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Collembola in the process of secondary succession of the pine forests of Puszcza Białowieska

Abstract. A study of *Collembola* communities was carried out in *Pinus silvestris* stands of various ages in Puszcza Białowieska. The study revealed that the *Collembola* communities become stabilised in an older pine plantations (poole wood).

INTRODUCTION

A number of papers estimates abundance or of both abundance and biomass of springtails in coniferous forest (HUHTA et al. 1967, 1969, HUHTA, KOSKENNIEMI 1975, HUHTA 1976, PERSSON et al. 1980). The species composition of *Collembola* of coniferous forests is also well known (GRINDBERG 1961, POOLE 1961, 1962, ALEJNIKOVA, MARTYNOVA 1966, BODVARSSON 1974, LOHM et al. 1977, BÅATH et al. 1980, PERSSON et al. 1980, HÅGVAR 1984, VILLKAMA, HUHTA 1986, KUZNETSOVA 1988, PONGE 1991, 1993). Species composition and abundance of *Collembola* communities in Polish pine forests are available (SZEPTYCKI 1967, KACZMAREK 1973, 1975, WEINER 1981, STERZYŃSKA, KUZNETSOVA in press).

Studies in coniferous forest associations evaluate the composition of *Collembola* communities in relation to the plant cover, soil fertility and chemistry (HÅGVAR 1982, 1983, 1984a); the effect of environmental factors on the pattern distribution of *Collembola* in pine plantations (POOLE 1962); impact of nitrogen fertilisation, acidification, liming and silvicultural practices on *Collembola* of pine forests (HUHTA et al. 1967, LOHM et al. 1977, BÅATH et al. 1980, HÅGVAR 1984, VILLKAMA, HUHTA 1986); relations beetwen the food resources and the collembolan diet in plantations of pine (PONGE 1991).

The influence of succession processes on *Collembola* communities is discussed (DUNGER 1967, HUHTA 1976, USHER et al 1982, HÅGVAR 1984, KOEHLER,

BORN 1989, RUSEK 1994). The study of the effect of refforestration are very scare (HUHTA et al 1967, SOUSA, DA GAMA 1994).

AREAS OF STUDY, MATERIAL, METHODS

The study was carried out in pine forest associations (*Peucedano-Pinetum* – subcontinental pine forest) and regenerating stands of pine of different ages. The investigation was conducted in the pine forests of Puszcza Białowieska in the Sitki reserve. Sites were selected in the following age classes of pine forest:

– 1–2-year-old culture of a pine plantation established on a cutting area, stumps not pulled out, ground cover completely altered.

– 4–6-year-old culture of a pine plantation established on a cutting area, stumps not pulled out, ground cover only with grasses

– 10–20-year-old young stand of a pine plantation with an admixture of birch, ground cover (mosses, heather, grass)

– 40–60-year-old of pine plantation (pole wood), a very dense forest stand, mosses predominating in the ground cover

– an old pine forest (100 years) – a thinned forest stand with mosaic ground cover (mosses, litter, heather, fern, whortleberry).

Collembola were collected using a standard steel corer (5.1 cm in diameter, 20 sq. cm. in area) down to a depth of 10 cm 10–20 samples were taken at each site, only in spring (March, April, May). A total of 1399 specimens were collected in pine plantations including 134 in the 1–2-years of ages, 342 in the 4–6-years, 246 in the 10–20-years, 412 in the 40–60-years and 265 in old stand (100 years).

Analysis of the structure of the Collembola communities were estimated on the basis of five distributions: a geometric series, brocken stick distribution, a logarithmic series, a lognormal distribution, a negative binomial distribution. Species diversity (actual) was measured with Shannon-Weaver and Simpson index of diversity and potential species diversity by Pielou index. All methods for processing data are explanation: TROJAN 1992, TROJAN at al 1994.

STRUCTURE OF THE TAXOCOENE

Species composition, abundance, species diversity

1–2-year-old culture of pine plantation. 10 species were registered in the *Collembola* communities (Tab. I). *Pachytoma* sp. n. is the dominant, accounting for 80.6% of community abundance. Another relatively abundant species is *Anurophorus septentrionalis* – a species prefering the coniferous litter. Its proportion in the community is 6.0%. The species is probably able to survive near stumps that have not been pulled out and are surrounded by remains of organic matter (forest litter). Community abundance is low – 333 ind./sq.m.

Species such as: *Xenylla boerneri* – a common forest species occurring under protruding tree bark in mosses, lichens, coniferous litter; *Onychiurus absoloni* – a forest species, found under the bark of decaying trunks and in the litter; *Onychiurus furcifer* – a rare forest species found in the litter and under the bark

in trees, were found in very small numbers and survived owing to the presence of remains of decaying stumps. Another group of *Collembola* species rarely found in the 1–2-year-old culture comprises species alien to the forest habitat, e.g. open area species (*Lepidocyrtus cyaneus*).

Table I. Species composition, abundance (n) and percentages of *Collembola* in 1–2-year-old cultures of pine in Puszcza Białowieska: n – number of individuals/sq.m.

No	Species	n	%
1	*Pachyotoma* sp.n.	270.0	80.6
2	*Anurophorus septentrionalis* PALISSA	20.0	6.0
3	*Isotoma notabilis* SCHÄFF.	17.5	5.2
4	*Folsomia quadrioculata* (TULLB.)	5.0	1.5
5	*Isotomiella minor* (SCHÄFF.)	5.0	1.5
6	*Mesaphorura macrochaeta* RUSEK	5.0	1.5
7	*Xenylla boerneri* AXELS.	5.0	1.5
8	*Onychiurus furcifer* (BÖRN.)	2.5	0.7
9	*Onychiurus absoloni* (BÖRN.)	2.5	0.7
10	*Lepidocyrtus cyaneus* TULLB.	2.5	0.7

Table II. Species composition, abundance (n) and percentages of *Collembola* in 4–5-year-old cultures of pine in Puszcza Białowieska: n – number of individuals/sq.m.

No	Species	n	%
1	*Schoetella ununguiculata* (TULLB.)	332.5	38.9
2	*Xenylla brevicauda* (TULLB.)	182.5	21.3
3	*Folsomia quadrioculata* (TULLB.)	155.0	18.1
4	*Isotoma notabilis* SCHÄFF.	65.0	7.6
5	*Sminthuridae* sp.j.	27.5	3.2
6	*Onychiurus armatus* TULLB.	20.0	2.3
7	*Mesaphorura macrochaeta* RUSEK	15.0	1.8
8	*Proisotoma minima* (ABS.)	15.0	1.8
9	*Entomobryidae* sp.j.	12.5	1.5
10	*Isotomiella minor* (SCHÄFF.)	7.5	0.8
11	*Neanura muscorum* (TEMPL.)	5.0	0.6
12	*Hypogastruridae* sp.j.	5.0	0.6
13	*Lepidocyrtus cyaneus* TULLB.	5.0	0.6
14	*Isotoma* sp.j.	2.5	0.3
15	*Tomoceridae* sp.j.	2.5	0.3
16	*Bourletiella hortensis* (FITCH)	2.5	0.3

4–5-year-old culture of pine plantation 16 *Collembola* species were recorded with *Schoetella ununguiculata* as the dominant (38.9%) – xerophilous species, frequently recorded from xerothermal habitats and associated with coniferous litter. Another abundant species are: *Xenylla brevicauda* – a boreal-alpine species occurring in forest litter, mosses and lichens, and common eurytopic species such as *Folsomia quadrioculata* and *Isotoma notabilis* (Tab. II). In this

stand species preferring insolated open habitats, such as *Lepidocyrtus cyaneus* and *Bourletiella hortensis* appear. Community abundance is low – 855 ind./sq.m.. It is, however, twice as high as in the 1–2-year-old culture.

Young stand (10–20 years old). 21 species were identified in *Collembola* communities (Tab. III). The dominant species is *Folsomia quadrioculata* – a eurytopic species, commonly recorded in various types of forest and open habitats. The group of co-dominants consists of *Pachyotoma* sp.n., which is dominant in 1–2-year-old cultures of pine, and a large group of young individuals of the family *Entomobryidae*. *Schoetella ununguiculata*, which predominated in *Collembola* communities in 4–5-year-old cultures, has shifted to the subdominant group. In the community, appear species common in forest habitats, such as *Lepidocyrtus lignorum*, *Pseudachorutes parvulus*, the corticophilous *Vertagopus cinereus*, or even characteristic of forests with coniferous litter and mor or moder type of humus (*Mesaphorura yossi*, *Pseudosinella zygophora*, *Microanurida pygmaea*). The abundance of the *Collembola* community is triple highest to that recorded in the culture stages (3075 ind./sq.m).

Table III. Species composition, abundance (n) and percentages of *Collembola* in 10–20-year-old stands of pine in Puszcza Białowieska: n – number of individuals/sq.m.

No	Species	n	%
1	*Folsomia quadrioculata* (TULLB.)	812.5	26.4
2	*Pachyotoma* sp.n.	437.5	14.2
3	*Entomobryidae* sp.j.	325.0	10.6
4	*Isotoma notabilis* SCHÄFF.	262.5	8.5
5	*Isotomiella minor* (SCHÄFF.)	262.5	8.5
6	*Onychiurus armatus* TULLB.	237.5	7.7
7	*Mesaphorura macrochaeta* RUSEK	162.5	5.3
8	*Lepidocyrtus lignorum* (FABR.)	125.0	4.1
9	*Sminthuridae* sp.j.	112.5	3.7
10	*Schoetella ununguiculata* (TULLB.)	75.0	2.4
11	*Pseudosinella zygophora* (SCHILLE)	50.0	1.6
12	*Isotoma* sp.j.	37.5	1.2
13	*Lepidocyrtus* sp.j.	37.5	1.2
14	*Vertagopus cinereus* (NIC.)	37.5	1.2
15	*Pseudachorutes parvulus* BÖRN.	25.0	0.8
16	*Mesaphorura yossi* (RUSEK)	12.5	0.4
17	*Entomobrya nivalis* (l.)	12.5	0.4
18	*Neanura muscorum* (TEMPL.)	12.5	0.4
19	*Anurida pygmaea* BÖRN.	12.5	0.4
20	*Xenylla brevicauda* (TULLB.)	12.5	0.4
21	*Cyphoderus albinus* NIC.	12.5	0.4

Pole wood (40–60 years old). 27 species were recorded in *Collembola* communities (Tab. IV). The dominant is *Isotoma notabilis* – a common eurytopic species, occurring numerously in the majority of communities in both forest and

open natural habitats. The co-dominant species group includes abundantly recorded young individuals of the genus *Isotoma* (mainly *I. hiemalis* and *I. notabilis*) and the common forest species of *Isotomiella minor* as well as a large group of juvenile individuals representing the family *Entomobryidae*. The proportions of the remaining species are low and are classified in the dominance classes of recedents and subrecedents. Community abundance is high (5150 ind./sq.m.).

Table IV. Species composition, abundance (n) and percentages of *Collembola* in 40–60-year-old stands of pine in Puszcza Białowieska: n – number of individuals/sq.m.

No	Species	n	%
1	*Isotoma notabilis* SCHÄFF.	1625.0	31.6
2	*Isotoma* sp.j.	1287.5	25.0
3	*Isotomiella minor* (SCHÄFF.)	1175.0	22.8
4	*Entomobryidae* sp.j.	425.0	8.3
5	*Pogonognathellus flavescens* (TULLB.)	62.5	1.2
6	*Onychiurus absoloni* (BÖRN.)	50.0	1.0
7	*Orchesella flavescens* (BOURL.)	50.0	1.0
8	*Lepidocyrtus lignorum* (FABR.)	50.0	1.0
9	*Isotoma hiemalis* SCHOTT.	37.5	0.7
10	*Pseudosinella zygophora* (SCHILLE)	37.5	0.7
11	*Pachyotoma* sp.n.	37.5	0.7
12	*Neanura muscorum* (TEMPL.)	37.5	0.7
13	*Lepidocyrtus* sp.j	37.5	0.7
14	*Onychiurus armatus* TULLB.	37.5	0.7
15	*Mesaphorura yossi* (RUSEK)	25.0	0.5
16	*Willemia anopthalma* BÖRN.	25.0	0.5
17	*Folsomia quadrioculata* (TULLB.)	25.0	0.5
18	*Pseudachorutes parvulus* BÖRN.	12.5	0.7
19	*Anurophorus septentrionalis* PALISSA	12.5	0.7
20	*Anurophorus laricis* NIC.	12.5	0.7
21	*Mesaphorura macrochaeta* RUSEK	12.5	0.7
22	*Proisotoma minima* (ABS.)	12.5	0.7
23	*Allacma fusca* (L.)	12.5	0.7
24	*Tomoceridae* sp.j.	12.5	0.7
25	*Burletiella hortensis* (FITCH.)	12.5	0.7
26	*Schoetella ununguiculata* (TULLB.)	12.5	0.7
27	*Lipothrix lubbocki* (TULLB.)	12.5	0.7

Mature stand (100 years old). 25 species were recorded in the *Collembola* community (Tab. V). The dominant species are: *Isotomiella minor, Isotoma notabilis, Pseudosinella zygophora. Neanura muscorum* and *Anurophorus septentrionalis* – a species associated with coniferous litter. Appear *Onychiurus subuliginatus*, preferring acidified habitats (PONGE 1991) and *Willemia aspinata* or *Onychiurus absoloni* (the latter two occur in forests with coniferous litter).

Community abundance is lower at this stage than in the pole wood (3312.5 ind./sq.m.).

Table V. Species composition, abundance (n) and percentages of *Collembola* in 100–year-old stands of pine in Puszcza Białowieska: n – number of individuals/sq.m.

No	Species	n	%
1	*Isotomiella minor* (SCHÄFF.)	1475.0	44.5
2	*Isotoma notabilis* SCHÄFF.	850.0	25.7
3	*Pseudosinella zygophora* (SCHILLE)	275.0	8.3
4	*Isotoma* sp.j.	112.5	3.4
5	*Folsomia quadrioculata* (TULLB.)	100.0	3.0
6	*Neanura muscorum* (TEMPL.)	75.0	2.3
7	*Tomoceridae* sp.j.	37.5	1.1
8	*Anurophorus septentrionalis* PALISSA	37.5	1.1
9	*Onychiurus absoloni* (BÖRN)	37.5	1.1
10	*Mesaphorura macrochaeta* RUSEK	37.5	1.1
11	*Entomobryidae* sp.j.	37.5	1.1
12	*Onychiurus subuliginatus* GISIN	25.0	0.8
13	*Isotoma hiemalis* SCHÖTT.	25.0	0.8
14	*Willemia aspinata* STACH	25.0	0.8
15	*Pseudosinella* sp.j.	25.0	0.8
16	*Orchesella flavescens* (BOURL.)	25.0	0.8
17	*Schoetella ununguiculata* (TULLB.)	12.5	0.8
18	*Sminthuridae* sp.j.	12.5	0.8
19	*Pachyotoma* sp.n.	12.5	0.8
20	*Onychiurus armatus* TULLB.	12.5	0.8
21	*Isotmoa tigrina* TULLB.	12.5	0.8
22	*Lepidocyrtus* sp.j	12.5	0.8
23	*Pseudachorutes parvulus* BÖRN.	12.5	0.8
24	*Proisotoma* sp.	12.5	0.8
25	*Entomobrya* sp.	12.5	0.8

Analysis of species composition similarity

The species composition similarity of *Collembola* communities was measured using MARCZEWSKI-STEINHAUS's index:

where s refers to the statistical probability of two elements being compared within a series, a and b are the number of elements in series A and B respectively, and w is the number of elements common to series A and B.

It was revealed that species composition similarity for *Collembola* communities of the pole wood and mature stand stages is quite high (53%). A 40% species composition similarity was obtained for the communities inhabiting the two older stages (pole wood and mature stand) on the one hand and those living in the young stand on the other. The community found in the early stages of succession differs markedly in species composition from the other communities (Tab. VI).

Table VI. Species composition similarity diagram for *Collembola* communities in the varoius ages of pine stands studied, according to Marczewski-Steinhaus.

	1–2 year	4–5 year	10–20 year	40–60 year	> 100 year
1–2 year		0.20	0.19	0.23	0.25
4–5 year			0.32	0.39	0.32
10–20 year				0.41	0.44
40–60 year					0.53
> 100 year					

Ecological classification of the species

The dominant group in *Collembola* communities consists of hemiedaphic species inhabiting the litter layer and euedaphic soil dwellers. The group of hemi- and euedaphic species has the greatest share in communities inhabiting the 1–2-year-old culture. In the other communities the number of species is not high, resulting in a low proportion in the community. On the other hand, atmobiotic and epigeic species appear.

In the studied stands of various ages of *Pinus silvestris*, just as in all kinds of habitats, the dominant group in communities of *Collembola* is mesohigrophilous species. In the culture, young stand and pole wood stages, numerous thermophilous and xerophilous species occur e.g. *Schoetella ununguiculata*.

Table VII. Percentages of selected ecological groups in *Collembola* communities in the varius age of pine stands under study.

Pine stands		1–2 year	4–5 year	10–20 year	40–60 year	> 100 year
Layer preferences	atmobios		6.2	4.8	3.7	
	epigeic				18.5	8.0
	hemiedaphic	60.0	50.0	52.3	40.7	36.0
	euedaphic	30.0	12.5	19.1	18.5	20.0
	others	10.0	31.3	23.8	18.5	36.0
Moisture requirements	xerophilous		12.5	14.3	11.1	4.0
	mesohygrophilous	90.0	56.2	61.9	70.4	60.0
	hygrophilous					
	unknown	10.0	31.3	23.8	18.5	36.0
Ecological plasticity	eurytopic	30.0	18.7	33.3	18.5	16.0
	forest polytopic	40.0	18.7	28.5	44.4	32.0
	forest oligotopic	10.0	12.5	4.8	7.4	12.0
	open area polytopic	10.0	12.5		3.7	4.0
	open area oligotopic					
	myrmecophilous			4.8		
	corticophilous			4.8	3.7	
	compost		6.3		3.7	
	unknown	10.0	31.3	23.8	18.5	36.0

The number of forest species and their proportions in the communities studied is similar in all the communities investigated. On the other hand, the numbers and proportions of open area species are higher only in the initial stages of succession, while myrmecophilous and corticophilous species appear in later stages (Tab. VII).

Overlap with statistical estimates

The structure of *Collembola* communities in the varoius ages of the pine stands in Puszcza Białowieska was analysed from the viewpoint of the degree of overlap with 5 models adopted for use in structural analyses (TROJAN 1992). The results concerning the probability of overlap of the empirical distributions obtained in the study with the theoretical models, estimated using the chi-square test, show that the *Collembola* communities occurring in early stages of succession (4–5-year-old culture and 10–20-year-old young stand) have a structure similar to the negative binomial distribution (Tab. VIII). An overlap between the species abundance distribution and the negative binomial distribution is observed when the catches are not total – collecting samples are much less abundant than the community of animals living in nature (TROJAN 1992). In the case of small soil animals, including *Collembola*, all dynamics methods frequently used in the field have an error (PHILIPSON 1971).

Table VIII. Assessment of similarity between the empirical structures of *Collembola* communities of the various ages of pine stands and selected statistical distributions of binomial distribution.

Pine stands / Statistic distributions	1–2 year	4–5 year	10–20 year	40–80 year	> 100 year
Logaritmic series	0.000000	0.000000	0.000000	0.000000	0.000000
Lognormal distribution	0.000000	0.000000	0.000000	0.000000	0.000000
Negative binomial distribution	0.080183	0.602795	0.590208	0.000032	0.019472
Geometric series	0.000001	0.001626	0.441725	0.000001	0.000001
Broken stick distribution	0.000000	0.000001	0.000002	0.000003	0.000003

Estimation of the number of species

An attempt to estimate species capacity was made, based on the structural features of the communities, i.e. the distribution of species abundance in the community. The overlap of the empirical distributions judged on the *Collembola* material from soil samples with the negative binomial distribution in two of the succession stages studied: 4–5-year-old culture and 10–20-year-old young stand give the possibilities to estimate the theoretically number of *Collembola* species in this habitat. It was revealed that in both stages the number of species recorded is lower than the potential species capacity of the habitats under investigation. In the culture 16 species were identified, while 25 could be expected to live there, and in the young stand the actual number of species was 21 and the expected number, 33.

Potential and actual species diversity

Actual species diversity was measured with SHANNON-WEAVER's and SIMPSON's indices (Tab. IX). The values of the two indices suggest that *Collembola* communities in the succession stages under study differ in the degree of diversity. The lowest diversity was recorded in the communities inhabiting the 1–2-year-old culture. The community has a peculiar structure of dominance with one species constituting over 80% of the community. The highest species diversity was recorded in the young stand. In the other stages of succession the values of species diversity indices are similar to one another, which is the result of a similar distribution of abundance of individuals within the species.

At each stage of succession, however, the potential species diversity is higher. The realisation of species diversity, measured with the H max index, may be much higher in each of the succession stages under investigation.

Table IX. Species diversity indices: H' (Shannon-Weaver) and I (Simpson) of *Collembola* communities in the various ages of pine stands.

Pine stands	1–2 year	4–5 year	10–20 year	40–60 year	> 100 year
Diversity indices					
Actual					
Shannon-Weaver H'	1.3813	2.6492	3.5224	2.8440	2.8342
Simpson I	0.4205	0.0258	0.0054	0.0164	0.0432
Potential					
H max	3.3219	4.0000	4.3923	4.7549	4.6439

SUMMARY

Due to changes in soil conditions induced by *Pinus silvestris* refforestration and maturing of tree stands transformations are also observed in animal communities inhabiting the stand. Changes are seen the species composition, abundance and structure of dominance. Analysis of the transformations occurring in springtail communities living in forest stands of various ages allows to assess the rate of these changes.

Species composition of *Collembola* differs markedly between the succesive tree stands. Similarities are only seen between communities inhabiting older stands (pole wood and mature stand). Differences are also observed in the structure of dominance in *Collembola* communities. In younger age classes the number of low-abundance species is reduced and only one strong dominant is observed. In older age classes (pole wood, mature stand) the community is formed by greater number of co-dominant species, and the low-abundance species group is much more numerous. The composition of the dominant species group changes in the successive tree stands, but the substitution is never complete. Formerly dominant species are usually still seen in the community, but they occupy a different position in the structure of dominance. Community

abundance is the lowest at the culture stage, and the highest in the pole wood. When compared to theoretical models, the structure of the actual communities are closely related to the negative binomial distribution. Species diversity, expressed as Shannon-Weaver's and Simpson's indices, is the highest in the young stand stage.

Our analysis has shown that *Collembola* communities become stabilised in older stands of pine. The *Collembola* communities inhabiting the young stand and pole wood are a preliminary stage for the formation of communities characteristic of natural mature pine forests.

In the succesive tree stands, the young stand have the greater species potential for realisation of species diversity compared to the pole wood or mature stand. In mature stands, where habitat conditions become estabilised, species diversity of *Collembola* is lower. GILLER (1984, after DEHARVENG, BEDOS 1993) has associated the degree of species diversity with heterogeneity of the habitat. In the succesive tree stands studied, the habitat becomes more heterogeneous as a result of the development of the layer structure of the stand and changes in soil conditions. Stratification, both vertical and horizontal, provides a number of new niches. Particularly important is the formation of the humus layer. The relation between *Collembola* communities and the type of humus formed has been discussed by PONGE (1993). Species diversity may also increase with food resource (PIANKA 1966). In stable ecosystems, productivity decreases or stay in constant level. Species diversity may also decrease in such ecosystems.

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STRESZCZENIE

[Tytuł: *Collembola* w szeregu sukcesji wtórnej borów sosnowych Puszczy Białowieskiej]

Badaniami objęto dojrzałe zbiorowiska borów sosnowych z zespołu *Peucedano-Pinetum* oraz różnowiekowe fazy regeneracji tych zbiorowisk (uprawa 1–2 lata, uprawa 4–6 lat, młodnik 10–20 lat, drągowina 40–60 lat). Poza standartowymi parametrami mierzącymi zmiany w strukturze zagrupowań jak skład gatunkowy, liczebność struktura dominacyjna, testem χ^2 oceniono podobieństwo zgodności uzyskanych empirycznie rozkładów w oparciu o struktury zgrupowań *Collembola* w badanym szeregu sukcesyjnym z 5 opracowanymi do analizy struktury fauny modelami (TROJAN 1992). Podjeto rownież próbę oszacowania pojemności gatunkowej w oparciu o cechy strukturalne zgrupowań oraz różnorodności gatunkowej aktualnej mierzonej wskaźnikami SHANNON-WEAVERA i SIMPSONA oraz potencjalnej mierzonej wkaźnikiem PIELOU.

Stwierdzono, że ze względu na zmieniające się w przebiegu sukcesji warunki glebowe oraz starzenie się drzewostanu zmienia się skład gatunkowy, liczebność i struktura dominacji zgrupowań *Collembola*. W grupie gatunków dominujących w kolejnych stadiach wiekowych drzewostanu sosnowego dochodzi do wymiany gatunków, chociaż nie jest to wymiana całkowita. Wiekszość gatunków najczęściej pozostaje w zgrupowaniu zajmując tylko inną pozycję w strukturze dominacyjnej. Liczebność zgrupowań jest najniższa w stadium uprawy a najwyższa w drzewostanach średniej klasy wieku.

Uzyskane empirycznie modele struktur zgrupowań w stadiach młodszych drzewostanu sosnowego (4–6 lat, 10–20 lat) są najbardziej zbliżone do rozkładu dwumianowego ujemnego, a estymowana liczba gatunków w obydwu tych stadiach powinna być wyższa niż stwierdzona. Poszczególne stadia sukcesyjne są środowiskami o wyższej potencjalnej różnorodności gatunkowej. W badanym szeregu sukcesyjnym młodnik jest stadium o największych potencjalnych możliwościach realizacji różnorodności gatunkowej w stosunku do zgrupowań zasiedlających tak stadia młodsze jak i starsze. Stabilizacja zgrupowań *Collembola* następuje w starszych drzewostanach sosnowych (stadium drągowiny).

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