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THE OCCURRENCE OF SOIL MESOFAUNA IN ORGANIC CROPS

Summary

This study presents the quantitative and qualitative analysis of soil arthropods (Arachnida: Acari, Hexapoda: Collembola) occurring in four norfolk crop rotation, cultivated by organic method. The field research was carried out in the years 2014-2015 at the Experimental Research Station Swojec, belonging to the Wrocław University of Environmental and Life Sciences and at an organic farm in Kamieniec Wrocławski, Poland. In both locations, irrespectively of crop type, Prostigmata were the most common soil mites. Astigmata and predatory Gamasida were less numerous, while Oribatida were the least numerous. The largest number of springtails was noted in organic cultivation of winter rye. Less numerous Collembola were present in oat and fodder pea, and in the smallest number in organic cultivation of potato. Obtained results suggest that organic cultivation of cereals promotes the occurrence of beneficial mesofauna, mainly due to the lower frequency of agrotechnical activities in comparison to potato cultivation. The most numerous species of Collembola were: representatives of genera Mesaphorura and Desoria.
***Key words**: organic crops, soil arthropods, mites, springtails*

WYSTĘPOWANIE MEZOFAUNY GLEBOWEJ W UPRAWACH EKOLOGICZNYCH

Streszczenie

Celem pracy była analiza ilościowa i jakościowa zgrupowań stawonogów glebowych (Arachnida: Acari, Hexapoda: Collembola) występujących w czterech uprawach płodozmianu norfolskiego, prowadzonych metodą ekologiczną. Doświadczenie polowe prowadzono w latach 2014-2015, w Rolniczym Zakładzie Doświadczalnym Swojec, należącym do Uniwersytetu Przyrodniczego we Wrocławiu oraz w gospodarstwie ekologicznym w Kamieńcu Wrocławskim. W obu miejscowościach, niezależnie od rośliny uprawnej, do najliczniejszych roztoczy glebowych należały Prostigmata. Mniej liczne były Astigmata oraz drapieżne Gamasida, a najmniej liczne Oribatida. W przypadku skoczogonków najwięcej tych stawonogów stwierdzono w ekologicznej uprawie żyta ozimego. Mniej licznie Collembola występowały w uprawie owsa i grochu pastewnego, a w najmniejszej liczbie w ekologicznej uprawie ziemniaka. Na podstawie przeprowadzonych badań można stwierdzić, że ekologiczna uprawa zbóż sprzyja występowaniu pożytecznej mezofauny, głównie ze względu na mniejszą częstotliwość wykonywania zabiegów agrotechnicznych w porównaniu do uprawy ziemniaka. Najliczniej oznaczanymi gatunkami Collembola były: Mesaphorura oraz przedstawiciele rodzaju Desoria.
***Słowa kluczowe**: uprawy ekologiczne, mezofauna glebowa, roztocze, skoczogonki*

1. Introduction

Ecological farming is seen as environmentally friendly due to its low impact on the environment. Reduction of the number of agrotechnical treatments, not using mineral fertilizers, as well as synthetic, chemical plant protection products, contribute to the maintenance of biodiversity and homeostasis of agroecosystems [1, 2, 3]. One of the bases of ecological farming, which should provide the proper functioning of ecosystem, is using the appropriately selected and diversified crop rotation. Well selected composition of plant species may favorably affect the soil properties and thus create a habitat suitable for beneficial soil mesofauna development [4, 5]. The most numerous representatives of this group are mites (Acari) and springtails (Collembola), making up even 90% of soil organisms [6, 7]. They significantly affect the habitat status they live due to the wide range of occurrence in trophic nets and the role they play in decomposition of organic residues and in consequence, on the cycle of the organic matter in the environment [8]. By their adaptation to the soil environment and high sensitivity towards products such as pesticides or mineral fertilizers, they are considered as bioindicators of changes taking place in the soil environment, mainly in agrocenoses [9]. Agrotechnical activities changing the physical and chemical properties of soil can have a crucial impact on the abundance of soil mesofauna. In terms of the properties of plant and agrotechnical treatments used during its cultivation, using appropriately selected crop rotation will significantly modify the quantitative and qualitative composition of organisms chosen to analysis.

This work presents quantitative and qualitative analysis of soil arthropods (Arachnida: Acari and Hexapoda: Collembola) occurring in the norfolk crop rotation system cultivated by organic method.

2. Material and methods

The studies were conducted at the Experimental Research Station Swojec (51°07'02,4"N, 17°08'25,2"E) belonging to the Wrocław University of Environmental and Life Sciences and at an organic farm in Kamieniec Wrocławski (51°05'37.7"N, 17°10'21.3"E) located 10 km from Wrocław, Poland. In both locations organic crops are cultivated since 11 years on light, good rye soil classes. The research was conducted on four agricultural crops, i.e. winter

rye (variety Dańkowskie Złote), oat (variety Rajtar), fodder pea (variety Roch) and potato (variety Vineta) were used. The plants were cultivated on plots of area of 32 m^2 (8 x 4 m), distributed randomly in three replications. In both of the locations the agrotechnical operations were performed in a similar way in each of the experimental treatment. Plants were cultivated conventionally with the use of plough (stubble cultivation, deep ploughing). Sowing or planting were carried out according to data compatible with their district requirements. Pre-sowing tillage was made with the use of aggregate, cultivator and harrow. The highest numbers of treatments were performed in the potato field, including top dressing treatment, earthing-up threefold. During the period of mass appearance of Colorado potato beetle, the biological product Novodor SC (based on the *Bacillus thuringiensis* var. *tenebrionis*, authorized in organic farming) was applied twice in the potato field.

Occurrence of soil mesofauna was tested on soil samples collected with the cylindrical corer with diameter 5 cm and depth 10 cm. The samples were collected from both locations twice in spring (in the middle of May and in the beginning of June) in each year of the study. Six samples were collected diagonally across each plot (total 144 samples in one data). Soil arthropods were extracted in Tullgren's funnels modified by Murphy [11]. Appropriately labeled samples were exposed to intensive light and high temperature for 24 h in the funnels. After the extraction, the arthropods were stored in plastic containers filled with 75% ethyl alcohol. Afterwards the specimens were counted and identified. Mites were classified to orders (*Prostigmata, Astigmata, Gamasida, Oribatida*), while the springtails were identified to precise species. Species identification was carried out according to keys by Fjellberg [12] and Hopkin [13].

Statistica 12.5, MVSP 3.2 and spreadsheet Microsoft Excel 2007 were used to analyze the obtained results. The analysis of variance (ANOVA) at the significance level of $\alpha \leq 0.05$ was used to prove the significance of differences in the number of soil mesofauna in tested components of crop rotation. N – the number of all individuals, as well as n_i – the number of species individuals, were determined during the ecological analysis of soil mesofauna. This enabled the calculations of the following indicators: Shannon-Weaver's overall species diversity $H' = -\sum_{i=1}^{S} pi(\log_2(pi))$, where: S – the number of species, pi – share of i^{th} species, Pielou's distribution uniformity of species frequency $\left(J' = \frac{H'}{\log_2 S}\right)$, (where: H' – Shannon-Weaver's index of an overall species diversity, S – the number of species) and Simpson's species diversity $D = 1 - \sum_{i=1}^{S}\left(p_i^2\right)$ (pi – share of i^{th} species in groupings and S – the number of species).

The similarity in groupings of springtails occurrence in components of norfolk crop rotation was shown on dendrograms and calculated according to Jaccard's index $Pxy = \frac{c}{a+b-c} \cdot 100\%$, where: c – the number of common species for x and y, a – the number of species in set x, b – the number of species in set y ($a + b - c = n$).

3. Results

3.1. Soil mites

In total, 1587 mites were collected and identified in Swojec, and 1927 in Kamieniec Wrocławski during the whole study period, in all of variants (Table 1). In 2014, in Swojec, the highest number of mites was noted in winter rye cultivation (208 individuals). These arthropods were less numerous in fodder pea (188 individuals) and oat (181 individuals), while the least numerous in potato cultivation (114 individuals).

Prostigmata was determined as the most numerous Acari group in all of tested crops (Fig. 1). Mites from Astigmata and Gamasida genera were less numerous, while the specimens of Oribatida order were observed in the smallest numbers. The abundance of Prostigmata in winter rye (108 individuals) was significantly higher than in potato (38 individuals) (df=3, F=2.88, p=0.049). Gamasida were significantly more numerous in fodder pea (61 individuals) in comparison to potato (34 individuals) (df=3, F=0.99, p=0.037). Mites belonging to the order Oribatida occurred in significantly higher number in fodder pea (12 individuals) and rye (10 individuals) in comparison to potato (4 individuals) and oat (1).

In the same location, in 2015, the highest number of Acari was also noted in winter rye, i.e. 409 individuals (Table 1).

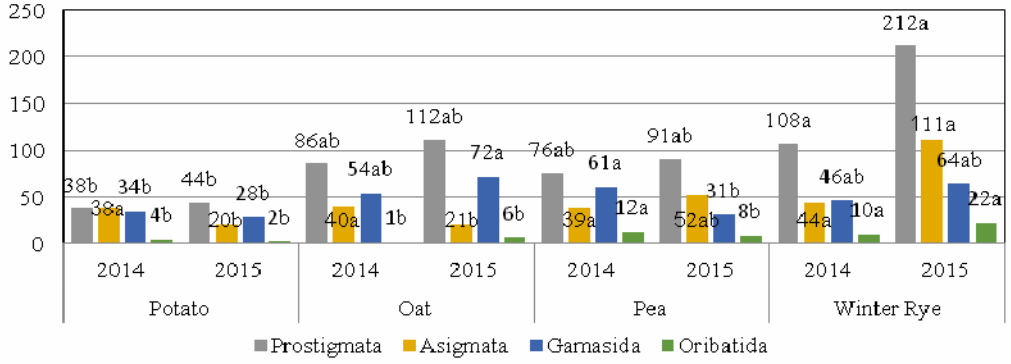

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Fig. 1. The number of Acari in organic crops in Swojec in 2014-2015
Rys. 1. Liczebność Acari na uprawach ekologicznych w Swojcu w latach 2014-2015

Tab. 1. Total number of soil mesofauna collected in Swojec in 2014-2015
Tab. 1. Liczebność mezofauny glebowej zebranej w Swojcu w latach 2014-2015

	Potato		Oat		Pea		Winter Rye		Total		
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	Total
Mites	114	94	181	211	188	182	208	409	691	896	1587
Springtails	47	61	106	142	109	103	141	197	403	503	906

Source: Authors' own research / Źródło: opracowanie własne

Tab. 2. Total number of soil mesofauna collected in Kamieniec Wrocławski in 2014-2015
Tab. 2. Liczebność mezofauny glebowej zebranej w Kamieńcu Wrocławskim w latach 2014-2015

	Potato		Oat		Pea		Winter Rye		Total		
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	Both
Mites	134	64	142	270	229	207	248	633	753	1174	1927
Springtails	62	70	110	256	100	113	180	348	452	787	1239

Source: Authors' own research / Źródło: opracowanie własne

In oat, 211 of these arthropods were found, 182 in fodder pea and 94 in potato. Significant differences in occurrence of each mites group were observed for all of the identified groups. Prostigmata were significantly more numerous in winter rye cultivation (212 individuals), when compared to potato (44) (df=3, F=9.76, p=0.00). Within the same crop a significantly greater number of Astigmata was observed (111 individuals) than in oat (21) and potato (20) (df=3, F=14.71 p=0.00). Gamasida were significantly more numerous in oat (172 individuals) in comparison to fodder pea (31) and potato (28 individuals) (df=3, F=5.10 p=0.00). The less numerous mite groups, i.e. Oribatida, occurred in statistically higher number in rye (22 individuals) in comparison to the other of research treatments (df=3, F=6.948 p=0.00).

In Kamieniec Wrocławski during study conducted in 2014, the highest number of mites was collected in winter rye (248 individuals), while they were less numerous in fodder pea (229 individuals). The smallest numbers of these organisms were noted in oat (142) and potato (134) (Table 2).

In all components of the norfolk crop rotation the most numerous group of Acari was Astigmata, except the oat field, where the most numerous were predatory Gamasida. The least numerous was Oribatida (Fig. 2). Significantly more individuals of Prostigmata were observed in fodder pea (86) and winter rye (84), in comparison to oat (40 individuals) and potato (34 individuals) (d=3, F=5.65, p=0.002). Also the Astigmata were significantly more numerous in winter rye and fodder pea (94 and 92 individuals respectively), compared to potato (44 individuals) and oat (32 individuals) (d=3, F=4.15, p=0.01). Taking into account Gamasida and Oribatida, no significant differences were found.

In 2015 in the same locality, the highest number of Acari was collected in winter rye (633 individuals), less in oat (270 individuals) and fodder pea (207), the least of them - in potato (64 individuals) (Table 2). The largest number of mites belonged to the order Prostigmata. The only exception: potato cultivation, where Gamasida were the most numerous. Prostigmata were significantly more numerous in winter rye (241 individuals) in comparison to other crops (oat - 117, fodder pea - 109, potato - 16) (d=3, F=12.66, p=0.00). Astigmata were significantly more numerous in oat (72 individuals), fodder pea (55 individuals) and potato (22 individuals), when compared to winter rye, where 160 mites were found (d=3, F=8.87, p=0.00). Gamasida were significantly more numerous in winter rye (201 individuals) in comparison to other crops (oat - 64 individuals, pea and potato - 24 individuals) (d=3, F=32.46, p=0.02). The least numerous Oribatida were significantly less numerous in potato (2 individuals) in comparison to winter rye (31 individuals) (d=3, F=13.18, p=0.00).

3.2. Springtails

The total number of springtails collected in research in Swojec was 906 and 1239 at Kamieniec Wrocławski (Tables 3 and 4). 403 representatives of Collembola were collected in 2014 in all crops in Swojec (Table 3). These arthropods were significantly more numerous in winter rye (141 individuals) in comparison to potato (47 individuals) (df=3, F=1.84 p=0.01). No significant differences in the number of other springtails between other treatments of the study were noted. The largest group of Collembola species (11) was identified in winter rye. Less species were observed within pea and oat (in each 7) and the smallest number in potato (5). Overall species diversity in winter rye confirmed by Shannon-Weaver index (H'=1.783) was the highest in comparison to the other treatments. Simpson index, which includes the species dominancy, reached the highest value in fodder pea (0.806), lower in rye (0.801), oat (0.704) and the lowest in potato (0.38). The values of Jaccard's similarity index for springtail assemblages in individual habitats in Swojec were shown on a dendrogram (Fig. 3). In 2014 springtails were the most diverse community, occurring in potato compared to those in winter rye (0.233). The highest similarity was confirmed for Collembola community in oat and fodder pea (0.737).

During the second year of study (2015), at Swojec, in total 503 springtails were collected (Table 3). Significantly higher number of these arthropods was noted in winter rye (197) in comparison to potato (47 individuals) and fodder pea (103 individuals) (df=3, F=3.68 p=0.02). In winter rye the largest number of Collembola species (13) was also noted. In oat were 7 species, while in potato as well as in fodder pea 6. Obtained values of springtails species richness in winter rye were confirmed by both Shanonn-Weaver's (1.849) and Simpson's (0.806) indices of overall species diversity. The lowest values of these indexes were in potato (H'=1.025, D=0.551). The highest similarity of springtails assemblages was noted between pea and potato (0.737), while the highest difference was between rye and oat (0.52) (Fig. 3).

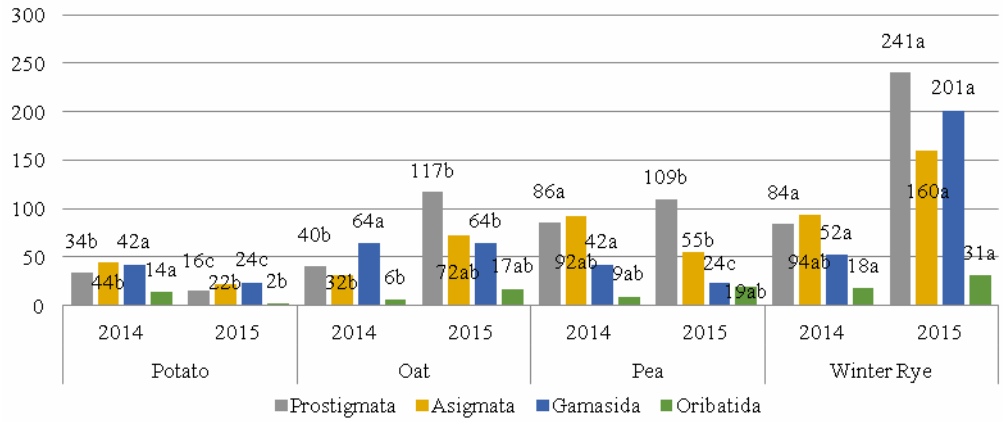

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Fig. 2. The number of Acari in organic crops in Kamieniec Wrocławski in 2014-2015
Rys. 2. Liczebność Acari na uprawach ekologicznych w Kamieńcu Wrocławskim w latach 2014-2015

Table 3. Species composition of Collembola in organic crops in Swojec in 2014-2015
Tab. 3. Skład gatunkowy skoczogonków w uprawach ekologicznych w Swojcu w latach 2014-2015

Species	*Potato*				*Oat*				*Pea*				*Winter Rye*			
	2014		2015		2014		2015		2014		2015		2014		2015	
	N*	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Mesaphorura spp.	25	0.53	36	0.59	38	0.36	51	0.36	20	0.18	37	0.36	29	0.21	42	0.21
Desoria tigrina (Nicolet)			3	0.05	41	0.39	45	0.32	24	0.22	16	0.16	39	0.28	59	0.30
Hypogastrura spp.	11	0.23	19	0.31	11	0.10	19	0.13	12	0.11	15	0.15	21	0.15	27	0.14
Proisotoma minuta (Tullberg)							21	0.15	12	0.11	9	0.09	32	0.23	19	0.10
Desoria multisetis (Carpenter & Phillips)			1	0.02	7	0.07	2	0.01	9	0.08	3	0.03	11	0.08	34	0.17
Bourletiella hortensis (Fitch)			1	0.02	2	0.02	1	0.01	31	0.28	23	0.22	3	0.02	5	0.03
Smithurudes parvulus (Latreille)			1	0.02	5	0.05	1	0.01	1	0.01					1	0.01
Stenaphorura spp.	4	0.09											2	0.01	3	0.02
Pseudosinella alba (Packard)	6	0.13													2	0.01
Brachystomella parvula (Schäffer)					2	0.02	1	0.01					1	0.01	1	0.01
Spaheridia pumilis (Krausbauer)													1	0.01	1	0.01
Parisotoma notaibilis (Schäffer)															2	0.01
Isotomiella minor (Schäffer)	1	0.02											1	0.01		
Isotomodes productus (Axelson)							1	0.01					1	0.01		
Heteromurus nitidus (Templeton)															1	0.01
Total	47b**	100	61b	100	106	100	142	100	109	100	103b	100	141a	1	197a	1
No. species	5		6		7		9		7		6		11		13	
Simpson - Index D	0.638		0.551		0.704		0.73		0.806		0.767		0.801		0.806	
Shannon-Weaver Index H'	1.23		1.025		1.444		1.483		1.737		1.588		1.783		1.849	
Pielou - Index J'	0.529		0.396		0.514		0.467		0.618		0.614		0.515		0.499	

*N - number of individuals, **significant differences

Source: Authors' own research / Źródło: opracowanie własne

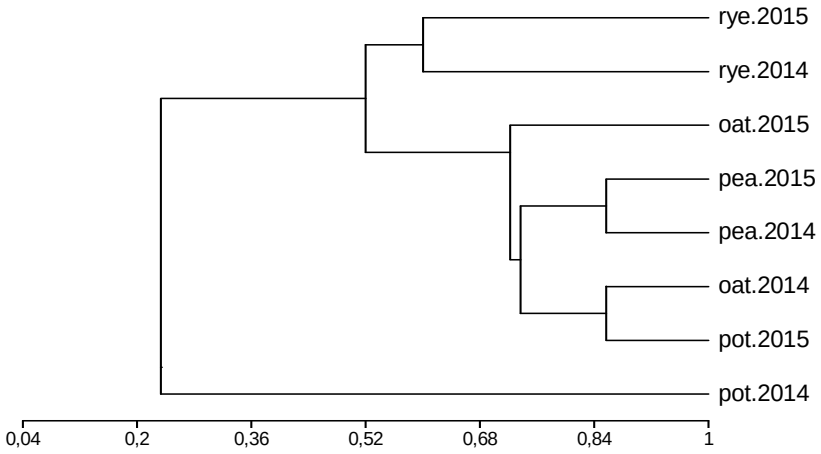

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Fig. 3. Dendrogram of springtails groupings similarity in organic crops in Swojec in 2014-2015
Rys. 3. Dendrogram podobieństw zgrupowań skoczogonków w uprawach ekologicznych w na Swojcu w latach 2014-2015

A total number of 452 springtails were noted in 2014 at organic farm in Kamieniec Wrocławski (Table 4). Significantly higher number of Collembola was in winter rye (180 individuals) in comparison to pea (100 individuals) and potato (62). In this year significantly higher number of springtails was also in oat (110 individuals) and fodder pea compared to potato (d=3, F=10.80, p=0.00). In winter rye the highest number of species (13) was identified. Less species were recorded in oat (10), potato (9) and pea (8). Despite the highest number of collected arthropods in rye, the highest species biodiversity characterized oat cultivation. Index of Shannon-Weaver's overall species diversity for Collembola assemblages in this crop was H'=1.874. Taking into account the Simpson's species biodiversity index, the highest value was reached in oat (0.806), lowest in potato (0.722), and the lowest in winter rye (0.660) and fodder pea (0.649). Similarity in springtails occurring in such crops was shown on dendrogram of habitats similarity (Fig. 4). The highest similarity was noted for fodder pea and potato (0.889), while the most diverse were mentioned crops compared to rye and oat (0.555).

In 2015, 787 springtails were collected (Table 4). Significantly greater number of these organisms was found in winter rye field (348 individuals) and oat (256 individuals) in comparison to pea and potato (113 and 70 individuals respectively) (d=3, F=13.17, p= 0.00). Similar as in the first year of study, the highest number of identified species belonged to Collembola which was in rye (14). In oat 13 species were identified, while the least was in fodder pea and potato (7 species). The highest overall species diversity was noted in oat (H'=1.755), while the lowest in fodder pea (H'=1.348). This tendency was not confirmed by Simpson's index (potato 0.728, oat 0.726, rye 0.652, fodder pea 0.649). Similarity of habitats presented on dendrogram with the use of Jaccard's index (Fig. 4) shows, that winter rye and oat (0.929) are the most similar habitats due to the Collembola occurrence. The assemblages of springtails of lowest similarity were found in fodder pea and potato (0.556).

Table 4. Species composition of Collembola in organic crops in Kamieniec Wrocławski in 2014-2015
Tab. 4. Skład gatunkowy skoczogonków w uprawach ekologicznych w Kamieńcu Wrocławskim w latach 2014-2015

Species	*Potato*				*Oat*				*Pea*				*Winter Rye*			
	2014		2015		2014		2015		2014		2015		2014		2015	
	N*	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Mesaphorura spp.	29	0.47	31	0.44	36	0.33	122	0.48	52	0,52	59	0,52	99	0,55	198	0,57
Desoria tigrina (Nicolet)	8	0.13	12	0.17	17	0.15	41	0.16	27	0,27	29	0,26	25	0,14	38	0,11
Hypogastrura spp.	3	0.05	5	0.07	22	0.20	24	0.09			4	0,04	8	0,04	21	0,06
Brachystomella parvula (Schäffer)	11	0.18	9	0.13					2	0,02			19	0,11	24	0,07
*Desoria multisetis (*Carpenter & Phillips)	2	0.03	1	0.01	11	0.10	21	0.08	3	0,03	7	0,06	7	0,04	13	0,04
Folsomia fimetaria (Linnaeus)	5	0.08	11	0.16	11	0.10	9	0.04	7	0,07	9	0,08			9	0,03
Proisotoma minuta (Tullberg)	2	0.03			2	0.02	6	0.02	2	0,02			9	0,05	6	0,02
Proisotoma minima (Absolon)	1	0.02					11	0.04	6	0,06	2	0,02	3	0,02	3	0,01
Spaheridia pumilis (Krausbauer)					4	0.04	9	0.04					3	0,02	3	0,01
Isotoma viridis (Bourlet)			1	0.01	2	0.02	4	0.02					2	0,01	7	0,02
Hetermosminthurus viridis (Linnaeus)							5	0.02					2	0,01	8	0,02
*Isotomodes productus (*Axelson)	1	0.02			3	0.03	1	0.00	1	0,01			1	0,01	7	0,02
Parisotoma notaibilis (Schäffer)					2	0.02	2	0.01			3	0,03	1	0,01	5	0,01
Bourletiella hortensis (Fitch)							1	0.00					1	0,01	6	0,02
Total	62c**	100	70 b	100	110bc	100	256a	100	100b	100	113b	100	180a	100	348a	100
No. species	9		7		10		13		8		7		13		14	
Simpson - Index D	0.722		0.728		0.806		0.726		0.646		0.649		0.66		0.652	
Shannon-Weaver Index H'	1.631		1.527		1.874		1.755		1.356		1.348		1.578		1.661	
Pielou Index J'	0.516		0.543		0.564		0.474		0.452		0.48		0.426		0.436	

*N - number of individuals, **significant differences

Source: Authors' own research / Źródło: opracowanie własne

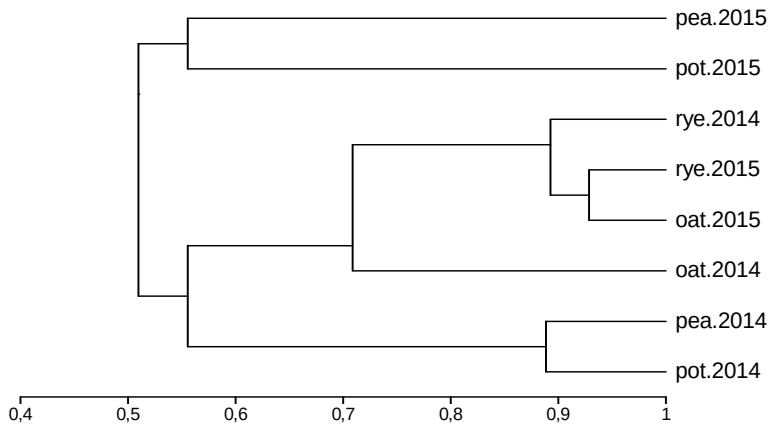

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Fig. 4. Dendrogram of springtails groupings similarity in organic crops in Kamieniec Wrocławski in 2014-2015
Rys. 4. Dendrogram podobieństw zgrupowań skoczogonków w uprawach ekologicznych w Kamieńcu Wrocławskim w latach 2014-2015

4. Discussion

The influence of crop rotation on entomofauna (including the organisms living in the soil environment) should be taken into account by the organic farms. Choosing proper plant species and varieties for cultivation may lead to more abundant occurrence of soil arthropods. These animals can have beneficial effects on processes taking place in the soil. Mites and springtails are the most numerous representatives of edaphic mesofauna, which is a crucial element of trophic systems. Dirilgen et al. [14] showed that Prostigmata and Oribatida are the most numerous mites. These organisms play a significant role in detritus decomposition. In this study Prostigmata were the most numerous, however Oribatida were the smallest group within all identified Acari, in contrast to the aforementioned results of Dirilgen et al. [14]. Wissuwa et al. [15] observed that species composition and the number of soil mites are closely related to the crop species. The length of the cultivation period of specific crops is also significant. Young plantations, commonly cultivated in crop rotation with no more than two species, usually present lower biodiversity levels than four-field crop rotation. Moreover, the quantity of mentioned organisms is closely related to increased soil treatments, which in organic farms is under stress caused mainly by mechanic removal of weeds. Lehmitz et al. [16] suggest that Oribatida have the highest share in mite's population in the soils, where no plants were cultivated previously (i.e. meadows). They are considered as pioneer organisms colonizing new ecological niches. Low share of these mites can be caused by long-term agrotechnical influence on the soil (above 10 years of cultivation). Gamasida are an important group of mites to maintain the balance in the ecosystem. Due to their predatory lifestyle they strongly reduce the number of unwanted organisms and have a positive impact on sustaining the balance of soil life [17]. Their number can be different and depend on the species adaptation to the environment, as well as possibility of migration to fields. Crops with longer vegetation period, properly developed root system and smaller requirements due to the soil treatments will create better conditions for soil mite's development. Results of this study show that crops having beneficial effect on occurrence of soil mesofauna were rye and oat, in which the highest number of these arthropods was noted.

Springtails are important groups of soil mesofauna. Due to their strong adaptation to soil environment, they are very sensitive to agrotechnical treatments and by many authors are mentioned to be the indicators of soil quality [18, 19]. Sabais et al. [20] noted, that crop species, including their root system and plants density per area unit can affect qualitative and quantitative composition of springtails. According to Eisenhauer et al. [21], the highest number of species will occur in crop rotation with no less than three crop species in comparison to the monoculture. In own research the highest number of Collembola was noted in cereals, especially in winter rye. Peterson observed that the number of springtails and their species composition depends not only on crop species but also on length of its stay on the field [22]. The reason of the highest diversity of springtails in winter rye may be affected by the longest stay of this crop on the field among other species. Springtails and mites are geobionts. That means agrotechnical treatments will play an important role on their presence in the soil environment. The smallest number of springtails and mites was observed in potato cultivation. In comparison to the other crops in crop rotation, the potato plants density and level of soil coverage by their epigeal organs in the first phase of plants vegetation is the smallest. Moreover, top-dressing weed removal took place in potato cultivation. This treatment influences the soil structure and indirectly the mesofauna quantity [23, 24]. Gruss et al. [25] also proved, that soil mesofauna occurs in higher numbers in winter rye in comparison to potato. This research shows that the representatives of genera *Mesaphorura* and *Hypogastrura,* and *Desoria tigrina* were the most numerous. In his research, Peterson [22] also showed that the representatives of *Mesaphorura* genus are the most numerous springtails in organic crops (mainly in winter crops).

5. Conclusions

1. The highest number of soil mites was found in organic cultivation of winter rye and oat in both locations in both years of study. Prostigmata were the most common group identified in four tested components of norfolk crop rotation.
2. The highest number of springtails and their highest species diversity was observed in winter rye. Representatives of genera *Mesaphorura*, *Hypogastrura* and *Desoria* were dominant in the assemblages of Collembola within each of the tested crops.
3. The smallest number of soil mesofauna representatives was found in organic cultivation of potato. Possible reasons were low density of plants and frequent weeds removal treatments carried out after the plants emergence.

6. References

[1] Birkhofer K., Ekroos J., Corlett E.B., Smith H.G.: Winners and losers of organic farming cereal farming in animal communities across Central and Northern Europe. Biological Conservation, 2014, 175, 25-33.

[2] Hyvönen T., Ketoja E., Salonen J., Jalli H., Tiainen, J.: Weed species diversity and community composition in organic and conventional cropping of spring cereals. Agriculture, Ecosystems and Environment, 2003, 97, 131-149.

[3] Rigby D., Cáceres D.: Organic farming and the sustainability of agricultural systems. Agricultural Systems, 2001, 68, 21-40.

[4] Velykis A., Satkus A.: Influence of crop rotations and reduces tillage on weed population dynamics under Lithuania's heavy soil condition. Agronomy Research, 2006, 4, 441-445.

[5] Smith J.L., Cycling of nitrogen through microbial activity, in: Hatfield J.L., Steward B.A. (Eds.), Soil biology: Effects on soil quality. Lewis Publishers, Tokyo, 1994.

[6] Lavelle P., Faunal activity and soil processes: adaptive strategies that determine ecosystem function. [In:] Begon M. (ed.), Advances in Ecological Research. Academic Press, New York, 1997, 93-132.

[7] Axelsen J.A., Thorup-Krisensen K.T.: Collembola and mites in plots fertilized with different types of green manure. Pedobiologia, 2000, 44, 556-566.

[8] Crossley D.A. Jr., Mueller B.R., Perdue J.C.: Biodiversity of microarthropods in agricultural soils: relations to processes. Agriculture, Ecosystems and Environment, 1992, 40, 37-46.

[9] Boczek J., Błaszak Cz.: Roztocze (Acari) – znaczenie w życiu i gospodarce człowieka. Warszawa: Wyd. SGGW, 2005, 7-30.

[10] Stone D., Ritz K., Griffiths B.G., Orgiazzi A., Creamer R.E.: Selection of biological indicators appropriate for European soil monitoring. Applied Soil Ecology, 2016, 97, 12-22.

[11] Murphy P.W.: A modified funnel method for extracting soil mesofauna. 1956, Trans. 6th Int. Congr. Soil Sci., Paris, C: 255-262.
[12] Fjellberg A.: The Collembola of Fennoscandia and Denmark. Part II. Entomobryomorpha and Symphypleona. 2007, Fauna Entomologica Scandinavica, 42, 252 ss.
[13] Hopkin S.P., A key to the springtails (Collembola) of Britain and Ireland. Field Studies Council (AIDGAP Project), 2007.
[14] Dirilgen T., Arroyo J., Dimmers W.J., Faber J., Stone D., Martins da Silva P., Carvalho F., Schmetz R., Griffiths B.S., Francisco R., Creamer R.E., Sousa J.P.: Mite community composition across a European transect and its relationships to variation in other components of soil biodiversity. Applied Soil Ecology, 2016, 97, 86-97.
[15] Wissuwa J., Salamon J.A., Frank T.: Oribatida (Acari) in grassy arable fallows are more affected by soil properties than habitat age and plant species. European Journal of Soil Biology, 2013, 59, 8-14.
[16] Lehmitz R., Russell D., Hohberg K., Christian A., Xylander W.E.R.: Active dispersal of oribatid mites into young soil. Applied Soil Ecology, 2012, 55, 10-19.
[17] Ruf A., Beck L.: The use of predatory soil mites in ecological soil classification and assessment concepts, with perspectives for oribatid mites. Ecotoxicology and Environmental Safety, 2005, 62, 290-299.
[18] Heyer W., Hülsbergen K.J., Wittmann Ch., Papaja S., Christen O.: Field related organisms as possible indicators for evaluation of land use intensity. Agriculture, Ecosystems and Environment, 2003, 98, 453-461.
[19] Twardowski J.: Wpływ uproszczeń w uprawie roli pod pszenicę ozimą na zgrupowania stawonogów epigeicznych i glebowych, Wydawnictwo Uniwersytetu Przyrodniczego we Wrocławiu, 2010, 107, 141 ss.
[20] Sabais A.C.W., Scheu S., Eisenhauer N.: Plant species richness drivers the density and diversity of Collembola in temperate grassland. Acta Oecologica, 2011, 37, 195-202.
[21] Eisenhauer N., Sabais A.C.W., Scheu S.: Collembola species composition and diversity effects on ecosystem functioning vary with plant functional group identity. Soil Ecology and Biochemistry, 2011, 43, 1697-1704.
[22] Petersen H.: Collembola populations in and organic crop rotation: Population dynamics and metabolism after conversion from clover-grass ley to spring barley. Pedobiologia, 2000, 44, 502-515.
[23] Brennan A., Fortune T., Bolger T.: Collembola abundances and assemblage structures in conventionally tilled and conservation tillage arable system. Pedobiologia, 2006, 50, 135-145.
[24] Larsen T., Schjønning P., Axelson J.: The impact of soil compaction on eudaphic Collembola. Appl. Soil Ecol., 2004, 26, 273-281.
[25] Gruss I., Hurej M., Twardowski J.: The effect of crop plant on soil mesofauna diversity. Progress in Plant Protection, 2013, 53(4), 668-673.