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STRUCTURAL CHARACTERISTICS OF THE PREDATORY MITE POPULATIONS (Acari: Mesostigmata) AT LOCAL SCALE FROM TWO TYPES OF GRASSLAND ECOSYSTEMS IN THE FĂGĂRAŞ MOUNTAINS -ROMANIA

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Abstract

Soil mites have been used as bioindicators at local, regional or even at national scales. The present study demonstrated that soil microhabitats are characterised by different structural patterns of soil mite populations. This study was conducted in August 2021, in two types of grassland ecosystems (intensely grazed and moderately grazed with sheep) in the Făgăraş Mountains- Romania. At the local spatial scale, 10 transects were established in each grassland. In total 200 soil samples were analysed, revealing the presence of 33 soil mite species, with 93 individuals. Dominant species were Gaeolaelaps nolli and Gaeolaelaps aculeifer. The population characteristics were analysed for each transect and each grassland, using the following indices: taxa diversity, numerical abundance, dominance, evenness, equitability, Shannon-Wiener index of diversity, Bray-Curtis index of Similarity. Making a comparison, in the moderately grazed grassland the species diversity and the numerical density were higher than those from intensely grazed ecosystem.

Key words*: grazed, mite, soil, structure, transects.*

INTRODUCTION

Grasslands represent one of the most important ecosystems in the world (Vannoppen et al., 2023). This type of ecosystem is involved in soil formation, erosion control, storage of atmospheric carbon, nutrient cycling, biodiversity support and food provision. At the same time it provides a habitat for plants and invertebrates, including soil invertebrates. The main threats to grassland ecosystems are: conversion of native grassland areas to crops and introduced pasture, clearing of native grassland for urban expansion, invasion by exotic plants, overgrazing, soil and habitat disturbance by vehicles, rock removal or rock crushing operations, changes in agricultural practices, poor management of remnant grassland areas, climate change and abandonment of traditional forms of land use. Most of the grassland in the temperate-climate zone in Central and Western Europe developed as a result of human activity and can be considered as semi-natural habitats (Szczęch et al., 2023). Predatory mites are one of the most common and abundant invertebrate groups in soil. They are very sensitive to any environmental disturbance such as the highly intensive grazing of grasslands. Overgrazing decreases the vegetation cover, increases erosion, compacts the soil, and creates favourable conditions for invasive species. Overgrazing influences the proprieties of soil, including its biological activity (Kairis et al., 2015; Manu et al., 2023). There are abundant studies regarding the characteristic structure of predatory soil mites from different type of ecosystem all over the Europe, especially as part of monitoring programmes (Gardi et al., 2009; Dirilgen et al., 2016; Arjen de Groot et al., 2016; Griffiths et al., 2016).

All these studies were made at a large spatial scale, even as great as the European scale, but taking into account the local scales. Based on soil fauna, including the mites, some bioindicators have been selected, taking into account the land use type of ecosystems, climatic zones, and different types of treatments (Gardi et al., 2009; Griffiths et al., 2016). A very complex study made in ten European countries, belonging to four bio-climatic zones (Alpine, Atlantic, Continental and Mediterranean) and 3 land uses (arable, grassland and forestry) demonstrated that these two variables had a significant effect on soil mite communities (Griffiths et al., 2016). Within and between climatic zones, we consider many climatic variables (temperature, humidity, precipitation, wind, etc), and especially those that influence the soil substrate (for soil fauna) at European, national, regional or local scale. Land use type refers to the relationship between people and the land. On the one hand, the edaphic fauna is influenced by the physical and chemical properties of soil, whilst on the other hand, according to the Burton et al., 2022, "soils are a fundamental determinant of plant communities, with soil biota being linked to them directly through symbiosis and herbivory, and indirectly via decomposition and nutrient cycling". These influences are more obvious at the local scale or even at the level of microhabitats (Arjen de Groot et al., 2016; Chiriac et al., 2022; Manu et al., 2022; 2023). Thus, the main objectives of the research were to characterise the structures of the soil mite communities at the local scale from two grasslands, considering their management types (moderately and intensively grazed ecosystems) and the vegetation cover of the samples.

MATERIALS AND METHODS

Study areas

The research was carried out in the Făgăraş Mountains, Romania, which have the status of a protected area under the European ecological network Natura 2000. The study was made in August 2021, in two types of alpine grasslands: Galbena grassland- moderately grazed by sheep and Vemeşoaia grassland - intensely grazed by sheep (Figure 1) (Manu et al., 2023). The complete description of the abiotic (soil) parameters in these investigated areas was presented by Chiriac et al., in 2022.

The Galbena moderately grazed grassland is located at $45^0$37'47.8"N, $024^0$23'57.9'E at 1710 m altitude, on a slope of 15^0-20^0 and with a West exposure. The soil type is dystric lithosol and humbric-lithic regosol. The vegetation was dominated by *Nardus stricta* (11.99%), *Festuca rubra* (16.62%), *Agrostis capillaris* (17.15%) and *Vaccinium myrtillus* (28.61%).

The Vemeşoaia intensively grazed grassland is situated at $45^0$32'44.7"N, $024^0$26'30.6'E at 1747 m altitude, on a slope of 15^0 and with a South exposure. The soil type is dystric-lithic regosol. The vegetation was dominated by *Nardus stricta* (11.68%), *Festuca rubra* (21.75%), *Agrostis capillaris* (12.11%) and *Vaccinium myrtillus* (2.74%).

In terms of vegetation type, the two grasslands belongs to the dominant association *Violo declinatae –Nardetum* Simon 1966, equivalent to the Romanian habitat R3609 South-east Carpathian grasslands with *Nardus stricta* and *Viola declinata* (Doniță et al., 2005).

In order to evaluate the structure of predator soil mite populations at the local scale, ten lines/transects, each of 100 m, were established in each grassland (line 1 to line 10). The distance between each line was 20 metres. On each line 10 soil samples were taken at a spacing between samples of 10 metres (Figure 1).

Soil fauna sampling

In total, 200 soil samples were collected, with a Macfadyen soil core (diameter of 5 cm), at 10 cm depth (Macfadyen 1953; 1961). In each grassland, 100 soil samples were taken (10 samples on 10 lines or transects). The mites were extracted for 10-14 days using the Berlese-Tullgren method, using natural light and heat (Berlese, 1905; Tullgren, 1917; Southwood, 1966; Southwood & Henderson, 2000; Krantz & Walter, 2009). Due to the high number of samples collected from the field (200) and to the limited number of samples which could be sorted at one time (75 samples), some samples were kept in a refrigerator (at 4^0C) until the next extraction (14 days) (Manu & Honciuc, 2010).

Taxonomic identification and counting were made using a Zeiss stereo-microscope. Soil fauna were preserved in ethyl alcohol (75%-96%) (Krantz & Walter, 2009).

The mites were identified to species level using the published identification keys (Ghilyarov & Bregetova, 1977; Balş, 1981; Karg, 1993; Mašán, 2003; Mašán & Fenďa, 2004; Mašán, 2007; Gwiazdowicz, 2007; Mašán et al., 2008; Mašán & Halliday, 2013; De Moraes et al., 2022).

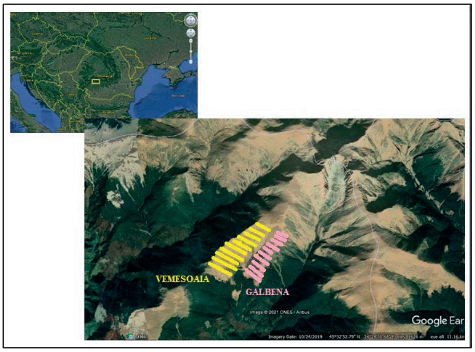

Figure 1. The geographical location of investigated areas at Galbena (pink lines) and Vemeşoaia grasslands (yellow lines), in the Făgăraş Mountains, in 2021

Data processing

Statistical analysis was made using PAST software (Hammer et al., 2001) and the following indices were assessed: Dominance_D; Simpson_1-D; Shannon_H; Evenness_e^H/S; Equitability_J, Bray-Curtis index of Similarity (qBC). The ANOVA test was used for the standard statistical analysis for univariate data (as numerical abundance, density and vegetation coverage).

RESULTS AND DISCUSSIONS

In both types of grasslands 33 soil mite species (93 individuals) were identified, with a density by 4700 individuals/square metre. Of these identified species, 15.15% were common species in both grasslands, 57.57% were characteristic of the Galbena grassland (moderately grazed) and 27.27% for Vemeşoaia (intensely grazed ecosystem) (Tables 1, 2). The common species for both grasslands were *Gaeolaelaps aculeifer, Gaeolaelaps nolli, Lysigamasus lapponicus, Ololaelaps placentula* and *Veigaia nemorensis*. These species have also been identified in other grasslands in Romania (Manu et al., 2022; 2023).

In the moderately grazed grassland from Făgăraş Mountains- Galbena, 24 Mesostigmata species were identified, with a density of 2500 individuals/square metre. The dominant species were *Gaeolaelaps aculeifer, Gaeolaelaps nolli, Alloparasitus oblongus* and *Ololaelaps sellnicki*. The total vegetation cover in this area was 98.55%. Within the ten investigated lines, we observed that lower values for the number of species, numerical abundance and density were recorded in lines 6 and 7, on the opposite being parameters from the lines 3, 8, 9 and 10, with the highest values. The difference of these parameters (numerical abundance and density) between the ten lines is significant ($p = 0.0029$). The highest values of dominance were recorded in lines 1, 6, and 7, where only one individual of each species was identified. A more balanced structure of mite communities was recorded in lines 2 and 4 (Table 1). Vegetation cover fluctuated between 100% (on lines 1, 7, 8, 9) and 97% or 96.62% (on lines 3 and 6) (Table 1). The differences in vegetation cover between lines are not significant ($p = 1$)

Table 1. Structural characteristics of soil mite populations from Galbena grassland, Făgăraş Mountains, 2021 (± standard error)

No.	Species	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Total
1	*Gamasellodes bicolor*										1 ± 0.03	1
2	*Gaeolaelaps aculeifer*			1 ± 0.03					2 ± 0.04	1 ± 0.03	2 ± 0.06	6
3	*Gaeolaelaps nolli*				1 ± 0.03	1 ± 0.03		1 ± 0.03	1 ± 0.03	1 ± 0.03	2 ± 0.06	6
4	*Alloparasitus oblongus*				1 ± 0.03	1 ± 0.03					3 ± 0.06	5
5	*Leptogamasus paracarpaticus*			1 ± 0.03								1
6	*Leptogamasus* sp.								1 ± 0.03			1
7	*Lysigamasus lapponicus*					1 ± 0.03						1
8	*Macrocheles montanus*			1 ± 0.03								1
9	*Olodiscus minima*			1 ± 0.03								1
10	*Ololaelaps placentula*		1 ± 0.03	1 ± 0.03								2
11	*Ololaelaps sellnicki*	1 ± 0.04			1 ± 0.03					2 ± 0.04		5

12	*Onchodellus siculus*		1 ± 0.03									1
13	*Oodinychus obscurasimilis*			1 ± 0.03								1
14	*Oodinychus* sp.									1 ± 0.03		1
15	*Pachylaelaps resinae*			1 ± 0.03								1
16	*Pachylaelaps* sp.								1 ± 0.03	1 ± 0.03		2
17	*Pachyseius humeralis*			1 ± 0.03								1
18	*Prozercon* sp.			1 ± 0.03								1
19	*Rhodacarellus silesiacus*			2 ± 0.06								2
20	*Trachytes aegrota*					2 ± 0.06			1 ± 0.03	1 ± 0.03		4
21	*Trachytes irenae*								1 ± 0.03			1
22	*Trachytes* sp.						1 ± 0.03		1 ± 0.03			2
23	*Urodiaspis pannonica*								1 ± 0.03			1
24	*Veigaia nemorensis*			1 ± 0.03								1
	Total number of individuals	2	2	12	3	5	1	1	9	7	8	49
	Total number of species	1	2	11	3	4	1	1	8	6	4	24
	Numerical density	100	100	600	150	250	50	50	450	350	400	2500
	Dominance_D	1	0.5	0.097	0.333	0.280	1	1	0.136	0.184	0.281	0.07
	Simpson_1-D	0	0.5	0.903	0.667	0.720	0	0	0.864	0.816	0.719	0.93
	Shannon_H	0	0.693	2.369	1.099	1.332	0	0	2.043	1.748	1.321	2.9
	Evenness_e^H/S	1	1	0.972	1	0.947	1	1	0.964	0.957	0.937	0.76
	Equitability_J		1	0.988	1	0.961			0.983	0.976	0.953	0.91
	Vegetation coverage (%)	100	97.5	97	98.9	98.11	96.62	100	100	100	97.32	98.55

In the intensely grazed grassland in the Făgăraş Mountains - Vemeşoaia, only 14 Mesostigmata species were identified, with a density of 2200 individuals/square metre. The dominant species were *Gaeolaelaps nolli, Pachydellus furcifer* and *Zercon carpathicus*. The total vegetation cover in this area was 90.4%. In the ten investigated lines, we observed that the lower values for number of species, numerical abundance and density were recorded on lines 6 and 8, and the highest values of these being parameters in the lines 4, 7 and 10. The differences for these parameters (numerical abundance and density) between the ten lines is significant (p = 0.0448). Comparing the other structural parameters for soil mites on all ten lines, we observed that the highest values of dominance were recorded on lines 5, 6, 7, 8, and 9. The highest values of evenness and equitability parameters were recorded on lines 2 and 4 (Table 2). Vegetation cover fluctuated between 100% (on lines 2, 3, 4) and 69% or 88.5% (on lines 1 and 6) (Table 2). These differences in vegetation cover between lines is not significant (p = 0.9998).

Table 2. Structural characteristics of soil mite populations from Vemeşoaia grassland, Făgăraş Mountains, 2021 (± standard error)

No.	Species	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Total
1	*Amblyseius* sp.									1 ± 0.03		1
2	*Asca bicornis*					1 ± 0.03						1
3	*Gaeolaelaps aculeifer*				1 ± 0.03							1
4	*Gaeolaelaps nolli*		3 ± 0.06		1 ± 0.03	1 ± 0.03	1 ± 0.03	1 ± 0.03		1 ± 0.03		8
5	*Hypoaspis austriacus*			1 ± 0.03			1 ± 0.03			1 ± 0.03	1 ± 0.03	4
6	*Leptogamasus tectegynellus*	1 ± 0.03						1 ± 0.03				2
7	*Lysigamasus lapponicus*				2 ± 0.06							2
8	*Ololealaps placentula*										1 ± 0.03	1

9	*Onchodellus alpinus*				2 ± 0.04							2
10	*Pachydellus furcifer*	1 ± 0.03	1 ± 0.03	2 ± 0.06	2 ± 0.04			1 ± 0.03				7
11	*Pachydellus* sp.							1 ± 0.03	2 ± 0.06		3 ± 0.06	6
12	*Veigaia nemorensis*			1 ± 0.03				1 ± 0.03				2
13	*Zercon carpathicus*	1 ± 0.03			1 ± 0.03						3 ± 0.09	5
14	*Zercon* sp.			1 ± 0.03		1 ± 0.03						2
	Total number of individuals	3	4	5	9	3	2	5	2	3	8	44
	Total number of species	3	2	4	6	3	2	5	1	3	4	14
	Numerical density	150	200	250	450	150	100	250	100	150	400	2200
	Dominance_D	0.333	0.625	0.280	0.185	0.333	0.500	0.200	1	0.333	0.313	0.11
	Simpson_1-D	0.667	0.375	0.720	0.815	0.667	0.500	0.800	0	0.667	0.688	0.89
	Shannon_H	1.099	0.562	1.332	1.735	1.099	0.693	1.609	0	1.099	1.255	2.39
	Evenness_e^H/S	1	0.877	0.947	0.945	1	1	1	1	1	0.88	0.78
	Equitability_J	1	0.811	0.961	0.968	1	1	1		1	0.91	0.9
	Vegetation coverage (%)	69	100	100	100	79	88.5	89.6	87	93.5	97.3	90.4

In order to highlight the similarities or dissimilarities between soil mite communities from the ten lines in each investigated grassland, the Bray-Curtis Similarity index (qBC) was calculated. In the Galbena grassland (moderately grazed ecosystem), the highest Bray-Curtis similarity index was obtained between populations from line 1- line 4, line 4 - line 5, line 4 - line 7 and line 8 - line 9 (qBC = 0.5 for each) (Figure 2). These similarities could be explained by the complete vegetation cover on these lines, by the presence of common species with quite similar biological and ecological requirements *e.g.*: *Gaeolaelaps aculeifer, Gaeolaelaps nolli, Ololealaps sellnicki* and *Trachytes aegrota*. These species have a wide ecological tolerance, being recorded in similar ecosystems throughout Europe, as well as Romania (Karg 1993; Mašán, 2007; Mašán & Halliday, 2013; De Moraes et al, 2022; Manu et al., 2022; 2023).

In the Vemeşoaia grassland (intensely grazed ecosystem), the highest Bray-Curtis similarity index was obtained between populations from line 1- line 7 (qBC = 0.5), line 2- line 7 (qBC = 0.44), line 3-line 7 (qBC = 0.4) and line 5- line 6 (qBC = 0.4) (Figure 3). Species such as *Gaeolaelaps nolli, Leptogamasus tecegynellus, Pachydellus furcifer* and *Veigaia nemorensis* were common on these lines, with similar numerical abundance. The small differences between vegetation coverage could be a possible explanation for these similarities.

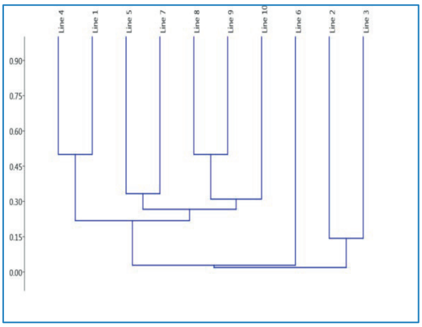

Figure 2. Bray-Curtis Similarity index between soil mite populations from Galbena grassland

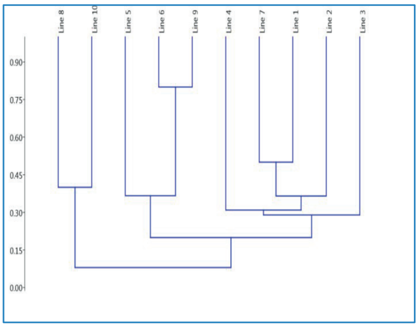

Figure 3. Bray-Curtis Similarity index between soil mite populations from Vemeşoaia grassland

Comparing the two grasslands and considering their management types (moderately and intensive grazed grasslands), we observed that in the Galbena (moderate grazing) the soil mite communities were more abundant, with greater species diversity. Being a moderately grazed ecosystem, the vegetation cover is more complete compared to that of the intensively grazed site. The vegetation layer creates a microhabitat with characteristic environmental conditions (more humid substrate, lower soil temperature, increased soil pH, etc.). Studies have revealed that enhanced species richness of plant mixtures positively affects the diversity of the soil fauna. Habitat/microhabitat loss caused by the deterioration of soil physical-chemical properties is the primary factor affecting soil fauna (Sylvain & Wall, 2011; Kudureti et al., 2023).When results are compared between these sites and similar studies elsewhere in Romania (number of species and numerical abundance), we conclude that the data obtained are comparable with those from grazed and ungrazed grasslands in the Făgăraş Mountains, and with natural, chemical and organically-fertilised ecosystems in the Bucegi Mountains, but lower than pastures from the Central Moldavian Plateau or polluted grasslands from Zlatna-Trascău Mountains (Manu et al., 2022; 2023).

CONCLUSIONS

Soil mite communities were investigated from two management types of grassland (moderately and intensely grazed by sheep), at the local/microhabitat scale, considering vegetation cover. In total, 33 species were identified, with 93 individuals and 4700 individuals/square metre. The type of grassland management influenced the structures of the soil mite communities, phenomena highlighted by the different values of statistical parameters (*e.g.* number of species, numerical abundance, dominance, evenness, equitability, etc.). The moderately grazed grassland was characterised by the highest values of these structural parameters, as well as vegetation cover. There were characteristic species in each type of ecosystem, demonstrating indirectly the local influence of environmental conditions for each microhabitat. Even where we considered the type of grassland management or spatial scale, the environmental biotic and abiotic parameters were very important factors that could influence the soil mite communities and hence we consider that further investigations are needed. The present study demonstrated that anthropogenic impact (in this case grazing) on natural ecosystems influences the structure of mite communities, even at local scale.

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