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**The faunal complex of *Collembola* in lowland subcontinental pine forests
(*Peucedano-Pinetum*) of Poland, Byelorussia, Lithuania and Russia**

Abstract. Species composition of *Collembola* has been studied in comparable pine forest areas situated in various regions of Central and Eastern Europe. 45 *Collembola* species have been found. A group of *Collembola* species characteristic of „mossy” pine forests has been identified.

INTRODUCTION

There are a number of papers dealing with the *Collembola* of coniferous forests. Studies of the influence of environmental factors on horizontal and vertical distribution of *Collembola* in coniferous forests have been undertaken by POOLE (1961, 1962, 1964). The qualitative and quantitative composition of *Collembola* communities in Swedish coniferous forests has been estimated by BÖDVARSSON (1975). The occurrence of *Collembola* in Norwegian coniferous forests and their relations to plant cover, soil fertility and soil chemistry have been evaluated by HÅGVAR (1982, 1983, 1984). There are also papers concerned with the species composition and abundance of the *Collembola* population in coniferous forests in Poland (KACZMAREK 1972, 1976; SZEPTYCKI 1967; WEINER 1981) Lithuania (GRINBERGS 1961) the taiga and forest-steppe zone (ALEJNIKOVA, MARTYNOVA 1966; BYZOVA 1964; KUZNETSOVA 1988) as well as their abundance, biomass and contribution to soil respiration in Finnish coniferous forests (HUHTA et al 1967, 1969; HUHTA, KOSKESNIEMI 1975; HUHTA 1976) and in Swedish forests (PERSSON et al 1980). Also numerous are papers investigating the influence of nitrogen fertilization, acidification, liming and silvicultural practices on coniferous forest *Collembola* (LOHM et al. 1977; BÅÅTH et al. 1980; HUHTA et al. 1967; VILKAMAA, HUHTA 1986; HÅGVAR 1984).

The aim of our study was to show that in comparable natural coniferous forest complexes characteristic of the Central and Eastern European Lowland, *Collem-*

bola communities living under similar regimes of environmental factors have similar species composition.

STUDY AREAS

The research was carried out in pine forests, one of the dominant habitat types in Central and Eastern Europe. Pine forests develop in sandr plains and plain terraces of fluvial accumulation, and, exceptionally, in denuded morainic plateaux, accumulation moraine belts or alluvial cones (MATUSZKIEWICZ 1993).

The materials were collected in the following areas:

- Puszcza Białowieska (Poland), a subcontinental (*Peucedano-Pinetum*) forest (detailed geobotanical description to be found in MATUSZKIEWICZ et al. (1993)).
- Berezinsky Biospheric Reserve (Byelorussia), a *Peucedano-Pinetum* forest; the phytosociological classification was based on unpublished materials by J. M. MATUSZKIEWICZ
- forests in the Vitebsk Area (Byelorussia) in vegetational associations comparable to *Peucedano-Pinetum* with moss dominant in the ground cover.
- forests in the Smolensk Area (Russia) in pine forest associations with moss dominant in the ground cover.
- forests in the Vilnius Area (Lithuania) in pine forest associations with moss dominant in the ground cover.

MATERIAL, METHODS

Both quantitative and qualitative samples were drawn in the study areas. The samples were taken in various microhabitats (mosses, lichens, decayed tree trunks). In the Berezinsky Biospheric Reserve in 1991, materials were collected using qualitative methods only (22 samples) while in the other areas quantitative methods were employed, materials being collected with a 5x5 cm split corer (pine forests in the Vitebsk, Smolensk and Vilnius area) or a split corer with a diameter of 5,1 cm (Puszcza Białowieska). 15 samples were drawn in the forests in the Smolensk, Vitebsk and Vilnius areas, while in Puszcza Białowieska 25 samples were obtained.

All materials were extracted in Tullgren funnels.

RESULTS

45 *Collembola* species were found in the areas studied (Tab. I).

Subcontinental (*Peucedano-Pinetum*) pine forests distributed in the Central and Eastern European Lowland are characterized by the occurrence of the following groups of Collembolan species:

Group I - species common to the regions under study, forming a group of constant elements of the *Peucedano-Pinetum* pine forest association and similar association types. These include obligatory forest species: *Xenylla brevicauda*,

Oligaphorura absoloni, *Anurophorus septentrionalis*, *Isotoma hiemalis*, mainly forest species *Isotomiella minor*, *Neanura muscorum*, *Orchesella bifasciata*, *O. flavescens* and eurytopic species *Microanurida pygmaea*, *Folsomia quadrioculata*, *Isotoma notabilis*, *Lepidocyrtus lignorum*, *Sphaeridia pumilis*.

Group II: species from the group of constant species that were not found in all forest areas studied. Their absence is due to differences in the number of samples taken in individual areas and different sampling periods. This group includes species such as: *Schoettella unuguiculata*, *Choreutinula inermis*, *Willemia anophthalma*, *W. denisi*, *Protaphorura armata*, *Mesaphorura macrochaeta*, *Pseudachorutes parvulus*, *Willowsia buski*, *Entomobrya nivalis*, *E. coricalis*, *E. marginata*, *Pogonognathellus flavescens*, *Ptenothrix atra*, *Megalothorax minimus*.

Group III: accidental species, whose occurrence is related to the presence in the association studied of certain favourable environmental conditions. This group of species comprises:

Protaphorura subuliginata - an acidophilous species (PONGE 1993) registered from various habitats such as: wet meadows, under stones, pieces of wood, in ant hills, in beechwood litter; European species. The species was found in pine forests in the Vilnius area (Lithuania).

Entomobrya quinquelineata - an epigeal species associated with sunny grassy spots; European species. According to SZEPTYCKI (1967) the species is characteristic of xerothermal greens and occurs on plants growing in dry and warm habitats. The species was found in the Berezinsky Biospheric Reserve (Byelorussia) in samples with lichens collected at the edge of the coniferous forest near a road.

Seira squamoornata - a rarely registered xerothermal species living on low-growing plants, mostly in meadows and grassy places (STACH 1964). This Eastern European species was found in a pine forest association (mature stand, over 100 years old) in the Berezinsky Biospheric Reserve (Byelorussia) in litter samples taken near trees.

Allacma fusca - a forest species commonly occurring in forest associations with numerous stumps and decaying wood. It has also been found in tree trunks and stumps, under stones and on herbaceous plants. It is probably a Western-Palearctic species. In the areas studied it was only found in the Smolensk area (Russia).

Arrhopalites secundarius - a species occurring in wet habitats, associated with wet deciduous forests, found in swamps, in the taiga and forest-steppe. In the pine forests studied it was only found in the Vitebsk area (Byelorussia).

Arrhopalites cochlearifer - species, associated more with wet places (forest litter, swamps), probably European. In the pine forests studied it was only found in the Vitebsk area (Byelorussia).

Lipothrix lubbocki - a species occurring in wet and shady places, in the litter, in moss and decaying tree trunks in mixed forests, European species, found also in the North Africa. In the pine forests studied it was only recorded in the Vitebsk area (Byelorussia).

Dicyrtomina minuta - a forest species, found on stumps, under stones, under pieces of wood. It is probably a Western-Palearctic species registered only in the Smolensk area (Russia).

Neelus murinus - a species recorded in wet habitats, found in moss, caves, on decayed trunks. A cosmopolitan species. It was only recorded in the Berezinsky Biospheric Reserve (Byelorussia).

Group IV: species whose occurrence is characteristic of a given area (in zoogeographical terms). The following species seem to belong to this group:

Seira squamoornata - this is perhaps an Eastern-European species. By now it has only been found in Poland, the Ukraine, Slovakia and Austria and for the first time recorded in Byelorussia.

Arrhopalites secundarius - species registered in a few stands in Europe (WEINER 1981). In the pine forests studied it was only found in the Vitebsk area (Byelorussia).

Arrhopalites cochlearifer - species recorded in a few stands in Europe (CHRISTIAN 1987, FJELLBERG 1980). In the pine forests studied it was only found in the Vitebsk area (Byelorussia).

Pseudosinella zygophora - probably a Central-European species. It occurs in the forest litter, humus, under stones, in rodents' nests and in ant hills. In the pine forests studied it was only found in Puszcza Białowieska. It probably does not penetrate into Eastern Europe.

Table I. Distribution of *Collembola* in pine forests (*Peucedano-Pinetum*) of Poland, Byelorussia, Lithuania and Russia

Species	Regions				
	Białowieska Puszcza	Berezinsky Reserve	Vitebsk Area	Smolensk Area	Vilnius Area
<i>Xenylla brevicauda</i> TULLB.	+	+	-	+	+
<i>Schoettella ununguiculata</i> (TULLB.)	+	+	-	-	-
<i>Choreutinula inermis</i> (TULLB.)	-	+	-	-	+
<i>Willemia anophthalma</i> BÖRN.	+	+	+	-	+
<i>Willemia denisi</i> MILLS	+	+	-	+	+
<i>Oligaphorura absoloni</i> (BÖRN.)	+	+	+	+	+
<i>Protaphorura armata</i> (TULLB.)	+	+	-	-	+
<i>Protaphorura subuliginata</i> GISIN	+	-	-	-	+
<i>Mesaphorura yossi</i> (RUSEK)	+	-	-	-	-
<i>Mesaphorura macrochaeta</i> RUSEK	+	+	+	-	+
<i>Micranurida pygmaea</i> BÖRN.	-	+	+	+	+
<i>Neanura muscorum</i> (TEMPL.)	+	+	+	+	+
<i>Pseudachorutes dubius</i> KRAUSB.	-	-	+	-	-
<i>Pseudachorutes parvulus</i> BÖRN.	+	+	+	+	-
<i>Friesea mirabilis</i> (TULLB.)	-	+	-	-	-
<i>Anurophorus laricis</i> NIC.	+	-	-	-	-
<i>Anurophorus septentrionalis</i> PALISSA	+	+	+	+	+
<i>Folsomia quadrioculata</i> (TULLB.)	+	+	+	-	+
<i>Isotomiella minor</i> (SCHÄFF.)	+	+	+	+	+
<i>Isotoma notabilis</i> SCHÄFF.	+	+	+	+	+
<i>Isotoma tigrina</i> TULLB.	+	-	-	-	-

<i>Isotoma hiemalis</i> SCHÖTT	+	+	+	+	+
<i>Lepidocyrtus lignorum</i> (FABR.)	+	+	+	+	+
<i>Lepidocyrtus violaceus</i> (LUBB.)	-	-	-	+	-
<i>Pseudosinella zygophora</i> (SCHILLE)	+	-	-	-	-
<i>Willowsia buski</i> (LUBB.)	-	-	+	+	+
<i>Entomobrya quinquelineata</i> BÖRN.	-	+	-	-	-
<i>Entomobrya nivalis</i> (L.)	-	-	+	+	-
<i>Entomobrya corticalis</i> (NIC.)	+	+	-	+	-
<i>Entomobrya marginata</i> (TULLB.)	+	-	-	+	+
<i>Entomobrya lanuginosa</i> (NIC.)	+	-	-	-	-
<i>Entomobryoides myrmecophilus</i> (REUT.)	+	-	-	-	-
<i>Orchesella bifasciata</i> NIC.	+	+	+	+	+
<i>Orchesella flavescens</i> (BOURL.)	+	+	+	+	+
<i>Seira squamomata</i> (STSCHERB.)	-	+	-	-	-
<i>Pogonognathellus flavescens</i> (TULLB.)	+	+	+	-	+
<i>Allacma fusca</i> (L.)	+	-	-	+	-
<i>Sphaeridia pumilis</i> (KRAUSZ.)	+	+	+	+	+
<i>Arrhopalites secundarius</i> GISIN	-	-	+	-	-
<i>Arrhopalites cochlearifer</i> GISIN	-	-	+	-	-
<i>Lipothrix lubbocki</i> (TULLB.)	+	-	+	-	-
<i>Ptenothrix atra</i> (L.)	-	-	+	+	-
<i>Dicyrtomina minuta</i> (FABR.)	-	-	-	+	-
<i>Megalothorax minimus</i> WILLEM	-	+	+	-	+
<i>Neelus murinus</i> FOLSOM	-	+	-	-	-
Number of species	30	29	25	22	23

DISCUSSION

Natural oligo- and mesotrophic acidophilous forest associations where the pine is predominant in the forest stand and the herb layer is usually composed of dwarf shrubs or grass and mosses, are common in the Lowland in the subcontinental areas of Central Europe and in Eastern Europe (MATUSZKIEWICZ 1981). In coniferous forests of the *Dicranio-Pinion* association there exists a characteristic group of *Collembola* species typical of pine (mossy) forests.

Characteristic features of the collembolan fauna in coniferous forests in southern (highland) and northern (lowland) parts of Poland have been emphasized by SZEPTYCKI (1967), WEINER (1981), and KACZMAREK (1972, 1975). According to SZEPTYCKI (1967) a high degree of affinity for coniferous forests can be assumed for: *Tullbergia callipygos*, *Willemia anophthalma* and *Anurophorus laricis*; *Willemia denisi* and *Choreutinula inermis* are rarer species but also characteristic ones. SZEPTYCKI established that xero- and thermophilous species prefer forest associations with pine and beech while umbriphilous and hydrophilous ones occur in an association variety with spruce. In the study of the collembolan fauna of the Pieniny Mountains, WEINER (1981) also states that there is a well-defined group of litter samples containing the following species: *Folsomia multisetata*, *Lipothrix lubbocki*, *Protaphorura armata*, *Isotoma notabilis*, *Anurophorus cuspidatus*, *Orchesella bifa-*

sciata, *Pseudosinella zygophora*, *Willemia anophthalma*, *Tomocerus minor* and *Onychiurus variotuberculatus*. KACZMAREK (1972, 1975) states that lowland pine forests in Poland (Mazovian Lowland and Puszcza Kampinoska) are the only locality where *Onychiurus absoloni*, *Isotoma hiemalis*, *Proisotoma minuta*, *Orchesella flavescens* can be seen. A similar species composition has been observed in pine forests in Lithuania (GRINBERGS 1961), Russia (ALEJNIKOVA, MARTYNOVA 1966; BYZOVA 1963; KUZNETSOWA 1988) and in pine forests in Northern Europe (BÖDVARSSON 1973; HÅGVAR 1984).

Apart from the diversification of plant associations, forest collembolan fauna diversity is known to be affected by macroclimatic, zoogeographical and historical factors (GISIN 1943.; SZEPTYCKI 1967). The fauna of coniferous forests situated in the lowlands, compared to those located in the highlands or in the mountains, does not contain montane species.

The synecology of soil organisms is much less advanced than in the case of other animal groups. There is not only lack of specific information on species composition and abundance of soil animals in particular ecosystems or plant associations, but also absence of a clear definition of the relationship occurring between the plant association and the species inhabiting it (PONGE 1993).

Collembolan communities have been investigated by many authors. The studies have established that there is a strong relationship between species composition and the plant cover and sometimes soil conditions. Most earlier studies (CASSAGNAU 1961; NOSEK 1967) were inclined to prove that the living environment of soil organisms is determined by vegetation. The authors did not assume a direct influence of e.g. soil chemistry on soil animal communities. The concept of the synusia was developed (GISIN 1943; CASSAGNAU 1961; NOSEK 1967), with each synusia having a characteristic species composition. GISIN estimated *Collembola* sensitivity to specific environmental factors and classified the *Collembola* species into ecological categories (xerophiles, hygrophiles, etc). SZEPTYCKI (1967) classified collembolan species according to their affinity for known plant association types. GISIN (1943) and SZEPTYCKI (1967) investigated the influence of soil acidity on communities of *Collembola*, but attributed the effect mainly to the presence of coniferous plants. A recent research (PONGE 1993) has shown that the species composition undergoes modification when the type of humus formed is changed, and a direct relationship to the vegetation is not necessary until soil environment conditions are changed. This is an extremely important finding for certain typical soil (edaphic) species. The occurrence of epigeal and atmobiotic species depends more on the presence of trees. Nevertheless, the relationship seems more complex and not as direct as is indicated in the above studies. Maintaining a certain regime of environmental conditions including soil chemistry and vegetation influences the type of humus forming and may, therefore, play a decisive role in stabilizing the species composition of *Collembola*.

In coniferous forest communities of *Collembola*, and particularly in an association as well defined in phytosociological terms as *Peucedano-Pinetum* and comparable associations situated in the Lowland of Central and Eastern Europe, one can expect to find a constant and stable group of *Collembola* species. The subcontinental (*Peucedano-Pinetum*) pine forest and comparable associations situa-

ted in the Lowlands are formed under similar geomorphological conditions and maintain relatively constant environmental conditions such as humidity, light, soil type and the type of humus formed. *Collembola* communities in this association type will certainly contain eurytopic species in the group of constant elements, such as can be seen in other forest and non-forest associations. There will also be an abundant group of characteristic species (acidophilous forms or species associated with the formation of a specific type of humus). The constant and characteristic species group in the pine forest habitat will depend on the geographical location of the association.

It appears that the group of species characteristic of the *Peucedano-Pinetum* association type of the Lowland of Eastern and Central Europe consists of the following: *Xenylla brevicauda*, *Schoetella ununguiculata*, *Choreutinula inermis*, *Willemia anophthalma*, *Willemia denisi*, *Oligaphorura absoloni*, *Microanurida pygmaea*, *Anurophorus septentrionalis*, *Orchesella bifasciata*, *Orchesella flavescens*.

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STRESZCZENIE

[Tytuł: Faunistyczny kompleks *Collembola* niżowych borów sosnowych (*Peucedano-Pinetum*) Polski, Białorusi, Litwy, Rosji]

Badaniami objęto analogiczne niżowe zbiorowiska boru sosnowego (*Peucedano-Pinetum*) z obszaru Europy Środkowej i Wschodniej. Praca zawiera wykaz fau-

nistyczny skoczogonków występujących w borach Puszczy Białowieskiej (Polska), Rezerwatu Berezynskiego (Białoruś), lasów okolic Wilna, Smoleńska i Witebska (Tabela 1). Wyodrębniono 4 grupy gatunków. Grupę gatunków stałych i jednocześnie charakterystycznych dla zbiorowiska boru sosnowego typu *Peucedano-Pinetum*, gatunków stałych, wchodzących w skład grupy gatunków charakterystycznych, ale nie w każdym z badanych obszarów stwierdzonych, grupę gatunków przypadkowych, których występowanie jest związane z wystąpieniem określonego mikrośrodowiska i grupę gatunków, których występowanie w danym regionie jest związane z ich ograniczonym rozprzestrzeniem (zoogeografizm). Przedyskutowano problemy związane z czynnikami warunkującymi wystąpienie określonego charakterystycznego składu gatunkowego *Collembola* i wpływu zbiorowiska roślinnego na ich skład.
