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Soil microarthropod-plant community relationships in alpine moss- sedge heath

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ABSTRACT

Above-ground vegetation has long been acknowledged as an important driver of below-ground decomposer communities. Here we compare the relationship between the plant community and four microarthropod groups (oribatid, mesostigmatic and prostigmatic mites and Collembola) in alpine moss-sedge heath. We assess the relative importance of plant growth forms (PGF), mean vegetation chemistry and plant community composition in influencing the microarthropod community composition. Microarthropod and plant community composition was recorded at 15 alpine *Racomitrium lanuginosum* heath sites in the UK. The correlation between the microarthropod community and the plant community was 0.76, 0.44, 0.34 and 0.59 for Oribatida, Prostigmata, Mesostigmata and Collembola, respectively (Procrustes analysis). Plant species composition was more important in determining community composition for microarthropods that are herbivores/fungivores/detritivores (Oribatida and Prostigmata and Collembola) than PGF or vegetation chemistry. Predatory microarthropods (Mesostigmata) were influenced by PGF, but not plant species composition or vegetation chemistry. This may reflect the importance of physical habitat structure for these species. We conclude that there is a strong relationship between the plant community composition and the soil microarthropod community but measures such as PGF or mean vegetation chemistry are too coarse to be useful in predicting the microarthropod community composition, because mites respond strongly to heterogeneity between plant species.

1. Introduction

Above-ground vegetation has long been acknowledged as an important driver of below-ground decomposer communities. Plants may exert a direct influence on microarthropods via their leaf and root litter because a wide range of soil microarthropods feed on plant litter and/or the associated decomposer micro-organisms e.g. fungal mycelia. Litter quality/quantity and associated fungal species vary between plant species and many microarthropods show a degree of selectivity in their choice of litter or fungal food source (Hubert et al., 2001; Klironomos et al., 1992; Schneider and Maraun, 2005). Litter type or quality has been shown to strongly influence the soil microarthropod community (Fujii and Takeda, 2012; Hansen, 1999; Hansen and Coleman, 1998; Taylor and Wolters, 2005). For example different species of tree litter have different oribatid mite assemblages (Hansen, 1999; Hansen and Coleman, 1998; Taylor and Wolters, 2005). Litter mixtures contain a greater variety of microhabitats, substrate types and fungal growth forms than the litter of a single plant species (Hansen and Coleman, 1998). This results in litter mixtures containing a greater variety of mite species (Hansen and Coleman, 1998). Changes in plant community composition and the corresponding changes in litter availability, quantity and quality may therefore be expected to drive changes in the soil microarthropod community. In addition, the plant community composition will alter the soil moisture, temperature and pH which, in turn, will influence the microarthropods (Bardgett and Wardle, 2010; Bradford et al., 2007; Eisenhauer et al., 2011; Lindo and Gonzalez, 2010). One might, therefore, expect a close and predictable relationship between the plant community and the soil microarthropod community. In Spitsbergen, Seniczak and Plichta (1978) showed that the abundance of oribatid mites was greater under *Saxifraga oppositifolia* (L.) than under lichen patches, and that a different mite community was found under moss patches versus patches of *S. oppositifolia*. Coulson et al. (2003) showed that although the microarthropod species composition under six different plants was broadly similar, the numerical

Abbreviations: PGF, plant growth form.
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abundance of the constituent species varied widely, and was sufficiently distinctive to characterise particular plant species. However, the plant species sampled by Coulson et al. (2003) generally form patches, such that it was possible to obtain soil samples from underneath just one species of plant. In plant communities that are composed of an intimate mixture of species, the microarthropod community may be influenced by many different plant species but the strength of this relationship is unknown.

Alpine regions are important reservoirs of biodiversity and support ecosystems containing significant stocks of carbon (Britton et al., 2011). It is important to improve our understanding of the links between the alpine plant community and the below-ground soil fauna community to predict how external drivers of above-ground vegetation dynamics e.g. climate change or land use change may affect ecosystem processes. Alpine vegetation composition is known to have changed (Armitage et al., 2012; Armitage et al., 2014; Britton et al., 2009) – and is predicted to change further – due to climate change. Microarthropods are known to be important in nutrient cycling and in carbon and nitrogen budgets (Glime, 2013; Lindo and Gonzalez, 2010). However, the link between changes in alpine plant communities, changes in microarthropods and changes in carbon and nitrogen budgets is unknown. The first stage in identifying these linkages is to assess the relationship between the alpine plant community and the microarthropod community. In this study, we test this relationship in samples from 15 alpine *Racomitrium lanuginosum* – *Carex bigelowii* heaths (from now on referred to as *Racomitrium* heath). *Racomitrium* heath is an alpine habitat found on mountain summits at relatively high latitudes and levels of oceanicity. It is dominated by the moss *Racomitrium lanuginosum* (Hedw.) intermixed with graminoids and forbs (Armitage et al., 2014) such that the microarthropod community is likely to be influenced by an intimate mixture of plant species rather than just one plant species (cf. Coulson et al., 2003). Previous studies of microarthropods in *Racomitrium lanuginosum* – *Carex bigelowii* heaths have assessed microarthropod abundance but not identified individuals to species level (Bardgett et al., 2002).

Our first aim was to describe the microarthropod community of alpine moss/sedge heath in the UK, as this was previously unknown. Our second aim was to test the strength of the relationship between plant community composition and four microarthropod groups: oribatid, mesostigmatic and prostigmatic mites and Collembola. We hypothesised that this relationship would be strongest for oribatid mites and Collembola (groups that feed on plant litter and associated fungi) and weakest for the predatory mesostigmatic mites. Our third aim was to assess if this relationship was due to (i) the dominance of particular plant growth forms (PGFs) (mosses, graminoids, lichens, shrubs and forbs), (ii) mean vegetation chemistry or (iii) the individual species composition of the plant community. Our final aim was to assess if these three groups of plant community variables (plant species composition, PGF and mean vegetation chemistry) explained the same or different parts of the variation within the microarthropod community.

2. Materials and methods

2.1. Field sites, sampling and mite identification

At 15 alpine *Racomitrium* heath sites (Fig. 1) a 1 ha area of homogenous vegetation was marked out; in each quarter of the 1 ha area two 1 m^2 quadrats were randomly placed. The percentage cover of all plant species in the quadrat was estimated by eye. From the centre of each quadrat one soil core was taken giving eight cores per site and 120 cores in total. Soil cores were 5 cm in diameter and included the vegetation, litter and soil to a depth of 8 cm. The cores were kept cool until they could be extracted, which happened within 3 days of sampling. From within each quadrat a 0.1 m by 0.1 m section of the vegetation was harvested for chemical analysis with all vegetation biomass removed to bare ground. Sampling occurred between July and September 2011. See Mitchell et al. (2016) for additional details of sites and methods.

Fig. 1. Location of the 15 alpine moss-sedge heath sites used in the survey. The sites come from five regions with 3 sites sampled in each region. In Wales (WA): CA = Carneddau, EF = Elidir Fach, SN = Snowdon. In the Lake District (LA): FA = Fairfield, GR = Grasmoor, SK = Skiddaw. In the Southern Uplands (SU): BL = Broad Law, CO = Corserine, ME = Merrick. In the Southern Highlands (SH): CA = Cairngorms, CM = Creag Meagaidh, GM = Glas Maol. In the Northern Highlands (NH): BR = Breabag, MC = meal nan Ceapraichen, TC = Tom a' Choinich.

Soil invertebrates were extracted from the cores in Tullgren funnels over the course of 7 days during which the temperature was gradually increased from room temperature to 60 °C. The organisms were collected in 70% ethanol and sorted under a stereo-microscope. Adult oribatid mites were identified to species using a compound microscope and a range of literature including Weigmann (2006) and an unpublished key by M. Luxton. Two oribatid mite groups were only identified to superfamily and family level respectively: Oppioidea and Brachychthoniidae. Astigmata mites were identified to cohort level. All oribatid nymphs were lumped together. Mesostigmatic and prostigmatic