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**Communities of *Enchytraeidae* (*Oligochaeta*) in the pine forest
succession sere of Puszcza Białowieska**

Abstract. The structure of *Enchytraeidae* communities inhabiting the soil in pine forest stands of various ages situated in Puszcza Białowieska has been analysed. The greatest transformations in *Enchytraeidae* communities have been observed in younger stands. Older stages of the sere are characterized by stabilization of the communities, which is associated with the establishment of specific soil conditions resulting from humus formation.

INTRODUCTION

Enchytraeidae are among the most abundant groups of soil mesofauna. They are particularly important in mesotrophic pine forests, where earthworms occur in very small numbers. Coniferous litter decomposition is accomplished mainly by small soil organisms such as enchytraeids, mites and springtails. *Enchytraeidae* participate in the process of humification, contributing to the formation of mineral-organic complexes constituting the moder type of humus. Their contribution to the mineralization processes is considerable as they occur in abundance and have a high metabolic rate. The aim of this study was to analyse the structural transformations of *Enchytraeidae* communities developing in the course of succession of the pine forest. The changes were assessed by examining species composition, abundance, structure of dominance as well as actual and potential species diversity.

The papers dealing with the occurrence of enchytraeids in Polish pine forests are concerned with the species composition and abundance of their communities. Papers by GÓRNY (1975) and MAKULEC (1983) are concerned with the occurrence of enchytraeids in Puszcza Kampinoska. A paper by PILIPIUK (1993) provides a more detailed insight into the structure of *Enchytraeidae* communities in five forest complexes representing either the suboceanic

(*Leucobryo-Pinetum* – Babimost forest district, Bory Tucholskie, Roztocze NP) or subcontinental (*Peucedano-Pinetum* – Puszcza Biała and Puszcza Białowieska) association types. There is, however, lack of data on the occurrence of enchytraeids in stands of various ages in Poland, such that could allow to trace the course of succession. Such studies have been carried out in Scandinavia by HUHTA, KARPINEN, NURMINEN and VALPAS (1967) and HUHTA, NURMINEN and VALPAS (1969). They were, however, concerned only with abundance changes and did not contain data on species composition. LOHM, LUNDKVIST, PERSSON and WIREN (1977) have conducted a more detailed study of enchytraeid communities in pine forest stands of various ages.

By analysing enchytraeid communities in stands of various forest ages one can examine changes occurring in the ecosystem under study in the process of succession. Changes in soil conditions, observed in the course of succession, are accompanied by changes in the species composition, abundance and dominance structure of *Enchytraeidae* communities.

AREAS, METHODS AND MATERIAL

The study was conducted in four succession stages of the pine forest sere in Puszcza Białowieska, which represents the subcontinental (*Peucedano-Pinetum*) habitat type of the pine forest. The stages analysed were: culture (2–3 years), young stand (15–20 years), pole wood (40–60 years) and mature forest (100–110).

20 samples, 20 sq. cm in area and 15 cm deep, were taken at each study site. The specimens were then extracted according to O'Connor's method. In order to drive the enchytraeids out of the samples, they were heated from above with 40 W bulbs, resulting in the animals moving down to tubes filled with cold water entering the samples from below. The material obtained in this way consisted of 2317 individuals, which were subsequently life-determined. The material comprised 465 specimens from the culture stage, 389 from young stands, 659 from the pole wood and 804 from mature forests.

The following indices were used to describe the communities studied: Sørensen's index of species composition similarity, Morisita's index (modified by Horn) of dominance structure similarity, an index of dominance, and Shannon-Weaver's index of general diversity. The following models of species abundance distribution in a community were also tested: geometrical series, broken stick model, logarithmic series, lognormal series and negative binomial distribution. They are described in detail in a paper by TROJAN (1992).

RESULTS

10 species of enchytraeids were recorded in the stands studied in the four age classes of forest (Tab. I). An earlier study of the mature forest in Puszcza Białowieska yielded 6 species, with at least 5–6 found per site. Studies of other *Peucedano-Pinetum* forests: in Puszcza Biała (PILIPIUK 1993) and in Białołęka Dworska (KASPRZAK 1981) also resulted in finding 6 enchytraeid species. In their

earlier studies of Puszcza Kampinoska, GÓRNY (1975) found 6 species, and MAKULEC (1983) – 8 species. The total number of *Enchytraeidae* species ever recorded in these forests is now 16. All the above data pertain to older stands. On the other hand, LOHM et al. (1977) found only 2 *Enchytraeidae* species in pine forest stands of various age. *Cognettia sphagnetorum* was a species which occurred in all Polish pine forests of the *Peucedano-Pinetum* type. This species is constant for coniferous forests, exhibits broad environmental range, reacting quickly to the changing conditions, reproduces asexually through fragmentation. Other species frequently occurring in pine forests include: *Mesenchytraeus pelicensis* and *Bryodrilus ehlersi* as well as species of the genus *Achaeta*.

Table I. Species composition and density of *Enchytraeidae* in pine forest stands of various ages in Puszcza Białowieska.

Species	Culture		Young stand		Pole wood		Mature stand	
	n/m ²	%	n/m ²	%	n/m ²	%	n/m ²	%
<i>Mesenchytraeus pelicensis</i> ISSEL.					50	0,3		
<i>Mesenchytraeus</i> sp.			125	1,29	775	4,71	375	1,87
<i>Buchholzia simplex</i> NIEL. et CHRIST.			50	0,51				
<i>Buchholzia</i> sp.			25	0,26				
<i>Bryodrilus ehlersi</i> UDE			25	0,26				
<i>Cognettia sphagnetorum</i> (VEJD.)	11625	100	9400	96,65	15525	94,23	19325	96,14
<i>Marionina</i> sp.			50	0,51	125	0,76		
<i>Fridericia ratzeli</i> EIS.			25	0,26				
<i>Fridericia</i> sp.			25	0,26				
<i>Achaeta</i> sp.							400	1,99
Total	11625		9725	100	16475	100	20100	100

A comparison of the number of species registered in the stands studied reveals that the highest number of species was registered in young stands (8), and the lowest – in pine cultures (1). The pole wood accommodate fewer species – 4, and mature stands, 3. The species composition of *Enchytraeidae* communities differed among the age classes (Tab. I). While leaving aside the reduction of the number of species to just one species in the first stage of succession, it can be noticed that young stands create conditions for the survival of 7 more species. In the subsequent stages of succession, the structure of the community is reduced due to elimination of accessory species occurring in the young stand stage, although there appear new species that do not occur in earlier stages.

The similarity of species composition, expressed as Soerensen's index, is the highest for communities inhabiting the soil in the pole wood and mature forest (57%), reaching minimum values for culture and young stand *Enchytraeidae* communities (22%). Thus, as the ecosystem matures, *Enchytraeidae* communities become more and more similar with respect to species composition.

The communities under study are characterized by a relatively uniform structure of dominance. The share of the dominant species is subject to little variation in individual stands. *Cognettia sphagnetorum* is the dominant at all the stands, constituting from 94% to 100% of the community. The core of the community in all succession stages except the culture stage is also formed of species of the genus *Mesenchytraeus* (Tab. I). In all but the first stage of succession, the core consists of the same species, while changes take place in the group of species of smaller shares in the structure of dominance.

All the communities studied were shown to possess very similar structures of dominance, expressed as Morisita's index, which equalled 0.99 in all cases.

An assessment was made of the degree of correspondence of the structure of the *Enchytraeidae* communities under study to the five models on which structural analysis was based (TROJAN 1992). An assessment of the probability that the empirical distributions will correspond to the models, conducted using the chi-square test, showed that the structures of communities from certain stands bear some similarity to the theoretical distributions (Tab. II).

Table II. The probability of correspondence of the structures of *Enchytraeidae* communities to theoretical models of species abundance distribution.

Stand age	szpg	mppz	szlog	szln	rdn
Culture	1.00	-	-	-	-
Young stand	0.00	0.00	0.00	-	0.00
Pole wood	0.00	0.00	0.57	-	0.14
Mature stand	1.00	1.00	-	1.00	1.00

szpg= geometrical series
 mppz= broken stick model
 szlog= logarithmic series
 szln= lognormal series
 rdn= negative binomial distribution

The correspondence of the empirical abundance distribution to the negative binomial distribution enables to estimate the potential number of species for the community inhabiting the soil in mature stands. It was shown that the number of species registered best reflects the actual species capacity since the actual number of species is equal to the prediction. Such estimation cannot be provided for other succession stages due to the small degree of correspondence between the empirical and theoretical distributions.

Communities of enchytraeids inhabiting younger stands are characterized by smaller density than those from older stands. The lowest abundance of enchytraeids was noted in young stands, the highest in mature forest. The community reaches optimum living conditions in the most mature stage of the sere (Tab. I).

Species diversity of enchytraeids is substantially influenced by structural relations. The actual diversity (H') equals 0 in the first stage and never exceeds

0.4 in the subsequent stages. Greater changes are observed in potential diversity (H_{max}). It reaches a maximum in the young stand stage to decrease considerably in the subsequent stages. The degree of realization of the habitat potential for the development of community diversity is low, not exceeding 20% throughout the sere (Tab. III).

Table III. Species diversity of *Enchytraeidae* communities.

Stand age	H'	H'max
Culture	0.00	0.00
Young stand	0.36	3.00
Pole wood	0.38	2.00
Mature stand	0.28	0.16

where:

H' - Shannon and Weaver's index

H'max - value of H'

Three succession stages - young stands, the pole wood and mature stands - are habitats of higher potential species diversity. It is indicated that species diversity, expressed as the maximum values of the H' index - H'max, can be higher in each of these stands. The communities inhabiting these stands realize the potential to a small extent.

CONCLUSIONS

1. *Enchytraeidae* communities occurring in the soil of mature pine stands in Puszcza Białowieska are similar to communities inhabiting subcontinental (*Peucedano-Pinetum*) pine forests as regards species composition and dominance structure.

2. Secondary succession is associated with transformations of *Enchytraeidae* communities.

3. In the initial stage of succession (culture), when the soil is most degraded, only one *Enchytraeidae* species survives. The species is dominant in the subsequent stages.

4. The greatest number of species occur in young stands. The parameter decreases afterwards.

5. The structures of dominance in three succession stages are similar.

6. The abundance of enchytraeid communities is higher in older stands than in earlier stages of succession.

7. Species diversity is the lowest in the most mature stand.

8. The greatest transformations of enchytraeid communities take place in the earlier stages of the sere: culture and young stands. In older stages the community becomes stabilized. This is related to stabilization of habitat

conditions, type of humus and rate of its formation, which prevents sudden changes in soil conditions.

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STRESZCZENIE

[Tytuł: Zgrupowania *Enchytraeidae* w szeregu sukcesyjnym borów świeżych Puszczy Białowieskiej.]

Analizowano zmiany, jakim podlegają w trakcie sukcesji zgrupowania wazonkowców. W tym celu porównano skład gatunkowy i strukturę zgrupowań tych zwierząt w różnowiekowych drzewostanach sosnowych. Badaniami objęto 4 stadia sukcesyjne boru świeżego *Peucedano-Pinetum* w Puszczy Białowieskiej. Stwierdzono, że największe przekształcenia zgrupowań *Enchytraeidae* mają miejsce w młodszych stadiach szeregu sukcesyjnego. Wykształcenie warstwy humusu, jakie następuje w starszych drzewostanach, przeciwdziała gwałtownym zmianom warunków glebowych i sprzyja powstaniu bardziej stabilnych zgrupowań wazonkowców o najniższej różnorodności gatunkowej i najwyższej liczebności.