STUDIES ON PREDATORY MITES (ACARI: MESOSTIGMATA) IN ROMANIAN SOILS

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Abstract. The paper presents the studies upon predatory mites carried out in Romania. The method used for highlighting the subject is a comprehensive literature survey. We concluded that studies before 2006 provided scarce information about the ecology of predator soil mite communities from different types of ecosystems, highlighting mostly the taxonomical aspects. Later studies provided information about the ecology of the predator soil mite populations from different types of terrestrial ecosystems (shrubs, cliffs, urban, grasslands, etc), and about the correlations between these invertebrates and different environmental variables from natural or anthropic areas from Romania.

Keywords: predatory soil mites, Mesostigmata, invertebrates, Romania.

Rezumat. Studii privind acarienii prădători (Acari: Mesostigmata) din solurile României. Lucrarea prezintă studiile referitoare la acarienii prădători realizate în România. Metoda utilizată pentru a evidenția aceste studii a fost o analiză amplă a literaturii în domeniu. Am concluzionat că studiile realizate până în anul 2006 au oferit destul de puține informații despre ecologia comunităților de acarieni din diferite tipuri de ecosisteme, accentul punându-se mai mult pe aspectele taxonomice. Studiile ulterioare au furnizat mai multe detalii despre ecologia populațiilor de acarieni din mai multe tipuri de ecosisteme (tufărișuri, stâncării, zone urbane, pajiști, etc.) și de asemenea, despre relațiile dintre aceste nevertebrate de sol și diferite variabile de mediu, din zone naturale sau antropizate, din România.

Cuvinte cheie: acarieni prădători din sol, Mesostigmata, nevertebrate, România.

INTRODUCTION

Soil fauna includes those animals that spend their entire life or only part of their life cycle in the soil (MANU & HONCIUC, 2010c; MANU et al., 2020). It plays an essential role in the processes of decomposition of plant material, contributing to the genesis of the soil. Depending on the degree to which these invertebrates are involved in decomposition processes, the most important are: earthworms (Oligocheta), nematodes (Nematoda), springtails (Collembola) and mites (Mites). Mites are a group of arthropods with a great global diversity, belonging to the Arachnida class and including over 40,000 registered species. Mites belong to several functional groups (decomposers, herbivores, predators or parasites) (MANU & HONCIUC, 2010b; HUGUIER et al., 2014). The species that live in the soil depend on its structure and composition (STĂNESCU & GWIAZDOWICZ, 2004; SANDA et al., 2006a, SANDA et al., 2006b). Mites are invertebrates with an extraordinary ability to adapt; they live in aquatic and terrestrial habitats, in favourable or extreme environmental conditions, such as rocks (MANU, 2011a; MANU & ONETE, 2014a; MANU & ONETE, 2015). They can use almost any food resource (STĂNESCU & JUVARA-BALȘ, 2005; HONCIUC & STĂNESCU, 2005; MANU et al., 2013; MANU et al., 2017a; KONTSCHÁN et al., 2015; MANU et al., 2017b).

Their presence in each habitat type is due to the complex of evolutionary, ecological and stochastic factors (STĂNESCU & HONCIUC, 2006). The trophic adaptability of mite species varies greatly, from omnivores (especially those living in the soil) to parasitic, highly specialized species that live and feed on a particular host (CONSTANTINESCU et al., 2011). Mites play an important role in the circuit of micro and macro-elements known for the development of primary producers. The role of mites is very important in achieving the soil-litter interface relations (CĂLUGĂR & HUȚU 1999; MANU, 2008a). They also participate in soil processes (HONCIUC & STĂNESCU, 2000; STĂNESCU & HONCIUC, 2004; MANU et al., 2018a, b), for example: humidification, mineralization, nutrient circuit, thus influencing soil fertility and productivity (CĂLUGĂR, 2009 ; MANU et al., 2018c).

The productivity of ecosystems largely depends on the combined action of the microbiota and mites, which participate together with abiotic factors in the organic matter circuit, by accelerating the process of biodegradation and decomposition of organic products (STĂNESCU & HONCIUC, 2005; CĂLUGĂR & HUȚU, 2008; MANU, 2013a). Soil fauna in relation to soil microorganisms actively participates in the degradation processes of plant biomass (CĂLUGĂR, 2019). Due to their small (microscopic) size, they are often neglected, although they are very important in the decomposition of organic matter (MANU & HONCIUC, 2010b; MANU, 2011b). It contributes to the improvement of soil characteristics and plays key roles in many processes that increase the success of ecological restoration (MANU et al., 2018d). Among the first mentions regarding the predatory mites in Romania we mention the work of Solomon from 1985 in which it is said that among the groups of mites, predators are those of the order Mesostigmata. This order occupies a wide variety of habitats. A large part of them are predators and the rest are parasites of mammals, birds, reptiles or even other invertebrates (HONCIUC & STĂNESCU, 2003). Being predators, they are at the end of food chains, which is why they are sensitive to changes in their living environment (CĂLUGĂR & HUȚU, 1999; CIORNEI, 2003).

This is one of the advantages of using this group in scientific papers. In addition, it is widespread, abundant, diverse and has a short life cycle. This group is in direct contact (by feeding or dermal) with the soil and its potential contaminants (HUGUIER et al., 2014). Mesostigmata mites are considered bioindicators for several reasons: their

functional role in soil ecosystems as predators, the high richness of species in their communities, their relatively high abundance and robustness in sampling and extraction methods.

Predators are more active and respond more quickly to changes in environmental parameters. They are considered bioindicators for soil quality, especially in forest ecosystems, where they find adequate environmental conditions for their development (MANU & ONETE, 2013b; MANU & ONETE, 2014a). The aim of our paper was to make a synthesis and a critical analysis of the literature on predatory mites in Romanian soils since the first studies in this field were published.

MATERIALS AND METHODS

The method used to make this synthesis of the literature was the critical analysis of the articles found on Google Scholar using keywords: "mites" and "Romania". Of those 140 papers analysed, only those that treated only mites that belonged to the order Mesostigmata were included in the study. Subsequently, a database was created in Excel where the following information was included: bibliographic reference, article title, abiotic and biotic environmental variables. Also, the used population parameters were identified in each article.

Analysing all this information, each article was classified in a certain category (taxonomic description, inventory type article, population study or ecological study). Moreover, future research perspectives based on the aspects less studied or highlighted in the analysed literature were also drawn from this database.

RESULTS AND DISCUSSION

The first bibliographical references regarding mites in Romania were found in a critical analysis of literature from 1969 made by Solomon and Roznovăț. Solomon in 1971 says that the history of the study of mites is only a decade.

There are four levels on which we can divide the studied literature according to its complexity: the oldest publications (since 1969) are taxonomic descriptions in which the structural elements of individuals are measured and described in detail (UJVARI & CĂLUGĂR, 2010). Later (1971-2015), the inventory studies where the species present in a certain habitat appear in the form of lists were added to these descriptions. These studies were conducted because the knowledge was at an early stage and it was essential for researchers to know what species exist and which is the structure of their body. Later, population studies dominated in the literature, describing the structure of the population by age (juveniles, adults, etc.), taking into account the numerical density and relating the population to the area unit (one square meter). The latest studies in the field are ecological. These are much more complex. They make correlations between the population parameters and the studied environmental factors (temperature, humidity, pH, degree of vegetation cover, degree of soil compaction, etc.) (Table 1).

The abundance and diversity of the mite fauna differs depending on the altitude, the soil composition, precipitation, the structure of the vegetal coverage (STĂNESCU & GWIAZDOWICZ, 2004; MANU, 2010a; MANU, 2010b). Also, ecological studies focused on differences in the altitudinal gradient or in relation to certain types of anthropogenic impact (heavy metal pollution, changing land use, application of various fertilizers, overgrazing, etc.) (MANU et al., 2015a, b, c, 2018d, 2019, 2021).

Table 1. Types of acarological studies depending on the evolution over time.

Type of scientific article	Number of articles	Years	Bibliographic reference
Taxonomic description	4	1969-2013	Roznovăț and Solomon, 1969; Călugăr, 2008; Ujvari and Călugăr, 2010; Pocora et al., 2013
Species inventory	16	1971-2015	Solomon, 1971; Solomon, 1985; Honciuc and Stănescu, 2003; Stănescu and Gwiazdowicz, 2004; Stănescu and Juvara-Balș, 2005; Honciuc and Stănescu, 2005; Stănescu and Honciuc, 2005; Manu and Honciuc, 2006; Călugăr, 2006; Călugăr and Huțu, 2008; Călugăr, 2009; Constantinescu et al., 2011; Manu, 2011a; Manu and Ion, 2014; Manu and Onete, 2014a; Chireceanu et al., 2015
Population study	15	1999-2019	Călugăr, 1999; Honciuc and Stănescu, 2000, 2004, 2005; Sanda et al., 2006a; Sanda et al., 2006b; Manu 2008b; Honciuc and Manu, 2010; Manu and Honciuc, 2010b; Călugăr, 2013; Manu, 2012; Manu et al., 2013; Manu, 2013a, b; Manu and Onete, 2013; Călugăr and Ivan, 2016; Călugăr, 2019
Ecological study	30	2003-2021	Ciornei et al., 2003; Manu, 2008a; Manu, 2009; Manu and Honciuc, 2010b, c; Manu, 2010a, b; Manu, 2011b, c; Manu, 2012; Manu, 2013a; Manu and Onete, 2014b; Manu and Onete, 2015; Manu et al., 2015a, b, c; Manu, 2016; Poliță et al., 2016; Manu, 2017; Manu et al., 2017c, b, d; Manu et al., 2018a, b, c, d; Călugăr, 2018; Manu et al., 2019; Manu et al., 2020; Fiera et al., 2020; Manu et al., 2021

Depending on the ecosystem type in which predatory mites are studied, the papers can be divided into several categories (forests, urban areas, meadows, cliffs, agricultural lands, saline habitats, caves, swamps, etc.). Predatory mites are widely distributed in most types of ecosystems (HONCIUC & MANU, 2010). The natural forest is the most favourable habitat for soil mites (Mites: Mesostigmata: Gamasina) (MANU, 2012).

The number of soil mites is very high in the soil of forest ecosystems where it represents more than 80% of the number of individuals in the soil fauna (STĂNESCU & HONCIUC, 2004a; MANU, 2009, 2013a; MANU et al, 2018c). This type of ecosystem is extremely complex, as the interaction among species but also among them and environmental parameters determines the structure of the ecosystem and its functions. This can be correlated with the fact that from the studied body of literature, the highest percentage (50%) is occupied by studies conducted in forest ecosystems (Fig. 1).

There is also a lack of studies in swamp and salt ecosystems, probably due to their difficult access. A small number of papers have also been found in cave ecosystems. In Romania, there are few studies on the order of Mesostigmata in urban areas, all conducted in parks or forests near the city (MANU, 2008b; MANU et al., 2021). Also, studies on soil fauna in meadows, especially predatory mites (Mites - Mesostigmata) have been scarce (CĂLUGĂR, 2006; MANU, 2016). The publications that mentioned the type of ecosystem in which the study was carried out were taken into account when drawing up the diagram below (Fig. 1).

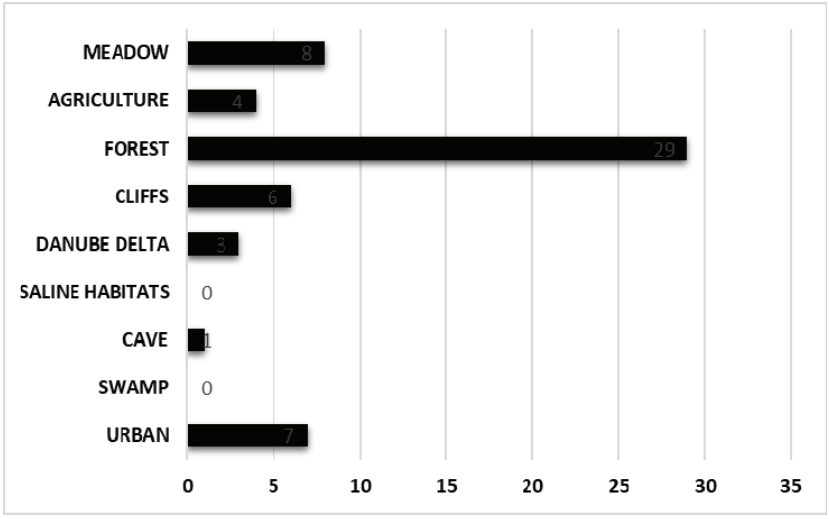

Figure 1. Types of ecosystems in which predatory mites have been studied.

In order to be able to describe the structure and dynamics of predator mite populations (their ecology), it is imperative to describe the environmental parameters that can be abiotic: (altitude, exposure, slope, temperature, precipitation, humidity, pH, impact type, etc.) and biotic (vegetation, the relationship of predatory mites with other groups). Most of the papers analysed by us included these variables (Fig. 2). Variables can be measured regionally (general description of the study area) or locally (different measurements for each soil sample collected). Most researchers measured these variables locally (MANU, 2008b; MANU, 2011b, c) (Fig. 3).

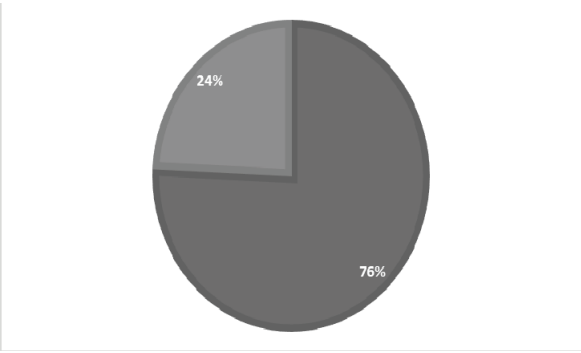

Figure 2. Papers with (76%) and without (24%) measured environmental variables.

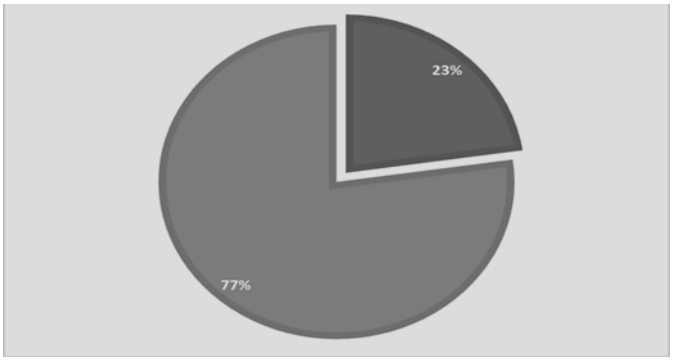

Figure 3. Environmental variables measured locally (77%) or regionally (23%).

The most frequently measured abiotic environmental variables at the local level were humidity, pH and temperature (Fig. 4). The species that live in the soil depend mainly on its structure, the content of detritus and humus, humidity, pH and temperature (STĂNESCU & HONCIUC, 2005; MANU, 2011c).

In Romania, studies on predatory mites in the soil that use population parameters have shown that abiotic factors and biotic factors have influenced the structure and dynamics of these invertebrate communities (MANU & ION, 2014).

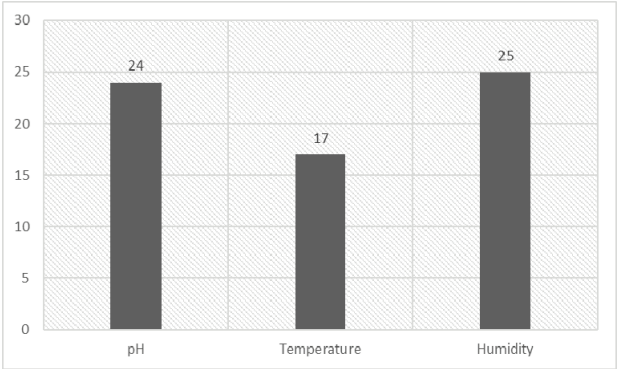

Figure 4. Number of papers using abiotic environmental variables on soil level.

Considering the biotic environmental variables, we can discuss about the relationship of predatory mites with vegetation or other soil fauna groups. It can be observed that the highest percentage of articles correlated the mite populations with the vegetation structure (Fig. 5). The plant species diversity and dominance modify the local environmental variables: light, temperature, soil moisture and chemical quality of the substrate. As these variables are modified, the composition of the invertebrate community is also modified. Plant species diversity is positively correlated with invertebrate diversity (CĂLUGĂR, 2019; CIFUENTES-CROQUEVIELLE et al., 2020; FIERA et al., 2020).

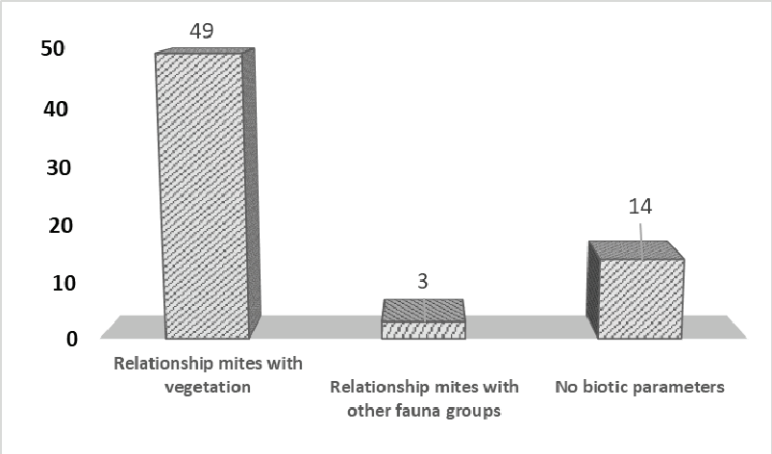

Figure 5. Number of scientific papers correlating predatory mite fauna with biotic variables (vegetation or other fauna groups).

Studies have shown that edaphic fauna, whose life cycle is largely in the first ten centimetres of soil, is significantly affected by soil removal and storage (MANU et al, 2019). Among soil invertebrates, mites are considered very sensitive to heavy metal contamination (MANU et al., 2015b; MANU, 2017; MANU et al., 2018d). The most common heavy metals studied are: Cu, Zn, Pb and As (Table 2). Species diversity and their numerical density decrease significantly with increasing pollutant concentration (CĂLUGĂR, 2012; MANU et al., 2015b). Due to the high diversity and small size of soil fauna, their monitoring studies are few (CĂLUGĂR & IVAN, 2016; MANU et al, 2019), even if these invertebrates are useful bioindicators of the impact of anthropogenic activities and can be used to define soil condition and quality.

Table 2. Heavy metals treated in scientific papers.

	Cu	Zn	Pb	As	Mn	Ni	Cd	Cement dust
Călugăr, 2012								x
Manu et al., 2015a	x	x	x	x	x	x		
Manu, 2016	x	x	x	x	x	x		
Manu et al., 2017b	x	x	x	x				
Manu et al., 2017e	x	x	x	x				
Manu et al., 2018c	x	x	x				x	
Manu et al., 2019	x	x	x	x	x	x		

CONCLUSIONS AND PERSPECTIVES OF FUTURE RESEARCH

Groups of invertebrates are often neglected due to identification difficulties or lack of specialists in the field.

Given the low number of papers regarding salty, cave, swamp ecosystems thus more studies are necessary in the future.

Most of the analysed papers presented the correlation between vegetation and soil fauna, which is directly influenced by the composition of vegetation. The relationship between soil fauna and other groups of fauna is insufficiently investigated in Romania, in spite of the importance of the subject.

Future studies are needed to reveal the relationship among the functional fauna groups, the relationship of plants with functional groups of invertebrates. From all the studied articles, only a fairly small number focused on the correlation of soil fauna with the heavy metal concentration from the soil. This correlation is of particular importance and should be intensively researched in the coming years as it could have undesirable effects on both the diversity of plant species and invertebrates and on human health. Studies in urban areas are also of interest for social welfare and should be further developed.

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