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Species diversity and distribution of Collembola in the vicinity of Polish Polar Station, Hornsund area, Spitsbergen

ABSTRACT: Species diversity of Collembola was studied in the vicinity of Polish Polar Station, Hornsund area, West Spitsbergen. A list of 32 species has been compiled, and their distribution over microlandscapes and microhabitats in the study area has been presented.

K e y w o r d s: Arctic, Spitsbergen, tundra, soil fauna, Collembola.

Introduction

Collembola can be regarded as one of the most abundant and diverse groups of soil invertebrates in Arctic tundra and polar desert ecosystems (Černov 1978). In the course of our investigations on soil animal populations of tundra sites in Hornsund area (May–September, 1989), Collembola showed the highest population density after nematodes and the largest number of species among the soil arthropods (Byzova, Uvarov and Petrova 1995). The aim of this paper is to present species list of Collembola collected and the data on their distribution over study area.

Investigated area

Material was collected in various sites within the 0.5–2 km wide and ca. 40 km long lowland zone along the northern and north-western coast of Hornsund, between Gnålberget (Gnål Mt., the eastern point) and Werenskioldbreen (Werenskiold Glacier, the north-western point) (Karczewski 1984). Sampling was usually made by a 5 × 5 cm metal corer to the depth of 5 to 15 cm. In several cases samples were taken as pieces of topsoil substrate with vegetation, of

arbitrary dimensions (larger than 5 × 5 × 5 cm samples). Springtails were extracted from the samples in Tullgren funnels.

Here we characterise briefly the ten main microlandscapes (denoted as Roman figures) and plant associations (capital letters) which were searched for Collembola in the study area. Number of samples is shown in square brackets. For the detailed description of microlandscapes IV–VII see Byzova, Uvarov and Petrova (1995), plots 1, 3, 2 and 4, respectively.

I. Littoral area of Isbjornhamna and Hyttevika bays, S. and W exposition (A) [9].

II. Isbjornhamna, supralittoral and coastal area with small patches of tundra vegetation, S exposition (C, F, H) [11].

III. Terminal moraine of Werenskiold Glacier, rock debris with patches of mosses and higher plants, W exposition (C, F, H, I, K, L, M) [17].

IV. Polygonal tundra on marine terraces (B, C, F, G, H, I, J, M) [150].

V. Mossy/lichenous tundra (C, F, G, H, I) [75].

VI. Mossy site of *Calliergon stramineum* with a small amount of *Aulacomium palustre, Ptilidium ciliare, Drepanocladus uncinatus, Pohlia* sp., *Tritomaria quinquelineata* (D) [75].

Landscapes IV, V and VI are situated on the plain of raised marine terraces at the foot of Ariekamen/Fugleberget mountain system, S exposition.

VII. Terraces on the slope of Ariekammen Mt., below the colony of Little Auks (*Alle alle*), S and SE exposition. Compact mosses (*Aplodon wormskioeldi, Tetraplodon mnioides, Pohlia* sp., *Ceratodon purpurescens, Calliergon sarmentosum, Brachythecium* sp., *Mnium* sp.) with patches of meadow herbs (*Cerastium alpinum, Cochlearia arctica, Oxyria* sp.) (E) [60]. This site receives considerable biogenic supply from the bird colony. Only dominant species of Collembola are here mentioned (in square brackets in Tab. 1).

VIII. Different tundra plant associations (mosses prevailing) on the plain between Revdalen and Hyttevika, SW exposition, mainly wet sites (C, I, J, M) [14].

IX. Vegetation on rocks (C, F, J, M) [18].

X. Microcatena on the slope of Gnålberget (Gnål Mt.), zones from *Larus* sp. colony on cliffs down to the littoral, SE exposition (N, O, P, R, S, T) [18].

A — decaying algae and sand beneath on the littoral (I) [9].

B — "open ground" (with crusts of algae) of polygonal tundra (IV) [75].

C — different associations of pure mosses: compact mosses (*Bryum* sp., *Districhium* sp., *Oncophorus wahlenbergii* v. *compactus* etc.), loose mosses (*Rhacomitrium canescens, Polytrichum alpinum, Drepanocladus uncinatus, Ptilidium ciliare*), wet mosses (*Calliergon sarmentosum, C. stramineum, Calliergon* sp., *Sphagnum* spp., *Bryum criophilum, Philonthis* sp. (II, III, IV, V, VIII, IX) [31].

D — see VI [75].

E — see VII [60].

F — pure associations of fructicose lichens (*Sphaerophorus globosus, Cetraria nivalis, Cetraria* sp., *Cladonia mitis, C. gracilis, C. amarurocreae,*

Cladonia sp., *Cladina rangiferina, Stereocaulon* sp., *Thamnosia vermicularis*) (II, III, IV, V, IX) [44].

G — pure associations of compact crustose lichen *Ochrolechia gonatoides* (IV, V) [7].

H — associations of *Saxifraga oppositifolia, S. caespitosa, S. nivalis* (II, III, IV, V) [39].

I — associations of polar willow (*Salix polaris, S. reticulata*) and mosses (*Dicranum* sp. and *Mnium* sp.) (III, IV, V, VIII) [70].

J — associations of *Luzula confusa* and mosses (IV, VIII, IX) [4].

K — associations of *Polygonum viviparum* at the stream side (III) [2].

L — wet ground in the stream bed (III) [3].

M — grass associations with mosses: *Poa alpigena, Deschampsia* sp.+*Drepanocladus uncinatus, Cladonia mitis; Duportia philosanthia*+*Aulacomium palustre* and others; *Festuca vivipara*+*Dicranum* sp., etc. (III, IV, VIII, IX) [10].

Associations N, O, P, R, S, T are situated within the common watershed along the organic-rich downflow from bird colonies on Gnålberget, subsequently from the upper to the lower zone (X) [18]. Zones O–R are characterized by thick vegetation cover on rocky debris, organic layer being almost absent.

N — zone of bird guano below vertical cliff with the *Larus* sp. colony, up to 1 m wide [3].

O — zone of *Poa alpigena* spp. *colpodea*, 1–3 m wide [3].

P — zone of *Cochlearia groenlandica*, some tens m wide [3].

R — zone of *Cochlearia arctica*, some tens m wide [3].

S — zone of meadow vegetation (*Cerastium alpinum, Saxifraga sernua* and mosses) [3].

T — compact mosses at the foot of Gnålberget [3].

Results and discussion

Material collected in different plant communities of Hornsund coastal tundra made it possible to reveal 32 species of springtails representing 19 genera from 9 families (Tab. 1). The highest species diversity was recorded in the families of Isotomidae (11 species from 4 genera), Hypogastruidae (6 species from 4 genera), and Onychiuridae (6 species from 2 genera). Neanuridae was represented by 3 species (3 genera), Entomobryidae by 2 (2 genera), other families by 1 species each. The richest genera were *Folsomia, Isotoma* and *Onychiurus* with 5, 4 and 4 species, respectively. Fauna of Spitsbergen springtails, revised by Valpas (1967) and Fjellberg (1984, 1994) includes 49 species, excluding dubious records of 3 species more. In the latter list Isotomidae are also dominating, making up about 40% of the species number. That seems to be typical for Collembola faunas in the Arctic (Černov 1978,

Table 1.

Distribution of Collembola over microlandscapes in the vicinities of Polish Polar Station, Hornsund area, Spitsbergen. First records for Hornsund are denoted with (*). Symbols — in the text

Species	Microlandscapes	I	II	III	IV	V	VI	VII	VIII	IX	X
Xenylla humicola (Fabricius, 1780)		+	+	+	+	+	+	+	+	+	+
Hypogastrura tullbergi (Schäffer, 1900)			+	+	+	+	+		+	+	
H. viatica (Tullberg, 1871)		+		+			+		+		+
Ceratophysella longispina (Tullberg, 1876)				+	+	+	+		+	+	
C. succinea (Gisin, 1949)*									+		
Willemia anophthalma Börner, 1901*			+	+						+	
Friesea quinquespinosa Wahlgren, 1990*			+			+				+	+
Anurida polaris (Hammer, 1954)*			+	+	+	+	+		+	+	+
Micranurida pygmaea Börner, 1901*				+	+	+	+		+	+	
Tullbergia sp.			+								
T. arctica Wahlgren, 1900				+							
Onychiurus duplopunctatus, (Strenzke, 1954)*											+
O. arcticus (Tullberg, 1876)			+							+	
O. macfadyeni (Gisin, 1953)*		+		+						+	
O. groenlandicus (Tullberg, 1876)		+	+	+	+	+	+		+	+	+
Pseudanurophorus inoculatus Bödvarsson, 1957*					+	+					
Folsomia quadrioculata (Tullberg, 1871)		+	+	+	+	+	+	+	+	+	+
F. regularis Hammer, 1953			+			+	+		+	+	
F. bisetosa Gisin, 1953*		+	+	+	+		+			+	+
F. alpha Grow et Christiansen, 1976			+			+			+		
F. taimyrica Martynova, 1973*					+						+

Table 1 — *continued*

Species / Microlandscapes	I	II	III	IV	V	VI	VII	VIII	IX	X
Agrenia bidenticulata (Tullberg, 1876)			+			+		+	+	+
Isotoma notabilis Schäffer, 1896*			+						+	
I. anglicana Lubbock, 1862		+	+	+	+			+	+	+
I. tshernovi Martynova, 1974*		+	+	+	+	+		+	+	
Isotoma sp. juv.						+				
Lepidocyrtus lignorum Fabricius, 1793								+	+	
Entomobrya sp. juv. (?*subarctica* Stach, 1962)				+						
Megalothorax minimus Willem, 1900*									+	
Arrhopalites principalis Stach, 1945*				+						
Sminthurides malmgreni (Tullberg, 1876)		+	+	+	+	+		+		
Sminthurinus concolor (Meinert, 1896)									+	
Total number of species	6	15	17	15	14	14	[2]	16	20	11

McLean, Behan and Fjellberg 1978, Byzova *et al.*, 1986, Ananeva, Babenko and Černov 1987) and, according to Černov (1978), is connected with a regular increase in the part of relatively primitive species (from the families of Isotomidae, Hypograstruridae and Onychiuridae) and a decrease in the one of more advanced and specialized forms (representatives of Entomobryidae and Symphypleona) along the zonal gradient from forest landscapes to polar deserts. This phenomenon has been noted for many other groups of plants and animals as well (Černov 1978).

All the species in our list have been previously reported from Spitsbergen, however, according to the geography of records (Fjellberg 1994), 15 species are being first recorded now for Hornsund (Tab. 1). At present, Collembola fauna of Hornsund area consists of 34 species [see list of Tab. 1 + *Folsomia sexoculata* mentioned by Fjellberg (1994) and + *F. diplophthalma* recorded by Stach (1962) — both absent in our collections], and Hornsund can be regarded as one of the best studied Spitsbergen regions for that group, together with Ny Alesund and Longyearbyen with 44 and 25 species, respectively (Fjellberg 1994). Southern (Hornsund), central (Longyearbyen) and northern (Ny Alesund) regions of Spitsbergen show rather similar lists of springtails; thus, Longyearbyen has 20 and 22 common species with Hornsund and Ny Alesund, respectively, those latter having 29 species in common.

Specificity of the studied fauna from the viewpoint of its geographical position is indicated by a high number of circumpolar, N. European and Arcto-alpine species making up about 60% of the list. The other part of the fauna is composed of widely distributed (Holarctic or cosmopolitan) species which is also characteristic of the zones of tundra and Arctic deserts (Černov 1968, Ananeva, Babenko and Černov 1987).

Analysis of the life forms' composition (after Stabaeva 1970) does not reflect vertical stratification of the group in the soil due to the small thickness of the inhabited soil layer and weak differentiation of soil horizons. Besides, according to Černov (1968) and Ananeva, Babenko and Černov (1987), for Arctic conditions a shift of soil dwelling Collembola species to surface-lying soil levels with more favourable temperature regime, is typical. In the study area, more than 50% of the species can be normally qualified as representatives of edaphic life forms; about 30% are related to top litter layer, and atmobiotic forms are practically absent. This composition is characteristic of Arctic sites (Ananeva 1973, Ananeva, Babenko and Černov 1987).

Table 1 shows the distribution of Collembola species over the microlandscapes in the study area. A rather similar species richness was recorded in the typical tundra habitats with diverse vegetation (combining different plant associations of mosses, lichens, herbs and grasses): II – VI, VIII, IX. They were inhabited by 14 – 20 species of springtails, mainly by 10 – 12 background ones, that is the reason for the high level of faunistic similarity between these microlandscapes (Tab. 2). The highest diversity (17 – 20 species) was recorded

Table 2.

Jaccard similarity indices (%) between the studied microlandscapes (see Tab. 1)

	II	III	IV	V	VI	VIII	IX	X
I	23.5	35.3	23.5	17.6	33.3	22.2	23.8	41.7
II		45.5	42.9	61.1	45.0	47.6	52.2	36.8
III			52.4	47.6	63.2	57.1	60.9	40.0
IV				61.1	52.6	47.6	40.0	36.8
V					55.6	66.7	47.8	31.6
VI						66.7	47.8	38.9
VIII							50.0	35.0
IX								34.8

in the vegetation on rocks and rocky debris (III, IX), despite the considerably lower level of sampling; that may possibly reflect a higher level of warming up of inhabited substrate on rocks during summer. In the more specific microlandscapes, Collembola species composition underwent reduction (littoral areas, I) and changed (microcatena at the foot of Gnålodden, exposed to the strong impact of biogenic flow from bird colony, X), causing the drop in the values of similarity coefficients.

Table 3 represents Collembola distribution over plant associations in the study area, regardless of their belonging to a landscape. Species richness of springtails in different associations was very different, and in the better studied sites (A–D, F, H, I, M) fluctuated from 6 to 21. The highest diversity was recorded in the association of fructicose lichens (F), that may probably be connected with their wide distribution among different microlandscapes and, hence, with variations of Collembola species content in the surrounding vegetation. In the associations of other typical tundra plants 14–17 species of springtails were recorded. Species diversity was reduced on "open ground" plots of polygonal tundra (B) and within littoral areas. Finally, the most specific fauna occurred in the vertical microzones along the Gnålodden microcatena, being composed of the species tolerant to high nutrient concentrations in soil: *Hypogastrura viatica, Xenilla humicola, Onychiurus duplopunctatus* and ubiquitous *Folsomia quadrioculata.*

The problem of landscape or biotopic affinity of particular species can be discussed only cautiously at the present stage of investigation, due to unequal level of sampling in the habitats under study. Therefore single occurrence in the samples of *Ceratophysella denticulata, Tullbergia arctica, Isotoma* sp., *Entomobrya* (? *subarctica*), *Megalothorax minimus, Arrhopalites principalis* should not yet be regarded as a basis for any definite conclusions. However, lack of a species in the most thoroughly studied microlandscapes (IV, V, VI) or microhabitats (B, C, D, F, H, I) gives certain ground for suggestion of its absence or extreme

Table 3.

Distribution of Collembola over microhabitats in the vicinities of Polish Polar Station, Hornsund area, Spitsbergen. Symbols — in the text

Species	Microhabitats	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T
Xenylla humicola		+	+	+	+	+	+	+	+	+	+	+		+	+		+	+	+	
Hypogastrura tullbergi			+	+	+		+	+	+	+	+	+		+						
H. viatica		+		+	+					+		+		+	+	+	+	+	+	+
Ceratophysella longispina			+	+	+				+			+	+	+						
C. succinea				+																
Willemia anophthalma							+		+		+		+							
Friesea quinquespinosa				+					+								+			
Anurida polaris			+	+	+		+	+	+	+		+		+			+		+	
Micranurida pygmaea				+	+		+	+	+	+	+			+						
Tullbergia sp.									+											
T. arctica													+							
Onychiurus duplopunctatus															+	+	+	+		
O. arcticus							+													
O. macfadyeni		+		+			+		+	+	+		+							
O. greoenlandicus		+	+	+	+		+	+	+	+	+	+		+					+	+
Pseudanurophorus inoculatus							+	+		+										
Folsomia quadrioculata		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
F. regularis				+	+		+	+	+	+	+			+						
F. bisetosa		+	+		+		+		+	+			+			+				
F. alpha				+			+	+		+										
F. taimyrica			+														+	+		

Table 3— *continued*

Species	Microhabitats	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T
Agrenia bidenticulata					+						+	+		+		+				
Isotoma notabilis				+			+		+		+		+							
I. anglicana			+	+			+	+	+	+		+	+	+		+	+		+	
I. tshernovi			+	+	+		+	+	+	+	+			+						
Isotoma sp. juv.					+															
Lepidocyrtus lignorum							+							+						
Entomobrya sp.										+										
Megalothorax minimus							+													
Arrhopalites principalis							+													
Sminthurides malmgreni			+	+	+		+		+	+			+	+						
Sminthurinus concolor							+							+						
Total number of species		6	11	17	14	[2]	21	11	17	16	11	9	9	15	4	6	8	5	6	3

rarity there (see Tabs. 1 and 3). Comparing total Collembola list of polygonal tundra with the one for proper polygons, species avoiding patches of open ground can be delimited (e.g. *Micranurida pygmaea, Pseudonurophorus inoculatus*). Certain preliminary conclusions can be made on the extent of polytopy in some species. Thus, *Folsomia quadricoculata* was an obligatory element of Collembola list in practically every sample. *Xenylla humicola* was also observed in almost all the microlandscapes or habitats. In more than half of the microhabitats *Onychiurus groenlandicus, Hypogastrura tullbergi, Isotoma anglicana, Anurida polaris* and *H. viatica* were found. According to Fjellberg's (1994) data this eurotopy is characteristic of many species on Arctic islands as well.

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Streszczenie

Collembola należy uważac za jedną z najliczniejszych grup Arthropoda glebowych, zamieszkujących tundrę arktyczną.

W trakcie badań przeprowadzonych w okolicach Polskiej Stacji Polarnej w Hornsundzie stewierdzono 32 gatunki Collembola żyjących w różnych mikrohabitatach tego ekosystemu (Tab. 1, 2, 3).