Folia biologica (Kraków), vol. **53** (2005), Supplement

The Influence of Sheep, Cattle and Horse Grazing on Soil Mites (Acari) of Lowland Meadows

Bogusław CHACHAJ and Stanisław SENICZAK

Accepted November 4, 2005

CHACHAJ B., SENICZAK S. 2005. The influence of sheep, cattle and horse grazing on soil mites (Acari) of lowland meadows. Folia biol. (Kraków) **53** (Suppl.): 127-132.

Soil mites in lowland pastures grazed by sheep, cattle and horses and hay-growing meadows were investigated near Bydgoszcz. Samples were taken in spring, summer and autumn of 2001 and 2002 from the lower parts of plants (0-3 cm) and 2 soil layers, 0-3 cm and 3-6 cm. The grazing animals reduced the density of mites and species richness of Oribatida as compared to the control plots. The impact of sheep and cattle grazing on mites was higher than that of horses. Among the mites the Oribatida predominated, while the Gamasida were less abundant. Some species preferred the meadows while others preferred the pastures. *Liebstadia similis* predominated in the pastures grazed by sheep and cattle and *Heminothrus peltifer* – on those grazed by horses. Most mites inhabited the lower parts of plants; their density in the soil decreased with soil depth.

Key words: Pasture grazing, sheep, cattle, horses, Acari, Oribatida, Gamasida.

Bogusław CHACHAJ, Stanisław SENICZAK, Department of Ecology, University of Technology and Agriculture, Kordeckiego 20, 85-225 Bydgoszcz, Poland.
E-mail: chachaj@mail.atr.bydgoszcz.pl

The activity of grazing animals in pastures depends on their number per ha and species. Different grazers modify to a different extent the plant associations and the soil. Sheep and cattle walk on 2 hooves and damage the turf more than horses, which have one hoof. Treading by grazing animals affects the physical properties of the soil such as porosity, bulk density, infiltration (GIFFORD & DADKHAH 1980; TOLLNER *et al.* 1990; DI *et al.* 2001). Grazers affect the plant composition because the sheep browse more selectively than cattle and horses. Grazing animals also stimulate the soil fauna through their excrements. Additionally, pastures are subject to other human activities such as draining and fertilising, and therefore are usually poorer in mite species than meadows (BARDGETT & COOK 1998; BEHAN-PELLETIER 1999). Generally these activities favour soil bacteria and accelerate the decay of soil organic matter, decreasing the heterogeneity and stability of the landscape.

The aim of this study was to assess the influence of sheep, cattle and horse grazing on soil mites, with species analysis of Oribatida, which usually predominate in mite associations and comprise mainly saprophags.

Material and Methods

The study areas were located in the Noteć valley near Bydgoszcz. The sheep (Polish merino breed) and cattle (Polish black-white breed) pastures were situated in Zielonczyn, the horse (Wielkopolska breed) pasture in Gorzeń, and the control plots (hay-growing meadows) were in both villages (Fig. 1). The plant associations were classified with the BRAUN-BLANQUET method, modified by BARKMAN *et al*. (1964). The hay-growing meadow in Zielonczyn (plot 1) was classified as *Molinio-Arrhenatheretea*. A total of 29 vascular plant species were recorded, with dense *Dactylis glomerata* L. and less frequent *Deschampsia caespitosa* (L.),

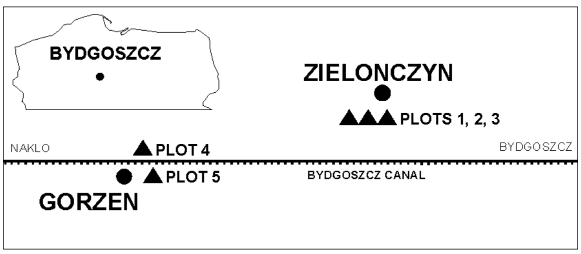

Fig. 1. The location of investigated pastures and meadows.

Phleum pratense L., *Poa pratensis* L. and *Galium mollugo* L.

In the sheep pasture (plot 2) the number of plant species was limited to 17; the plant association was between *Lolio-Cynosuretum*, *Matricario matricarioidis-Polygonetum arenastri* and flooded *Potentilletum anserinae*. Typical meadow species (*Poa pratensis*, *Ranunculus repens* L. and *Achillea millefolium* L.) predominated here and plants which tolerate grazing were frequent (*Lolium perenne* L., *Bellis perennis* L., *Trifolium repens* L., *Plantago major* L. and *Potentilla anserina* L.). In the cattle pasture (plot 3) 25 plant species were present, forming the plant association *Lolio-Cynosuretum*. Typical meadow plant species predominated and plants which tolerate grazing were less frequent (*Trifolium repens*, *Bellis perennis* and *Lolium perenne*).

The hay-growing meadow in Gorzeń (plot 4) belonged to the plant association *Arrhenatheretum elatioris*, with 21 vascular plant species, dense *Arrhenatherum elatius* (L.). P. BEAUV. ex J. PRESL & C. PRESL and less frequent *Plantago lanceolata* L., *Achillea millefolium* and *Galium mollugo*. The horse pasture (plot 5) had 18 plant species and represented the plant association *Stellario palustris-Deschampsietum cespitosae*, with dense *Deschampsia cespitosa* and less frequent *Ranunculus repens*, *Potentilla anserina* and *Poa pratensis*. The plant cover in the cattle pasture was 90%, in the other pastures and meadows it was 100%. All pastures were used for grazing for about 20 years and in the last 5 years the number of individuals (and weight in t ha^{-1}) was the following: sheep – 25 (1.3), cattle – 2.5 (1.0) and horses – 6.7 (4.0). The soils belong to the mucky soil group.

Samples of 16.7 cm^2 x 9 cm high were taken in spring, summer and autumn in 2001 and 2002, in all plots in 20 replicates, including the lower parts of plants (G, 0-3 cm) and 2 soil layers, S1 (0-3 cm) and S2 (3-6 cm). The mites were extracted in modified TULLGREN funnels. The Oribatida were determined to species or genus, both the juvenile stages and adults. From a total of 1,800 samples nearly 34,810 mites were determined, including 23,966 Oribatida. Mites were characterised by abundance (*A*), dominance (*D*) and constancy (*C*) indices, and the species diversity with the SHANNON *H* index (ODUM 1982). In statistical calculations the TUKEY HSD test (ANOVA/MANOVA of Statistica5) was used. Additional information on the study areas, plant associations and list of oribatid species has been published earlier (CHACHAJ *et al.* 2005; CHACHAJ & SENICZAK 2005).

Results

Sheep, cattle and horse grazing reduced the density of mites and species number of Oribatida compared to the control plots (Table 1). The influence of sheep and cattle grazing on mites was higher than that of horses, which is mainly connected with the pressure on the soil of 2 hooved sheep and cattle, and one hooved horses. In this investigation the mean pressure of sheep was 1.1 kg cm^{-2}, cattle 2.0 kg cm^{-2} and horses 1.8 kg cm^{-2}. Among the mites, the Oribatida predominated, and the Gamasida were less abundant. Fewer species of Oribatida inhabited the pastures and the *H* index was distinctly lower than in the meadows.

Table 1

Density (*A* in thousand indiv. m^{-2}) of mites and species number (*S*) and *H* index of Oribatida in the investigated plots; * – significantly different at P<0.05

Group		Plot				
		1	2	3	4	5
Acari	*A*	22.4	9.2*	12.0	78.4	52.7*
Gamasida	*A*	4.4	3.0	1.9*	7.3	6.2
Oribatida	*A*	11.7	3.5	6.9	59.4	38.8*
	S	24	20	22	31	19
	H	2.1	1.6	1.4	2.3	1.0

In the control plot in Zielonczyn (plot 1) *Scheloribates laevigatus* predominated (Table 2), *Achipteria coleoptrata*, *Eupelops occultus*, *Malaconothrus* sp. and *Oribella paoli* were less abundant. Sheep grazing favoured *Eupelops occultus*, which was the most abundant, less abundant species included *Topobates* sp., *Heminothrus peltifer* and *Achipteria coleoptrata*. In cattle pastures *Eupelops occultus* also predominated, *Liebstadia similis*, *Scheloribates laevigatus* and *Liebstadia humerata* were less abundant. In the control plot in Gorzeń (plot 4) *Scheloribates laevigatus* also predominated, *Liebstadia similis*, *Eupelops occultus* and *Achipteria coleoptrata* were less abundant. In the horse pasture, *Heminothrus peltifer* highly predominated, while *Eupelops occultus*, *Topobates* sp. and *Achipteria coleoptrata* were less abundant. The constancy indices of all these species were rather high, as they are considered typical for meadows (RAJSKI 1968).

Most oribatid species were sensitive to animal grazing and their density in the pastures was lower than in the meadows. Some species (*Eupelops occultus*, *Heminothrus peltifer*, *Topobates* sp.) tolerated animal grazing more than the others (*Scheloribates laevigatus* and *Achipteria coleoptrata*), and achieved a higher dominance index in pastures than in meadows. *Eupelops occultus* predominated in the pastures grazed by sheep and cattle,

Table 2

Density (*A* in thousand indiv. m^{-2}), dominance (*D*) and constancy (*C*) indices of some oribatid taxa in the investigated plots; * significantly different at P<0.05; + at *A*<0.1

Taxon	Plot														
	1			2			3			4			5		
	A	*D*	*C*	*A*	*D*	*C*	*A*	*D*	*C*	*A*	*D*	*C*	*A*	*D*	*C*
Achipteria coleoptrata (L.)	2.3	19.9	74	0.3*	7.7	26	+*	0.2	2	6.4	10.9	97	2.3*	5.9	78
Achipteria 1	+	0.1	2							2.4	4.1	76	+*	+	1
Eupelops occultus (C. L. Koch)	1.3	11.5	69	1.4	39.2	68	2.4	34.6	79	6.9	11.5	98	6.3	16.1	98
Heminothrus peltifer (C. L. Koch)	0.1	1.1	17	0.4	10.2	27	+	0.1	1	0.1	0.1	6	26.6*	68.5	99
Liebstadia humerata Sellnick	+	0.1	2	+	0.3	2	0.2	2.1	6	2.2	3.7	59	+*	+	2
L. similis (Michael)	+	0.2	3	+	0.4	3	2.2*	31.4	75	12.2	20.6	10	+*	+	3
Malaconothrus sp.	1.3	10.9	57				+*	0.1	1	2.4	4.1	68	0.2*	0.4	12
Nanhermannia comitalis Berlese	+	0.2	3	+	0.6	3	+	0.1	1	1.4	2.4	56	0.1*	0.3	12
Oribella paoli Oudemans	1.2	10.3	42				+*	0.1	1	2.8	4.7	68	+*	+	2
Scheloribates laevigatus (C. L. Koch)	3.6	30.8	87	+*	0.4	3	1.8	26.4	77	15.7	26.5	10			
S. latipes (C. L. Koch)	0.3	2.2	19							3.2	5.4	89	+*	+	1
Topobates sp.				1.1	32.2	63				0.5	0.8	14	3.1*	8.0	83
Trichoribates novus (Sellnick)	0.5	4.4	43	+*	0.3	2	+*	0.2	2	0.1	0.2	14	0.1	0.1	8

Table 3

Density (thousand indiv. m^{-2}) of adult (a) and juvenile stages (j) of Oribatida and some oribatid taxa in the investigated plots

Taxon		Plot				
		1	2	3	4	5
Oribatida	a	5.8	2.1	3.0	27.7	12.6
	j	5.9	1.3	3.9	31.6	26.2
A. coleoptrata	a	1.9	0.2	<0.1	3.8	1.6
	j	0.5	0.1	<0.1	1.6	0.6
Achipteria 1	a	<0.1			2.4	<0.1
	j				1.1	
E. occultus	a	0.7	0.8	1.2	4.3	3.4
	j	0.6	0.5	1.2	2.6	2.8
H. peltifer	a	<0.1	0.1		<0.1	5.3
	j	0.1	0.3	<0.1	<0.1	21.3
L. similis	a		<0.1	1.0	4.0	<0.1
	j	<0.1	<0.1	1.1	8.2	<0.1
Malaconothrus sp.	a	0.7			1.3	0.1
	j	0.6		<0.1	1.1	+
N. comitalis	a	<0.1	<0.1	<0.1	0.4	0.1
	j	<0.1	<0.1		1.0	<0.1
N. nanus	a	0.2		<0.1	0.2	0.1
	j	0.1		<0.1	0.3	<0.1
O. paoli	a	0.3			1.7	<0.1
	j	0.9		<0.1	1.1	
S. laevigatus	a	1.2	<0.1	0.5	4.7	
	j	2.4		1.3	11.0	
S. latipes	a	0.1			1.5	<0.1
	j	0.1			1.8	
Topobates sp.	a		0.7		0.4	1.8
	j		0.4		0.1	1.3
T. novus	a	0.1	<0.1	<0.1	<0.1	<0.1
	j	0.4	<0.1	<0.1	0.1	<0.1

Table 4

Vertical distribution of mites and adult (a) and juvenile stages (j) of Oribatida in the investigated plots (density in indiv. 100 cm^{-3} is given); G – lower part of plants, S1 and S2 – soil layers; + at <0.1 indiv. 100 cm^{-3}; nd – not divided into adult and juvenile stages

Taxon	Layer	Plot 1			Plot 2			Plot 3			Plot 4			Plot 5		
		a	j	a+j	a	j	a+j	a	j	a+j	a	j	a+j	a	j	a+j
Acari	G	nd	nd	42	nd	nd	19	nd	nd	28	nd	nd	176	nd	nd	134
	S1	nd	nd	28	nd	nd	8	nd	nd	9	nd	nd	77	nd	nd	36
	S2	nd	nd	5	nd	nd	3	nd	nd	3	nd	nd	7	nd	nd	6
Oribatida	G	11	13	24	5	4	9	8	11	19	60	82	142	34	78	112
	S1	8	6	14	2	+	2	2	1	4	31	23	54	8	9	16
	S2	1	+	1	+	+	+	+	+	+	1	1	2	1	+	1
A. coleoptrata	G	4	1	5	+	+	+	+		+	9	1	10	4	1	5
	S1	2	1	3	+	+	+	+		+	3	4	11	1	1	3
	S2	+	+	+		+	+				+	+	+	+	+	+
E. occultus	G	2	2	3	2	2	4	3	3	6	11	6	17	10	7	17
	S1	1	+	1	1	+	1	1	1	2	3	2	5	2	2	3
	S2	+	+	+	+		+	+	+	+	+	+	+	+	+	+
H. peltifer	G	+	+	+	+	1	1					+	+	14	67	81
	S1	+	+	+										3	4	7
	S2		+	+							+	+	+	+	+	+
L. similis	G		+	+		+	+	3	4	6	11	27	38		+	+
	S1		+	+	+		+	1	+	1	2	1	3	+		+
	S2								+	+	+	+	+			
Malaconothrus sp.	G	1	1	1							1	1	2	+	+	+
	S1	2	1	3					+	+	3	3	6	+	+	+
	S2	+	+	+							+	+	+			
O. paoli	G	+	+	+					+	+	1	+	2	+		+
	S1	1	3	4							4	3	8			
	S2	+	+	+							+		+			
S. laevigatus	G	3	7	10	+		+	1	4	5	11	35	46			
	S1	1	1	2	+		+	+	+	1	4	2	6			
	S2	+	+	+	+		+		+	+	+	+	+			
S. latipes	G	+	+	1							4	6	10			
	S1	+		+							1	+	1			
	S2										+	+	+	+		+
Topobates sp.	G				2	1	3				1	+	1	5	3	8
	S1				+	+	1				+	+	+	1	1	2
	S2				+		+					+	+	+	+	+

while *Heminothrus peltifer* was the most abundant in the pasture grazed by horses.

In all plots, juvenile stages predominated among oribatid mites, except the sheep pasture in which adults were more abundant (Table 3). In some species (*Heminothrus peltifer*, *Liebstadia similis* and *Scheloribates laevigatus*) the juvenile stage was distinctly more abundant than adults, while in the other species the density of juvenile stages and adults was similar or the adults predominated.

In all investigated plots most oribatid species were recorded from the lower part of plants, both as juveniles and adults, and their density decreased with soil depth (Table 4). Such a distribution was observed in abundant species such as *Scheloribates laevigatus*, *Achipteria coleoptrata*, *Eupelops occultus*, *Heminothrus peltifer* and *Topobates* sp., but some species (*Malaconothrus* sp. and *Oribella paoli*) preferred the upper soil layer.

Discussion

Soil mesofauna, including mites, play an important role in soil processes and in decomposition of organic matter (WALLWORK 1976), and on the other hand the content and type of organic matter affect the abundance and species composition of soil fauna. In forest soils, with thick litter and mycelium-feeding fauna, mites are very abundant (SENICZAK 1978), while in agricultural soils, with bacterial-feeding fauna and quick decay of soil organic matter, the density of mites is rather low (BARDGETT & COOK 1998; BEHAN-PELLETIER 1999).

Treading pastures by grazing animals affects the physical properties of the soil and plant growth and usually degrades the living conditions for mites. For example, DI *et al.* (2001) observed increased bulk density and decreased macroporosity and humidity of soil with increasing intensity of treading. Probably for this reason sheep, cattle and horse treading distinctly reduced the density and species number of mites in the investigated pastures, compared to the meadows, as in BARDGETT & COOK (1998) and HUBERT (2000). In this study the influence of sheep and cattle grazing on mites was higher than that of horses, which was probably caused by greater turf damage by two hooved grazers. Treading also increased the participation of clover, which tolerated grazing and increased N content in the soil and therefore accelerated the decay of soil organic matter, decreasing the density of mites.

Oribatida predominated in the mite communities, with the most abundant *Scheloribates laevigatus* in both meadows, and less abundant *Achipteria coleoptrata* and *Eupelops occultus*, considered typical for meadows (RAJSKI 1968). Some mite species (*Scheloribates laevigatus*, *Achipteria coleoptrata*, *Oribella paoli*) preferred meadows, while the others (*Eupelops occultus*, *Heminothrus peltifer*, *Topobates* sp.) preferred pastures. In sheep and horse pastures *Eupelops occultus* predominated while *Heminothrus peltifer* was the most abundant in the horse pasture.

Many oribatid species lived on the lower parts of plants, which has important epidemiological significance because these organisms may be considered as potential hosts of cestoids from the group of Anoplocephalata, which parasitize sheep and cattle (RAJSKI 1959; SENGBUSH 1977). The presence of juvenile stages of these mites on the lower parts of plants also suggests that some oribatid species can reproduce there.

In the pastures the domination index of some species, mainly *Heminothrus peltifer*, was higher, and the species richness of mites was lower than in the meadows, which suggests decreasing heterogeneity of the habitat (THIENEMANN 1939) and has functional consequences. Intensive grazing favours the bacterial pathways (BARDGETT & COOK 1998), with bacterial-feeding fauna, and reduces the species richness of Oribatida and makes the habitat less heterogeneous, compared to fungal pathways, with fungal-feeding fauna, and consequently decreases the stability of the landscape.

The mite communities of pastures are poor in species, making it relatively easy to investigate the biology and ecology of soil mites. For example, LUXTON (1982, 1983) determined the juvenile stages and adults of many species of Cryptostigmata, Mesostigmata, Prostigmata and Astigmata in the pastures of New Zealand and showed their seasonal dynamics and the number of generations during the year.

The obtained results led to the following conclusions:

1. Sheep, cattle and horse grazing reduced the density of mites and species number of Oribatida in comparison to hay-growing meadows; the impact of sheep and cattle grazing on mites was higher than that of horses.

2. Some mite species (*Scheloribates laevigatus*, *Achipteria coleoptrata*, *Oribella paoli*) preferred meadows, while others (*Eupelops occultus*, *Heminothrus peltifer*, *Topobates* sp.) preferred pastures.

3. *Eupelops occultus* predominated in the pasture grazed by sheep and cattle, and *Heminothrus peltifer* – grazed by horses.

4. The soil mites as a group and the Oribatida preferred the lower parts of plants.

References

BARKMAN J. J., DOING H., SEGAL S. 1964. Kritische Bemerkungen und Vorschlage zur quantitativen Vegetationsanalyse. Acta Bot. Neerl. **13**: 394-419.

BARDGETT R. D., COOK R. 1998. Functional aspects of soil animal diversity in the agricultural grasslands. Applied Soil Ecology **10**: 263-276.

BEHAN-PELLETIER V. 1999. Oribatid mite biodiversity in agroecosystems: role for bioindication. Agriculture, Ecosystems and Environment **74**: 411-423.

CHACHAJ B., SENICZAK S., WALDON B., KOBIERSKI M. 2005. The effect of sheep, cattle and horse grazing on the meadow mites (Acari). Zesz. Nauk. ATR Bydgoszcz. Zootechnika **36**: (in press). (In Polish).

CHACHAJ B., SENICZAK S. 2005. The effect of sheep, cattle and horse grazing on some oribatid mites (Acari, Oribatida). Zesz. Nauk. ATR Bydgoszcz. Zootechnika **36**: (in press). (In Polish).

DI H. J., CAMERON K. C., MILNE J., DREWRY J. J., SMITH N. P., HENDRY T., MOORE S., REINEN B. 2001. A mechanical hoof for simulating animal treading under controlled conditions. New Zeland of Agricultural Research **44**: 111-116.

GITFORD G. R., DADKHAH M. 1980. Trampling effects on rangeland. Utah Science **41**: 71-73.

HUBERT J. 2000. The oribatid community (Acari: Oribatida) on a dry cow pasture. Ecológia (Bratisl.) **19**: 354-364

LUXTON M. 1982. Studies on the invertebrate fauna of New Zealand peat soils IV. Pasture soils on Rukuhia peat. Pedobiologia **24**: 297-308.

LUXTON M. 1983. Studies on the invertebrate fauna of New Zealand peat soils V. Pasture soils on Kaipaki peat. Pedobiologia **25**: 135-148.

ODUM E. 1982. Fundamentals of Ecology. PWR & L. Warsaw. (In Polish).

RAJSKI A. 1959. Moss-mites (Acari: Oribatei) as intermediate hosts of Anoplocephalata. Review. Zesz. Nauk. UAM. Biol. Poznań **2**: 163-192. (In Polish).

RAJSKI A. 1968. Autecological-zoogeographical analysis of moss mites (Acari, Oribatei) on the basis of fauna in the Poznań environs. Part II. Fragm. Faun. **14**: 277-403.

SENGBUSH H. G. 1977. Review of oribatid mites-anoplocephalan tapeworm relationship (Acari: Oribatei: Cestoda: Anoplocephalidae). Proc. Symp. East. Br. Ent. Soc. Am. **70**: 87-102.

SENICZAK S. 1978. Juvenile stages of moss mites (Acari, Oribatei) as an essential component of agglomerations of these mites transforming the organic matter of soil. Rozprawy UMK Toruń. (In Polish).

THIENEMANN A. 1939. Grundzüge einer allgemainen Oecologie. Arch. Hydrobiol. **35**: 267-285.

TOLLNER E. W., CALVERT G. V. & LANGDALE G. 1990. Animal trampling effects on soil physical properties of two Southeastern U.S. Ultisols. Agriculture, Ecosystems and Environment **33**: 75-87.

WALLWORK J. A. 1976. The distribution and diversity of soil fauna. Academic Press, London.