POLSKA AKADEMIA NAUK
MUZEUM I INSTYTUT ZOOLOGII

FRAGMENTA FAUNISTICA

Tom 36 Warszawa, 30 X 1993 Nr 6

Irmina PILIPIUK

Enchytraeidae (*Oligochaeta*) of pine forests in Poland

[With 3 Tables and 8 Figures in the text]

Abstract. The structure of *Enchytraeidae* communities of *Leucobryo-Pinetum* and *Peucedano-Pinetum* pine forests was analysed. One community-type was registered. Differences in species composition and dominance structure related to regional phytosociological diversity and limiting influence of anthropogenous pressure on community density were observed.

INTRODUCTION

Enchytraeidae are one of the most abundant groups of soil mesofauna that take part in the mineralization of organic matter. They play a particularly important role in oligotrophic pine forests where earthworms are very rarely found. Despite the fact that organic matter mineralization intensity in the intestine of enchytraeids is lower than that of lumbricids, the contribution of the former to the flow of energy through the ecosystem is high, this being due to their high abundance and metabolism rate. ABRAHAMSEN (1973) showed that even if the total biomass of earthworms is bigger than that hat of *Enchytraeidae* (in spruce forests on fertile soils), the total body surface area is higher in the latter and it is their metabolism that has larger significance to the flow of energy through such ecosystems.

There are a number of papers concerning the occurrence of *Enchytraeidae* in various types of coniferous forests and most of these papers describe *Enchytraeidae* of Scandinavian coniferous forests. NURMINEN (1976b) provides a comprehensive faunistic survey of enchytraeids inhabiting various habitats in Norway, Sweden and Finland, including 43 stands in boreal pine forests and 31 stands in spruce forests. ZALESSKA (1982) and DÓZSA-FARKAS (1985) carried out faunistical analyses of spruce forests located in the vicinity of Moscow and of a Hungarian pine forest respectively. The species composition of *Enchytraeidae* communities of a spruce-larch-Douglas fir plantation was studied in Wales by O'CONNOR (1957), while GÓRNY (1975b) conducted a similar study for Polish pine

forest stands. Data concerning the habitat conditions required by different *Enchytraeidae* species and the diversification of *Enchytraeidae* communities in pine forests are still scarce. Papers on the ecology of this group of animals are particularly worth noticing (ABRAHAMSEN 1972, NURMINEN 1967a, PETERSEN and LUXTON 1982).

A number of papers discusses the changes in *Enchytraeidae* communities resulting from soil acidification and liming (BĘĘTH, BERG at all 1980; HUHTA, HYVÖNEN, KAASALAINEN at all 1986; LUNDKVIST 1977; PERSSON, HYVÖNEN at al. 1985), nitrogen-phosphorus-potassium fertilization (HEUNGENS 1980, HUHTA 1984), urea fertilization (ABRAHAMSEN and THOMPSON 1979) and copper pollution (BENGTSSON and RUNDGREN 1982). Influence of silvicultural practices as clear-cutting, burning and afforestation was studied by HUHTA and KARPINEN at all (1967), HUHTA, NURMINEN and VALPAS (1969) and LUNDKVIST (1973).

The role of *Enchytraeidae* and other soil animals in the process of decomposition was studied by BERG, LOHM at all (1980) and by PETERSEN and LUXTON (1982). ABRAHAMSEN (1973) and MAKULEC (1983) discussed the importance of *Enchytraeidae* in coniferous forest soils in bioenergetic terms.

The aim of the present paper was to study *Enchytraeidae* communities of pine forest in Poland. Species composition, density and dominance structure were analysed. Species constancy and community similarities also were surveyed. Vertical stratification and the frequency of enchytraeids in microhabitats were studied as well.

The fauna of the studied coniferous forests was analysed in terms of regional phytosociological diversity. Comparison of the Enchytraeidae according to decreasing anthropopressure (in historical terms) connected with different intensity of silvicultural practices was also studied.

Industrial pollution and exposure to pests were taken into consideration as well.

STUDY AREAS

The researches were carried out in pine forests located in five different regions of Poland. Polish pine forests of different regions differ in phytosociological terms. The areas in Babimost forest distr., Bory Tucholskie and Roztocze NP belong to the suboceanic pine forest habitat type, while the stands in Puszcza Biała and Puszcza Białowieska represent the subcontinental pine forest habitat type (MATUSZKIEWICZ 1987).

The study areas in Babimost forest distr. are situated on formerly arable soils. The vegetation growing there should belong to the *Leucobryo-Pinetum* type forest, but in fact it has been deformed to a large extent. The vegetation of division 103 has degenerated so much that it can no longer be considered a representative of this type of forest habitat.

Specimens were collected from 15 stands, three stands have been chosen in each of the five areas. In all of the study areas there is mature forest stand (90–120 years old).

The studied areas were the following:
Bory Tucholskie – divisions 306b, 340a, 346.
Puszcza Biała – divisions 34f, 38b, 62g.
Puszcza Białowieska – divisions 538Bf, 667Bf, 668Af.
Roztocze NP – divisions 38, 178, 198.
Babimost forest distr. – divisions 103, 105a, 105b.

The soils of the studied areas belong to the rusty soil and podzolic soil subtypes. The humus can be classified as moder, moder/mor and mor. The sand found in these soils belongs to the loose sand type and to veakly loamy sand type.

The information concerning the type of soil, humus and sand was used while analysing the materials. A more detailed analysis of soil, humus and sand types in each stand must, therefore, be provided.

Rusty soils were found in all stands in Bory Tucholskie, Puszcza Biała and Babimost forest distr. as well as in the 668Af division stand in Puszcza Białowieska and in division 178 in Roztocze NP. Podzolic soils were found in divisions 538Bf and 667Bf in Puszcza Białowieska and in division 38 in Roztocze NP. Iron-humus podzolic soil was found only in division 198 in Roztocze NP. The "moder" type of humus formation was registered in divisions 306b, 340a in Bory Tucholskie, divisions 34f, 38b in Puszcza Biała, in division 668Af in Puszcza Białowieska and in division 178 in Roztocze. The "moder/mor" humus was found in division 346 in Bory Tucholskie, division 62g in Puszcza Biała, division 667Bf in Puszcza Białowieska and division 105b in Babimost forest distr., while the "mor" humus was found in division 538Bf in Puszcza Białowieska, divisions 38 and 198 in Roztocze NP and in divisions 103 and 105a in Babimost forest distr.

Loose sand was present in the soil profiles of all stands in Bory Tucholskie, Puszcza Białowieska and Babimost forest distr. as well as in division 198 in Roztocze NP. The veakly loamy sand was found in Puszcza Biała and in divisions 38 and 178 in Roztocze NP.

The classification of the study areas according to decreasing anthropopressure (in historical terms) – connected with different intensity of silvicultural practises – goes as follows: Babimost forest distr., Bory Tucholskie, Puszcza Biała, Roztocze NP, Puszcza Białowieska. According to Nunberg's classification of Polish forests into different forest wholesomeness zones (KOEHLER 1971), Babimost forest distr. and Bory Tucholskie are situated in the zone of constant exposure to pests, Puszcza Biała – in the zone of periodic exposure, while Roztocze NP and Puszcza Białowieska represent resistant to pests. The situation changes, however, when the influence of industrial anthropopressure is considered. MOLSKI at all divide the area of Poland into four zones of sulphur pollution (the basis for this classification is the sulphur content in dry mass of pine cones) (BREYMEYER 1987). According to this classification, Babimost forest distr. is located in the zone of the greatest pollution (zone 4), Puszcza Biała, Roztocze, and Bory Tucholskie belong to zone 2 and Puszcza Białowieska is situated in the least polluted zone 1.

MATERIAL AND METHODS

A total of 24708 *Enchytraeidae* specimens were collected. They were collected in the years 1986-1988. Sampling took place in spring (April, May) and autumn (October, November). The research started in the autumn of 1986 and the last samples were collected in the spring of 1988. Each time 20 random soil samples were taken from each stand with a steel corer. The samples were 20 cm^2 in area and 10 cm deep. In 1987 the type of microhabitat was also taken into consideration in the sampling. Bilberry, heath, moss, grass and litter were the main types of ground cover. Fern and lichens were also taken into consideration in some of the sites. In autumn of 1987 two methods of sampling were used in Puszcza Biała in order to compare the values of *Enchytraeidae* community densities; apart from random sampling, four samples were taken in each of the five microhabitats. Average values of community densities obtained from one microhabitat were multiplied by the total area occupied by this microhabitat. The products counted for each microhabitat were summed to give the value of community density per 1 m^2. The data on the area occupied by each microhabitat had been found in MATUSZKIEWICZ's at all. paper (1993).

In spring 1988 in all the study areas samples were collected from the bilberry patch only. Apart from that, quantitative samples were collected in order to complete the material. O'CONNOR's apparatus was used for extracting specimens (GÓRNY 1981), which were then life-determined. In order to examine vertical stratification, every sample from Puszcza Biała, Puszcza Białowieska and Roztocze NP was divided into five strata which were then extracted separately.

In order to estimate the similarities between *Enchytraeidae* communities, Morisita's index was used.

SPECIES COMPOSITION

17 *Enchytraeidae* species were registered in the studied pine forests. Eight species were only found occasionally: each in one of the 15 stand (Tab. I). 6 to 9 species were noted in each area; 6 species were found in Puszcza Biała, Puszcza Białowieska, 8 species were observed in Roztocze NP, 9 – in Babimost forest distr.. In Bory Tucholskie 10 species were found, but one was uncertain.

The number of species registered at one stand ranges from 3 to 8. The greatest differences were noted in Babimost forest distr. (3 to 8 species). Exactly the same number of 5 species was found in all the sites in Puszcza Białowieska. The stand that was the poorest in the number of species (division 105b of Babimost forest distr.) was inhabited by *Cognettia sphagnetorum*, *Mesenchytraeus pelicensis* and *Achaeta eiseni*. These three "high-fidelity" species form the core of enchytraeid communities in all studied areas.

C. sphagnetorum was the most common species registered at all stands. This species shows a strong preference for coniferous forests. It was registered by ABRAHAMSEN (1972) in all types of pine forests and spruce forests that he examined. NURMINEN (1967b) also recorded this species at all stands in pine forests, at a vast majority of the stands in spruce forests as well as in areas

Table I. *Enchytraeidae* species and their frequency in studied stands in pine forests.

	Species	Puszcza Biała			Puszcza Białowieska			Roztocze NP			Bory Tucholskie			Babimost forest distr.		
		34f	38b	62g	538Bf	667Bf	668Af	38	178	198	306b	340a	346	103	105a	105b
1.	*Achaeta camerani* Cog.													+		
2.	*A. eiseni* Veid.		+	+	+	+	+		+	+	+	+	1	+	+	+
–.	*Achaeta* sp.		+	+	+	+	+	+	+	1	+	+	2	+	+	+
3.	*Bryodrilus ehlersi* Ude	+	+				+					+	+			
4.	*Buchholzia appendiculata* (Buchh.)												+			
–.	*Buchholzia* sp.								+							
5.	*Cognettia anomala* (Cer.) cf.												+			
6.	*C. glandulosa* (Mich.)	+		+	+	+	+	+								
7.	*C. spagnetorum* (Vejd.)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
8.	*Enchytraeus buchholzi* Vejd.	+			+	+		+								
–.	*Enchytraeus* sp.										+					
9.	*Echytronia* sp.												+			
10.	*Fridericia bulboides* Niel. et Christ.							+		+						
–.	*Fridericia* sp.							+	+	1						
11.	*Henlea perpusilla* Friend.										+					
12.	*H. ventriculosa* d'Udek.														+	
–.	*Henlea* sp.										+					
13.	*Marionina argentea* (Mich.)								+	+	+				+	
14.	*M. cambrensis* O'Conn.														+	
15.	*M. riparia* Bret.														+	
–.	*Marionina* sp.							1	2	2						
16.	*Mesenchytraeus flavus* (Lev.)												+	+	+	
17.	*M. pelicensis* Issel.	+	+	+	1			+	+	+	+	+	+	+	+	+
–.	*Mesenchytraeus* sp.	+	+	+	+	+	+	+	1	+	+	+	+	1	1	1
Number of species		6			6			8			10			9		

Frequency

3 – 75,1–100,0%; 2 – 50,1–75,0%; 1 – 25,1–50,0%; + – < 25,0%

situated in birch forests and moorlands. Although *C. sphagnetorum* has been found to live in many other habitats in Poland, including beech forests, spruce and spruce-fir forest stands (KASPRZAK 1979) and carr forests, linden-oak-hornbeam forests, mixed forests and coniferous forests (MAKULEC 1983), but it is less abundant there than in coniferous forests. This species should, therefore, be considered selectively characteristic for pine forests. This species' frequency at all the stands was very high so that it should be considered an absolutely constant species.

In the studied pine forests *M. pelicensis* was a low-frequency (occasional) species, but it exhibited a high degree of fidelity. It was found in 13 stands, and immature individuals of the genus *Mesenchytraeus* EIS. were registered at 15 stands. In Poland, this species has been noted at pine forest stands (GÓRNY 1975b), spruce forest stands (KASPRZAK 1979), and in a carr forest habitat (MAKULEC 1983). It has not been found in linden-oak-hornbeam forest, beech forest and mixed coniferous forest. It was rarely noted in pine forests and spruce forests in Norway (ABRAHAMSEN 1972) and Finland (NURMINEN 1967b). In terms of fidelity, it is also a selectively-characteristic species in the studied forests.

Frequency of *A. eiseni* was also low, and it was considered accidental in most of the stands. The species exhibited high fidelity: it was found at 13 stands, and immature individuals of the genus *Achaeta* VEJD. were recorded at 14 sites. MAKULEC (1983) registered this species in linden-oak-hornbeam forest, carr forests, mixed and coniferous forest. KASPRZAK (1979, 1981) noted it in linden-oak-hornbeam forest, spruce forest stand. It was not recorded in pine forests of Norway (ABRAHAMSEN 1972) and Finland (NURMINEN 1967b). In the studied pine forests, it should be considered as an accompanying species.

Despite a few exceptions, the frequency of other species found in one or some of the stands was low. Those species were accidental species. It should be noted, however, that the genus *Mesenchytraeus* was an accompanying genus in the three stands in Babimost forest distr. and in one stand in Roztocze NP; the genus *Marionina* was noted as constant at two stands in Roztocze NP.

The constancy of the occurrence of each species in the five studied areas was also analysed. *C. sphagnetorum* was an absolutely constant (euconstant) species in all the areas. Other species found in Puszcza Białowieska and Puszcza Biała belonged to the accidental species class. The data on the constancy of enchytraeid genera showed that the genera *Marionina* MICH. and *Mesenchytraeus* were constant genera in Roztocze NP and Babimost forest distr. respectively.

The analysis of species composition for each object shows that Roztocze NP enchytraeid community differs most considerably from other communities. There, individuals of the genera *Marionina* and *Fridericia* MICH. are found in all stands. The genus *Marionina* is an element of the core of this community, such cores being composed of species *C. sphagnetorum*, *M. pelicensis* and *A. eiseni* in all the objects.

OCCURRENCE OF ENCHYTRAEID SPECIES IN DIFFERENT MICROHABITATS

The number of *Enchytraeidae* species found in the five microhabitats varied from 4 to 12. The smallest numbers were noted under the least numerous microsites of ferns and lichens (Tab. II). The greatest number of species – 12 – species was found under moss. These data were obtained from patches of vegetation and litter in all stands. If we were to analyse the number of species found in different microhabitats in each of the areas, the figures would only range from two to six species registered in one type of microhabitat.

Six species were found occasionally, in one microhabitat at one stand. *Henlea ventriculosa* was found in one microsite at two stands. *C. sphagnetorum* and *M. pelicensis* as well as individuals of the genera *Achaeta* and *Marionina* were noted in all microhabitats. *A. eiseni* and *Marionina argentea* as well as *Fridericia* sp. individuals were recorded in six microhabitats. *Cognettia glandulosa* and *Enchytaeus buchholzi* – in five patches, *Bryodrilus ehlersi* – in three microsites, *Henlea perpusilla* and *Mesenchytraeus flavus* in two microhabitats only.

Only the species *B. ehlersi* can be said to show preference for the patch of litter, since it was recorded at as many as five stands in this microhabitat, while in moss and grass it occurred only at one stand. *A. eiseni* occurred mostly in moss (in 8 stands), *Achaeta* sp. individuals also preferred this type of microhabitat. No differences in the frequency of each species were reported comparing the data from the studied microhabitats.

Densities of *Enchytraeidae* communities living in different microhabitats were compared. The highest densities were most often recorded for communities living under the plot of moss (6 stands) (Fig. 1). No correlations were found while analysing seasonal fluctuations in *Enchytraeidae* community densities under different ground cover plots in Puszcza Białowieska and Roztocze NP stands. Both in spring and autumn enchytraeid communities living under different microsites and in different stands were highly subject to fluctuations in density (Fig. 2).

DENSITY OF ENCHYTRAEID COMMUNITIES

There are considerable differences in the abundance of enchytraeid communities, both if data from different stands are considered and as far as spring and autumn data are concerned. (Tab. III). Data on the density of enchytraeid communities gathered from so many stands twice a year can only be of an approximate nature. In a majority of stands, the highest densities were noted in spring. On an average the highest densities were reported in Puszcza Białowieska, the densities of the Puszcza Biała and Roztocze communities were a little bit lower, respectively, while the lowest densities were registered in Babimost forest distr. and Bory Tucholskie. The differences between different stands were often greater than those noted for different areas. The highest autumn densities were noted for Roztocze NP, a little lower densities were reported for Puszcza Biała and then came Puszcza Białowieska, Bory Tucholskie and Babimost forest distr. Generally, it can be said that higher densities of *Enchytraeidae* were

Table II. Frequency of *Enchytraeidae* under different microhabitats.

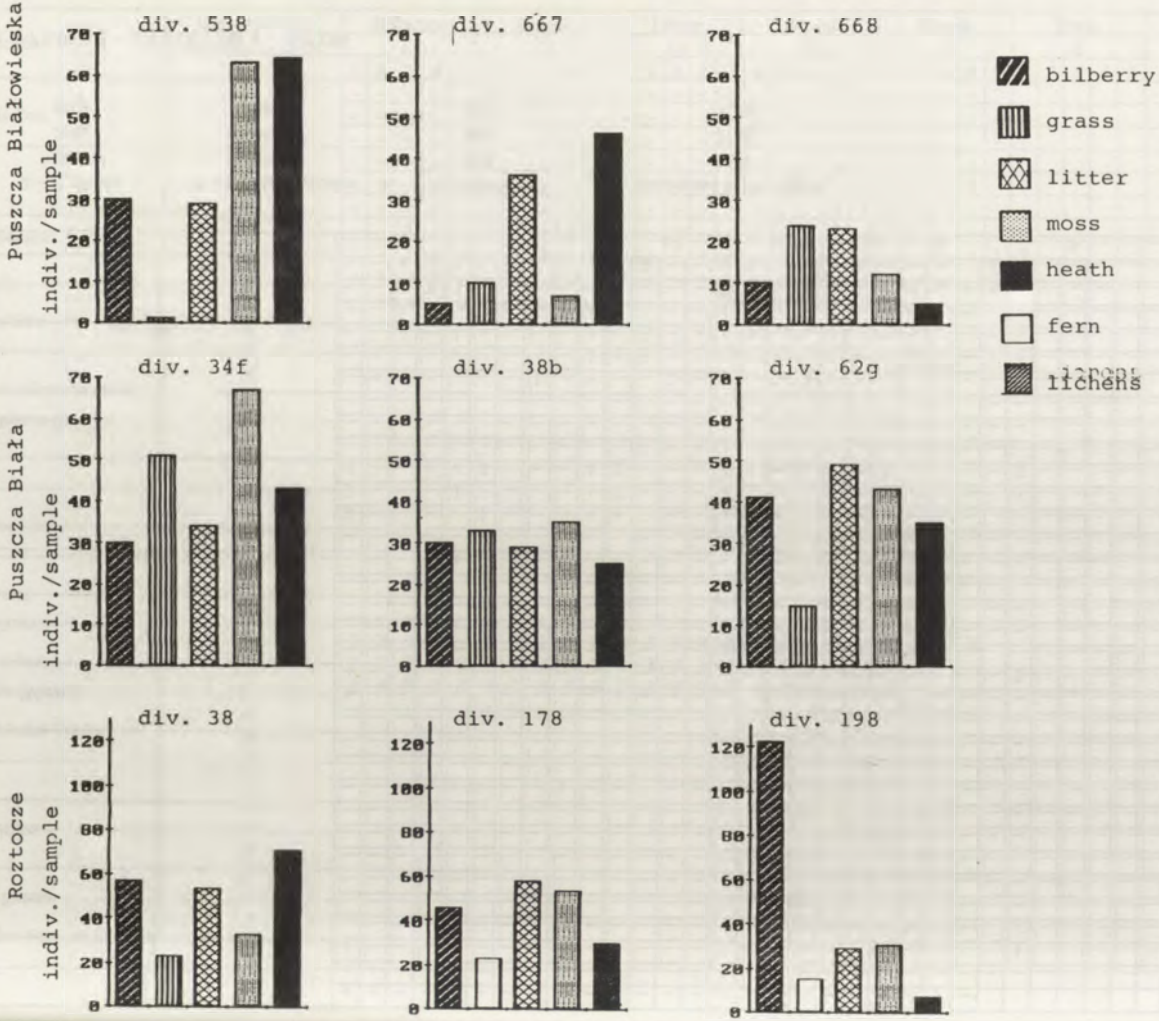
Lp.	Species	Microhabitat	Bilberry					Grass					Litter					Moss					Heath					Fern					Lichens				
		number stands	14					14					15					15					13					2					4				
		area	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1.	*Achatea camerani* Cog.	a	–	–	–	–		–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–									–	–
		b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
2.	*A. eiseni* Veld.	a	–	–	–	–		–	–	–	–	–	–	–	+	–	–	–	–	+	+	+	–	–	–	+										–	–
		b	+	–	–	–	–		–	+	–	–	–	–	–	–	–	–	+	–	–	+	–	–	–	1	–	-								–	
		c	+	–	–	1	–	–	+	+	1	–	–	+	–	–	–	–	+	–	1	+	1	–	–		–	+								–	
		a	+	–	1	–		–	–	–	2	1	+	–	+	–	–	+	–	+	+	–	–	–	–	–										–	+
–.	*Achaeta* sp.	b	1	–	–	+	+		–	1	1	+	–	–	–	+	+	–	1	–	–	1	–	–	–	+	1	2								1	
		c	+	+	–	1	–	–	2	–	2	1	1	+	–	+	+	+	1	+	2	1	1	–	+		1	1								1	
		a	–	–	–	–		–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–										–	–
3.	*Bryodrilus ehlersi* Ude	b	–	–	–	–	–		–	–	–	–	–	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	+	–	–	–	–	1	+	–	–	–	+	–	–	–	–	–		–	–								–	
		a	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
4.	*Bucholzia appendiculata* (Buchh.)	b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–		–									–	
		a	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
–.	*Buchholzia* sp.	b	–	–	–	–	–		–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
		a	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
5.	*Cognettia anomala* (Cer.) cf.	b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–		–	–								–	
		a	–	+	–	–		–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	–	–										–	–
6.	*C. glandulosa* (Mich.)	b	–	–	–	–	–		–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	+	+	–	–	–	+	+	–	–	–	–	+	–	–	–	–	+	–	–	–	–	–		–	–								–	
		a	3	3	3	3		3	3	1	3	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3										3	2
7.	*C. sphagnetorum* (Vejd.)	b	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3														3	
		c	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3														3	
		a	–	+	+	–		+	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	+										–	–
8.	*Enchytraeus buchholzi* Vejd.	b	–	–	–	–	–		–	–	–	–	–	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
		a	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
–.	*Enchytraeus* sp.	b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
		a	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
9.	*Enchytronia* sp.	b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
		a	+	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
10.	*Fridericia bulboides* Niel. et Christ.	b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	

–.	*Friderica* sp.	a	+	–	–	–		+	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–										–	–
		b	+	–	–	–	–		–	–	–	–	+	–	–	–	–	+	–	–	–	–	1	–	–	–	–	–								–	
		c	1	–	–	–	–	–	–	–	–	–	1	–	–	–	–	+	–	–	–	–	+	–	–		–	1								–	
11.	*Henlea perpusilla* FRIEND.	a	–	–	–	–		–	–	–	–	+	–	–	–	–	–	–	–	–	+	–	–	–	–	–										–	–
		b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
12.	*H. ventriculosa* d'UDEK.	a	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
		b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
–.	*Henlea* sp.	a	–	–	–	–		–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
		b	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–		–	–								–	
13.	*Marionina argentea* (MICH.)	a	–	–	–	–		1	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–										–	–
		b	+	–	–	–	+		–	–	–	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–								–	
		c	+	–	–	–	–	–	–	–	–	–	1	–	–	–	–	+	–	–	–	–	+	–	–		–	1								–	
14.	*M. cambrensis* O'CONN.	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–											–	–
		b	–	–	–	–	+		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
15.	*M. riparia* BRET.	a	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–										–	–
		b	–	–	–	–	+		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–								–	
		c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–								–	
–.	*Marionina* sp.	a	2	–	–	–		1	–	–	–	+	+	–	–	–	+	2	–	–	–	–	–	–	–	–										2	+
		b	2	–	–	–	1		–	–	–	+	2	–	–	–	–	2	–	–	–	+	2	–	–	–	–	+								–	
		c	3	–	–	–	+	3	–	–	–	1	2	–	–	–	1	1	–	–	–	+	1	–	–		–	2								–	
16.	*Mesenchytraeus flavus* (LEV.)	a	–	–	–	–		–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–											
		b	–	–	–	–	–		–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–									
		c	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–		–	–									
17.	*M. pelicensis* ISSEL.	a	–	+	+	–		–	–	1	–	+	–	–	1	–	+	–	–	2	+	+	–	–	+	–										2	+
		b	–	+	–	–	+		–	–	–	1	+	–	–	+	+	+	–	–	–	+	+	–	–	–	+	+								–	
		c	+	–	–	–	1	–	–	–	–	+	–	–	–	+	+	1	–	–	–	+	+	–	–		–	+								–	
–.	*Mesenchytraeus* sp.	a	+	+	+	+		+	+	–	–	+	–	+	+	–	1	–	–	+	+	+	–	–	+	–										1	1
		b	+	–	–	1	1		+	–	–	1	2	+	–	–	2	2	–	+	–	1	2	+	–	+	+									–	
		c	+	–	+	–	1	–	–	–	+	1	2	2	–	–	2	1	+	–	–	1	+	+	+		1									1	
	Number of species				9					11					10					12					8					5					4		

1 – Roztocze NP: a 38, b 178, c 198
2 – P. Biała: a 34f, b 38b, c 62g
3 – P. Białowieska: a 538Bf, b 667Bf, c 668Af
4 – B. Tucholskie: a 306, b 340, c 346
5 – Babimost forest distr.: a 103, b 105a, c 105b

	1 – Roztocze NP	2 – P. Biała	3 – P. Białowieska	4 – B. Tucholskie	5 – Babimost forest distr.
a	38	34f	538Bf	306	103
b	178	38b	667Bf	340	105a
c	198	62g	668Af	346	105b

– species no recorded
Frequency
3 – 75.1–100%; 2 – 50.1–75.0%; 1 – 25.1–50.0%; + – <25.0%



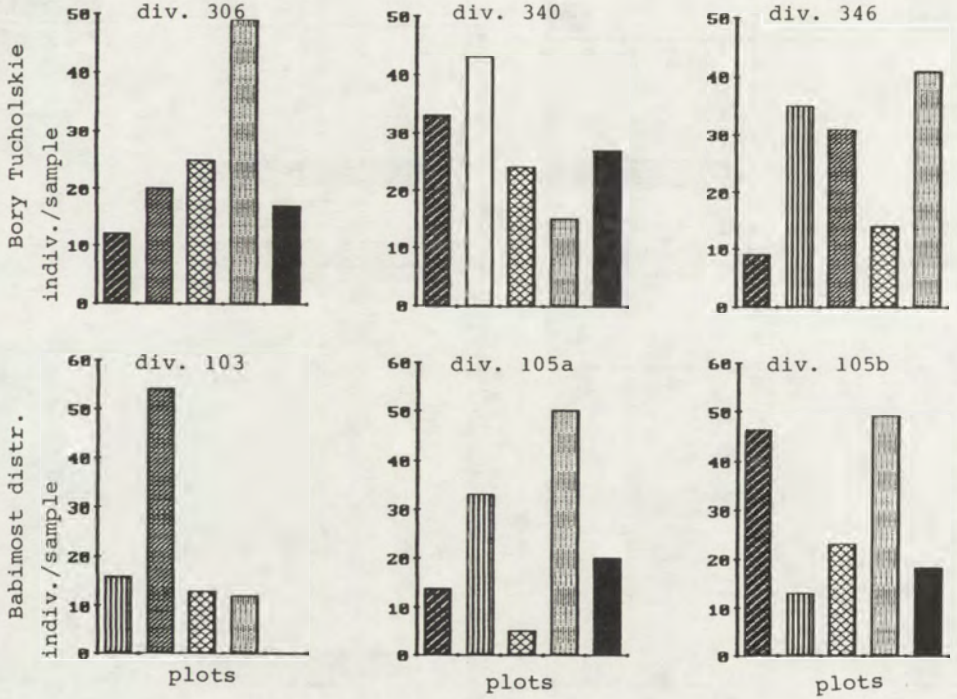


Fig. 1. Average densities of *Enchytraeidae* under different microhabitats.

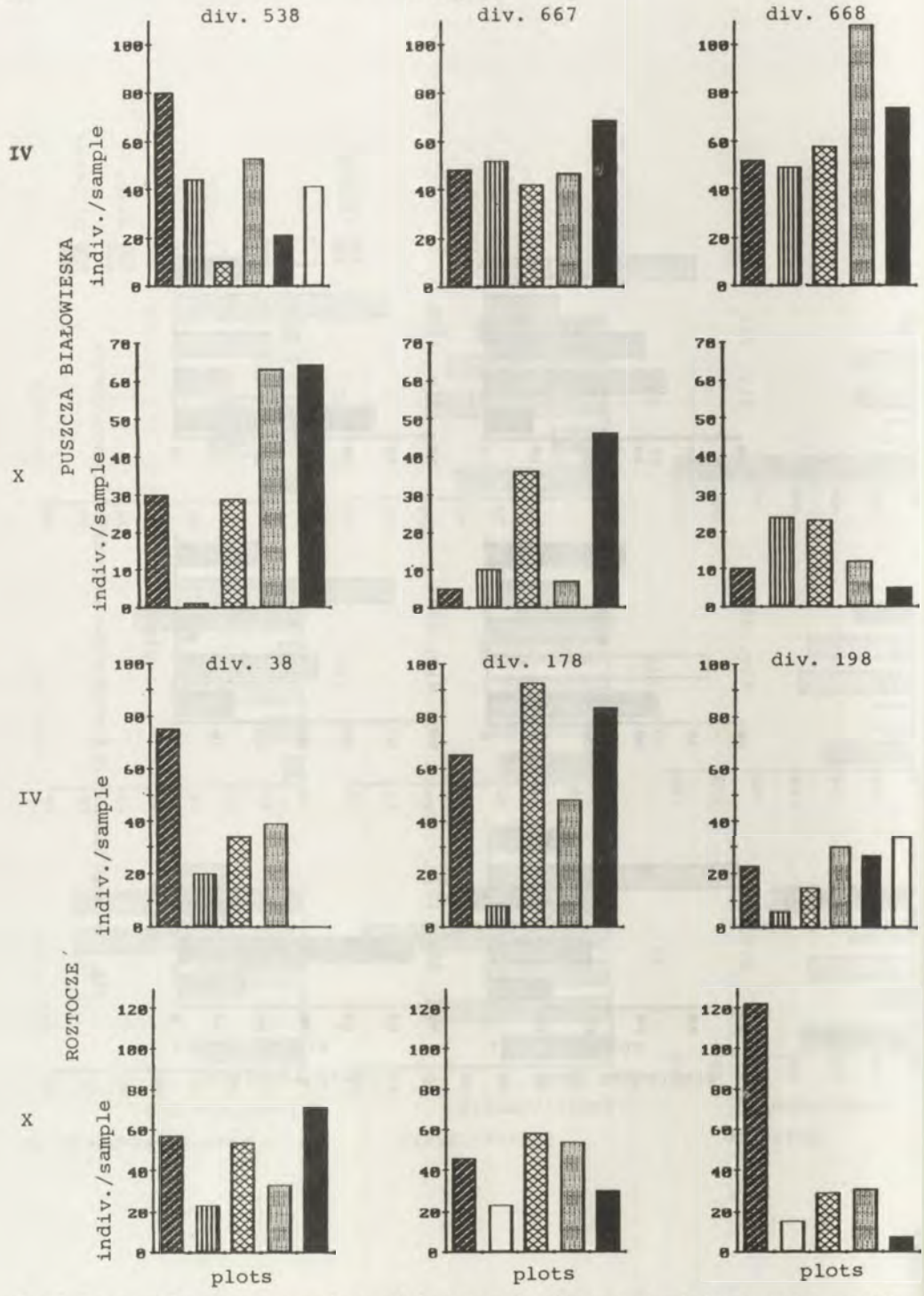


Fig. 2. Seasonal fluctuation in enchytraeid density under different microhabitats (in Puszcza Białowieska and Roztocze PN).

characteristic for Puszcza Białowieska, Puszcza Biała and Roztocze with little differences among the three areas, while Bory Tucholskie and Babimost forest distr. communities usually had much lower densities, but also similar to each other.

The data on Puszcza Biała community densities obtained by means of two different methods were very similar. In division 34b, the data from random sampling showed the density to equal 20 000 individuals/m^2. According to the data obtained from sampling microhabitats — each mictohabitat's share in the total area was taken into account — the density equaled 23 255 individuals/m^2. The figures for division 38b were 13 900 and 16 015 individuals/m^2 respectively, and the figures for division 62g equaled 16 375 and 16 600 individuals/m^2 respectively.

Table III. Enchytraeidae densities in stands in pine forests studied in 1987 ($N \cdot 10^3$ indiv./m^2).

	P. Biała			P. Białowieska			Roztocze NP			B. Tucholskie			Babimost forest distr.		
div.	34f	38b	62g	538Bf	667Bf	668Af	38	178	198	306	340	346	103	105a	105b
IV	38.53	23.13	17.15	22.88	2533	20.43	20.43	31.50	12.35	16.30	15.25	10.50	22.03	20.80	14.13
X	20.00	13.90	16.38	18.78	10.33	23.80	23.80	21.13	20.48	12.13	14.28	13.05	9.55	12.13	14.90
x	29.26	19.24	17.75	20.83	17.83	22.11	22.11	26.31	16.41	14.21	14.76	11.78	15.79	16.46	14.51

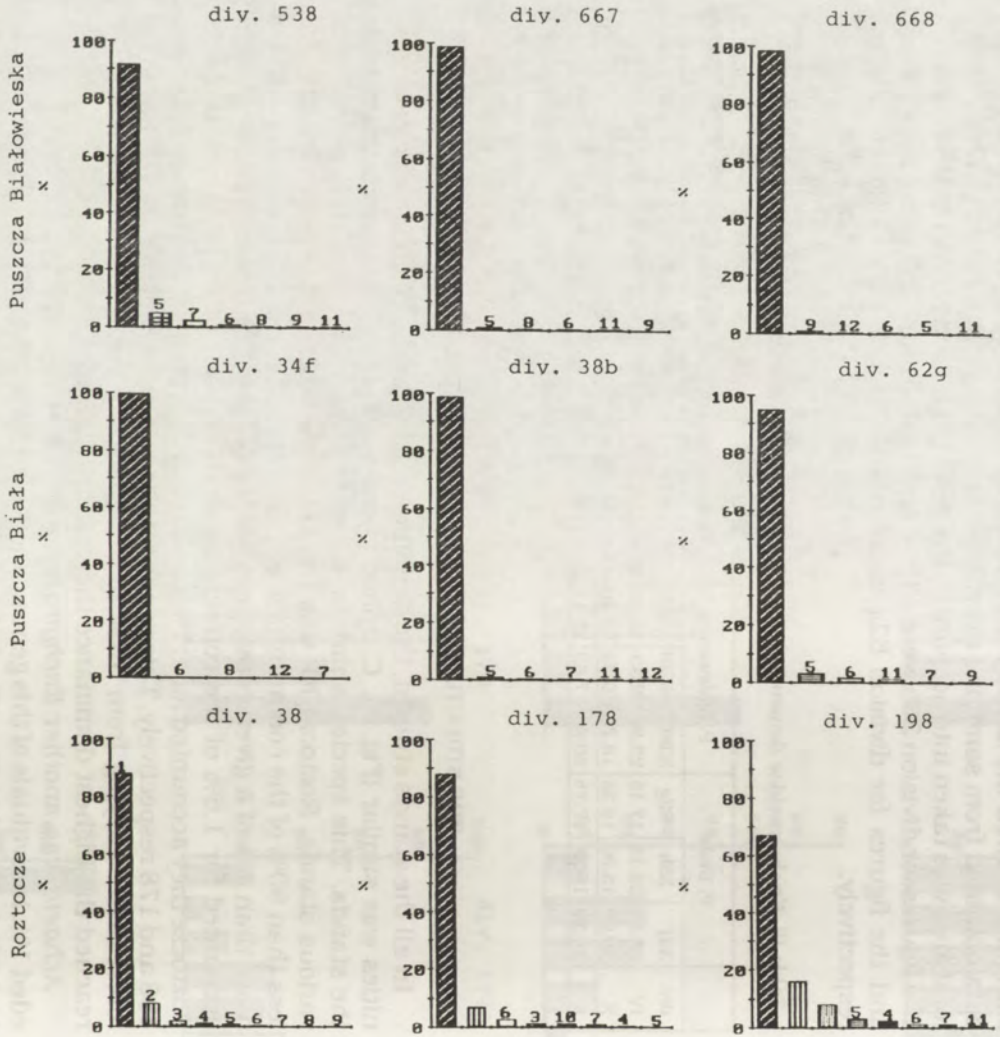
THE STRUCTURE OF DOMINANCE OF THE COMMUNITIES

In all the stands studied, the dominance structure of *Enchytraeidae* communities was similar (Fig. 3), *C. sphagnetorum* being the dominant species in all the stands. This species' share in a community ranges from 67% to 99.7% in various stands. Roztocze NP was the only area where this species constituted less than 90% of the communities. For the other species, only a few constituted more than 1% of a given community: individuals of the genus *Mesenchytraeus* accounted for 1.6% of the community from division 62g in Puszcza Biała. In Roztocze they accounted for 1.1% and 2.5% of the communities living in divisions 198 and 178 respectively. This genus reached its highest dominance in Babimost forest distr., varying from 3.1% to 7.7% in various stands. *M. pelicensis* also reached the highest dominance there: from 1.2% to 4.1%.

Achaeta was another *Enchytraeidae* genus, whose dominance indices exceeded 1%. Individuals of this genus constituted from 3% (a stand in Puszcza Biała) to 4.8% (a stand in Bory Tucholskie) of a community. In divisions 340 and 346 in Bory Tucholskie, the dominance index for the species *A. eiseni* ranged from 1.7 to 4.2%.

Only in one stand in division 306 of Bory Tucholskie, the dominance index for the genus *Henlea* MICH. was 2.5%.

Marionina was one more genus whose share in a community might outreach 1%, which was the situation in one of the stands in division 105b of Babimost forest distr. Here this genus accounted 3.5% of the community. The highest



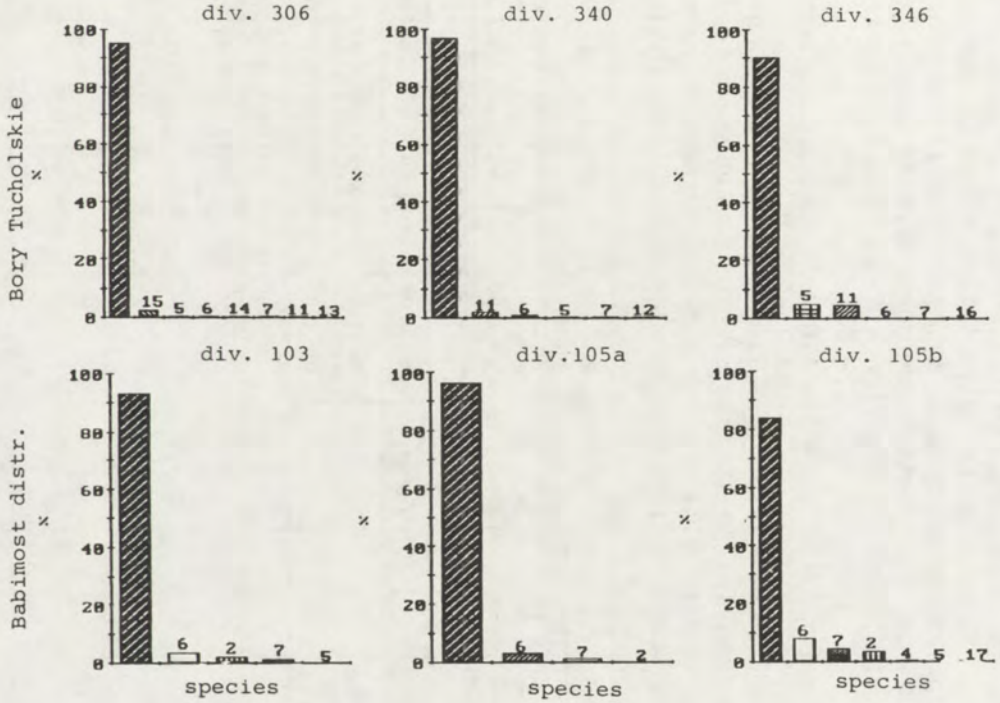


Fig. 3. The structure of dominance of *Enchytraeidae* communities of stands studied: 1 – *C. sphagnetorum*, 2 – *Marionina* sp., 3 – *Fridericia* sp., 4 – *M. argentea*, 5 – *Achaeta* sp., 6 – *Mesenchytraeus* sp., 7 – *M. pelicensis*, 8 – *E. buchholzi*, 9 – *C. glandulosa*, 10 – *Buchholzia* sp., 11 – *A. eiseni*, 12 – *B. ehlersi*, 13 – *Enchytraeus* sp., 14 – *H. perpusilla*, 15 – *Henlea* sp., 16 – *B. appendiculata*, 17 – *H. ventriculosa*

dominance figures for this genus were noted in Roztocze NP, ranging from 6.8% in division 178 and 7.9% in division 38 to 15.8% in division 198. The species *M. argentea* formed 1.1% of the community of division 38 and 2.3% of the community of division 198 in this area.

The share of the genus *Fridericia* reached above 1% of a community only in Roztocze NP. In this area it varies from 1 to 8%.

The data from the studied objects showed that *C. sphagnetorum*, *Mesenchytraeus* sp. and *M. pelicensis* as well as *Achaeta* sp. and *A. eiseni* were the most important species and genera as far as the structure of dominance was concerned. The Roztocze enchytraeid communities displayed the most distinct dominance structure, with a high percentage of the genera *Marionina* and *Fridericia*.

ESTIMATION OF SIMILARITY OF THE ENCHYTRAEID COMMUNITIES

Morisita's formula was the basis for estimating similarities between enchytraeid communities of the studied areas. The data on species composition and dominance structure indicated a high similarity between the communities. The communities' similarity graph (Fig. 4) supports this thesis. The figure shows

	34f	38b	62g	538Bf	667Bf	668Af	38	178	198	306	340	346	103	105a	105b
34f		0.99	0.99	0.99	0.99	0.99	0.98	0.89	0.99	0.99	0.99	0.99	0.99	0.99	0.97
38b			0.99	0.99	0.99	0.99	0.98	0.90	0.90	0.99	0.99	0.99	0.99	0.99	0.97
62g				0.93	0.99	0.99	0.99	0.99	0.91	0.99	0.99	0.99	0.99	0.99	0.98
538Bf					0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98
667Bf						0.99	0.98	0.99	0.90	0.99	0.99	0.99	0.99	0.99	0.97
668Af							0.98	0.99	0.90	0.99	0.99	0.99	0.99	0.99	0.97
38								0.99	0.95	0.99	0.98	0.98	0.99	0.99	0.98
178									0.94	0.99	0.99	0.99	0.99	0.99	0.99
198										0.91	0.90	0.92	0.92	0.91	0.94
306											0.99	0.99	0.99	0.99	0.98
340												0.99	0.99	0.99	0.98
346													0.99	0.99	0.98
103														0.99	0.99
105a															0.98
105b															

Fig. 4. *Enchytraeidae* communities similarity graph (Morisita's index applied).

Morisita's coefficiency index to range from 0.99 to 0.89, which means that all communities were very similar. The differences between stands situated within one object were very slight, the figures being 0.99 from most of the cases. Bigger differences can only be seen in Roztocze NP. The community from division 198 differed a little from the communities of other stands in this object, with the figures equaling 0.95 and 0.94. This community was most different from the communities inhabiting the remaining objects. The index of coefficiency of this community in relation to the remaining communities varies from 0.95 to 0.89. Another community that was a little different from others was the community from 105th division of Babimost forest distr. The coefficiency index of this community in relation to most of the remaining communities equals 0.98 and 0.97. The data obtained give further evidence for the differences in the structure of dominance.

VERTICAL DISTRIBUTION OF *ENCHYTRAEIDAE*

In order to analyse the vertical distribution of *Enchytraeidae* in the studied stands, percentages of *Enchytraeidae* specimens found in five horizons of soil were compared. In the course of research the vertical distribution of all specimens found in a given stand, vertical stratification of enchytraeids collected from under different microhabitats, and vertical distribution of species were analysed.

In the first horizon which corresponded to the L layer of the soil, 47 to 63% of specimens were found. 16 to 34% of specimens occurred in the second horizon (F layer), from 7 to 14% of enchytraeids were collected from the third horizon (H layer), while the remaining two horizons (A1 and A2 layers) harboured 4 to 10% of specimens.

The vertical distribution of enchytraeids in relation to soil type, mechanical properties of the soil and the type of litter was also analysed. This analysis revealed that in podzols with loose sand and "mor" humus (division 538 in Puszcza Białowieska and division 198 in Roztocze) 31–32% of specimens were found in the lower three horizons. When soils with veakly loamy sand and "mor" humus were considered, the three horizons harboured 15–21% of enchytraeids (Fig. 5).

The analysis of vertical distribution of enchytraeids living under different microsites of litter and vegetation was based on the data from three stands in Puszcza Biała, Puszcza Białowieska and Roztocze NP. No correlations were found between vertical distribution of enchytraeids and microhabitats which would be present in all the stands. Only in the samples taken from under patches of litter in Roztocze can be seen a more uniform distribution of enchytraeids in the soil profile. 30–42% of specimens were found in the first horizon there. However, the respective data for Puszcza Białowieska were 49–56% (Fig. 6).

No seasonal fluctuations were found, either, when vertical distribution of enchytraeids was examined in stands in Puszcza Biała, Puszcza Białowieska and Roztocze in spring and autumn (Fig. 7).

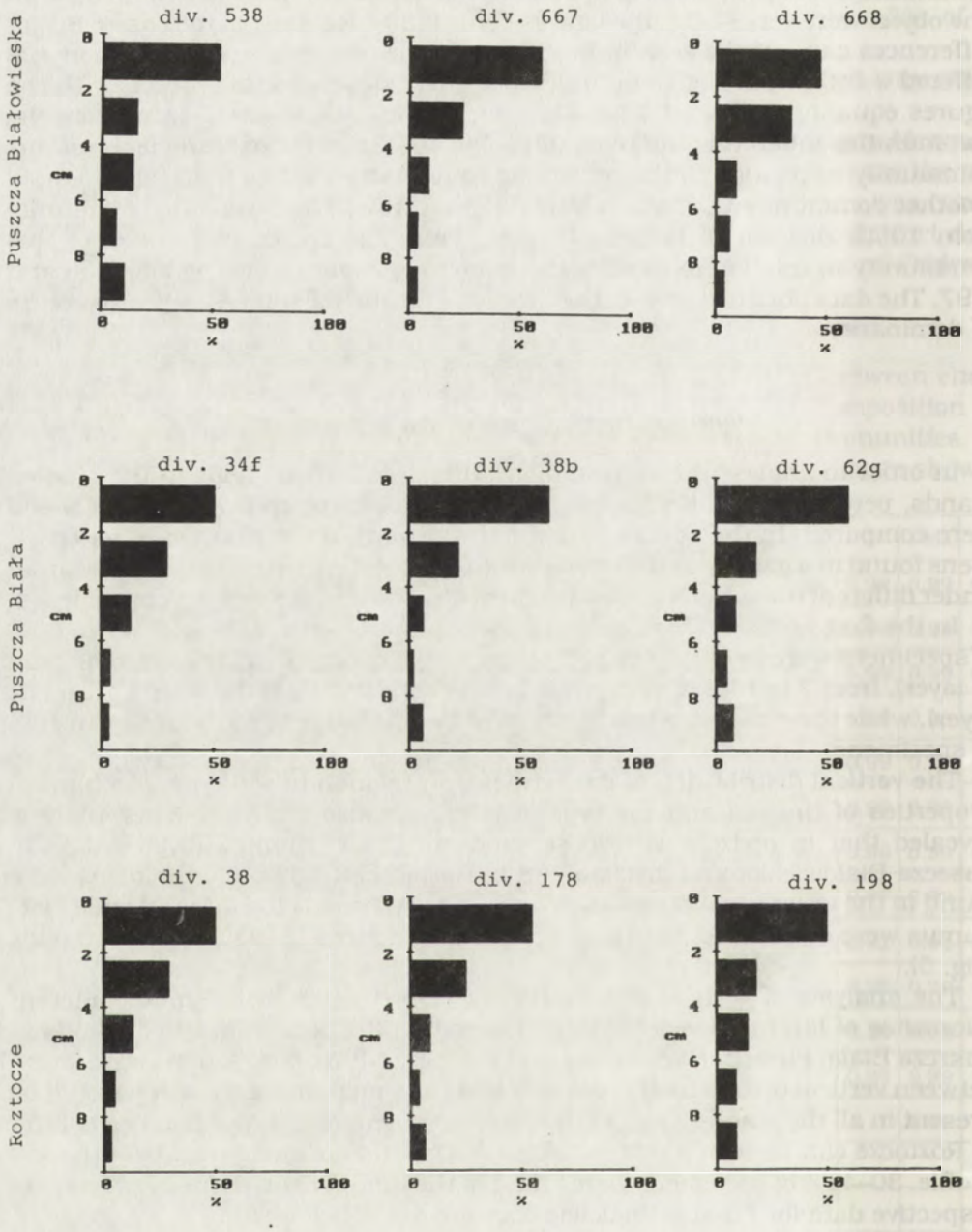
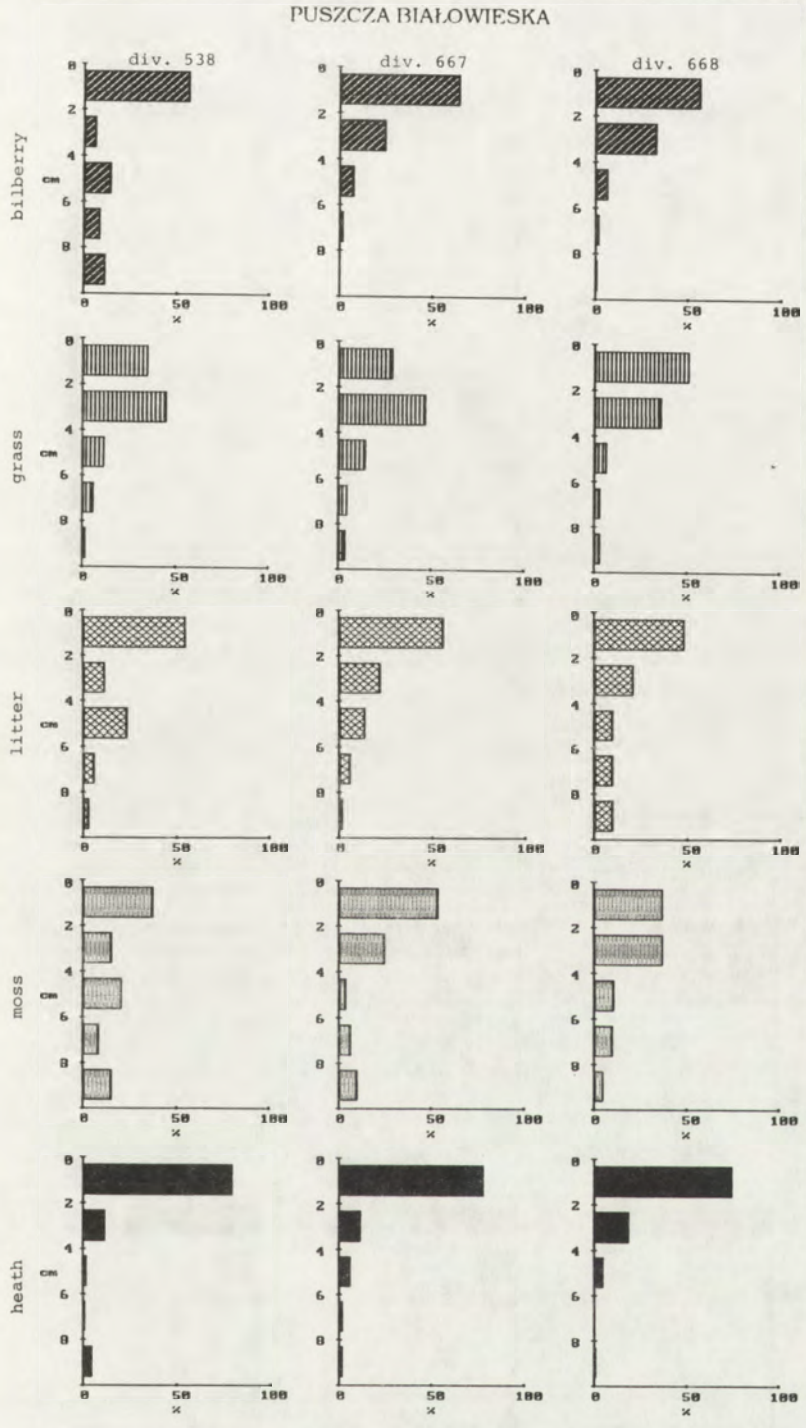
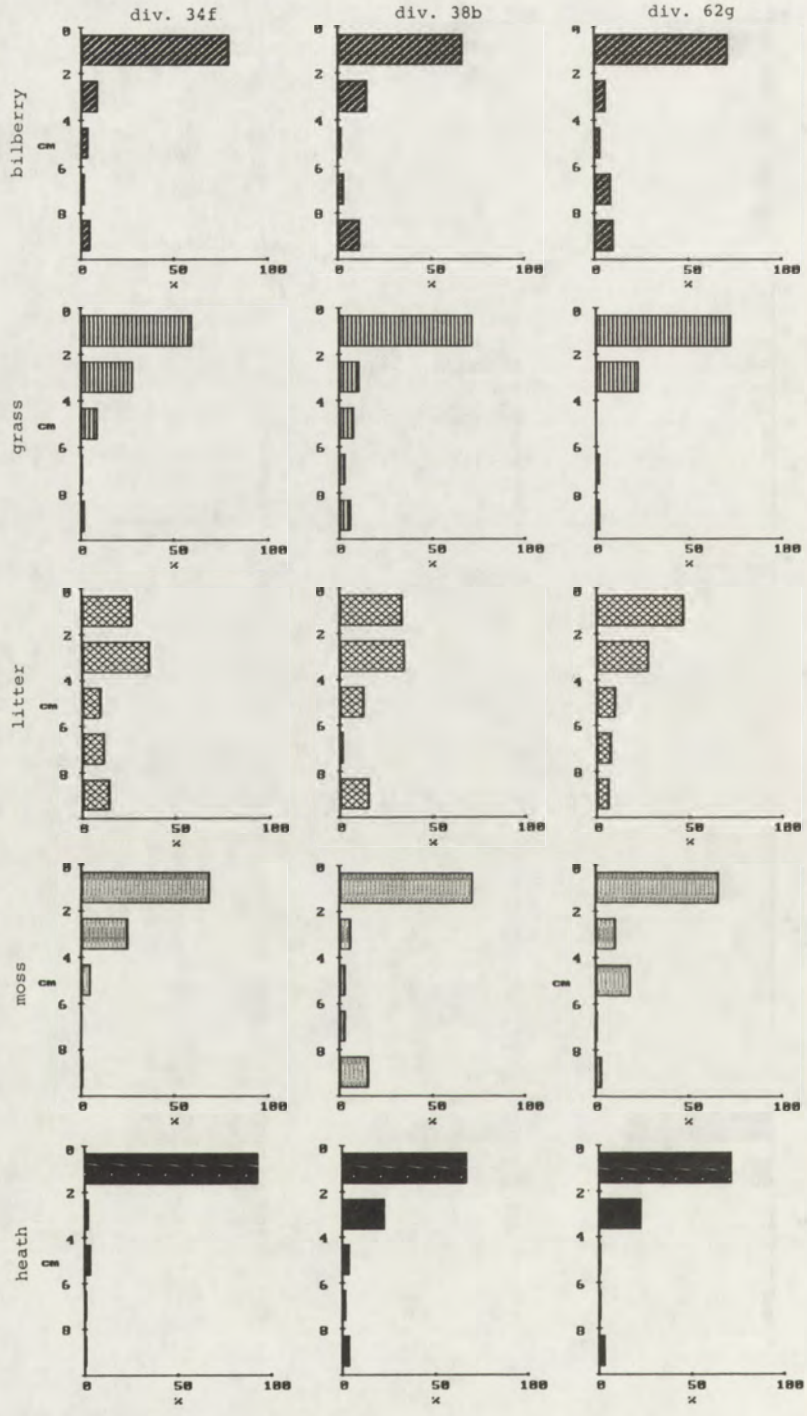


Fig. 5. Vertical distribution of *Enchytraeidae* of stands in Puszcza Białowieska, Puszcza Biała and Roztocze NP.



PUSZCZA BIAŁA



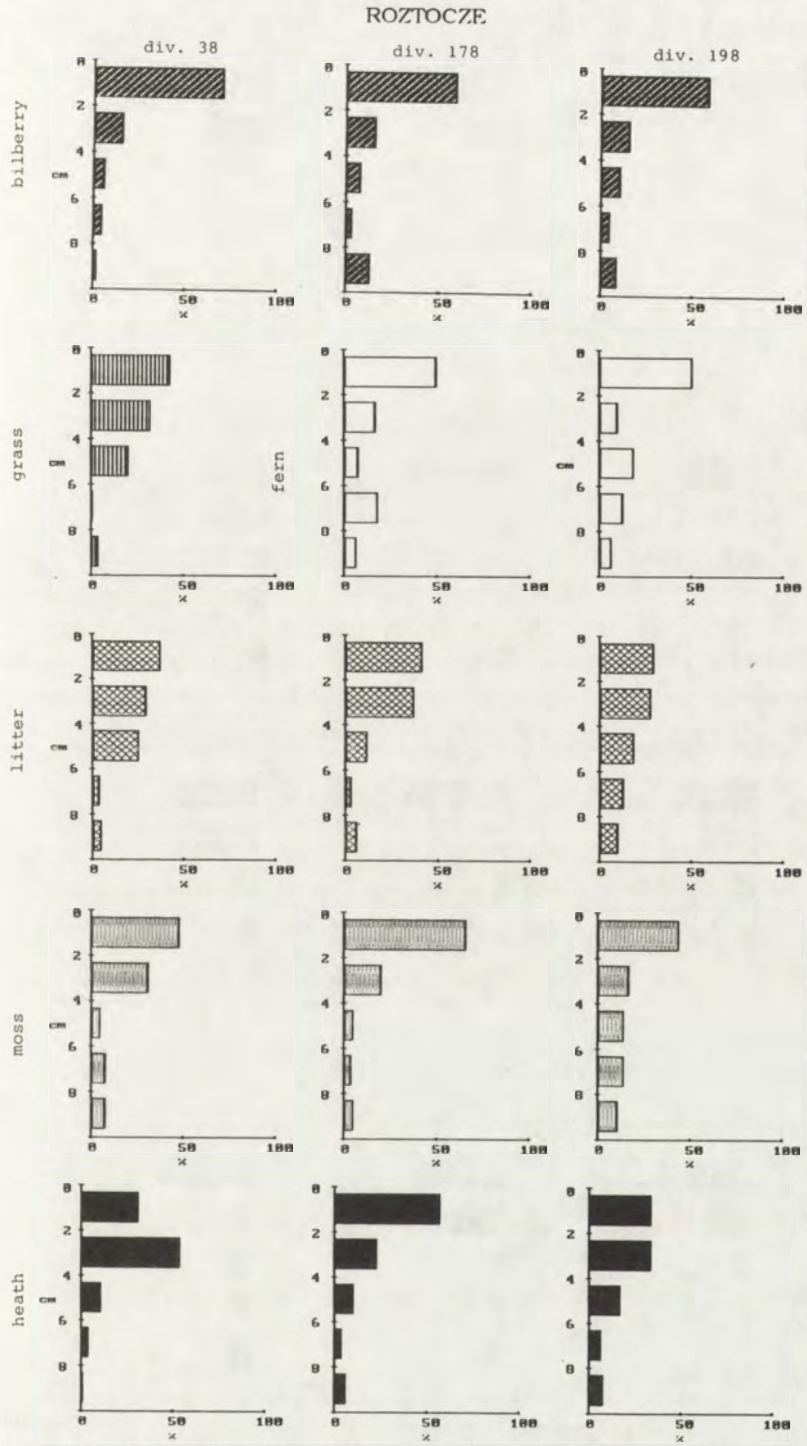


Fig. 6. Vertical distribution of *Enchytraeidae* under different microhabitats in: a – Puszcza Białowieska, b – Puszcza Biała, c – Roztocze NP.

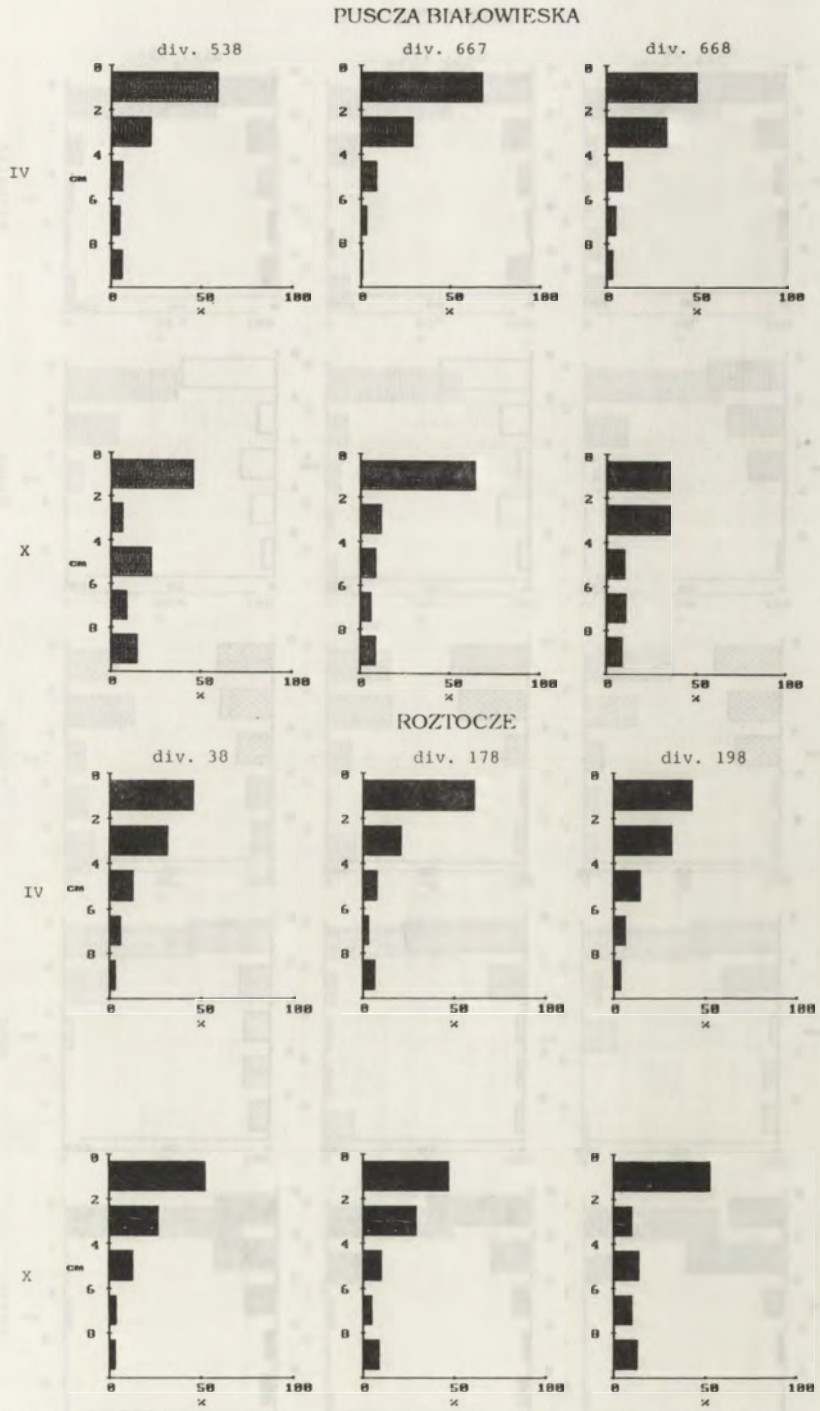
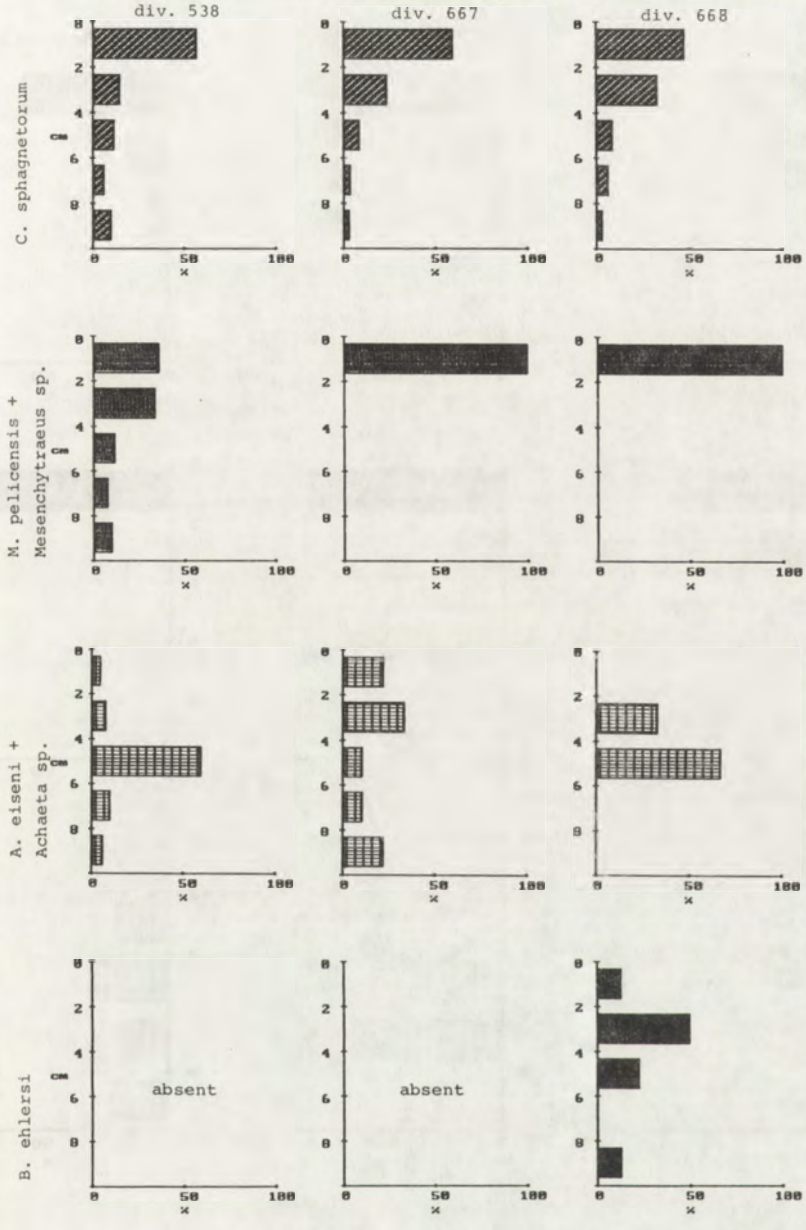


Fig. 7. Seasonal differences in vertical distribution of *Enchytraeidae* in: a – Puszcza Białowieska, b – Roztocze NP.

PUSZCZA BIAŁOWIESKA



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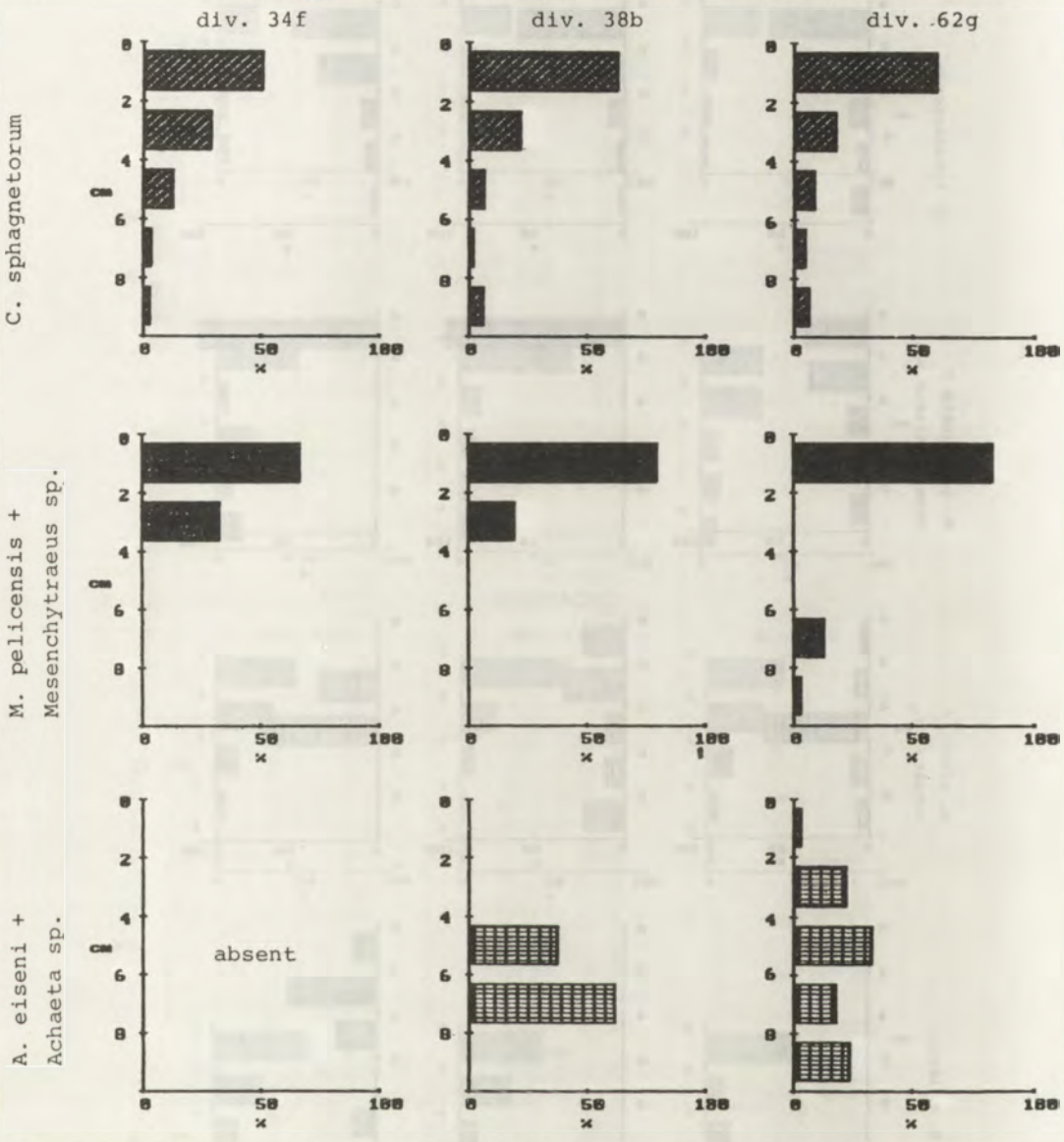

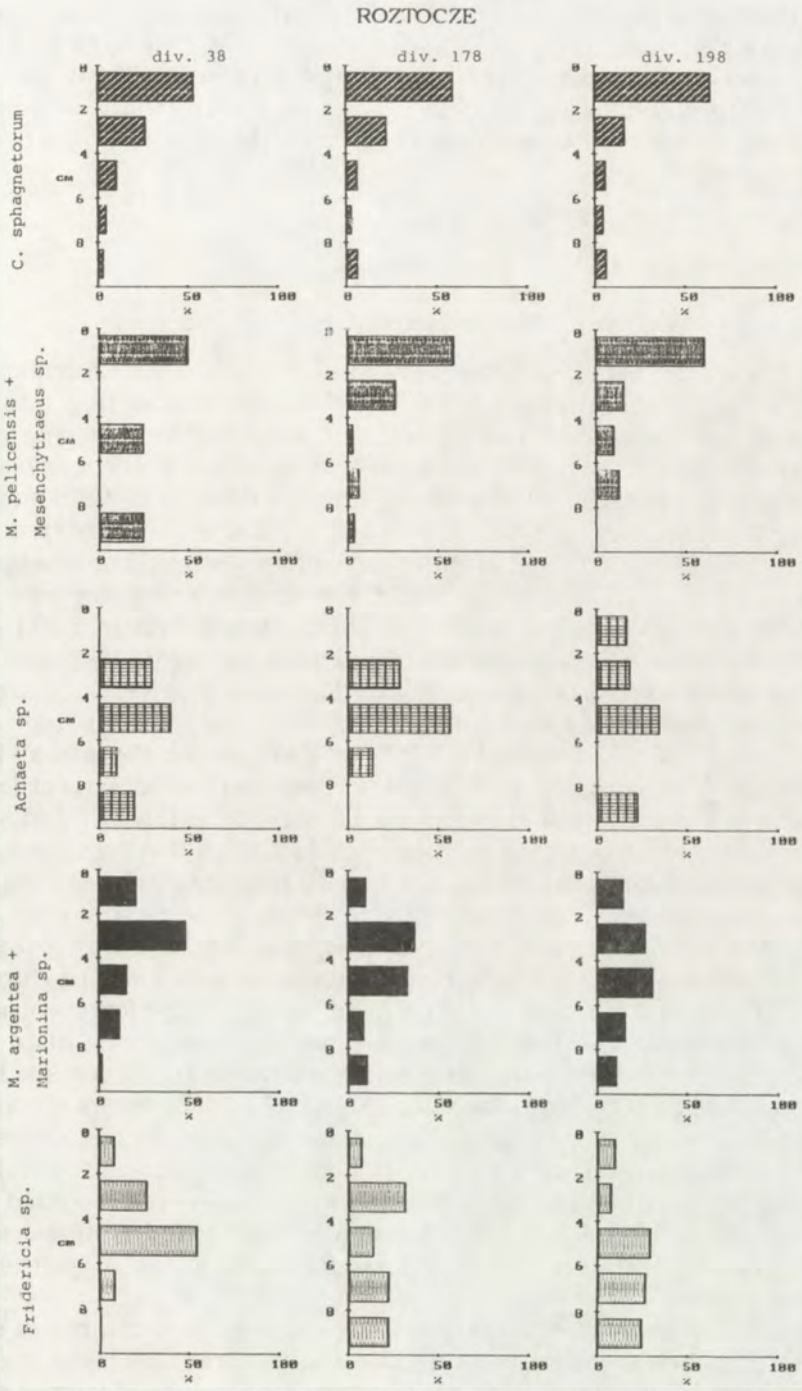

Fig. 8. Vertical distribution of *Enchytraeidae* species of stands studied in: a – Puszcza Białowieska, b – Puszcza Biała, c – Roztocze NP.

The vertical stratification of some of the more numerous *Enchytraeidae* species was also examined (Fig. 8). *C. sphagnetorum*, *M. pelicensis* and individuals of the genus *Mesenchytraeus* were found predominantly in the upper horizons. 60–80% of individuals of these species were found in the first horizon. Enchytraeids of the genera *Achaeta*, *Marionina* and *Fridericia* as well as *B. ehlersi* usually inhabited the deeper strata.

DISCUSSION

Species composition

The list of enchytraeid species registered in the studied pine forests should include three more species known to inhabit pine forests, so that total of 20 *Enchytraeidae* species can be said to occur in Poland. The following are the species that were not recorded in the studied pine forests: *Achaeta bohemica* (VEJD.), *Hemienchytraeus bifurcatus* NIEL et CHRIST., (MAKULEC 1983) and *Buchholzia fallax* MICH. (GÓRNY 1975b). The number of species registered in the studied pine forests varied from 6 to 9: each of the *Peucedano-Pinetum* type forests was inhabited by 6 species, while 8–9 species were observed in the *Leucobryo-Pinetum* type forests. GÓRNY (1975b) registered 7 enchytraeid species in the *Peucedano-Pinetum* type forest in Kampinos NP, while MAKULEC (1983) recorded 8 species in a pine forest also situated in Kampinos NP. Compared with the data on the number of species found in Polish pine forests is high. Three enchytraeid species were registered in pine forests by BęęTH, BERG at al. (1980); HUHTA, HYVONEN, KAASALAINEN (1986), while SPRINGETT (1963) recorded four species. LUNDKVIST (1983) found 6 species of *Enchytraeidae* in Swedish pine forests and so did ABRAHAMSEN and THOMPSON (1979) in their research over a pine-spruce forest. NURMINEN (1967a, b) recorded 6 species at 43 stands within the same vegetation type, one to four species being registered at each stand. ABRAHAMSEN (1972) recorded 8 species in the South-Eastern Norway (2–7 species at each stand). DÓZSA-FARKAS (1985) found as many as 9 species in a Hungarian pine forest. The highest number of enchytraeid species in the forests studied in this research were noted for Bory Tucholskie and Babimost forest distr.

The following species were found in Scandinavian boreal pine forests, but not in Polish pine forests: *Cognettia laponica* NURM., *Mesenchytraeus glandulosus* (LEV.), *Enchytraeus norvegicus* ABRAH. *Marionina simillina* NIEL et CHRIST. was noted in English pine forests. Of the mentioned above species, *M. glandulosus* and *E. norvegicus* have been found in Poland, but they were not recorded during this study. Common to the areas mentioned above is a number of species that also occur in Polish pine forests as *C. sphagnetorum*, *M. flavus*, *M. pelicensis*, *A. eiseni* and *B. ehlersi*.

Hungarian pine forest (DÓZSA-FARKAS 1985) differs considerably in species composition from Polish pine forests. In this forest, three species of the genus *Fridericia* were registered which are not found in pine forests of Poland and the Northern Europe. In Poland, only one species of this genus – *F. bulboides* – was

found in Roztocze NP. The species *Stercutus niveus* MICH. has only been found in Hungarian pine forest and not in any other pine forest.

Species composition of *Enchytraeidae* communities changes with geographical latitude. It also seems that the number of enchytraeid species increases as the climate gets warmer, since the highest numbers of enchytraeid species have been registered in suboceanic pine forests in Poland and Hungary. In Puszcza Kampinoska, located on the border of suboceanic and subcontinental pine forest zones, 7 and 8 species were found.

Occurrence of enchytraeid species under different microhabitats

The results obtained seem to confirm GÓRNY's earlier findings (1975b): the greatest number of species live under the microsite of moss, fewer species are found under litter and bilberry and the fewest – under heath. However, GÓRNY did not find any species that would prefer any microsite of vegetation or litter. He analysed data from two stands in one area (Puszcza Kampinoska), while the present data were gathered at 15 stands in 5 objects. When numbers of species registered under one patch in a given area are compared, it can be seen that there are wide fluctuations in the number of species and one cannot conclude that some microhabitat is particularly preferred by enchytraeids. ABRAHAMSEN (1972) suggests that there may be correlations between vegetation type and the occurrence of some *Enchytraeidae* species. He also speaks of a positive correlation between the number of plant species and the number of *Enchytraeidae* species.

The differences in density between *Enchytraeidae* communities of different microhabitats in the same stand and between communities living under the same microhabitat in different stands seem to confirm GÓRNY's findings (1975b). However, GÓRNY is of the opinion that the species composition and the structure of communities living in two study areas, where the proportions of the plots are different, are similar to each other, the only difference between the two areas being absolute values of density: the density recorded at one of the area was twice as high as that of the other area. Such differences were not recorded in the present study.

Density

The estimation of density of *Enchytraeidae* communities contains some errors. On comparison, data on density obtained by random sampling and the "microhabita" method show both methods to produce similar results. It seems, however, that the latter method gives overestimated results. This is due to the fact that it is impossible to exactly estimate each microhabitat's proportion in the total area. The sum of each microsite's shares sometimes exceeds 100%. Differences in density resulting from fluctuations of the area of the microhabitats are obvious, since plants influence conditions in the soil, especially moisture. It seems, though, that it is safer to use the random sampling method where *Enchytraeidae* show clustered distribution tendencies and do not prefer any particular microhabitat.

The number of samples in each series was sufficient, but samples were taken only twice a year, which does not suffice to provide a complete picture of seasonal fluctuations in the abundance of *Enchytraeidae*. More frequent sampling was impossible with the objects being distant from one another. This method, however, enables researchers to compare data from many stands in a relatively short time.

GÓRNY (1975b) also reported considerable variations in the abundance of *Enchytraeidae* (2800 to 5600 individuals/m^2) at two stands in Puszcza Kampinoska. MAKULEC's average *Enchytraeidae* density figures (1983) were 16 830–54 320 individuals/m^2. Average densities in Norvegian pine forests (ABRAHAMSEN 1972) were from 980 to 47 800 individuals/m^2. The highest density – 81 280 individuals/m^2 – was noted for a *Pinus* litter *Enchytraeidae* community by SPRINGETT (1963). High densities – about 40 000 individuals/m^2 – were noted in Finnish pine forests by HUHTA, HYVONEN, KAASALAINEN at al. (1986). Other papers report lower densities. LUNDKVIST, for instance, noted densities ranging from 6000 to 23 000 individuals/m^2 in coniferous forests of central Sweden; PERSSON, BÅÅTH at al. (1980) reported about 16 000 individuals/m^2 in a 120-years'-old pine forest; DÓZSA-FARKAS noted a density of 15 000 individuals/m^2 in a Hungarian pine forest. HUHTA, NURMINEN, VALPAS (1969) reported variations in density ranging from 5000 to 12 400 individuals/m^2. The fluctuations in density registered in this study are by no means different from those found in other papers. O'CONNOR suggests that the big fluctuations observed result from the tendencies among *Enchytraeidae* to live in groups. The fluctuations are also related to periods of high or low soil moisture that had occurred just before the sampling (ABRAHAMSEN 1972). The watering of microhabitats of moss and bilberry throughout the vegetational season resulted in a triple increase in *Enchytraeidae* density as compared with the control microhabitats (GÓRNY 1975a).

Structure of enchytraeid communities

Well-marked dominance of *C. sphagnetorum* is a phenomenon peculiar to pine forests. PERSSON, BÅÅTH (1980) report that *C. sphagnetorum* dominance index reaches 99.9% in a 120-years'-old pine forest. Similar data are reported by ABRAHAMSEN, THOMPSON (1979) – 95–100%, LUNDKVIST (1983) – 99%, PETERSEN, LUXTON (1982) – 96%, LUNDKVIST (1982) – 90–100%, ABRAHAMSEN (1972) – 98–99%, NURMINEN (1967a) – 85–100%. A little lower dominance indices of *C. sphagnetorum* are reported by DÓZSA-FARKAS (1985) – 78.7% and SPRINGETT – 42% in pine forest litter. In a Polish pine forest, GÓRNY (1975b) obtained for this species dominance index of 82–96%, and MAKULEC (1983) – 94.5% on the average. The results obtained in this study are very close to those found in other papers. Differences in the structure of dominance occur mainly in case of these species which dominance indices are below 1%, which, in turn is due to high indices reported for *C. sphagnetorum*. ABRAHAMSEN (1972) says that the abundance of other species typical of pine forests never exceeds 10% and often rates

below 1%. In the forests studied, the abundance of only a few species exceeded 1%. These are: *A. eiseni*, *M. argentea* and *M. pelicensis*.

Higher dominance indices of species other than *C. sphagnetorum* are reported by NURMINEN (1967a): in a pine forest *B. ehlersi* accounted for up to 50% of a community, while *M. flavus* constituted 10–15%. SPRINGETT (1963) also reported a different structure of dominance for pine forest litter, where *M. simillina* constituted 55% of the community, *M. glandulosus* – 2% and *A. eiseni* – 1%. A completely different structure of an enchytraeid community was reported by PIPER, MACLEAN and CHRISTENSEN (1982) for a *Pinus pumila* pine association located on the border between taiga and tundra: *Mesenchytraeus diverticulatus* PIPER, MACLEAN et CHRIST. – 51% and *Mesenchytraeus* species – 49%.

The similarity of the communities studied is very high, both when data from stands situated in one object are compared and while comparing different objects. This confirms ABRAHAMSEN's assertion (1972) that pine forest *Enchytraeidae* communities are poorly differentiated. Differences in species composition are noticeable in the communities of richer vegetation types.

While examining vertical stratification of *Enchytraeidae* of the stands studied, differences in soil composition, development of soil layers and the type of humus formation should be considered. GÓRNY (1975b) reports that 80–93% of specimens are found in the L, F, H, layers and 3-12 % – in the A1A2 horizons. Those data are similar to the findings of this study: 80–93% of specimens were collected from the L-H horizons, while 7–14% – from the A1A2 horizons. These data differ to some extent from those reported by ABRAHAMSEN (1972). In a Norwegian pine forest, 40% of specimens were found at a depth of 0–2 cm, 27% – at a depth of 2-4 cm and about 15% – at a depth of 4–6 cm. This is probably due to differences in the genetic horizons of the soil. Further evidence is provided here that *C. sphagnetorum* and *M. pelicensis* inhabit the upper layers of the soil, while individuals of the genera *Marionina*, *Achaeta* and *B. ehlersi* usually reside deeper in the soil. The absence of vertical migrations during the vegetational season is also confirmed. Vertical migrations may be caused by changes in soil moisture. Species like *C. sphagnetorum*, *M. pelicensis*, *M. flavus* and *E. buchholzi* are considered humus-related epigean species, while the genera *Achaeta* and *Marionina* and the species *E. parva* are considered mineral soil-related euedaphic species. Similar data on vertical stratification were obtained by SPRINGETT (1963). She reports that individuals of the genus *Mesenchytraeus* and the species *C. sphagnetorum* are the most numerous ones found in the litter, Marionina sp. are most abundant in the humus layer and *Achaeta* sp. – in the mineral soil. However, many species are known to inhabit various layers, so we can only speak of tendencies here, and not of strict correlations. GÓRNY (1975b) registered *B. ehlersi* and *Achaeta* sp. only in the litter and the decomposed matter layer, while only *C. sphagnetorum* occurred below the organic layer.

The occurrence of enchytraeids in relation to soil, sand and humus type was analysed. ABRAHAMSEN (1972) describes correlations between soil structure and the occurrence of enchytraeid species inhabiting mineral soil. He gives the example of *E. parva*, which is most abundant in sandy soil where particles are usually 0.02–0.6 mn and of *E. norvegicus*, which is most abundant where

particles are 0.6–2.0 mn. O'CONNOR (1957) suggests that thick cuticle of *Achaeta* individuals is probably an adaptation for living in compacted soil composed of small particles. However, individuals of this genus were not reported to occur in greater numbers in soils with the more compact veakly loamy sand than in soils which had loose sand in their profile.

An attempt to find differences in the occurrence of enchytraeids related to soil type, the type of sand in soil profile and the type of humus was unsuccessful. This id probably due to relatively small differences in mechanical composition that exist between podzolic and rusty soils and between loose and veakly loamy sand. Whatever the differences, enchytraeids do not perceive them. Some tendencies concerning vertical distribution were found while comparing podzols with "mor" humus and loose sand in profile and veakly loamy sand podzols ("mor" humus). More studies should be carried out in order to confirm the results obtained.

CONCLUSION

Regional diversity

The *Leucobryo-Pinetum*-type forest communities have a greater number of species. Both the total number of species and the numbers of species registered in each area were greater than those of the *Peucedano-Pinetum*-type forests.

The data on species composition, constancy and fidelity of each species, structure of dominance and the graph of similarity indicate that there is only one type on enchytraeid community in the pine forests studied. It is characterized by marked dominance of *C. sphagnetorum*. The core of this community-type also consists of *M. pelicensis* and *Mesenchytraeus* sp. as well as *A. eiseni* and *Achaeta* sp. This community-type is most considerably changed in Roztocze NP where the genera *Marionina* and *Fridericia* occur, *C. sphagnetorum* still being the dominant. Despite these differences, similarity indices are very high and no community-type can be considered characteristic of suboceanic pine forest or subcontinental pine forest only.

Lower densities noted in Bory Tucholskie and Babimost forest distr. are not characteristic for the *Leucobryo-Pinetum*-type forest *Enchytraeidae* communities since the densities recorded in Roztocze NP, which is also a suboceanic pine forest, are similar to those noted in the *Peucedano-Pinetum* – type forests.

Influence of anthropopressure

Because various effects of anthropogenous practices and of phytosociological regional differences are superimposed on one another, it is almost impossible to examine each one separately. The safest method in this case is to compare areas belonging to one vegetation type.

Our studies show that anthropogenous pressure does not result in poorer species composition. However, in areas where the pressure was very strong (Bory Tucholskie, Babimost forest distr.) lower densities of *Enchytraeidae* were recorded. Slight differences in the structure of dominance can hardly be ascribed to

anthropogenous pressure. The analysis of similarity indices does not suggest any influence of anthropogenous pressure either.

It seems, therefore, as strong an anthropopressure observed in the objects studied does not influence the structure of enchytraeid communities, but it has an adverse effect on the densities. Differences in species composition and the structure of dominance are related to local soil conditions and regional phytosociological diversification.

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

STRESZCZENIE

[Tytuł: *Enchytraeidae* (*Oligochaeta*) borów świeżych Polski]

Badaniami objęto strukturę zgrupowań *Enchytraeidae* w sosnowych borach świeżych *Peucedano-Pinetum* i *Leucobryo-Pinetum* położonych w pięciu różnych regionach Polski. Stwierdzono występowanie 17 gatunków. Analiza składu gatunkowego, stałości i wierności występowania poszczególnych gatunków, struktury dominacji oraz diagram podobieństw wykazały istnienie jednego zgrupowania *Enchytraeidae* w borach świeżych. Charakteryzuje się ono wysoką

dominacją *C. sphagnetorum*. W skład trzonu tego zgrupowania wchodzą także *M. pelicensis* i *A. eiseni*.

Nie stwierdzono różnic w frekwencji gatunków w próbach z różnych płatów roślinności. Średnie zagęszczenie wahało się od 11 780 do 29 260 osob./m^2. Przeprowadzona analiza rozmieszczenia pionowego *Enchytraeidae* w zależności od typu gleby, ściółki i w różnych płatach roślinności nie wykazała znaczących różnic ilościowych. Istnieją natomiast różnice w stratyfikacji pionowej poszczególnych gatunków.

Bory *Leucobryo-Pinetum* charakteryzują się większym bogactwem gatunkowym niż *Peucedano-Pinetum*. Stopień nasilenia antropopresji w badanych borach nie ma wpływu na strukturę zgrupowań wazonkowców, wpływa natomiast ograniczająco na ich zagęszczenia.

Redaktor pracy – prof. dr hab. R. Pisarska