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SPRINGTAILS (*COLLEMBOLA*) OF WARSAW AND MAZOVIA

ABSTRACT

There are 141 springtail species known from Mazovia, including 110 of the suborder *Arthropleona*, of which 44 were found in Warsaw and 41 in urban green areas.

In urban green areas, the cosmopolitan and European species have the highest proportion (63.4% of the species composition). The proportion of eurytopic species is similar in Mazovia and urban green areas (20%). In urban green areas, the number of species characteristic of open spaces is the highest, while the forest-dwelling species are almost completely eliminated, and hygrophilous and epigean species reduced. Expansive species are represented by *Cryptopygus bipunctatus* and *Pseudosinella immaculata*.

INTRODUCTION

The *Collembola* of Poland have not been well known so far. Most comprehensive data on these insects are given by Stach in his monographs [19—28]. They are summed up and supplemented in the catalogue of the *Apterygota* of Poland [29].

The first notes on the occurrence of springtails in the Mazovian Lowland can be found in Waga [34], who described a new species, *Achorutes bielanensis*, collected in Bielany and on the right Vistula bank, and also in the paper by Nasonov [12], who lists two species collected in Warsaw: *Podura aquatica* and *Lipura ambulans*. A more complete information on the species composition of *Collembola* living in Mazovia was given by Stach [29]. His data are largely supplemented by Kaczmarek [6, 7], but only from the Kampinos National Park. No other data on the springtails of Mazovia are available.

The main purpose of this paper is to compare springtail communities occurring in natural habitats of the Mazovian Lowland with those living in urban green areas of Warsaw, and to analyse mostly qualitative changes in springtail communities of different types of urban green areas in response to urban pressure.

The literature data [6, 7, 12, 29] are used here and the materials collected during one season (April—October 1976) by a group of workers from the Institute of Zoology, PAS. The general premisses of the study, study

area, and methods of material collecting are described elsewhere [2, 10, 11, 33]. The other materials, collected in 1974, 1975, and 1977, as a part of research on the problem "The effect of urban pressure on the fauna of Warsaw" will be processed later, thus the present paper should be considered as as a preliminary contribution.

SPECIES COMPOSITION

According to the catalogue by Stach [29], 70 springtail species were recorded from Mazovia. The papers by Kaczmarek [6, 7] supplement this list by 54 new species. In this paper, which is based on the literature data and on author's materials, 141 species have been recorded from Mazovia, including 107 species of the suborder *Arthropleona* (Tab. 6).

The occurrence of three species has been put in question in this area. These are either the species found long ago and probably erroneously identified (no confirmation of their occurrence in the more recent literature) or the species brought, met only in greenhouses, flats, etc. These are:

Onychiurus bureschi [6]. The species found in caves of Bulgaria, known from Stiria and the East Carpathians, living in caves under stones or under protruding bark of trees. It is a rare and scarce species. Its occurrence in Mazovia needs confirmation.

Paranurophorus armatus [29] — brought to Poland probably from China, found in flower-pot earth, does not occur in natural habitats.

Onychiurus ambulans [12] — recorded from many caves of Central Europe and West Germany (troglophilous species). From Mazovia recorded by Nasonov [12]. The occurrence of this species in Mazovia needs confirmation.

Within the administrative boundaries of Warsaw, 48 species of *Collembola* have been recorded, including 44 species of the suborder *Arthropleona* and 4 species of the suborder *Symphypleona* (Tab. 6). Since the data on the number of species of the suborder *Symphypleona* living in urban green areas are not complete, then the further analysis will be concerned with the suborder *Arthropleona*. In addition, the data from the suburbs, which are very fragmentary, have been excluded from the analysis of the species composition of springtails living in Mazovia and urban greenery.

The number of species of the suborder *Arthropleona* recorded in Warsaw accounts for about 41% of the *Arthropleona* of Mazovia (without Warsaw). In urban green areas, 41 species have been recorded, including 32 species in park lawns (29.9% of the *Arthropleona* of Mazovia), 21 species in lawns of housing estates (19.6%), and 27 species in the centre of the town (25.2%).

The number of species occurring in Warsaw, which is 41 has been reduced by half, as compared with natural habitats of Mazovia, where 86 species have been recorded. It is also interesting that the species composition

of springtails is largely transformed in the town, eight species being recorded only in urban green areas.

ZOOGEOGRAPHICAL ANALYSIS

In the zoogeographical analysis of springtails of Mazovia, the distribution of particular species is considered in the chorological sense. The data on the present distribution of springtails are based on Salomon's catalogue [18] and papers by Stach [19, 29]. A detailed description of the zoogeographical elements distinguished is given in the paper on the study methods [33].

Most of the springtail species have very large geographical ranges. This is mostly due to the fact that particular species can easily be brought to other continents. It is well known that many springtail species are characterized by large ecological amplitudes, thus they can live in similar microhabitats of extremely different biotopes.

The following zoogeographical elements have been distinguished in the springtails of Mazovia (excluding Warsaw): cosmopolitan, Holarctic, Palaearctic, European, Euro-Siberian, boreal, mountain, submediterranean, and Mediterranean. The largest group is made up of the species with Holarctic ranges (34.8%), European ranges (32.5%) and cosmopolitan ranges (19.8%), while the species with Palaearctic (4.7%), Euro-Siberian (3.5%) and boreo-mountain ranges (3.5%) form a small group (Tab. 1).

The Euro-Siberian species occurring in Mazovia include *Pogonognathellus longicornis*, *Pseudachorutes dubius*, and *Microanurida forsslundi*. They are closely distributed in northern parts of the Palaearctic region, and on numerous dispersed sites in the mountains and in the European Lowland, mainly on moors.

The group of boreo-mountain species is represented by *Xenylla schillei*, the species spread over the mountains of Europe (the Carpathians, Alps, Pyrenees), known only from southern Tuva and by *Anurida granulata*, the species recorded from Scandinavia, northern Asia, and mountains of Central Europe. The group of mountain species is also represented by *Tetrodontophora bielanensis*, a circumpannonian species, the natural northern range of which goes through southern Poland [3]. It is numerous in Bielany (a suburbium of Warsaw), where it was probably brought with flood waters of the Vistula.

The group of species with unknown ranges includes those which have recently been described, and have been recorded from lew sites, such as *Lepidocyrtus nigrescens* or *Mesaphorura krausbaueri*. The latter species is known almost all over the world, and also recorded from many sites in Poland, including the Mazovian Lowland. However, according to Rusek [15], the name *krausbaueri* denotes at least four genera and ten species. Since the designation of the specimens of this species collected from Mazovia

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

Zoogeographical element	Mazovia		Warsaw							
			Urban green areas							
			Total		Parks		Housing estates		Town centre	
	N	%	N	%	N	%	N	%	N	%
Cosmopolitan	17	19.8	13	31.7	8	25.0	7	33.3	11	40.8
Holarctic	30	34.8	9	22.0	9	28.1	5	23.8	7	25.9
Palaearctic	4	4.7	3	7.3	2	6.3	2	9.5	3	11.1
European	28	32.5	13	31.7	10	31.2	6	28.6	5	18.5
Euro-Siberian	82	33.5	—	—	—	—	—	—	—	—
Boreo-mountain	3	3.5	—	—	—	—	—	—	—	—
Submediterranean	—	—	1	2.4	1	3.1	—	—	—	—
Unknown	1	1.2	2	4.9	2	6.3	1	4.8	1	3.7

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

Group		Mazovia		Warsaw							
				Urban green areas							
				Total		Parks		Housing estates		Town centre	
		N	%	N	%	N	%	N	%	N	%
Living in forest	Oligotopic	11	14.5	1	2.4	1	3.1	—	—	—	—
	Polytopic	17	22.4	2	4.9	3	9.3	1	4.8	2	7.4
Living in open areas	Oligotopic	15	19.7	8	19.5	7	21.9	2	9.5	4	14.8
	Polytopic	7	9.2	11	26.8	7	21.9	6	28.6	8	29.6
Oligotopic		7	9.2	5	12.2	3	9.4	2	9.5	4	14.8
Eurytopic		16	21.1	9	22.0	7	21.9	8	38.1	6	22.2
Unknown		3	3.9	5	12.2	4	12.5	2	9.5	3	11.2

was not revised, it is difficult to give reliable data on the occurrence of particular species of the group *krausbaueri*.

The Euro-Siberian and boreo-mountain species are completely eliminated from urban green areas. Instead, the proportion of cosmopolitan species increased in Warsaw, as compared with Mazovia. The proportion of the European and Holarctic species is reduced in the town (Tab. 1). It is also interesting that typical southern, thermophilous species of springtails, not likely to occur in natural habitats of Mazovia, appeared in urban green areas. These are the species occurring only in lowlands of southern and central Europe, such as *Folsomides parvulus*, a species probably with the subatlantic range [30], or *Cyphoderus bidenticullatus*, a submediterranean species.

ECOLOGICAL ANALYSIS

A great majority of springtails are associated with the surface soil layer. The second important habitats is the litter layer and low herbaceous vegetation. Moreover, springtails can also live in such habitats as littoral waters, neustonic plants, and nests, mammal (e.g. rodent) nests, and caves. There are also winter-species occurring only on ice and snow.

The distribution of springtails is firstly determined by the soil type, litter type (made of broad leaves or needles), the degree of litter decomposition, pH, and microclimatic factors (e.g. humidity, temperature).

The species composition of springtail communities occurring in meadows and crop fields usually is very similar to that of the communities living in forests. It is difficult, therefore, to distinguish the species characteristic of specific plant communities. It is possible only in few cases. The species characteristic of coniferous forests are represented by *Anurophorus laricis*, *Willemia anophthalma*, and *W. aspinata* [30]. These are rather stenotopic species, which need neddle litter, very acid and with a completely different decomposition type as compared with broad-leaf litter. Also myrmecophilous, troglophilous, and hygrophilous species show narrow habitat preferences. These are usually the species the occurrence of which in a given biotope (ant nests, caves, water bodies) is determined not only by narrow habitat requirements but also by corresponding adaptations in their morphology.

The ecological analysis of the *Collembola* of the Mazovian Lowland and urban green areas in Warsaw does not involve winter species (*Isotoma hiemalis*, *I. intermedia*, and *Hypogastrura socialis*) and hygrophilous species (*Podura aquatica*, *Hypogastrura viatica*, *Ballistura schötti*, *B. crassicauda*, *Isotomurus alticolus*, and *I. ciliatus*).

ECOLOGICAL AMPLITUDE

Springtail communities occurring in Mazovia are dominated by eurytopic species (*Isotoma notabilis*, *Onychiurus armatus*, *Folsomia quadrioculata*, *Lepi-*

docyrtus lanuginosus [7]). Also in Warsaw these are most common, most abundant and usually dominant species [32]. In urban communities of springtails there are no forest-dwelling species (Tab. 2), such as *Anurophorus laricis, Willemia anophthalma* and *W. aspinata*, which are common in *Vaccinio myrtylli-Pinetum* of the Kampinos forest. Also polytopic forest--dwelling species such as *Onychiurus granulosus* [7] are lacking. Instead, *Lepidocyrtus lignorum*, the species quoted by Szeptycki [30] as characteristic of the forest fauna, is common in all types of urban green areas. Other, non-numerous forest-dwelling species are preserved only in parks. These are *Orchesella bifasciata, Entomobrya corticalis*, and *Folsomia fimetaria* (*F. fimentaria* was also found in the housing estate Wierzbno).

In addition to eurytopic and scarce forest-dwelling species, urban green areas are inhabited also by the species characteristic of open areas (moist meadows, pastures, saxicolous and xerothermal grasslands). These are mostly polytopic species. Also the proportion of oligotopic species is high. These are both xerophilous and thermophilous species associated with plant communities of open spaces. This group also includes myrmecophilous species such as *Cyphoderus albinus, C. bidenticulatus*, or *Entomobryoides myrmecophilus*. Some urban green areas are inhabited by the species with much narrower habitat requirements, e.g. *Hypogastrura vernalis*, a xerophilous species occurring on alkaline sites, characteristic of xerothermal grasslands [30].

MOISTURE REQUIREMENTS

Soil moisture is one of the more important factors limiting the occurrence of springtails. A great majority of the *Collembola* living in Mazovia belongs to mesohygrophilous species occurring in soil, litter, low herbaceous plants, or in caves. In Mazovia there are many hygrophilous species living in soils permanently or sporadically wet (*Lepidocyrtus ruber, Tomcerus minor, T. minutus, Isotomurus palustris, I. plumosus*). There are also representatives of the xerophilous fauna occurring in saxicolous and xerothermal grasslands (*Orchesella xerothermica, Hypogastrura vernalis*, or *Schoetella ununguiculata*).

Green areas of Warsaw, like natural habitats of Mazovia, are dominated by mesohygrophilous species, accounting for more than 50% of the *Arthropleona*. It has been found that the number of hygrophilous species is lower in urban habitats, particularly in housing estates and in the centre of the town, as compared with the number in the Mazovian Lowland (Tab. 3). But the species considered as hygrophilous, such as *Brachystomella parvula* and *Isotoma viridis*, are common in urban green areas. In very low numbers and only on single sites such hygrophilous species were found as *Frisea afurcata* and *Orchesella villosa*. The occurrence of hygrophilous species in urban green areas can suggest that the overdrying of soils in the towns is much lower than indicated by climatic data [9], or that some "hygrophilous" springtails have considerably higher ecological amplitudes than known so far. The proportion of xerophilous species in springtail communities of Warsaw green

Table 3. Proportions of groups with different moisture preferences in springtails of Warsaw and non-urban habitats of Mazovia (N—number of species)

Habitat preference	Mazovia		Warsaw							
			Urban green areas							
			Total		Parks		Housing estates		Town centre	
	N	%	N	%	N	%	N	%	N	%
Hygrophilous	13	17.1	5	12.2	4	12.5	2	9.5	2	7.4
Mesohygrophilous	43	56.6	22	53.7	18	56.2	15	71.4	17	63.0
Xerophilous	18	23.7	8	19.5	6	18.8	1	4.8	5	18.5
Unknown	2	2.6	6	14.6	4	12.5	3	14.3	3	11.1

Table 4. Proportions of groups with different vertical distribution in springtails of Warsaw and non-urban habitats of Mazovia (N—number of species)

Group	Mazovia		Warsaw							
			Urban green areas							
			Total		Parks		Housing estates		Town centre	
	N	%	N	%	N	%	N	%	N	%
Epigeon	12	15.8	1	2.4	1	3.1	1	4.8	—	—
Hemiedaphon	43	56.6	26	63.5	19	59.4	13	61.9	15	55.6
Euedaphon	21	27.6	14	34.1	12	37.5	7	33.3	12	44.4

areas is similar to that in the Mazovian Lowland. In urban green areas such species characteristic of xerophilous fauna were found as *Hypogastrura vernalis*, *Schoetella ununguicalata*, *Folsomides parvulus*, *Entomobrya marginata*, or *E. multifasciata*.

STRATIFICATION

The biology of many springtails is poorly known and it may be difficult to tell whether a given species inhabits soil, or litter, or the herb layer. For this reason *Collembola* are frequently classified according to their morphology. Such a classification prepared by Christiansen [1] is used in the present paper. It gives an approximate information on the layer in which a given species lives.

It has been found that in urban green areas, like in other habitats of Mazovia, a large proportion of the species are associated with the litter layer (hemiedaphic species) (Tab. 4). In urban green areas, however, the proportions between the number of euedaphic and epigean species are different than in the Mazovian Lowland. In the urbicoenosis the proportion of euedaphic species is slightly increased, and the proportion of epigean species is drastically reduced.

FEEDING HABITS

An analysis of the diet of springtails of the suborder *Arthropleona* shows that most of their species can be considered as typical polysaprophages. On the basis of the morphology of mouth parts, most sprintails have been classified to the group of biting exophages. The recent studies have shown that some *Collembola* classified as sucking species (of the genus *Brachystomella* Ågren et *Neanura* MacGill) feed on the suspension of small organisms living in the water film on soil particles (Adams and Salmon 1972, Singh 1969, both quoted in Szeptycki [31]). This type of feeding is likely to be common in the family *Neanuridae*.

The main food of springtails is decomposed plant material, bacteria, protozooans, fungi, spores, and faeces of arthropods. Both the type of food taken and the way of feeding show that springtails play an important part in the mechanical and chemical decomposition of organic debris, dissemination of fungal spores, and activation of microorganisms. Thus these are breaking down and humifying saprophages at the same time. They transform organic matter into humus. Only the species of the genera *Frisea* D.T. and *Anurida* Lab., with piercing-sucking mouth parts, are often quoted as predatory or carrion-eating.

Food concentration, measured as the content of organic matter or as the number of microorganisms (mostly bacteria and fungi) is; like the soil type and moisture, the main factor determining the distribution of soil *Collembola* [1].

In urban green areas the density of springtails is largely reduced [32] as compared with natural habitats of Mazovia [6, 7]. One of the reasons is likely to be a considerably reduced food supply (a very low content of organic matter in the soil of urban lawns, lack of plant litter).

ABUNDANCE AND EXPANSIVENESS

The proportion of sporadic species decreased from 24.3% in natural habitats of Mazovia to 3.7% in the centre of the town. Also the proportions of numerous and scarce species were changed. In urban green areas the species classified as numerous predominate (Tab. 5).

In urban green areas the proportion of two expansive species, *Cryptopygus bipunctatus* and *Pseudosinella immaculata*, is high. They commonly occur in all types of green. *Cryptopygus bipunctatus* most often predominates springtail communities of urban green areas [32]. In Mazovia it was found in small numbers in a bog pine forest (*Vaccinio myrtilli-Pinetum*), in moors (*Caricetum elatae* and *Carici-Agrostetum caninae*), and on *Stellario-Deschampsietum* meadows in the Kampinos forest [7]. It was similarly non-numerous in the Pieniny mountain range [35, 36], near Poznań [8, 37], in the Kraków-Wieluń upland [14, 19, 30] and in the Tatra mountains [19, 26]. *P. immaculata* was recorded mainly from caves [26, 29].

DISCUSSION

The fauna of *Collembola* occurring in urban green areas is largely impoverished as compared with that living in natural habitats of Mazovia. First of all, the percentage of cosmopolitan species is twice as high in urbicoenoses (Tab. 1), while the mountain-boreal and Euro-Siberian species are completely eliminated from the town. The appearance of submediterranean species in urban green areas, e.g. *Cyphoderus bidenticulatus*, is interesting. They do not occur in natural habitats of Mazovia.

Apart from this, in the springtail communities of urban green areas in addition to ubiquitous species also the species associated with open areas, such as *Mesaphorura krausbaueri*, *Isotoma viridis*, *Brachystomella parvula*, or *Metaphorura affinis* play the main part. Frequently these are the species characteristic of xerothermal grasslands (*Hypogastrura vernalis*) or abundantly occurring near human settlements and in crop fields (*Isotomodes productus*). Also the proportion of myrmecophilous species such as *Cyphoderus albinus* or *Entomobryoides myrmecophilus* is increased. Some of them occur only in the urban habitat (19.5% of the species have not been recorded from Mazovia), which is characterized by specific climatic conditions (low relative air humidity, considerable overdrying of the urban habitat, increases in temperature, etc.) and habitat conditions (physico-chemical transformation of urban soils and biotic transformations, e.g. an increase in the proportion of ants in the

Table 5. Proportions of groups with different abundances in springtails of Warsaw and non-urban habitats of Mazovia (N—number of species)

Group	Mazovia		Warsaw							
			Urban green areas							
			Total		Parks		Housing estates		Town centre	
	N	%	N	%	N	%	N	%	N	%
Numerous	28	36.8	25	61.0	21	65.6	15	71.4	18	66.7
Scarce	27	35.5	9	22.0	6	18.8	33	14.3	7	25.9
Sporadical	19	25.0	6	14.6	4	12.5	2	9.5	1	3.7
Unknown	2	2.7	1	2.4	1	3.1	1	1	1	3.7

soil macrofauna [13]). It has been shown that urbicoenoses provide suitable conditions for the occurrence of thermo- or xerophilous species, south-European, such as *Cyphoderus bidenticulatus* or *Neotullbergia ramicuspis*.

Urban communities of springtails are dominated by mesohygrophilous species (with a high tolerance to soil moisture), xerophilous species are numerous, while many hygrophilous species common in Mazovia, such as *Lepidocyrtus ruber*, *Isotomurus palustris*, or *I. plumosus*, have been eliminated. Also the number of soil-dwelling species is higher in urbicoenoses, while the epigean species are eliminated. The expansive springtails are represented by *Cryptopygus bipunctata* and *Pseudosinella immaculata*.

In urban communities not only the species diversity but also the density of springtails decreased. One of the possible reasons is a limited food supply (lack of leaf litter). A great decrease in the density of such breaking down and humifying saprophages as springtails is likely to have a negative effect on the efficiency of decomposers and, consequently, the mineralization and humification processes go less rapidly.

THE SPECIES NEW TO POLAND

Ceratophysella succinea Gisin

Warsaw-Wierzbno, August 12, 1976, seven specimens found in the soil of a lawn near a street crossing the housing estate. The species probably most frequently taken for *Ceratophysella armata* (Nic.). Recorded from Europe (Switzerland, Sweden, Germany, Czechoslovakia) and from eastern part of Greenland (Jan Mayen Islands [4, 16, 18].

SPECIES NEW TO MAZOVIA

Hypogastrura assimilis Krausb.

Warsaw-MDM, July 6, 1976, one specimen.

Hypogastrura purpurescens (Lubb.)

Warsaw-MDM, June 4, 1976, one specimen.

Hypogastrura vernalis (Carl)

Warsaw-MDM, June 4, 1975, five specimens.

Hypogastrura viatica (Tullb.)

Warsaw–Raszyn, July 1978, found on the water surface (mass appearance), leg. D. Wiśniewska.

Willemia intermedia Mills

Warsaw — Saxon Garden, Łazienki park, MDM, single specimens. Rare species, recorded from few sites in Poland [36, 37].

Frisea afurcata Denis

Warsaw — Łazienki park, July 6, 1976, one specimen. A littoral species living on sea coasts, river banks, and on the margins of other water bodies, also in wetland. So far noted only from the Pieniny mountains range [36].

Mesaphorura krausbaueri s. Rusek [15]

Warsaw — Saxon Garden, Łazienki park, Wierzbno, MDM. Common in all types of urban green areas. Earlier recorded only from meadow biotopes, prefers meso- and xerothermal meadows [17]. In Poland recorded from the Poznań region [8] and from the Pieniny mountains [36].

Stenaphorura quadrispina Börn.

Warsaw — Saxon Garden, Łazienki park, Białołęka Dworska, Radziejowice (Jaktorów forest), scarce in urban green areas and in non-urban habitats.

Isotomodes productus (Axels.)

Commonly recorded in all types of urban green areas, and not numerous in Białołęka Dworska (a suburbium).

Lepidocyrtus lignorum (F.)

Commonly found in all types of urban green areas of Warsaw, in non-urban habitats (Białołęka Dworska), and in natural habitats (Kampinos and Jaktorów forests).

Pseudosinella immaculata (Lie Pett.)

Numerous in the soils of lawns in parks and housing estates (Warsaw — Saxon Garden, Łazienki park, Wierzbno).

Pseudosinella zygophora (Schille)

Recorded only outside the urban green areas of Warsaw, in the Kampinos forest, Jaktorów forest, and scarce in the suburbs.

CONCLUSIONS

1. In urban green areas of Warsaw there were 41 *Arthropleona* species recorded, while 86 species are known from the Mazovian Lowland; 33 species (38.4%) occur in both Warsaw and Mazovian Lowland.

2. In Warsaw, eight species new to Mazovia have been recorded. These are *Hypogastrura assimilis, H. purpurescens, Ceratophysella succinea, Willemia intermedia, Frisea afurcata, Mesaphorura krausbaueri* sensu Rusek 1971, *Isotomodes productus*, and *Pseudosinella immaculata*.

3. The species commonly occurring in urban green areas are *Cryptopygus bipunctatus, Lepidocyrtus languinosus, L. cyaneus, L. lignorum, Isotoma notabilis, I. viridis*, and *Isotomiella minor*, while in the Kampinos forest [7] the dominant species are *Folsomia fimetaroides, F. quadrioculata, Isotomiella minor, Isotoma notabilis, Lepidocyrtus languinosus, Onychiurus armatus*. and *Tullbergia krausbaueri*.

4. In springtail communities of urban green areas, the highest proportion have cosmopolitan species (31.7% of the number of species), while Holarctic species in the Mazovian Lowland (34.8%). The proportion of the number of boreo-mountain and Palaearctic species is similar in the two habitat types. In urban green areas there are no boreo-mountain and Euro-Siberian elements, and the submediterranean element appears.

5. Green areas of Warsaw are inhabited by the highest number of species associated with open spaces (46.3%) and eurytopic species (22%). The

proportion of the number of polytopic and oligotopic species associated with forests is low (7.3%). In the Mazovian Lowland most species belong to forest-dwellers (36.9%). The proportions of the species associated with open areas and eurytopic species are 28.9% and 21.1%, respectively.

6. In Warsaw and Mazovia, mesohygrophilous species predominate, accounting for 53.7 and 56.6% of the total number of species, respectively, while the proportion of hygrophilous species is largely reduced in urban green areas as compared with the Mazovian Lowland.

7. In urban green areas there occur two expansive species: *Cryptopygus bipunctatus* and *Pseudosinella immaculata*.

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Table 6. Check-list of *Collembola* species occurring in Warsaw and Mazovia

○ — literature data
● — proved literature data
\+ — unpublished data
? — doubtful information

No.	Species	Mazovia	Suburban areas	Warsaw			
				Parks	Green areas in housing estates	Town centre	Other sampling areas
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	*Podura aquatica* L.	○	–	–	–	–	○
2	*Hypogastrura assimilis* Krausb.	–	–	–	–	+	–
3	*Hypogastura manubrialis* (Tullb.)	○	–	–	–	+	–
4	*Hypogastura purpurescens* (Lubb.)	–	–	–	–	+	–
5	*Hypogastrura socialis* (Uzel)	○	–	–	–	–	–
6	*Hypogastrura vernalis* (Carl)	–	–	–	–	+	–
7	*Hypogastrura viatica* (Tullb.)	+	–	–	–	–	–
8	*Ceratophysella armata* (Nic.)	○	–	–	–	–	–
9	*Ceratophysella succinea* Gisin	–	–	–	+	–	–
10	*Schoettella unuguiculata* (Tullb.)	○	–	+	–	–	–
11	*Choreutinula inermis* Tullb.	○	–	–	–	–	–
12	*Xenylla brevisimilis* Stach	○	–	–	–	–	–
13	*Xenylla maritima* Tullb.	○	–	–	–	–	–
14	*Xenylla schillei* Börn.	○	–	–	–	–	–
15	*Willemia anophthalma* Börn.	○	–	–	–	–	–
16	*Willemia aspinata* Stach	○	–	–	–	–	–
17	*Willemia intermedia* Mills	–	–	+	–	+	–
18	*Brachystomella parvula* (Schäff.)	○	–	+	+	–	–
19	*Frisea afurcata* Denis	–	–	+	–	–	–
20	*Frisea mirabilis* (Tulb.)	○	–	+	+	–	–
21	*Odontella lamellifera* (Axels.)	○	–	–	–	–	–
22	*Pseudachorutes dubius* Krausb.	○	–	–	–	–	–
23	*Pseudachorutes sucrassus* Tullb.	○	–	–	–	–	–
24	*Anurida granulata* Agrell	○	–	–	–	–	–
25	*Anurida granaria* (Nic.)	○	–	–	–	–	–
26	*Anurida tullbergii* Schött	–	–	–	–	–	○
27	*Microanurida forsslundi* Gisin	○	–	–	–	–	–
28	*Microanurida pygmea* Börn.	○	–	–	–	–	–
29	*Neanura muscorum* (Templ.)	○	–	–	–	–	–
30	*Neanura tetrophthalma* (Stach)	○	–	–	–	–	–
31	*Tetrodontophora bielanensis* (Waga)	○	●	–	–	–	–
32	*Onychiurus absoloni* (Börn.)	○	–	–	–	–	–
—	*Onychiurus ambulans* L.	–	–	–	–	–	?
33	*Onychiurus armatus* (Tullb.)	●	+	+	+	+	○
—	*Onychiurus bureschi* Handsch.	?	–	–	–	–	–
34	*Onychiurus fimetarius* (L.)	○	–	–	–	–	–
35	*Onychiurus furciferus* (Börn.)	○	–	–	–	–	–
36	*Onychiurus granulosus* Stach	○	–	–	–	–	–
37	*Onychiurus variabilis* Stach	○	–	–	–	–	–
38	*Metaphorura affinis* (Börn.)	–	–	+	–	+	–

1	2	3	4	5	6	7	8
39	*Mesaphorura krausbaueri* Börn.	○	–	+	+	+	–
40	*Stenaphorura quadrispina* Börn.	–	–	+	–	–	–
41	*Neotullbergia ramicuspis* (Gisin)	–	–	–	+	–	–
—	*Paranurophorus armatus* Stach	?	–	–	–	–	–
42	*Anurophorus laricis* Nic.	○	–	–	–	–	–
43	*Folsomides parvulus* Stach	○	–	+	–	+	–
44	*Isotomodes productus* (Axels.)	–	–	+	+	+	–
45	*Folsomia candida* Will.	–	–	+	–	+	●
46	*Folsomia fimetaria* (L.)	○	–	+	–	+	–
47	*Folsomia quadrioculata* (Tullb.)	●	–	+	+	+	–
48	*Folsomia fimetaroides* (Axels.)	○	–	–	–	–	–
49	*Proisotoma minima* (Abs.)	○	–	–	–	–	–
50	*Proisotoma minuta* (Tullb.)	–	–	–	–	–	○
51	*Ballistura schoetti* (D. T.)	○	–	–	–	–	–
52	*Ballistura crassicauda* (Tullb.)	○	–	–	–	–	–
53	*Cryptopygus bipunctatus* (Axels.)	○	–	+	+	+	–
54	*Cryptopygus termophilus* (Axels.)	○	–	–	–	+	–
55	*Isotomiella minor* (Schäff.)	●	–	+	+	+	–
56	*Pseudoisotoma sensibilis* (Tullb.)	○	–	–	–	–	–
57	*Vertagopus cinerea* (Nic.)	○	–	–	–	–	–
58	*Isotoma hiemalis* Schött	○	–	–	–	–	–
59	*Isotoma intermedia* Schött	○	–	–	–	–	–
60	*Isotoma notabilis* Schäff.	○	–	+	+	+	–
61	*Isotoma olivacea* Tullb.	○	–	–	–	–	–
62	*Isotoma violacea* Tullb.	○	–	–	–	–	–
63	*Isotoma viridis* Bourl.	●	+	+	+	+	○
64	*Isotomurus alticolus* (Carl)	○	–	–	–	–	–
65	*Isotomurus ciliatus* Stach	○	–	–	–	–	–
66	*Isotomurus palustris* (Müll.)	○	–	–	–	–	–
67	*Isotomurus plumosus* (Stach)	○	–	–	–	–	–
68	*Cyphoderus albinus* Nic.	○	–	+	–	+	–
69	*Cyphoderus bidenticulatus* (Parona)	–	–	+	–	–	–
70	*Tomcerus minutus* (Tullb.)	○	–	–	–	–	–
71	*Tomcerus minor* (Lubb.)	○	–	–	–	–	–
72	*Tomcerus vulgaris* (Tullb.)	○	–	–	–	–	–
73	*Pogonognathellus flavescens* (Tullb.)	○	–	–	–	–	–
74	*Pogonognathellus longicornis* (Müll.)	○	–	–	–	–	–
75	*Orchesella albofasciata* Stach	○	–	–	–	–	–
76	*Orchesella bifasciata* Nic.	○	○	+	–	–	–
77	*Orchesella cincta* (L.)	○	○	–	–	–	–
78	*Orchesella flavescens* (Bourl.)	●	○	–	–	–	–
79	*Orchesella multifasciata* Scherb.	○	–	–	–	–	–
80	*Orchesella pseudobifasciata* Stach	○	–	–	–	–	–
81	*Orchesella spectabilis* Tullb.	○	–	–	–	–	–
82	*Orchesella villosa* (Geoffroy)	–	–	+	–	–	–
83	*Orchesella xerothermica* Stach	○	–	–	–	–	–
84	*Heteromurus nitidus* (Templ.)	○	–	–	–	–	+
85	*Entomobrya arborea* (Tullb.)	○	–	–	–	–	–
86	*Entomobrya corticalis* (Nic.)	●	●	+	–	–	–
87	*Entomobrya marginata* (Tullb.)	○	–	–	+	+	–
88	*Entomobrya multifasciata* (Tullb.)	○	–	+	–	+	–

1	2	3	4	5	6	7	8
89	*Entomobrya muscorum* (Nic.)	○	–	–	–	–	–
90	*Entomobrya nivalis* (L.)	○	–	–	–	–	○
91	*Entomobrya superba* (Reut.)	○	–	–	–	–	–
92	*Entomobrya quinquelineata* Börn.	○	–	–	–	–	–
93	*Entomobrya violaceolineata* Stach	○	–	–	–	–	–
94	*Entomobryoides myrmecophilus* (Reut.)	○	–	+	+	+	○
95	*Sinella curviseta* Brook	–	–	–	–	–	○
96	*Willowsia buski* (Lubb.)	○	–	–	–	–	–
97	*Seira domestica* (Nic.)	–	–	–	–	–	○
98	*Lepidocyrtus curvicollis* Bourl.	○	–	–	–	–	–
99	*Lepidocyrtus cyanus* Tullb.	○	+	+	+	+	–
100	*Lepidocyrtus lanuginosus* (Gmel.)	○	+	+	+	+	–
101	*Lepidocyrtus lignorum* (F.)	–	+	+	+	+	–
102	*Lepidocyrtus nigrescens* Szeptycki	–	–	+	–	–	–
103	*Lepidocyrtus paradoxus* Uzel	○	–	+	+	–	–
104	*Lepidocyrtus ruber* Schött	○	–	–	–	–	–
105	*Pseudosinella alba* (Pack.)	○	–	+	+	+	–
106	*Pseudosinella immaculata* (Lie Pett.)	–	–	+	+	+	–
107	*Pseudosinella zygophora* (Schille)	+	–	–	–	–	–
108	*Neelus murinus* Fols.	○	–	–	–	–	–
109	*Megalothorax minimus* Will.	○	–	–	–	+	–
110	*Sminthurides aquaticus* (Bourl.)	○	–	–	–	–	–
111	*Sminthurides malmgreni* (Tullb.)	○	–	–	–	–	–
112	*Sminthurides schoetti* (Axels.)	○	–	–	–	–	–
113	*Sminthurides penicillifer* (Schäff.)	○	–	–	–	–	–
114	*Sminthurides pseudassimilis* Stach	○	–	–	–	–	–
115	*Sphaeridia pumilis* (Krausb.)	○	–	–	–	–	–
116	*Stenacidia violacea* (Reut.)	○	–	–	–	–	–
117	*Arrhopalites principalis* Stach	○	–	–	–	–	–
118	*Arrhopalites pygmaeus* (Wank.)	○	–	–	–	–	–
119	*Sminthurinus aureus* (Lubb.)	○	–	+	–	–	–
120	*Sminthurinus bimaculatus* (Axels.)	○	–	–	–	–	–
121	*Sminthurinus elegans* (Fitch)	○	+	–	–	–	–
122	*Sminthurinus niger* (Lubb.)	○	–	–	–	–	–
123	*Bourletiella arvalis* (Fitch)	○	–	–	–	–	–
124	*Bourletiella hortensis* (Fitch)	○	–	–	–	–	–
125	*Deuterosminthurus bicinctus* (Koch)	○	–	–	–	–	–
126	*Deuterosminthurus circumfasciatus* Stach	○	–	–	–	–	–
127	*Deuterosminthurus repandus* (Agren)	○	–	–	–	–	–
128	*Heterosminthurus bilineatus* (Bourl.)	○	–	–	–	–	–
129	*Heterosminthurus insignis* (Reut.)	○	–	–	–	–	–
130	*Heterosminthurus linnaniemi* (Stach)	○	–	–	–	–	–
131	*Heterosminthurus novelineatus* (Tullb.)	○	–	–	–	–	–
132	*Lipothrix lubbocki* (Tullb.)	○	–	–	–	–	–
133	*Allacma fusca* (L.)	○	–	–	–	–	–
134	*Sminthurus flaviceps* Tullb.	○	–	–	–	–	–
135	*Sminthurus viridis* (L.)	○	○	–	–	–	–
136	*Caprainea marginata* (Schött.)	○	–	–	–	–	–
137	*Dicyrtomina minuta* (O. Fabr.)	○	–	–	–	–	–
138	*Dicyrtomina minuta* var. *flavosignata* (Tullb.)	○	–	–	–	–	–
139	*Dicyrtoma fusca* (Luc.)	○	–	–	–	–	–

1	2	3	4	5	6	7	8
140	*Ptenothrix atra* (L.)	○	–	–	–	–	–
141	*Ptenothrix leucostrigata* Stach	○	–	–	–	–	–

SKOCZOGONKI (*COLLEMBOLA*) WARSZAWY I MAZOWSZA

STRESZCZENIE

Przeprowadzono analizę składu gatunkowego *Collembola* z rzędu *Arthropleona* na stanowiskach naturalnych Mazowsza oraz w zieleni miejskiej Warszawy.

Na podstawie danych z piśmiennictwa [6, 7, 12, 29] i badań prowadzonych przez Instytut Zoologii Polskiej Akademii Nauk wykazano z całego obszaru Niziny Mazowieckiej 141 gatunków *Collembola* w tym 7 gatunków z podrzędu *Arthropleona*. Na obszarze warszawskiej aglomeracji miejskiej znaleziono 44 gatunki *Arthropleona*, w tym na trawnikach parkowych — 32, na trawnikach osiedlowych — 21 i w centrum miasta — 27 gatunków. Występowanie 7 gatunków *Collembola* ograniczone jest tylko do aglomeracji miejskiej (Tab. 6).

Analizując udział poszczególnych elementów zoogeograficznych stwierdzono, że na Nizinie Mazowieckiej największy udział mają gatunki holarktyczne, europejskie i kosmopolityczne. Niedużą grupę stanowią gatunki o zasięgu palearktycznym, eurosyberyjskim i borealno-górskim (Tab. 1). W zgrupowaniach *Collembola* zieleni miejskiej stwierdzono całkowite wyeliminowanie gatunków europejskich i borealno-górskich, wzrost udziału gatunków o zasięgu kosmopolitycznym i spadek udziału gatunków o zasięgu holarktycznym oraz pojawienie się gatunków południowych: *Folesomides* i *Cyphioderius biolenticulatus*. Stwierdzono również, że w zgrupowaniach *Collembola* zieleni miejskiej udział gatunków eurytopowych jest podobny jak w środowiskach naturalnych Mazowsza i stanowi ponad 30% składu gatunkowego. Natomiast w dużym stopniu wyeliminowane są gatunki leśne, a wzrasta udział gatunków politopowych i oligotopowych terenów otwartych (Tab. 2). Zmniejszeniu ulega również udział gatunków wielgociolubnych (Tab. 3) i epigeicznych (Tab. 4).

W zieleni miejskiej zdecydowanie wzrasta udział gatunków licznych natomiast spada udział gatunków nielicznych i sporadycznych (Tab. 5). Na badanym terenie wyraźnie zaznacza się ekspansywny charakter dwóch gatunków: *Cryptopygus bipunctatus* i *Pseudosinella immaculata*.

НОГОХВОСТКИ (*COLLEMBOLA*) ВАРШАВЫ И МАЗОВИИ

РЕЗЮМЕ

Из Мазовецкой низменности известно 141 вид *Collembola* из них 110 видов из подгруппы *Arthropleona*, из которых на территории варшавского городского комплекса констатировали 44 вида, в городских зеленых насаждениях 41 вид.

В городской зелени четко доминируют космополитические и эвритопные виды, составляющие 63,4% видового состава. Процентное содержание эвритопных видов сходно на Мазовецкой низменности и в городской зелени (20%). В городской зелени констатитовано больше всего видов характерных для открытых территорий и почти полное отсутствие лесных видов, а также падение количества гигрофильных и эпигенических видов. Экспансивными видами в городской зелени являются: *Cryptopygus bipunctatus* и *Pseudosinella immaculata*.