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***Lumbricidae* of linden-oak-hornbeam forests of the Mazovian Lowland**

[With 2 Tables and 2 Figures in the text]

Abstract. Species composition, abundance and dominance structure of earthworm associations from linden-oak-hornbeam (*Tilio-Carpinetum*) forests of the Mazovian Lowland were analysed. Occurrence of seven species was stated. There was no association of *Lumbricidae*, characteristic of *Tilio-Carpinetum* forests. The analysed associations present an intermediate form between the associations occurring in coniferous forests and those from environments, with soil pH close to neutral.

INTRODUCTION

Family *Lumbricidae* has an important part in the decomposition and retention of the organic matter. In consequence of high ecological amplitude it inhabits almost all biotopes. Three groups of earthworms have been distinguished on the basis of individual characteristics and trophic specialization: surface (litter feeders) species, mixed-type species (penetrating humus and mineral soil), and a third group of species, which lives mainly in the mineral soil. This classification is connected also with different tolerance of earthworms to the acidification and moisture of the soil. Simultaneously these are the main factors, which influence the formation of associations of *Lumbricidae* in various environmental conditions.

In the afforested territories in Poland the occurrence of fifteen species of *Lumbricidae* was stated. Out of these, 10 species occurred in lowland forests (PLISKO 1973). Usually there are no data on the occurrence of earthworms in different forest types. Most often the information given concerns, whether these are deciduous or coniferous forests. More precise data on *Tilio-Carpi-*

netum forests can be found in the studies of PLISKO (1969), who stated, the occurrence of four species of earthworms in this type of forest, and PILIPIUK (1981), where three species of *Lumbricidae* are listed. ROŻEN (1982) reported the occurrence of eight species of *Lumbricidae* in the *Tilio-Carpinetum* forests of the Niepołomicka Forest. In a study on the occurrence of earthworm associations in various environments in the southern Sweden, NORDSTRÖM and RUNDGREN (1973) reported the occurrence of eleven species of earthworms in the similar type forests of Skania.

The aim of the present study was to analyse the fauna of *Lumbricidae* of the *Tilio-Carpinetum* forests of the Mazovian Lowland. Species composition, density and dominance structure of the associations of the studied groups of animals were estimated.

STUDY AREA, METHODS, MATERIAL

The studies were carried out in 1976–1982 on five plots in *Tilio-Carpinetum* forests:

1. Dębina reserve, near Klembów — brown earths, mull type humus:
A — a typical *Tilio-Carpinetum*, moist forest;
B — a humid variant of the typical *Tilio-Carpinetum*, wet forest;
2. Modrzewina reserve near Belsk — degraded brown leached earths;
3. Cyganka reserve near Truskaw in the Kampinos National Park — soil of the degraded black earth type, mull type humus;
4. *Tilio-Carpinetum* forest in Radziejowice — brown earths, acidified.

A geobotanic characteristic of these sites is given in the introductory paper by KOTOWSKA and NOWAKOWSKI (1989) and the general outline of the research project — in the study by BAŃKOWSKA and GARBARCZYK (1989).

The material was collected by the SATCHELL formaldehyde method 4–5 times during the vegetation season (April–October). Earthworms were simultaneously dislodged from 3 samples of a total surface area of 1 m². In this purpose 0.3 % formalin solution was used. Altogether 1746 specimens of earthworms were collected.

RESULTS

1. Species composition

In the studied *Tilio-Carpinetum* forests the occurrence of seven species of earthworms was stated. These are the following: *Aporrectodea caliginosa* SAV., *A. rosea* SAV., *Dendrobaena octaedra* SAV., *Dendrodrilus rubidus* SAV., *Lumbricus rubellus* HOFFM., *L. terrestris* L., *Octolasion lacteum* OERLEY.

Table I. Species composition and average density of earthworms on the studied sites (individuals/m²)

No.	Species	Site				
		Dębina res. (A)	Dębina res. (B)	Modrzewina res.	Cyganka res.	Radziejowice
1	<i>Aporrectodea caliginosa</i>	6.9	1.2	0.6	—	0.3
2	<i>Aporrectodea rosea</i>	5.2	11.9	0.1	—	—
	<i>Aporrectodea</i> sp.	28.3	22.6	3.8	—	—
3	<i>Dendrobeana octaedra</i>	11.7	10.2	2.6	6.4	9.8
4	<i>Dendrodrilus rubidus</i>	0.2	0.9	1.0	0.4	0.3
	<i>Dendrobeana</i> sp.	10.9	18.6	5.9	12.3	8.5
5	<i>Lumbricus rubellus</i>	1.1	2.4	—	0.9	—
6	<i>Lumbricus terrestris</i>	—	—	4.1	—	7.2
	<i>Lumbricus</i> sp.	1.9	1.1	5.0	0.3	2.3
7	<i>Octolasion lacteum</i>	—	3.1	1.3	1.1	—
	<i>Octolasion</i> sp.	—	0.7	0.2	1.7	—
	Total	66.2	72.7	24.6	23.1	28.4
	N species	5	6	6	4	4

From four to six species of earthworms occurred on individual sites (Tab. I). Four species of earthworms occurred in a spot of *Tilio-Carpinetum* in an alder carr (Kampinos National Park): *D. octaedra*, *D. rubidus*, *L. rubellus* and *Eiseniella tetraedra* SAV. (PLISKO 1969). Three species: *A. caliginosa*, *A. rosea* and *L. terrestris* occurred in the *Tilio-Carpinetum* forest in Białołęka Dworska (remnants of a former park of 0.4 ha in surface area, surrounded with arable land) (PILIPIUK 1981). Altogether 8 species are known from the *Tilio-Carpinetum* forests of the Mazovian Lowland. *A. caliginosa*, *D. octaedra* and *D. rubidus* are absolutely constant, *A. rosea*, *L. rubellus* and *O. lacteum* are constant and *L. terrestris* is an accessory species in the studied forests. In the *Tilio-Carpinetum* forests of the Niepolomicka Forest *L. terrestris* was not present, but another species occurred there — *Fitzingeria platyura* f. *montana* (CERNOVITOV) (ROŻEN 1982). This is a species, which occurs in the southern Poland in montane and submontane regions. From six to eleven species of *Lumbricidae* occurred in the *Tilio-Carpinetum* forests of southern Sweden. Apart from the species, which occur in the discussed forests of the Mazovian Lowland three more species were reported: *Allolobophora chlorotica* SAV., *Aporrectodea longa* UDE and *Lumbricus castaneus* SAV. (NORDSTRÖM and RUNDGREN 1973).

The similarity of earthworm associations from the five studied sites was evaluated with MRŠIĆ index (MRŠIĆ 1982). From the values of this index it follows, that the similarity was highest between the associations from the two sites in the Dębina reserve. This similarity arises from the habitat conditions, which are alike on these sites. Slightly lower is the similarity between the associations from the sites in Radziejowice and Cyganka reserves, and between

the former and Modrzewina reserve (Fig. 1). The similarity between the associations from the humid variant in the Dębina reserve and Radziejowice *Tilio-Carpinetum* was the lowest. These sites differ in the degree of acidity and humidity of the soil.

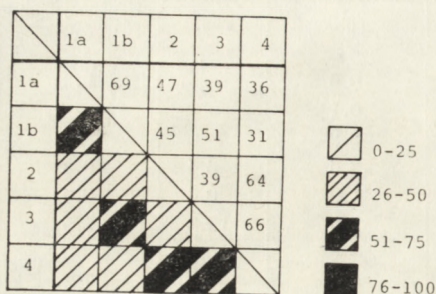


Fig. 1. Similarity index (after MRŠIĆ) of earthworm associations on the studied plots.

2. Abundance

Large differences were found in the density of earthworms per m². It varies from 23 to 73 individuals/m² on individual sites. Similar average densities of earthworms were found on three sites: in Modrzewina and Cyganka reserves and in the Radziejowice forest. Much higher abundances of earthworms were noted for the Dębina reserve in the typical *Tilio-Carpinetum* as well as in its humid variant. On this site the soils are brown, undegraded, characterized with high humidity, what ensures good conditions for the development of earthworms. For comparison, in the Białoleka Dworska *Tilio-Carpinetum* the density of earthworms was 54 ind./m². In more fertile and humid the same types of forests in Scania the earthworm density was much higher. It ranged from 67 to 226 ind./m² (NORDSTRÖM and RUNDGREN 1973).

3. Ecological analysis

Of the species, which occur in the studied forests, *D. octaedra* and *D. rubidus* belong to surface-living species. They are most abundant in soils of a low pH (3.3–5.5). *O. lacteum* and *L. rubellus* represent the "mixed" type. They occur in litter and in the mineral soil as well. *O. lacteum* prefers less acid soils of pH 5.5–6.5 and of higher humidity. The remaining deep-burrowing three species: *A. caliginosa*, *A. rosea* and *L. terrestris* live in the mineral soil and do not tolerate considerable acidification of the soil. In general, they prefer soils of pH above 4.5. *E. tetraedra*, a species reported from *Tilio-Carpinetum* forests by PLISKO (1969), is amphibiotic, and prefers soil pH between 3.8 and 4.5. In spite of their wide tolerance to soil acidity, the discussed species form abundant populations, only in the given ranges of pH (NORDSTRÖM and RUNDGREN 1974).

These authors stated, that *D. octaedra* and *O. lacteum* occur commonly in fertile similar forests, but their density is low. Thus the occurrence of *D. octaedra* on all sites in the studied forests speaks for considerable acidification of the soils.

4. Dominance structure

Dominance structure of earthworm associations varies considerably from site to site (Fig. 2). On the site of the typical *Tilio-Carpinetum* on the Dębina forest reserve, the dominance index values are similar for three species of earthworms (included juvenile forms): *A. caliginosa* — 35%, *D. octaedra* — 34% and *A. rosea* — 26%. In the humid variant of *Tilio-Carpinetum* on this site *A. rosea* accounts for 45% and *D. octaedra* for 38%. *L. terrestris* (37%) dominated in the Modrzewina reserve and *D. octaedra* accounted for 28% of earthworms, which occur there. There was some degree of similarity between the earthworm associations from these three sites to the *L. terrestris* — *A. caliginosa* — *A. rosea* association (NORDSTRÖM 1976), which is marked for its species richness and high density. In all the studied associations, however, *D. octaedra* is the subdominant, what brings about considerable differences in the structure of these associations. In the Cyganka reserve, and in Radziejowice *D. octaedra* dominated, and accounts for 78% of earthworms occurring in the former and for 64% in the latter forest. *L. terrestris* (33%) is a second abundant species

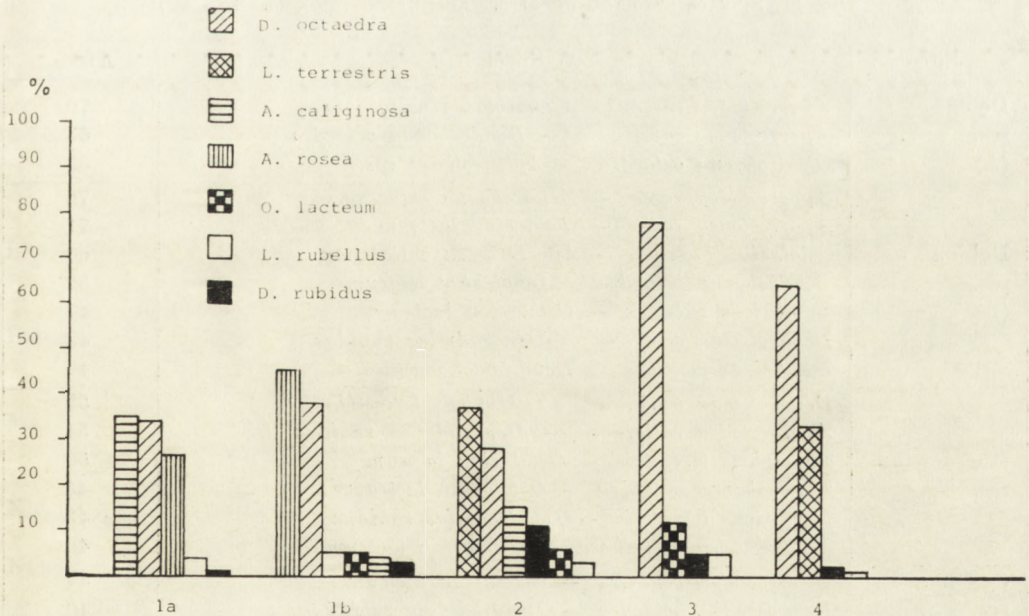


Fig. 2. Dominance structure of earthworm associations on the studied plots.

in Radziejowice. *A. caliginosa* and *D. rubidus* occur there also, but in small numbers. The earthworm association occurring in the Cyganka reserve is identical to the *D. octaedra* association described by NORDSTRÖM and RUNDGREN (1973) as characteristic for coniferous forests. This association is poorer in species and of low density (Tab. I). The characteristic species are *D. octaedra* and *D. rubidus*, frequently also *L. rubellus* and *A. caliginosa*. The presence of a mixed coniferous forest in the close neighbourhood was the cause of the formation of this association. The *Tilio-Carpinetum* forest there is in a form of a narrow belt between a marsh in a depression without an outlet, and a mixed coniferous forest, and can be treated as an ecotone. The presence of a considerable proportion of *L. terrestris* on the site in Radziejowice, besides the dominance of *D. octaedra*, causes this association to be different from any of the known associations of earthworms. The influence of the neighbouring mixed coniferous forest is marked on this site too. *A. caliginosa* – *L. terrestris* – *A. rosea* association occurred in the *Tilio-Carpinetum* forest in Białoleka Dworska (PILIPIUK 1981). Thus there is no typical association of earthworms, characteristic of *Tilio-Carpinetum* forests of the Mazovian Lowland. Deciduous forests of Skania, which differ floristically from the studied forests and are more fertile and humid, various associations of earthworms occurred, usually either *D. octaedra* – *L. rubellus* or *A. rosea* – *A. caliginosa* – *L. terrestris* (NORDSTRÖM and RUNDGREN 1973).

Table II. Species association, after SÖRENSEN index (AIS > 40)

Site	Species	AIS
Dębina res. (A)	<i>Aporrectodea rosea</i> – <i>Aporrectodea caliginosa</i>	70
	<i>Aporrectodea caliginosa</i> – <i>Dendrobaena octaedra</i>	63
	<i>Dendrobaena octaedra</i> – <i>Aporrectodea rosea</i>	53
Dębina res. (B)	<i>Aporrectodea rosea</i> – <i>Dendrobaena octaedra</i>	76
	<i>Aporrectodea rosea</i> – <i>Octolasion lacteum</i>	71
	<i>Octolasion lacteum</i> – <i>Aporrectodea caliginosa</i>	60
	<i>Dendrobaena octaedra</i> – <i>Octolasion lacteum</i>	52
	<i>Lumbricus rubellus</i> – <i>Octolasion lacteum</i>	47
	<i>Dendrobaena octaedra</i> – <i>Dendrodrilus rubidus</i>	42
Modrzewina res.	<i>Lumbricus rubellus</i> – <i>Dendrobaena octaedra</i>	40
	<i>Dendrobaena octaedra</i> – <i>Lumbricus terrestris</i>	59
	<i>Aporrectodea caliginosa</i> – <i>Dendrodrilus rubidus</i>	54
	<i>Lumbricus terrestris</i> – <i>Octolasion lacteum</i>	50
	<i>Dendrobaena octaedra</i> – <i>Octolasion lacteum</i>	45
	<i>Lumbricus terrestris</i> – <i>Dendrodrilus rubidus</i>	43
Cyganka res.	<i>Aporrectodea caliginosa</i> – <i>Octolasion lacteum</i>	40
	<i>Dendrobaena octaedra</i> – <i>Octolasion lacteum</i>	44
Radziejowice	<i>Dendrobaena octaedra</i> – <i>Dendrodrilus rubidus</i>	40
	<i>Lumbricus terrestris</i> – <i>Dendrobaena octaedra</i>	61

SÖRENSEN index (AIS) (Tab. II) was calculated in order to evaluate species association on individual sites. The highest index values were noted for the species from the sites in the Dębina reserve. In the typical *Tilio-Carpinetum* the most strongly associated were *A. rosea*, *D. octaedra* and *O. lacteum*. In the Modrzewina reserve and in Radziejowice *D. octaedra* and *L. terrestris* were the most strongly associated species. The lowest values of this index were noted for the Cyganka reserve, where relatively most associated were *D. octaedra* and *O. lacteum*. Thus the most strongly associated were the species with the highest per-cent proportions and on them the structure of the studied associations is based.

SUMMARY

Seven species of earthworms, common in the Mazovian Lowland occurred in the *Tilio-Carpinetum* forests. Differences in the species composition, abundance and structure of the studied associations are considerable. A marked per-cent proportion of *D. octaedra* on all study sites speaks for strong acidification of the soil. Modifications of the associations depends on changes of the floristical composition and the degree of the soil acidification. There is no single association of earthworms, characteristic for *Tilio-Carpinetum* forests. There is a number of them, as indicated by the species composition, dominance structure, species association and similarity indices of associations. They are an intermediate form between the associations occurring in coniferous forests and those from environments with soil pH close to neutral, as in urban lawns (PILIPIUK, unpublished data) and arable soils (NORDSTRÖM 1976).

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STRESZCZENIE

[Tytuł: *Lumbricidae* lasów grądowych Niziny Mazowieckiej]

W badanych lasach grądowych stwierdzono występowanie 7 gatunków dżdżownic. Największe podobieństwo wykazują zespoły dżdżownic na stanowiskach o najbardziej zbliżonych warunkach siedliskowych. Zespoły dżdżownic ze stanowisk różniących się znacznie stopniem zakwaszenia i wilgotnością gleby są natomiast najbardziej odmienne. Największe zagęszczenie osiągała omawiana grupa zwierząt na stanowiskach o glebach brunatnych, niezdegradowanych, o dużej wilgotności. Występowanie na wszystkich stanowiskach w badanych lasach gatunku *D. octaedra* świadczy o dość znacznym zakwaszeniu gleby. W analizowanych grądach występują różne zespoły dżdżownic. Kilka z nich wykazuje cechy podobne do zespołu *L. terrestris*—*A. caliginosa*—*A. rosea*, jednak wszędzie gatunkiem subdominującym jest *D. octaedra*, co powoduje różnice w budowie tych asocjacji. Pozostałe zespoły są identyczne z asocjacją *D. octaedra*, charakterystyczną dla lasów iglastych. Nie stwierdzono jednego, charakterystycznego dla lasów grądowych, zespołu dżdżownic. Zespoły badanych lasów stanowią formę pośrednią między asocjacjami występującymi w borach a zgrupowaniami, jakie znajdowano w glebach zieleńców miejskich lub na polach uprawnych.

РЕЗИОМЕ

[Заглавие: *Lumbricidae* лесов гряда Мазовецкой низменности]

В исследованных липово-грабовых лесах найдено 7 видов дождевых червей. Наибольшего сходства достигают сообщества лумбрицид из местонахождений с наиболее сходными условиями среды. Сообщества из место-

нахождений, которые значительно отличаются степенью кислотности почвы и ее влажностью наиболее различаются. Наибольшую плотность достигли лумбрициды на коричневых почвах, не подверженных деградации, с высокой влажностью. *D. octaedra* встречался на всех станциях в исследованных лесах, что свидетельствует о значительной кислотности почвы. В анализируемых грудках встречаются различные сообщества лумбрицид. У нескольких из них наблюдаются сходные признаки с сообществом *L. terrestris* — *A. caliginosa* — *A. rosea*, однако субдоминирующим видом является везде *D. octaedra*, что ведет к различиям в строении этих сообществ. Остальные сообщества идентичны с ассоциацией *D. octaedra*, характерной для хвойных лесов. В исследованных лесах отсутствует одно сообщество, характерное для грудки. Сообщества исследованных лесов занимают промежуточное положение между ассоциациями, встречающимися в борах и теми, которые встречались в почвах городских зеленых территорий и культивируемых полей.
