Scientific Papers. Series D. Animal Science. Vol. LXIX, No. 1, 2026
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

IMPACT OF HABITAT FRAGMENTATION ON SOIL MITE COMMUNITIES (Acari-Mesostigmata) FROM TWO SMALL PROTECTED AREAS FROM BRAŞOV COUNTY, ROMANIA

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Abstract

One of the main threats of terrestrial ecosystems is habitat fragmentation. This threat has impact even on soil fauna, as predator mites. The present study wants to demonstrate that the mite community structures and species diversity are strongly correlated with the type of fragmented habitats, from two fragmented Natura 2000 site: Forest and Eutrophic Marshes from Prejmer (ROSCI0170) and Lempeş Fortress Hill-Hărman Marsh (ROSCI0055), characterized by the presence of different ecosystems: calcareous fens, alluvial, oak-hornbeam and beech forests. In 2018, eighty soil samples were investigated. In total, 29 species of Mesostigmata were identified. Considering the numerical abundance and species richness of Mesostigmata, we observed that the highest value was obtained in Prejmer protected area. If we make this comparison, considering the four fragments from each investigated area, we observed that in the fragments characterized by wet ecosystems (calcareous fens with Cladium mariscus (L.) Pohl), soil mites found the most favorable environmental conditions for their development. Each investigated fragments from the two protected areas were defined by the characteristically pattern of the soil mite structures, according to the applied statistical analysis.

Key words*: habitat, mite, predator, soil*, *structure.*

INTRODUCTION

One of the most threats on terrestrial ecosystems is habitat fragmentation. If we consider the soil fauna this threat significantly impacts it through many mechanisms: isolating populations, decreasing population parameters (as species richness and abundance), altering community composition, and increasing species/population vulnerability to extinction (Rantalainen et al., 2008). The habitat fragmentation, which is often caused by anthropic activities (as forest cutting, urban extinction, intensive agriculture), creates disconnected, smaller patches, disrupting the ability of soil organisms to disperse and access resources, which can lead to ecosystem decay and instability in soil food webs (Rantalainen et al., 2008; Lopezosa et al., 2023; Winfrey et al., 2025; Yan et al., 2025). In this situation, what soil fauna should do? One of the possible answers is to respond. But the response of the on many soil processes (pedogenesis, nutrient cycle, decomposition of organic matter, etc.) (Krantz & Walter, 2009). Mesostigmata mites soil fauna to the habitat fragmentation depends on one hand, by organism's body size, trophic level, mobility and generation time. On the other hand some features of habitat fragments (as shape, size, isolation, as well as the presence and connectivity of habitat corridors, influence the survival and dispersal of soil fauna (Rantalainen et al., 2008; Lopezosa et al., 2023; Winfrey et al., 2025). Environmental microclimate (soil water content, soil acidity, precipitations) and the vegetation coverage constitute local drivers that could influence the impact of habitat fragmentation on soil biodiversity, which is a vital biological component for ecosystem functions like nutrient cycling and soil building. Mites (Acari) are one of the most abundant taxonomic groups from soil fauna, occupying diverse trophic niches (from decomposers to predators), participating directly or indirectly are those soil invertebrates that are mainly predators, free-living, very mobile species,

which participate indirectly on decomposing process of organic matter (Potapov et al., 2022). In Europe, studies regarding the influence of habitat fragmentation on soil mesostigmatids revealed that the communities' composition was changed, the species diversity and abundance were decreased (Rantalainen et al., 2008; Kamczyc et al., 2023). In Romania, studies regarding the influence of fragmented habitats on soil fauna communities are scarce (Manu et al., 2021).

In this context presented above, the main objectives of this study are: 1) to identify the community structures of Mesostigmata mites two protected areas, characterized by different types of ecosystems influenced by habitat fragmentation; 2) to measure some population parameters of Mesostigmata communities (Shannon diversity, dominance, evenness and equitability indices) and 3) to highlighting the correspondence between investigated habitats and Mesostigmata species.

MATERIALS AND METHODS

Study area

The research on soil mite fauna was made in November 2018, in two fragmented Natura 2000 sites from Braşov County, Romania: Forest and Eutrophic Marshes from Prejmer (ROSCI0170) and Lempeş Fortress Hill-Hărman Marsh (ROSCI0055).

The nature reserve Forest and Eutrophic Marshes from Prejmer has an area of 345 hectares. If we consider the type of habitats it is characterized first of all by eutrophic marshes and then by meadows, forests and shrubs.

The second protected area Lempeş Fortress Hill-Hărman Marsh has an area of 374 hectares, characterized by alluvial forests, calcareous fens, beech forests and oak-hornbeam forests (Figure 1; Table 1).

The classification of habitats was made according to Doniţă et al., 2005; Gafta & Mountford, 2008 (Table 1).

Table 1. Geographical and habitat description of investigated fragments from Forest and Eutrophic Marshes from Prejmer (ROSCI0170) and Lempeş Fortress Hill-Hărman Marsh (ROSCI0055) ecosystems, Romania

Investigated area	Short name	N	E	Altitude	Habitat
Prejmer - first fragment	PF1	45^{0}43'46.04"	25^{0}44'09.03"	514 m	7210* calcareous fens with *Cladium mariscus*
Prejmer - second fragment	PF2	45^{0}44'52.22"	25^{0}43'48.66"	503 m	91 EO alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae*).
Prejmer - third fragment	PF3	45^{0}44'56.90"	25^{0}42'08.94"	508 m	91 EO alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)*.
Prejmer - fourth fragment	PF4	45^{0}44'55.46"	25^{0}41'15.64"	501 m	91 EO alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae*).
Hărman - first fragment	HF1	45^{0}43'03.63"	25^{0}40'03.61"	514 m	7210* calcareous fens with *Cladium mariscus*
Hărman - second fragment	HF2	45^{0}43'07.30"	25^{0}40'00.08"	498 m	9170 Galio-Carpinetum oak-hornbeam forests
Hărman - third fragment	HF3	45^{0}44'12.63"	25^{0}40'27.07"	511 m	9170 Galio-Carpinetum oak-hornbeam forests
Hărman - fourth fragment	HF4	45^{0}43'07.30"	25^{0}40'00.08"	498 m	9130 Asperulo-Fagetum beech forests

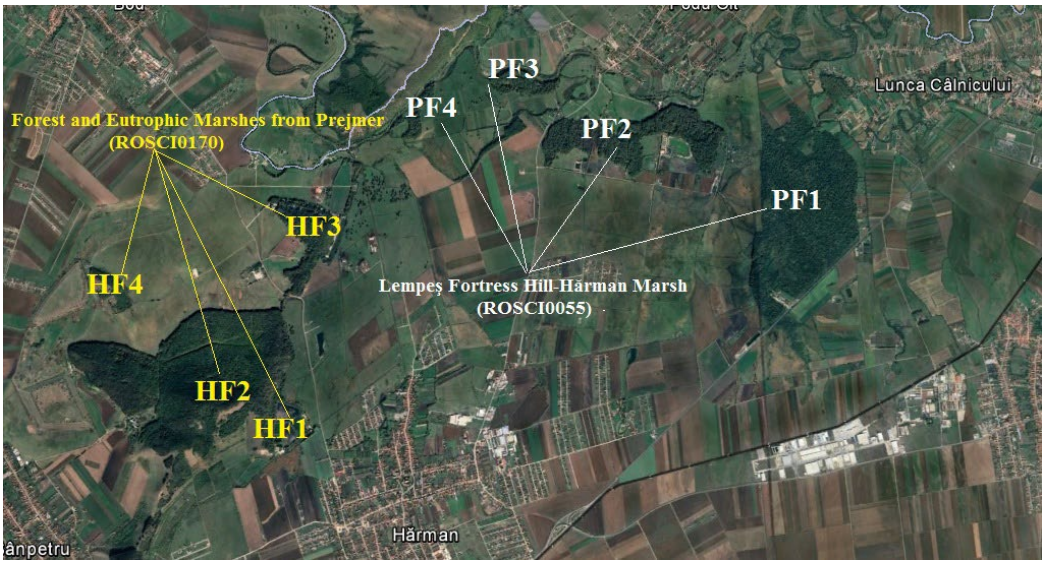

Figure 1. Localization of the investigated fragments from Forest and Eutrophic Marshes from Prejmer (ROSCI0170) (yellow color) and Lempeș Fortress Hill-Hărman Marsh (ROSCI0055) (white color) ecosystems, Romania (original source)

Soil samples

In each protected areas 40 soil samples were collected, with Macfadyen corer (to a depth of 10 cm with a, by 5 cm diameter) (Macfadyen, 1961). In total 80 soil samples were analyzed. The samples were taken randomly. Each soil sample was put in plastic bags, labeled and transported in the lab for extraction. The fauna were extracted for ten days, using natural light and heat, with a modified Berlese-Tullgren funnels, in ethylic alcohol (Berlese, 1905; Tullgren, 1917; Krantz & Walter, 2009). For taxonomical identification the most specialized keys were used (Ghilyarov & Bregetova 1977; Hyatt, 1980; Karg, 1993; Mašán & Fendá, 2004; Mašán, 2007; Mašán et al., 2008; Mašán & Halliday, 2010, 2013; Özbek & Halliday, 2015; Mašán, 2018).

Data analysis

The individual rarefaction and the correspondence analysis (CA) between identified Mesostigmata species and analyzed fragments from the two protected areas were calculated using the BioDiversity Pro 2.0 software, PAST (Hammer et al., 2001). The same software was used to calculate some population parameters for mites as Shannon diversity index (H), dominance (D), evenness (H/S) and equitability (J).

RESULTS AND DISCUSSIONS

The individual rarefaction shows us that the sampling effort was not sufficient, although in Prejmer area the results are better (Figure 2). In total 29 species of Mesostigmata was identified. Considering the numerical abundance of Mesostigmata communities, we observed that the highest value was obtained in Prejmer protected area (Table 2). If we make this comparison, considering the four fragments from each investigated area, we observed that fragments characterized by wet ecosystems (calcareous fens with *Cladium mariscus*) the soil mites found the most favorable environmental conditions for their development (PF1 and HF1). The same trend was observed for species richness (Table 2).

Table 2. Numerical abundance of the identified Mesostigmata species from Forest and Eutrophic Marshes from Prejmer (ROSCI0170) and Lempeş Fortress Hill-Hărman Marsh (ROSCI0055), Romania (± standard error)

Species	PF1	PF2	PF3	PF4	Total P	HF1	HF2	HF3	HF4	Total H
Amblyseius sp. (Am sp)						1 ± 0.1				1± 0.25
Cilliba sp. (Cill sp)	1 ± 0.1				1 ± 0.25					
Discourella sp. (Dis sp)								2 ± 0.13		2± 0.50
Eviphis ostrius (Ev os)	5 ± 0.17				5 ± 1.25	1 ± 0.1				1± 0.25
Gaeolaelaps praesternalis (Ga pr)						1 ± 0.1				1± 0.25
Gamasellodes bicolor (Ga bi)						1 ± 0.1		1 ± 0.1		2± 0.28
Geholaspis mandibularis (Ge ma)		2 ± 0.13			2 ± 0.50	1 ± 0.1				1± 0.25
Holoparasitus sp. (Ho sp)						1 ± 0.1	1 ± 0.1			2± 0.28
Laelaspis astronomicus (La as)						2 ± 0.13				2± 0.5
Leioseius lawrencei (Le la)						1 ± 0.1				1± 0.25
Lysigamasus misellus (Ly mi)	1 ± 0.1	1 ± 0.1			2 ± 0.29					
Lysigamasus tectegynellus (Ly te)	1 ± 0.1				1 ± 0.25					
Macrocheles recki (Ma re)						1 ± 0.1				1± 0.25
Olopachys suecicus (Ol su)		1 ± 0.1			1 ± 0.25					
Oodinychus sp. (Oo sp)	6 ± 0.43			13 ± 1.19	19 ± 3.09					
Pachydellus furcifer (Pa fu)						1 ± 0.1				1± 0.25
Pachyseius humeralis (Pa hu)	1 ± 0.1	2 ± 0.13			3 ± 0.48				1 ± 0.1	1± 0.25
Pachyseius subhumeralis (Pa sub)		1 ± 0.1			1 ± 0.25					
Pachyseius wideventris (Pa wi)					1 ± 0.25					
Paragamasus similis (Pa si)		1 ± 0.1			1 ± 0.25	1 ± 0.1				1± 0.25
Pergamasus sp. (Pe sp)				1 ± 0.1	1 ± 0.25					
Prozercon traegardhi (Pr tr)	2 ± 0.13	3 ± 0.21			5 ± 0.75			1 ± 0.1	1 ± 0.1	2± 0.28
Pseudouropoda sp. (Ps sp)		1 ± 0.1			1 ± 0.25					
Trachytes aegrota (Tr ae)	2 ± 0.13				2 ± 0.50					
Trachytes sp (Tr sp)	3± 0.21				3 ± 0.48					
Veigaia exigua (Ve ex)	2 ± 0.20	2 ± 0.1		1 ± 0.1	5 ± 0.75					
Veigaia nemorensis (Ve ne)	4 ± 0.22	2 ± 0.1			6 ± 1					
Vulgarogamasus kraepelini (Vu kr)	1± 0.1				1 ± 0.25					
Vulgarogamasus remberti (Vu re)						2 ± 0.13				2± 0.28
Total number individuals	29	16	0	16	**61**	14	1	4	2	**21**
Total number species	12	10	0	4	**19**	12	1	3	2	**15**

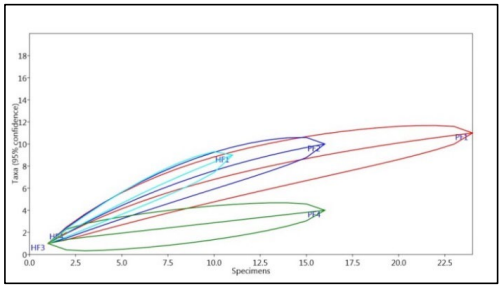

Figure 2. The individual rarefaction of the Mesostigmata communities from Forest and Eutrophic Marshes from Prejmer (ROSCI0170) and Lempeş Fortress Hill-Hărman Marsh (ROSCI0055) ecosystems, Romania

Comparing with other studies from other pedoclimatic regions from Europe, the species diversity from our study is lower with studied made in forests from continental area (20 species) or Atlantic zone (14 species), but in peat bogs this parameter recorded comparable or even higher value that in other countries (12 species in Romania, comparing with 3 species in Ireland or 14 species in Poland (Arroyo et al., 2013; Diriligen et al., 2016; Graczyk et al., 2025).

At national level, the numerical abundance and species richness is much lower in studied fragments, comparing with deciduous forests from other regions of Romania (13-22 Mesostigmata species) (Manu et al., 2013).

If we consider the population parameters, we observed that the highest value of dominance was obtained in Prejmer area (0.14), in comparison with Hărman (0.04). In Prejmer

area, fragment PF4 recorded the highest dominance (0.67), PF1 the highest Shannon index of diversity (2.27), PF2 the highest value of evenness (0.92) and the highest value of equitability (0.96) (Figure 3). In Hărman area the HF2 and HF3 recorded the highest values of dominance (0.50), of evenness and equitability indices (1 for each) and fragment HF1 the highest Shannon index of diversity (1.71) (Figure 3).

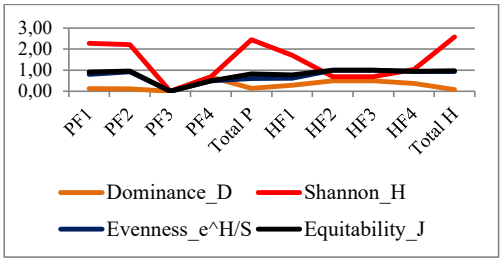

Figure 3. The statistical parameter of the Mesostigmata communities from Forest and Eutrophic Marshes from Prejmer (ROSCI0170) and Lempeş Fortress Hill-Hărman Marsh (ROSCI0055), Romania

In Prejmer area, the high dominance in PF4 was due the presence in high numerical abundance of Oodinychus species. On the whole ecosystem the dominant species were *Eviphis ostrinus, Prozercon traegardhi, Veigaia exigua* and *Veigaia nemorensis*, species which equitable distributed especially in fragments PF2 and PF3 (Table 2). The most humid soil from fen fragment (PF1) possible to create more favorable conditions for a high species richness, but the characteristic edaphic conditions from alluvial forest fragments (especially more organic matter, soil water content, lower temperature, etc) are preferred habitat for the dominant species. *Veigaia nemorensis* prefers habitats with moderate to low humidity, such as certain forest and grassland areas. It is a surface dweller and is commonly found near the top of the soil layers, often in association with organic matter and humus (Manu et al., 2017; Graczyk et al., 2025). *Veigaia exigua* prefers temperate forest habitats, particularly the upper soil layers like moss or the litter and organic humus layers (Manu et al., 2017). *Eviphis ostrinus* is recognized as generalist species, being found in a variety of environments, including fens, forests, grasslands, and other ecosystems (Salmane & Brumelis, 2010; Madej et al., 2011). Forests are habitats where *Prozercon traegardhi* had been frequently identified as a dominant species, showing high numerical densities in the litter and fermentation layer and the humus layer (Salmane & Brumelis, 2010).

In Hărman area, in the species were mostly equitable distributed (especially in HF2 and HF3), due to the similar habitat conditions (oak-hornbeam forests) (Table 2). If we consider the numerical abundance, besides *Prozercon traegardh,* there are few species more dominant, as: *Gamasellodes bicolor, Laelaspis astronomicus* and *Vulgarogamasus remberti* (Table 2). All species are predators, preferring upper layers of soil and leaf litter, especially in forest ecosystems like pine, beech and deciduous forests, where can find other small invertebrates, like nematodes-their preferred food. These species are associated with other animal taxa, as *Laelaspis astronomicus* which is often found in association with other arthropods, such as ants or *Vulgarogamasus remberti* which is associated with mice and voles (Hyatt, 1980; De Moraes et al., 2022).

Using correspondence analysis we highlighted the correlation between the investigated habitats/fragments and soil mite species. This analysis revealed the presence of four groups: 1) HF1 and HF2, characterized by the presence of *Vulgarogamasus remberti, Pachydellus furcifer, Laelaspis astronomicus, Leioseius lawrencei* and *Gaeolaelaps praesternalis*; 2) HF3, HF4, PF1, PF2 favorable for species *Veigaia exigua, Veigaia nemorensis, Vulgarogamasus kraepelini, Lysigamasus misellus, Prozercon traegardhi, Pachyseius subhumeralis, Pachyseius humeralis*; 3) characteristics species only for PF4, as *Pachyseius wideventris;* 4) species which have any habitat preference as *Paragamasus similis* and *Geholaspis mandibularis*, which are opportunistic predators, always searching for prey (Figure 4). These results demonstrated that even from the vegetation point of view the investigated fragments are different, it is possible that the similar environmental conditions (as presence of moss layer, high soil water content, presence of organic matter from marsh and forests soils) to be the cause of the characteristic spatial dynamics and species grouping.

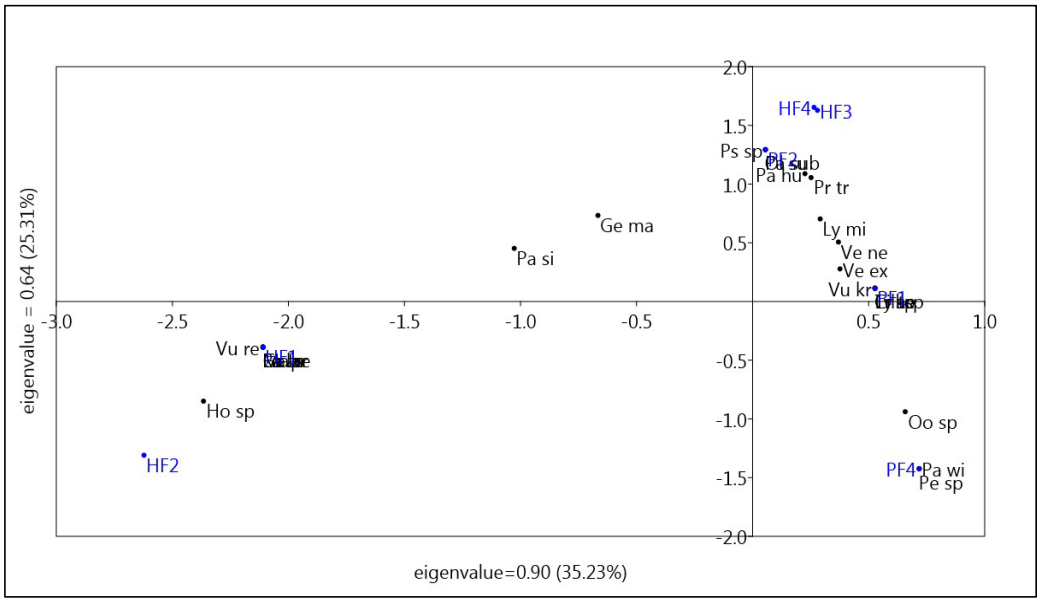

Figure 4. Correspondence analysis (CA) between identified Mesostigmata species and analysed fragments from Forest and Eutrophic Marshes from Prejmer (ROSCI0170) and Lempeş Fortress Hill-Hărman Marsh (ROSCI0055), Romania (the short names of the Mesostigmata species are mentioned in Table 1)

CONCLUSIONS

In 2018, an ecological study was made on soil predator mite fauna (Acari-Mesostigmata) from two Natura 2000 sites (Forest and Eutrophic Marshes from Prejmer - ROSCI0170 and Lempeş Fortress Hill-Hărman Marsh - ROSCI0055), which are characterized by the fragmented habitats, as: 7210* calcareous fens with *Cladium mariscus*; 91 EO alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*; 9170 Galio-Carpinetum oak-hornbeam forests and 9130 Asperulo-Fagetum beech forests. In total, 80 soil samples were analyzed, revealing the presence of 29 Mesostigmata species, which characteristic community structure for each fragment/ecosystem. This feature was highlined by some population parameters as: numerical abundance, specis richness, dominance, Shannon index of diversity, evenness and equitability. The highest values of numerical abundance, species richness and dominance were obtained in Prejmer protected area. On the other hand the highest values of evenness and equitability indices were obtained in Hărman protected area. Considering the investigated fragments, we observed that in the calcareous fens the numerical abundance and species richness recorded the highest values, in comparison with the other fragments, represented by forests. Canonical analysis revealed the presence of four groups of mites, revealing the influence of habitat characteristics of invertebrate's spatial distribution.

ACKNOWLEGMENTS

This study was funded through project number RO1567-IBB01/2026 of the Institute of Biology Bucharest of the Romanian Academy; Research Stationary Posada.

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