are living the undergrowth canopy layer, 3. Larvae and imagines are living on above ground part of herbs, 4. Larvae are feeding on the roots, imagines on above ground part of coniferous trees, 5. Larvae are feeding on the roots, imagines in the canopy layer of undergrowth 6. Larvae are feeding on the roots, imagines on the above ground part of herbs, 7. Polyphagous species, 8. Weevils are developing in wood dust, 9. Species are migrating for hibernation, 10. Species arrived accidentally, 11. Unknown development.

The development cycle of 47 species found in all the areas studied is associated exclusively with trees. The species account for over 40% of the total

number of species (the 1st, 2nd, 4th and 5th biotic groups). Another numerous group consists of species that migrate to pine forests in order to hibernate (9th biotic group). These were the most abundant in Puszcza Biała and Roztocze. The least numerous group is that of species that develop in rotting wood. They occurred only in Puszcza Białowieska, which is due to the fact that compared to the other forest areas in Puszcza Białowieska there is a lot of rotting wood on the forest floor. One more possible reason is that weevils exhibiting such a biology are not abundant at all.

The classification of weevils into the biotic groups was taken into account when a quantitative analysis of the beetles was performed. The dominant species in all the forest areas studied are those associated exclusively with the canopies of coniferous trees, predominantly pines (Tab. III). This stratocenosis is the developing place for the larvae and the feeding ground for the imagines of these species. The greatest abundance indices were noted for this group in Roztocze, while in Bory Tucholskie the species were the least abundant (almost four times as little). The second most abundant group in all the forest areas is the polyphagous species' group. In Puszcza Biała, Bory Tucholskie and Roztocze, the structure of dominance of the biotic groups is similar, with species from the 1st biotic group (developing in the canopies of coniferous trees) far outstripping the other groups. On the other hand, the structure of dominance in Puszcza Białowieska is much more uniform. The first biotic group remains in the lead, but polyphagous species are abundant there as well. This phenomenon is due to the species richness of the vegetation growing in the area. The abundance indices of species from the remaining biotic groups are low, the only exception being a slight increase in the abundance of weevils whose larvae and imagines develop in the canopies of undergrowth-forming deciduous trees in Puszcza Białowieska.

Table III. Abundance index (n) for the weevils in various biotic groups in four pine forest complexes in Poland. (Specification of weevil biotic group number the same as for Table II)

Biotic group	Puszcza Białowieska		Roztocze N. Park		Puszcza Biała		Bory Tucholskie		All forest complexes	
	n	%	n	%	n	%	n	%	n	%
1	10.88	46.01	19.43	83.72	15.83	76.79	5.23	68.67	12.84	68.41
2	2.53	10.68	0.55	2.37	0.29	1.41	0.13	1.74	0.88	4.66
3	0.09	0.39	0.12	0.51	0.43	2.08	0.02	0.32	0.17	0.88
4	0.07	0.30			0.67	3.23	0.12	1.56	0.21	1.14
5	0.03	0.13			0.02	0.08			0.01	0.06
6	0.23	0.96	0.10	0.42	0.57	2.75	0.03	0.44	0.23	1.23
7	8.60	36.33	2.04	8.78	2.40	11.66	1.87	24.61	3.73	19.85
8	0.01	0.04								0.01
9	0.57	2.40	0.89	3.84	0.32	1.54	0.19	2.45	0.49	2.62
10	0.04	0.17	0.01	0.04	0.04	0.19			0.02	0.12
11	0.61	2.58	0.07	0.31	0.05	0.27	0.02	0.21	0.19	1.01
Total	23.66	100.00	23.21	100.00	20.61	100.00	7.62	100.00	18.78	100.00

SPECIES COMPOSITION, ABUNDANCE AND STRUCTURE OF DOMINANCE

The total number of weevil species identified in all the forest areas studied was 116 (Tab. I), which accounts for about 14% of curculionid fauna in Poland. 77 species were found in Puszcza Białowieska, 56 in Puszcza Biała, 43 in Bory Tucholskie and 52 in Roztocze National Park (Tab. II).

The structure of dominance of the beetles estimated using abundance values obtained by pitfall trapping and sweeping reveals a marked dominance of species which live in the canopies of coniferous trees both as larvae and adults. *Rhinomacer attelaboides* was the dominant in pine forests, and was followed by *Strophosoma capitatum*, *Anthonomus phyllocola* and *Brachonyx pineti* (Fig. 5). Of these three species, only *S. capitatum* is polyphagous, while the others are associated with either pine or spruce. Other species occurring quite abundantly in this habitat include *Doydirhynchus austriacus*, *Magdalis linearis*, *Apion fulvipes*, *Apion simile* and *M. phlegmatica*. Only *A. fulvipes* and *A. simile* are the species that do not feed on coniferous trees. They should not, however, be considered accidental in this habitat. *A. simile* develops on birch, which is a species characteristic of pine forests, while *A. fulvipes* uses pine forests as his wintering area.

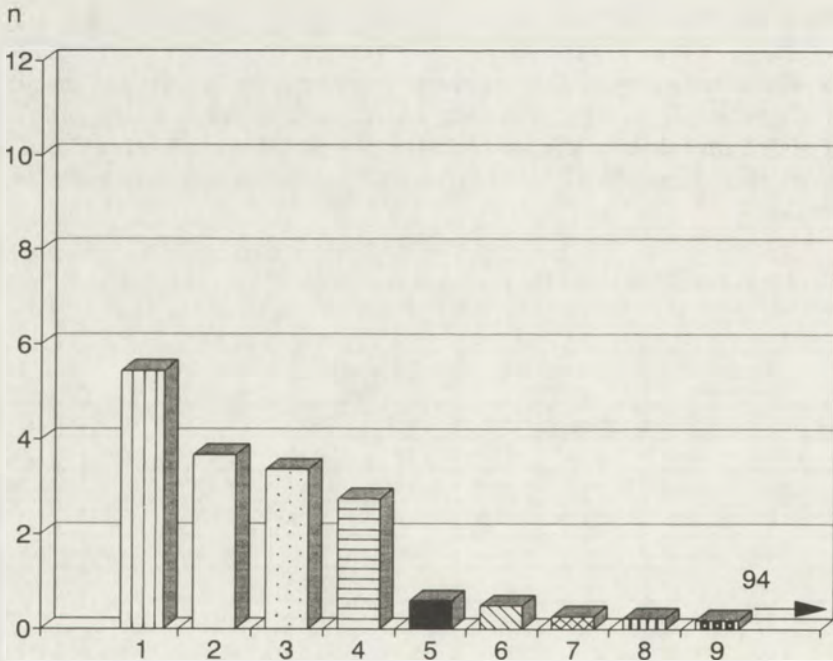


Fig. 5. Dominant structure of *Curculionidae* communities in all the studied areas of the forest complexes. 1. *Rhinomacer attelaboides*, 2. *Strophosoma capitatum*, 3. *Anthonomus phyllocola*, 4. *Brachonyx pineti*, 5. *Magdalis linearis*, 6. *Doydirhynchus austriacus*, 7. *Apion fulvipes*, 8. *Apion simile*, 9. *Magdalis phlegmatica*. n - abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

The quantitative research carried out in mature stands growing in the areas studied revealed a slightly smaller number of species (some species were only caught in younger stands). The weevil community of mature stands in pine forests is composed of 103 species (Tab. IV).

Table IV. Parameters of weevil dominance structure in four mature stand of pine forest complexes in Poland

n – abundance index, N – number of species, \bar{H} – index of species diversity

	Puszcza Białowieska	Roztocze N. Park	Puszcza Biała	Bory Tucholskie	All forest complexes
n	23.68	23.24	20.61	7.63	75.10
N	67	52	44	31	103
\bar{H}	3.34	2.69	2.58	3.17	3.22

Puszcza Białowieska

67 species were identified in the mature stands of this forest area (Tab. IV). *S. capitatum* was the dominant species, and the group of subdominants consisted of *B. pineti*, followed by *R. attelaboides* and *A. phyllocola*. Other species abundantly found in the coniferous forest of this area include: *A. simile*, *Phyllobius arborator*, *Attelabus nitens*, *Magdalis linearis* and *Rhynchaenus rusici* (Fig. 6). In Puszcza Białowieska, the polyphagous species and species feeding on deciduous trees are more abundant than species found on coniferous trees.

24 species (36.4%) were collected sporadically in the mature stands of this forest. These species should be considered rare since most of them feeds on host plants that actually grow in this area. Only 7.6% are species whose host plants do not occur there and they should be therefore considered accidental.

Roztocze National Park

52 weevil species were collected in the mature stands of this forest area (Tab. IV). The dominant species there was *Anthonomus phyllocola*, with *R. attelaboides* in the second place (Fig. 7). Other abundant species were: *S. capitatum*, *B. pineti*, *Doydirhynchus austriacus*, *A. fulvipes*, *M. linearis*, *M. phlegmatica* and *Rhynchaenus fagi*. The majority of the most abundant species in this area are associated with pine, except the polyphagous *S. capitatum* and *R. fagi* whose larvae mine beech leaves.

15 species were noted only sporadically in this area, accounting for 29.4% of the total number of species identified. The host plants of 6 of these species (11.7%) do not occur in the area.



Fig. 6. Dominant structure of *Curculionidae* communities in Puszcza Białowieska. 1. *Strophosoma capitatum*, 2. *Brachonyx pineti*, 3. *Rhinomacer attelabooides*, 4. *Anthonomus phyllocola*, 5. *Apion simile*, 6. *Pyllobius arborator*, 7. *Attelabus nitens*, 8. *Magdalis linearis*, 9. *Rhynchaenus ruscici*. n – abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

Puszcza Biała

A total of 44 weevil species were found in mature stands growing in this area (Tab. IV). *R. attelabooides* functioned as the dominant there and was followed by *B. pineti* and *S. capitatum*. Other abundant species included: *M. linearis*, *Hylobius abietis*, *Apion marchicum*, *Anthonomus phyllocola*, *Apion curtirostre* and *D. austriacus* (Fig. 8).

The prevailing group in this forest area consists of species that feed on coniferous trees. One polyphagous species (*S. capitatum*) and species whose development is associated with *Rumex* sp. (*A. marchicum*, *A. curtirostre*) are also abundant there. The *Rumex* sp. are represented by *R. acetosella*, which grows abundantly in the area.

15 species (32% of species found in the area) occurred only sporadically there. Half of them (8 species – 15.2%) are weevils whose host plant do not grow in Puszcza Biała and should be consequently considered accidental to the area.

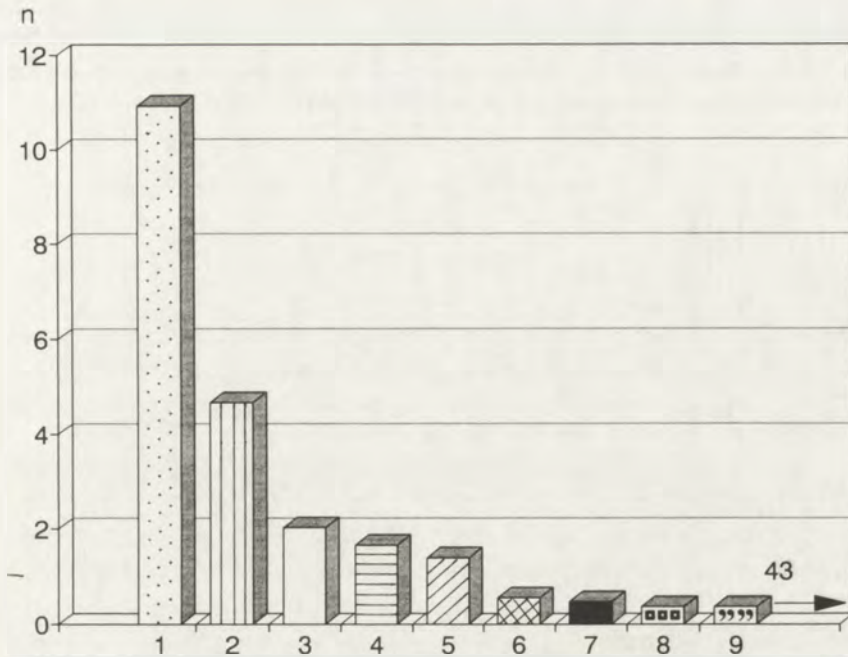


Fig. 7. Dominant structure of Curculionidae communities in Roztocze National Park. 1. *Anthonomus phyllocola*, 2. *Rhinomacer attelaboides*, 3. *Strophosoma capitatum*, 4. *Brachonyx pineti*, 5. *Doydirhynchus austriacus*, 6. *Apton fulvipes*, 7. *Magdalis linearis*, 8. *Magdalis phlegmatica*, 9. *Rhynchaenus fagi*. n – abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

Bory Tucholskie

31 species were registered in the mature stands of this forest area (Tab. IV). The dominant species was *B. pineti*, followed by *S. capitatum* and *R. attelaboides*. *M. linearis*, *A. phyllocola*, *M. phlegmatica*, *Strophosoma fulvicorne*, *D. austriacus* and *Ceutorhynchus floralis* were also abundant (Fig. 9). The above group of the species most abundant in the area consists mostly of species associated with coniferous trees, but there are also two polyphagous species (*S. capitatum* and *S. fulvicorne*) as well as one species that hibernates in this habitat but whose host plant grows outside the area (*C. floralis*).

7 species (24%) were caught sporadically in Bory Tucholskie. All of them had their host plants there.

Imagines of weevils usually live and penetrate in the above-ground parts of plants. Barber's method of pitfall trapping is therefore not suitable for collecting most weevil species, especially those active at night. 7 species caught in the

sampling were collected solely by means of this method. Barber's method seems to be helpful in determining the dominance structure of weevil communities only for: *Otiorhynchus scaber*, *S. capitatum*, *H. abietis* and *H. pinastri* since these species are caught in the greatest numbers with Barber's traps.

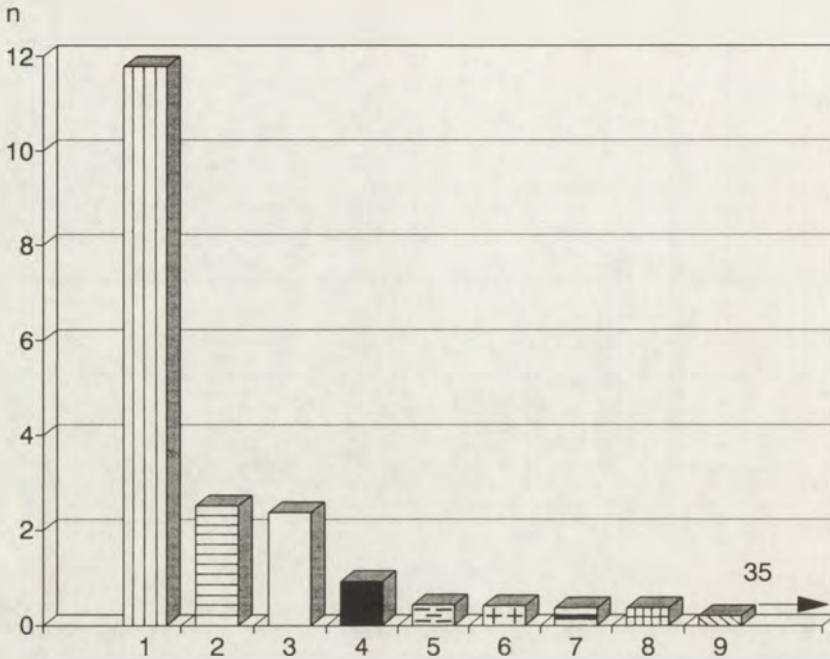


Fig. 8. Dominant structure of *Curculionidae* communities in Puszcza Biała. 1. *Rhinomacer attelabodes*, 2. *Brachonyx pineti*, 3. *Strophosoma capitatum*, 4. *Magdalis linearis*, 5. *Hylobius abietis*, 6. *Apion marchicum*, 7. *Anthonomus phyllocola*, 8. *Apion curtirostre*, 9. *Doydirhynchus austriacus*. n - abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

The richest *Curculionidae* community of those investigated inhabited the mature stands of Puszcza Białowieska. This area is the least transformed one and has the most diversified flora. The abundance of the polyphagous dominant *S. capitatum* and of species feeding on deciduous trees exceeds the abundance of species associated with the coniferous trees which are the most characteristic of pine forests. The structure of dominance of this community is relatively uniform, with the dominant *S. capitatum* accounting for 8.6%, and the subdominant *B. pineti* for 4.2% of the community. Moreover, this community has also the highest index of species diversity (Tab. IV). A slightly poorer *Curculionidae* community was that in Roztocze N. P. although this forest area belongs to the floristically poorer association type of the suboceanic pine forest (*Leucobryo-Pinetum*). However, owing to the diversification of the environments surrounding the study sites, and the practice of establishing nature reserves aimed at

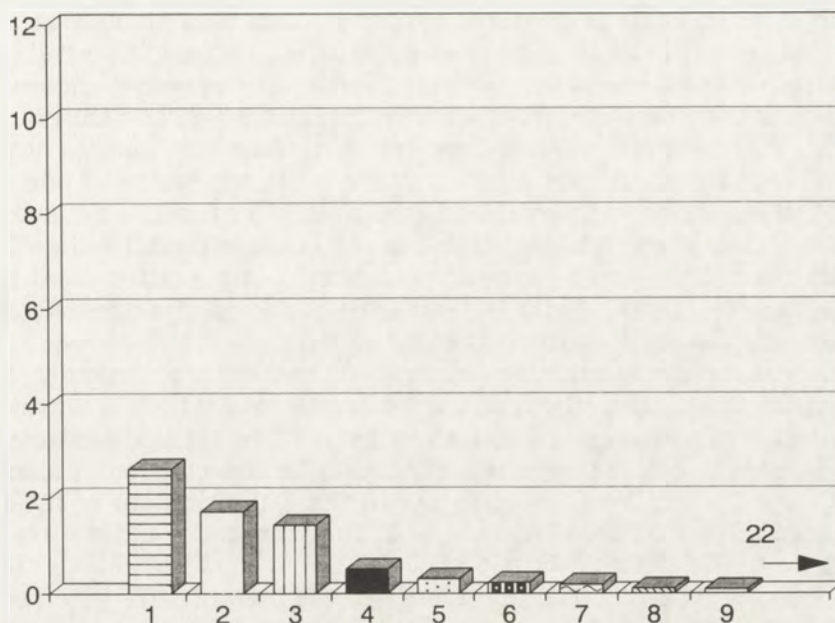


Fig. 9. Dominant structure of *Curculionidae* communities in Bory Tucholskie. 1. *Brachonyx pineti*, 2. *Strophosoma capitatum*, 3. *Rhinomacer attelaboides*, 4. *Magdalis linearis*, 5. *Anthonomus phyllocola*, 6. *Magdalis phlegmatica*, 7. *Strophosoma fulvicorne*, 8. *Doydirhynchus austriacus*, 9. *Ceutorhynchus floralis*. n - abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

restoring the natural state of the plant associations of the forest, suitable conditions are created for the occurrence of an ample-sized weevil community. One should also mention the presence of beech in selected study sites there since they are the only study sites where this tree species grows. Compared to the Puszcza Białowieska weevil community, this one has a greater abundance of species associated with coniferous trees and a different structure of dominance. Polyphages and species feeding on deciduous trees are much less abundant than in Puszcza Białowieska. The structure of dominance is characterized by marked supremacy of the dominant *A. phyllocola*. Due to this, the value of the index of species diversity (Tab. IV) in the area is smaller than in Puszcza Białowieska. The total abundance of the dominant reaches 10.9, compared to 4.7 of the subdominant *R. attelaboides*. *A. phyllocola*, the dominant species in Roztocze, was also classified in the group of dominant species in Puszcza Białowieska. Apart from pine, it also feeds on spruce, which is quite numerous in the two forest areas. Although Puszcza Biała belongs to the same plant association type as Puszcza Białowieska (the subcontinental pine forest *Peucedano-Pinetum*), the weevil community of the former region is relatively poor. This

is mainly due to the structure of the pine forest habitat there. About 90% of the stands in Puszcza Biała is occupied by pine, which was planted as artificial renewal and grows predominantly in monocultures. Such a forest structure has a definite adverse effect on the species diversity of the weevil community. A comparison of the weevil communities from this forest area and the other areas shows that the dominant species here are, as in Roztocze, species associated with coniferous trees. Another similar feature is the supremacy of one species, namely *R. attelaboides*, with an abundance index of 11.8, while the abundance index of *B. pineti*, the subdominant species in Puszcza Biała reaches 2.6. The high abundance of the whole community combined with a rather small number of species recorded accounts for the low value of the species diversity index in that region (the lowest of all the regions) (Tab. IV).

The *Curculionidae* communities in Bory Tucholskie are markedly different from those inhabiting the other coniferous forest areas, which is mostly due to the high degree of environmental transformation. It should also be stressed that Bory Tucholskie belong to the floristically poorer *Leucobryo-Pinetum* association type. All these factors have probably led to the establishment of the poorest weevil community of all those investigated. The abundance indices are similar for the three forest areas described above, while in Bory Tucholskie the value falls three times (Tab. IV). The abundance of the dominant *B. pineti* is only a little higher than of the subdominant *S. capitatum*.

As the forest areas become more transformed, the number of weevil species occurring there diminishes accordingly. The abundance indices obtained for these areas decrease only slightly in the first three forest areas, while in Bory Tucholskie a triple decrease is observed. This rapid decrease of the abundance index together with only a slight reduction of the number of species result in an rise of the index of species diversity (Fig. 10). In the forest areas studied, the index of species richness decreases with the growing environmental degradation, but in Bory Tucholskie a reverse phenomenon is observed.

The structure of dominance of the communities studied in Bory Tucholskie is characterized by a uniform distribution. A similar (relatively uniform) model of dominance structure was also noted for Puszcza Białowieska. Owing to this, the similarity of the dominance structures expressed as Morisita's index (Tab. V) was the greatest for these two forest areas.

The values of species composition similarity index, determined for weevil communities inhabiting mature stands by means of Jaccard's and Sørensen's formula (Tab. VI), oscillate between 0.45 and 0.56. The values are relatively little diversified and indicate that the similarity of species composition of the weevil communities oscillates around 50%. The lowest values were obtained when Puszcza Białowieska was compared to any of the other areas, while the highest values were obtained for Puszcza Biała and Bory Tucholskie. In spite of the fact that the two forests represent different plant association types as far as the stand structure is concerned, they are very similar to each other. The differences between them pertain mostly to the species composition of the herbaceous vegetation. Even though some of these plants are potential hosts for *Curculionidae*, the species which feed on them were not found in the forests. Less than

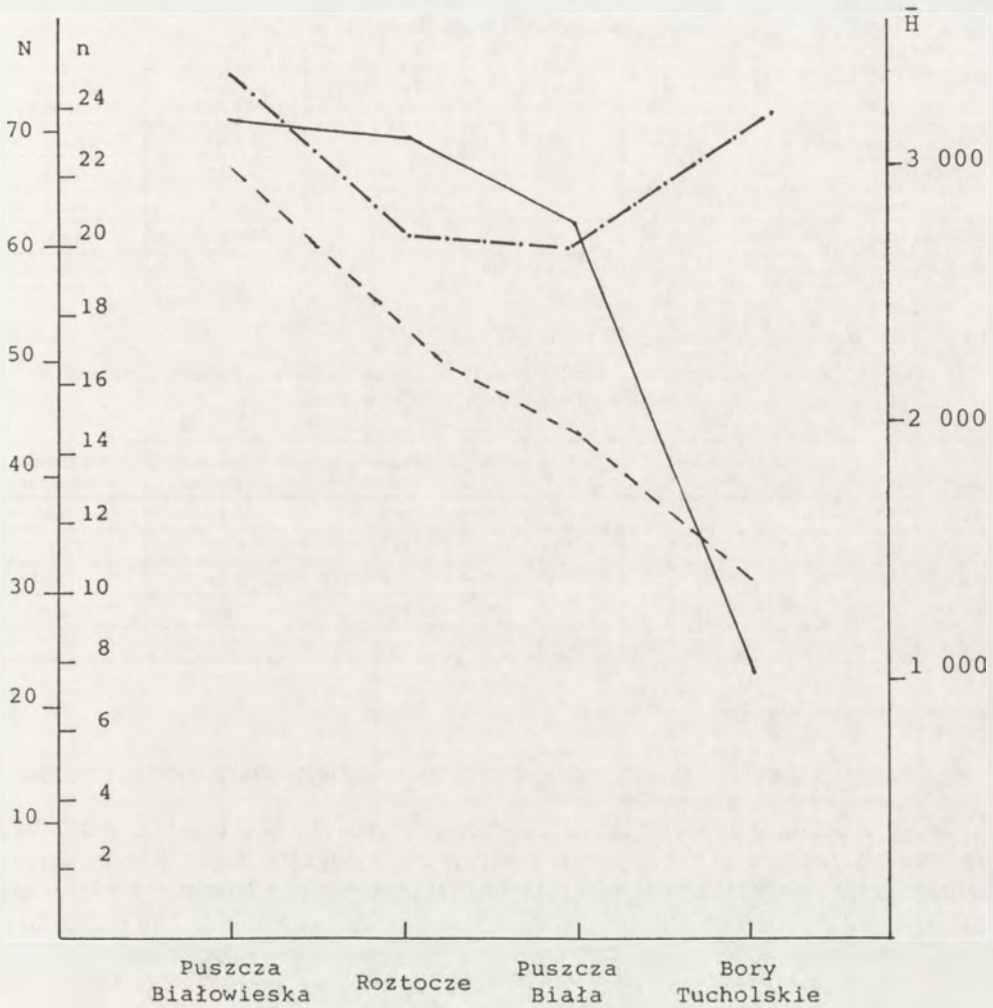


Fig. 10. Parameters of weevil dominance structure in the pine forests. --- N - number of species, — n - abundance index, - · - · - H - index of species diversity

20% of the total number of species are associated with herbaceous plants, while about 40% are dendrophilous. A conclusion can be drawn that the species composition of weevil communities in pine forests depends more on the species composition of the stand. In Puszcza Biała and Bory Tucholskie the stands are composed mainly of pine with a small percentage of birch. Oak trees are also present in small abundances in the areas studied while spruce, hornbeam (*Carpinus betulus*) and beech are absent.

Table V. Similarity of the domination structure of weevils communities in pine forests expressed in terms of the Morisita index

	Puszcza Białowieska	Roztocze N. Park	Puszcza Biała	Bory Tucholskie	All forest complexes
Puszcza Białowieska	x	0.49	0.57	0.87	0.85
Roztocze N. Park		x	0.45	0.42	0.75
Puszcza Biała			x	0.63	0.79
Bory Tucholskie				x	0.81
All forest complexes					x

Table VI. Species composition similarity in weevil communities in forest complexes (by Jaccard's and Sørensen's formula)

	Puszcza Białowieska	Roztocze N. Park	Puszcza Biała	Bory Tucholskie	All forest complexes
Puszcza Białowieska	x	0.45	0.45	0.47	0.79
Roztocze N. Park	27	x	0.52	0.51	0.67
Puszcza Biała	25	25	x	0.56	0.60
Bory Tucholskie	23	21	21	x	0.46
All forest complexes	67	52	44	31	x

WEEVIL COMMUNITIES AND PHYTOSOCIOLOGICAL DIVERSIFICATION OF THE STANDS

The floristic composition of the coniferous forests studied is quite diversified. The vegetation cover of these areas is diversified geographically, due to certain natural factors including the location of the area relative to other regions and seas, surface features, irrigation, climate, soil composition etc. The differences in floristic composition occurring between the two plant association types: the suboceanic and subcontinental pine forest are superimposed by differences resulting from human activities and forest economy.

There are also differences in quantitative relations of individual plant species. In the tree layer in Puszcza Biała, Bory Tucholskie and Roztocze, pine is the dominant species. In Puszcza Białowieska no tree species was classified as dominant, with pine, birch and spruce being co-dominant species. Bory Tucholskie have a much smaller number of plant species in the herb layer. A distinctive feature of this coniferous forest is a high proportion of *Deschampsia flexuosa*. This, however, does not affect the occurrence of weevils since this plant is not the host plant of any particular weevil species inhabiting this environment. Nevertheless, an indirect influence can actually be observed since other host plants are ousted from the area. A lot of species belonging to the families *Compositae*, *Liliaceae* and other do not occur in Bory Tucholskie. The floristic impoverishment definitely contributes to the decrease in the number of weevil species.

The differences in species composition of the flora of the pine forests studied are observed in every vegetation layer. The pine forests of Puszcza Białowieska and Roztocze N. P. have a constant proportion of spruce in the shrub layer and in the tree layer, even though they belong to different regional variations. One more characteristic of the pine forests of Roztocze is the presence of fir (*Abies alba*) and beech in the two layers. The occurrence of spruce in these areas increases the abundance of *Anthonomus phyllocola* and *Hylotius pinastri*, which not only live on pine but on common spruce as well. The presence of beech in the pine forest of Roztocze, on the other hand, increases the abundance of *Rhynchaenus fagi*, which was identified only in this forest area. The larva of this species is monophagous and mines beech leaves (BALE 1978). The adult form inhabits every forest layer, feeding not only on beech leaves, but also the leaves of hornbeam or raspberry (*Rubus* sp). The imago hibernates in tree canopies and litter (BALE 1981).

Hazel, which was found only in the pine forests of Puszcza Białowieska and Roztocze, is the host plant to the weevil *Apoderus coryli*, a species that was caught only in these forest areas.

The presence of large numbers of such deciduous trees as birch, oak or aspen (*Populus tremula*) in Puszcza Białowieska, as compared to the coniferous forests of the other regions, explains why species associated with these trees, such as *Pselaphorhynchites tomentosus*, *P. longiceps*, *Byctiscus populi*, *Deporaus mannerheimi*, *Curculio pyrrhoceras*, *Magdalis exarata*, *Rutidosoma globulus*, *Coeliodes rubicundus*, *C. erythroleucos*, *Rhynchaenus quercus*, and *R. avellanarum* were only registered in this area. Two of the above species: *R. quercus* and *B. populi* had been previously identified in the pine forests of Puszcza Biała (SZUJECKI 1959). Special attention should be paid to *R. quercus*. Its larva mines only leaves of oak (KOZŁOWSKI 1985). In 1954 this species appeared in large numbers in Puszcza Biała, while in Białowieża National Park it was not recorded at all at that time (KARPIŃSKI 1958). In the course of this study it was not identified in Puszcza Biała. On the other hand, *P. longiceps*, which lives on willow, *Coeliodes rubicundus*, which inhabits birch, and *Curculio pyrrhoceras* which lives on *Sisymbrium* sp., are species that had been previously recorded from the suboceanic pine forest of Roztocze National Park (CMOLUCH, ŁĘTOWSKI 1987).

Being typical phytophages, weevils occur most of all in the areas where their host plants can grow. In the pine forests studied, milfoil (*Achillea millefolium*) of the *Compositae* family occurred only in Puszcza Biała, while *Galeopsis tetrachit* of the *Labiatae* family was identified only in Roztocze. *Trichosiromus barnevillei*, a species that can only develop on milfoil, though it may occur on other species of the *Compositae* family, was only recorded in Puszcza Biała. *Ceutorhynchus angulosus*, which develops only on *G. tetrachit*, occurred only in Roztocze.

SEASONAL VARIATIONS IN THE WEEVIL COMMUNITIES

The group of species which had the greatest influence on the seasonal variations, i.e. those which were the most abundant in the forests studied, include *Rhinomacer attelaboides*, *Strophosoma capitatum*, *Brachonyx pineti* and

Anthonomus phyllocola. *R. attelaboides* is a species whose imago appears in mid-April and is present till mid-June. By that time, the females will have laid the eggs. Mature larvae pupate in the soil (DIECKMANN 1974). The imago of the new generation is probably the hibernating form. It hibernates in the soil and becomes active next spring. Due to this, adult specimens of this species are collected only in spring. Adult individuals of *S. capitatum* occur from April to October (DIECKMANN 1980). The couples copulate from early spring to the end of July. At the beginning of September adult individuals of the next generation start to appear. These will hibernate in the soil and become active again in spring. This species has two abundance peaks during the season: the first one occurs in spring when the new imagines appear after the hibernation period, and the second, in autumn, is due to the appearance of the imagines of the next generation. An analogous cycle with two peaks of abundance in spring and autumn is observed in the case of *B. pineti*. The imagines of this species can be collected from mid-April to October (DIECKMANN 1988, ŚLIWA, PILAWA 1976). After copulating in spring, the females lay eggs from the beginning of May to the beginning of June. The larvae appear in mid-May and prey for about eight weeks. The pupation occurs from mid-June to mid-July. In mid-July the adult forms of the next generation start to appear and prey until October. They hibernate in the soil under fallen leaves. *A. phyllocola* is a species, whose imagines can be collected from April to August. After hibernating and copulating in spring, the females lay eggs starting from mid-June. The next generation appears from mid-June to mid-July. The hibernating form is the imago, which hibernates in the soil (DIECKMANN 1988). The species has two abundance peaks: in spring when adult beetles appear after the hibernation, and in summer when the next generation appears.

Puszcza Białowiecka

In the first sampling season, the highest abundance was noted in mid-May (Fig. 11). It was followed by a fall which started at the beginning of June and continued until the beginning of October. Then the abundance started to increase again. *Strophosoma capitatum*, *Rhinomacer attelaboides*, *Brachoryx pineti* were the most abundant species in this forest area with *Anthonomus phyllocola* being also abundant in the second sampling season. The spring abundance peak is related chiefly to the appearance of the imagines of *R. attelaboides* and *B. pineti* in the canopies. At the same time, *Strophosoma capitatum* was the most abundant species in the herb layer. Two peaks of abundance of *S. capitatum* were observed in this area at the end of May and in September. In the first sampling season, the species' abundance in spring was twice as high as in autumn. In the second sampling season, on the other hand, the values were similar, the autumn abundance being a little higher. In the second sampling season, the spring peak of abundance of weevils was not observed. Apart from *R. attelaboides* and *B. pineti*, *A. phyllocola* was also abundant in the canopy layer in that season. Two peaks of abundance of weevils

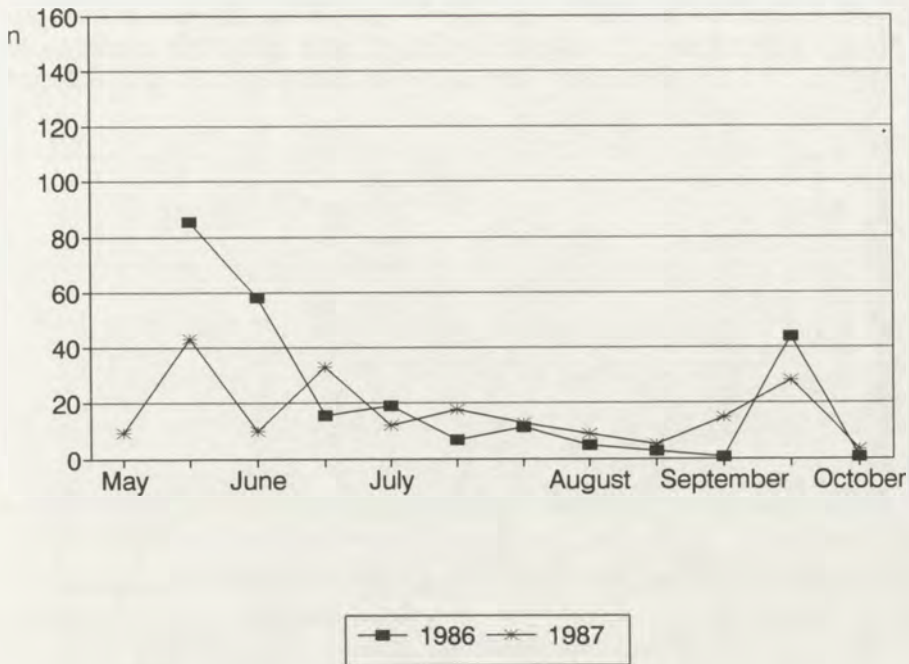


Fig. 11. Seasonal abundance variations of *Curculionidae* communities in Puszcza Białowieska in 1986 and in 1987. n - abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

occurred in the first half of the year: the first one, in spring, was related to the appearance of the imagines of *A. phyllocola* after hibernation, while the second one, in mid-June, was due to the appearance of *R. attelaboides* and *B. pineti* after hibernation. The period of the highest abundances in spring was followed by a gentle fall. The abundance increased again in September, which was exclusively due to an increased abundance of *S. capitatum* in the herb layer. In the second sampling season, the abundance of weevil in spring was twice as high as that in the previous year.

Roztocze National Park

Due to the fact that in the first sampling season sampling in canopies started in Roztocze as late as mid-June, the data obtained cannot be used in a phenological analysis (Fig. 12). *Anthonomus phyllocola* and *R. attelaboides* were the species which affected the shape of the phenological curve in the second sampling season. In that season, the peak abundances were recorded in the first half of May. Afterwards the abundance of weevils decreased gradually. *R. attelaboides* was noted only in spring, while *A. phyllocola* was last collected at the end of August. That species had its peak abundance in mid-May and then

in mid-July. The hibernating imagines of *A. phyllocola* appeared from April to mid-June, while the next generation appeared from mid-June to mid-July. The phenology of this species in Roztocze is the same as reported in the literature.

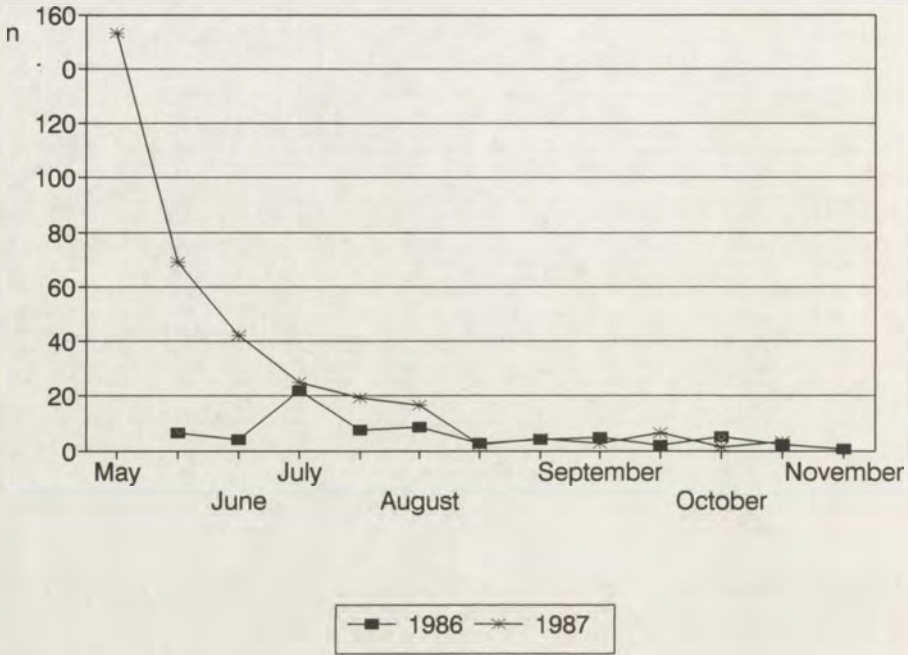


Fig. 12. Seasonal abundance variations of *Curculionidae* communities in Roztocze National Park in 1986 and in 1987. n - abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

Puszcza Biała

In this area the annual abundance curve was shaped chiefly by *R. attelaboides*, *B. pineti* and *S. capitatum*. In the first sampling season, the greatest abundances were noted in spring at the end of May (Fig. 13). They should be ascribed to the occurrence of *R. attelaboides* in the canopies as this species was the dominant in the area. The shape of the phenological curve in the second sampling season was modeled by: *R. attelaboides*, *B. pineti* in the canopies and *S. capitatum* in the herb layer, all of which were the most abundant species. Two abundance peaks of these species were observed in spring: one in mid-May and a smaller one in mid-June. They were followed by a gentle fall in abundance leading eventually to nil, which lasted until mid-September. After that, the abundance rose again, which was due to an increase in the abundance of *S. capitatum* and *B. pineti* in the herb layer. The imago of the latter species appears at the end of April and can be found until mid-October. In both sampling seasons

the species was the most abundant in the herb layer around the end of September. Adult individuals of this species were registered in the herb layer in autumn. They were actually the next generation looking for wintering places in the litter. The total abundance of weevils in Puszcza Biała in the first sampling season was twice as high as in the second season. In both seasons the highest abundances of weevil were observed in the same period, namely, the second half of May. When one compares the abundances obtained from the beginning of June to the end of the vegetational season in the two sampling seasons, the values turn out to be very similar. The double increase in the total number of specimens is due to the differences in the spring.

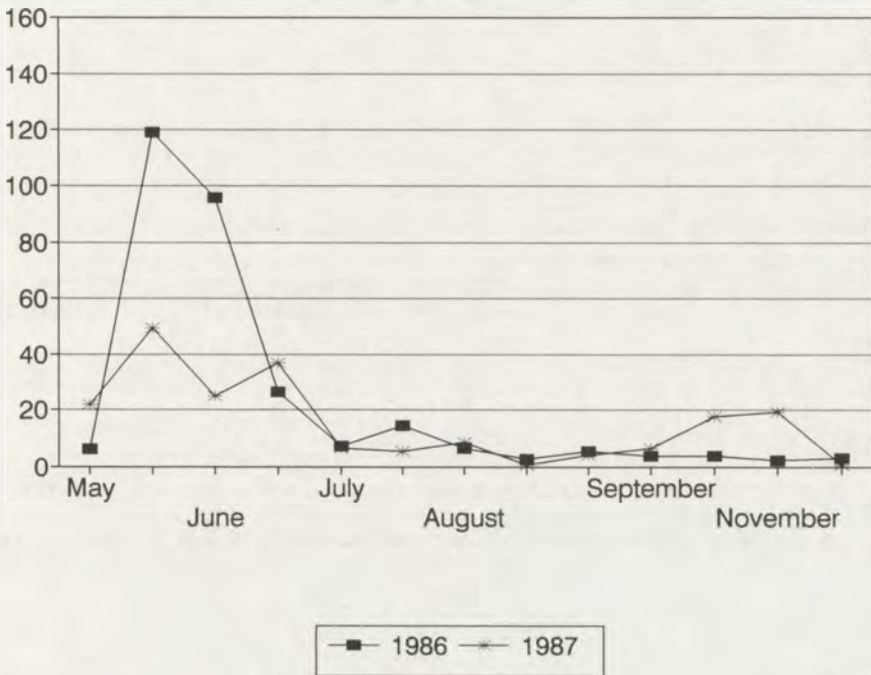


Fig. 13. Seasonal abundance variations of *Curculionidae* communities in Puszcza Biała in 1986 and in 1987. n – abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

Bory Tucholskie

The curve of seasonal abundance variations on this area is shaped by the dominant species *B. pineti*, *S. capitatum* and *R. attelaboides* (Fig. 14). The peak of abundance in the first season (the first half of May) was caused predominantly by rises in the abundance of *B. pineti* and *R. attelaboides* caught in canopies of pines. In June and the first half of July the abundance decreased to nil. A small rise in abundance noted in mid-September, was due to the appearance of

S. capitatum and *B. pini* in the herb layer. In the second sampling season the phenological curve was affected by the same species. The total abundance, however, was considerably smaller than in the first year, and the peak of abundance occurred at the end of May while in 1986 it was observed in the first half of the month.

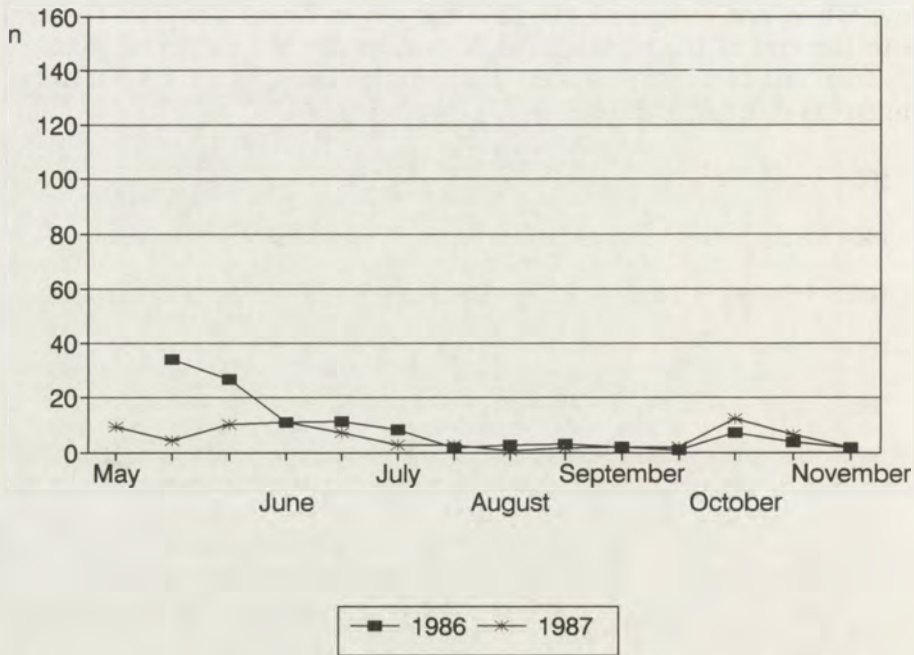


Fig. 14. Seasonal abundance variations of *Curculionidae* communities in Bory Tucholskie in 1986 and in 1987. n – abundance index (for the Moericke's pitfall traps in the canopy layer and the sweeping net in the herb layer).

On June 26, 1986, in certain forest divisions, Decis EC mixed with diesel oil was sprayed from a plane in order to fight the larvae of the European pine sawfly (*Neodiprion serdifer*). The analysis of weevil abundance in this area in the two years shows that the spraying did not affect the abundance of imagines of weevils.

In all the forests studied peak abundances were observed in early spring and early summer, which was due to the appearance of *R. attelaboides*, *B. pini* and *A. phyllocola* in the canopy layer. At that time the species copulate and lay eggs in tree canopies. Abundance indices obtained for the herb layer were then superimposed on the indices obtained for the canopy layer. In the former stratocenosis, the seasonal abundance variations are chiefly affected by *S. capitatum*, which has two abundance peaks in spring and in autumn. Further changes are caused by *B. pini*, which occurs most abundantly in autumn, and

A. phyllocola, which is the most numerous in spring and quite abundant in early summer.

A ZOOGEOGRAPHICAL ANALYSIS

The species occurring in pine forests were assigned to the following zoogeographical elements: the Holarctic, Palearctic, Euro-Siberian, Western-Palearctic, Euro-Sibero-Caucasian, Euro-Caucasian, European, Subadriatico-Pontic and mountainous.

The zoogeographical analysis comprised two aspects: qualitative – based on the number of species recorded in each of the forest areas, and quantitative which took into consideration the indices of weevil abundance in the mature stands of the forest areas studied and the division of weevils into the biotic groups.

The most abundant geographical elements among all the weevil species identified in the pine forests studied are those with a wide geographical range, namely, the Holarctic and Palearctic elements (Tab. VII). Other elements of relatively high abundance are listed below in the order of descending abundance: European, Euro-Siberian, Western-Palearctic and Euro-Sibero-Caucasian. Such a model of abundance is observed in each of the forests studied. In Puszcza Biała, Bory Tucholskie and Roztocze, Holarctic elements dominate over Palearctic elements. A reverse order is observed in Puszcza Białowieska with Palearctic elements playing a major role (Tab. VII). European elements were also present in considerable abundances in Puszcza Białowieska and Roztocze. On the other hand, in Puszcza Biała and Bory Tucholskie, European and Western-Palearctic elements play an important role together with species of Holarctic, Palearctic and European distribution. The only mountain species was only registered in Roztocze. It had been previously identified there (SMRECZYŃSKI 1972).

Table VII. Zoogeographical composition of the weevil species in the pine forest

N – number of species, % – proportion of a given element in the number of species

Forest complexes Zoogeographical element	Puszcza Białowieska		Roztocze N. Park		Puszcza Biała		Bory Tucholskie		All forest complexes	
	N	%	N	%	N	%	N	%	N	%
Holarctic	20	25.97	18	34.62	15	26.79	13	30.23	30	25.86
Palearctic	23	29.87	15	28.85	13	23.21	8	18.60	31	26.72
Euro-Siberian	6	7.79	3	5.77	8	14.29	5	11.63	12	10.34
Western-Palearctic	7	9.09	5	9.62	6	10.71	6	11.95	9	7.76
Euro-Sibero-Caucasian	7	9.09	3	5.77	3	5.36	3	6.98	8	6.90
Euro-Caucasian	3	3.90			2	3.57			5	4.31
European	9	11.69	6	11.54	7	12.50	7	16.28	17	14.66
Subadriatico-Pontic	2	2.60	1	1.92	2	3.57	1	2.33	3	2.59
Mountainous			1	1.92					1	0.86
Total	77	100.00	52	100.00	56	100.00	43	100.00	116	100.00

The quantitative examination of zoogeographical diversification of weevils in the forests studied produced different results. The most numerous species were the Western-Palearctic, European, Palearctic and Euro-Siberian elements (Tab. VIII). Different zoogeographical elements were dominant in each of the forest areas. In Puszcza Białowieska, the European element was dominant and followed by the Euro-Siberian and Palearctic elements, while in Puszcza Biała the Western-Palearctic element dominates over the European one. The Bory Tucholskie weevil community has the Euro-Siberian element as the dominant with the European and Western-Palearctic elements occupying the subsequent positions. A completely different pattern is observed in Roztocze N. P. where Palearctic species dominate over the Western-Palearctic and European.

Table VIII. Quantitative zoogeographical composition of the weevils communities in the pine forest

n – relative abundance index (for Moericke's traps in the canopy layer and a sweeping net in the herb layer) % – proportion of a given element in relative abundance index

Forest complexes Zoogeographical element	Puszcza Białowieska		Roztocze N. Park		Puszcza Biała		Bory Tucholskie		All forest complexes	
	n	%	n	%	n	%	n	%	n	%
Holarctic	0.88	3.71	0.45	1.95	0.74	3.61	0.19	2.43	2.26	3.01
Palearctic	3.19	13.47	11.72	50.52	1.53	7.42	0.52	6.71	16.95	22.56
Euro-Siberian	4.46	18.83	1.65	7.13	2.57	12.45	2.68	34.86	11.35	15.11
Western-Palearctic	4.46	18.83	6.07	26.17	12.17	59.07	1.62	21.12	24.32	32.37
Euro-Sibero-Caucasian	0.88	3.73	0.36	1.55	0.06	0.29	0.24	3.10	1.54	2.05
Euro-Caucasian	0.04	0.17			0.03	0.17			0.08	0.10
European	9.69	40.94	2.93	12.63	3.45	16.75	2.43	31.56	18.49	24.61
Subadriatico-Pontic	0.07	0.31	0.01	0.05	0.05	0.24	0.02	0.21	0.15	0.20
Total	23.66	100.00	23.20	100.00	20.60	100.00	7.68	100.00	75.15	100.00

If the zoogeographical diversification of the weevil species is examined from the viewpoint of the biotic groups, one can see that the Palearctic species are usually dendrophilous (1st, 2nd, 4th and 5th biotic groups) or are classified as species that hibernate in pine forests (9th biotic group), while the Holarctic species are inhabiting the herb layer (3rd and 6th biotic groups) (Tab. IX).

A quantitative zoogeographical analysis reveals that the most abundant species are Western-Palearctic, European, Palearctic and Euro-Siberian, but only those of them which belong to the first and seventh biotic groups (species developing in tree canopies and polyphages) (Tab. X). The most important Western-Palearctic species is *Rhinomacer attelaboides*, the most important Palearctic species, *Anthonomus phyllocola*, and Euro-Siberian, *Brachonyx pineti*.

The zoogeographical analysis allows to state that the greatest numbers of species represented elements of wide distribution ranges, namely, Holarctic and

Palearctic, while the most abundant elements were the European, Western-Palearctic and Palearctic.

Table IX. Number of species in zoogeographical diversification of weevil biotic group. (Specification of weevil biotic group number the same as for Table II)

Zoogeographical element \ Biotic group	1	2	3	4	5	6	7	8	9	10	11	Total
Holarctic		2	6	1	1	6	3		5	3	3	30
Palearctic	2	10	1	1	1	3			9	3	1	31
Euro-Siberian	6	1	1				1	1			2	12
Western-Palearctic	2	3	2			1			1			9
Euro-Sibero-Caucasian	1	3		1			1				2	8
Euro-Caucasian		1			1	1		1			1	5
European	2	4		1			2		3	1	3	16
Subadriatico-Pontic		1							1	1	1	4
Mountainous											1	1
Total	13	25	10	4	3	11	7	2	19	8	14	116

Table X. Relative abundance index (for Moericke's traps in the canopy layer and a sweeping net in the herb layer) of zoogeographical elements in weevil biotic groups. (Specification of weevil biotic group number the same as for Table II)

Zoogeographical element \ Biotic group	1	2	3	4	5	6	7	8	9	10	11	Total
Holarctic		0.83	0.53	0.15	0.02	0.24	0.03		0.47	0.03		2.28
Palearctic	13.45	0.89	0.04	0.50	0.02	0.51			1.52	0.03		16.96
Euro-Siberian	11.22	0.04	0.01				0.02				0.07	11.35
Western-Palearctic	23.70	0.33	0.09			0.17						24.29
Euro-Sibero-Caucasian	0.69	0.78		0.03			0.01				0.03	1.54
Euro-Caucasian		0.02			0.01			0.01			0.03	0.07
European	2.33	0.50		0.18			14.85		0.02	0.03	0.60	18.50
Subadriatico-Pontic		0.12							0.01		0.03	0.15
Total	51.38	3.50	0.66	0.85	0.05	0.92	14.91	0.01	2.01	0.09	0.75	75.12

The size and shape of the geographical range of a species depends on the diameter of its ecological requirements, on its adaptability, on the range of the habitats suitable for the species and on the species' ability to migrate (UDVARDY 1978). Our analysis confirms the above thesis. The most numerous species in pine forests are species of the Western-Palearctic and Palearctic distributional types, which embrace the geographical range of the pine forest. This group should be extended to cover the European species, mainly *S. capitatum*, which

is included in this group because it is not capable of covering great distances due to lack of wings.

A separate issue that should be mentioned while discussing the questions of zoogeography is an increase in the dispersive ability associated with geographical parthenogenesis observed in the beetles studied. As a result of parthenogenesis, weevils of the genera *Otiorhynchus* and *Trachyphloeus* form polyploid races, characterized by a greater degree of ecological tolerance than diploid ones (SUOMALAINEN 1948). All the species belonging to these genera which were identified in the areas studied have a holarctic geographical range.

ABUNDANCE OF PESTS AND DOMINANT SPECIES

As phytophages, weevils play a major role in forest biocenoses. By damaging flowers and fruit they undermine the reproductive ability of plants. Weevils also inhibit plant development since they feed on vegetative parts of plants. A number of weevils are well-known pests, the genera *Hylobius* and *Pissodes* being especially harmful to forests (KARPIŃSKI 1958). The adult forms of these weevils feed predominantly on top parts of main sprouts and the bark causing serious silvicultural damage. Species of the genus *Magdalis* (especially *M. frontalis*) may also be harmful, particularly to cultures, by driving corridors in the pulp, bast and sapwood (BURZYŃSKI 1971). Other species of this family: *Brachonyx pineti*, *Brachyderes incanus* and *Strophosoma capitatum* damage the assimilating apparatus and are also considered dangerous when appearing in large numbers (CHŁODNY 1982).

The following species that occurred abundantly in the study material are considered pests to coniferous forests: *S. capitatum*, *B. pineti* and *H. abietis*. *S. capitatum* occurs in relatively large numbers in all forest layers, reaching highest abundances in spring and autumn (Fig. 15, 16). Such abundance distribution, resulting from the biology of this species, has been confirmed by other authors (SZMIDT, STACHOWIAK 1980). *Brachonyx pineti* feeds on pine canopies and hibernates in the soil. It occurred abundantly in canopies in spring (Fig. 17) and in the herb layer in autumn (Fig. 2). Rises of abundance of this species occur in different forest layers at different times. They are directly attributable to the biology of this species. *H. abietis* does considerable damage particularly to cultures of pine and spruce. It was more abundant in Puszcza Biała and Bory Tucholskie (Tab. I) than in Puszcza Białowieska and Roztocze N. P. In a pine forest habitat, the date of felling influences the time of the occurrence of the greatest damage caused by this species (KORCZYŃSKI 1984). Depending on the time of felling, an increase in the abundance of this species may take place in May and June (following summer felling) or from June to September (after winter felling). In the forests studied, rises of abundance of this species were observed in May and June. Most of the areas exposed to this species' activity particularly strongly are situated in transformed pine forest habitats. Cultures growing on the weakest soils are more strongly damaged by species of the genus *Hylobius* and the trees are less resistant, than in cultures planted on more fertile soils.

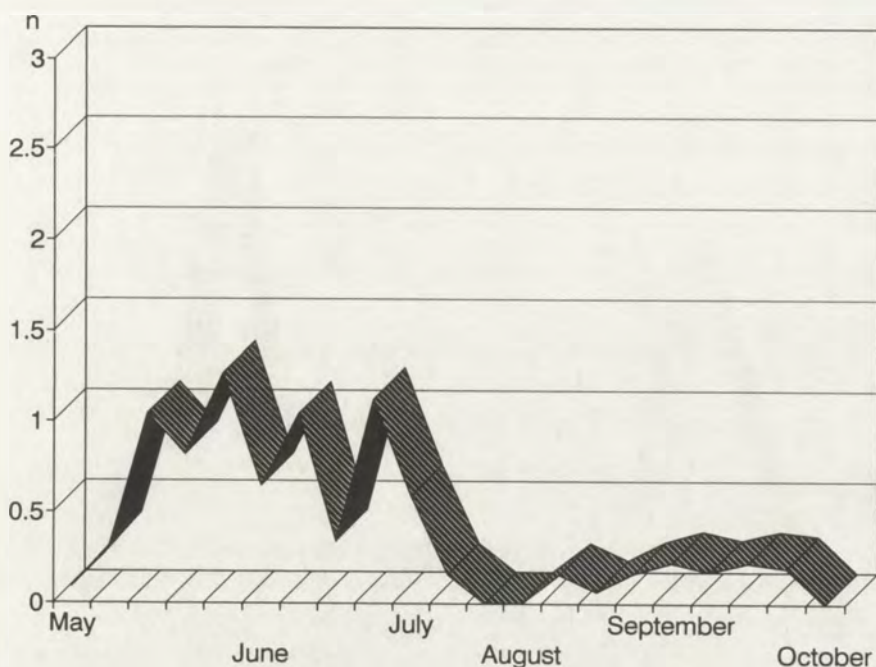


Fig. 15. Seasonal abundance variations of *Strophosoma capitatum* in the pine forests canopy layer. n – abundance index for the Moericke's pitfall traps.

Not all weevil species considered to be coniferous forest pests were found in large abundances in the forests under study. Species of the genus *Pissodes*, *Brachyderes incarus* and *Magdalis frontalis* were caught only sporadically.

R. attelaboides was the most frequent species in the material obtained from pine canopies. This species is considered rare (CMOLUCH 1979). *Doydirhynchus austriacus* is another rare species, but it was relatively abundant in pine canopies in all the forests examined. Both species were caught almost exclusively in spring (Fig. 18, 19). The high abundances of the two species are largely due to the particular sampling method employed (Moericke's pitfall traps). Traditionally, researches use sweeping nets to collect their specimens. This method, however, cannot produce high abundances of the weevils which spend their development cycle in pine canopies.

SUMMARY AND DISCUSSION OF RESULTS

116 *Curculionidae* species were identified in the Polish pine forests examined. The weevil communities are characterized by occurrence of species associated with plants typical of this forest association type, both in the layer of trees, undergrowth and the forest floor.

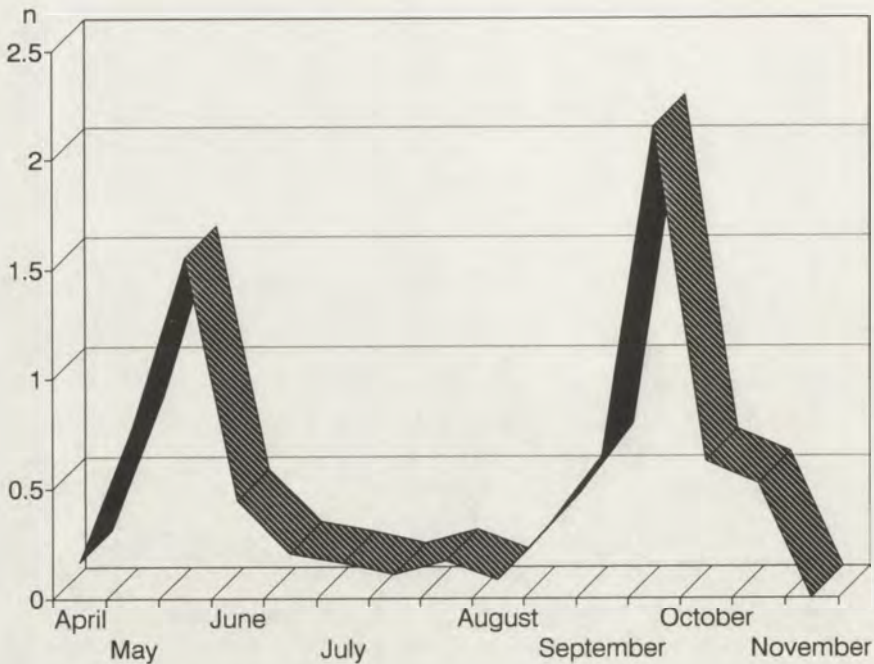


Fig. 16. Seasonal abundance variations of *Strophosoma capitatum* in the pine forests herb layer. n – abundance index for the sweeping net.

The species occurring in the pine forests examined have been divided into 11 biotic groups. Eight groups comprised species whose development cycle is associated with plants typical of this habitat. The specific organ of the host plant which the larvae and imagines feed on the basis for the classification. Groups with the greatest numbers of species consisted of weevils whose larvae and imagines develop in coniferous tree canopies (1st biotic group), canopies of undergrowth-forming trees (2nd biotic group) and above-ground parts of herbaceous plants (3rd biotic group). Another numerous group embraces species whose larvae develop on roots and imagines feed on herbaceous plants (6th biotic group). The most abundant species are those whose larvae and imagines develop in canopies of coniferous trees as well as polyphagous species (7th biotic group). Apart from species that feed on habitat-specific plants, also numerous are species which have not got their host plants in pine forests but migrate into this habitat to hibernate (9th biotic group). They have also been considered typical of this habitat.

16 of the species identified in the study were common to all the forests studied. Most of them are dendrophilous and some are exclusively associated with coniferous trees.

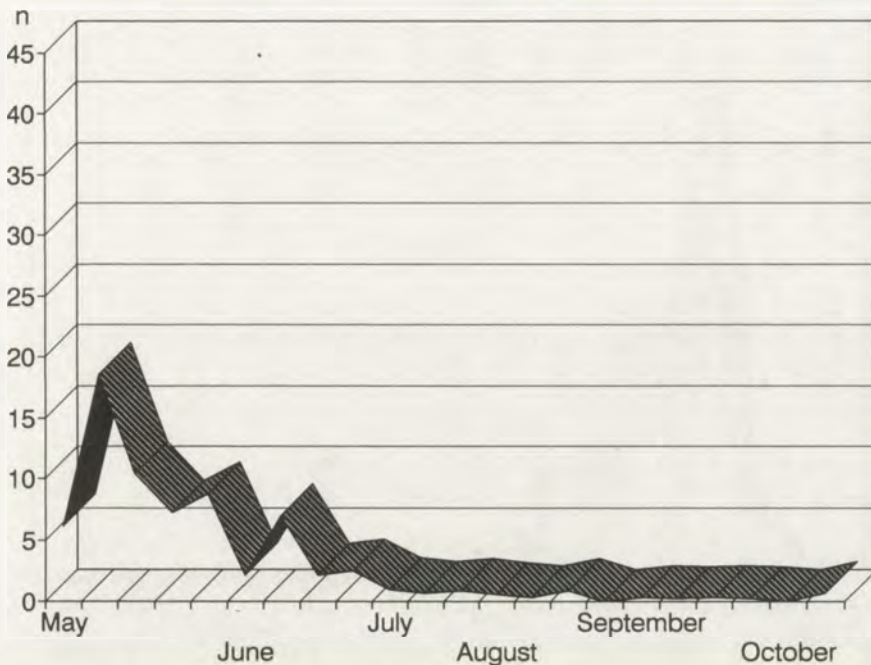


Fig. 17. Seasonal abundance variations of *Brachonyx pineti* in the pine forests canopy layer. n – abundance index for the Moericke's pitfall traps.

The classification of *Curculionidae* into the biotic groups provided for an analysis of ecological diversification of the weevil community in pine forests. The most abundant species were those developing in canopies of coniferous trees, chiefly pine, which is the stand-forming species in this forest association.

Weevils that feed in canopies of coniferous trees are much more abundant than the other groups in Puszcza Biała, Bory Tucholskie and Roztocze. In Puszcza Białowieska, the difference in abundance is not that large, since polyphagous species are also abundant there as well as species that develop in canopies of deciduous trees forming the undergrowth layer in this area. The increased abundance of polyphagous species and species that feed on deciduous trees in Puszcza Białowieska results not only from the floristic richness of the subcontinental pine forest, but also the mosaic of environmental types surrounding the study sites in this area.

As far as mature stands are concerned, each of the forest areas studied had a different weevil species as the dominant: *S. capitatum* was the dominant in Puszcza Białowieska, *R. attelaboides* in Puszcza Biała, *B. pineti* in Bory Tucholskie and *A. phyllocola* in Roztocze. The composition of the most abundant species' group (i.e. dominants and subdominants) is, however, very similar in each of the forests.

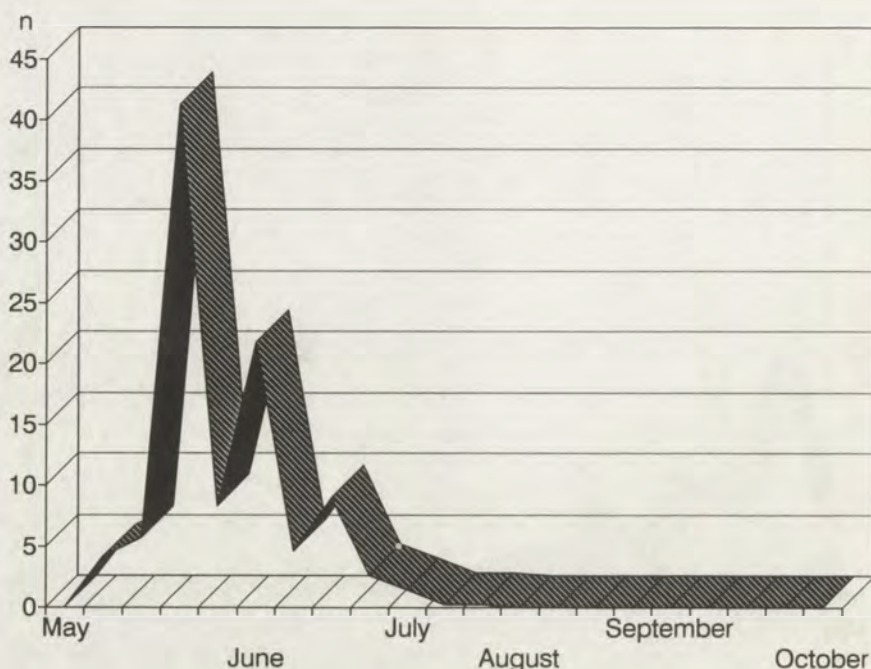


Fig. 18. Seasonal abundance variations of *Rhinomacer attelaboides* in the pine forests canopy layer. 'n' - abundance index for the Moericke's pitfall traps.

The highest abundance values in the pine forest weevil communities were obtained in spring and early summer. The abundance variations were influenced above all by the most abundant species such as: *R. attelaboides*, *B. pineti*, *S. capitatum* and *A. phyllocola*. The phenology of these species as was obtained in our study parallels that known from literature.

In zoogeographical terms, the greatest shares in *Curculionidae* communities are those of widely distributed weevil species representing the Holarctic and Palearctic elements. A quantitative analysis, however, revealed European, Western-Palearctic and Palearctic species to be dominant. The above three zoogeographical distribution ranges include the phytogeographical range of pine forest.

Comparing weevil communities from different forest areas, one can see substantial differences in species richness, abundance and dominance structure. In the case of typical phytophages such as *Curculionidae*, species richness depends on the species diversification of the vegetation of the habitats studied. The latter is, in turn, relative to the degree of habitat transformation caused by various silvicultural practices. The forest areas studied have been ranked in the descending order of the degree of transformation of the habitats. Puszcza Białowieska is the area least transformed by man and is simultaneously classified as a forest resistant to pests. It is followed by the forests of Roztocze

in this classification. Puszcza Biała is a forest area where industrial pollution and the cutting of large areas have resulted in a substantial transformation of the forest. Bory Tucholskie is the area most distorted from the natural state. The situation has been caused both by pollutant emission and pillage forest economy that has been going on in the area for a couple of centuries. The transformation processes have been aggravated by massive invasions of pests and forest fires.

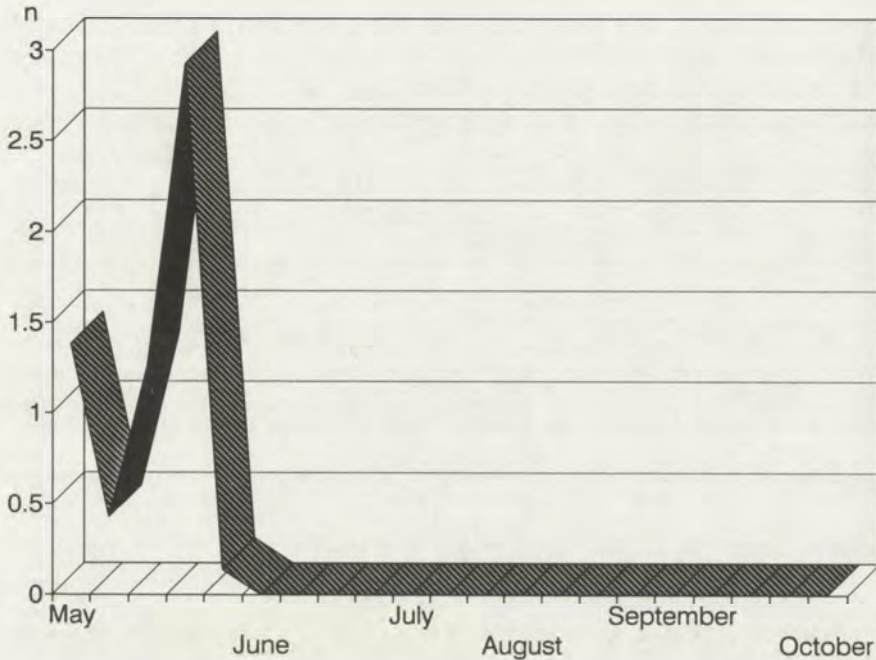


Fig. 19. Seasonal abundance variations of *Doydirhynchus austriacus*, in the pine forests canopy layer. n – abundance index for the Moericke's pitfall traps.

The ranking of the forest areas in the order of increasing degree of transformation coincides with one based on the descending number of species and abundance. The greatest number of species with the highest abundances were found in Puszcza Białowieska, followed by a slightly smaller number of species in Roztocze National Park, then in Puszcza Biała and Bory Tucholskie.

Similar patterns are observed as far as species richness is concerned. This parameter also decreases as the degree of transformation grows (Tab. IV). The Bory Tucholskie weevil community is an exception here. This can be attributed to a change in the proportion between the decreasing number of species and the index of abundance, a phenomenon that occurs in more transformed areas. This difference somehow confirms theses concerning changes in the structure of zoocenoses caused by urbanizing pressure, even though the theses were based

on results of studies conducted in urbanized areas (PISARSKI 1979, PISARSKI, TROJAN 1976). The studies prove that with increasing urbanizing pressure the number of animal species decreases, while their abundance first increases and starts to diminish only under great urbanizing pressure. Our study has shown that as forest environments become more and more transformed, the decrease in the number of animal species is initially accompanied by only a slight reduction of abundance, which decreases substantially only in strongly transformed areas.

A similar tendency was observed concerning the degree of similarity of weevil communities composed of species associated with pine forests related to mature stands in each of the forest areas studied (Tab. VI).

Our study has proven that the differences in species richness between the suboceanic pine forest type (represented by Puszcza Białowieska and Puszcza Biała) and the floristically poorer subcontinental pine forest (represented by Bory Tucholskie and Roztocze N. P.) do not influence the richness of *Curculionidae* communities.

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STRESZCZENIE

[Tytuł: Struktura zgrupowań ryjkowców (Coleoptera, Curculionidae) wybranych borów świeżych Polski]

Badaniami objęto zgrupowania ryjkowców (sensu lato) uwzględniające gatunki zaliczane do następujących rodzin: *Attelabidae*, *Rhinomaceridae*, *Apionidae* i *Curculionidae*.

Celem pracy była charakterystyka zgrupowań ryjkowców występujących w wybranych borach świeżych na terenie Polski. Postawione zadania zrealizowano poprzez zbadanie składu gatunkowego, sezonowych zmian liczebności, struktury dominacyjnej i liczebności *Curculionidae*. Ponadto pomocne w osiągnięciu tego celu było również opracowanie charakterystyki ekologicznej badanych chrząszczy oraz analiza porównawcza struktury zgrupowań występujących na badanych powierzchniach.

Badania prowadzono w zbiorowiskach roślinnych związku *Dicrano-Pinion* z klasy *Vaccinio-Piceetea* należących do dwóch zespołów borów świeżych: *Peucedano-Pinetum* i *Leucobryo-Pinetum* w latach 1986 i 1987. Drzewostany były zlokalizowane w czterech kompleksach borów sosnowych świeżych na terenie Polski: (*Peucedano-Pinetum*) w Puszczy Białowieskiej i Puszczy Białej oraz (*Leucobryo-Pinetum*) w Borach Tucholskich i w Roztoczańskim Parku Narodowym.

Podczas prowadzonych badań zebrano około 7.5 tysięcy imagines ryjkowców należących do 116 gatunków. Materiał odławiano różnymi metodami ilościowy-

mi. W warstwie koron ryjkowce odławiano pułapkami Moerickego, a w warstwie runa czerpakiem entomologicznym. Ponadto zastosowano uzupełniające metody odłowu służące do pełniejszego określenia składu gatunkowego zgrupowań ryjkowców: pułapki Barbera, przesiewanie ściółki, pułapki Moerickego umieszczone na powierzchni ziemi, odłowu "na upatrzonego" (spod kamieni i kory oraz z próchna).

Do charakterystyki zgrupowań ryjkowców zastosowano wskaźnik bogactwa gatunkowego (Shannona i Weavera), natomiast przy porównywaniu zgrupowań wskaźnik podobieństwa składu gatunkowego (Jaccarda-Sørensen) i podobieństwa struktury dominacyjnej (Morisity).

Gatunki występujące na terenie borów świeżych podzielono, w oparciu o ich bionomię, na 11 grup. Zastosowany podział pozwolił na analizę zróżnicowania ekologicznego *Curculionidae*. Najliczniejsze były gatunki rozwijające się w koronach drzew iglastych, głównie na sośnie.

Porównanie zgrupowań ryjkowców w zbadanych kompleksach leśnych wykazuje różnice w bogactwie gatunkowym, liczebności i strukturze dominacyjnej. Najwięcej gatunków i najwyższe ich liczebności stwierdzono w Puszczy Białowiejskiej, niewiele mniej wykazano z Roztoczańskiego Parku Narodowego, mniej z Puszczy Białej, a najmniej z Borów Tucholskich. W każdym z badanych kompleksów leśnych na terenie starodrzewów dominantem był inny gatunek ryjkowca, jednak skład grupy gatunków najliczniej występujących: dominantów i subdominantów w poszczególnych kompleksach jest do siebie zbliżony.

Przeprowadzona analiza fenologiczna wykazała największe liczebności zgrupowań ryjkowców w okresie wiosennym i wczesnego lata.

Zgrupowania *Curculionidae* w borach świeżych charakteryzują się największym udziałem gatunków o szerokim typie rozmieszczenia: holarktycznym i palearktycznym. Natomiast pod względem ilościowym dominowały wśród nich gatunki o europejskim, zachodniopalearktycznym i palearktycznym typie rozszedlenia. Zasięg tych ryjkowców mieszczą się w areale boru świeżego.

W badanych kompleksach leśnych nie wszystkie gatunki ryjkowców uznane za szkodniki lasów iglastych zostały odnotowane w znacznych liczebnościach. Natomiast inne, uznawane za rzadko łowione, są bardzo licznie reprezentowane w materiale zebranym w koronach sosen.