EFFECTS OF SHEEP TREADING ON PLANT COVERING AND SOIL ORIBATIDA (ACARI) IN A WOODED HAY MEADOW IN SOGN (NORWAY)

WPŁYW WYDEPTYWANIA GLEBY PRZEZ OWCE NA POKRYCIE ROŚLINNOŚCI I GLEBOWE MECHOWCE (ACARI, ORIBATIDA) ZADRZEWIONEJ ŁĄKI W SOGN (NORWEGIA)

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ABSTRACT

Effects of sheep treading on plant covering and soil oribatid mites in a traditionally maintained wooded hay meadow in Sogn (Norway) were investigated. Samples were taken under the elm trees in 2 zones, situated 1m from the elm trunks, heavily treaded by sheep, and 5m from these trunks. The sheep treading decreased the plant covering, especially mosses, and the density of Oribatida, but increased the participation of their juvenile stages. The Oribatida occupied mainly the upper soil layer and the density distinctly decreased with the soil depth, but the sheep treading appeased the differences of density of mites in soil layers, comparing to the zone situated 5m from the elm trunks.

KEY WORDS: traditional farming, wooded hay meadow, elm trees, sheep treading, Oribatida, juvenile stages

STRESZCZENIE

Zbadano wpływ wydeptywania gleby przez owce na roślinność i glebowe mechowce na tradycyjnie utrzymywanej, zadrzewionej łące w Sogn w Norwegii. Próby pobrano z łąki pod wiązami w 2 strefach, oddalonej 1m od pni drzew, silnie wydeptanej przez owce oraz 5m od pni drzew, jako strefie kontrolnej. Wydeptywanie łąki przez owce zmniejszyło pokrycie roślinności, zwłaszcza mchów, a także liczebność mechowców, ale zwiększyło udział ich stadiów młodocianych. W obu strefach liczba gatunków mechowców była zbliżona. Mechowce skupiały się głównie w górnej warstwie gleby, a ich zagęszczenie zmniejszało się wraz z głębokością. Wydeptywanie łąki przez owce złagodziło różnice w zagęszczeniu roztoczy w profilu glebowym w porównaniu do strefy odległej 5m od pni drzew.

SŁOWA KLUCZOWE: tradycyjne użytkowanie łąki, łąka zadrzewiona, wiązy, wydeptywanie gleby, owce, mechowce, stadia młodociane

DETAILED ABSTRACT

Zbadano wpływ wydeptywania gleby przez owce na roślinność i glebowe mechowce na tradycyjnie utrzymywanej, zadrzewionej łące w Sogn w Norwegii. Próby pobrano z łąki pod wiązami w 2 strefach, oddalonej 1m od pni drzew, silnie wydeptanej przez owce oraz 5m od pni drzew, jako strefie kontrolnej. Próby gleby o objętości 20cm^2 x 11cm głębokości pobrano w 30 powtórzeniach, a następnie podzielono je na 4 warstwy: trawę (G, 2-5cm), dolną część trawy i górną warstwę gleby (H1, 1cm traw + 1cm gleby) i środkową (H2, 2-6cm) i dolną (H3, 6-11cm) warstwę gleby. Mechowce wypłaszano w aparatach Tullgrena (ogółem 3,112 roztoczy). Wydeptywanie łąki przez owce zmniejszyło pokrycie roślinności, zwłaszcza mchów, a także liczebność mechowców, ale zwiększyło udział ich stadiów młodocianych. W obu strefach liczba gatunków mechowców była zbliżona. Mechowce skupiały się głównie w górnej warstwie gleby, a ich zagęszczenie zmniejszało się wraz z głębokością. Wydeptywanie łąki przez owce złagodziło różnice w zagęszczeniu roztoczy w profilu glebowym w porównaniu do strefy odległej 5m od pni drzew.

INTRODUCTION

In Western Norway there are still small farms, in which wooded hay meadows are used for production of fodder for sheep since a long time. Some deciduous trees like elm (Ulmus glabra) and ash (Fraxinus excelsior) grow there and are pollarded every 4-6 years, and their branches with leaves are used as fodder for sheep. The trees grow rare in the meadow, what allow the sunrays to come and stimulate the growth of herb layer, which is extensively grazed by sheep in spring and autumn, and scythed in July. This way two layers of biocenose are used for production of fodder, the tree and grass layer, supporting farmers with much more fodder for sheep than the open meadows, with only grass layer. Besides, the wood from the wooded meadows is used by farmers for tools and fire. However, during the last century these farms have been intensely displaced by conventional farming, with the application of mineral fertilizers and higher grass production.

The wooded hay meadow in Sogn represents an extensive, natural farming, situated far from the industry, and therefore is very interesting for study on the connections between plants and soil invertebrates, including oribatid mites, in semi natural ecosystem. The herb layer produces the organic matter and protects the soil against intensive evaporation, while the trees additionally produce the litter and improve living conditions for soil mites. Among the mites the most abundant were usually Oribatida, which are very good decomposers; they transform organic matter, releasing mineral compounds necessary for plant growth. They consume a lot and have in their alimentary canals a symbiotic microflora, which easily digests organic matter, even those resistant to decay such as cellulose, lignin and chitin [21, 23]. Therefore, under the tree canopies the mites are more abundant and richer in species [10, 19] than in conventional meadows, with more human practices and a mineral fertilisation. The wooded meadows improve the climate conditions of agricultural landscape because they reduce the speed of wind and accumulate more rainfall and snow than the open areas. Besides, the trees also shade the soil and protect it against an intensive evaporation, increase the species diversity of the landscape, its heterogeneity and scenic and aesthetic value [1, 2, 5, 12].

The aim of this study was to investigate the effects of sheep treading on the plant covering and the density, species number and age structure of soil oribatid mites in a traditionally maintained wooded hay meadow in the farm Grinde (Sogn, Norway).

STUDY AREAS

The farm Grinde is located on the northern side of the Sognefjord in Sogn og Fjordane interior, Leikanger municipality in Western Norway (EIS 50, N 61°11´, E 06°45´), in O1 section, with slightly oceanic climate, yearly precipitation 800-1200mm and boreonemoral vegetation zone [9]. It is a unique region, where wooded meadows have been used by farmers for centuries. An early activity of man was noted here from 2500 – 2400 BC, and farm activity, with arable fields from 500 BC. The vegetation, history and management of this area have been described [1, 2, 3].

The investigated wooded hay meadow is located 115 - 125m a. s. l., on the moraine with intrusions of marine sediments and glacial-fluvial depositions. It has an eastern exposure and is located on a steep terrain, with a slope 31-40^0. This meadow have been used for generations with sheep grazing in spring and autumn, scything in July, and tree pollarding in 4-6-year cycles. During grazing the sheep often rested near the elm trees, and therefore the vegetation and soil were heavily treaded by them. This meadow was fertilized with sheep dung every third year until World War II, and between 1940 - 1991 with some mineral fertilizers and dolomite. The pollarding ended in 1973 and scything in 1980, and then the elm crowns grew huge, affecting the light conditions, air temperature and soil humidity under the tree canopies [3]. However, this meadow was restored in 1992/93, with pollarding and scything in a traditional way. Floristic characterization of

Table 1. Covering of plant species (in %) in the investigated zones under the elm trees. Plant species with covering ≤1.0 are listed bellow
Tabela 1. Pokrycie gatunków roślin (w %) w badanych strefach pod wiązami. Gatunki roślin z pokryciem ≤1.0 są wyszczególnione poniżej

Zones – strefy	S1	S5
Covering of plants - pokrycie roślin %	87.5	100.0
Covering of mosses – pokrycie mchów (%)	7.5	21.5
Height of mosses – wysokośc mchów (cm)	2.4	4.3
Plagiomnium undulatum	31.0	45.0
Deschampsia cespitosa	29.4	10.8
Rhytidiadelfus squarrosus	28.0	25.0
Trifolium medium	0	27.5
Agrostis capillaries	6.6	22.1
Dactylis glomerata	16.9	8.6
Anthriscus sylvestris	7.6	6.2
Urtica dioica	8.7	0
Lathyrus pratensis	0	6.1
Filipendula ulmaria	0.1	5.2
Oxalis acetosella	4.3	0
Atrichum undulatum	4.0	0.2
Stellaria graminea	0.6	3.3
Marchantiophyta	3.0	0
Vicia sepium	0.7	2.5
Trifolium pretense	-	1.7
Anthoxantum odoratum	0.3	1.5
Hypericum maculatum	0	1.5
Deschampsia flexuosa	1.4	0
Vicia cracca	0.2	1.3
Trifolium repens	0.1	1.2
Others – inne	3.2[a]	7.2[b]

[a] - *Anthyrium filix-femina*, *Galeopsis* sp., *Galium aparine*, *Festuca rubra*, *Phleum pratense*, *Myosotis* sp., *Plagiomnium cuspidatum*, *Ranunculus acris*, *R. repens*, *Rumex acetosa*.
[b] – *Angelica sylvestris*, *Cerastium fontanum*, *Cirriphyllum piliferum*, *Geum* sp., *Festuca rubra*, *Phleum pratense*, *Pimpinella saxifrage*, *Ranunculus acris*, *Rumex acetosa*, *R. acetosella*, *Valeriana sambucifolia*.

investigated meadow was given earlier [3].

METHODS

In the wooded hay meadow we took samples under 3 elm trees (as replicates) in the first decade of May 2003. Under each tree 2 zones were chosen, 1m (S1) from the elm trunks, heavily treaded by sheep, and 5m (S2) from these trunks. Soil samples of 20cm^2 x 11cm deep, with grass were taken in 30 replicates, and they were further divided into 4 vertical layers: grass (G, 2-5cm), lower part of grass and upper soil horizon (H1, 1cm vegetation + 1cm soil) and middle (H2, 2-6cm) and lower (H3, 6-11cm) soil horizon. The Oribatida were extracted from the material in Tullgren funnels (3,112 mites in a total), conserved and determined to species or genus, including the juvenile stages. The oribatid mites we characterized by the abundance (A) and dominance (D), species number (S) and Shannon H indices [16]. We verified the densities of mites with the Tukey test according to ANOVA/MANOVA program of Statistica5. List of species of Oribatida was given earlier [19].

RESULTS

Herb cover

The wooded meadows represent an intermediate, nutrient-rich 'old' meadow [after 8], with high plant covering, including grasses, herbs and mosses. However, the sheep often rested near the elm trunks and their threading distinctlly reduced the plant covering, comparing to the zone situated 5m from these trunks (Tab. 1). Near the elm trunks mosses were also shorter than 5m from trunks. The

Table 2. Abundance (*A* in thousand individ./m^2) and dominance (*D*) indices of some oribatid taxa, and species number (*S*) and Shannon *H* indices of oribatid mites in the investigated zones under the elm trees. * significantly different at p= 0.05; tot- adults, juv- juvenile stages

Tabela 2. Wskaźniki liczebności (*A* w tys. osobn./m^2), dominacji (*D*) niektórych taksonów mechowców oraz liczba gatunkow (S) i wskaźnik Shannona *H Oribatida*. * różnice istotne statystycznie przy p= 0.05; tot – okazy dorosłe, juv - stadia młodociane

Taxa – taksony		S1		S5	
		A	*D*	*A*	*D*
Oribatida	Tot	20.4*	-	37.1	-
	Juv	6.2	30.4	9.9	26.7
	S	30	-	31	-
	H	2.32	-	2.34	-
Achipteria coleoptrata (L.)	Tot	4.2*	20.6	10.0	27.0
	Juv	2.3	11.3	6.1	16.4
Ceratozetes gracilis (Michael)	Tot	0.1*	0.5	0.8	2.2
	Juv	0,1	0.5	0.3	0.8
C. peritus Grandjean	Tot	2.1	10.3	1.0	2.7
	Juv	1,5	7.4	0.5	1.3
Eupelops occultus (C.L.Koch)	Tot	1.5	7.4	1.8	4.9
	Juv	0.8	3.9	1.0	2.7
Galumna obvia (Berlese)	Tot	0.2	1.0	0.6	1.6
	Juv	0.1	0.5	0.4	1.1
Hemileius initialis (Berlese)	Tot	1.8	8.8	0.8	2.2
	Juv	0.2	1.0	0.3	0.8
Liebstadia similis (Michael)	tot	2.4	11.8	2.1	5.7
	juv	0.3	1.5	0.3	0.8
Minunthozetes semirufus (C.L.Koch)	tot	4.2	20.6	9.2	24.8
Scheloribates laevigatus (C.L.Koch)	tot	0.2	1.0	0.2	0.5
	juv	0	0	0.1	0.3

sheep threading eliminated some species near the elm trunks, but their dung enriched the soil fertility and some others plant species grew there. Such plants as Trifolium medium, Trifolium pretense, Agrostis capillaris, Lathyrus pratensis and Hypericum maculatum were absent near the elm trunks (Tab. 1), but Urtica dioica, Oxalis acetosella, Deschampsia flexuosa and Dactylis glomerata tolerated sheep threading and dung and were present or more abundant near the elm trunks.

Oribatid mites

The sheep treading significantly decreased the density of Oribatida, comparing to zone situated 5m from the elm trunks (Tab. 2). However, near the elm trees the participation of juvenile stages of Oribatida was higher than in the zone situated 5m from the elm trunks, and the number of species and the Shannon H index was similar as in the zone situated 5m from the elm trunks.

In the investigated zones only two species were relatively abundant, Achipteria coleoptrata (L.) and Minunthozetes semirufus (C. L. Koch). The sheep threading significantly reduced the density of these species, but increased the participation of juvenile stages in the population of A. coleoptrata, comparing to the zone situated 5m from the elm trunks. Minunthozetes semirufus was represented mainly by the adults.

Most oribatid species were sensitive to sheep treading, but some species, like Ceratozetes peritus (Grandjean), Hemileius initialis (Berlese) and Liebstadia similis (Michael) tolerated it and their density near the elm trunks was higher than in the zone situated 5m from these trunks. Near the elm trunks the population of Ceratozetes peritus was also richer in the juvenile stages than 5m from these trunks. Some species, like Achipteria

Table 3. Vertical distribution of some oribatid taxa (tot) and their juvenile stages (juv) in the investigated zones under the elm trees (density of mites/100cm^3 is given); G- grass layer; A-, B- soil layers

Tabela 3. Pionowe rozmieszczenie niektórych taksonów mechowcow (tot) i ich stadiów młodocianych (juv) w badanych strefach pod wiązami (podano zagęszczenie roztoczy/100cm^3); G- poziom trawy; A-, B- poziomy glebowe

Name of taxa – nazwa taksonu		S1			S2		
		G	A	B	G	A	B
Oribatida	tot	2.6	86.3	3.8	2.5	151.8	3.4
	juv	0.3	28.3	1.0	0.3	40.3	1.2
Achipteria coleoptrata	tot	0.1	19.5	0.4	0.4	43.5	0.4
	juv	0	11.5	0.2	0	26.5	0.3
Ceratozetes peritus	tot	0	10.3	0.1	0	4.3	0.2
	juv	0	7.5	0	0	2.3	0.1
Eupelops occultus	tot	0.4	6.5	0	0.8	6.8	0.1
	juv	0.1	4.3	0	0.1	4.0	0.1
Galumna obvia	tot	0	0.8	0	0	2.3	0.1
	juv	0	0.5	0	0	2.0	0.1
Hemileius initialis	tot	0.4	7.5	0.4	0.4	2.8	0.1
	juv	0.1	0.8	0	0	0.8	0.1
Liebstadia similis	tot	0.5	9.8	0.2	0.3	9.0	0.1
	juv	0.1	1.0	0.1	0	1.5	0.1
Minunthozetes semirufus	tot	1.0	17.3	0.8	0.6	42.3	0.6
	juv	0	0.3	0	0	0	0
Scheloribates laevigatus	tot	0.1	0.8	0	0	1.0	0.1
	juv	0	0.3	0	0	0.5	0

coleoptrata, Eupelops occultus (C. L. Koch) and Galumna obvia (Berlese) were rich in the juvenile stages, while the others were not.

In all plots the oribatid mites lived mainly in the lower part of grass and the upper soil horizon, including the juvenile stages, and their density decreased with the soil depth (Tab. 3). In the lower part of grass relatively large or quick moving species, like Achipteria coleoptrata, Eupelops occultus, Liebstadia similis, Minunthozetes semirufus and Scheloribates laevigatus were present. In the upper soil horizon the juvenile stages of mites comprised about 1/3 of a the total individuals, while in the lowest soil horizon the mites occurred occasionally. The sheep treading appeased the differences of density of mites in the soil layers, comparing to less treaded zone of meadow.

DISCUSSION AND CONCLUSIONS

Traditionally maintained wooded hey meadows represent relatively sustainable ecosystems, which can produce quite much fodder for sheep during decades or even centuries [2], due to presence of tree and grass layers. The trees take water and mineral compounds from deep parts of soil and deposit them with the litter into upper soil horizons, increasing the soil fertility. They also shade the soil and provide it with the litter, as a natural fertilizer, improving living conditions for soil microarthropods, including oribatid mites. Therefore the density and species number of Oribatida in the investigated zones under trees were distinctly higher than in the open meadow [19]. Similar effect was observed in the shelterbelts with the trees in the agricultural landscape [13–15, 20, 22].

In contrast, the production of conventional meadows depends mainly on mineral fertilization and without it the soil fertility and crop decrease very quickly. Additionally, high doses of fertilizers may create problems for consumers, including soil mites, increasing the differences of density between seasons, comparing to the control plot [18].

The sheep treading near the elm trunks reduced the plant covering, especially mosses and consequently the density of Oribatida, what is consistent with the literature [4, 7, 11]. However, the species number and the Shannon H

index of Oribatida was not reduced, and the participation of juvenile stages was higher than in the zone 5m distant from the elm trunks, what may be explained by the sheep activity. The sheep fertilize the soil by dung and mix it with narrow hooves with the soil, increasing the soil fertility. Not intensive sheep grazing in Poland reduced both the density and species number of Oribatida comparing to a hay meadow [7].

In the investigated wooded hay meadow Achipteria coleoptrata and Minunthozetes semirufus were rather abundant, while the typical meadow species like Scheloribates laevigatus and Liebstadia similis were not abundant. The participation of juvenile stages in the oribatid mite associations was about 1/3 of the total oribatid mites, what seems to be typical for sustainable meadows. In conventional meadows, which were fertilized with ammonia water, Liebstadia similis predominated, and their juvenile stages were more abundant than the adults [18]. In the plot fertilized with a dose of 200kg N/ha, the juvenile stages comprised even 83% of summer population of this species, while in the wooded meadow they comprised at most 24% of a the total population. Abundant juvenile stages of Oribatida play an important role in decomposition of litter because they have quicker metabolisms than the adults [6]. Their gut microflora is also richer and more active than that of adults [21].

In the investigated wooded meadow some oribatid species lived on grasses, as potential hosts of cestoids from the group of Anoplocephalata [8, 17], which parasitizes sheep. In conventional meadows the density of these mites is distinctly higher [18] than in wooded meadow, what increases the epidemiological threat for sheep from cestoids.

The obtained results led to the following conclusions:

1. The sheep treading reduced the plant covering, especially mosses.

2. The sheep treading reduced the density of Oribatida, increased the participation of their juvenile stages, but did not change the number of mite species.

3. The sheep treading appeased the differences of density of mites in soil layers, comparing to the zone situated 5m from the elm trunks.

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