



Top-down control of soil microarthropods – Evidence from a laboratory experiment

Katja Schneider, Mark Maraun*

Technische Universität Darmstadt, Institut für Zoologie, Schnittspahnstrasse 3, 64287 Darmstadt, Germany

ARTICLE INFO

Article history:

Received 30 March 2008

Received in revised form

3 October 2008

Accepted 13 October 2008

Available online 6 November 2008

Keywords:

Top-down control

Generalist predators

Oribatida

Mesostigmata

Collembola

ABSTRACT

Predator–prey interactions are of eminent importance as structuring forces for animal communities. The present study investigates if and how strongly the density of soil microarthropods is controlled by top-down forces, i.e. predation by mesostigmatid mites (Mesostigmata, Acari). We set up a laboratory experiment running for ten weeks with undisturbed soil cores taken from the field using two densities of predatory mesostigmatid mites: (1) ambient density (control) and (2) increased density (addition of seven *Pergamasus septentrionalis* and eight *Lysigamasus* sp. individuals). Increased predator density resulted in a decrease in the density of Oribatida, Collembola and Protura whereas the density of other taxa including Astigmata, Prostigmata and Uropodina was not significantly affected. Additionally, the species number of Oribatida was also not significantly affected. Taxa of Oribatida and Collembola were differently affected by increased predator density. Among Collembola, densities of Poduridae and Sminthuridae were reduced, whereas Entomobryidae were not affected. Among Oribatida, densities of Oppiidae and Suctobelbidae were reduced whereas Desmonomata, Poronota and *Tectocephus* were not affected. Grouping of Oribatida into different size classes and into classes differing in sclerotization suggests that smaller mites (200–300 µm) and mites with less sclerotization were more heavily affected than larger mites and mites with strong sclerotization. The results indicate that predatory mesostigmatid mites have the potential to control the density of certain taxa of soil microarthropods. In particular, small and little sclerotized prey is susceptible to predator control indicating that predator defense is an important component of the life history tactics of soil microarthropods, especially of Oribatida.

© 2008 Elsevier Ltd. All rights reserved.

1. Introduction

Soil decomposer animals, i.e. animals that consume mainly dead organic material, are assumed to be predominantly bottom-up controlled since otherwise organic material in terrestrial systems would accumulate which is not the case (Hairston et al., 1960). This assumption has been confirmed for certain taxa of soil invertebrates by resource addition experiments in the field (Scheu and Schaefer, 1998; Rantalainen et al., 2004) whereas other studies found only weak or indirect effects after resource manipulation (Scheu, 2002; Salamon et al., 2006). However, the assumption of bottom-up control of soil animals only applies to primary decomposer species feeding on detritus. In recent studies it has been shown that most soil microarthropod species do not only feed on litter but additionally (or exclusively) on fungi (Schneider et al., 2004; Chahartaghi et al., 2005; Pollierer et al., 2007), on

dead and living animals (Illig et al., 2005) or on higher plants, lichens and algae (Erdmann et al., 2007). For these secondary decomposers and predators the factors controlling their density are virtually unknown.

Understanding the importance of top-down forces in terrestrial ecosystems is crucial since predators affect the trophic structure of soil food webs (Cousins, 1987) and consequently the flow of carbon and nutrients in the soil systems (Hättenschwiler and Gasser, 2005), thereby affecting plant growth (Van der Putten et al., 2001) and decomposition processes (Scheu, 2002). Additionally, predation on soil decomposers and fungal feeders may affect the diversity of soil animal taxa (Cole et al., 2005). Preferential predation on more abundant prey species has been shown to reduce interspecific competition among prey species thereby increasing prey diversity (Wardle, 2006; Huntley and Kowalewski, 2007).

Top-down forces have been shown to be important in soil animal communities – at least locally or temporarily (Scheu et al., 2003; Murray et al., 2006), e.g. fungivorous microarthropods have been shown to reduce fungal biomass (Lenoir et al., 2007), and root-feeding nematodes can be top-down controlled by predatory nematodes and mites (Laakso and Setälä, 1999; Neutel et al., 2002; Chen et al., 2007). Using cytochrome oxidase I as a molecular

* Corresponding author. Present address: University of Goettingen, Institute of Zoology and Anthropology, Berliner Str. 28, 37073 Goettingen, Germany. Tel.: +49 6151 165219/551 395557; fax: +49 6151 166111/551 395448.

E-mail addresses: marau@bio.tu-darmstadt.de, mmaraun@gwdg.de (M. Maraun).

marker Read et al. (2006) showed that mites and Collembola feed on nematodes in the laboratory and in the field supporting the assumption that top-down forces are important in regulating soil animal communities under natural conditions. However, apart from predators of nematodes top-down control of soil animal populations has hardly been studied. Predator–prey interactions are common in soil animal communities including intra-guild predation (Halaj et al., 2005), trophic level omnivory (Snyder and Wise, 2001) and cannibalism (McNabb et al., 2001) but these interactions occur mainly among predators, and their role for top-down control of lower trophic level prey populations is little understood. In a laboratory experiment Peschel et al. (2006) have shown that the predatory mite *Pergamasus septentrionalis* feeds on conspecifics, collembolans and some species of Oribatida when no other prey is available. However, the relevance of these results for the field remained unclear. In addition, in that study only a single prey individual was offered, and there was no possibility for the prey to hide.

The aim of the present study was to investigate the potential of soil animal predators (predatory mesostigmatid mites) to reduce the number of soil microarthropods (Oribatida, Collembola, Astigmata, Prostigmata, Uropodina, Protura) in a laboratory experiment. We used a combination of a large and small predatory mesostigmatid mite species to investigate the potential of predators of different size to control prey populations. The following hypotheses were investigated. (1) Predatory mesostigmatid mites reduce the number of prey individuals of all soil microarthropod taxa except that of Oribatida since the latter are strongly sclerotized, (2) juveniles are more frequently consumed than adults and (3) large species are in a size refugium compared with smaller species and are therefore less susceptible to predation.

2. Material and methods

2.1. Sampling of soil cores and mesostigmatid mites

Intact soil cores were taken from an oak–hornbeam forest (Kranichsteiner Wald) in April 2003. The forest is located ca. 8 km northeast of Darmstadt in Hesse, Germany, at 150–175 m a.s.l. The tree layer is dominated by 190-year-old oak (*Quercus robur*), with interspersed beech (*Fagus sylvatica*) and hornbeam (*Carpinus betulus*). The herb layer is dominated by *Luzula luzuloides*, *Milium effusum*, *Anemone nemorosa* and *Polytrichum formosum*. Parent rock is Rotliegendes covered with drifting sand. The soil types are dystric gleysols and orthic luvisols (FAO–UNESCO classification); the humus form is a typical moder. The pH of the soil varies between 3.6 and 4.3. The average annual precipitation in Darmstadt is ca. 700 mm and the average annual temperature is 9.5 °C. Ten soil cores of a diameter of 5 cm and a height of 10 cm were taken from an area of 100 m². Immediately after sampling each core was placed in a plastic tube (microcosm; diameter 5 cm, height 15 cm). To prevent emigration of micro- and macroarthropods the top and the bottom of the tubes were closed with gauze of a mesh size of 48 µm. The microcosms were stored in a climate chamber at 13 °C until the end of the experiment. Adult Mesostigmata were collected from the litter of the Kranichsteiner forest using heat extraction (MacFadyen, 1961). They were kept in plastic vessels (diameter 7 cm) at 13 °C and simultaneously placed in the microcosms at the start of the experiment (see below). The experiment ran for 10 weeks.

2.2. Experimental design and sampling

The set-up of the experiment started two days after establishing the microcosms. In five microcosms (high-predator treatment) seven large adult Mesostigmata (*P. septentrionalis* (Gamasina);

mean length ~1500 µm) and eight smaller adult Mesostigmata (*Lysigamasus* sp. (Gamasina); ~600 µm) were added. Five control microcosms were left untreated. Microcosms were placed in a climate chamber at 13 °C and incubated in darkness. Each microcosm was irrigated with about 5 ml distilled water at 5-day intervals. The calculation of the amount of water needed was based on the gravimetric measurement of the loss of water. To maintain the high density of Mesostigmata, three *P. septentrionalis* and two *Lysigamasus* sp. individuals were added to the high-predator treatment five weeks after experimental set-up resulting in ten individuals of each of the predatory mite species in the high-predator treatments.

After ten weeks soil cores were taken from the microcosms and separated into two horizons, 0–5 cm and 5–10 cm. Soil microarthropods were extracted using heat (MacFadyen, 1961). Uropodina, Astigmata, Prostigmata and Protura were counted, Collembola were determined to group level (Poduromorpha, Isotomidae, Entomobryidae, Sminthuridae) and Oribatida to species, genus or family level. Further, we measured the density of Gamasina at the end of the experiment to investigate if interactions between predator taxa took place.

Since the phylogeny of mesostigmatid mites is not resolved we separate Mesostigmata into Uropodina and Gamasina. Uropodina are monophyletic and are defined as the tortoise-shaped mites within Mesostigmata. All other (non-Uropodina) mesostigmatid mites are termed Gamasina.

2.3. Statistical analysis

The data of this study were analysed in a hierarchical way which means that the effects of high-predator density on higher taxonomic groups were analysed first and (if significant), subsequently, the effect on lower taxonomic levels was studied. First, the effect of high-predator densities on the density of microarthropod taxa (Oribatida, Astigmata, Prostigmata, Gamasina, Uropodina, Collembola, Protura), the density of juvenile and adult Oribatida and the diversity of Oribatida (species number) were investigated using one-way analysis of variance. The analyses were carried out using SAS 9.13 (SAS Institute Inc., Cary, USA).

Second, we tested whether if the density of taxa of Collembola (Entomobryidae, Isotomidae, Poduromorpha, Sminthuridae) and Oribatida (Enarthronota, Desmonomata, Mixonomata, *Tectocephus*, Oppiidae, Suctobelbidae, Poronota and others; see Appendix for grouping of species into supraspecific taxa) changed in high-predator treatments using principal component analysis (PCA) implemented in CANOCO 4.5 (Microcomputer Power, Ithaca, NY) with the factor ‘Gamasina’ as supplementary variable. Microarthropod densities were log-transformed prior to the analyses to increase homogeneity of variance and only species which occurred in at least three samples were included. Discriminant function analysis (DFA) was carried out with the sample scores of the first two axes in Statistica 7.1 (Statsoft, Tulsa, OK). Subsequently, protected ANOVAs (Scheiner and Gurevitch, 2001) were performed to locate which of the Collembola and Oribatida groups contributed to significant DFA results. These analyses were implemented in SAS 9.13.

To determine whether Gamasina preferentially fed on certain Oribatida, oribatid mite species occurring in at least three samples were grouped according to the degree of sclerotisation (slight, little, intermediate, strong; see Appendix for grouping) and body size (<200 µm, 200–300 µm, 300–500 µm, >500 µm; see Appendix for grouping). The degree of sclerotisation was estimated from the degree of darkness of the cuticle. The role of sclerotization and body size as predator defense were analysed by using the sclerotization and body size classes as dependent variables and by analysing the effect of predators by one-way multivariate analysis of variance

Download English Version:

<https://daneshyari.com/en/article/2026822>

Download Persian Version:

<https://daneshyari.com/article/2026822>

[Daneshyari.com](https://daneshyari.com)