POLISH ACADEMY OF SCIENCES • INSTITUTE OF ZOOLOGY
MEMORABILIA ZOOLOGICA

MEMORABILIA ZOOL.	42	3—18	1987

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STRUCTURE OF SPRINGTAIL (*COLLEMBOLA*) COMMUNITIES IN THE URBAN GREEN OF WARSAW

ABSTRACT

Species composition and structure of springtail communities were analysed in three types of urban green: parks, green of housing estates, and streetside green. From all these communities, the species associated with forests were eliminated, and from the communities occurring in green of housing estates and in streetside green also hygrophilous and epigean species were absent. In parks, two community types occurred. One was dominated by *Isotoma viridis* and the other one by *Lepidocyrtus lignorum*. In housing estate and streetside green, *Cryptopygus bipunctatus* was the expansive species.

INTRODUCTION

Collembola communities were analysed as a part of the complex studies carried out at the Institute of Zoology on urban zoocoenoses of Warsaw. Some data on numbers and species composition of the *Collembola* of Warsaw have already been published (Sterzyńska 1979, 1981, 1982).

Springtails are the group of insects comprising organisms strictly associated with soil (euedaphic), also forms associated with litter (hemiedaphic) and epigean forms. Also corticophilous, myrmecophilous, troglophilous, and synanthropic species are known. Not so long ago springtails were classified as unspecialized saprophages feeding on fallen leaves, mycelium, spores, and humus, and only few of them were known to be predators or microphytophages (Christiansen 1964). The most recent investigations (Usher et al. 1982) seem to show, however, that springtails are more specialized consumers, and besides detritophagous species there are many mycophages and predators (feeding mostly on microorganisms).

Springtails are widely distributed in soils of different types. The formation of aggregations, species composition, and community structure depend on soil moisture, humus type, nutrient content in food, and food pollution, e.g., with heavy metals

(Nosek 1981, Bengtsson et al. 1983, Josse and Verhoef 1983, Testerink 1983).

The purpose of this paper is to analyse the species composition and structure of springtail communities in different types of urban green, and to show the possible effects of urban pressure on these communities.

STUDY AREA, MATERIAL, AND METHODS

Collembola of urban green areas were studied in 1976—1978. The material was collected from three types of urban green such as parks, housing estates, and streetside green. Parks were represented by the Łazienki Park (in 1976, plots I and II)[1], park at the Cemetery of Soviet Soldiers (in 1976, plots I and II), the Saxon Garden (in 1976, plot II) and the Park of Culture and Leisure (in 1977, plots I and II; both these plots had a rubble soil and were located on the lower terrace of the park, on the site of potential *Tilio-Carpinetum* stachietosum).

Materials from green of housing estates were collected in Wierzbno, which is a loosely built area (in 1976, plots I and II) and in the centre of the town, in closely built-up areas of M.D.M. (in 1976, plot I—a courtyard lawn) and in Konstytucji Square (in 1978, small patches of soil around linden trees in the square)[2].

In streetside green, the material was collected from streetside plots and interlane plots at the following points of Warsaw: Ujazdowskie Avenue (in 1976, plot I—a lawn along the Łazienki Park), Żwirki i Wigury Avenue (in 1978, lawns near the park at the Cemetery of Soviet Soldiers; plot I—an interlane lawn, plot II—a streetside lawn), Marszałkowska Street (in 1976, plot I—an interlane lawn adjacent to the Saxon Garden), Woronicza Street (in 1976, plot I—a streetside lawn in Wierzbno housing estate), Zbawiciela Square (in 1978, plot I—a totally isolated interlane lawn).

The study areas and plots are described in detail by Kubicka et al. (1985) and some also by Nowakowski (1981).

Soil samples were taken at monthly intervals from April till October from all the plots (only in the Park of Culture and Leisure samples were taken over the year). Each series consisted of 10 samples of a surface area of 20 cm^2 and 10 cm deep. The samples were extracted using Tullgren apparatus. The total material consisted of about 8,000 individuals.

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[1] The plots are numbered after Kubicka et al. (1985).

[2] The plot at Konstytucji Square is typical of closely built-up areas in large cities because of its location and the way of management. In this paper it is classified to the group of housing estate plots, and not to the streetside plots as in Kubicka et al. (1985).

[Note: this discrepancy has been accepted at the author's request (W. Cz.)].

Table 1. Species composition and abundance (in thousands of individuals/m²) of springtail communities in urban green of Warsaw

No.	Type of green, study areas, plots / Species	Parks									Green of housing estates						Streetside green							
		Cemetery of Soviet Soldiers		Łazienki Park		Saxon Garden	Culture and Leisure Park		All Parks		Wierzbno		M.D.M.	Konstytucji Square	All housing estates		Żwirki i Wigury Avenue		Ujazdowskie Avenue	Marszałkowska Street	Woronicza Street	Zbawiciela Square	All streets	
		I	II	I	II	II	I	II	$\bar{x}$	%	I	II	I	II	$\bar{x}$	%	I	II	I	I	I	I	$\bar{x}$	%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	*Hypogastrura manubrialis* (Tullb.)	–	–	–	–	–	–	9.0	1.3	0,03	–	–	130.0	–	32.5	2,99	7.1	–	–	–	–	–	1.2	0.03
2	*H. assimilis* Krausb.	–	–	–	–	–	–	–	–	–	–	–	10.0	–	2.5	0.23	7.1	–	–	–	–	–	1.2	0.03
3	*H. vernalis* (Carl.)	35.7	–	–	–	–	–	36,4	10.3	0.23	–	–	280.0	–	70.0	6.43	7.1	–	–	–	–	14.3	3.6	0.10
4	*H. purpurescens* (Lull.)	–	–	–	–	–	–	–	–	–	–	–	10.0	–	2.5	0,23	7.1	–	–	–	–	–	1.2	0.03
5	*Ceratophysella succinea* Gisin	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	70.0	–	11.7	0.34
6	*Ceratophysella* sp.	7.1	–	–	–	–	–	–	1.0	0.02	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7	*Xynella grisea* Axels.	–	–	–	–	–	–	4.5	0.6	0.01	–	–	–	–	–	–	–	7.1	–	–	–	–	1.2	0.03
8	*X. brevisimilis* Stach	–	–	–	–	–	–	4.5	0.6	0.01	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9	*Schoetella ununguiculata* (Tullb.)	–	–	–	12.5	–	–	–	1.8	0.04	–	–	–	–	–	–	–	–	–	–	–	7.1	1.2	0.03
10	*Willemia intermedia* Mills	–	–	–	–	–	–	13.6	1.9	0.04	–	–	10.0	–	2.5	0.23	–	–	10.0	10.0	–	35.7	9.3	0.27
11	*Brachystomella parvula* (Schäff).	–	14.3	–	112.5	200.0	–	–	46.7	1.05	–	–	–	–	–	–	164.3	7.1	–	–	220.0	285.7	112.8	3.31
12	*Frisea mirabilis* (Tullb.)	–	–	–	149.0	–	5.6	54.5	29.9	0.67	10.0	–	–	–	2.5	0.23	–	–	–	–	–	–	–	–
13	*Frisea afurcata* Denis	–	–	–	12.5	–	–	–	1.8	0.04	–	–	170.0	–	42.5	3.95	–	14.3	30.0	–	–	–	7.4	0.22
14	*Anurida* sp.	–	–	–	–	20.0	–	–	2.9	0.06	–	–	–	–	–	–	–	7.1	–	–	–	–	1.2	0.03
15	*Onychiurus armatus* s. Stach	257.0	149.9	30.0	137.5	100.0	–	77.3	107.4	2.42	–	10.0	110.0	25.0	36.3	3.33	228.5	171.4	60.0	20.0	90.0	42.9	102.1	2.99
16	*Onychiurus granulosus* Stach	–	–	–	–	–	–	31.8	4.5	0.10	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17	*Mesaphorura krausbaueri* Börn	–	–	110.0	50.0	50.0	–	40.9	35.8	0.81	60.0	–	170.0	–	57.5	5.28	14.3	28.6	20.0	60.0	20.0	–	23.8	0.70
18	*M. macrocheta* Rusek	107.1	7,1	–	–	–	77.8	40.9	33.3	0.75	–	–	–	87.5	21.9	2,01	–	92.8	–	–	–	135.7	38.0	1.12
–	*M. krausbaueri* group "3"	–	–	–	–	–	–	4.5	0.6	0.01	–	–	–	–	–	–	14.3	–	–	–	–	–	2.4	0.07
19	*M. hylophila* Rusek	21.4	7.1	–	–	–	–	168.2	28.1	0.63	–	–	–	–	–	–	–	28.6	–	–	–	–	4.8	0.14
20	*M. critica* Rusek	21.4	7.1	–	–	–	–	195.5	32.0	0.72	–	–	–	18.5	4.6	0.43	35.7	28.6	–	–	–	71.4	22.6	0.67
–	*M. sylvatica* group "2"	–	–	–	–	–	–	4.5	0.5	0.01	–	–	–	–	–	–	–	–	–	–	–	107.1	17.8	0.52
21	*Metaphorura affinis* Börn	64.3	42.8	–	12.5	–	–	–	17.1	0.39	–	–	–	–	–	–	14.3	21.4	70.0	10.0	–	–	19.2	0.57
22	*Stenaphorura quadrispina* (Börn)	7.1	–	10.0	12.5	20.0	–	4.5	7.7	0.17	–	–	–	87.5	21.9	2.01	57.1	21.4	10.0	–	–	21.4	18.3	0.54
23	*Neotullbergia ramicuspis* (Gisin)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.0	7.1	2.9	0.08
24	*Neotullbergia crassicuspis* (Gisin)	–	–	–	–	–	–	13.6	1.9	0.04	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25	*Anurophorus laricis* (Nic.)	–	–	–	–	–	–	9.0	1.3	0.03	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26	*Folsomides parvulus* Stach	–	–	–	–	10.0	–	4.5	2.1	0.05	–	–	–	–	–	–	–	–	20.0	10.0	–	–	5.0	0.15
27	*Isotomodes productus* (Axels.)	–	7.1	–	150.0	20.0	55.6	131.8	52.1	1.18	10.0	20.0	130.0	–	40.0	3.68	21.4	50.0	–	10.0	10.0	50.0	23.5	0.69
28	*Folsomia candida* Will.	–	–	–	12.5	–	–	–	1.8	0.04	–	–	10.0	–	2.5	0.23	–	–	–	–	–	–	–	–
29	*Folsomia fimetaria* (L.)	7.1	7.1	–	–	–	716.7	399.9	161.5	3.65	–	–	10.0	–	2.5	0.23	7.1	50.0	–	–	–	42.9	16.7	0.49
30	*F. quadrioculata* (Tullb.)	7.1	–	–	150.0	10.0	–	159.1	46.6	1.05	20.0	–	10.0	50.0	20.0	1.84	–	7.1	10.0	–	10.0	21.4	8.1	0.24
31	*Proisotoma brevidens* Stach	–	–	–	–	–	5.6	9.0	2.1	0.05	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	*Proisotoma minima* (Abs.)	–	–	–	–	–	5.6	40.9	6.6	0.15	–	–	–	–	–	–	–	–	–	–	–	–	–	–
33	*Proisotoma minuta* (Tullb.)	–	14.3	–	–	–	83.3	290.9	55.5	1.25	–	–	–	87.5	21.9	2.01	–	–	14.3	–	–	–	2.4	0.07
34	*Cryptopygus bipunctatus* (Axels.)	7.1	–	610.0	275.0	350.0	16.7	86.4	192.2	4.33	40.0	10.0	750.0	12.5	203.1	18.67	42.8	756.8	20.0	140.0	10.0	2057.1	504.4	14.79
35	*C. termophilus* (Axels.)	–	7.1	–	–	–	950.0	127.3	155.0	3.49	–	–	–	–	–	–	292.7	14.3	–	10.0	–	121.4	73.1	2.14
–	*C. termophilus* (5 eyes)	–	–	–	–	–	283.3	45.5	47.0	1.06	10.0	10.0	10.0	–	7.5	0.69	–	–	–	–	–	–	–	–
36	*Isotomiella minor* (Scätt)	7.1	7.1	190.0	100.0	490.0	5.6	354.5	164.9	3.72	–	–	–	–	–	–	–	21.4	–	10.0	–	–	5.2	0.15
37	*Isotoma divacea* Tullb.	–	–	–	–	–	138.9	9.0	21.1	0.48	–	–	–	–	–	–	–	–	–	–	–	–	–	–
38	*Istotoma notabilis* Schätt	856.8	692.6	120.0	337.5	160.0	377.8	1068.2	516.1	11.64	30.0	130.0	430.0	62.5	163.1	14.99	1370.9	1770.7	–	80.0	20.0	1657.1	816.4	23.94
39	*Isotoma viridis* Bourl	1378.0	1135.3	140.0	150.0	380.0	1177.8	1136.5	785.4	17.71	20.0	130.0	30.0	–	45.0	4.14	457.0	1792.2	30.0	30.0	30.0	1107.1	574.4	16.84
40	*Isotoma violacea* Tullb.	–	–	–	–	–	–	13.6	1.9	0.04	–	–	–	–	–	–	–	–	–	–	–	–	–	–
41	*Isotoma palustris* (Müll.)	21.4	292.8	–	–	–	876.2	109.1	185.7	4.19	–	–	–	–	–	–	7.1	21.4	–	–	–	7.1	5.9	0.17
42	*Cyphoderus albinus* Nic.	14.3	–	30.0	62.5	60.0	–	4.5	24.5	0.55	–	–	–	2.5	0.6	0.06	50.0	28.6	10.0	20.0	–	100.0	34.7	1.02
43	*C. bidenticulatus* (Parona)	–	–	–	–	10.0	–	–	1.4	0.03	–	–	–	–	–	–	–	–	–	–	–	–	–	–
44	*Orchesella bifasciata* Nic.	42.8	–	–	50.0	–	–	–	13.3	0.30	–	–	–	–	–	–	–	–	–	–	–	–	–	–
45	*Heteromurus nitidus* (Templ.)	–	14.3	–	–	–	38.9	72.7	18.0	0.41	–	–	–	–	–	–	–	78.6	–	–	–	21.4	16.7	0.49
46	*Entomobrya nivalis* (L.)	28.6	–	–	–	–	–	–	4.1	0.09	–	–	–	–	–	–	–	14.3	–	–	–	–	2.4	0.07
47	*E. multifasciata* (Tullb.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.0	–	–	1.7	0.05
48	*E. marginata* (Tullb.)	–	7.1	–	–	–	5.6	–	1.8	0.04	–	–	–	–	–	–	–	–	–	20.0	30.0	–	8.3	0.24
49	*E. corticalis* (Nic.)	–	7.1	20.0	–	–	–	–	3.9	0.09	–	–	–	–	–	–	–	–	–	–	–	–	–	–
50	*Entomobryoides myrmecophilus* (Reut.)	35.7	14.3	40.0	37.5	60.0	16.7	36.4	34.4	0.78	–	60.0	80.0	–	35.0	3.22	199.9	121.4	–	80.0	320.0	92.9	135.7	3.98
51	*Sinella cocea* (Schött.)	–	–	–	–	10.0	5.6	–	2.2	0.05	–	–	–	–	–	–	–	–	–	30.0	–	–	5.0	0.15
52	*Seira domestica* (Nic.)	–	7.1	–	–	–	–	–	1.0	0.02	–	–	–	–	–	–	–	–	–	–	–	–	–	–
53	*Lepidocyrtus paradoxus* Uzel	–	–	–	–	10.0	–	–	1.4	0.03	–	–	–	–	–	–	–	–	–	–	–	–	–	–
54	*Lepidocyrtus lignorum* (F.)	–	–	50.0	425,0	150.0	–	4.5	89.9	2.03	–	20.0	10.0	–	37.5	0.69	–	135.7	80.0	200.0	–	–	69.3	2.03
55	*L. lanuginosus* (Gmel.)	7.1	–	510.0	1087.5	10.0	–	18.2	233.3	5.26	30.0	–	20.0	12.5	15.6	1.44	7.1	–	–	90.0	70.0	–	27.9	0.82
56	*L. cyaneus* Tullb.	28.6	57.1	150.0	12.5	230.0	94.4	154.5	103.9	2.34	70.0	10.0	–	–	20.0	1.84	–	35.7	–	70.0	230.0	535.7	145.2	4.26
57	*L. violaceus* Lubb.	7.1	7.1	–	–	–	–	–	2.0	0.05	–	–	–	–	–	–	–	–	–	90,0	–	–	15.0	0.44
58	*Pseudosinella immaculata* (Lie Pett.)	14.3	14.3	10.0	137.5	90.0	55.6	227.3	78.4	1.77	80.0	–	–	–	20.0	1.84	50.0	7.1	–	20.0	30.0	92.9	33.3	0.98
59	*Pseudosinella alba* (Pack.)	–	85.7	60.0	75.0	110.0	22.2	290.9	92.0	2.07	80.0	90.0	60.0	12.5	60.7	5.57	28.6	128.5	10.0	–	30.0	–	32.9	0.96
60	*P. zygophora* (Börn.)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7.1	–	–	–	–	–	1.2	0.03
61	*Neelus murinus* Fols.	–	–	–	–	–	22.2	31.8	7.7	0.17	–	–	–	–	–	–	–	–	–	–	–	14.3	2.4	0.07
62	*Megalothorax minimus* Will.	–	–	–	–	–	–	195.5	27.9	0.63	–	–	–	–	–	–	14.3	–	–	–	–	14.3	4.8	0.14
63	*Sphaeridia pumillis* (Kraus.)	442.7	685.4	–	–	–	488.9	395.5	287.5	6.49	–	60.0	–	–	15.0	1.38	35.7	71.4	–	–	–	–	17.9	0.52
64	*Arrhopalites caecus* (Tullb.)	28.6	21.4	–	–	30.0	–	–	11.4	0.26	140.0	–	–	–	35.0	3.22	–	–	–	–	–	35.7	5.9	0.17
65	*Sminthurinus niger* (Lubb.)	–	–	20.0	–	–	–	–	2.9	0.06	50.0	10.0	–	–	15.0	1.38	–	–	70.0	–	–	14.3	14.1	0.41
66	*S. aureus* (Lubb.)	357.0	399.8	130.0	175.0	500.0	1083.3	986.4	518.8	11.71	80.0	100.0	–	12.5	48.1	4.42	806.8	414.1	180.0	110.0	–	678.6	364.9	10.70
67	*Bourletiella hortensis* (Fitch)	28.6	50.0	–	–	–	–	31.8	15.8	0.36	–	–	–	–	–	–	57.1	28.6	–	–	–	–	14.3	0.42
68	*Bourletiella lutea* (Lubb.)	–	–	–	–	–	116.7	–	16.7	0.38	50.0	–	–	–	12.5	1.15	–	28.6	–	–	–	–	4.8	0.14
69	*Deuterosminthurus repandus* (Agren)	78.5	21.4	–	–	–	322.2	68.2	70.0	1.58	–	–	–	–	–	–	21.4	–	–	–	–	35.7	9 5	0.28
70	*Sminthurus viridis* (L.)	28.6	–	–	–	–	–	–	4.1	0.09	–	–	–	–	–	–	14.3	14.3	–	–	–	–	4.8	0.14
	Total density	3948.8	3783.8	2230.0	3736.5	3080.0	7048.8	7217.6	4435.0	100.00	780.0	660.0	2440.0	471.0	1087.8	100.00	4048.2	6033.5	630.0	1130.0	1200.0	7428.3	3411.7	100.00
	Number of species	29	28	17	24	24	26	44			16	12	19	12			3029	34	15	22	16	28		

SPECIES COMPOSITION

In urban green areas of Warsaw, a total of 70 springtail species were recorded (Tab. 1). In parks, 64 species were found, in green areas of housing estates, 32 species, and in streetside green, 54 species. The greatest number of species was noted in the Park of Culture and Leisure (47) and in the park at the Cemetery of Soviet Soldiers (38 species). The number of species recorded from the Łazienki Park and the Saxon Garden was lower by half (26 and 24, respectively).

In lawns of housing estates both loosely (Wierzbno) and closely (M.D.M.) built, 19 species were recorded. In small patches of bare ground around lindens at Konstytucji Square there were 12 species. The largest amount of species in streetside green was recorded from Żwirki i Wigury Avenue, 34 species from the streetside lawn and 29 species from the interlane lawn (a total of 43 species). On the remaining plots, the following numbers of species were noted: Zbawiciela Square, 28 species, Marszałkowska Street, 22 species, Woronicza Street, 16 species, and Ujazdowskie Avenue, 15 species (Tab. 1).

In parks, the most abundant species was *Isotoma viridis*, a species typical of open areas. Also eurytopic species were abundant, such as *Isotoma notabilis*, *Sminthurinus aureus*, *Sphaeridia pumilis*, and *Lepidocyrtus lanuginosus*. Parks were the only sites where polytopic species typical of forests occurred, such as *Onychiurus granulosus* (the Park of Culture and Leisure), *Orchesella bifasciata* (Cemetery of Soviet Soldiers, Łazienki), and *Xenylla brevisimilis* (the Park of Culture and Leisure), a very rare species so far recorded only from Kampinoska Forest by Kaczmarek (1973) and from the Pieniny Mountains by Weiner (1981). Other species limited only to parks comprised conticophilous *Entomobrya corticalis* (the Cemetery of Soviet Soldiers, Łazienki), xerophilous *Xenylla grisea* (the Park of Culture and Leisure), usually occurring near human settlements, myrmecophilous *Cyphoderus bidenticulatus* (Saxon Garden), so far known from only one site in Poland (Sterzyńska 1982), and xerophilous *Schoetella ununguiculata* (Łazienki), associated with open habitats.

A different species composition was observed in the communities from lawn of housing estates. The most abundant species was *Cryptopygus bipunctatus*, a polytopic species typical of open habitats. Other abundant species included eurytopic *Isotoma notabilis*, *Hypogastrura vernalis*, an oligotopic species typical of open habitats with alkaline soils, *Mesaphorura krausbaurei*, and *Pseudosinella alba*, a polytopic species preferring open habitats. No species limited only to green of housing estates was recorded from the study plots.

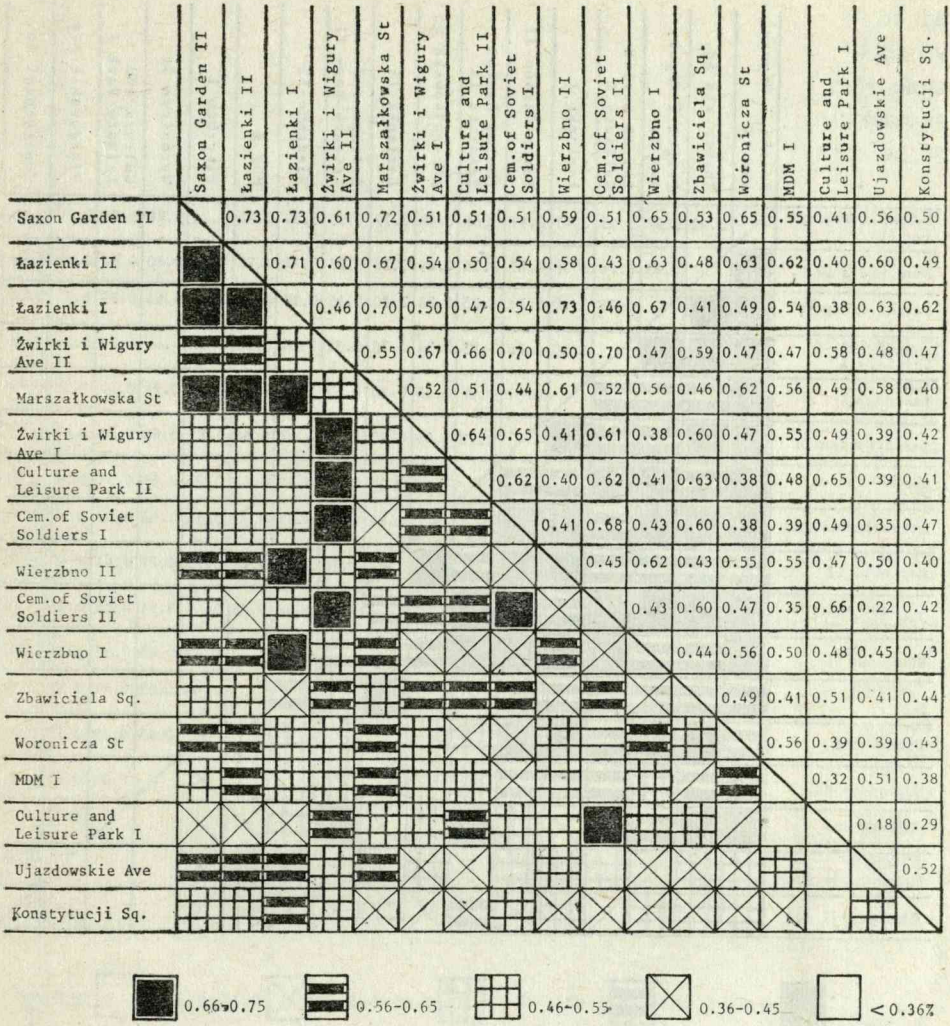
The most abundant species in streetside green was *Isotoma notabilis*. Other abundant species were *Isotoma viridis* and *Cryptopygus bipunctatus* (both polytopic species of open habitats), and *Sminthurinus aureus* (eurytopic). Only in the streetside green such species as *Entomobrya multifasciata* (an oligotopic species associated with open habitats, xero- and thermophilous), *Neotullbergia ramicuspis* (the species

not recorded so far from Poland, captured at Woronicza Street and on the isolated interlane lawn at Zbawiciela Square) were noted.

In urban green areas of Warsaw, the absolutely constant species ($75\% \leqslant C \leqslant 100\%$, according to the four-degree Tischler scale) consisted of *Isotoma notabilis*, *Cryptopygus bipunctatus*, and *Isotoma viridis* ($C = 94\%$), *Pseudosinella alba*, *Onychiurus armatus* s. Stach, and *Sminthurinus aureus* ($C = 88\%$), and *Pseudosinella immaculata*, *Lepidocyrtus cyaneus*, and *Isotomodes productus* ($C = 76\%$). The group of constant species ($50\% \leqslant C < 75\%$) was made up of *Lepidocyrtus lanuginosus* and *Isotomiella minor* ($C = 70.5\%$), *Mesaphorura krausbaueri*, *Stenophorura quadrispina*, *Folsomia quadrioculata*, and *Cyphoderus albinus* ($C = 65\%$), as well as *Entomobryides myrmecophilus* (59%), and *Lepidocyrtus lignorum* (53%). The largest group of the absolutely constant and constant species was represented by eurytopic species (*Isotoma notabilis*, *Isotomiella minor*, *Folsomia quadrioculata*, *Lepidocyrtus lanuginosus*, and *Lepidocyrtus lignorum*) and the species typical of open habitats such as crop fields and meadows (*Stenaphorura quadrispina*, xerophilous *Isotomodes productus* and *Pseudosinella alba*, and *Isotoma viridis*, a species abundant in early-successional communities, by many authors considered as a hygrophilous species associated with meadows). A high constancy in the study habitats was characteristic of myrmecophilous species such as *Cyphoderus albinus* and *Entomobryides myrmecophilus*, and also of synanthropic species such as *Cryptopygus bipunctatus* (a south-European species rarely recorded from non-urban habitats) and *Pseudosinella immaculata* (a troglophilous species). The group of accessory species ($25\% \leqslant C < 50\%$) consisted of 22 species. The most constant species in this group were *Folsomia fimetaria* (47%) and *Cryptopygus termophilus* (41%). The group of accidental species ($C < 25\%$) comprised 36 members.

The similarity of springtail communities from the study plots in Warsaw was analysed by means of Sörensen index (qualitative similarity) and Bray and Curtis index (quantitative similarity)[3]. The similarity of the species composition between springtail communities, as measured by Sörensen index, largely varied from 0.18 to 0.73, with a mean of 0.51. The most similar species composition was found for the communities from the park plots and the plots adjacent to parks, e.g., between the communities from the Saxon Garden and Marszałkowska Street (index 0.72), or between the communities in the transect in the park at the Cemetery of Soviet Soldiers and that at Żwirki i Wigury Avenue (mean index 0.64). A high similarity in the species composition was also found for Wierzbno II and Łazienki II (0.73). The lowest similarity was found between springtail communities from the streetside lawn at Ujazdowskie Avenue and the Park of Culture and Leisure I (0.18), and from the same streetside lawn and the Cemetery of Soviet Soldiers I and II (0.22 and 0.33). The most distinct communities occurred at Konstytucji Square, Ujazdowskie Avenue, and the Park of Culture and Leisure I (Tab. 2).

[3] A modified Sørensen index, in which the number of species is replaced by the number of individuals of these species.



	Saxon Garden II	Łazienki II	Łazienki I	Żwirki i Wigury Ave II	Marszałkowska St	Żwirki i Wigury Ave I	Culture and Leisure Park II	Cem.of Soviet Soldiers I	Wierzbno II	Cem.of Soviet Soldiers II	Wierzbno I	Zbawiciela Sq.	Woronicza St	MDM I	Culture and Leisure Park I	Ujazdowskie Ave	Konstytucji Sq.
Saxon Garden II		0.73	0.73	0.61	0.72	0.51	0.51	0.51	0.59	0.51	0.65	0.53	0.65	0.55	0.41	0.56	0.50
Łazienki II			0.71	0.60	0.67	0.54	0.50	0.54	0.58	0.43	0.63	0.48	0.63	0.62	0.40	0.60	0.49
Łazienki I				0.46	0.70	0.50	0.47	0.54	0.73	0.46	0.67	0.41	0.49	0.54	0.38	0.63	0.62
Żwirki i Wigury Ave II					0.55	0.67	0.66	0.70	0.50	0.70	0.47	0.59	0.47	0.47	0.58	0.48	0.47
Marszałkowska St						0.52	0.51	0.44	0.61	0.52	0.56	0.46	0.62	0.56	0.49	0.58	0.40
Żwirki i Wigury Ave I							0.64	0.65	0.41	0.61	0.38	0.60	0.47	0.55	0.49	0.39	0.42
Culture and Leisure Park II								0.62	0.40	0.62	0.41	0.63	0.38	0.48	0.65	0.39	0.41
Cem.of Soviet Soldiers I									0.41	0.68	0.43	0.60	0.38	0.39	0.49	0.35	0.47
Wierzbno II										0.45	0.62	0.43	0.55	0.55	0.47	0.50	0.40
Cem.of Soviet Soldiers II											0.43	0.60	0.47	0.35	0.66	0.22	0.42
Wierzbno I												0.44	0.56	0.50	0.48	0.45	0.43
Zbawiciela Sq.													0.49	0.41	0.51	0.41	0.44
Woronicza St														0.56	0.39	0.39	0.43
MDM I															0.32	0.51	0.38
Culture and Leisure Park I																0.18	0.29
Ujazdowskie Ave																	0.52
Konstytucji Sq.																	

Table 2. Diagram of similarity in the species composition (Sørensen index) of springtail communities in urban green of Warsaw)

The quantitative similarity of springtail communities, as measured by Bray and Curtis index, largely varied between 0.19 and 0.95, with a very high mean of 0.69 (Tab. 3). The highest values of the similarity index were found for the communities from the two plots in the park at the Cemetery of Soviet Soldiers, from street-side plots adjacent to this park (Żwirki i Wigury Avenue), and from the isolated lawn at Zbawiciela Square (mean index 0.92). Also the communities from the park plots at the Łazienki Park and the Saxon Garden and from the interlane plots at Marszałkowska Street were very similar (mean index 0.91). The lowest similarity

	Żwirki i Wigury Ave II	Zbawiciela Sq.	Żwirki i Wigury Ave I	Cem.of Soviet Soldiers I	Łazienki I	Saxon Garden II	Cem.of Soviet Soldiers II	Marszałkowska St	Łazienki II	Culture and Leisure Park II	Wierzbno II	MDM I	Wierzbno I	Woronicza St	Culture and Leisure Park I	Ujazdowskie Ave	Konstytucji Sq.
Żwirki i Wigury Ave II		0.92	0.94	0.93	0.83	0.91	0.88	0.86	0.79	0.95	0.87	0.80	0.78	0.78	0.84	0.57	0.60
Zbawiciela Sq.			0.89	0.88	0.80	0.87	0.70	0.84	0.76	0.85	0.78	0.71	0.83	0.80	0.82	0.56	0.65
Żwirki i Wigury Ave I				0.89	0.80	0.77	0.95	0.83	0.80	0.85	0.79	0.70	0.66	0.64	0.79	0.44	0.64
Cem.of Soviet Soldiers I					0.80	0.78	0.95	0.74	0.76	0.85	0.84	0.68	0.67	0.66	0.78	0.54	0.46
Łazienki I						0.92	0.66	0.95	0.88	0.71	0.74	0.76	0.86	0.76	0.47	0.59	0.64
Saxon Garden II							0.72	0.89	0.95	0.74	0.82	0.68	0.81	0.68	0.53	0.60	0.47
Cem.of Soviet Soldiers II								0.65	0.70	0.91	0.84	0.47	0.64	0.65	0.91	0.47	0.69
Marszałkowska St									0.87	0.69	0.75	0.76	0.63	0.63	0.57	0.64	0.39
Łazienki II										0.76	0.56	0.81	0.75	0.77	0.42	0.47	0.54
Culture and Leisure Park II											0.68	0.63	0.65	0.51	0.89	0.41	0.48
Wierzbno II												0.67	0.62	0.65	0.52	0.64	0.41
MDM I													0.64	0.63	0.41	0.52	0.53
Wierzbno I														0.45	0.45	0.50	0.36
Woronicza St															0.31	0.19	0.24
Culture and Leisure Park I																0.33	0.27
Ujazdowskie Ave																	0.46
Konstytucji Sq.																	

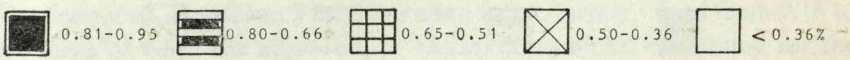


Table 3. Diagram of quantitative similarity (Bray and Curtis index) for springtail communities in urban green of Warsaw

was found for the communities from the streetside plots at Woronicza Street and Ujazdowskie Avenue (0.19).

The most distinct springtail communities occurred at Konstytucji Square, Ujazdowskie Avenue, Woronicza Street, and the Park of Culture and Leisure. Similarity in the species composition was high only for the communities from large parks and adjacent plots. The quantitative similarity revealed that springtail communities of urban green are much more uniform, especially in parks. The high values of Bray and Curtis index for the communities from the parks and the streetside plots

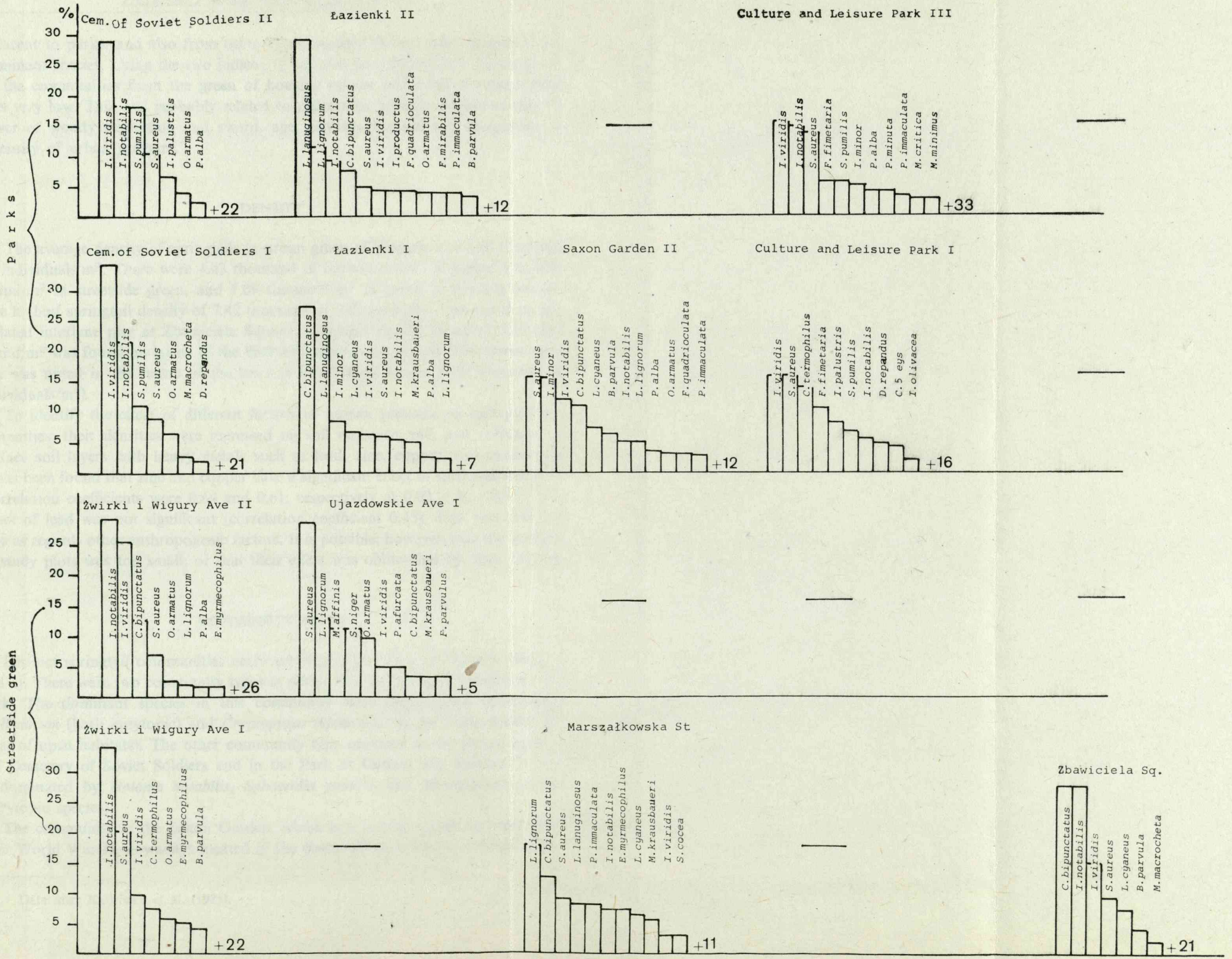
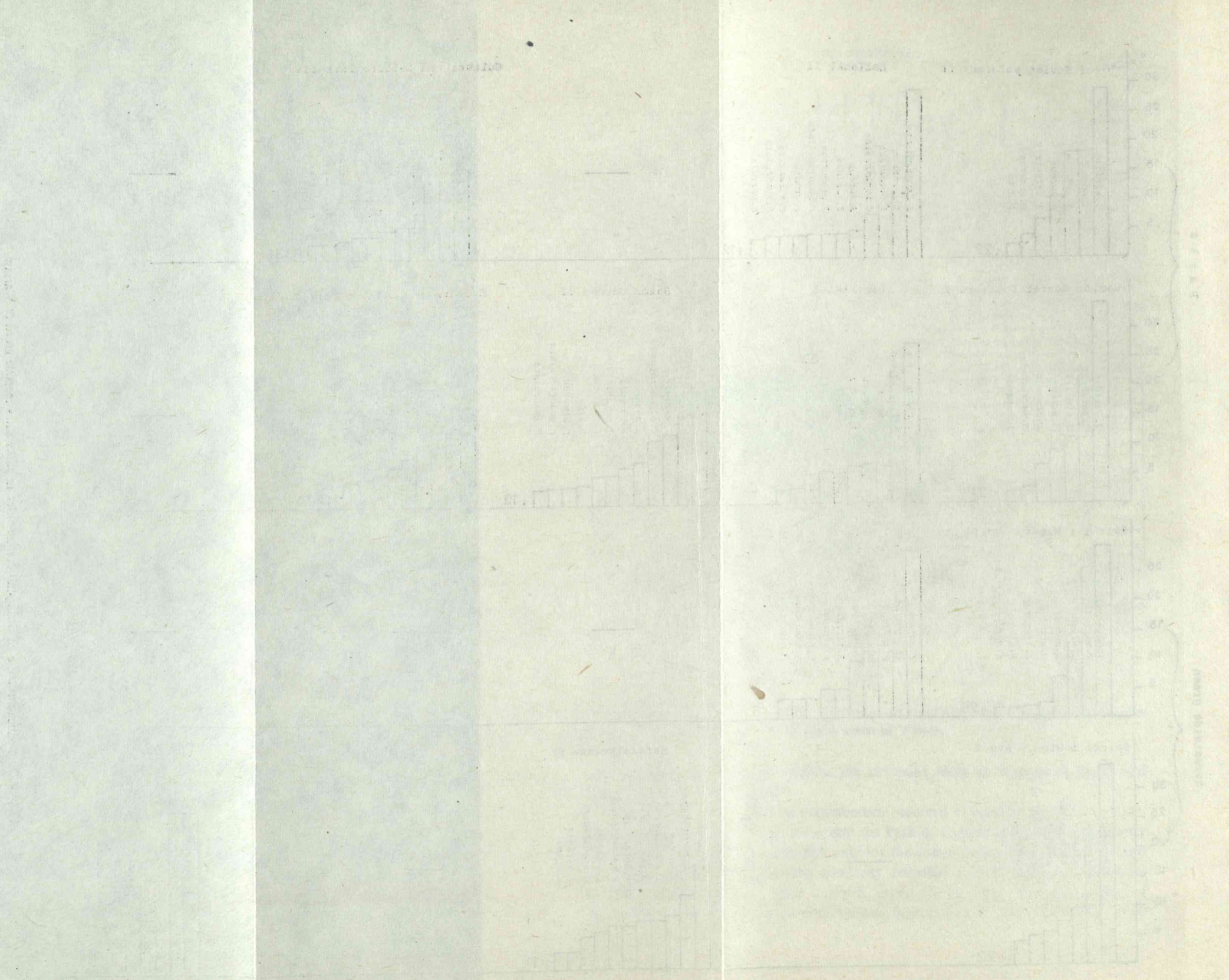


Fig. 1. Dominance structure of String-tail communities in parks and streetside green of Warsaw



adjacent to parks, and also from other plots, resulted from a high density of the dominant species. Using the two indices, it has also been found that the similarity of the communities from the green of housing estates and some streetside plots was very low. This was probably related to differential habitat conditions such as cover of woody vegetation and sward, age, physico-chemical soil properties, or intensity of urban pressure.

DENSITY

The average density of springtails in urban green of Warsaw was 3.96 thousand of individuals/m^2. There were 4.43 thousand of individuals/m^2 in parks, 3.41 thousand/m^2 in streetside green, and 1.09 thousand/m^2 in green of housing estates. The highest springtail density of 7.42 thousand of individuals/m^2 was noted on the isolated interlane plot at Zbawiciela Square. A similar density of about 7.13 thousand/m^2 was found on lawns of the Park of Culture and Leisure. The lowest density was noted in the centre of the town at Konstytucji Square (0.47 thousand of individuals/m^2).

To identify the effect of different factors of human pressure on springtail communities, their densities were regressed on soil moisture, pH, and pollution of surface soil layers with heavy metals such as lead, zinc, copper, and cadmium[4]. It has been found that zinc and copper have a significant effect of springtail densities (correlation coefficients were 0.64 and 0.61, respectively at $0.02 < P < 0.03$). The effect of lead was not significant (correlation coefficient 0.45). This was also the case as regards other anthropogenic factors. It is possible, however, that the number of study plots was too small, or that their effect was obliterated by other factors.

COMMUNITY TYPES

Distinct springtail communities occurred in green habitats of Warsaw (Figs. 1 and 2). There were two community types in parks. One in Łazienki, which is an old park. The dominant species in this community were *Lepidocyrtus lanuginosus*, *L. lignorum* (both eurytopic) and *Cryptopygus bipunctatus* (a polytopic species typical of open habitats). The other community type occurred in the young park at the Cemetery of Soviet Soldiers and in the Park of Culture and Leisure. It was co-dominated by *Isotoma notabilis*, *Sphaeridia pumilis*, and *Sminthurinus aureus* (eurytopic species).

The community in the Saxon Garden, which is a very old park, reconstructed after World War II, nowadays located in the centre of the town on a typically an-

[4] Data after Kubicka et al. (1985).

thropogenic, rubble soil, was dominated by *Sminthurinus aureus*, *Isotomiella minor*, *Isotoma viridis*, and *Cryptopygus bipunctatus*. This community was of an intermediate character between the two earlier described. The Saxon Garden was the only one where *Isotomiella minor*, an eurytopic species, was in the group of dominants. As a subdominant species it occurred in the Łazienki Park (plot I) and the Park of Culture and Leisure (plot II).

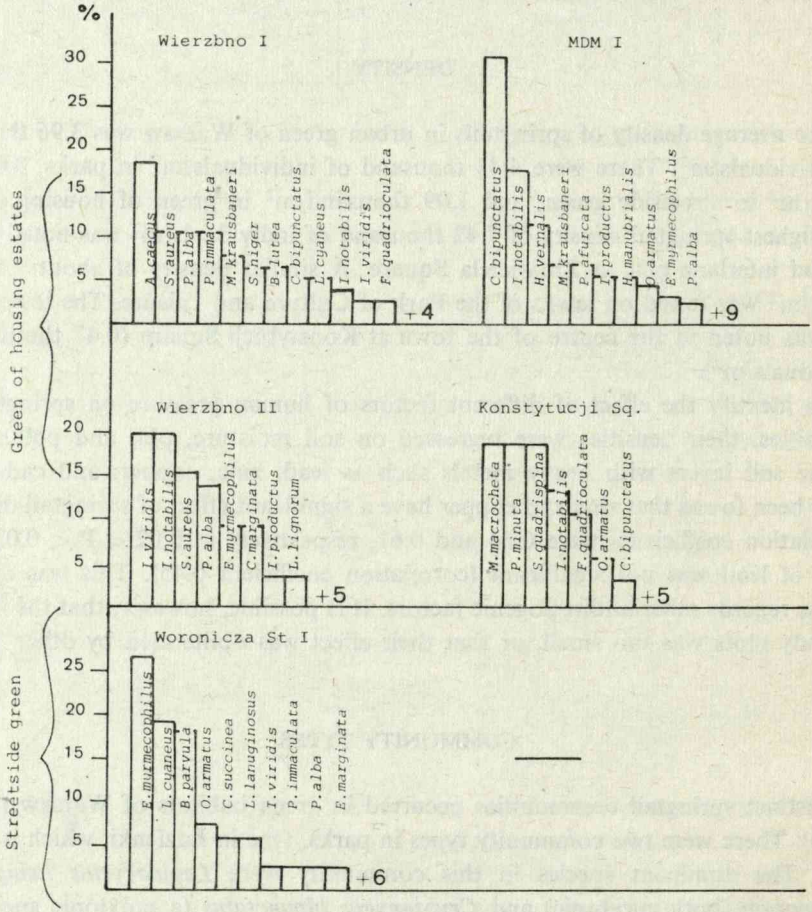


Fig. 2. Dominance structure of springtail communities in green of housing estates and streetside green of Warsaw

Distinct communities occurred in housing estates. The dominant species on the open, heavily trampled lawn Wierzbno I, was *Arrhopalites caecus*, a xerophilous, soil species typical of open habitats, mostly crop field. The co-dominant species were *Sminthurinus aureus* (eurytopic, occurring on herbaceous plants), *Pseudosinella alba* (xerophilous, typical of open habitats), and *Pseudosinella immaculata* (troglophilous, probably synanthropic in urban green). In the centre of the town, two communities were distinguished. One (M.D.M. I) was dominated by *Crypto-*

pygus bipunctatus, *Isotoma notabilis*, and *Hypogastrura vernalis* (an oligotopic species living in open habitats with alkaline soils). The other community (at Konstytucji Square) was co-dominated by *Mesaphorura macrochaeta* (probably a eurytopic species), *Proisotoma minuta* (eurytopic), *Stenaphorura quadrispina* (polytopic, typical of open habitats), and *Isotoma notabilis* and *Folsomia quadrioculata* (both eurytopic). Only the community from Wierzbno II, which was well managed, wooded, with a dense herb layer, was similar to the communities from young parks (Figs. 1 and 2).

Springtail communities from streetside and interlane green at Żwirki i Wigury Avenue (plots I and II) were similar to those from the nearby park at the Cemetery of Soviet Soldiers. The community from streetside green in Ujazdowskie Avenue (close to the Łazienki Park) differed from the communities in parks. It was dominated by *Sminthurinus aureus*, *Lepidocyrtus lignorum*, and *Metaphorura affinis* (a polytopic species living in open habitats). The subdominant species was *Folsomides parvulus* (a xerophilous species typical of open habitats). The community from the interlane plot at Marszałkowska Street was dominated by *Lepidocyrtus lignorum* and *Cryptopygus bipunctatus*. This community was similar to that in the Saxon Garden, and also to the community in the isolated interlane plot at Zbawiciela Square. The community from Zbawiciela Square was dominated by *Cryptopygus bipunctatus*, *Isotoma notabilis*, and *I. viridis*. Still another community type occurred in the streetside plot at Woronicza Street. It was dominated by *Entomobryides myrmecophilus* (a myrmecophilous species), *Lepidocyrtus cyaneus*, and *Brachystomella parvula* (species characteristic of open habitats). This community largely differed from the ones occurring in the nearby housing estate (Wierzbno I and II).

Springtail communities in parks were dominated by eurytopic species, or by the species associated with open habitats. A frequent dominant was the hygrophilous species *Isotoma viridis*. Synanthropic species such as *Cryptopygus bipunctatus* and *Pseudosinella immaculata* appeared in them. Lack of leaf litter eliminated the species associated with forests from this community. Also the communities from housing estates and streetsides were dominated by the species typical of open habitats and by eurytopic species. In contrast to the communities from open habitats, they were more often dominated by xero- and thermophilous species such as *Arrophalites caecus*, *Pseudosinella alba*, and *Folsomides parvulus*. In all the types of urban green under study, the community type and its dominance structure were strongly affected by sward depth, type of plant cover, shrubs and trees, and, consequently, by the degree of insolation and soil moisture. In the case of streetside green, the neighbourhood of a large green complex, e.g., a park, was important.

ECOLOGICAL ANALYSIS

The ecological analysis of springtail communities is similar to that presented in the paper on species composition and origin of the fauna of Warsaw (Sterzyńska 1982). It involves the ecological amplitude of springtails and their habitat prefe-

rences, taking into account species composition and proportion of different ecological elements (Tabs. 4, 5, and 6).

In springtail communities from parks, the highest proportions in terms of the

Table 4. Proportion of elements with differential ecological amplitudes and habitat preferences in springtail communities from various types of urban green; N—number of species, d—density in number of individuals/m²

Element / Type of green		Synanthropic	Eurytopic	Polytopic		Oligotopic		Unknown preferences
				forest	open areas	forest	open areas	
Parks	N	4.7	37.5	7.8	20.3	4.7	14.1	10.9
	d	0.1	59.0	0.3	11.3	0.4	25.0	3.9
Green of housing estates	N	3.0	54.6	—	24.2	—	9.1	9.1
	d	0.2	44.9	—	41.4	—	11.1	2.4
Streetside green	N	1.9	40.5	1.9	23.1	1.9	19.2	11.5
	d	0.1	51.8	0.1	26.7	0.1	18.8	2.4

Table 5. Proportions of elements with differential moisture requirements in springtail communities from various types of urban green; N—number of species, d—density in the number of individuals/m²

Element / Type of green		Hygrophilous	Mesohygrophilous	Xerophilous	Unknown preferences
Parks	N	6.3	56.2	29.7	7.8
	d	22.7	67.7	7.6	2.0
Green of housing estates	N	9.1	66.6	18.2	6.1
	d	8.5	68.1	22.9	0.5
Streetside green	N	9.6	53.9	26.9	9.6
	d	18.1	72.6	8.1	1.2

Table 6. Proportion of elements associated with different soil layers in springtail communities from various types of urban green; N—number of species, d—density in the number of individuals/m²

Element / Type of green		Euedaphie	Hemiedaphie	Epigean
Parks	N	43.8	35.9	20.3
	d	26.1	50.1	23.8
Green of housing estates	N	48.5	36.3	15.2
	d	45.4	42.8	11.8
Streetside green	N	42.3	36.5	21.2
	d	26.1	57.4	16.5

number of species were found for poly- and oligotopic species associated with open habitats (42.4%), including as many as 28.3% for polytopic and 14.1% for oligotopic species. Also the number of eurytopic species was high (37.5%). The number of poly- and oligotopic species associated with forests was 12.5%. In springtail communities from green of housing estates, the highest number was noted for eurytopic species (54.6%) and for the species typical of open habitats (33.3%). Species typical of forests were absent. In streetside green, like in parks, the number of poly- and oligotopic species typical of open habitats was highest (42.3%). The number of eurytopic species was 40.5%, and that of forest species, 3.8%.

In terms of the number of individuals representing the ecological elements distinguished, the highest proportions in parks were noted for eurytopic species (59%), then for poly- and oligotopic species typical of open habitats, which accounted for 36.3%, of which 25.2% were represented by oligotopic species typical of open habitats. The proportion of forest springtails was very low (0.7%). In the communities from green of housing estates, the highest proportions were noted for the species associated with open habitats (52.5%). The proportion of eurytopic species was similar (44.9%). In springtail communities from streetside green, eurytopic species accounted for 51.8%, poly- and oligotopic species associated with open habitats for 45.5%, and poly- and oligotopic species associated with forests for only 0.2% (Tab. 4).

Thus, the number of poly- and oligotopic species associated with open habitats was the highest (relatively) in the communities from parks and streetside green; in the streetside green, the number of eurytopic species was the highest. The species typical of forests were eliminated from urban communities. They were replaced by the species associated with open habitats and by synanthropic species. With respect to the number of individuals, eurytopic, and poly- and oligotopic species associated with open habitats showed highest proportions in parks and streetside green. In parks these were mostly oligotopic species associated with open habitats, and in streetside green, polytopic species associated with open habitats. Green of housing estates was dominated by a group of species associated with open habitats, but these were mostly polytopic species. The proportion of eurytopic species was also high.

Humidity belongs to important abiotic factors influencing the species composition and structure of springtail communities and their distribution in the habitat. The communities from parks were dominated by mesohygrophilous species (56.2%). Xerophilous species accounted for 29.7% and hygrophilous species for 6.3%. The communities from green of housing estates were also dominated by mesohygrophilous species (66.6%). The number of xerophilous species was 18.2%, and of hygrophilous species, 9.1%. In the communities from streetside green, mesohygrophilous species accounted for 53.9%, xerophilous, for 26.9%, and hygrophilous, for 9.6% of all the species.

With respect to the number of individuals, springtail communities from all the

types of urban green were dominated by mesohygrophilous species. In the communities from parks, hygrophilous springtails accounted for 22.7%, and xerophilous species for 7.6%. In the green of housing estates, xerophilous species accounted for 22.9% of the community and hygrophilous species for merely 8.5%. In streetside green, the proportion of hygrophilous species was 18.1% and of xerophilous species, 8.1% (Tab. 5).

Thus, the number of mesohygrophilous species was the highest in the communities from parks, housing estates, and streets. The numbers of xerophilous and hygrophilous species were much lower. As regards the number of individuals, mesohygrophilous species also had the highest proportions in springtail communities of all the types of urban green. In parks and streetside green, besides mesohygrophilous species, the proportion of hygrophilous species was also very high, and the proportion of xerophilous species was low. Such a high proportion of hygrophilous species at a relatively low number of these species was due to the very high abundance of *Isotoma viridis*. In green of housing estates, the proportions of hygrophilous and xerophilous species were opposite to those in parks and streetside green. The proportion of xerophilous species in the latter habitats was three times higher than that of hygrophilous species.

An analysis of springtail preferences for different soil layers revealed that the number of edaphic species was the highest in all types of urban green (Tab. 6). Also the number of hemiedaphic (living in leaf litter) species was high. The number of epigean species was low. As regards the number of individuals, the highest proportions in parks and streetside green were found for hemiedaphic springtails. In green of housing estates, the proportion of edaphic species was much higher than in other types of urban green (Tab. 6).

In parks and streetside green, the proportions of different ecological groups in springtail communities were similar. This was not the case, however, of the communities from green of housing estates, where the proportions of xerophilous and edaphic springtails were much higher. The forest species were absent.

CONCLUSIONS

There were 70 springtail species recorded from urban green of Warsaw. In parks, 64 species were noted, accounting for 91.4% of the *Collembola* of urban green. The richest habitats were relatively young parks (the Park of Culture and Leisure and the park at the Cemetery of Soviet Soldiers), where 80% of the urban springtails were found (56 species). In green of housing estates, 33 species were noted (47.1%), and in streetside green, 54 species (77.1%), including as many as 45 species (64.3% of the fauna) in streetside green adjacent to large parks.

The most constant species in urban green comprised *Isotoma viridis*, *I. notabilis*, *Cryptopygus bipunctatus*, *Lepidocyrtus cyaneus*, *Sminthurinus aureus*, *Isotomodes productus*, *Onychiurus armatus* s. Stach, *Lepidocyrtus lanuginosus*, *Isotomiella minor*,

Mesaphorura krausbaueri, *Stenaphorura quadrispina*, *Folsomia quadrioculata*, *Cyphoderus albinus*, *Entomobryides myrmecophilus*, and *Lepidocyrtus lignorum*. They represent eurytopic species, species characteristic of open habitats (crop fields, meadows), myrmecophilous species, and synanthropic species.

The communities from plots located with in particular study areas, e.g., parks, had the highest similarity of species composition. Also the communities from streetside lawns were similar to those from parks. The communities from the plots with site conditions atypical for urban green areas, high humidity and soil covered with litter practically all the year round (for example the community of *Collembola* from the Park of Culture and Leisure), characterized by a high density and large number of species were the most different. Intensified action of anthropogenic factors, too, resulted in advanced degradation of ecological conditions (lack of sward, high concentrations of heavy metals, increased salinity and decreased humidity of the soil). In effect, the communities of *Collembola* on such sites are much improverished, for example, the communities from Ujazdowskie Avenue and the Konstytucji Square.

Community abundance can be treated as a measure of the modification of urban zoocoenoses. In the urban green areas under study, the highest springtail densities were found in parks and in streetside green (4.43 and 3.41 thousand individuals/m^2, respectively). In green of housing estates, springtail density was 1.09 thousand individuals/m^2. Their abundance was affected by some heavy metals (zinc and copper) in soil. Other factors of anthropogenic pressure (soil overdrying, alkalization, and pollution with lead) had no noticeable effects, but it could have been a result of a compensatory effect of other environmental factors. Also morphological and physiological adaptations of springtails could be important. Two detoxicating mechanisms are known in springtails. One is the regulation of consumption, e.g., through storing different amounts of energy in spring and autumn communities, hibernation (Testerink 1983), or temporary starvation (Usher et al. 1982). The other goes through the activation of "intestinal cells," functionning like chloragocytes in earthworms (Josse and Verhoef 1983).

Two types of springtail communities can be distinguished in urban parks. One is dominated by *Lepidocyrtus lanuginosus*, *L. lignorum*, and *Cryptopygus bipunctatus*, and it occurs in old parks. The other one is dominated by *Isotoma viridis*, *I. notabilis*, and *Sphaeridia pumilis*, and it occurs in young parks.

Cryptopygus bipunctatus is an absolutely constant species in springtail communities from green of Warsaw, and it is clearly expansive in green of housing estates and in streetside green. Its occurrence in an old park established on a forest site provides evidence that local communities undergo synanthropization under urban pressure. *Isotoma viridis* is an early successional species associated with open habitats (Usher et al. 1982). It predominates in much younger parks, established on ancient farms.

The communities from green of housing estates and from streetside green were

dominated by variable species, this being probably due to a large diversity of environmental conditions in these habitats. Only the groups od dominant species from streetside green adjacent to parks were similar to the respective communities from these parks.

Springtail communities in urban green were dominated by poly- and oligotopic species associated with open habitats, and also by eurytopic species. These groups were represented by the highest number of species and individuals. The number of the species associated with forests was the highest in parks (12.5%) and much lower in streetside green (3.8%). They did not occur in green of housing estates. The number of individuals in the group of the species associated with forests accounted for 0.7% of the community in parks, and for 0.2% in streetside green. In springtail communities from all the types of urban green, then umber of mesohygrophilous species was the highest (from 54% to 67%). The proportion of individuals of these species exceeded 68%. The number of xerophilous species was rather high, and in parks it was about 30%, in streetside green, 27%, and in green of housing estates, 18%. The number of hygrophilous species was the lowest (6—10%). As regards the number of individuals, the communities from parks and streetside green were dominated by hygrophilous species, and the communities from green of housing estates were dominated by xerophilous species. Moreover, urban communities of springtails mostly consisted of edaphic species. Hemiedaphic species were also well represented, and the number of epigean species was low (6—10%). As regards the number of individuals, the communities from parks and streetside green were dominated by hemiedaphic species. Only in the green of housing estates, the proportion of edaphic species was twice as high as in parks or streetside green (about 50% of the communities). This can be attributed to a large modification of environmental conditions there (heavily overdried soil, poor sward, heavy insolation, trampling, etc.). Under such conditions, only springtails adapted to poor and simple diet can survive. Deeper soil layers are less affected by changes in environmental conditions than surface layers, and the organisms living there have a relatively high chance of surviving in this generally unsuitable habitat.

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STRUKTURA ZGRUPOWAŃ SKOCZOGONKÓW (*COLLEMBOLA*) ZIELENI MIEJSKIEJ WARSZAWY

STRESZCZENIE

W ramach badań prowadzonych przez Instytut Zoologii PAN nad zoocenozami miejskimi analizowano skład gatunkowy i strukturę zgrupowań *Collembola* występujących w zieleni Warszawy. Badania prowadzono w parkach, osiedlach mieszkaniowych i zieleni ulicznej. Łącznie stwierdzono występowanie 70 gatunków skoczogonków; 64 w parkach, 33 w osiedlach i 54 przy ulicach. Gatunkami absolutnie stałymi i stałymi w urbicenozie są: *Isotoma viridis*, *I. notabilis*, *Cryptopygus bipunctatus*, *Pseudosinella alba*, *P. immaculata*, *Lepidocyrtus cyaneus*, *Isotomodes productus*, *Onychiurus armatus* s. Stach, *Sminthurinus aureus*, *Lepidocyrtus lanuginosus*, *Isotomiella minor*, *Mesaphorura krausbaueri*, *Stenaphorura quadrispina*, *Folsomia quadrioculata Cyphoderus albinus*, *Entomobryides myrmecophilus* i *Lepidocyrtus lignorum*.

Składy gatunkowe i struktura zgrupowań z poszczególnych stanowisk, a także różnych typów zieleni Warszawy są na ogół podobne. Wyodrębniają się jedynie zgrupowania ze stanowisk odznaczających się specyficznymi warunkami siedliskowymi, np. silnie ocienionych, z dużą ilością opadłej ściółki, a także silnie skażonych metalami ciężkimi.

W zgrupowaniach w zieleni parkowej i ulicznej najwięcej jest gatunków politopowych i oligotopowych związanych z terenami otwartymi, natomiast w zieleni osiedlowej największy udział mają gatunki eurytopowe. We wszystkich typach zieleni miejskiej Warszawy przeważają gatunki mezohigrofilne i edaficzne. Pod względem liczby osobników największy udział w zgrupowaniach mają skoczogonki eurytopowe oraz poli- i oligotopowe terenów otwartych oraz mezohigrofilne i hemiedaficzne (jedynie w zgrupowaniach z zieleni osiedlowej nieznacznie dominują osobniki z grupy gatunków edaficznych).

Zależnie od grupy gatunków dominujących wyodrębniono dwa typy parkowych zgrupowań

Collembola. Pierwsze, charakterystyczne dla parków starych, z dominantami: *Lepidocyrtus lanuginosus*, *L. lignorum*, *Cryptopygus bipunctatus* i drugie, charakterystyczne dla młodych parków, z dominantami: *Isotoma viridis*, *I. notabilis*, *Spaeridia pumilis*. *Isotoma viridis* to gatunek związany z terenami otwartymi, wilgociolubny, zaliczany do form wczesnosukcesyjnych. Zieleń osiedlowa i zieleń uliczna nie mają sobie właściwych, stałych typów zgrupowań skoczogonków. Charakterystycznym dla nich gatunkiem jest *Cryptopygus bipunctatus*. Zgrupowania ze stanowisk ulicznych położonych w sąsiedztwie parków są podobne do zgrupowań z tych parków.

СТРУКТУРА КОМПЛЕКСОВ НОГОХВОСТОК (*COLLEMBOLA*) ГОРОДСКИХ ЗЕЛЕНЫХ НАСАЖДЕНИЙ ВАРШАВЫ

РЕЗЮМЕ

В рамках исследований, проводимых Институтом зоологии ПАН по городским зооценозам, проанализировали видовой состав и структуру комплексов *Collembola*, встречающихся в городской зелени Варшавы. Исследования были проведены в парках, жилых районах и уличных насаждениях. Всего констатировано 70 видов ногохвосток: 64 в парках, 33 в жилых районах и 54 на улицах. К видам встречающимся абсолютно постоянно и постоянным в урбиценозах относятся: *Isotoma viridis*, *I. notabilis*, *Cryptopygus bipunctatus*, *Pseudosinella alba*, *P. immaculata*, *Lepidocyrtus cyaneus*, *Isotomodes productus*, *Onychiurus armatus s. Stach*, *Sminthurinus aureus*, *Lepidocyrtus lanuginosus*, *Isotomiella minor*, *Mesaphorura krausbaueri*, *Stenaphorura quadrispina*, *Folsomia quadriculata*, *Cyphoderus albinus*, *Entomobryoides myrmecophilus* и *Lepidocyrtus lignorum*.

Видовой состав и структура комплексов в отдельных пунктах, а также разных типах городской зелени в основном сходны. Выделяются только комплексы из пунктов, отличающихся специфическими условиями среды, как, например, очень затененных, с большим количеством подстилки из опавших листьев, а также сильно загрязненных тяжелыми металлами.

В комплексах из парков и уличной зелени встречается больше всего политопных и олиготопных видов, приуроченных к открытым пространствам, в то время как в зеленых насаждениях жилых районов наибольший процент занимают эвритопные виды. Во всех типах городской зелени встречаются преимущественно мезофильные и эдафические виды. С точки зрения численности особей наиболее высоким содержанием в комплексах характеризуются эвритопные, а также поли- и олиготопные ногохвостки открытых пространств и эдафильные и гемиэдафильные виды (единственно в комплексах из зелени жилых районов незначительно доминируют особи и группы здрафических видов).

Выделено два типа парковых комплексов *Collembola* в зависимости от группы доминирующих видов. Первый, характерный для старых парков, с доминантими: *Lepidocyrtus lanuginosus*, *L. lignorum*, *Cryptopygus bipunctatus* и второй, характерный для молодых парков, с доминантами: *Isotoma viridis*, *I. notabilis*, *Sphaeridia pumilus*. *Isotoma viridis*—это вид, приуроченный к открытым пространствам, влажнолюбивый, причисляемый к формам ранней сукцессии. Зелень жилых районов и уличных насаждений не имеют свойственных им, постоянных типов комплексов ногохвосток. Характерным для них видом является *Cryptopygus bipunctatus*. Комплексы из уличных насаждений, находящихся по соседству с парками, сходны с комплексами из этих парков.