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Short research contribution

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COMPARISON OF COLLEMBOLA (SPRINGTAILS) COMMUNITIES IN MEADOWS AND FORESTS ON DRAINED PEAT SOILS OF DIFFERENT ORIGIN

ABSTRACT: The results of the study carried out in areas that differed in soil moisture in two years differing in the amount of precipitation provide evidence that drained peatlands on sedge-moss peat managed as meadows enhance a higher stabilization of Collembola communities than the adjacent areas subjected to spontaneous forest succession: changes in numbers are small, biomass is higher than in the forest, and the similarity of species composition from year to year is higher than in the forest. The dominance structure, the same species being dominant, is almost identical.

In the alder peat, the most suitable conditions for the development of Collembola communities are created in the area subjected to spontaneous forest succession after drainage, rather than in drained meadows. Collembola community in the forest was characterized by a higher abundance and biomass and a higher index of species diversity than in the meadow, and by a higher species similarity from year to year.

KEY WORDS: Collembola, peats, meadow, forest

Collembola, like Acarina, constitute the most abundant group of soil mesofauna occurring in all soils of the globe. Their numbers are highest in the upper soil layer up to 7–10 cm deep. Most springtails (Collembola) respirate through the cuticle, and only some species of *Symphypleona* have tracheae (Stach 1951). For this reason, variation in soil moisture affects their numbers and even species composition of the community. Thus, they can be used as indicators of changes occurring in moisture of the upper soil layer during the succession of terrestrial ecosystems subjected to different management. (Vannier 1970, Petersen and Luxtron 1982, Rusek 1984).

This paper compares Collembola communities in meadows and forests, developed on peat soils derived from different substrates, in the years that differed in the amount of precipitation.

The effects of the following factors on numbers, biomass, dominance structure, and similarity of species composition were analysed:

1) management type – comparison of meadows and forests,

2) peat type – a meadow and a forest on sedge-moss peat, and a meadow and a forest on alder peat,

3) variation in moisture conditions in successive years.

The study was conducted in the fen Wizna (ca. 8 000 ha) located in the marginal ice valley of the river Biebrza, north-eastern Poland. It was drained in the 1960s, ploughed, and cultivated for hay. Some drained peripheral parts were not cultivated and they were invaded by forest.

The following study sites of area ca 2500m² each were chosen: site A – a meadow and a forest with a higher soil moisture and porosity on sedge-moss peat (SMP) where in September of 1979 the soil moisture of the meadow was 81% by weight and the volume of mesopores was 51% (pF=2–4.2) and site C – a meadow and a forest on alder peat (AP) with a lower moisture and porosity, where, in the same period, the moisture of the meadow was 61% by weight and the volume of mesopores was 29% (Okruszko 1977, Kaczmarek 1992). The sedge-moss meadow A was predominated by *Festuca rubra* L.. and *Carex rostrata* Stokres. and the forest A by *Betula pubescens* Ehrh., *Pinus silvestris* L., *Vaccinium myrtillus* L., grasses and mosses. The alder-peat meadow C was predominated by *Festuca rubra* L., *Poa pratensis* L., and weeds, and the forest C by *Alnus glutinosa* (L.), *Betula pubescens* Ehrh., *Urtica dioica* L., and grasses. According to the botanical classification, forest A is a birch-pine swamp *Thelypteridi-Betuletum* Czerwiński 1972, and forest C is a birch swamp *Betuletum Pubescentis-Verrucosae* Pałczyński 1975 (Pacowski 1977, Kloss 1991).

The study was conducted in two growing seasons: 1978 and 1979. These seasons markedly differed in the amount of precipitation, which in the period between 1 April and 1 November was 447.8 mm in 1978 and 257.7 mm in 1979.

Soil cores were taken with a metallic corer 10 cm² in area and 7 cm deep. From 10 to 15 cores were taken from each site every month from April to November. During two years 186 samples were taken from meadow A and 188 from meadow C, 174 from forest A and 161 from forest C. The fauna was extracted by using Tullgren funnels, and Collembola from each sample were identified to species, measured, and counted. Their biomass was calculated from the measurements of their sizes (Dunger 1968, Kaczmarek 1963). Similarity of species composition in egzamined biotops was determined by index:

$$P = \frac{c}{a+b-2c} \qquad (1)$$

where:
a – the number of species in biotop A for the egzamined period,
b – the number of species in biotop B for the egzamined period,
c – the number of mutual species for the same period in biotops A and B
$P <0,\infty>$
and species diversity by Shannon index:

$$H' = -\sum_{i=1}^{S} \frac{N_i}{N} \log 2 \frac{N_i}{N} \qquad (2)$$

where:
Ni – the number of specimens of species i found in the whole study period in the biotop
N – the total number of specimens found in the whole study period in the biotop
S – the number of species
$H' <0, \infty>$ Index P and H' were calculated for every of four habitats (meadow and forest A and meadow and forest C examined (Table 1).

In total, 47 springtail species were recorded from the two meadows and two forests. The numbers 48 – 54 on the list (Appendix) are juvenil specimens determined only to genera. In both the sedge-moss peat and the alder peat, the number of species noted during both years was higher in the forest than in the meadow. The difference between biotops was smaller for the sedge-moss peat than for the alder peat (Table 1).

As the number of samples was small, chances for capturing rare species varied depending on the weather. For example, *Isotomiella minor* did not occur in forest A and was rare in forest C in 1978, whereas it was abundant in both forests in 1979, i.e. in the dry year. The higher fluctuations in numbers of individual species, the more probable were differences in the species composition at the same site between drier and wetter years. The index of species similarity "P" (Table 1) reflects the relative stability of the community in ecosystem at variable weather conditions.

Total numbers of Collembola in both meadows almost did not vary from year to year (Table 1). Among more abundant species, nearly a stable level in the alder meadow over the two years was noted for *Isotoma notabilis*, a small species (up to 1 mm long) living in deeper soil layers. The same was obserwed for larger species *Onychiurus armatus* (up to 3 mm long), *Isotoma viridis* (up to 4.3 mm long), and for smaller species such as *Proisotoma minima* (up to 0.8 mm long) and *Messaphorura* spp. (up to 1.3 mm long).

In forests, year-to-year fluctuations in numbers were higher than in the meadows

Table 1. Comparison of *Collembola* communities in two years: 1978 (447.8 mm of season precipitation) and 1979 (257.7 mm of season precipitation) at sites that differed in peat origin (A – sedge-moss peat, C – alder peat) and in the type of management (meadow and forest)

Peat type	Sedge – moss peat (A)						Alder peat (C)					
Type of menagement	Meadow			Forest			Meadow			Forest		
Year	1978	1979	Both years	1978	1979	Both years	1978	1979	Both years	1978	1979	Both years
Number of species	21	20	27	24	25	33	12	13	21	28	23	32
Index of species similarity "P"	1.07			0.94			0.46			1.26		
Mean numbers ($N \times 10^3 \times m.^{-2}$)	10.4	10.8	10.6	27.7	10.4	19.1	4.7	4.3	4.5	47.8	23.5	35.6
Ratio of numbers in successive years	0.96			2.6			1.09			2.3		
Mean biomass (mg w. w. $m.^{-2}$)	552.8	372.9	462.8	382.1	165.6	273.8	107.6	51.4	79.5	1141	550.6	845.8
Ratio of biomass in successive years	1.48			2.3			2.09			2.07		
Mean biomass of individual (µg)	53.15	34.52	40.26	13.79	15.92	14.33	22.89	11.95	17.66	23.87	23.72	23.75
Index of species diversity H'			0.807			0.552			0.598			0.742

(Table 1). In the forest on alder peat, where in the dry year numbers were reduced by half, respective ratios > 2 (Table 1) relatively stable numbers were noted only for *Onychiurus armatus* (Appendix). In the sedge-moss peat, where numbers were reduced almost to one-third, no such species were recorded.

The total biomass of Collembola in alder peat was higher in the forest than in the meadow in both years, and in sedge-moss peat it was higher in the meadow than in the forest. In the dry year, biomass was reduced to about 50%, and only in the sedge-moss meadow to about 70% (Table 1).

Differences in changes between numbers and biomass of springtails in the meadows, where in the dry year their abundance remained unchanged and biomass markedly declined, imply that small individuals were relatively more abundant in the dry year. This pattern was better expressed in the drier alder meadow, where the abundance of small species, *Proisotoma minima* and *Mesaphorura* spp., increased, and that of the large species *Isotoma viridis* decreased. In the sedge-moss meadow, the abundance of "large" species clearly decreased, and the abundance of young stages of different species increased.

The Shannon H' index for the four sites confirmed a higher species diversity in the meadow 0.807 as compared with the forest 0.552 on sedge-moss peat , and a higher species diversity in the forest 0.742 than in the meadow 0.598 in alder peat (Table 1).

The proportion of the main dominant was higher in the forests (till 71%) than in the meadows (till 47%). The most stable dominance from year to year was observed in the sedge-moss peat on meadow A (Table 2).

Thus far, the development of the communities of soil heterotrophic fauna in presented peatland was analysed only in meadows (Andrzejewska *et al.* 1983, Kajak *et al.* 1985, Ciesielska et *al.* 1991, Kaczmarek 1991, 1998, Makulec 1991, Pętal 1991, Wasilewska 1991). These

Table 2. Percentage annual dominance of the most abundant species

Peat	Sedge moss peat A				Alder peat C			
Species	Meadow		Forest		Meadow		Forest	
	1978	1979	1978	1979	1978	1979	1978	1979
Isotoma viridis	9	8			47	15		
Isotoma notabilis	12	0	71	40	36	36	63	31
Mesaphorura spp.	14	18			16	36		
Onychiurus armatus	33	31	5	6			10	21
Isotomiella minor			0	18			1.1	13

analyses also include Collembola. They provide evidence that in the whole invertebrate biocoenotic system, the species diversity and the mean body weight within taxa are declining with decreasing soil moisture of drained meadows developed on peats of different origin.

Physico-chemical properties of peat soils and their transformations arising from their differential use in the middle basin of the river Biebrza were analysed in detail by Gotkiewicz *et al.* (1983), Niklewska *et al.* (1991), Okruszko (1991), Róg (1991) Sapek *et al.* (1991). It has been found that reduced moisture combined with increased aeration of the soil, is stimulating the biological processes. Meadow vegetation with shallow roots has a stronger drying effect on the upper soil horizon, whereas a deep root system of *Betula pubescens* dries deeper layers to 30 cm. The upper soil layer in the forest is markedly loosen, better aerated than in the meadow, and also CO_2 evolution is higher in it indicating a higher biological activity. It has been found that forests on drained peats intensify soil mineralization. The study of Collembola communities in soils of meadows and forests derived from peats of different origin (sedge-moss A and alder peats C) has shown that the number of species, their abundance and biomass are lower in the meadow on drier alder peat C, and, as expected, the decline in all these parameters in the drier year was stronger than in the meadow on the sedge-moss peat A. On the contrary, in the forest the index of species diversity was higher in the drier peat C, and total numbers and biomass were considerably higher than in the forest on the sedge-moss peat A with a higher moisture content. These results corroborate with the conclusions that increased watering ensuring a higher water table can prevent destructive effects of tree stands on the soil, such as overdrying, aeration, and nitrogen mineralization.

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Appendix. List of *Collembola* species according to taxonomic position and their abundance in all samples

no.	Peat	Sedge – moss peat A				Alder peat C			
	Type of menagement	meadow		forest		meadow		forest	
	Year	1978	1979	1978	1979	1978	1979	1978	1979
	Number of samples	102	84	90	84	104	84	86	75
1	*Orchesella cincta (L.)*			1	1				
2	*Orchesella sphagneticola Stach.*				3				
3	*Orchesella flavescens (Bourl.)*			18	6			10	11
4	*Eutomobrya nivalis (L.)*				2		1	1	
5	*Tomocerus vulgaris* (Tullb.)				2				
6	*Pogonognathellus flavescens* (Tullb.)			10	2			49	13
7	*Pogonognathellus longicornis* (Müll.)				1				
8	*Lepidocyrtus ruber* Schött	16	2	1	1	11			7
9	*Lepidocyrtus lanuginosus* (Gmel.)	1		3	1			11	11
10	*Lepidocyrtus lignorum* (Fabr.)	1		5		1		36	4
11	*Lepidocyrtus cyaneus* Tullb.				1				
12	*Lepidocyrtus sp.* Bourl.							6	
13	*Sinella myrmecophila* (Reut.)			1					
14	*Pseudachorutes sp.* Tullb.				1				
15	*Pseudachorutes dubius* Krausb.							3	
16	*Ceratophysella armata* (Nic.)	122	88			2		2	40
17	*Ceratophysella granulata* Stach					1			
18	*Friesea mirabilis* (Tullb.)	13	11					25	39
19	*Frisea emuctonata* (Stach)	1							
20	*Brachystomella parvula* (Schäff.)	11	2	1				1	
21	*Willemia anophthalma* Börn.			15	29		2	23	38
22	*Willemia aspinata* Stach			36	18			7	
23	*Neanura muscorum* (Templ.)	3	3	2	3			2	
24	*Anurida ellipsoides* (Stach)							73	
25	*Anurida pseudogranaria* Stach				7			5	4
26	*Anurida sp.* Laboulb.			5	15	1			2
27	*Micranurida pygmaea* Börn.			10	4	2	2	4	7
28	*Vertagopus arborea* (L.)	1							
29	*Isotomurus palustris* (Müll.)	69	35	1		1	3	20	2
30	*Isotomurus subciliatus + I. Sp.* Stach	1	39						
31	*Isotoma viridis* Bourl.	93	72	70	10	201	53	61	8
32	*Isotoma notabilis* Schäff.	132	6	1782	353	178	131	2613	540
33	*Isotoma olivacea* Tullb.		1		1		5		1
34	*Proisotoma minuta* (Tullb.)	12	12				1		
35	*Proisotoma minima* (Abs.)	39	29	3	1		26	4	9
36	*Proisotoma sp.* Börn.	28	2	1				53	3
37	*Isotomiella minor* (Schäff.)	6	4		161			47	231
38	*Folsomia quadrioculata* (Tullb.)		1	1		3		523	148
39	*Folsomia fimetaria* (L.)						1	2	
40	*Folsomia sp.* Will.							1	
41	*Cryptopygus bipunctatus* (Axels.)		1	1					1

42	*Willowsia sp.* Shoeb.	3							
43	*Isotomodes productus* (Axels.)	1							
44	*Onychiurus armatus* (Tullb.)	348	286	131	50	4	5	415	364
45	*Onychiurus affinis* Årg.		2	331	117		1	53	148
46	*Onychiurus sp.* Gerv.		1	5					
47	*Mesaphorura sp.* Börn.	151	168	58	87	74	131	40	112
48	*Orchesella juv. sp.*								1
49	*Entomobrya juv. sp. sp.*			1		1			
50	*Pogonognathellus juv. sp. sp.*			1				14	21
51	*Lepidocyrtus juv. sp. sp.*	7				12		6	1
52	*Isotomurus juv. sp. Sp.*		141						
53	*Isotoma juv. sp. sp.*		6					1	
54	*Proisotoma juv. sp.*	1							
	Total individuals	**1060**	**912**	**2494**	**877**	**492**	**362**	**4111**	**1766**
	Number of individuals $(N\times10^3\times m^{-2})$	**10.3**	**10.8**	**27.7**	**10.4**	**4.7**	**4.3**	**47.8**	**23.5**