

MEMORABILIA ZOOL.	36	253—261	1982
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MILLIPEDES (*DIPLOPODA*) OF WARSAW AND MAZOVIA

ABSTRACT

More than 5 800 specimens of millipedes belonging to 40 species have been collected in Warsaw and Mazovia. A new species to Poland, *Ophiodesmus albanus* (Latz.), was found. Six main zoogeographical elements were distinguished. The European element was represented by 26 species. Four ecological elements were distinguished, from which synanthropic species were most abundant in Warsaw (13 species) and forest-dwelling species were most abundant in Mazovia (16 species).

INTRODUCTION

In the studies on millipedes (*Diplopoda*) carried out so far in Poland the attention was mostly paid to natural habitats. Their results are summed up by Stojałowska [14, 15]. Relatively few workers were interested in largely transformed habitats. Some works, however, describe synanthropic millipedes of the Sudeten Mountains [2], Lublin [1, 12, 13] and Wrocław [10].

The first remarks on the occurrence of some millipedes in Warsaw are provided by Ślósarski [16]. Jawłowski [5], who studied the millipedes of Warsaw surroundings, also reports some species occurring in the town. Scarce data on millipedes of Warsaw can be found in Dziadosz [4], dealing with the distribution of millipedes over Poland. The papers quoted above contain all what we know about the occurrence of this group in Warsaw.

The present paper is based on the comprehensive study on the fauna of Warsaw, carried out by a group of workers of the Institute of Zoology, Polish Academy of Sciences, in 1974—1978. Theoretical assumptions of this study, a detailed description of the study area and methods are published elsewhere [3, 8, 9, 17].

In addition, the following habitats were under study: greenhouses of the Botanical Garden, University of Warsaw, a belt of wasteland near the housing estate Jelonki, Bielany wood, allotments, and a belt of thicket along the Vistula margin.

Such additional methods were used as sifting the litter by means of an entomological sieve, catching the animals hidden under stones, logs, and in various crevices providing shelter for millipedes. A total of more than 5 800 specimens were collected.

The nomenclature and taxonomic order follow that used by Jeekel [6] and Stojakowska [15]. The evidence specimens are in the collection at the Institute of Zoology, Polish Academy of Sciences.

SPECIES COMPOSITION

There are 84 millipede species recorded from Poland so far. In the Mazovian Lowland, including Warsaw, 40 species were found, this accounting for about 47% of the *Diplopoda* of Poland. In this respect the Mazovian Lowland belongs to the richest regions of Poland. This richness is due to the large habitat diversity in Mazovia. There are here wet deciduous forests, rich in species, as well as large towns (Warsaw), abounding in synanthropic species.

In Warsaw, including suburban areas, there are 34 millipede species and the species diversity is equal to that in non-urban areas of Mazovia. In urban areas of Warsaw millipede communities were also largely diversified. The number of species dropped with growing urban pressure from 18 in the suburbs to 4 in the centre of the town.

The most interesting fauna was observed in old urban parks located on the Vistula escarpment and in the Bielany wood. These areas are refuges of the species associated with forests and shrubs because of their natural and seminatural vegetation.

The millipedes occurring in Warsaw are characterized by a high species diversity at a small density, as compared to that in their potential habitats. A large proportion is represented by synanthropic species.

ZOOGEOGRAPHICAL ANALYSIS

The millipedes occurring in Warsaw belong to six major zoogeographical elements (Tab. 1).

1. The cosmopolitan elements is represented by *Oxidus gracilis* and *Ophiodesmus albonatus*. These species were found only in Warsaw.

2. The Holarctic element is represented by five species: *Blaniulus guttulatus*, *Cylindroiulus frisius*, *C. caeruleocinctus*, *Ophiulus fallax*, and *Brachyiulus pusillus*. The proportion of the species belonging to this element increases with growing urban pressure. It is 14% in Mazovia, while in green areas of housing estates and in the centre of the town 43 and 50%, respectively.

3. The Palearctic element is represented by *Polyxenus lagurus*, occurring in Mazovia and in the suburbs of Warsaw.

4. The European element is richest in species (26) and abundant in the majority of the study plots. These are: *Glomeris connexa*, *G. hexasticha*, *Heteroporatia vihorlatica*, *Mastigophorophyllon saxonicum*, *Craspedosoma simile*, *Brachydesmus superus*, *Polydesmus inconstans*, *P. complanatus*, *Boreoiulus tenuis*, *Choneiulus palmatus*, *Nemasoma varicorne*, *Proteroiulus fuscus*, *Napoiulus venustus*, *Cylindroiulus arborum*, *C. britannicus*, *C. truncorum*, *C. occultus*, *Julus scandinavicus*, *J. terrestris*, *Leptoiulus proximus*, *L. minutus*, *Microiulus laeticois*, *Chromatoiulus projectus kochi*, *Unciger foetidus*, *Ommatoiulus sabulosus*, and *Polyzonium germanicum*.

The European species are most abundant in the Mazovian Lowland.

5. The south-European element is represented by *Leptophyllum nanum*. This species occurs in Mazovia and in the suburbs.

6. The south-eastern element is represented by three species: *Trachysphaera costata*, *Heteroporatia bosniensis* and *Strongylosoma stigmatosum*. This element is most abundant in parks.

Urban pressure has a reducing effect not only on the abundance of millipedes but also on the number of zoogeographical elements. In Mazovia and suburban areas five zoogeographical elements can be distinguished, while in the areas subject to highest urban pressure (green areas of housing estates and the centre) only Holarctic and European elements were present. The species representing these two elements have a high ecological tolerance, which enables them to inhabit the areas unfavourable for the species with narrow habitat requirements [11, 14].

The great majority of millipede species occurring in Mazovia and Warsaw belong to the widespread European element. This element also dominates in the other regions on Poland. The millipedes of Warsaw include two species genetically alien. These are *Orthomorpha gracilis* and *Ophiodesmus albonatus*, both originating from the tropics and now present almost all over the world. The other species are distributed over Europe or over its large parts.

ECOLOGICAL ANALYSIS

Millipedes occurring in Mazovia and Warsaw belong mostly to the species with relatively high ecological amplitudes and due to this they can inhabit several habitat types.

In the study plots, four major ecological elements of millipedes can be distinguished (Tab. 2).

1. Ubiquitous species such as *Polyxenus lagurus*, *Brachydesmus superus*, *Polydesmus inconstans*, *P. complanatus*, *Proteroiulus fuscus*, *Uuciger foetidus*, and *Ommatoiulus sabulosus*.

This element is most abundantly represented in Mazovia and in the suburbs (7 species). Since they are largely resistant to urban pressure, the

Table 1. Proportions of zoogeographical elements in millipedes 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	—	—	—	—	2	6.4	—	—	—	—	—	—
Holarctic	5	14.0	2	11.0	5	16.0	3	21.0	3	43.0	2	50.0
Palearctic	1	3.0	1	5.0	—	—	—	—	—	—	—	—
European	26	69.0	13	72.0	20	65.0	9	64.0	4	57.0	2	50.0
South-European	1	5.0	1	5.0	1	3.0	—	—	—	—	—	—
Southeast-European	1	5.0	1	5.0	3	9.0	2	14.0	—	—	—	—

Table 2. Proportions of groups with different habitat preferences in millipedes of Warsaw and non-urban habitats of Mazovia (N—number of species)

Species	Mazovia		Warsaw									
			Suburbs		Urban green areas							
	Total				Parks		Housing estates		Other			
	N	%	N	%	N	%	N	%	N	%	N	%
Ubiquitous	7	19.0	7	39.0	6	19.0	4	29.0	3	43.0	1	25.0
Synanthropic	11	30.0	1	5.0	13	42.0	8	57.0	4	57.0	3	75.0
Living in forest	16	45.0	8	44.0	10	32.0	2	14.0	—	—	—	—
Living in open areas	2	5.0	2	11.0	2	6.0	—	—	—	—	—	—

ubiquitous species from a large proportion of the millipedes inhabiting parks, green areas of housing estates and the centre of the town.

2. Synanthropic species such as *Oxydus gracilis*, *Ophiodesmus albonanus*, *Blaniulus guttulatus*, *Boreoiulus tenuis*, *Choneiulus palmatus*, *Nopoiulus venustus*, *Cylindroiulus arborum*, *C. britannicus*, *C. frisius*, *C. truncorum*, *C. caeruleocinctus*, *C. occultus*, and *Brachyiulus pusillus*.

Synanthropic species belong to most abundant millipedes occurring in most of the study plots. Their proportion increased with growing urban pressure from 5% in the suburbs to 75% in the centre of the town. The recorded high proportion of synanthropic species in the fauna of Mazovia is a consequence of the fact that many study plots were located in urbanized areas.

3. Forest-dwelling species such as *Glomeris connexa*, *G. hexasticha*, *Trachysphaera costata*, *Heteroporatia bosniensis*, *H. vihorlatica*, *Mastigophorophyllum saxonicum*, *Craspedosoma simile*, *Strongylosoma stigmatosum*, *Nemasoma varicorne*, *Leptophyllum nanum*, *Julus scandinavicus*, *Leptoiulus proximus*, *L. minutus*, *Microiulus laeticollis laeticollis*, *Chromatoiulus projectus kochi*, *Ch. sjaelandicus*, *Sarmatiulus vilnensis*, and *Polyzonium germanicum*.

The species associated with forests are most abundant in Mazovia and suburban areas. Their proportions are closely related to the degree of urban pressure. In the areas with natural and seminatural plant cover (the Mazovian Lowland and suburbs) they reached about 45% of the community (Tab. 2). They also colonized urban parks but are absent in heavily urbanized areas (green areas of housing estates and the centre of the town).

4. The species associated with open spaces, such as *Julus terrestris* and *Ophiulus fallax*. The species of this group are least abundant in Mazovia and Warsaw. They are susceptible to urban pressure and are firstly eliminated from urban green.

The classification of *Diplopoda* into the ecological elements listed above is very rough since most faunal data do not precise ecological conditions in the site of material collection.

Most of the millipede species live in litter and top soil layers. They frequently occur under stones, logs, and in depressions filled with dead plant parts. Some species (*Polyxenus lagurus*, *Nemasoma varicorne*, *Proteroiulus fuscus*, and *Nopoiulus venustus*) can live under protruding bark of deciduous trees and in old tree holes.

The density of millipedes in urban green areas is usually lower than in natural habitats. Generally they are dominated by eurytopic species (*Unciger foetidus*) and by synanthropic ones (*Cylindroiulus occultus*, *C. caeruleocinctus*). In the suburbs in the areas covered with natural and seminatural vegetation, *Polydesmus complanatus* and *Glomeris connexa* are dominants.

All millipedes are saprophages feeding on dead plant parts and fungi.

DISCUSSION

The species diversity and numbers of millipedes occurring in Warsaw largely depend on the age and type of green. The species richness is highest in old parks (such as Łazienki), with large green patches, dense lawns with clumps of shrubs where the litter is preserved, providing shelter for animals. In new-established parks (the Cemetery of Soviet Soldiers) there are only few synanthropic species (*Brachydesmus superus*, *Cylindroiulus caeruleocinctus*) and eurytopic species (*Unciger foetidus*). Millipedes do not occur in small streetside lawns since the soil is heavily overdried there.

A large percentage of millipede species occurring in Mazovia and Warsaw belong to the group of expansive animals, which successfully colonized almost the whole Europe (the European element). This is related to a high ecological amplitude of these animals, which enables them adaptation to changing habitat conditions. Synanthropic species, particularly those of the genus *Cylindroiulus*, native to the Mediterranean, are an excellent example here. Due to their high ecological amplitude, they extended their range by invading the areas subject to human management and then also seminatural and natural habitats.

Urban pressure firstly eliminates the species associated with forests and thickets. They still occur in the suburbs but they do not colonize parks. From the group of eurytopic species, which abundantly occur in Poland, only single species were able to colonize parks and some types of green areas in housing estates.

CONCLUSIONS

1. Warsaw, including the suburbs, forms a mosaic of habitats where 34 millipede species can find suitable conditions, as compared with 36 species living in natural habitats of the Mazovian Lowland.

2. As many as 63% of the millipedes occurring in Mazovia and Warsaw belong to the European element and they are common over Poland.

3. The number of species have dropped with increasing urban pressure from 36 in natural habitats to 4 in the centre of the town. In the areas subject to the heaviest urban pressure only eurytopic and synanthropic species occur.

4. *Ophiodesmus albonanus*, the species new to Poland, has been found in the greenhouses of the Botanical Garden, University of Warsaw.

THE SPECIES RARE OR NEW TO THE FAUNA OF MAZOVIA AND POLAND

Trachysphaera costata (Waga)

This species was known from the park in Natolin near Warsaw [5]. From 1935 no one specimen was found in this region [4]. During several years of the present study

one specimen was caught by a Barber trap in a lawn at Arkadia. In Warsaw there is probably a northernmost stand of this species.

Oxidus gracilis (C. L. Koch)

Seven specimens of this species were caught in greenhouses of the state farm Mysiadło. It is known from greenhouses almost over Poland. It is probably native to India, known from the tropics, widespread in greenhouses in Europe.

Ophiodesmus albonanus (Latz.)

This new to Poland species was found in greenhouse of the Botanical Garden, Warsaw University (one male). Morphological structure of the gonopods on the specimen caught corresponds to the description and drawing presented by Schubart [11]. This species is known from many greenhouse in West and North Europe.

Boreoiulus tenuis (Bigler)

One male of this rare in Poland species was caught in a lawn in Warsaw. It is of Atlantic origin and synanthropic in other regions. In Poland rarely recorded from gardens and greenhouses.

Scarce stands in natural habitats are known only from the Lublin upland [15].

Cylindroiulus truncorum (Silvestri)

It was caught in greenhouse of the Botanical Garden, University of Warsaw. In Poland it occurs in gardens, greenhouses, and sometimes outside buildings.

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Table 3. Check-list of *Diplopoda* species occurring in Warsaw and Mazovia

No.	Species	Mazovia	Warsaw				
			Suburban areas	Parks	Green areas in housing estates	Town centre	Other sampling areas
1	2	3	4	5	6	7	8
1	<i>Polyxenus lagurus</i> (L.)	○	+	—	—	—	—
2	<i>Glomeris connexa</i> C. L. K.	●	+	—	—	—	●
3	<i>Glomeris hexasticha</i> Brdt.	●	—	—	—	—	●
4	<i>Trachysphaera costata</i> (Waga)	—	—	+	—	—	○
5	<i>Heteroporatia bosniensis</i> Verh.	—	+	+	—	—	●
6	<i>Heteroporatia vihorlatica</i> Att.	○	—	—	—	—	—
7	<i>Mastigophorophyllon saxonicum</i> Verh.	●	●	—	—	—	●
8	<i>Craspedosoma simile</i> Verh.	●	+	—	—	—	●
9	<i>Brachydesmus superus</i> Latz.	●	+	+	+	—	○
10	<i>Polydesmus inconstans</i> Latz.	●	+	+	+	+	○
11	<i>Polydesmus complanatus</i> (L.)	●	+	—	—	—	○
12	<i>Ophiodesmus albonanus</i> (Latz.)	—	—	—	—	—	+
13	<i>Oxidus gracilis</i> C. L. K.	—	—	—	—	—	●
14	<i>Strongylosoma stigmatosum</i> (Eichw)	●	—	—	—	—	○
15	<i>Blaniulus guttulatus</i> (F.)	●	—	+	+	—	○
16	<i>Boreoiulus tenuis</i> (Bigl.)	○	—	+	—	—	○
17	<i>Choneiulus palmatus</i> (Nëm.)	●	—	+	—	—	○
18	<i>Nemasoma varicorne</i> C. L. K.	●	+	—	—	—	○
19	<i>Proterioulus fuscus</i> (Am St.)	●	+	+	—	—	○
20	<i>Nopoiulus venustus</i> (Mein.)	○	—	+	—	—	○
21	<i>Cylindroiulus arborum</i> Verh.	○	—	+	—	—	○
22	<i>Cylindroiulus britanicus</i> (Verh.)	○	—	—	—	—	○
23	<i>Cylindroiulus frisius</i> (Verh.)	●	+	+	+	+	○
24	<i>Cylindroiulus truncorum</i> (Silv.)	○	—	—	—	—	●
25	<i>Cylindroiulus caeruleocinctus</i> (Wood)	○	—	+	+	+	○
26	<i>Cylindroiulus occultus</i> (C. L. K.)	●	—	+	+	+	○
27	<i>Leptophyllum nanum</i> (Latz.)	—	—	—	—	—	—
28	<i>Julus scandinavicus</i> Latz.	○	—	—	—	—	—
29	<i>Julus terrestris</i> L.	●	+	—	—	—	○
30	<i>Leptoiulus proximus proximus</i> (Nëm.)	●	+	—	—	—	○
31	<i>Leptioulus minutus</i> (Por.)	○	—	—	—	—	—
32	<i>Microiulus laeticollis laeticollis</i> (Por.)	○	—	—	—	—	○
33	<i>Ophiulus fallax</i> (Mein.)	○	+	—	—	—	○
34	<i>Brachyiulus pusillus</i> Leach)	○	—	—	—	—	○
35	<i>Chromatoiulus projectus kochi</i> (Verh.)	●	+	—	—	—	—
36	<i>Chromatoiulus sjaelandicus</i> (Mein.)	○	—	—	—	—	—
37	<i>Unciger foetidus</i> (C. L. K.)	●	+	+	+	—	○
38	<i>Ommatoiulus sabulosus</i> (L.)	●	+	—	—	—	○
39	<i>Sarmatiulus vilnensis</i> (Jawł.)	●	—	—	—	—	—
40	<i>Polyzonium germanicum</i> Brdt.	●	+	—	—	—	—

KROCIONOGI (*DIPLOPODA*) WARSZAWY I MAZOWSZA

STRESZCZENIE

W czasie prowadzonych badań nad krocionogami Warszawy i Mazowsza zebrano ponad 5 800 okazów. Stwierdzono występowanie 40 gatunków krocionogów co stanowi 47% fauny krajowej. W cieplarniach Ogrodu Botanicznego UW znaleziono *Ophiodesmus albonanus* (Latz.), nowy dla Polski gatunek *Diplopoda*. Wyróżniono 6 zasadniczych elementów zoogeograficznych, z których najliczniejsze to europejski (26 gatunków) i holarktyczny (5 gatunków). Krocionogi występujące w Warszawie w większości są gatunkami ekspansywnymi, o szerokim rozmieszczeniu geograficznym. Wyróżniono 4 elementy ekologiczne, z których najliczniejszymi w Warszawie są gatunki synantropijne (13), a na Mazowszu gatunki leśne (16).

ДВУПАРНОНОГИЕ (*DIPLOPODA*) ВАРШАВЫ И МАЗОВИИ

РЕЗЮМЕ

При проведении исследований по двупарноногим Варшавы и Мазовии было собрано свыше 5800 особей и констатировано 40 видов, что составляет 47% фауны Польши. В оранжереях Ботанического сада Варшавского университета найден *Ophiodesmus albonanus* (Latz.) — новый для Польши вид *Diplopoda*. Выделено 6 основных зоогеографических элементов, наиболее многочисленный из них — это европейский (26 видов) и голарктический (5 видов). Двупарноногие, встречающиеся в Варшаве принадлежат в основном к экспансивным видам с широким географическим распространением. Выделены 4 экологических элемента, из которых наиболее многочисленными в Варшаве являются синантропные виды (13), а в Мазовии лесные виды (16).