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STRUCTURE OF ENCHYTRAEID (*OLIGOCHAETA*, *ENCHYTRAEIDAE*) COMMUNITIES IN URBAN GREEN AREAS OF WARSAW

ABSTRACT

Enchytraeids occurring in soils of green habitats in parks, housing estates, and streetside greens in Warsaw comprised 22 species. Their mean density was about 8000 individuals \times m⁻². A particularly high density was recorded in green areas of loosely built-up housing estates (about 1 000 individuals \times m⁻², on the average). The genus *Fridericia* reached the highest proportion in the community. Large fluctuations in enchytraeid density over the year were caused by different cultivation treatments on the lawns and by heavy seasonal over-drying. Intense traffic did not effect much the occurrence and density of this group. The important factors were soil type, moisture, content of organic matter, age of vegetation, also the type and intensity of cultivation treatments.

INTRODUCTION

Enchytraeids are common saprophages humifying organic matter in soils of different types. They belong to most important biocoenotic regulatory factors in soil, since they usually occur in high densities, have a high feeding rate, and largely stimulate microbiological decomposition of soil organic matter. They play an important part in many soil-forming processes, particularly in structuring the soil and increasing its fertility, this being of great importance to heavily degraded urban soils. The enchytraeids of urban areas of Warsaw are relatively well known (Kasprzak 1981a, b, Kasprzak et al. 1979). But so far no quantitative data were available, particularly on the density of enchytraeid worms in different types of urban habitats on the structure of their communities and species diversity. These issues are discussed in the present paper.

STUDY AREAS AND METHODS

Soil samples were taken from three types of urban green habitats: parks, green areas of housing estates (closely and loosely built-up), and

streetside green areas (adjacent to large parks and isolated). The following urban parks were under study: the Łazienki Park (plots I, II, and IV¹), the park at the Cemetery of Soviet Soldiers (plots I and II), the Saxon Garden (plot II), and the Praski Park (plots I, II and III). Green habitats of loosely built-up areas were examined on two plots (I, II) of Wierzbno housing estate, and those of closely built-up areas were examined at Wilcza Street, M.D.M. (plots I, II), and Hoża Street. The streetside green areas adjacent to parks were represented by Ujazdowskie Avenue, Żwirki i Wigury Avenue (plot I), Marszałkowska Street, Woronicza Street, and Niepodległości Avenue. An isolated streetside plot was examined at Grójecka Street. Also some data were used on suburban habitats (the quarter Białołęka Dworska in Warsaw and the palace park in Ursynów). All these study sites, like most of the Warsaw area, are located on the site of a potential linden-oak-hornbeam (*Tilio-Carpinetum*) community. Their detailed description is given by Kubicka, Chudzicka, and Wysocki in this volume. All the plots were sampled on the following dates: September 3—10 and October 22, 1974, April 15—22 and June 20—24, 1975 (leg. et det. M. Górny), and September 15, 1976, May 24 and September 23, 1977 (leg. et det. K. Kasprzak). In 1974—1975 the samples were 20 cm² in surface area, 5 cm deep, and 100 cm³ in volume, while in 1975—1977 the respective dimensions were 8.6 cm², 9.5 cm, and 81 cm³. The samples were taken by means of a device which did not disturb the natural soil layering. A series of ten samples was taken each time from each plot. In the two study periods, a total of 1070 samples was taken from all the plots containing 8600 individuals. Enchytraeid worms were extracted from soil at 40°C for 3 hours using O'Connor's (1955, 1971) method. They were identified to species in vivo and from preparations according to the method developed by Nielsen and Christensen (1959) and modified by Kasprzak (1975a, in print). Also unpublished data of Górny (1974, 1975) are used here.

SPECIES RICHNESS AND DENSITY

Enchytraeid worms occurring in urban green areas of Warsaw consisted of 22 species representing 8 genera (Tab. 1). They accounted for about 25% of all the enchytraeid species recorded in Poland so far (Kasprzak 1981a). It should be noted that the number of species occurring in Warsaw is high as compared with other habitats. A similar high number of species was recorded, for example, in the soil of mid-forest meadows

¹ The symbols of plots according to Kubicka et al. (1986).

(Kairesalo 1978) and beech forests (Dozsa-Farkas 1973). Soil, decaying logs, and litter of a natural oak-hornbeam (*Querceto-Carpinetum*) forest were inhabited by 26 species (Kasprzak 1975b). The density of most enchytraeid species, including most abundant species occurring in Warsaw, in many habitats of Poland is unknown. The observations made so far in both anthropogenic and almost natural habitats show that some species (e.g., *Cognettia sphagnetorum*, *Henlea ventriculosa*, *Buchholzia appendiculata*, *Fridericia bisetosa*, *F. paroniana*, *F. galba*, *F. ratzeli*, *Enchytraeus buchholzi*) are of mass occurrence in Poland. Also in urban green areas of Warsaw there is a group of species abundant in most habitats under study. First of all, these are all species of the genus *Fridericia* (*F. bisetosa*, *F. bulboides*, *F. galba*, and *F. ratzeli*), and to a lesser extent *Henlea ventriculosa*, *Buchholzia appendiculata*, and *Enchytraeus buchholzi*. The contribution of the genus *Fridericia* to the total enchytraeid density was particularly high in soils of parks (70%) and isolated streetside green areas (83%) (Tab. 2). Such a high dominance of the genus *Fridericia* was characteristic, for example, of north-European mid-forest meadows (Nurminen 1967). No correlation was found between the species richness and density of enchytraeid worms on any of the plots.

In soils of suburban habitats of Białoleka Dworska 9 species were recorded, accounting for about 10% of all the enchytraeid species recorded from Poland so far and for 40% of all the species occurring in soils of green habitats of Warsaw (Kasprzak 1981b). In soil of the linden-oak-hornbeam forest at Białoleka Dworska, the dominant species was *Buchholzia appendiculata* (75% of the total abundance of the community), while the soil of a meadow on the linden-oak-hornbeam forest site was dominated by young individuals of *Fridericia* sp. and *F. bisetosa* (jointly 66% of all individuals).

The mean density of enchytraeids in soils of green areas of Warsaw was about 8000 individuals \times m⁻². The highest mean density was recorded in soils of green in loosely built-up areas, parks, and streetside zones adjacent to vast green areas. In this last habitat type the highest density of 25000 individuals \times m⁻² was noted for Warsaw. As compared with other anthropogenic habitats, e.g., soils of agroecosystems, all study habitats of Warsaw were characterized by markedly lower densities of enchytraeids. For instance, a mean density of enchytraeids in soils of meadows and pastures ranged from 25000 to 80000 individuals \times m⁻², and their mean density in soils of potato fields was up to 23000 individuals \times m⁻² (Kasprzak 1980, 1982, Kasprzak, Ryl 1978). Mean densities of enchytraeids in soils of an linden-oak-hornbeam forest (*Tilio-Carpinetum*), pine forest (*Peucedano-Pinetum*), and meadows on the site of an linden-oak-hornbeam forest and alder-ash carr (*Circaeo-Alnetum*) in Białoleka Dworska,

Table 2. Characteristics of enchytraeid communities in different urban green habitats of Warsaw

Habitat	Number of species	Density (individuals \times m ⁻²)		Proportion of different genera in total density (per cent)								Species with highest proportion
		min.-max.	Average	<i>Fridericia</i> Mich.	<i>Henlea</i> Mich.	<i>Achaeta</i> Vejd.	<i>Enchytraeus</i> Henle	<i>Buchholzia</i> Mich.	<i>Cognattia</i> Niel. et Christ.	<i>Mesenchytraeus</i> Eis.		
Parks	17	4721-18085	9456	70.1	13.2	8.4	2.8	3.9	1.5	0.1	<i>Fridericia bisetosa</i> , <i>F. bulboides</i> , <i>F. leydigi</i> , <i>F. rotzeli</i> , <i>F. galba</i> , <i>Achaeta eiseni</i> , <i>Buchholzia appendiculata</i> , <i>Henlea ventriculosa</i>	
Green of housing estates												
— in closely built-up areas	9	756-6852	3716	31.9	23.2	1.6	39.2	4.1	—	—	<i>Fridericia bisetosa</i> , <i>F. bulboides</i> , <i>F. gracilis</i> , <i>Henlea similis</i> , <i>H. perpusilla</i> , <i>H. ventriculosa</i> .	
— in loosely built-up areas	13	9366-13351	11359	67.7	28.7	2.1	1.0	0.5	—	—	<i>Fridericia bulboides</i> , <i>F. galba</i> , <i>Henlea ventriculosa</i> , <i>H. perpusilla</i> , <i>Enchytraeus buchholzi</i> , <i>Buchholzia appendiculata</i>	
Streetside green areas												
— adjacent to other green areas	8	1863-24600	9429	22.6	14.1	53.2	6.8	3.0	0.3	—	<i>Achaeta eiseni</i> , <i>Enchytraeus buchholzi</i> , <i>Henlea ventriculosa</i> , <i>Fridericia bisetosa</i> , <i>F. galba</i>	
— isolated	2	—	697	83.4	16.6	—	—	—	—	—	<i>Fridericia bisetosa</i>	

where the species composition and dominance structure are similar from one year to another (Kasprzak 1981b), were generally much lower than in soils of urban green areas of Warsaw.

Large seasonal fluctuations of enchytraeid densities were observed in all the study plots in Warsaw. Their densities were relatively high in soils of streetside and interlane green areas adjacent to large green habitats with a relative soil moisture of about 15% and containing much litter (about $200 \text{ g} \times \text{m}^{-2}$). Low densities of enchytraeids were noted mostly in soils of streetside and interlane green located far from large green habitats, generally characterized by a low content of litter (less than $200 \text{ g} \times \text{m}^{-2}$), and soil moisture less than 15%. They were also low in soils of isolated green of housing estates. In these habitats enchytraeids were periodically lacking. This was mostly the case of new-established lawns (e.g., at Hoża and Grójecka Streets), frequently on rubble soil with poor structure.

DESCRIPTION OF COMMUNITIES

Although there were differences in the dominance structure of enchytraeid communities from one urban habitat to another (Kasprzak 1981a), they all showed some specific features (Tab. 2).

Parks. The number of species was the highest in parks but it largely varied from one study area to another (from 3 to 12 species). A particularly high number of species and high enchytraeid densities were recorded in soils of the Saxon Garden and the Łazienki Park. The density of enchytraeids was also high in the park at the Cemetery of Soviet Soldiers and the Praski Park, but the number of identified species was markedly lower there. *Buchholzia appendiculata* reached relatively high densities in the Łazienki Park, while it was infrequently noted and sparse on all the other plots. Instead, it was dominant in soils of the linden-oak-hornbeam forest and in a meadow on the site of an linden-oak-hornbeam forest in suburban areas (Kasprzak 1981b). Among the most abundant representatives of the genus *Fridericia*, particularly abundant and frequent in parks were *F. bisetosa* and *F. galba*. In the soil of the park in Ursynów, the numbers of enchytraeid species and their density were low as compared with those in most parks of Warsaw.

Green areas of housing estates. Both the number of species and the total density of enchytraeids in this habitat depended on the character of built-up areas. Enchytraeid communities of green areas in loosely built-up areas were characterized by a higher number of species and very high mean densities, as compared with those occurring in green habitats of closely built-up areas. The density of enchytraeids was higher there than in all the other habitats under study. Green habitats of loosely built-up

areas were rather unevenly occupied by enchytraeids. A markedly higher density of these animals was recorded in the soil covered with shrubs. The densities of *Fridericia bisetosa*, *F. bulboides*, *Henlea ventriculosa*, and *H. perpusilla* were particularly high.

Streetside green areas. In the soil of isolated streetside green habitats, the species richness and density of enchytraeids were the lowest of all the study plots. In the plots adjacent to vast green areas, the density and species composition of enchytraeids were largely diversified. Dominant species varied from one plot to another. These were *Achaeta eiseni* (Ujazdowski Avenue, Marszałkowska Street), *Fridericia bisetosa* (Żwirki i Wigury Avenue), *Henlea ventriculosa* (Woronicza Street), and *F. galba* (Niepodległości Avenue).

THE EFFECT OF URBAN PRESSURE

The present data show that among many factors of urban pressure adversely affecting urban fauna, the detrimental effect of arteries of traffic on enchytraeid communities can be put in question. The observations made so far suggest that this effect is not direct and may be totally lacking. It has been found that the density of enchytraeid in the soil of green habitats adjacent to streets with much traffic can be even higher than in soils of green habitats more distant from streets. In the soil of streetside green at Marszałkowska Street close to the Saxon Garden, located between two lanes with much traffic, the density of enchytraeids ($24600 \text{ individuals} \times \text{m}^{-2}$) was more than two times as high as in the soil within the Saxon Garden ($10138 \text{ individuals} \times \text{m}^{-2}$). But the number of species was higher in the park; enchytraeids contributing most to the total density included representatives of the genus *Fridericia* (74%) and a hydrophilous (amphibiotic) species, *Henlea ventriculosa* (15%). In the soil of streetside green, the highest contribution to the total enchytraeid density was due to *Achaeta eiseni* (88%), a species more resistant to soil overdrying; representatives of the genus *Henlea* were lacking from this area. In other study areas located at streets with much traffic (Żwirki i Wigury Avenue, Ujazdowski Avenue), the density of enchytraeids was markedly lower. No correlation was found between enchytraeid density and the concentration of heavy metals (lead) in soil.

CONCLUSIONS

1. In soil of parks, housing estates, and streetside green areas, enchytraeid communities relatively rich in species but less dense than in agroecosystems were recorded. The highest proportion in the total density was reached by representatives of the genus *Fridericia*, which showed the greatest adaptability to changing habitat conditions. Only the community of the

Łazienki Park was predominated by *Buchholzia appendiculata*, a species associated with humus of the mor type, and characteristic of the soil and litter of linden-oak-hornbeam forests. The proportion of this species, occurring mainly in the surface soil layer was low or null in the other parks and other habitats under study. This was related to low and variable soil moisture, and to destruction of the surface soil layer, for example, as a result of litter removing.

2. Dominance structure of the community differed from one study area to another, and no correlation was found between species richness and density. Such a correlation is common in natural habitats, but it does not seem to be always clearly seen in anthropogenic habitats, where high densities need not be coupled with species richness.

3. Both high densities and high number of enchytraeid species are mainly characteristic of permanent green areas, with a high content of soil organic matter and litter, and most of all with a high relative soil moisture (more than 15%). High enchytraeid densities in the soil of loosely built-up areas indicate particularly suitable habitat conditions there. This is mainly due to the fact that shrub cover prevents soil overdrying, and soil surface is not so heavily destroyed by trampling as in closely built-up areas.

4. The density of respective species and the species composition of enchytraeid communities vary largely over the year. This may result from the application of various cultivation treatments on lawns and, in particular, from mechanical treatment of soil and its temporal heavy overdrying. This accounts for large declines in enchytraeid densities.

5. Intense traffic is not an important factor reducing the distribution and density of enchytraeids. Important factors include soil type and moisture, content of organic matter in soil, age of the green area also types and intensity of cultivation treatments.

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STRUKTURA ZGRUPOWAŃ WAZONKOWCÓW (*OLIGOCHAETA*, *ENCHYTRAEIDAE*) W ZIELENI MIEJSKIEJ WARSZAWY

STRESZCZENIE

W glebach zielenców parkowych, osiedlowych i przyjezdniowych Warszawy stwierdzono występowanie bogatej pod względem liczby gatunków fauny *Enchytraeidae* (22 gatunki), której średnie zagęszczenie wynosi około 8000 osobników $\times m^{-2}$. Szczególnie wysokie zagęszczenie *Enchytraeidae* występuje w glebie zielenców osiedlowych o zabudowie luźnej (średnio około 11.000 osobników $\times m^{-2}$) (Tab. 1 i 2) Zarówno wysokie zagęszczenie, jak i największa liczba gatunków występują głównie na zielencach wieloletnich, charakteryzujących się dużą zawartością w glebie substancji organicznej i ściółki, a przede wszystkim stosunkowo wysoką wilgotnością gleby (powyżej 15%). Największy udział w zagęszczeniu mają przedstawiciele rodzaju *Fridericia* Mich., wykazujące spośród wszystkich *Enchytraeidae* największe zdolności

adaptacyjne do zmieniających się warunków środowiskowych. Nie stwierdzono występowania w żadnym ze środowisk zgrupowań gatunków o powtarzającej się strukturze dominacyjnej. Duże zmiany zagęszczenia w ciągu roku spowodowane są stosowaniem różnych zabiegów pielęgnacyjnych na trawnikach oraz silnym okresowym przesuszeniem. Wzmożony ruch uliczny nie jest decydującym czynnikiem ograniczającym występowanie i zagęszczenie *Enchytraeidae*. Podstawowe znaczenie ma głównie rodzaj gleby, jej wilgotność, zawartość substancji organicznych, wiek zieleńca oraz rodzaj i intensywność stosowanych zabiegów pielęgnacyjnych.

СТРУКТУРА СООБЩЕСТВ ЭНХИТРЕИД (*OLIGOSCHAETA*, *ENCHYTRAEIDAE*) ГОРОДСКИХ ЗЕЛЕННЫХ НАСАЖДЕНИЙ ВАРШАВЫ

РЕЗЮМЕ

В почве городских парков, зелени жилых районов и уличных насаждений Варшавы констатировали 22 вида *Enchytraeidae*. Плотность *Enchytraeidae* составляет в среднем около 8000 особей/м². Особенно высокая плотность наблюдалась в почве зеленых насаждений жилых районов в среде свободной застройки (в среднем около 11 000 особей/м²). Наиболее высоким содержанием в сообществах характеризовались представители рода *Fridericia* Mich. Значительные изменения плотности *Enchytraeidae* на протяжении года связаны с работами по уходу за газонами и сильным временным иссушением субстрата. Интенсивное уличное движение не является решающим фактором, ограничивающим встречаемость и плотность *Enchytraeidae*. Основную роль играет род почвы, ее влажность, содержание органических веществ, возраст насаждений и характер, а также интенсивность ухода за ними.