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EARTHWORMS (*OLIGOCHAETA, LUMBRICIDAE*) OF WARSAW AND
MAZOVIA

ABSTRACT

In Mazovia 12 species of the family *Lumbricidae* were recorded, and within the administrative boundaries of Warsaw 15 species, of which two species only in suburbs. Urban areas are colonized by the species known from nonurban areas of Mazovia, and by introduced species both eurytopic, with large geographical ranges and high ecological amplitude, and oligotopic with preference to dry habitats. These are mainly species adapted to the life in deeper soil layers, in habitats of low moisture well supporting alkaline conditions, thus with adaptations permitting them to inhabit the soil transformed by urbanization processes.

INTRODUCTION

This work was done as a part of the complex studies conducted by the Institute of Zoology PAS, and concerned with the effects of urban pressure on the fauna. This is one of the set of contributions centered upon the origin of the fauna of Warsaw. Some works have already been published, including those on essential premises [18], phytosociological characteristics of Mazovia [5], description of urban habitats and the extent of the studies on them [10], as well as the methods used [1].

The objective of the study is an analysis of the occurrence of earthworms in Warsaw, as compared with the faunistic composition of the family *Lumbricidae* in Mazovia. Also an attempt was made to explain why some species were successful and other failed to live in the urban habitat.

The following materials are used in the present paper: literature data on the occurrence of earthworms in Warsaw and Mazovia, museum collection of the Institute of Zoology PAS, and the author's own materials collected in 1976—77.

Faunistic studies on the family *Lumbricidae* in Poland have been carried out since the end of the past century. The first publication on the earthworms of Warsaw surroundings was prepared by Nusbaum in 1891 [11]. In the interwar period rather intensive study was carried out on the earthworm fauna, but not in the Mazovia region nor in Warsaw. The study

in these terrains were continued after the second World War [12]. In 1962 a catalogue was issued containing the data on the occurrence of earthworms in Poland [6]. The paper by Plisko [13] on the geographical distribution and ecology of earthworms merits special attention. It also contains a survey of the studies on earthworms. In addition, the papers on earthworms of the Mazovia [4, 7, 8, 14], Warsaw surroundings [9, 12] and Warsaw [3, 12], are of great importance. On the basis of the quoted literature and the author's own studies, the state of knowledge on the earthworm fauna can be considered as rather good. The study carried out up to the present involves many sites, although some types of habitats have been omitted.

SPECIES COMPOSITION

In Poland 32 earthworm species have been recorded [15]. The countryside terrains in Mazovia are inhabited by 12 species, and within the administrative borders of Warsaw 15 species were found, including 2 occurring only in suburban areas (Tab. 3). Ten species are rather frequently noted in Mazovia. These are *A. caliginosa*, *A. chlorotica*, *A. rosea*, *D. octaedra*, *D. rubida*, *E. foetida*, *L. rubellus*, and *L. terrestris*. The two other species (*A. georgii* and *L. baikalensis*) have been found in few habitats and in low numbers.

In Warsaw, including suburban areas, 8 species common to the whole Mazovia were recorded: *A. caliginosa*, *A. chlorotica*, *A. rosea*, *D. octaedra*, *D. rubida*, *E. foetida*, *L. rubellus*, and *L. terrestris*. The remaining two of the ten species common in Mazovia (*E. tetraedra* and *O. lacteum*) were found only in the Warsaw suburbs [12].

Five of the species recorded are not known from suburbs and noted exclusively in the town: *A. georgii*, *A. longa*, *D. veneta*, *L. castaneus*, and *O. cyaneum*. Such species as *A. georgii* and *O. cyaneum* were found only in allotments. This location suggests that they could be moved with earth or plants from distant areas. *D. veneta*, known only from the greenhouse of the Botanical Garden, University of Warsaw, is certainly a brought species.

A. longa should be considered as a species new to Warsaw. It was firstly found here by Jopkiewicz [3] and then by the author. Another species, *L. castaneus*, has not been recorded from Mazovia so far, but is known from the whole Poland. Both these species occur in typical green spaces of urban areas. They were found in large numbers on several sites.

Among 13 species found in Warsaw only six occur frequently and abundantly. These are *A. caliginosa*, *A. chlorotica*, *A. rosea*, *A. longa*, *L. castaneus*, and *L. terrestris*. They inhabit sites typical of urban green areas. Thus, among 10 species rather abundant in Mazovia, only four found suitable conditions in habitats characteristic of the town. In addition, two species known from Poland but not from Mazovia have been noted here. It follows from this that the number of earthworm species in Warsaw is similar to

that in Mazovia, though only in part these are the same species (Tab. 3). On the other hand, however, this list of the species occurring in the town can be incomplete since in urban areas such habitats as margins of ponds, sewages, as well as wet areas, rich in organic matter, were almost completely excluded from the study. Although the proportion of such areas to the total urban green area is relatively small, the species recorded from similar habitats of Mazovia, but not from Warsaw, can occur there.

Comparing the urban habitats under study (Tab. 3), it can be seen that the number of earthworm species was the lowest in the green areas of housing estates, while there is no difference in the number of species between parks and lawns in the centre of the town. The observed differences do not allow us to distinguish any habitat which could be considered as a source of the earthworm fauna, nor any habitat particularly impoverished in the number of the species.

GEOGRAPHICAL ANALYSIS

According to Plisko [15], all species recorded in Mazovia and Warsaw, except for *A. georgii*, *D. veneta*, and *L. baikalensis*, are megaporeutic and cosmopolitan. These are species which resettled post-glacial terrains and were brought by man over different continents. The oligoporeutic species can be classified into two groups. One involves the species which in fact did not colonize the regions subjected to the Pleistocene glaciation. They occur in southern Poland. The second group involves recessive, relict species such as *A. georgii* and *L. baikalensis*.

In the present paper, like in the whole volume, other criteria of geographical classification are used [1]. This classification is based on the present occurrence of individual species rather than on historical reasons of their distribution. The zoogeographical classification of all species has been based on the analysis of their ranges and, if possible, on the frequency of their occurrence in a given area. Using such criteria, most of the megaporeutic species are considered as cosmopolitan and one species is Holarctic. Originally they were Palaearctic species [16] but recently they have enlarged their ranges.

Most of the species occurring in Mazovia and Warsaw have been considered as cosmopolitan (Tab. 1). In Mazovia, 10 out of 12 species recorded are cosmopolitan (*A. caliginosa*, *A. chlorotica*, *A. rosea*, *D. octaedra*, *D. rubida*, *E. foetida*, *E. tetraedra*, *L. rubellus*, *L. terrestris*, and *O. lacteum*). The remaining two species, *A. georgii* and *L. baikalensis*, are considered as European species.

The suburbs of Warsaw are also inhabited by 10 cosmopolitan species, the same as in Mazovia. In the town 8 cosmopolitan species were found, including 6 common to Mazovia (*A. caliginosa*, *A. chlorotica*, *A. rosea*, *D. octaedra*, *L. rubellus*, and *L. terrestris*); the two remaining species include *A. longa* and *O. cyaneum*. The European species, *L. balkanensis*, has

not been observed in the town. Among European species only *A. georgii* has been noted in Warsaw. In addition, there occurs here a Holarctic species *L. castaneus* and a brought mediterranean species *D. veneta*. The latter has been excluded from the quantitative analysis of the contribution of individual species belonging to particular geographical elements (Tab. 1), since it has been recorded only in the greenhouse of the Botanical Garden.

Tab. 1. Proportions of zoogeographical elements in earthworms of Warsaw and non-urban habitats of Mazovia
(N — number of species)

Zoogeographical element	Mazovia		Warsaw									
			Suburbs		Urban green areas							
	Total				Parks		Housing estates		Town centre			
	N	%	N	%	N	%	N	%	N	%	N	%
Cosmopolitan	10	83.0	10	100.0	8	80.0	7	88.0	4	66.0	7	88.0
Holarctic	—	—	—	—	1	10.0	1	12.0	1	17.0	1	12.0
European	2	17.0	—	—	1	10.0	—	—	1	17.0	—	—

Among six species which found suitable living conditions in the town, five are cosmopolitan species (*A. caliginosa*, *A. chlorotica*, *A. longa*, *A. rosea*, and *L. terrestris*) and one belongs to Holarctic species (*L. castaneus*). Thus the species with large geographical ranges are favoured under urban conditions (Tab. 1).

ECOLOGICAL ANALYSIS

ECOLOGICAL AMPLITUDE AND HABITAT PREFERENCE

Eurytopic earthworms, so with a high environmental amplitude, involve such species as *A. caliginosa*, *A. longa*, *A. rosea*, *L. castaneus*, and *L. terrestris*, occurring in almost all habitats. Oligotopic species, inhabiting different habitats but preferring biotopes with definite moisture, acidity, or organic matter content, are represented by *A. chlorotica*, *A. georgii*, *D. octaedra*, *D. rubida*, *D. veneta*, *E. foetida*, *E. tetraedra*, *L. baikalensis*, and *O. lacteum*. Stenotopic species, characteristic of particular biotopes, are represented by *O. cyaneum*, occurring in Poland only in agrocoenoses. A quantitative comparison of the species characterized by different environmental amplitudes shows that oligotopic species prevail in the countryside and suburban habitats of Mazovia, while eurytopic species in towns (Tab. 2).

Among eurytopic species occurring in Warsaw, *A. caliginosa* was also found in the countryside in all types of habitats. *A. rosea*, *L. rubellus* and *L. terrestris* do not inhabit only marshy meadows. *A. longa* is known from cultivated soils, forest biotopes, steppes and forest-steppes. *L. castaneus* occurs

Tab. 2. Proportions of groups with different ecological amplitudes in earthworms of Warsaw and non-urban habitats of Mazovia
(N — number of species)

Group	Mazovia		Warsaw									
			Suburbs		Urban green areas							
	Total				Parks		Housing estates		Town centre			
	N	%	N	%	N	%	N	%	N	%	N	%
Eurytopic	4	33.3	4	40.0	6	60.0	6	75.0	3	50.0	5	62.5
Oligotopic	8	66.6	6	60.0	3	30.0	2	25.0	3	50.0	2	25.0
Stenotopic	—	—	—	—	1	10.0	—	—	—	—	1	12.5

in forests, meadows, pastures, fallow grounds and margins of crop fields [13]. Among oligotopic species *A. chlorotica* occurs in two forms: green and pink. The green form occupies moist habitats, the pink one drier habitats [17]. This species lives in meadows, pastures, crop fields and fallow grounds; occasionally also in forests.

All the mentioned species of the genus *Allolobophora* do not tolerate a high soil acidity, while the species of the genus *Lumbricus* are highly tolerant of variations in soil acidity [2]. Among species of the genus *Dendrobaena*, *D. octaedra* occurs in dry meadows, wet and dry pastures, and in the forest litter. *D. rubida* inhabits dry pastures and forest litter. The two species occupy habitats with high acidity, in towns their numbers being low. Also *E. foetida*, preferring wet habitats, was very scarce in the town. Two species, *E. tetraedra* and *O. lacteum*, common in Mazovia but not in the town on the study plots, occur in all habitats except for dry meadows and pastures. The other species sporadically occurring in the town, include *A. georgii*, known from wet meadows and crop fields, and *D. veneta*, the brought species, inhabiting soils rich in humus [15].

The species associated with top soil layers are scarce in the town (genus *Dendrobaena*). The only species of this group which found suitable conditions there is *L. castaneus*. However, the species living in deeper soil layers largely predominate. They are represented by *L. terrestris* and species of the genus *Allolobophora*.

In the study plots in Warsaw, therefore, eurytopic and oligotopic species predominate, preferring dry habitats and thus frequently met in the towns. As the analysis shows, the species successful in finding suitable conditions in the town belong mostly to the forms inhabiting almost all habitat types, or preferring dry meadows and pastures. These are species adapted to deeper soil layers, with a high tolerance of soil pH and low soil moisture. The species occurring in wet habitats were lacking on the urban study plots, but it is possible that they occur in the town in rare, nonstudied wet habitats. Urbanization also limits the occurrence of species preferring highly acid habitats and associated with top soil layers. The factors mostly res-

possible for the success of the species in the town are the tolerance of alkalization, drying up soil and raking the litter, and no preference to definite habitat types. Consequently, it is difficult to decide which of the natural habitats was the source of urban earthworms.

FOOD HABITS

All earthworms are saprophages; they feed on the remains of dead plant and animal organic matter mixed with soil particles. They have a preference for dead leaves and roots of dead plants, thus for the decaying plant remains. The species inhabiting top soil layers take mainly organic matter, while those living deeper take large amounts of mineral material [2].

ECOLOGICAL EVALUATION OF THE GROUP

As it has already been mentioned, the oligoporeutic earthworms occurring in the study plots (*A. georgii* and *L. baikalensis*) belong to the relict, recessive species. They occur sporadically, in a small number of individuals both in the town (*A. georgii*) and in the countryside (*A. georgii* and *L. baikalensis*). The megaporeutic species, instead, are highly expansive and they can easily adapt themselves to new climatic and habitat conditions. Such megaporeutic species as *A. longa*, *O. cyaneum* and *L. castaneus* have a patchy distribution over their range and are rather scarce in Poland. Two of these three species, *A. longa* and *L. castaneus*, form rather abundant populations in the town. The other megaporeutic species are numerous in Poland and reach high numbers in the town. To sum up, it can be stated that towns are first colonized by expansive and common species.

CONCLUSIONS

The comparison of the earthworm fauna inhabiting the town with that in the non-urbanized areas, shows that the numbers of species are similar but there are differences in species composition. Most of the species are the same in the two habitat types, but some of them occur either only in the town or only in non-urban habitats of Mazovia. Moreover, because it is easy to introduce earthworms as a result of cultivation treatments of green spaces in the town (transfer of soil and plants even from distant areas), the species not occurring in adjacent areas or even alien to the region, may appear in the town.

The earthworms occurring in the town belong firstly to expansive and eurytopic species, with a high adaptability to new habitat conditions. These are mainly megaporeutic and cosmopolitan species. Some of them are able to colonize mainly urban lawns due to the fact that they live in deeper soil layers in habitats with low moisture, and they are widely tolerant of soil pH. These are important adaptations in view of the fact that litter is raked and

removed, while soil is dried up and alkalinized in most of the urban green areas.

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Tab. 3. Check list of *Lumbricidae* species occurring in Warsaw and Mazovia

No.	Species	Mazovia	Warsaw				
			suburban areas	parks	green areas in housing estates	town centre	other sampling areas
	○ — literature data ● — proved literature data + — unpublished data						
1	<i>Allolobophora caliginosa</i> (Sav.)	●	●	●	●	●	●
2	<i>Allolobophora chlorotica</i> (Sav.)	●	●	●	●	●	●
3	<i>Allolobophora georgii</i> (Mich.)	○	—	—	○	—	—
4	<i>Allolobophora longa</i> Ude	—	—	●	—	+	—
5	<i>Allolobophora rosea</i> (Sav.)	●	●	●	—	○	○
6	<i>Dendrobaena octaedra</i> (Sav.)	●	●	○	+	+	—
7	<i>Dendrobaena rubida</i> (Sav.)	●	+	—	—	—	○
8	<i>Dendrobaena veneta</i> (Rosa)	—	—	—	—	—	○
9	<i>Eisenia foetida</i> (Sav.)	●	●	—	—	—	○
10	<i>Eiseniella tetraedra</i> (Sav.)	●	●	—	—	—	—
11	<i>Lumbricus baikalensis</i> Mich.	○	—	—	—	—	—
12	<i>Lumbricus castaneus</i> (Sav.)	—	—	●	—	+	—
13	<i>Lumbricus rubellus</i> Hoffm.	●	●	○	—	—	—
14	<i>Lumbricus terrestris</i> L.	●	●	●	●	●	○
15	<i>Octolasion cyaneum</i> (Sav.)	—	—	—	—	○	○
16	<i>Octolasion lacteum</i> (Oerley)	●	●	—	—	—	—

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DŹDŻOWNICE (*OLIGOCHAETA, LUMBRICIDAE*) WARSZAWY I MAZOWSZA

STRESZCZENIE

W pracy analizowano skład gatunkowy rodziny *Lumbricidae* w Warszawie i na terenach niezurbanizowanych Mazowsza. Próbowano wyjaśnić przyczyny pomyślnego bytowania lub ustępowania określonych gatunków ze środowiska zurbanizowanego. Otrzymane wyniki wykazały, że nie wszystkie gatunki dżdżownic znane z przyległych terenów niezurbanizowanych spotyka się w mieście, a jednocześnie, iż istnieje możliwość pomyślnego bytowania w warunkach miejskich gatunków introdukowanych. Przeprowadzona analiza geograficzna wskazuje na to, że w środowisku miejskim preferowane są gatunki o szerokich zasięgach geograficznych, ekspansywne, o dużych zdolnościach adaptacji do nowych warunków klimatycznych i środowiskowych. Czynnikiem wpływającym na pomyślne bytowanie niektórych gatunków dżdżownic w mieście, jak to wynika z analizy ekologicznej, jest ich przystosowanie do życia w głębszych warstwach gleby i siedliskach o niskiej wilgotności, oraz szeroka tolerancja wobec odczynu gleby. Preferowane są więc gatunki, które dobrze znoszą przesuszenie i alkalizację gleby oraz zgrabianie i wywożenie ściółki, co ma miejsce w większości terenów zieleni miejskiej.

ДОЖДЕВЫЕ ЧЕРВИ (*OLIGOCHAETA, LUMBRICIDAE*) ВАРШАВЫ И МАЗОВИИ

РЕЗЮМЕ

В Мазовии констатировали 12 видов из семейства *Lumbricidae*, а на территории Варшавы в её административных границах — 15 видов, из которых 2 вида встречались только в пригородах. В городских условиях встречаются виды, известные из неурбани-

зированных районов Мазовии или интродуцированные, имеющие широкий географический ареал и большую экологическую пластичность — эвритоппные или олиготопные, предпочитающие ксеротермные биотопы. Это главным образом виды, приспособившиеся к жизни в более глубоких слоях почвы, в биотопах с низкой влажностью, хорошо переносящие алкализацию, таким образом, обладающие адаптативными свойствами, которые дают им возможность существования в почве, преобразованной под влиянием урбанизации.

ISOPODS (ISOPODA) OF WARSAW AND MAZOVIA

ABSTRACT

In Mazovia and Warsaw 22 isopod species were recorded including 20 in Warsaw. Iso-pods of Warsaw and Mazovia belong to four geographical elements: cosmopolitan, Holo-artic, European, and southeastern. They represent three basic ecological elements: ubiquitous, mesanthropic and forest. An increase in the urban pressure was followed by an increase in the proportion of cosmopolitan and synanthropic species.

INTRODUCTION

In the studies carried out so far on terrestrial isopods (*Isopoda*, *Oniscoides*) of Poland, mostly natural environments were examined. Dominiaak [3] summed up the literature data and supplemented them with his own results. More or less sparse information on the occurrence of isopods in Warsaw is dispersed in the papers concerned with different regions of the country. One of them was prepared by Brylich [4], who quotes several isopod species caught in the Bielany Wood. The richest data are reported by Dominiaak [2, 3]. On the basis of the materials collected by the Institute of Zoology PAS and other sources, this author reports many species from Warsaw but without a detailed location.

This contribution is a part of the comprehensive studies of the fauna of Warsaw, carried out at the Institute of Zoology PAS in 1974–1978. Theoretical assumptions, habitat characteristics, and methods, are described in separate papers [1, 5–6].

Some additional sites were under study, such as hothouses of the Botanical Garden, University of Warsaw, a belt of wasteland near the settlement „Przyjaźń” in Jelonki quarter, Bielany Wood, allotments, a belt of undergrowth by the Vistula, and the Vistula escarpment. Also the material collected in rooms was used. In sum, the material of more than 4200 specimens was analyzed.