



Oribatid mite communities on the bark of dead wood vary with log type, surrounding forest and regional factors



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ABSTRACT

Dead wood is a crucial component of natural and semi-natural forest ecosystems. It is of eminent importance as habitat for a variety of animal species but its importance for microarthropods, a diverse group of small forest animals, has been little studied. We investigated how oribatid mite density, species richness, community structure and the proportion of parthenogenetic individuals on the bark of dead wood are affected by log type (beech, oak) and surrounding forest type (deciduous, coniferous) in three regions in Germany (Schorfheide-Chorin, Hainich-Dün, Schwäbische Alb). Additionally, we analyzed the trophic structure of oribatid mites from the bark of dead wood in one region (Hainich-Dün) using stable isotope ratios ($^{15}\text{N}/^{14}\text{N}$, $^{13}\text{C}/^{12}\text{C}$). Oribatid mite richness and community structure were significantly affected by log type, forest type and region. Oribatid mite communities comprised mainly soil and arboreal species but only few dead wood specialists indicating that dead wood in an early stage of decay functions as transitory habitat rather than specific microhabitat. However, some oribatid mites likely are adapted to dead wood as habitat by living phoretically on bark beetles (e.g., *Siculobata leontonycha*) or endophagous in fungi associated with dead wood (e.g., juvenile *Carabodes* species). The proportion of parthenogenetic oribatid mite individuals was rather low (~8%) suggesting that oribatid mites on dead wood predominantly rely on living food resources resembling arboreal communities but not those in soil. Natural variations in stable isotope ratios indicate that oribatid mites on the bark of dead wood span at least three trophic levels including lichen feeders, moss feeders, decomposers and fungal feeders with fungal feeders dominating.

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1. Introduction

Dead wood is an important component of forest ecosystems. However, in most European forests dead wood does not accumulate on the forest floor since trees typically are harvested. Further, dead wood is assumed to function as a source of diseases and is often removed to prevent, e.g., bark beetle infestations; under natural conditions it is decomposed by a complex community of microorganisms and invertebrates (Jonsson et al., 1998; Wermelinger, 2004; Lassauce et al., 2011). The importance of dead wood for biodiversity is increasingly appreciated and forests in Europe are allowed to age more naturally resulting in increasing amounts of dead wood on the forest floor (Müller-Using and Bartsch, 2003; Jonsson et al., 2005).

Dead wood harbors a large number of arthropod species temporarily or permanently colonizing this habitat, thus

contributing considerably to total forest diversity. Especially beetle communities in dead wood are well investigated due to their economic importance and their high diversity (Peltonen et al., 1998; Eidmann, 1992; Ehnström, 2001; Similä et al., 2003; Müller et al., 2008; Gossner et al., 2013). However, dead wood also provides habitat for many other arthropod taxa, including Diptera, Hymenoptera and Isopoda, which use it as a food resource, for breeding or shelter (Stokland et al., 2012). Furthermore, dead wood is inhabited by a variety of fungi, mosses and lichens which partly also occur in soil but some being restricted to dead wood. Especially basidiomycete fungi benefit from the accumulation of dead wood as they are the most important wood decomposers able to break down recalcitrant wood compounds including lignin. A large number of animal species benefit from the presence of fungi by feeding on fungal hyphae or sporocarps or using fungal sporocarps as habitat (Matthewman and Pielou, 1971; Maraun et al., 2014).

While insect and fungal communities in dead wood are well investigated only few studies investigated mite communities in dead wood. Mites (Acari) represent a diverse taxon with an

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estimated total species number of up to one million (Walter and Proctor, 1999). Oribatid mites (Oribatida) are a species rich and abundant taxon of mites occurring in soil of virtually all terrestrial ecosystems but also in microhabitats such as tree trunks, stumps, logs, lichens, mosses, fungal sporocarps and even fresh and salt water (Aoki, 1967; Schuster, 1979; Materna, 2000; Behan-Pelletier and Walter, 2000; Lindo and Winchester, 2006). On dead wood they are among the most numerous arthropod taxon (Abbott and Crossley, 1982; Seastedt et al., 1989).

Oribatid mite communities on bark overlap only little with those in soil, thereby the bark of trees represents a distinct habitat (Wunderle, 1992; Proctor et al., 2002; Erdmann et al., 2006; Fischer et al., 2010a). However, it is little studied if oribatid mite communities from dead wood on the forest floor resemble those of the soil or those of the bark of trees or if dead wood is colonized by a specific oribatid mite community (but see Skubała and Maślak, 2009; Huhta et al., 2012).

Unraveling the feeding habits of oribatid mites from dead wood may contribute to the understanding of their community structure. It has been shown that oribatid mites in soil mostly feed on litter and fungi, whereas oribatid mites on the bark of trees often feed on lichens or mosses (Schuster, 1956; Luxton, 1972; Siepel and de Ruiter-Dijkman, 1993; Erdmann et al., 2007; Fischer et al., 2010a; Maraun et al., 2011). However, the trophic ecology of oribatid mite from dead wood has never been studied.

Another key for understanding the specific composition of oribatid mite communities may be their reproductive mode. It has been hypothesized that a high percentage of parthenogenetic individuals in oribatid mite communities points to the availability of resources whereas a high percentage of sexual species indicates resource limitation (Scheu and Drossel, 2007; Maraun et al., 2012). This is based on the assumption that the advantage of having genetically different progeny diminishes when resources are not limited and thus favors faster reproducing asexual species. The percentage of parthenogenetic individuals in soil is high (~50–80%) compared to the bark of living trees (~5–10%) (Fischer et al., 2010a; Maraun et al., 2012). How the ratio between parthenogenetic and sexual oribatid mites changes after death of trees and how dead wood is colonized by soil living oribatid mite species is unknown.

Generally, animal and plant communities are structured either by niche-based or neutral processes (Hutchinson, 1959; Hubbell, 2001). Oribatid mite community structure is affected by regional factors such as soil type, pH or climate that operate on the landscape level which points to the importance of niche-based processes (Erdmann et al., 2012; Mori et al., 2013). However, Caruso et al. (2012) emphasized that stochasticity also explains a considerable fraction of the variation in oribatid mite community structure.

Moreover, the surrounding habitat modifies local animal community composition (Tscharrntke et al., 2012) and this also applies to soil animals such as oribatid mites (Erdmann et al., 2012). Due to low dispersal capabilities of oribatid mites (Lehmitz et al., 2011) this might be of particular importance for the colonization of dead wood. However, oribatid mite community structure is also likely to vary with the species of dead wood either by differences in shelter opportunities or specific food sources, such as certain species of fungi or lichens.

We investigated the diversity, community structure, reproductive mode and trophic niches of oribatid mites on the bark of dead wood of two log types (beech and oak) in two different forest types (deciduous, coniferous) in three geographically separated regions in Germany (Hainich-Dün, Schwäbische Alb Schorfheide-Chorin). Our aim was to separate effects of log type, forest type and region on oribatid mite communities of dead wood. Additionally, we investigated trophic niches of oribatid mites on the bark of dead

wood in the Hainich-Dün. Generally, we expected the role of region in structuring oribatid mite communities to exceed that of log type and forest type since turnover of oribatid mite species in space has been shown to be high (Erdmann et al., 2012).

We hypothesized that log type (beech, oak) little affects oribatid mite community composition but rather oribatid mite density, with the more structured bark of oak resulting in higher densities than the little structured bark of beech. Furthermore, we expected the surrounding forest type to affect oribatid mite community structure by functioning as source for the colonization of tree logs. Finally, we hypothesized that region affects the species composition of dead wood since the climate differs strongly between the three study sites. The Schorfheide-Chorin is characterized by continental climate with cold winters and hot summers whereas the climate at the Schwäbische Alb and Hainich-Dün is more atlantic with mild winters and wet summers.

2. Materials and methods

2.1. Study sites

The study formed part of a long term dead wood experiment in the framework of the “Biodiversity Exploratories” (Fischer et al., 2010b), a large scale biodiversity project in three regions in Germany including coniferous (*Picea abies* in the Hainich-Dün and Schwäbische Alb *Pinus sylvestris* in the Schorfheide-Chorin) and deciduous forests (*Fagus sylvatica*). The geographical regions included (1) the Schorfheide-Chorin in the north-east of Germany (3–140 m a.s.l.), (2) the Hainich-Dün, a hilly region in central Germany (285–550 m a.s.l.), and (3) the Schwäbische Alb a low-mountain range in south-west Germany (460–860 m a.s.l.), spanning an overall latitudinal gradient of about 500 km. Mean annual temperatures for Schorfheide-Chorin, Hainich-Dün and Schwäbische Alb are 8–8.5, 6.5–8 and 6–7 °C with mean annual precipitation of 500–600, 500–800 and 700–1000 mm, respectively. More details on the study sites are given in Fischer et al. (2010b).

2.2. Sampling design

In 2009, logs of 13 tree species (*P. abies*, *P. sylvestris*, *Pseudotsuga menziessii*, *Larix decidua*, *F. sylvatica*, *Fraxinus excelsior*, *Acer pseudoplatanus*, *Carpinus betulus*, *Betula pendula*, *Populus spec.*, *Tilia sp.*, *Quercus sp.*, *Prunus avium*; ~4 m in length, ~32 cm in diameter) were placed in three coniferous and six deciduous forests in each region, where each log type was replicated in three subplots. The logs of each subplot were arranged in one row with a distance of approximately 1 m in between. All logs were cut from fresh standing trees. Only trunks were used for the study with the lower trunk region being excluded. For the present study we sampled beech and oak logs from one subplot in each of the nine forests (deciduous and coniferous) in three regions, resulting in a total of 54 samples.

2.3. Sampling, identification of species and stable isotope analysis

In November 2011, two years after the logs were placed in the forests, a bark sample of 30 × 30 cm of each plot was taken from the upper side of the logs, using a hand saw and a chisel. The bark on the logs was largely intact but started to detach from the wood beneath. In comparison with bark from living trees the bark was inhabited by fungi from both the upper and lower side. The wood underneath the bark was still virtually undecomposed. Bark samples were broken into smaller pieces and turned upside down in the extraction vessels. Animals were extracted by heat (Macfadyen, 1961) and stored in 70% ethanol until determination.

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