European Journal of Soil Biology 59 (2013) 8–14

Contents lists available at ScienceDirect

European Journal of Soil Biology

journal homepage: http://www.elsevier.com/locate/ejsobi

Original article

Oribatida (Acari) in grassy arable fallows are more affected by soil properties than habitat age and plant species☆

Janet Wissuwa*, Jörg-Alfred Salamon [1], Thomas Frank

University of Natural Resources and Life Sciences, Department of Integrative Biology & Biodiversity Research, Institute of Zoology, Gregor Mendel Straße 33, A-1180 Vienna, Austria

ARTICLE INFO

Article history:
Received 18 May 2013
Received in revised form
24 July 2013
Accepted 12 August 2013
Available online 28 August 2013
Handling editor: Stefan Schrader

Keywords:
Oribatida
Arable fallows
Habitat age
Plant functional group
Soil type
Soil properties
Assemblage analysis

ABSTRACT

Oribatid mites are one of the numerically dominant arthropod groups in soils. They play an important role in soil food webs via regulating the decomposition of organic matter and propagating microorganisms within the soil. To our knowledge, the influence of different plant functional groups on oribatid mites has not been studied in abandoned farmland with undisturbed succession before. The density and assemblage structure of oribatid mites in nine grassy arable fallows relative to three habitat age classes (2–3, 6–8, 12–15 years) and three selected plant species (legume: *Medicago sativa*, forb: *Taraxacum officinale*, grass: *Bromus sterilis*) were investigated in soil associated with single plants.

Mite density declined marginally not significant with habitat age because of high abundances of the ubiquitous species *Tectocepheus velatus sarekensis* and *Punctoribates punctum* in young and mid-aged fallows and their subsequent decline in old fallows. Oribatid mite density and species assemblage were not affected by plant species. Only *P. punctum* had significantly higher densities in *B. sterilis* samples than in *T. officinale* samples due to a higher amount of fine roots. Distance-based linear models revealed that 65% of the variation in mite assemblage was explained by soil properties, soil type, exposition and geographic position, while habitat age was of minor importance. Canonical correspondence analysis revealed that the mite assemblage was best explained by soil organic and microbial carbon, water content and pH.

1. Introduction

Over the past several decades agricultural intensification led to enormous land-use changes resulting in dramatic losses of biodiversity [1]. To counteract the loss of biodiversity agricultural land is converted to more natural ecosystems [2] like grassy arable fallows or wildflower areas, which are designed to enhance arthropod diversity and abundance of beneficial arthropods [3]. The establishment of such semi-natural habitats targets mainly plants and above-ground invertebrates [4–6] neglecting the response of soil invertebrates [7]. However, soil biodiversity is considerably higher than above-ground diversity at local scales [8]. Yet, there is relatively little information about the development of soil biodiversity after cessation of agricultural practices [9].

Mites are a major constituent of soil biodiversity in terms of taxonomic diversity, range of behaviors and lifestyles [10]. Oribatid mites are the third largest mite group [11] reaching densities up to 200,000 individuals m^{-2} in boreal forests [12]. They are actively involved in decomposition and nutrient cycling as well as the dispersal of microorganisms. Their fecal pellets are an integral component of soil structure in organic horizons [13].

Long-term studies on succession in oribatid mite assemblage structure in agroecosystems following initial disturbance are rare [13] and restricted to Central Europe [9,14–17]. Because most Oribatida groups are generally reduced due to mechanical disturbances [18] they should benefit from the abandonment of arable land. Furthermore, the enhanced habitat diversity due to a well-developed vegetation cover with increased successional age [19] provides more microhabitats and food resources facilitating colonization and population growth. Despite being generally sensitive to disturbance oribatid mites show a considerable variation in sensitivity among taxonomic groups [12] from taxa common in

* Corresponding author. Tel.: +43 668 3063150; fax: +43 1 47654 3203.
E-mail addresses: janet.wissuwa@boku.ac.at, janet_wissuwa@yahoo.de (J. Wissuwa), jasalamon@yahoo.de (J.-A. Salamon), thomas.frank@boku.ac.at (T. Frank).
[1] Present address: Kapellenbrink 16, D-30655 Hannover, Germany.

1164-5563/$ – see front matter © 2013 The Authors. Published by Elsevier Masson SAS. All rights reserved.
http://dx.doi.org/10.1016/j.ejsobi.2013.08.002

cultivated soils and heavily disturbed habitats like Tectocepheidae and Oppiidae [13] to very sensitive taxa with long life-cycle and low fecundity like Enarthronota [12]. Such differences in sensitivity likely affect the species composition in different successional stages.

To our knowledge, there are just four investigations about plant species effects on oribatid mites [20–23]. However, plant species vary in palatability to consumers as well as quality and quantity of litter they produce [24], influencing the soil food web [25]. The presence of legumes has been shown to enhance decomposition [26,27], microbial biomass [28] and soil fauna feeding activity [29]. Soil fauna like earthworms [26] and Collembola [30] benefited from the presence of legumes. Similar to Collembola, oribatid mites mainly feed on plant material and microorganisms [13] and are therefore likely affected by resource quality pertaining to plant functional groups or single plant species. Oribatid mites have been shown to vary in abundance and species assemblage between different plant species [20,22]. The effect of plant species on soil organisms has previously been studied in monocultures or artificially established communities with sown mixtures of chosen plant species [20,22,30–33]. In contrast, in the present study the influence of single plant species (*Medicago sativa* as legume, *Taraxacum officinale* as forb, *Bromus sterilis* as grass) on Oribatida in grassy arable fallows belonging to different habitat age classes (2–3, 6–8 and 12–15 years) was studied under natural field conditions where plants could spread out naturally. The mite assemblage of the soil associated with single plants was investigated. This study was designed to test the following hypotheses:

1) The density and species richness of Oribatida increases with fallow age because the impact of the severe disturbances accompanying crop production subsides with increasing habitat age and the abundance and species richness of most Oribatida taxa is generally reduced due to mechanical disturbances [18].
2) The Oribatida assemblage differs between the age classes of the fallows because species sensitive to agricultural disturbances are expected to increase with continuing abandonment of farmland.
3) The density of Oribatida should be higher in *M. sativa* than in *B. sterilis* and *T. officinale* samples since microphytophagous Oribatida benefit from increased microbial biomass and macrophytophagous Oribatida benefit from the high quality litter in the presence of legumes.
4) The Oribatida assemblage differs between the three plant species because plant species differ in their effect on components of soil communities due to differences in quality and amount of organic matter produced [34].

2. Material and methods

2.1. Study region and fallows

This study was carried out in the Marchfeld region, which is part of the Vienna Basin and comprises an area of roughly 1000 km^2 east and north-east of Vienna, Austria. As a section of the Pannonian Plain it is characterized by a continental climate of high temperature and low precipitation in summer. Mean annual temperature is roughly 9 °C and mean total annual precipitation ranges between 500 and 600 mm [35]. 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 habitat age classes (2–3, 6–8 and 12–15 years) each including three sites. The positions of the fallows ranged from 48.2 to 48.4° northern latitude and from 16.5 to 16.9° eastern longitude. The size of the fallows ranged from 1000 to 29,000 m^2. The larger fallows were sampled in a smaller area of about 3000 m^2. The dominant soil types within this region belong to the class chernozem according to the electronic soil map for Austria [36]. The site parameters pH, soil type, geographic position, fallow age and exposition are given in Table 1.

2.2. Sampling and sample treatment

Four plots with at least 20 m distance from each other were randomly selected in the central axis of each fallow in May 2008. Applying a micro-scale approach soil cores (diameter 5.6 cm, height 10 cm) were taken at the base of five plant individuals from aggregations of five to more than ten individuals of each of the chosen three plant species at each plot. Soil fauna was extracted from the pooled material of three randomly chosen cores using a Berlese–Tullgren funnel with stepwise rise of illuminance from approximately 100 lux to maximum intensity with an intermediate step of 1000 lux in the course of three days. The material of two randomly selected cores per plant species and plot was mixed and sieved with a 2 mm mesh for the measurement of abiotic soil parameters and microbial parameters. Fractions for the different measurements were weighted into snap cap vials and stored in the fridge until measurement. Per fallow 12 samples (four plots × three plant species) were gathered for the investigation of soil fauna and 12 samples for the measurement of soil properties resulting in 108 samples for all nine fallows. Soil fauna was gathered in 10% sodium benzoate solution, transferred into 70% ethanol and determined to species level using the identification key of Weigmann [37].

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 calculated 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 [38] in fresh soil samples equivalent to 3.5 g dry weight. Basal respiration was calculated by averaging respiration rates at 10 and 20 h after starting the measurements. Microbial carbon was calculated from maximum initial respiratory response after addition of glucose in aqueous solution [7].

Table 1
Parameters of the nine investigated grassy arable fallows within the Marchfeld region (soil types were taken from http://gis.lebensministerium.at/eBOD/frames/index.php?&gui_id=eBOD, correlations with soil units according to the World Reference Base for Soil Resources were obtained from the Austrian Agency for Health and Food Safety).

Fallows	Abandoned in	Geographic position		Soil type	Exposition	Mean soil pH
		Longitude	Latitude			
Site 1	2006	16.871	48.225	Gleyic phaeozem	Plain	7.4
Site 2	2006	16.668	48.300	Calcaric phaeozem	Plain	6.6
Site 3	2006	16.490	48.307	Calcaric phaeozem	Plain	7.1
Site 4	2001	16.872	48.225	Gleyic phaeozem	Plain	7.3
Site 5	2000	16.591	48.306	Calcic chernozem	South	7.3
Site 6	2002	16.783	48.280	Calcaric phaeozem	Plain	7.0
Site 7	1994	16.723	48.341	Calcic chernozem	Plain	7.2
Site 8	1996	16.570	48.366	Calcareous tilled soil	South	7.4
Site 9	1993	16.574	48.201	Calcic chernozem	Plain	7.1