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Original article

The effect of microarthropods on litter decomposition depends on litter quality

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ABSTRACT

Many studies have investigated whether microbiota has been adapted to decompose a given litter type but we have limited information about the specific role of microarthropods in litter decaying processes. This experiment studied functional redundancy of microarthropods in a litter decomposition system by interchanging mesofauna among three different litter types. The study hypothesized that total microarthropod densities would be lower in foreign litter type than in original ('home') litter; and litter with foreign mesofauna would decompose slower than with native one. Scotch pine (*Pinus sylvestris*), Turkey oak (*Quercus cerris*) and black locust (*Robinia pseudoacacia*) litter were stored in microcosms with original microbiota. Microarthropods from the same ('home') or different ('foreign') type of litter were inoculated to microcosms. Litter mass loss and total density of collembolans, oribatid and other mites were recorded at the end of incubation (3 and 12 months). Litter quality determined total density of microarthropods irrespective of the origin of animals. Litter mass loss values differed in the three litter types. For pine litter, the origin of microarthropods had significant effects on litter mass loss. In oak litter, mainly microarthropod density influenced decomposition. Neither the origin nor the density of animals influenced the decomposition rate of black locust litter. Litter quality may have determined the different patterns of decaying. Mesofauna may enhance litter decomposition stronger in recalcitrant litter than in high-quality litter.

1. Introduction

Litter decomposition is an important process in nutrient cycling besides primary production. Climate, litter quality and soil biota determine the decay rate of dead plant material [1–4]. Microorganisms and soil-dwelling animals have different roles in biological decaying processes. Bacterial and fungal assemblages are responsible for the majority of litter decomposition [1,2,5]. Microarthropods, mainly Acari and Collembola, appear in high density and species richness in forest soil ecosystems (e.g. Ref. [6]) and affect decaying processes directly and indirectly [2,7–11] (Fig. 1a). Microarthropods directly increase decomposition rates with consuming and comminuting litter [8]. Their indirect influence in decaying processes is related to microorganisms. Mesofauna mobilize nitrogen by consuming litter thus making litter N content available for microorganisms [12]. In addition, bacterial and fungal feeder collembolans and mites increase the activity and distribution of microorganisms thereby enhancing decomposition processes [2,8,13]. However, it is unknown whether the relationship between microbial decomposers and soil fauna is specific or faunal effect is functionally redundant [2,14].

Home-field advantage (HFA) studies investigate the specific relation between the decomposer biota and litter types (Fig. 1b). In HFA experiments, plant detritus in litterbags is placed into native ('home') and 'foreign' habitats; and decaying rates of litter material are compared between 'home' and 'foreign' systems (e.g. Refs. [15,16]). Microbiota and/or soil fauna may have adapted to decompose their native litter type rather than a foreign litter type; if so, litter material should decay faster in home-field than in foreign habitat (e.g. Refs. [14,17]). Keiser et al. [18] suggested that decomposer microbes are primarily responsible for HFA processes.

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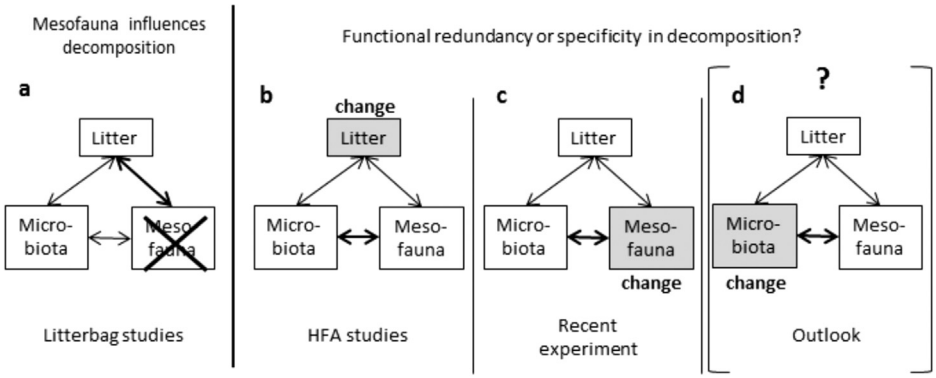

Fig. 1. How to investigate the role of soil-dwelling mesofauna in litter decomposition? **a** Litterbag studies proved that litter decomposes slower without mesofauna than with animals. **b** Home-field advantage (HFA) studies changed litter types between home and foreign sites and showed that mesofauna facilitate in different ways the decomposition of foreign and native litter. **c** This microcosm experiment changed the mesofauna assemblages among different litter-microbiota systems studying functional redundancy of mesofauna. **d** One possible improvement is when microbiota is changed between the mesofauna-litter systems.

However, litter quality influenced how soil fauna assisted the microbiota in decomposing litter material [11,19,20]. Few studies have distinguished the role of microbiota from that of soil fauna in HFA studies. Our knowledge is also limited about the relationship between decomposer microbes and mesofauna.

We used a microcosm experiment to investigate the specific relation between decomposing microbiota and microarthropods [21]. Mesofauna assemblages were interchanged among three different litter types involving original microbiota (Fig. 1c). 'Home' microcosms included litter with native microbiota and mesofauna. 'Foreign' microcosms contained litter with native microbiota and 'foreign' microarthropods. The experiment compared mesofauna densities and litter decomposition rates between home and foreign treatments. The study addressed the following question: have mesofauna assemblages been adapted to live in a given litter type and assist its native microbiota in litter decomposition? The first hypothesis was that mesofauna density is higher in home litter type compared to the foreign type. The second hypothesis was that litter mass loss is higher in home microcosms compared to foreign treatments.

2. Material and methods

2.1. Microcosm experiment

This study is part of a larger experiment which is described in a previous publication [22]. Here we describe the main aspects of the microcosm experimental design. Three larger litter samples were collected from three woodland types in Hungary: from a Scotch pine (*Pinus sylvestris*; final litter pH = ~5.98; N% = 1.35, C/N = ~34.52) plantation, from a native Tukey oak (*Quercus cerris*; final litter pH = ~5.32; N% = 1.64, C/N = ~22.44) forest, and from a black locust tree (*Robinia pseudoacacia*; final litter pH = ~6.77; N % = 2.06, C/N = ~17.60) plantation (data from Ref. [22]). The samples were collected at the beginning of the summer (May 31 and June 1 in 2011) so the litter material was not freshly fallen and had started to decompose during the winter and spring.

The three litter samples were mixed and homogenized separately (Fig. 2). The large samples were subdivided into 24 subsamples and stored temporarily in plastic bottles. Oak, pine and black locust litter subsamples had 65 g, 35 g and 50 g fresh weight, respectively. During the first 4 days of the experimental preparation, 3 × 6 subsamples (6 oak litter, 6 pine litter and 6 black locust litter subsamples) were sterilized with drying and heating (200 °C for 15 min). During this first drying process, mesofauna was extracted into alcohol. Dry mass of subsamples was measured after heating. It was the initial dry mass of litter samples on which calculation of relative mass loss was based. Then, litter material was crushed. Finally, subsamples were rewatered with filtered suspension of intact litter samples to reinoculate the litter with its original microbiota.

At the end of the fourth day, the defaunated and reinoculated litter subsamples were placed into plastic bottles which were placed under modified Berlese-Tullgren-funnels. Onto the top of the funnels, temporarily stored, intact litter subsamples were placed, and mesofauna were inoculated to the defaunated litter substrates (transferring process). After further 4 days, transferring was finished and the plastic bottles were stored as microcosms. Microcosms were placed into a semi-dark room. Temperature nearly followed the outside temperature but it was never lower than 6 °C and higher than 24 °C. Water loss was supplemented. For further technical details about microcosms, see Ref. [22].

The extracted litter in the funnel was heated (200 °C for 15 min), its dry mass was weighed and then, litter was reinoculated with microbiota. These subsamples were placed into plastic bottles and reused as litter substrates for the next transferring process. The reusing process was repeated twice (Fig. 2). It was necessary to minimize the variation caused by using high number of samples.

Mesofauna from the three litter types was transferred into home and foreign litter types (Fig. 2). For example, mesofauna from oak litter was transferred into defaunated oak litter (home treatment) and into defaunated pine and black locust litter (foreign treatments). All the treatments contained three replicates. Half of the microcosms were incubated for three months and half of them for 12 months. For the 12-month incubated microcosms, defaunated litter material was added after 6 months to compensate for the decomposed litter.

After 3 or 12 months, litter subsamples from all the microcosms were extracted into alcohol. Alcohol extracted microarthropods (also from the first drying process) were counted and sorted to collembolans, oribatid mites and other mites. After extraction, litter substrates were heated (200 °C for 15 min) and weighed. It was the final dry mass of each litter sample in a microcosm. Relative mass loss was calculated individually for each microcosm according to the initial and final dry mass of its litter content.

2.2. Data analyses

Densities of collembolans, oribatid and other mites of each microcosm were expressed by dividing the total number of