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Short Communication

Soil pore volume and the abundance of soil mites in two contrasting habitats

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Abstract

Microarthropods are mainly found in the organic layer of soils but show high spatial variability in abundance that remains poorly understood. A factor that could be influencing the abundance of microarthropods is the soil pore volume. Consequently, we tested the hypothesis that mite abundance is related to soil pore volume in two contrasting habitats. Heather moorland and birch woodland, with contrasting humus forms, showed high within-habitat variation in soil pore volume and mite abundance. The abundance of oribatid mites in both habitats and the abundance of mesostigmatid mites in heather moorland were strongly and positively related to the volume of pores in the range 60–300 μm. This supports the hypothesis that mite abundance is influenced by soil pore volume and we stress that soil structure should be considered as an explanatory variable when studying microarthropod communities.

Keywords: Mesostigmata; Microarthropods; Oribatida; Soil pore volume

Microarthropods are very abundant in the upper soil layers and have functional roles ranging from detritivores to predators, thus influencing nutrient cycling and other soil processes (Coleman et al., 2004). Yet our understanding of the factors that control microarthropod abundance is limited. Soil mites are one of the most abundant microarthropod groups. Maraun and Scheu (2000) discussed the differences in community structure and abundance of oribatid mites across a range of habitats that differed with respect to soil type, acidity, humidity, forest type, resource availability and disturbance, and considered most factors to have little influence on abundance except under extreme conditions. However, oribatid mite abundance increased with changing soil type from man-modified habitats to old-growth spruce and pine forests, which was associated with an increase in the depth of soil organic matter and a change in the humus form. In some studies, microarthropod abundance has been shown to change with soil type and increases with depth of the organic layer (Petersen and Luxton, 1982; Schaefer and Schauermann, 1990), although others have failed to observe an increase in collembolan and oribatid mite abundance with increasing organic matter depth (Scheu et al., 2003). A possible reason for the above inconsistencies may be that microarthropod abundance is related to pore volume. The total pore volume would increase with organic matter depth, but different humus forms have different structures and, hence, the same volume of soil might contain different volumes of pores.

The abundance of bacteria, protozoa and nematodes has been shown to correlate with pore volume (Hassink et al., 1993; Young and Ritz, 2000; Strong et al., 2004) and it has been hypothesized that microarthropod abundance decreases with soil compaction and/or decreased structural complexity due to loss of pore volume (Borcard and Matthey, 1995; Heisler and Kaiser, 1995; Battigelli et al.,

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2004). Two studies have found mite abundance to correlate with pore volume in mineral soils (Vreeken-Bruijs et al., 1998; Ducarme et al., 2004), but no one has investigated how mite abundance relates to pore volume in the organic layer. Consequently, we hypothesized that mite abundance within habitats increases with pore volume.

We sampled two contrasting habitats: heather moorland and birch woodland, with contrasting humus forms known to differ in mite abundances (Osler et al., 2006; Mitchell et al., 2007). The mor organic (O) horizon in heather moorland is usually about 10 cm deep (Miles and Young, 1980), whereas the mull-moder O horizon in birch woodland rarely exceeds 5 cm.

Soil samples were collected on 14 June 2006 at Tulchan, Speyside, Scotland, UK (57°25′N, 3°27′W). The site is approximately 270 m a.s.l. and has soils ranging from humus-iron podsols to brown podsols dominated by heather moorland, but with natural colonisation by birch (Miles and Young, 1980; Hester et al., 1991).

Twelve sampling points were randomly selected within each of a first-generation birch woodland and a heather moorland. At each point, one soil core measuring 3.5 cm diameter × 5 cm depth was collected from the organic layer below the litter layer for extraction of mites, and a second core adjacent to the first measuring 7.5 cm diameter × 5 cm depth was collected for estimating the soil pore volume. Mites were extracted using modified Tullgren funnels by increasing the temperature to 40 °C over 8 days, sorted into oribatid (excluding Brachychthonioidea) and mesostigmatid mites and counted.

The pore volume cores were saturated with water and the volume of pores was estimated by measuring the gravimetric soil water content, after equilibrating the large cores at 10, 50, 100 and 150 kPa suction pressure, using hanging water columns. These pressures correspond to those required to release water from pores with openings measuring approximately >300, 60–300, 30–60 and 20–30 μm, respectively. The pore volume was computed from the volume of water extracted between successive intervals of applied suction.

Soil moisture and bulk density were calculated from the cores used for extraction of mites. The cores were then sieved (2 mm mesh) and used to measure the pH and loss on ignition. Soil pH was measured in 15 ml water and 1.75 ml 0.1 M $CaCl_2$ using 5 and 1 g soil for mineral and highly organic samples, respectively. Loss on ignition was measured after 12 h at 900 °C.

Differences in mite abundance, pore volume and abiotic factors between habitats were tested using Student's *t*-test. Relationships between mite abundance and abiotic factors (including pore volume) were inspected with general linear models, with the abiotic factor as a continuous variable and the habitat as a categorical variable, whilst also testing for possible interactions. All statistics were performed in GenStat version 8.2 (VSN International, 2005).

All abiotic factors and mesostigmatid mite abundance differed between the two habitats (Table 1). Soil moisture content and loss on ignition were highest in heather moorlands, whereas bulk density and pH were greatest under birch. Mesostigmatid mite abundance was three times greater in soil under birch compared with moorland soils. The average abundance of oribatid mites appeared greater under birch than under heather, but not significantly so ($t_{22} = 1.64$, $P = 0.115$).

Table 1
Mean abundance of Oribatida and Mesostigmata (individuals m^{-2}) and soil properties measured in birch woodland and heather moorland (mean ± s.e., $n = 12$)

	Birch	Heather	t_{22}	P
Soil moisture (% dry weight)	79 ± 19	185 ± 13	−4.68	<0.001
Bulk density ($g\,cm^{-3}$)	0.50 ± 0.07	0.22 ± 0.02	4.12	<0.01
pH ($CaCl_2$)	3.65 ± 0.11	3.21 ± 0.03	3.94	<0.01
Loss on ignition at 900 °C (%)	28.9 ± 8.8	78.4 ± 5.8	−4.70	<0.001
Oribatida	33,174 ± 5789	21,134 ± 4499	1.64	>0.10
Mesostigmata	10,740 ± 2016	3032 ± 843	3.53	<0.01

T statistic associated significance levels from *t*-tests of difference between habitats are presented.

Table 2
Mean pore volume ($cm^3\,cm^{-3}$ soil) for birch woodland and heather moorland (mean ± s.e., $n = 12$)

Volume ($cm^3\,cm^{-3}$ soil)	Birch	Heather	t_{22}	P
Total	0.84 ± 0.03	0.97 ± 0.01	−4.20	<0.001
>300 μm	0.20 ± 0.02	0.20 ± 0.02	−0.08	>0.90
60–300 μm	0.12 ± 0.01	0.13 ± 0.01	−0.44	>0.60
30–60 μm	0.07 ± 0.01	0.10 ± 0.01	−2.24	<0.05
20–30 μm	0.06 ± 0.01	0.06 ± 0.01	−0.91	>0.30

T statistic and significance level from *t*-tests of difference between habitats are presented.

The total pore volume and volume of pores in the range 30–60 μm ($cm^3\,cm^{-3}$ soil) were slightly, but significantly, greater in heather moorland soils (Table 2). The pore volume available to mites depends on the soil moisture under field conditions (Smiles, 1988; Hassink et al., 1993). However, we did not need to adjust the volumes for soil moisture before relating them to abundances, as all large pores (>20 μm) would be available when the low soil moisture contents were measured. The abundance of oribatid mites and mesostigmatid mites was best explained by the volume of pores between 60 and 300 μm in both habitats. Oribatid mite abundance was related to pore volumes only ($F_{1,20} = 9.94$, $P < 0.01$) with no habitat ($F_{1,20} = 3.38$, $P > 0.05$) or interaction effect ($F_{1,20} = 0.10$, $P > 0.7$). The abundance of oribatid mites increased with increasing pore volume in both habitats (Fig. 1(a)). Only habitat had a significant effect on the abundance of mesostigmatid mites ($F_{1,20} = 12.34$, $P < 0.01$). However, when the habitats were tested separately with linear regression, there was a positive relationship between