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Comparative analysis of dominant species in springtail communities (*Hexapoda*: *Collembola*) of urban greens in Moscow and Warsaw

Abstract. Authors compared collembolan communities dwelling urboecosystems of Eastern and Central Europe using urban greens of Moscow and Warsaw as an example. Two types of urban biotopes (parks and street lawns) were analysed in comparison to non-urban forests and meadows. The regional peculiarities of springtail communities in the same type of urboecosystems were investigated. It was revealed that communities of soil-dwelling *Collembola* in parks of different cities are more similar than those of street lawns.

Key words: *Collembola*, urban ares, communities

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INTRODUCTION

A knowledge of irregularities of animal community formation in urban environment is necessary to understand the conditions for their surviving and stabilization. Modern industrial cities with their large spectrum of environmental disturbance (high level of pollution, human trampling, small sizes of green habitats etc.) create specific environmental properties for animals.

The investigations of soil microarthropod groups (*Collembola*, *Oribatida*) showed that they are abundant and diversified in urban soils (WEIGMANN 1984, STERZYŃSKA 1990, KUZNETSOVA 1994, KUZNETSOVA, STERZYŃSKA 1995).

Springtails are characterized by high rate of reproduction, low sensitivity to many pollutants (TRANVIK et al. 1993) and an ability to inhabit very small

island biotopes (KUZNETSOVA 1994). We can speculate that *Collembola* are characterized by rather high rates of community formation.

The long-term investigations of springtail fauna and their communities in soils of Warsaw and Moscow showed that almost all collembolan species which exist in natural biotopes can be revealed in urban area. Only few species having the more southern range in Europe were recorded in communities of Collembola of investigated urban ares. Therefore, the consideration of the faunistical similarities of Collembola communities of both cities gives the opportunity of comparing the collembolan fauna of these two different regions.

The aim of our study was to estimate the similarity of collembolan communities in different european cities on the base of groups of dominant species.

MATERIAL AND METHODS

Collembola communities in natural and seminatural soils (forests and meadows) surrounding the urban areas and in two types of urban biotopes (parks and street lawns) were analysed. Sampling methods and investigated areas were described in previous papers (STERZYŃSKA 1990, KUZNETSOVA 1994), except the seminatural meadows of alliance *Arrhenatherion elatioris* near Moscow from Domodedovsky, Podolsky and Istrinsky district (unpublished materials of KUZNETSOVA).

Only a "mass species" analysis was taken into account in comparison of *Collembola* of Warsaw and Moscow. The "mass species" is considered a species with abundance of more than 10% as dominants in each plot or with relative abundance of more than 2.5% in all compared plots. Additionally, we use the term "potential dominants" proposed by CHERNOVA and KUZNETSOVA (1990) for species which can dominate in a certain type of plant association.

Groups of springtail "mass species" were compared using numerical methods for community classification and ordination. Dendrograms were constructed basing on the similarity matrix which had been estimated according to CZEKANOWSKI's formula. The basis for grouping was the farthest neighbour clustering method (UPGMA). The basis method of ordination was PCA (PIELOU 1984).

The following taxonomical simplifications were made: species of the genus *Mesaphorura* BÖRNER, 1991 were considered together because the specific determination of this genus in some sampling area of Moscow was not available; *Lepidocyrtus* sp_1 includes *L. lignorum* and *L. lanuginosus*; *Lepidocyrtus* sp_2, includes *L. violaceus* and *L. cyaneus*; *Isotoma* sp. *viridis* gr. combines *I. viridis* with *I. anglicana*.

RESULTS

Collembolan communities in natural and seminatural soils

Forests. 8 biotopes were analysed. The complex of „mass species" includes 11 species. 7 of them are the common for Moscow and Warsaw regions. The distinct group of 4 dominant species: *I. minor, I. notabilis, F. quadrioculata, P. armata* can be revealed (Table I). *O. absoloni* is considered as a characteristic species for this type of biotope. While comparing the communities of *Collembola* of forest in the region of Moscow and Warsaw it can be seen that the share of *I. notabilis, P. parvulus* and *M. minimus* is higher in the region of Moscow but in the soil of investigated forests around Warsaw a relative abundance of *Mesaphorura* spp. is higher.

Table I. Dominant species of Collembola in natural deciduous forests near Moscow and Warsaw (relative abundance of species is given in percent of the total numbers of Collembola: "+" < 2.5% of the total number)
Districts of Moscow Area: 1 – Lyuberetzky, 2 – Leninsky, 3 – Podolsky, 4 – Istrinsky. Districts of Warsaw Area: 1 – Dębina, 2,3 – Modrzewina, 4 – Białołęka Dworska

Species	Moscow Area				Warsaw Area			
	1	2	3	4	1	2	3	4
Isotomiella minor (SCHAFF.)	41.5	27.7	8.2	32.9	16.6	26.2	19.2	
Isotoma notabilis SCHAFF.	13.4	30.4	15.7	21.3	6.7	7.4	16.4	+
Folsomia quadrioculata (TULLB.)	6.7	2.6	26.4	12.9	35.9	31.9	36.5	23.4
Protaphorura armata (TULLB.)	10.0	3.7	9.1	12.9	5.1	5.8	13.3	9.4
Lepidocyrtus sp_1	4.3	4.7	6.3	9.7	+	5.5	+	29.5
Oligaphorura absoloni (BÖRN.)	4.3	4.2	–	+	+	+	2.5	–
Pseudachorutes parvulus (BÖRN.)	4.1	9.4	9.4	+	–	–	–	–
Megalothorax minimus WILLEM	5.9	12.8	11.9	+	+	+	–	–
Mesaphorura spp.	+	+	2.5	+	11.2	7.2	+	+
Friesea mirabilis (TULLB.)	+	–	+	–	7.3	+	+	+
Pogonognathellus flavescens (TULLB.)	+	+	+	+	+	6.3	+	–
Number of specimens	491	382	318	155	3717	855	850	235
Number of samples	20	20	20	10	156	119	70	50

Meadows. 12 biotopes were compared. The complex of „mass species" in this type of biotopes is richer and includes 21 species (Table II). 2/3 of them (13 species) are common for both regions. The same eurytopic species dominate in meadow and forest biotopes (*I. notabilis, F. quadrioculata, P. armata*). *I. minor* is abundant in forest communities but it is not abundant in meadow soils in majority of cases. *Isotoma* sp. gr. viridis is characteristic and abundant species for meadow in all investigated sites. Other typical meadows species as *S. quadrispina, M. affinis, N. crassicuspis, I. productus, I. armatus, B. parvula*) rarely occur as dominant species.

Lepidocyrtus $sp._1$ is more common in the meadows around Moscow than in meadows around Warsaw. *I. productus* appears only in meadows around Warsaw.

Table II. Structure of collembolan communities in meadow soils near Moscow and Warsaw (relative abundance of species is given in percent of the total numbers of Collembola)

Districts of Moscow Area: 1 – Domodedovsky, 2–7 – Podolsky, 8 – Istrinsky. Districts of Warsaw Area: 1 – Chylice, 2 – Klembów, 3 – Białołęka Dworska, 4 – Zbroszki

Species	Moscow Area								Warsaw Area			
	1	2	3	4	5	6	7	8	1	2	3	4
Folsomia quadrioculata (TULLB.)	–	19.5	25.0	34.6	+	1.0	25.2	–	40.4	+	24.8	2.7
Mesaphorura spp.	18.7	+	4.2	+	–	3.1	+	–	3.6	5.1	4.1	36.7
Isotoma notabilis SCHÄFF.	13.4	9.2	4.2	5.6	15.8	54.4	18.2	10.5	9.7	23.8	4.0	2.5
Isotomiella minor (SCHÄFF.)	+	+	–	–	+	+	2.8	+	+	28.8	+	+
Isotoma viridis BOURL.	–	–	12.5	–	40.3	+	+	14.0	11.3	3.6	3.7	10.0
Protaphorura spp.	19.6	49.3	25.0	+	–	10.9	2.1	–	+	4.9	14.7	6.0
Lepidocyrtus sp_1	15.2	5.3	20.8	54.2	38.6	15.0	36.4	39.0	6.6	8.8	5.5	2.8
Friesea mirabilis (TULLB.)	3.6	–	–	–	–	–	–	–	3.6	+	+	+
Sphaeridia pumilis (KRAUSB.)	6.3	+	–	–	–	2.6	2.1	–	+	6.0	–	10.8
Folsomia fimetaria (L.)	–	–	–	–	–	–	–	–	4.0	+	4.5	–
Isotomodes productus (AXELS.)	–	–	–	–	–	–	–	–	–	+	2.7	4.7
Isotomurus palustris (MULL.)	–	–	4.2	–	–	–	+	–	+	5.3	–	–
Isotomodes armatus NAGL.	–	–	–	–	–	–	–	–	3.5	–	–	–
Metaphorura affinis (BÖRN.)	2.7	+	–	–	–	–	–	–	+	–	16.7	+
Stenaphorura quadrispina BÖRN.	–	2.5	–	+	–	2.1	+	–	+	+	+	2.0
Lepidocyrtus sp_2	–	–	–	–	–	–	–	7.0	4.4	+	+	6.0
Proisotoma minima (ABS.)	6.3	–	–	–	–	–	–	–	+	–	–	–
Onychiurus variabilis STACH	–	7.6	–	–	–	–	–	–	–	–	–	–
Megalothorax minimus WILLEM	+	+	4.2	–	–	–	–	–	+	+	–	+
Neotullbergia crassicuspis (GISIN)	–	–	–	–	–	5.7	–	–	–	–	–	–
Brachystomella parvula (SCHÄFF.)	–	–	–	–	–	–	–	24.6	+	–	+	–
Number of specimens	112	132	24	107	57	193	143	59	2802	1725	1801	1649
Number of samples	15	13	7	10	10	20	20	20	168	119	70	100

Collembolan communities of urban biotopes

Parks. In 12 investigated parks of Moscow and Warsaw 14 collembolan "mass species" were recorded. The majority (11 species) was common for the soils of parks of both regions. *I. notabilis*, *Lepidocyrtus* sp_1., *Isotoma* gr. *viridis* dominate in urban parks as in meadow collembolan communities (Table III). However, *F. quadrioculata* which dominate in forest and meadow soils is not usually abundant in urban biotopes. A typical forest springtail species have not been found in the parks of both cities. Only *I. minor* (which was treated as a "mass species") was recorded, but it was rarely dominating. The ruderal species of *Collembola* are numerous in urban soils whereas they are very rare in natural biotopes. *C. bipunctatus* occurs frequently in parks of Moscow and Warsaw. The other ruderal species *F. lawrencei* is more common in the parks of Moscow than in Warsaw. Besides, *M. mimimus* is often a „mass species" in green areas of Moscow. However, the small sminthurids (*S. pumilis* and *S. aureus*) play an important role in the springtail communities of Warsaw. These species were abundant in Moscow parks only in one spring season.

Street lawns. 18 collembolan "mass species" are revealed in the 12 investigated biotopes of this type. Half of them are common in street lawns in Moscow as well in Warsaw (Table IV). Like in parks, *Isotoma* sp. gr. viridis and *I. notabilis* dominate here, *Lepidocyrtus* sp_1 , *L.* $sp._2$ and *P. armata* are also abundant. The role of ruderal species (*F. fimetaria* and especially *C. bipunctatus*) is even bigger when compared to the collembolan communities in parks. In the soil of lawns compost species (*C. succinea*, *P. minuta*, *P. alba*) occur. The abundance of forest species *I. minor* is low in springtail communities of urban lawns.

Some regional differences were revealed in collembolan communities of street lawns of two cities. Myrmecophilous species (*E. myrmecophilus* and *Cyphoderus albinus* NIC.) are rather common in Warsaw lawns. *E. myrmecophilus* is a "mass species" in some street lawns. Both these species are rare in the investigated biotopes of Moscow. Another regional differences in occurence were revealed for epigeic species *S. aureus*. This species is abundant in lawns of Warsaw but in Moscow its density has a spring peak in other seasons this is rare. Besides, *B. parvula* – a species characteristc for meadow, is abundant in soils of Warsaw lawns in contrast to those in Moscow.

In the city areas of both regions vicarious species of *Isotoma* gr. *viridis* were found. *I. anglicana* achieves a high density mainly in Moscow while *I. viridis* in Warsaw.

The comparison of collembolan communities in natural and urban soils of two regions

The dendrograms were constructed for each group of biotopes. The forest communities of springtail are rather similar: the average mean of CZEKANOWSKI's coefficient is 0.52 and partial of overlapping of forest regional

Table III. Structure of collembolan communities in urban parks of Moscow and Warsaw (relative abundance of species is given in percent of the total numbers of Collembola)

Moscow parks: 1 – Neskuchny Sad, 2–5 – Botanical garden of Moscow University (2,3 – lime, 4 – oak, 5 – spruce plantations), 6 – Kuscovo, 7 – Bauman Garden; Warsaw parks: 1,2 – Łazienki, 3,4 – Cemetery of Soviet Soldiers, 5 – Saxon Garden.

Species	Moscow							Warsaw				
	1	2	3	4	5	6	7	1	2	3	4	5
Isotoma notabilis SCHAFF.	3.1	18.2	19.7	14.5	17.3	35.3	6.6	11.8	11.0	21.9	19.0	12.7
Isotomiella minor (SCHAFF.)	3.9	49.6	6.7	6.3	2.3	6.0	+	5.3	3.5	+	+	8.2
Protaphorura armata (TULLB.)	8.9	2.8	2.8	7.1	7.8	8.5	2.3	2.0	10.4	6.4	4.2	9.8
Mesaphorura spp.	+	2.0	+	+	+	12.4	19.1	8.3	+	3.9	+	+
Lepidocyrtus sp_1	13.0	5.7	32.7	6.1	43.7	3.2	+	14.9	16.1	+	+	2.2
Isotoma gr.*viridis*	7.2	–	–	–	+	+	+	5.1	3.9	35.0	31.3	9.8
Cryptopygus bipunctatus (AXELS.)	+	+	–	–	–	–	26.5	14.6	21.0	+	–	8.7
Sminthurinus aureus (LUBB.)	–	–	–	–	–	+	9.3	16.5	4.0	4.3	+	8.4
Sphaeridia pumilis (KRAUSB.)	–	–	–	+	–	–	–	6.1	+	5.3	7.9	6.3
Folsomia quadrioculata (TULLB.)	+	+	–	36.1	–	9.0	–	+	+	–	+	4.3
Onychiurus spp.s.str.	47.0	+	6.7	+	–	–	3.9	–	–	–	–	–
Pseudosinella alba (PACK.)	2.5	+	+	+	4.9	+	+	2.7	+	–	2.4	2.7
Folsomia lawrencei (BAGN.)	+	2.9	+	6.3	+	16.4	4.7	–	–	–	–	–
Megalothorax minimus (TULLB.)	–	+	19.2	14.7	14.3	+	+	–	–	–	–	+
Number of specimens	483	917	862	3271	2908	1058	257	457	705	553	508	678
Number os samples	20	20	38	40	38	20	20	86	89	68	69	101

Table IV. Structure of collembolan communities in street lawns of Moscow and Warsaw (relative abundance of species is given in percent of the total numbers of *Collembola*; "+" < 2.5% of the total number);
Moscow plots: 1,2 – Kibalchicha str., 3,4 – Raketny bl., 5 – Kr.Kazanetz str., 6 – near Kuskovo; Warsaw plots: 1 – Ujazdowskie Avenue, 2,3 – Żwirki i Wigury Avenue, 4 – Marszałkowska St., 5 – Woronicza St., 6 – Zbawiciela Square.

Species	Moscow						Warsaw					
	1	2	3	4	5	6	1	2	3	4	5	6
Protaphorura armata (TULLB.)	27.7	11.4	7.3	15.2	11.8	51.2	+	2.9	5.7	+	14.1	+
Lepidocyrtus sp.$_1$	11.8	–	27.9	13.8	3.0	+	2.8	+	–	5.8	+	–
Isotoma gr.viridis	2.7	10.5	41.4	19.8	3.6	+	6.7	30.4	11.5	+	+	15.3
Pseudosinella alba (PACK.)	10.0	–	5.3	8.6	9.9	+	+	+	+	3.7	2.6	–
Ceratophysella succinea (GISIN)	22.5	24.5	2.8	–	–	–	–	–	–	–	+	+
Folsomia fimetaria (L.)	6.2	12.3	+	–	–	–	–	+	+	+	–	+
Mesaphorura spp.	+	4.1	+	3.7	21.4	8.4	6.6	3.0	+	4.6	7.9	4.3
Isotoma notabilis SCHÄFF.	+	6.4	+	14.9	38.8	+	8.9	29.0	33.6	19.2	3.5	22.2
Cryptopygus bipunctatus (AXELS.)	–	13.2	–	–	+	27.0	+	12.0	+	10.8	8.9	27.4
Proisotoma minuta (TULLB.)	+	3.6	–	+	–	5.0	–	+	–	–	–	–
Lepidocyrtus sp.$_2$	3.1	+	3.5	13.4	6.2	–	+	+	–	6.1	4.3	7.0
Sminthurinus aureus (LUBB.)	–	+	+	+	–	–	39.5	3.7	11.4	24.9	2.5	4.2
Entomobryoides myrmecophilus (REUT.)	–	–	–	–	–	–	+	+	4.7	5.4	6.2	+
Cryptopygus thermophilus (AXELS.)	–	–	–	–	–	–	–	+	7.1	+	+	+
Brachystomella parvula (SCHÄFF.)	–	–	–	–	–	–	–	+	4.5	–	5.0	3.8
Isotomiella minor (SCHÄFF.)	–	+	+	+	+	–	+	+	–	+	8.5	–
Hypogastrura vernalis (CARL)	–	–	–	–	–	–	–	–	+	–	7.5	+
Friesea mirabilis (TULLB.)	–	+	+	–	+	–	–	–	–	–	+	–
Number of specimens	289	220	599	268	304	559	155	571	845	420	478	1041
Number of samples	19	15	20	15	19	20	94	66	50	112	86	69

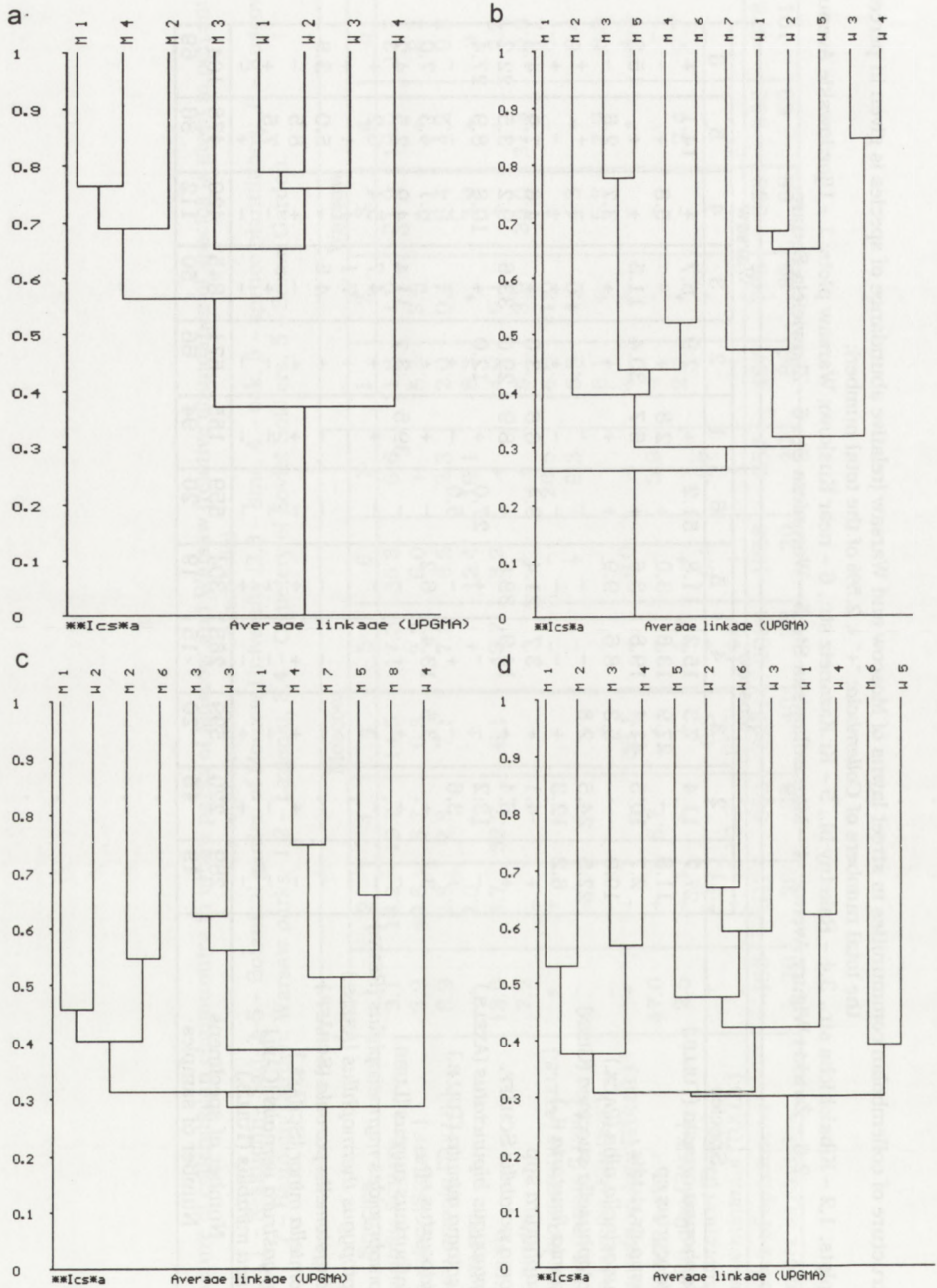

Fig. 1. Dendrograms of the similarity of the collembolan communities of two inestigated regions (a – forests, b – meadows, c – urban parks, d – street lawns; M – Moscow region, W – Warsaw region).

groups of collembolan communities can be observed (Fig. 1a). The communities of springtails in meadow soils are rather different in Moscow and Warsaw but the regional features of meadow collembolan communities are unclear. (Fig. 1b). Regional features of springtail communities are more characteristic in the street lawns and the parks (Fig. 1c, d).

Comparing all investigated plots of Warsaw and Moscow, it can be stated that there are not any clearly distinctive groups of collembolan communities characteristic for natural or urban habitats (Fig. 2).

An ordination of the communities of *Collembola* from 4 biotopes (forests, meadows, park lawns, street lawns) using PCA method showed a high similarity of all forests and park lawns in both regions (Fig. 3). On a contrary, a group of meadow collembolan communities and communities in street lawns have the wide scatter of plots.

The similar result is obtained when the „potential dominants" are compared (Fig. 4). The maximal overlapping of regional communities was found in urban parks and forests, the minimal one is characteristic for meadows and street lawns. Four species (*I. notabilis*, *P. armata*, *Lepidocyrtus* sp_1, *Mesaphorura* spp.) are included in the group of potential dominant of all investigated biotopes.

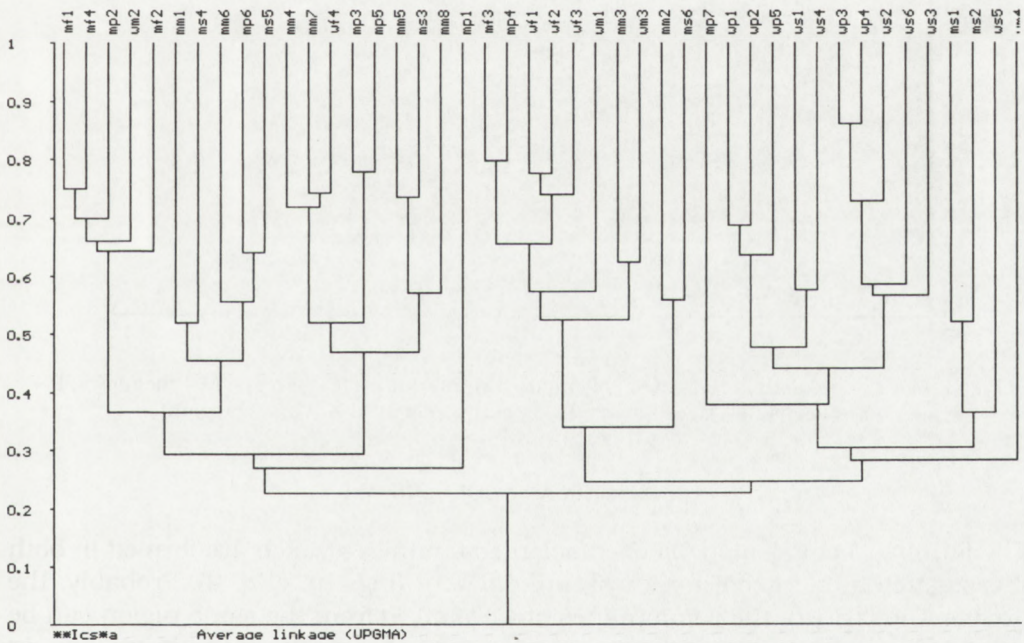

Fig. 2. Dendrogram of the similarity of all investigated collembolan communities (f – forests, m – meadows, p – urban parks, s – street lawns; M – Moscow region, W – Warsaw region).

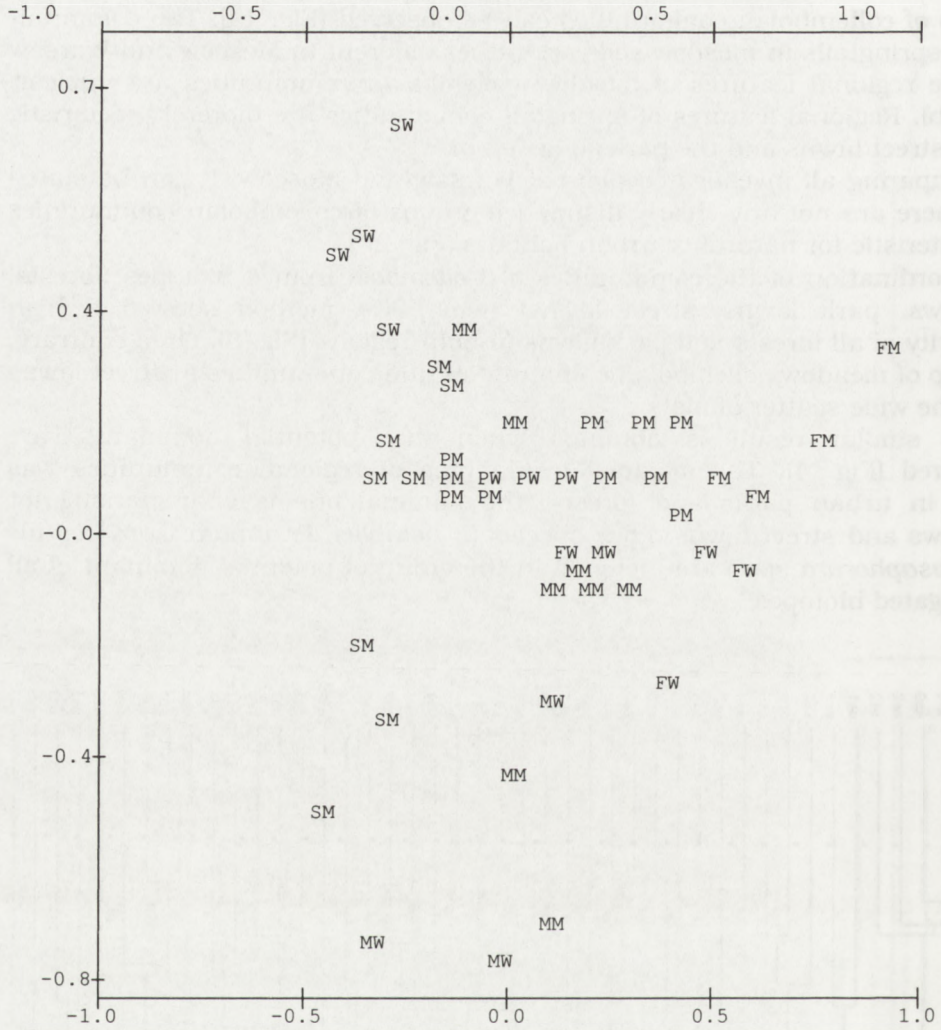

Fig. 3. Ordination of all investigated collembolan communities (F – forests, M – meadows, P – park lawns, S – street lawns; M – Moscow region, W – Warsaw region).

DISCUSSION AND CONCLUSIONS

The faunistic composition of collembolan communities which are formed in both investigated area (except for forest) are different (Fig. 1b, c, d, 2). Probably, the greater similarity of the communities of *Collembola* from the same region can be assumed as a result of climatological differences beetwen both regions or different history of animal populations in both regions. A peculiar feature of urban biotopes is the presence of a wide variety of ecofunctional groups of species in the collembolan community (eurytopic, forest, meadow, corticolous, ruderal, compost, myrmecophilous) (STERZYŃSKA 1990, KUZNETSOVA 1994). In

such conditions ecological niches overlap broadly but the competition and predator pressure are reduced (VACHRUSCHEV 1988). Consequently, population of species which inhabit urban areas have a chance to achieve a high level of density. In the studied areas, relatively similar and stable group of *Collembola* species dominates in forests as well as in urban parks (Tab. 1, 3). The wide scatter of data has been observed in the collembolan communities of street lawns (Fig. 1, 3). It can be assumed that there are at least two reasons for greater similarity between park collembolan communities in comparison to street lawns: 1) a longer period of their formation (investigated parks exist several decades or more); 2) a greater stablility and predictability of environmental conditions in this type of urban biotope. It may be concluded that in many urban parks collembolan communities exist in well-developed biotopes, whereas a majority of street lawn groupings demonstrate a broad spectrum of pioneer communities on early stages of their formation. Thus, at present different animal groups are on very different stages of the formation of community in urban environment.

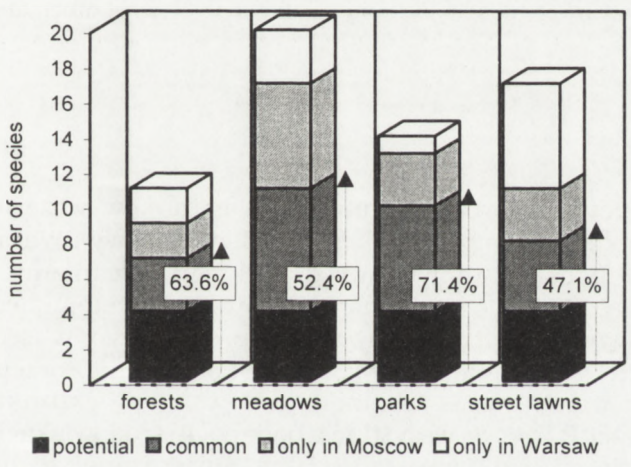

Fig. 4. The overlapping of potential dominants in collembolan communities of two regions.

The high degree of dissimilarity of species composition and domination in different cities were found for avifauna (VACHRUSCHEV, RAUTIAN 1993). The animal communities in cities (a historically modern type of environmental modification) probably still remain on early stages of formation.

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STRESZCZENIE

[Tytuł: Analiza porównanwcza dominujących gatunków w zgrupowaniach *Collembola* (*Hexapoda*: *Collembola*) zieleni miejskiej Moskwy i Warszawy]

Przeprowadzono badania prównanwcze nad zgrupowaniami *Collembola* Moskwy i Warszawy. Analizie poddano zgrupowania występujące w zieleni parkowej i na trawnikach przyulicznych, a porównawczo w środowiskach leśnych i łąkowych obu badanych regionów. Porównania przeprowadzono głównie w oparciu o tak zwane „gatunki masowe" tzn. gatunki o udziale procentowym powyżej 2.5% we wszystkich badanych środowiskach o udziale procentowym powyżej 10% danym stanowisku. Stwierdzono, że zgrupowania *Collembola* w obu badanych regionach różnią się między sobą, z wyłączeniem zgrupowań leśnych (Fig. 1 b, c, d, 2), które wykazują wyraźne zunifikowanie. Szczególną cechą zgrupowań *Collembola*, formowanych w obu porównywanych środowiskach miejskch jest znaczne upodobnienie się zgrupowań zasiedlających parki przy ogromnym ich zróżnicowaniu w glebach trawników przyulicznych. Sytuacja taka jest prawdopodobnie wynikiem dłuższego formowania się zgrupowań *Collembola* w glebach zieleńców parkowych oraz znacznie stabilniejszymi warunkami środowiskowymi, podczas gdy w glebach trawników przyulicznych większość tych struktur to zgrupowania pionierskie, na wczesnym etapie ich formowania.

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