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Research Article

Community structure of mesofauna in the light of qualitative and quantitative research on soil mites

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ABSTRACT

Research into structure and abundance of soil fauna communities should be based on material consisting of both qualitative and quantitative samples to provide reliable results. However, in practice it turns out that sometimes it is simply impossible to have both qualitative and quantitative samples. The study presents a comparative analysis of results obtained with qualitative and quantitative methods used in research into soil mites from the suborder Uropodina (Acari: Mesostigmata). The research was carried out in different regions of Poland. Both qualitative (sieving of soil and litter) and quantitative samples were collected in each of the examined ground plots. The results presented in the study show that zoocenological analysis based on both qualitative and quantitative samples gives similar results in the case of common and abundant species, and collecting 2 or 3 sievings in a given ground plot can be equivalent to large series of quantitative samples in faunistic research and monitoring of the environment. This stems from the fact that sieving of litter allow to obtain far more dense material than from quantitative samples. Due to the high density of sieving they contain more species and specimens, including specimens at different developmental stages found in the examined area. This type of sampling can be more efficient when the researcher needs a simple and fast method of collecting material for analysis, especially in the case of extensive research conducted in large areas, monitoring of changes in soil, as well as in taxonomic, biometric, biogeographical, and molecular research.

Keywords: Community structure; Abundance; Soil; Mesofauna; Quantitative; Qualitative; Uropodina.

1. INTRODUCTION

That little is known about the biology of many groups of soil invertebrates stems from the fact that there is no possibility to observe directly these organisms in their natural environment due to their small body size and their secret lifestyle. It is very hard to plan and conduct research into the ecology of soil mesofauna due to the fact that the available research methods are still deficient, and for this reason it is also hard to obtain results repeatable results or to confront the results with the results obtained in earlier studies [1-4]. The studies which take into consideration structure and abundance of communities of small soil invertebrates (mites, springtails, larvae and adult insects, other small arachnoids) are usually based on either qualitative or quantitative data [1, 5-9]. Qualitative samples (usually sieving of litter and soil) allow to determine

species composition of mesofauna communities and dominance structure, sex ratio, age, and occurrence frequency of taxa. When the samples are collected in regular intervals, the material also allows to analyze the phenology of soil invertebrates. However, if the analysis is aimed to estimate abundance of populations, density, and geographical distribution of populations, it can be carried out only on the basis of data obtained from quantitative samples, which allow to conduct the relevant statistical analyses.

The gradual deterioration of biodiversity caused mainly by the anthropopressure of the environment requires constant and regular monitoring. The most common problem in such cases is the lack of data about faunistic resources from earlier studies, which could be verified with the most recent data to determine the pace and trajectory of the changes occurring in soil. For this reason researchers often use old faunistic data from the available literature on the topic to evaluate changes in soil in longer periods of time. However, it is noteworthy to mention that most of these publications discussing different taxonomic groups of soil fauna, especially those about mites (Acari), were written on the basis of qualitative data [1, 5-7, 10-14]. There are very few studies based on quantitative data [1, 15-17]. In such cases it is very important to be aware of the reliability and usability of such studies, especially in comparative analyses of materials collected with qualitative and quantitative methods. One of the most significant factors in such comparative analyses is the sufficient and similar number of samples collected in the examined areas in different research periods or in different seasons. Interestingly, there are very few studies about soil fauna based on long-term research, and many of these studies are based on experiments conducted during a short period of time, i.e. usually 1-2 seasons, very rarely longer (maximum eight years) [18]. What is worse, the authors of these studies try to predict the effects of the possible changes in the analyzed communities of soil fauna [8, 9, 19-22]. Only the results presented in the studies by Athias-Binche [23-25], Błoszyk [1, 26, 27], Napierała [4, 28, 29], were obtained from analyses based on long-term research carried out in one area. However, there is no study that would be a comparative analysis evaluating results obtained by means of both the quantitative and qualitative method. The current study, which is based on long-term research conducted in the same conditions with both the quantitative and qualitative method of sample collection, is a comparative analysis of the obtained results. The research was conducted in a few distant areas. One of them consisted of two forest reserves in western Wielkopolska (Greater Poland), whereas the other two were the areas of The Gorce Mountains and Nature Reserve 'Cisy Staropolskie im. Leona Wyczółkowskiego in Wierzchlas' (Bory Tucholskie). The samples for the analysis (qualitative samples from sieving of litter and soil as well as quantitative samples) were collected simultaneously in all the examined areas and at the same time. This allowed to compare the results obtained from the samples collected with the two different methods.

The major aim of this study was to ascertain whether there are any differences in the community structure of soil mesofauna when the results of analyses based on material collected with the quantitative and qualitative method. The next aim is to evaluate the differences in the ecological indices such as dominance and constancy, which are commonly used in acarological research, calculated on the materials gathered with both types of methods. In our opinion this comparative analysis will allow to dispel the doubts about the differences evident in descriptions of structure of soil fauna based on quantitative and qualitative data.

2. MATERIALS AND METHODS

2.1. Study areas

The research was conducted in four areas located in different regions of Poland.

2.1.1. The Gorce Mountains

The Gorce Mountains (southern Poland, 49°33'N; 20°06'E) are a distinctly separated mountain range in the Western Beskidy (part of the Western Carpathians). The primeval forest is the most important environment in the park. The lower elevations are covered with lower mountain mixed forest called the Carpathian beech forest. It was only slightly affected by human activity in the past. The higher elevations are occupied by upper mountain

spruce forest. The highest peak is Turbacz Mt. (1,311 m a.s.l.).

In 1992 the system of permanent monitoring plots (PMPs) was established in 'The Gorce National Park' to record changes occurring in various ecosystems and at different trophic levels. The basis of this system was the so-called ATPOL grid (squares 10 km x 10 km). In the park the plot size was reduced to 400 m x 400 m. The junction points of the grid are the centers of the monitoring plots. They were marked permanently in the field. Due to the large number of the plots (433), they constitute a statistically adequate representation of the park. The basic information concerning all plots of the system (e.g. their localization and distribution of the natural elements) are presented in a special guide [30].

2.1.2. Jakubowo Nature Reserve

'Jakubowo Nature Reserve' covers an area of 4.22 ha (western Poland, 52°29'N 16°16'E) It preserves one of the most beautiful fragments ofan old oak-hornbeam forest (ca. 200 years old) in the Western part of Poland, with its beech-variant part (*Galio sylvatici-Carpinetum* var. with European beech, *Fagus sylvatica*) (UTM: WU 81). In this reserve the research was conducted in three phytosociologically different ground plots. A more detailed description of the plots can be found in Błoszyk [1] and Napierała [29].

2.1.3. Las Grądowy nad Mogilnicą Nature Reserve

'Las Grądowy nad Mogilnicą Nature Reserve' (8.9 ha) (western Poland, 52°28'N 16°14'E). It preserves a fragment of an oak-hornbeam forest (*Galio sylvatici-Carpinetum*), which is about 150 years old (UTM: WU 81). Also in this reserve the research was conducted in three ground plots, which were different as to their vegetation. A more detailed description of the examined ground plots is also available in earlier studies by Błoszyk [1] and Napierała [29].

2.1.4. Cisy Staropolskie im. Leona Wyczółkowskiego Nature Reserve

'Cisy Staropolskie im. Leona Wyczółkowskiego Nature Reserve' in Wierzchlas (89 ha) is located roughly 20 km E from Tuchola (Northern-west Poland, 53°30'N 18°07'E). The reserve protects the largest in Europe concentration of yew-trees, *Taxus baccata*. The vegetation in this reserve is diverse [31-33]. Much of the reserve, beside the yew-trees, is covered by oak-hornbeam tree stands and beech forests of degraded *Melico-Fagetum*. In damp basins of the land alder stands, and in places located higher there are also riparian forests [34].

2.2. Materials

The following paragraphs are a brief description of the methods used during sample collection sessions in the examined ground plots.

2.2.1. The Gorce Mountains

The material for the analysis was collected in such forests as coniferous fir-spruce forests, fecund Carpathian beech forests, pine forests in the upper montane zone and in stands between the zones in two research periods. In the first period (1968-1983), during which the qualitative samples were collected in the part of The Gorce Mountains, which are now part of 'The Gorce National Park'. In the second period (1992-1998) the soil samples were collected from 429 permanent monitoring plots located in 'The Gorce National Park' [13, 30].

The quantitative samples of soil (60-100 cm^2 each) were collected with a metal cylinder (10 cm deep). The qualitative samples were mainly sieved samples of forest leaf litter and soil, or less often unsieved samples from meadows or rotting deadwood.

2.2.2. Jakubowo and Las Grądowy nad Mogilnicą Nature Reserves

The mites were extracted between 1979 and 2006 from samples of litter and soil collected with a steel frame 4 x 4 cm to the depth of 10 cm, or with a cylinder with a diameter of 5 cm to the depth of 10 cm. In both reserves in each of the examined ground plots a series of 10 samples were taken. In the period between IV and VII, and in the period between IX and XI the samples were collected in two weeks intervals. In August and during winter

(i.e. between December and March) the samples were collected once a month. At the same time the qualitative samples were also collected (sieving of litter).

2.2.3. Cisy Staropolskie im. Leona Wyczółkowskiego Nature Reserve

In the reserve 'Cisy Staropolskie im. Leona Wyczółkowskiego' the material was collected by means of both methods in the period 1992-2010. The quantitative samples were collected with a metal cylinder with 5 cm diameter to the depth of 10 cm. At the same time the qualitative samples were also collected in the examined ground plots (sieving of litter).

The mites were extracted with the use of Tullgren funnels for 40-60 h and preserved in 75% ethyl alcohol. The whole material was then deposited in the Invertebrate Data Bank (The Natural History Collections, Faculty of Biology, Adam Mickiewicz University, Poznań).

2.3. Data analysis methods

The following classes of ecological indices for Dominance (D%) and Constancy (C%) were used in this study (see also Błoszyk [1]):

- Dominance: D5, eudominants (>30%); D4, dominants (15.1-30.0%); D3, subdominants (7.1-15.0%); D2, residents (3.0-7.0%); and D1, subresidents (<3%).
- Constancy: C5, euconstants (>50%); C4, constants (30.1-50%); C3, subconstants (15.1-30.0%); C2, accessory species (5.0-15.0%); and C1, accidents (<5%).

3. RESULTS

3.1. Species composition of Uropodina communities in the light of qualitative and quantitative data

The material collected in the area of Gorce contained 18 species of Uropodina, and 13 were found in the quantitative samples and 17 in the qualitative samples (Table 1). 12 (67%) species occurred in both types of samples, two species were only in the quantitative samples and the other four only in the sieving.

The number of Uropodina specimens found in the sieving was almost five times higher (4.7) than in the quantitative samples. Although the highest number of specimens found in one sample was usually much higher in the qualitative samples, the number of specimens was the same in the case of such species as *O. misella*, *U. tecta*, and *P. calcarata*.

In the material from the oak-hornbeam reserves 'Jakubowo' and 'Las Grądowy nad Mogilnicą' we found 15 and 11 Uropodina species respectively (Table 2 and 3). In 'Jakubowo', like in the case of Gorce, none of the two methods allowed to collect all the species occurring in this area. In the latter the quantitative samples contained all the species recorded so far in this area.

The samples from the reserve 'Cisy Staropolskie' contained 31 species of Uropodina (Table 4). In contrast to the examples adduced above, the quantitative samples did not contain as many as 14 species, which constitutes 46.7% of the whole community. Interestingly, the quantitative samples did not contain any specimens of *Trematurella elegans* and *Dinychus arcuatus*, which were numerous in the qualitative samples.

3.2. Dominance structure and frequency of occurrence of Uropodina species

On the basis of the material collected in area of Gorce (Table 5) and in 'Jakubowo' (Table 6), 'Las Grądowy' (Table 7), and 'Cisy Staropolskie im. Leona Wyczółkowskiego' (Table 8), we also carried out a zoocenological analysis of the Uropodina communities focusing on the structure of dominance and frequency of occurrence of the found species.

The tabulations presented above show that in the case of common and abundant species zoocenological analysis based on both quantitative and qualitative samples gives similar results (Tables 5-8). That means that in samples obtained by each type of method, almost the same species (marked in bold in Tables 5-8) form 'the core' of the community. The differences can be observed mainly in the case of rare and sporadic species, which are not found in quantitative samples.

Table 1. Number of Uropodina species found in the area of 'Gorce' depending on the type of collected material: N - number of specimens; min/max - minimum and maximum number of specimens found in one sample. Qualitative samples 416, quantitative samples 408.

Species	Quantitative		Qualitative	
	N	min/max	N	min/max
Trachytes irenae Pecina, 1970	1,071	1-46	6,387	1-126
Trachytes aegrota (C. L. Koch, 1841)	883	1-55	4,026	1-122
Olodiscus misella (Berlese, 1916)	223	1-16	234	1-16
Trachytes pauperior (Berlese, 1914)	203	1-12	495	1-27
Ciliba cassideasimilis Błoszyk, Stachowiak, Halliday 2006	50	1-11	244	1-30
Dinychus perforatus Kramer, 1882	33	1-4	129	1-11
Neodiscopoma splendida (Kramer, 1882)	30	1-6	225	1-36
Urodia spistecta Berlese, 1916	9	1-5	23	1-5
Trachytes minima (Trägardh, 1910)	5	1-4	20	1-9
Polyaspinus cylindricus Berlese, 1916	5	1-2	44	1-15
Pseudouropoda calcarata (Hirschmann et Zirngiebl-Nicol, 1961)	5	1-2	4	1-2
Olodiscus minima (Kramer, 1882)	5	1	35	1-7
Janetiella pulchella Berlese, 1904	2	1-2	-	-
Nenteria breviunguiculata (Willmann, 1949)	-	-	1	1
Dinychus arcuatus (Trägardh, 1922)	-	-	8	1-2
Dinychus carinatus Berlese, 1903	-	-	3	1
Oodinychus ovalis (C. L. Koch, 1839)	-	-	2	1
Oodinychus obscurasimilis (Hirschmann et Zirngiebl-Nicol, 1961)	-	-	1	1
Total	**2,524**		**11,881**	

Table 2. Number of Uropodina species found in the area of 'Jakubowo' depending on the collected material: N - number of specimens; min/max - minimum and maximum number of specimens found in one sample. Qualitative samples 1505, quantitative samples 56.

Species	Quantitative		Qualitative	
	N	min/max	N	min/max
Olodiscus minima (Kramer, 1882)	1,146	1-29	272	1-43
Trachytes pauperior (Berlese, 1914)	498	1-15	25	1-4
Trachytes aegrota (C. L. Koch, 1841)	460	1-12	383	1-65
Urodiaspis pannonica Willmann, 1952	234	1-22	70	1-16
Ciliba cassideasimilis (Błoszyk, Stachowiak et Halliday, 2008)	96	1-3	25	1-6
Urodiaspis tecta (Kramer, 1876)	78	1-4	118	1-14
Polyaspinus cylindricus Berlese, 1916	23	1-2		
Oodinychus ovalis (C. L. Koch, 1839)	16	1-4	21	1-3
Dinychus inermis (C. L. Koch, 1841)	3	1-2		
Trachytes lamda Berlese, 1903	1	1		
Pseudouropoda calcarata (Hirschmann, Zirngiebl-Nicol, 1961)	1	1		
Olodiscus kargi (Hirschmann, Zirngiebl-Nicol, 1969)	1	1		
Phaulodiaspis rackei (Oudemans, 1912)	1	1		
Nenteria stylifera (Berlese, 1904)	1	1		
Janetiella pyriformis (Berlese, 1920)			1	1
Total	**2,559**		**915**	

Table 3. Number of Uropodina species found in the area of 'Las Grądowy nad Mogilnicą' depending on the type of the collected material: N - number of specimens; min/max - minimum and maximum number of specimens found in one sample. Qualitative samples 351, quantitative samples 48.

Species	Quantitative		Qualitative	
	N	min/max	N	min/max
Trachytes aegrota (C. L. Koch, 1841)	567	1-15	178	1-26
Trachytes pauperior (Berlese, 1914)	401	1-21	15	1-5
Olodiscus minima (Kramer, 1882)	321	1-16	237	1-19
Trachytes lamda Berlese, 1903	93	1-3	-	-
Polyaspinus cylindricus Berlese, 1916	77	1-8	-	-
Urodiaspis tecta (Kramer, 1876)	39	1-4	85	1-17
Cilliba cassideasimilis (Błoszyk Stachowiak et Halliday, 2008)	22	1-5	-	-
Urodiaspis pannonica Willmann, 1952	14	1-2	8	1-3
Dinychus perforatus Kramer, 1882	2	1	30	1-9
Oodinychus ovalis (C. L. Koch, 1839)	1	1	8	1-2
Phaulodiaspis rackei (Oudemans, 1912)	1	1	2	1
Total	**1,538**		**563**	

Table 4. Number of Uropodina species found in the area of 'Cisy Staropolskie im. Leona Wyczółkowskiego' depending on the type of the collected material: N - number of specimens; min/max - minimum and maximum number of specimens found in one sample. Qualitative samples 253, quantitative samples 199.

Species	Quantitative		Qualitative	
	N	min/max	N	min/max
Trachytes aegrota (C. L. Koch, 1841)	194	1-21	435	1-76
Oodinychus ovalis (C. L. Koch, 1839)	137	1-13	995	1-81
Olodiscus minima (Kramer, 1882)	120	1-18	188	1-20
Urodiaspis tecta (Kramer, 1876)	87	1-7	657	1-44
Trachytes pauperior (Berlese, 1914)	40	1-14	20	1-4
Dinychus perforatus Kramer, 1882	35	1-8	344	1-43
Urodiaspis pannonica Willmann, 1952	20	1-4	109	1-11
Neodiscopoma splendida (Kramer, 1882)	20	1-10	184	1-41
Oodinychus karawaiewi (Berlese, 1903	19	1-9	110	1-17
Trachytes lamda Berlese, 1903	16	1-9	76	1-28
Oodinychus obscurasimilis (Hirschmann et Z.-Nicol, 1961)	15	1-2	96	1-11
Discourella modesta (Leonardi, 1889)	2	1	3	1
Janetiella pulchella (Berlese, 1904)	2	1	13	1-10
Dinychus inermis (C. L. Koch, 1841)	2	1	69	1-31
Olodiscus misella (Berlese, 1916)	1	1	1	1
Cilliba cassideasimilis (Błoszyk Stachowiak et Halliday, 2008)	1	1	13	1-4
Dinychura cordieri (Berlese, 1916)	1	1	2	2
Trematurella elegans (Kramer, 1882)			112	1-25
Dinychus arcuatus (Trägårdh, 1922)			75	1-25
Leiodinychus orbicularis (C. L. Koch, 1839)			8	1-7
Dinychus woelkiei Hirschmann et Zirngiebl-Nicol, 1969			8	1-7
Iphiduropoda penicillata (Hirschmann et Z.-Nicol, 1961)			5	1-4
Olodiscus kargi (Hirschamann et Z.-Nicol, 1969)			3	3
Dinychus carinatus Berlese, 1903			3	1-2
Phaulodiaspis rackei (Oudemans, 1912)			2	1
Oplitis sp.			2	2
Polyaspis patavinus Berlese, 1881			1	1
Pseudouropoda sp.			1	1
Uroobovella obovata (Canestrini et Berlese, 1884)			1	1
Cilliba rafalskii (Błoszyk Stachowiak et Halliday, 2008)			1	1
Uropoda orbicularis (Muller, 1776)			1	1
Total	**712**		**3,538**	

Table 5. Dominance (D%) and constancy of occurrence (C%) of Uropodina in the area of 'Gorce' expressed with relative values and classes. Bold - 'the core' of the community.

Species	Quantitative				Qualitative			
	D%	**C%**	**D**	**C**	**D%**	**C%**	**D**	**C**
T. irenae	42.42	49.38	D5	C4	53.76	88.70	D5	C5
T. aegrota	34.97	44.17	D5	C4	33.89	85.10	D5	C5
O. misella	8.83	21.09	D3	C3	1.97	20.19	D1	C3
T. pauperior	8.04	21.09	D3	C3	4.17	35.10	D2	C4
C. cassideasimilis	1.98	4.96	D1	C1	2.05	14.66	D1	C2
D. perforatus	1.31	4.96	D1	C1	1.09	13.46	D1	C2
N. splendida	1.19	4.47	D1	C1	1.89	12.50	D1	C1
U. tecta	0.36	0.74	D1	C1	0.19	3.13	D1	C1
T. minima	0.20	0.50	D1	C1	0.17	1.92	D1	C1
P. cylindricus	0.20	0.99	D1	C1	0.37	3.13	D1	C1
P. calcarata	0.20	0.99	D1	C1	0.03	0.72	D1	C1
O. minima	0.20	1.24	D1	C1	0.29	3.37	D1	C1
J. pulchella	0.08	0.25	D1	C1				
N. breviunguiculata	0.04	0.25	D1	C1	0.01	0.24	D1	C1
D. arcuatus	-				0.07	1.92	D1	C1
D. carinatus	-				0.03	0.72	D1	C1
O. ovalis	-				0.02	0.48	D1	C1
O. obscurasimilis	-				0.01	0.24	D1	C1
Total	**100**				**100**			

Table 6. Dominance (D%) and constancy of occurrence frequency (C%) of Uropodina in 'Jakubowo' expressed with relative values and classes. Bold - "the core" of the community.

Species	Quantitative				Qualitative			
	D%	**C%**	**D**	**C**	**D%**	**C%**	**D**	**C**
O. minima	44.78	29.97	D5	C3	29.73	60.71	D4	C5
T. pauperior	19.46	15.08	D4	C3	2.65	23.21	D1	C3
T. aegrota	17.98	17.81	D4	C3	41.86	75.00	D5	C5
U. pannonica	9.14	8.37	D3	C2	7.41	35.71	D3	C4
C. cassideasimilis	3.75	4.78	D2	C1	2.65	16.07	D1	C3
U.tecta	3.05	4.25	D2	C1	12.90	60.71	D	C5
P. cylindricus	0.90	1.26	D1	C1				
O. ovalis	0.63	0.66	D1	C1	2.22	21.43	D1	C3
D. inermis	0.12	0.13	D1	C1				
T. lamda	0.04	0.07	D1	C1				
P. calcarata	0.04	0.07	D1	C1				
O. kargi	0.04	0.07	D1	C1				
Ph. rackei	0.04	0.07	D1	C1				
N. stylifera	0.04	0.07	D1	C1				
J. pyriformis					0.11	1.79	D1	C1
Total	**100**				**100**			

Table 7. Dominance (D%) and constancy of occurrence frequency (C%) of Uropodina in 'Las Grądowy' expressed with relative values and classes. Bold - 'the core' of the community.

Species	Quantitative				Qualitative			
	D%	**C%**	**D**	**C**	**D%**	**C%**	**D**	**C**
T. aegrota	36.82	50.14	D5	C5	31.62	70.83	D5	C5
T. pauperior	26.04	41.03	D4	C4	2.66	18.75	D1	C3
T. minima	20.84	37.61	D4	C4	42.10	70.83	D5	C5
T. lamda	6.04	18.80	D2	C4				
P. cylindricus	5.00	11.11	D2	C2				
U. tecta	2.53	7.41	D1	C2	15.10	56.25	D4	C5
C. cassideasimilis	1.43	2.56	D1	C1				
U. pannonica	0.91	2.85	D1	C1	1.42	8.33	D1	C2
D. perforatus	0.13	0.57	D1	C1	5.33	25.00	D2	C3
O. ovalis	0.06	0.28	D1	C1	1.42	12.50	D1	C2
Ph. rackei	0.06	0.28	D1	C1	0.36	4.17	D2	C1
Total	**100**				**100**			

Table 8. Dominance (D%) and constancy of occurrence frequency (C%) of Uropodina in 'Cisy Staropolskie im. Leona Wyczółkowskiego' expressed with relative values and classes. Bold - "the core" of the community.

Species	Quantitative				Qualitative			
	D%	**C%**	**D**	**C**	**D%**	**C%**	**D**	**C**
T. aegrota	27.25	31.16	D4	C4	12.30	32.81	D3	C4
O. ovalis	19.24	24.62	D4	C3	28.12	40.06	D1	C3
O. minima	16.85	25.63	D4	C3	5.31	26.88	D2	C3
U. tecta	12.22	26.13	D3	C3	18.57	38.74	D4	C4
T. pauperior	5.62	5.03	D2	C2	0.57	5.53	D1	C2
D. perforatus	4.92	8.54	D2	C2	9.72	21.74	D3	C3
U. pannonica	2.81	5.53	D1	C2	3.08	13.4	D2	C2
N. splendida	2.81	3.52	D1	C1	5.20	15.02	D2	C3
O. karawaiewi	2.67	3.02	D1	C1	3.11	8.70	D2	C2
T. lamda	2.25	2.51	D1	C1	2.15	4.74	D1	C1
O. obscurasimilis	2.11	6.03	D1	C2	2.71	13.44	D1	C2
D. modesta	0.28	1.01	D1	C1	0.08	1.19	D1	C1
J. pulchella	0.28	1.01	D1	C1	0.37	0.79	D1	C1
D. inermis	0.28	1.01	D1	C1	1.95	3.16	D1	C1
O. misella	0.14	0.50	D1	C1	0.03	0.40	D1	C1
C. cassideasimilis	0.14	0.50	D1	C1	0.37	2.77	D1	C1
D. cordieri	0.14	0.50	D1	C1	0.06	0.40	D1	C1
T. elegans					3.17	9.09	D2	C2
D. arcuatus					2.12	4.35	D1	C1
L. orbicularis					0.23	0.79	D1	C1
D. woelkiei					0.23	0.79	D1	C1
I. penicillata					0.14	0.79	D1	C1
O. kargi					0.08	0.40	D1	C1
D. carinatus					0.08	0.79	D1	C1
Ph. rackei					0.06	0.79	D1	C1
Oplitis sp.					0.06	0.40	D1	C1
P. patavinus					0.03	0.4	D1	C1
Pseudouropoda sp.					0.03	0.40	D1	C1
U. obovata					0.03	0.40	D1	C1
C. rafalskii					0.03	0.40	D1	C1
U. orbicularis					0.23	0.79	D1	C1
Total	**100**				**100**			

4. DISCUSSION

Holding faunistic inventories and regular monitoring of the soil environment by means of long-term research is becoming a more and more common method of investigating changes occurring in communities of invertebrates inhabiting soil [27, 29, 35]. Also in taxonomic and zoocenological research into distribution of taxa there is still a need for effective yet not laborious methods of collecting material for analysis. In all these types of research sieving of litter and soil seem to be the best method. For example, in the case of the material collected in Gorce the average number of specimens in a quantitative sample was 6.2, whereas in the sieving it was 28.6. In 'Jakubowo' the former it was 1.7 and for the latter 16.3 specimens/sample, in 'Las Grądowy' 4.4 and 11.7 specimens/sample, and in 'Cisy Staropolskie' 3.6 and 14.0 specimens/samples (Tables 1-4). Moreover, the use of sieving allows to detect rare and sparse species, which are usually found in quantitative samples (Tables 1-8). This stems from the fact that these are species of low abundance in soil, and therefore, it is much harder to catch them by means of small corer to collect quantitative samples (up to 30 cm^2). Mites which occur with the frequency of fewer than 10 specimens per m^2 are caught accidentally or at all in quantitative samples collected in sessions with 10 and 30 series. The analyses presented above show that 2 or 3 sieving collected in a given area can be a good substitute for a series of quantitative samples, both in faunistic research and monitoring of the soil environment. It is possible mainly due to the fact that the material obtained from sieving is far more dense than that in quantitative samples, and for this reason it contains more species occurring in the examined area.

However, it should be borne in mind that sieving have one major drawback. These samples are collected from litter and the upper strata of soil, usually to the depth of 2 cm, whereas quantitative soil samples are usually taken to the depth of about 10 cm [15, 23-26, 36]. Thus, it is possible that species which live in the lower layers of soil, or their developmental forms, are not caught using the qualitative method. This is probably the reason why the qualitative material collected in 'Las Grądowy' did not contain some of the common species such as *T. lamda* and *P. cylindricus*.

It is also worth to mention that there is another serious disadvantage in using the sieving method to obtain soil mesofauna. This problem may be not very important for Uropodina, which are strongly sclerotized, but for other groups of invertebrate soil fauna. Many representatives of soil mesofauna are small and fragile invertebrates, which are often entirely destroyed during longer sieving and extracting processes. This concerns mainly such groups as subtle mites from the order Prostigmata, but also Collembola, Protura and Pauropoda, gentle non-arthropods, and soft immature stages*.

Nevertheless, the data show that in most cases the information about abundance and distribution of a taxon in a given area obtained from qualitative and quantitative samples is reliable in each case. Thus, in extensive research conducted in a large area collecting qualitative samples (in this case sieving of litter and soil) is a far better method than collecting quantitative samples, and the indices (expressed with relative values) calculated on the basis of the data obtained from them (e.g. D%, C%) accurately reflect the actual abundance and structure of communities of soil invertebrates. Collecting quantitative samples is also always recommended when the researcher needs a simple and reliable method of collecting material for analysis. This method is very useful especially in the case of collecting exotic material, which will be used to describe new taxa. As has been already said, qualitative samples contain far more dense material, which contains more specimens of a given species and different developmental forms, especially in places where collecting a large number of quantitative samples is impossible both now and in the future. On the other hand, large series of specimens allow to determine the range of morphological characteristics, which in turn considerably reduces the possibility of committing taxonomic errors and prevents coining taxonomic synonyms. Finally, quantitative samples are also more appropriate when there is a need for extracting material for biometric analysis, which usually requires a large number of specimens, and in research based on molecular techniques, which are becoming more and more popular in the research into soil fauna.

*To extract fragile forms and larvae from sieving samples one should use different methods of using Tullgrene's funnels. For example, the external part of the funnel should be cooled during the extraction process by wrapping it with a rag damped in cold water (this method was applied by Prof. Rafalski).

AUTHORS' CONTRIBUTIONS

JB: Conception of the paper and design of the first version of the manuscript; Analysis and interpretation of data; Technical support; Study supervision. JB and AN: Acquisition of data (collection of samples and identification of the species). AN: Interpretation of data; Preparation of final version of the manuscript; Preparation of the revised version of the manuscript; Administrative and technical support. Both authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors have no conflict of interest to declare.

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