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Preliminary study of the impact of pig or goat manure fertilization of a meadow on oribatid mites

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Abstract: We investigated the impact of pig or goat manure fertilization of a meadow with doses of 80 kg N ha^{-1}, 140 kg N ha^{-1}, and 200 kg N ha^{-1} (plots 1-6) on oribatid mites. A control plot (0) was left unfertilized. The manure was applied to the meadow in the early spring of 2012, and soil samples were collected in the spring of 2012 and 2013. In total, 6053 oribatid mites were examined, including 1163 juveniles. The effect of fertilizing on the Oribatida depended on the dose of manure, but not on its type. A low dose of pig or goat manure did not affect the density of Oribatida, whereas the other doses decreased it, but only the highest doses decreased it significantly, compared to the control. Species diversity decreased with the dose of manure. In total, 24 species of Oribatida were found and some species reacted differently to both types of manure. For example, a low dose of pig manure significantly increased the density of *Eupelops occultus*, whereas the density of other species significantly decreased under the influence of the highest dose of pig manure (*Achipteria coleoptrata*), highest doses of pig and goat manure (*Galumna obvia*, *Liebstadia similis*), and medium and highest doses of goat manure (*Scheloribates laevigatus*).

Keywords: pig manure, goat manure, fertilization, meadow, Oribatida

INTRODUCTION

The growing interest in small farms and agrotourism, including goat farms, is connected with production of farmyard manure, which can be easily used to fertilize the grasslands belonging to these farms. The scarcity of knowledge on the effect of farmyard manure on the oribatid mites in meadows, and lack of knowledge on the effect of goat manure, encouraged us to carry out the present study.

Farmyard manure is a mixture of solid or liquid animal excreta and straw bedding. Solid manure differs from liquid manure in having dry solid content above 20% (Blaustein et al. 2015). Manure in general is a very valuable fertilizer because it enriches soil with nutrients, such as nitrogen and potassium, but also with trace elements and organic matter. Moreover, it has a biological significance, because it increases the amount of bacteria and enzymes. Fertilizing with farmyard manure improves the soil structure (aggregation), sorption, chemical properties, air-water properties, and biological activity (Mazur 1997).

Sustainable agricultural practices promote the use of organic rather than mineral fertilizers, based on extensive studies carried out in different countries both in grasslands and in arable fields (reviewed by Dicks et al. 2013). The areas treated with organic rather than mineral fertilizers support a higher plant species richness (Koch & Meister 2000), diversity and cover (Jones & Haggar 1993) and/or are characterized by an increased abundance of earthworms (Wakeham-Dawson & Smith 2000) or their diversity, biomass and density (Fliessbach et al. 2000) and increased abundance of some other or all invertebrates investigated (Purvis & Curry 1984; Idinger & Kromp 1997; Pfotzer & Schuler 1997) and/or their species richness (Idinger & Kromp 1997).

So far the studies on the effects of organic fertilizers on oribatid mites of meadows focused on liquid manure, produced mostly by cattle (Bielska 1986; Sokołowska & Seniczak 2005; Graczyk et al. 2008, 2010; Kruczyńska & Seniczak 2011) and sometimes by pigs (Domek-Chruścicka & Seniczak 2005; Wasińska-Graczyk et al. 2009). Nakamura (1976) studied in a pasture the effect of cattle manure on the soil microarthropods, including the Acari and the Oribatida, but all the Oribatida were considered jointly, so we do not know about the reaction of different species to manure. Another study concerned the effect of farmyard cattle manure on the soil fauna in a grassland, but oribatid mites were not an abundant group there (Andrén & Lagerlöf 1983).

Based on some earlier studies (e.g. Domek-Chruścicka & Seniczak 2005; Wasińska-Graczyk et al. 2009), which showed a positive reaction of the mites to low and medium doses of liquid manure, but negative to high doses, we hypothesized that (1) the effect of manure on oribatid mites depends on its type and dose; (2) the lowest applied dose affects positively the density and species richness of Oribatida, while (3) the highest applied dose reduces the density and species richness of Oribatida; and (4) fertilization affects more strongly the juvenile forms than the adults.

MATERIAL AND METHODS

Study area

The study was carried out in a permanent meadow that belongs to the Agricultural Experimental Station of the University of Technology and Sciences in Minikowo (Fig. 1) located about 25 km from Bydgoszcz (53°8.46'N, 17°43.33'E). The climate of this area is moderately warm, with a mean annual air temperature of 7.6°C, precipitation of 432 mm, and 217 days of the growing season (Borys et al. 1997). The investigated meadow was established in 1998 with the following mixture of plants: 50% alfalfa (*Medicago sativa* L.), 15% fescue (*Festuca pratensis* Huds.), 15% timothy-grass (*Phleum pratense* L.), 10% white clover (*Trifolium repens* L.), and 10%

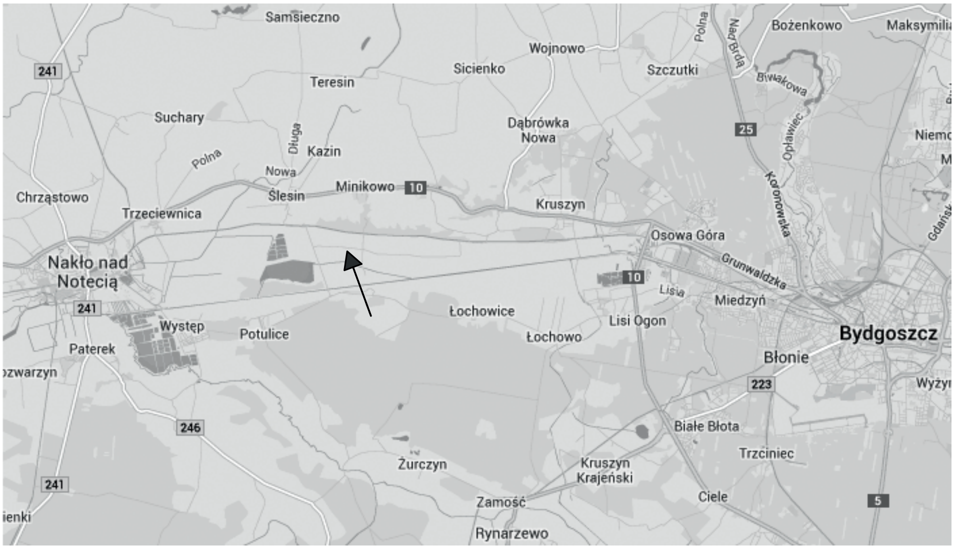

Fig. 1. Location of the study area: the arrow points to the meadow in the Agricultural Experimental Station in Minikowo

red clover (*Trifolium pratense* L.). The soil there was a typical Orthic Luvisol, which developed on fluvioglacial sands or boulder clay (Borys et al. 1997). The meadow is mown twice a year and was not fertilized before our experiment (in 1998-2011). The average hay yield (in metric tons) from the examined area is approximately 7.5 t ha^{-1} (Dembek & Łyszczarz 2008).

Sampling design

In this meadow, 7 plots of the same size (4 m × 4 m) were selected. They were separated from each other by buffer zones of 5 m × 5 m. In the early spring of 2012, six plots (numbered 1-6) were fertilized with 3 different doses (80 kg N ha^{-1}, 140 kg N ha^{-1}, and 200 kg N ha^{-1}) of pig and goat manure, while a control plot (0) was left unfertilized. The goat manure had a higher dry matter content (25%) than pig manure (23%), but lower nitrogen content (6.5 g·kg^{-1} wet weight) in comparison to pig manure (8.0 g·kg^{-1} wet weight) (Szczukowska 2015). The amount of dry matter of manure that corresponded to the N level mentioned above was in the case of pig manure – 43 t ha^{-1}, 76 t ha^{-1}, and 109 t ha^{-1}, and in the case of goat manure it was 49 t ha^{-1}, 87 t ha^{-1}, and 124 t ha^{-1}, respectively.

From each experimental plot, 10 samples of 50 cm^3 each were taken from 3 layers: lower part of the meadow plants (3 cm high), the upper layer of soil (to the depth of 3 cm) and the lower layer of soil (3–6 cm deep), which gave 30 samples from every plot, in the spring of 2012 and 2013. In total, 420 samples were collected.

Mite analyses

The mites were extracted using high-gradient Tullgren funnels and conserved in 70% ethanol. Next, the Oribatida were determined to species, including the juvenile forms, using the key of Weigmann (2006) and other relevant publications (Seniczak 1978a,b, 1988, 1990). The data for all layers were pooled. The average results of both years were analysed.

The *o*ribatid mite populations of individual species were characterized by the abundance (*A*), dominance (*D*) and constancy (*C*) indices, while oribatid communities were characterized by the number of species (*S*) and the Shannon (*H*') diversity index (Odum 1982). The basic statistical descriptors included the minimum, maximum, mean values and standard deviation. For the other statistical analyses, the values were log-transformed ln (x+1) (Łomnicki 2010). Normality of the distribution was tested with the Kolmogorov-Smirnov test, while the equality of variance in different samples, with the Levene test. The assumption of normality or equality of variance was met, so the Tukey test was used. The level of significance for all statistical tests was accepted at $\alpha = 0.05$. The calculations mentioned above were carried out with STATISTICA 10.0 software.

RESULTS

In total, 6053 oribatid mites were examined, including 1163 juveniles. The effect of fertilization with pig and goat manure on the Oribatida depended on the dose of manure. Lower and medium doses of both pig and goat manure (80 and 140 kg N ha^{-1}) did not change the total density of Oribatida in comparison to the control plot, while the high dose of manure (200 kg N ha^{-1}) decreased it significantly to 45% of the control value. However, the decrease in density concerned only the adults (Table 1).

In the investigated meadow, 24 species of oribatid mites were found in total. The highest number of species was in the plot fertilized with the lowest dose of pig manure, while the lowest species number was at the highest dose of the manure. The Shannon index decreased with the dose of both types of manure (Table 1).

Five oribatid species achieved the dominance above 10%: *Achipteria coleoptrata* (Linnaeus, 1758), *Eupelops occultus* (C.L. Koch, 1835), *Galumna obvia* (Berlese, 1914), *Liebstadia similis* (Michael, 1888), and *Scheloribates laevigatus* (C.L. Koch, 1835). At the species level, different reactions to both types of manure were observed. *Scheloribates laevigatus* was the dominant species in all plots throughout the whole experiment. It was the most abundant in the control plot and its density decreased significantly in plots fertilized with the medium and high dose (140 and 200 kg N ha^{-1}) of goat manure. Similarly, the density of adults was limited by the same doses of goat manure, while the juvenile forms were not affected by any type of fertilization. The dominance of *S. laevigatus* among the Oribatida generally increased with the dose of fertilizer (Table 2).

Like *S. laevigatus*, also other abundant species – *Liebstadia similis*, *Galumna obvia* and *Achipteria coleoptrata* – noticeably declined after the application of manure. *Liebstadia similis* decreased its abundance after fertilization with the highest dose (200 kg N ha^{-1}) of both types of manure. The negative reaction to fertilizer was

Table 1. Abundance (A, in 10^3 individuals/m^2; tot = total, ad = adults, juv = juveniles), number of species (S), and Shannon (H') index of Oribatida in the investigated plots; SD = standard deviation, F, p = results of the Tukey test

Parameter	Plot							ANOVA	
	0	1	2	3	4	5	6		
Manure	none	pig	pig	pig	goat	goat	goat		
Dose (kg N·ha^{-1})	0	80	140	200	80	140	200	F	p
Oribatida, tot A±SD, range	31.4^{ac}±7.8 21.4-44.2	41.2^{a}±14.4 21.4-64.4	21.6^{bc}±6.1 15.4-34.9	12.6^{d}±3.2 7.8-17.5	34.7^{ac}±13.5 18.4-57.8	25.2^{c}±9.4 13.5-44.0	15.9^{bd}±17.2 8.1-30.4	15.48	0.000
Oribatida, ad A±SD, range	26.3^{ab}±7.5 16.9-41.2	33.9^{a}±10.7 18.1-51.5	17.0^{b}±5.2 12.0-29.2	9.7^{c}±2.3 6.6-13.5	29.2^{ad}±12.0 13.2-48.8	20.6^{bd}±7.4 11.1-33.7	10.7^{c}±3.7 6.0-19.0	20.53	0.000
Oribatida, juv A±SD, range (% of total)	5.1^{ab}±2.0 2.4-7.5 16	7.3^{a}±4.5 2.7-15.4 18	4.6^{ab}±1.6 2.7-6.6 21	2.9^{b}±1.6 0.9-6.0 23	5.5^{ab}±2.2 2.4-9.0 16	4.5^{ab}±2.8 1.5-10.2 18	5.2^{ab}±5.7 1.2-20.5 33	2.32	0.043
S	17	19	13	11	17	17	14		
H'	2.01	1.92	1.78	1.52	2.02	1.95	1.72		

$^{a, b, c}$ mean values marked with the same letters are not significantly different at $p \leq 0.05$

Table 2. Abundance (A, in 10^3 individuals·m^{-2}; tot = total, ad = adults, juv = juveniles), dominance (D) and constancy (C, in % of total samples) indices of Oribatida in the investigated plots; SD = standard deviation; F, p = results of the Tukey test; * species with D<10% are listed below the table with numbers of all the plots where they were found

Parameter			Plot 0	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	ANOVA	
Manure			none	pig	pig	pig	goat	goat	goat		
Dose (kg N · ha^{-1})			0	80	140	200	80	140	200	F	p
Achipteria coleoptrata (Linnaeus, 1758)	A±SD	tot	$2.5^{a}\pm0.9$	$2.8^{a}\pm1.7$	$1.4^{ab}\pm1.0$	$0.5^{b}\pm0.4$	$2.2^{a}\pm1.1$	$2.1^{a}\pm1.0$	$1.4^{ab}\pm1.0$	6.98	0.000
	range		1.5-4.5	0.3-6.0	0.3-3.9	0-0.9	0.9-4.2	0.6-3.3	0.3-3.3		
		ad	$2.2^{a}\pm0.8$	$2.5^{a}\pm1.5$	$1.3^{ab}\pm1.0$	0.5b±0.4	$1.9^{a}\pm1.0$	$2.0^{a}\pm1.0$	$1.2^{ab}\pm0.9$	6.24	0.000
			1.2-3.9	0.3-5.1	0.3-3.6	0-0.9	0.6-3.3	0.6-3.3	0.3-3.1		
		juv	$0.3^{a}\pm0.3$	0.3a±0.3	$0.1^{a}\pm0.1$	0b	$0.3^{a}\pm0.4$	$0.1^{a}\pm0.1$	$0.2^{a}\pm0.3$	2.64	0.024
			0-0.6	0-0.9	0-0.3	0	0-0.9	0-0.3	0-0.9		
	D		7.9	6.7	5.7	3.9	5.2	8.1	7.1		
	C		100	90	85	45	95	95	70		
Eupelops occultus (C. L. Koch, 1835)	A±SD	tot	$5.2^{acd}\pm2.2$	$14.5^{b}\pm5.1$	$6.9^{ac}\pm3.3$	$2.6^{d}\pm1.3$	$9.1^{ab}\pm5.4$	$8.0^{abc}\pm5.2$	$3.7^{cd}\pm2.1$	10.77	0.000
	range		2.7-8.7	4.2-20.8	3.0-11.1	0.9-4.5	2.1-20.0	2.1-18.7	1.2-8.1		
		ad	$4.7^{acd}\pm2.1$	$13.2^{b}\pm4.7$	$6.1^{ac}\pm3.1$	$2.4^{d}\pm1.3$	$8.2^{ab}\pm4.8$	$7.1^{ab}\pm4.7$	$3.0^{cd}\pm1.4$	11.19	0.000
			2.4-8.7	3.9-18.1	2.7-10.5	0.6-4.5	1.5-16.6	2.1-17.5	1.2-5.4		
		juv	$0.5^{ab}\pm0.5$	$1.3^{a}\pm1.2$	$0.8^{ab}\pm0.6$	$0.1^{b}\pm0.1$	$0.9^{ab}\pm0.9$	$0.9^{ab}\pm1.0$	$0.7^{ab}\pm1.8$	3.06	0.011
			0-1.2	0.3-3.0	0-1.8	0-0.3	0.3-3.0	0-3.0	0-5.7		
	D		16.2	35.1	31.9	19.9	26.2	31.8	18.5		
	C		100	100	100	95	100	100	80		
Galumna obvia (Berlese, 1914)	A±SD	tot	$3.7^{a}\pm1.8$	$3.8^{a}\pm3.2$	$2.1^{a}\pm1.6$	$0.2^{b}\pm0.3$	$3.4^{a}\pm1.8$	$2.6^{a}\pm1.4$	$0.3^{b}\pm0.3$	19.75	0.000
	range		0.9-6.6	0.9-11.1	0.3-4.8	0-0.6	1.5-6.9	0.6-5.1	0-0.9		
		ad	$2.8^{a}\pm1.6$	$3.2^{a}\pm2.5$	$1.7^{a}\pm1.4$	$0.1^{b}\pm0.2$	$2.7^{a}\pm1.7$	$2.0^{a}\pm1.2$	$0.2^{b}\pm0.2$	16.71	0.000
			0.9-5.7	0.9-9.0	0.3-4.2	0-0.6	0.6-6.0	0-3.9	0-0.3		
		juv	$0.9^{a}\pm0.7$	$0.7^{ab}\pm0.8$	$0.3^{ab}\pm0.5$	$0.1^{b}\pm0.1$	$0.7^{ab}\pm0.6$	$0.6^{ab}\pm0.4$	$0.1^{b}\pm0.3$	4.30	0.001
			0-1.8	0-2.1	0-1.5	0-0.3	0-1.8	0.3-1.2	0-0.9		
	D		11.7	9.2	10	1.25	9.7	10.3	1.3		
	C		100	95	85	20	100	85	30		

Liebstadia similis (Michael, 1888)	*A*±SD	tot	3.9^{ad}±2.0	3.2^{abd}±1.7	1.8^{abc}±0.8	1.3^{bc}±0.7	5.0^{d}±2.8	2.3^{abd}±1.2	0.9^{c}±1.1	10.65	0.000
	range		1.5-8.1	0.3-5.4	0.6-3.3	0.3-2.4	1.8-9.9	1.2-5.1	0-3.3		
		ad	3.1^{a}±1.8	1.8^{abc}±1.2	0.9^{bcd}±0.7	0.5^{cd}±0.4	3.6^{a}±2.5	1.7^{ab}±0.9	0.4^{d}±0.5	11.99	0.000
			0.9-7.2	0-3.6	0-2.4	0-1.5	0.9-7.8	0.3-3.3	0-1.5		
		juv	0.8^{ab}±0.7	1.4^{a}±1.1	0.9^{ab}±0.2	0.8^{ab}±0.6	1.4^{a}±0.8	0.5^{ab}±0.6	0.5^{b}±0.6	3.10	0.011
			0-2.4	0.3-3.0	0.3-1.2	0-.2.1	0.3-3.0	0-1.8	0-1.8		
	D		12.1	7.8	9.1	10.5	14.4	9.2	4.9		
	C		100	90	90	85	95	90	50		
Scheloribates laevigatus (C. L. Koch, 1835)	*A*±SD	tot	10.8^{a}±2.4	10.1^{ab}±5.0	6.8^{ab}±2.4	6.3^{ab}±2.1	9.4^{ab}±4.3	6.3^{b}±3.4	5.9^{b}±3.4	3.74	0.003
	range		8.4-16.0	3.3-20.8	3.9-10.8	3.0-9.3	4.2-16.6	1.8-12.3	2.1-13.5		
		ad	8.5^{a}±2.6	7.5^{ab}±3.4	4.9^{ac}±2.2	4.9^{ac}±1.7	7.8^{ab}±3.6	4.9^{bc}±2.7	3.5^{c}±1.4	5.42	0.001
			5.4-13.8	2.4-14.7	2.7-9.0	2.7-7.5	3.0-13.2	1.2-9.3	1.5-6.6		
		juv	2.2^{a}±0.8	2.6^{a}±2.0	1.9^{a}±0.9	1.4^{a}±1.0	1.6^{a}±1.0	1.3^{a}±1.0	2.3^{a}±2.9	1.07	0.387
			0.9-3.3	0.3-6.0	0.6-3.0	0-3.3	0.3-3.0	0-3.0	0.3-9.9		
	D		34.4	24.4	31.6	50.4	27.0	25.2	38.9		
	C		100	100	100	100	100	100	100		

$^{a, b, c}$ mean values marked with the same letter are not significantly different at $p \leq 0.05$

* *Ceratozetes gracilis* (Michael, 1884) (0, 1, 2, 3, 4, 5, 6); *Damaeus onustus* C. L. Koch, 1841 (0, 1, 2, 3, 4, 5); *Dissorhina ornata* (Oudemans, 1900) (1, 2, 4, 5), *Eniochthonius minutissimus* (Berlese, 1903) (0, 1, 5, 6); *Hypochthonius luteus* Oudemans, 1917 (0, 1, 4); *Liebstadia humerata* (Sellnick, 1928) (0, 1, 2, 3, 4, 5, 6); *Malaconothrus monodactylus* (Michael, 1888) (2, 3, 6); *Metabelba pulverosa* Strenzke, 1953 (0, 1, 4, 5); *Nanhermannia nana* (Nicolet, 1855) (0, 1, 4, 5); *Nothrus palustris* C. L. Koch, 1839 (1, 2, 4); *Oppiella nova* (Oudemans, 1902) (0, 1, 2, 3, 4, 5, 6); *O. subpectinata* (Oudemans, 1901) (1); *Oribatula exilis* (Nicolet, 1855) (6); *Pantelozetes paolii* (Oudemans, 1913) (0, 1, 2, 4, 5, 6); *Parachipteria bella* (Sellnick, 1928) (0, 1, 3, 4, 5, 6); *Phauloppia lucorum* (C. L. Koch, 1841) (4, 5); *Platynothrus peltifer* (C. L. Koch, 1839) (0, 1, 2, 3, 4, 5, 6); *P. thori* (Berlese, 1904) (1); *Trichoribates novus* (Sellnick, 1928) (0, 1, 2, 3, 4, 5, 6)

only observed in adults of this species, but not in juveniles. The population density of *Achipteria coleoptrata* decreased after fertilization with the highest dose of pig manure, similarly to that of *Galumna obvia*, after fertilization with the highest dose of both types of manure. In both the species the adults and juveniles suffered from fertilizing.

In contrast to the species mentioned above, *Eupelops occultus* seemed to benefit from more intensive fertilization. After the application of the low dose of pig manure, its density increased nearly 3-fold in comparison to the control plot and this was due to the significant increase in the density of adults. Additionally, in all fertilized plots the dominance of *E. occultus* among the Oribatida was higher than in the control plot. In all species except *Scheloribates laevigatus*, the constancy index decreased with the dose of manure (Table 2).

DISCUSSION

In this study a negative effect of high doses of pig and goat manure (200 kg N ha^{-1}) on the oribatid mites was observed. The density of these mites decreased to 45%, in comparison to the control plot, and the number of species was also reduced. Similarly, Bielska (1986) observed a decrease in the density and number of species of Oribatida with an increasing amount of liquid manure. In other studies, however, high doses of liquid manure in the grasslands reduced the density of the mites, but not their species richness (Bolger & Curry 1980; Domek-Chruścicka & Seniczak 2005; Sokołowska & Seniczak 2005; Graczyk et al. 2008; Wasińska-Graczyk et al. 2009; Kruczyńska & Seniczak 2011).

Some of the cited studies were carried out in the same meadow as the experiment presented here, what is an advantage for comparison of the results. In different meadows the same doses of liquid manure may have a positive or negative effect on the mites, as presented by Bielska & Paszewska (1995). Additionally, many environmental factors can modify the effect of fertilizer on the mites. For example, moisture conditions can change the sensitivity of the microarthropods to organic or mineral fertilizers (Fratello et al. 1989). In the meadow in Minikowo the doses of cattle liquid manure that reduced the density of Oribatida ranged from 30 m^3·ha^{-1} to 90 m^3·ha^{-1}, which correspond to the doses of 90-270 kg N ha^{-1} (Domek-Chruścicka & Seniczak 2005; Graczyk et al. 2008; Kruczyńska & Seniczak 2011) and those of pig liquid manure were 20-60 m^3·ha^{-1}, which correspond to the doses of 60-180 kg N ha^{-1} (Wasińska-Graczyk et al. 2009).

In the present study, the highest applied dose of nitrogen deliberately exceeded the limit regulated by the law, which is 170 kg N ha^{-1} (Ustawa … 2007), to obtain more pronounced results. Similar experiments with elevated doses of nitrogen were also conducted by other authors, e. g. Jankowska-Huflejt (1998) tested the dose of 240 kg N ha^{-1}, and Trojanowski & Baluk (1992), up to 270 N ha^{-1}. Trojanowski & Baluk (1992) noted a positive influence of a dose of 180 kg of mineral N ha^{-1}, and a negative influence of higher doses of N on the density of mites.

Bolger & Curry (1980) explained that the applied fertilizer affected negatively the mites due to a toxic action of ammonia. This seems to be the main reason of the changes in mite density in the present study. Fertilization also increases the soil pH, and this may affect negatively the soil fauna, including the mites, because most species prefer acidic conditions. For example, a study of the effect of fertilization and pH on springtail communities in the forest soil showed that acidity was an essential factor changing them (Koskenniemi & Huhta 1986). However, such an explanation cannot be applied to the present study. The soil in the control plot had a neutral pH (7.3), and changes in pH after the application of manure were minute; the highest observed value of pH (7.4) was at the highest dose of goat manure (Szczukowska 2015).

Lower and medium doses of both types of manure (80 and 140 kg N ha^{-1}) did not affect the density of Oribatida, because they were probably too high to cause a positive effect. In the other experiments carried out in the same meadow, fertilization had a positive effect on the density of soil fauna, including the mites in general and the Oribatida, when the amount of applied pig or cattle liquid manure was 10-20 m^{3}·ha^{-1}, which corresponded to the doses of 30-60 kg N ha^{-1} (Domek-Chruścicka & Seniczak 2005; Sokołowska & Seniczak 2005). According to Miklaszewski (1982), the density of mites increased with higher doses of nitrogen. Also some other studies showed that fertilization positively affected the soil fauna, including the mites, increasing their density and/or species diversity (Nakamura 1976; Purvis & Curry 1984). However, it is difficult to compare the doses used there with the ones applied in the present experiment.

Weil & Kroontje (1979) tested several doses of poultry manure in arable soils, which were comparable (27 t, 54 t, 85 t and 110 t ha^{-1} annually) with the doses applied in the present study (pig manure – 43 t, 76 t and 109 t ha^{-1}, goat manure – 49 t, 87 t and 124 t ha^{-1}). The total abundance of soil arthropods increased in all fertilized plots in comparison to the control, so that contrasts with the results obtained here, but the species diversity was greatly reduced by the manuring, like in the present study. According to Weil & Kroontje (1979), if the manure is fresh, it may initially depress the native soil fauna, but after a month or so of decay, the soil fauna respond favourably. However, in their study the oribatid mites made up only a small fraction of the Acari.

Surprisingly, the fertilization reduced significantly the density of the adults, but not of the juveniles. This is in contrast with the observations of Bielska (1986), who reported that a more direct effect of liquid manure changed the ratio of adults to juveniles in favour of the adults. In the present study, the relatively high abundance of juvenile forms can be explained by a lower density of the predatory Mesostigmata after fertilization (Szczukowska 2015). These mites attack mostly the juvenile oribatids, so when their abundance decreased due to fertilization, the participation of juvenile forms increased.

Among the Oribatida, different species reacted differently to fertilization. The most abundant *Scheloribates laevigatus* was sensitive only to goat manure and its density decreased after the application of the medium and high dose of this fertilizer (140 and 200 kg N ha^{-1}). In other studies it also reacted negatively to cattle liquid manure (Graczyk et al. 2008; Kruczyńska & Seniczak 2011) and pig liquid manure (Wasińska-Graczyk et al. 2009). However, due the reduced density of oribatids, their dominance increased in the most fertilized plots, like in one of the earlier studies (Kruczyńska & Seniczak 2011). Other abundant species, *Liebstadia similis* and *Galumna obvia*, declined after the application of the highest dose of both types of manure, while *Achipteria coleoptrata*, only in the plot with the highest dose of pig manure. *Achipteria coleoptrata* also reacted negatively to cattle liquid manure (Graczyk et al. 2008). In contrast, *Eupelops occultus* reacted positively to low and middle doses of both kinds of manure, but negatively to the highest dose of pig and goat manure. Similar results were obtained in a study on the effect of ammonia water on mites, where *E. occultus* reacted positively to low and middle doses of nitrogen and negatively to a high dose (Seniczak et al. 2005).

CONCLUSIONS

The effect of farmyard manure on the total Oribatida depended on the dose but not on manure type. The highest dose of pig or goat manure (200 kg N ha^{-1}), decreased the density of Oribatida and reduced their species richness, while 2 lower doses did not affect the oribatid mites. However, at the species level, different reactions to pig and goat manure were observed: the density of most species was significantly reduced, compared to the control plot, but that of *Eupelops occultus* increased in the plot with a low dose of pig manure. These changes concerned the adults, not the juveniles.

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