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The Collembola community of a Central European forest: Influence of tree species composition

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ABSTRACT

The present study investigates the response of the Collembola community to replacement of beech by spruce or by mixed stands of beech and spruce in the Solling mountains (Germany). The study was carried out in three beech (*Fagus sylvatica*), spruce (*Picea abies*) and mixed stands of beech and spruce arranged in three blocks. The density, diversity and community structure of Collembola as well as microbial and abiotic parameters in the organic layers and mineral soil of the three spruce, three beech and three mixed stands were investigated. Major results are: (i) Collembola communities did not differ strongly between stand types and were dominated by *Folsomia quadrioculata* and *Mesaphorura* species, (ii) neither total abundance of Collembola nor densities of the hemiedaphic species *F. quadrioculata*, *Parisotoma notabilis* and *Isotomiella minor* significantly responded to stand type, (iii) in the mixed stands the fungal biomass was increased leading to high densities of fungal feeding Collembola (e.g. *Mesaphorura* sp.) and high species numbers of Collembola, (iv) the density of the epedaphic and partly herbivorous group Entomobryidae/Tomoceridae in the spruce stands exceeded that in the mixed and beech stands; presumably this was due to the higher diversity of the ground vegetation in the spruce stands. Canonical correspondence analysis (CCA) of the collembolan communities of L/F and H/Ah horizons also indicated that most of the epedaphic species were associated with the spruce stands. Moreover, results of the CCA indicated that soil pH is an important structuring force for collembolan communities. Overall, results suggest that stand type impact collembolan communities, presumably via changes in the amount and quality of food resources, such as fungal biomass and living plant material. However, differences in collembolan community structure between the investigated stand types were moderate supporting earlier findings that Collembola generally respond little to changes in the vegetation structure.

1. Introduction

The idea of establishing mixed forest stands that are better adapted to site conditions than spruce monocultures has attracted increasing attention from forest owners and governmental institutions over the last decades [10,27]. Currently, beech is being replanted and an increasing proportion of German forests are now mixed stands. Focusing on the reaction of the Collembola to forest conversion, this study investigates the response of the collembolan community to the replacement of beech by spruce or by mixed stands of beech and spruce. Collembola are among the most abundant arthropod groups in organic layers of forest soils [37] playing an important part in litter decomposition by grazing soil fungi and stimulating nutrient cycling [6,24]. Moreover, several Collembola taxa (e.g. *Frisea*-species) are important predators within soil food webs [25,56].

Collembola generally respond little to changes in the tree species composition of forest ecosystems [17,21,43]. On the other hand, different forest types influence the structure of collembolan communities via changes in the C-to-N ratio and pH of the organic layer [21,32,41,62]. The influence of different stand types (pure spruce and beech stands, mixed stands of beech and spruce) on Collembola in the Solling mountains (Germany) has been investigated in a previous study [43]. One important new aspect of the present study is the higher amount of study sites (three spruce, beech and mixed stands arranged in three blocks) leading to more representative conclusions about supraregional changes of collembolan communities due to forest conversion.

A second new aspect of the present study is the dosage of the ergosterol content of soil which is an indicator of fungal biomass

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[16], an important food resource for many collembolan species [31,55,58]. Besides the ergosterol content various other abiotic and microbial soil parameters (including microbial biomass) were measured to better understand the impact of tree species composition on the soil environment and collembolan communities.

In the present study, the following hypotheses were tested:

(1) Fungal feeding euedaphic taxa (e.g. *Mesaphorura* species) benefit from a higher fungal biomass in spruce stands compared to beech and mixed stands [36].
(2) The mean species richness of Collembola is higher in mixed stands than in pure stands of beech or spruce due to an increase in the diversity of food resources like fine roots [38], fungi [31,55] and litter [46,62].
(3) The density of epedaphic Collembola is more influenced by the diversity of ground vegetation than by litter type (spruce or beech or mixed litter) [43].

2. Material and methods

2.1. Sites and sampling

The study area is located in the Solling, a mountain range in Lower Saxony, Germany. The study was carried out in three beech (*Fagus sylvatica*), spruce (*Picea abies*) and mixed stands of beech and spruce arranged in three blocks (block I = forest district Fürstenberg, block II = forest district Mackensen, block III = forest district Eschershausen). The age of investigated stands varied between 100 and 110 years. The density, diversity and community structure of Collembola as well as microbial and abiotic parameters in the organic layers and mineral soil of the forest stands were investigated (nine sampling sites). The parent rock is red sandstone covered by an acid brown earth with a moder humus form (pH ($CaCl_2$) ca. 3.5–4.0).

In each of the nine sampling sites five plots (2 m^2) spaced at least 20 m apart from each other were selected at random. Large

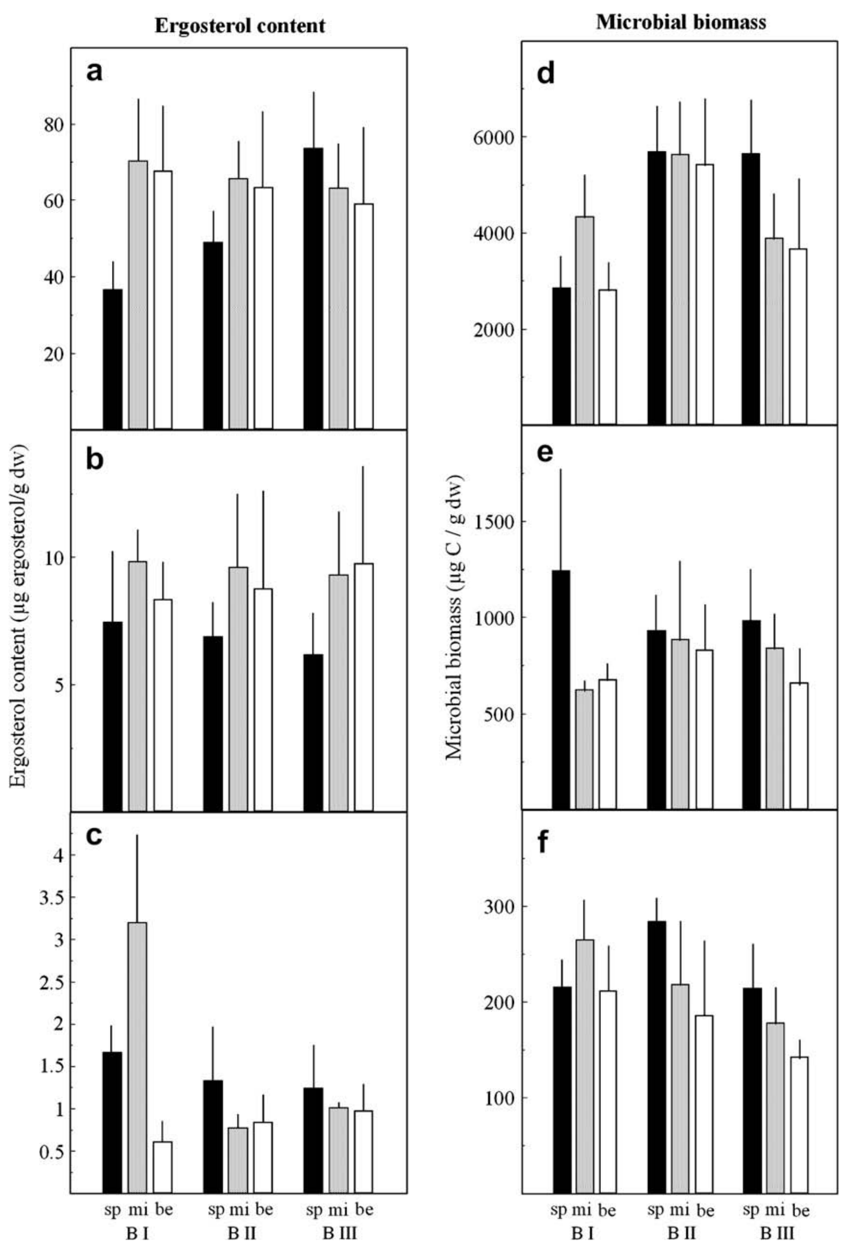

Fig. 1. Ergosterol content and microbial biomass in the L/F (a, d), H/Ah (b, e) and Bv horizon (c, f) in spruce (sp), beech (be) and mixed (mi) (spruce/beech) stands of the three blocks (B I, B II, B III) (n = 5). For statistical analysis see Tables 1 and 2.