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Effects of habitat age and plant species on predatory mites (Acari, Mesostigmata) in grassy arable fallows in Eastern Austria

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A B S T R A C T

Density, diversity and assemblage structure of Mesostigmata (cohorts Gamasina and Uropodina) were investigated in nine grassy arable fallows according to a factorial design with age class (2–3, 6–8, 12–15 years) and plant species (legume: *Medicago sativa*, herb: *Taraxacum officinale*, grass: *Bromus sterilis*) as factors. The response of Mesostigmata to habitat age and plant species was explored because this group belongs to the dominant acarine predators playing a crucial role in soil food webs and being important as biological control agents. To our knowledge, this combination of factors has never been studied before for Mesostigmata. A further rarely applied aspect of the present study is the micro-scale approach investigating the Mesostigmata assemblage of the soil associated with single plants. Four plots were randomly chosen at each fallow in May 2008. At each plot plant roots and the adjacent soil of five randomly selected plant individuals per plant species were dug out with steel cylinders for heat extraction of soil fauna and measurement of environmental parameters. In total, 83 mite taxa were identified, with 50 taxa being new to Austria. GLM analysis revealed a significant effect of plant species on mite density, with significantly more mites in *B. sterilis* than in *T. officinale* samples, and *M. sativa* samples being intermediate. This was in contrast to the assumption that the mite density is highest in *M. sativa* samples due to the propagation of plant quality effects to higher trophic levels. These results were probably caused by a higher amount of fine roots in grass samples leading to high densities of Collembola, which are preferred prey of predatory mites. Mite density did not significantly differ between the three age classes. A canonical analysis of principal coordinates (CAP) showed that the mite assemblage exhibited a weak yet significant separation between plant species, and a highly significant separation between age classes. Accordingly, different mite assemblages were found for the three age classes, while only few mite species were clearly associated with a single plant species. Finally, canonical correspondence analysis (CCA) revealed that the mite assemblage was best explained by soil organic carbon, total density of Collembola and water content.

1. Introduction

Conversion of intensive farmland towards more natural and species rich ecosystems needs to be included into the management of sustainable agriculture. Less or undisturbed habitat islands like fallows can serve as refuges for endangered species and increase species richness in rural landscapes (Gulvik et al., 2008). The transition of arable land to later successional habitats such as grassland includes changes in vegetation composition, soil fauna and microbial communities (Gormsen et al., 2006). Soil biota is an important component of terrestrial ecosystems because it governs essential ecosystem functions such as decomposition and recycling of organic residues, which influence plant community composition and primary production (Wardle et al., 2004). Furthermore, soil fauna may be of considerable importance for initial colonization as a vector for seed, spores and microbial propagules (Koehler, 2000; Walter and Proctor, 2004). Besides the increased interest in belowground communities over the last few decades, the knowledge of the factors regulating the composition of belowground communities remains limited (Nielsen et al., 2010). Microarthropods constitute a considerable and important part of soil fauna (Siepel and Maaskamp, 1994). Among the microarthropods, mites and Collembola are the most important groups in soil with overwhelming species richness and densities within the range of hundreds of thousands of individuals per m^2 (Koehler, 1999). As major predators of root pests, especially nematodes, mites are

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generally considered beneficial in soil (Walter and Proctor, 2004). The dominant acarine soil predators are found among the mite taxa Mesostigmata (Gamasida) and Prostigmata (Ruf and Beck, 2005; Walter and Proctor, 2004). The majority of Gamasina, which are a subset of Mesostigmata, are mobile predators feeding on nematodes, Collembola, enchytraeids, insect larvae and mites (Koehler, 1999). As main predators among soil mesofauna, Gamasina have a crucial position in the soil food web contributing significantly to energy and matter turnover (Ruf and Beck, 2005). They have an indirect influence on overall ecosystem performance by affecting population growth of other organisms and are used as bioindicators due to their functional role, high species richness, high abundance and robustness to sampling and extraction (Koehler, 1999). Despite their importance, studies about the succession of Mesostigmata are rare. In most cases there are short-term investigations ranging from less than three (Purvis and Curry, 1980; Streit et al., 1985; Wasylik, 1995) to five years (Lagerlöf and Andrén, 1988; Koehler, 1991). Furthermore, in most studies the investigated habitats are industrial reclamation sites (Hutson, 1980; Koehler, 1984; Madej and Stodolka, 2008) or reclaimed mining wastelands (Christian, 1993; Dunger, 1968; Madej and Skubala, 1996; Zerling and Prasse, 1986). In general, studies on soil mite communities in traditional, multifunctional farmland and on secondary succession following the abandonment of traditional farmland are lacking in Europe (Gulvik et al., 2008). Only one German study (Koehler, 2000) matches the age profile and habitat type investigated in the present work.

Studies concerning plant effects on soil mites are even scarcer (Badejo et al., 2002; Bezemer et al., 2010; St. John et al., 2006). However, plant species and plant functional group effects on different trophic levels of a soil food web have been studied using nematodes (Viketoft et al., 2005; Wardle et al., 2003) and Collembola (Salamon et al., 2004). Plant species identity influenced the community composition of soil organisms within each of three consumer levels meaning that community compositional effects are propagated through food chains (Wardle et al., 2003). For a long time, most soil organisms have been viewed as generalists, which are relatively insensitive to plant species identity (Bezemer et al., 2010). Yet plant species vary in their chemistry, physiology, rhizodeposition and the quality and quantity of the litter they produce (Maharning et al., 2009). Especially legumes increase soil fertility by nitrogen fixation and returning high quality litter to soil organisms (Mulder et al., 2002; Spehn et al., 2002; Temperton et al., 2007).

In the present study, we investigated the influence of single plant species (*Medicago sativa* as legume, *Taraxacum officinale* as forb, *Bromus sterilis* as grass) on predatory mites in grassy arable fallows belonging to different age classes (2–3, 6–8 and 12–15 years). A micro-scale approach, investigating the mites of the soil associated with single plants, was applied. To our knowledge, the combined effects of habitat age and plant species on soil mites under natural field conditions have not been studied so far. This study is designed to test the following hypotheses:

1) The density of mites is higher in *M. sativa* than in *T. officinale* and *B. sterilis* samples due to the propagation of plant quality effects to higher trophic levels. The high nitrogen content of *M. sativa* litter increases the growth of microorganisms attracting microbivorous soil fauna (e.g. Collembola), which is preyed upon by mesostigmatid mites.
2) The density and species richness of mites will increase with the successional age of fallows due to the decreased intensity of disturbances and increased habitat diversity because of a well developed vegetation cover.
3) The mite assemblages of the different age classes differ from each other due to the occurrence of early, intermediate and late species during succession (Koehler, 1998).

2. Material and methods

2.1. Sites

This study was carried out in the Marchfeld region comprising an area of roughly 1000 km^2 east and north-east of Vienna, Austria. It is part of the Vienna Basin, a section of the Pannonian Plain, characterized by a continental climate of high temperature and low precipitation in summer, with mean annual temperature over 9 °C and mean total annual precipitation between 500 and 600 mm (Hadatsch et al., 2000). In total, nine grassy arable fallows containing the targeted plant species *M. sativa* as legume, *T. officinale* as herb and *B. sterilis* as grass were selected. The fallows belonged to three different age classes (2–3, 6–8 and 12–15 years) each including three sites representing different stages of secondary succession (Scheu and Schulz, 1996). The dominant soil types were Chernozem, Parachernozem and Wet Chernozem. Most of the fallows were established via spontaneous succession and a few of the fallows were sown with a Lucerne fallow seed mixture. All fallows were mown once a year. The site parameters soil type, geographic position and size are given in Salamon et al. (2011).

2.2. Sampling and sample treatment

In May 2008, four plots with at least 20 m distance from each other were randomly selected in the center of each fallow. Within each plot roots and the associated soil of five individuals of *M. sativa*, *T. officinale* and *B. sterilis* were extracted using square steel cylinders (5.6 cm × 5.6 cm, length 10 cm) from aggregations of the chosen plant species. Altogether 108 samples were obtained (nine sites × four plots × three plant species). The material of two cylinders per plant species was pooled for the measurement of abiotic soil parameters and microbial biomass. The soil of three cylinders (approximately 940 cm^3) was combined for the extraction of the soil fauna.

Extraction was carried out in a Berlese–Tullgren funnel with stepwise temperature rise from lowest possible output power to maximum intensity with an intermediate step in the course of three days. The soil fauna was gathered in 10% sodium benzoate solution, transferred into 70% ethanol and stored therein until identification. Mites from the group Mesostigmata were mounted in Marc Andre reagent, dried for about one week and identified to species level using a differential interference contrast microscope and the identification key of Karg (1993).

The samples for the determination of soil parameters were sieved with a 2 mm mesh and partitioned for different measurements in the laboratory. Soil moisture was gravimetrically measured after drying at 105 °C for 24 h. A fraction of the dried soil was milled and prepared for the analysis of total carbon and nitrogen with an elemental analyzer (Carlo Erba, Milan). The pH was determined in an aqueous suspension of 10 g soil adjusted to 25 ml volume with 0.01 M $CaCl_2$ solution after shaking for 1 h applying the WTW pH-meter pH95 with SenTix 61 pH-electrode. Organic carbon was ascertained as difference of total and inorganic carbon after carbonate measurement with a Scheibler apparatus. Microbial parameters were determined from respiration measurements using an automated respirometer based on electrolytic oxygen microcompensation in fresh soil samples equivalent to 3.5 g dry weight. For details on determination of microbial carbon and basal respiration see Salamon et al. (2011).

2.3. Statistical analyses

To detect differences in mite density and species richness as well as for soil parameters the procedure GLM (General Linear Model) of the statistical software SAS 9.1 was used according to the design