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Feeding preferences of native terrestrial isopod species (Oniscoidea, Isopoda) for native and introduced leaf litter

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ABSTRACT

Due to current predictions for Central Europe that forecast higher frequencies of hot and dry summers, Mediterranean drought-tolerant oak species are being evaluated as future forest trees for German forest sites that are becoming increasingly damaged by water deficit. As a result of planting foreign tree species, the leaf litter composition and thus the food resources of native saprophagous macroarthropods will change, possibly altering primary decomposition processes. Therefore, experiments concerning the acceptance and palatability of introduced versus native litter for native isopods were undertaken. Consumption rates of four native isopod species (*Porcellio scaber*, *Oniscus asellus*, *Trachelipus rathkii*, *Trachelipus ratzeburgii*) were investigated in laboratory choice tests with introduced (*Quercus pubescens*, *Quercus frainetto*, *Quercus ilex*) and comparable native (*Fagus sylvatica*, *Quercus robur*) leaf litter. Litter was characterized by measurement of C/N-ratios and lignin content. Although species-specific preferences of isopods could be observed in the experiments, Mediterranean oak litter was consumed by all investigated species. Furthermore, two isopod species even preferred the leaf litter of the introduced *Q. ilex*. Compared to native beech or oak litter, litter from these introduced tree species thus apparently do not negatively influence the consumption rates of terrestrial isopods. Possible reasons for the determined preferences are discussed.

1. Introduction

Current climate models predict a scenario for Central Europe that implies an increasing frequency of hot and dry summers as well as a raise of the average summer temperature of approximately 4 °C within the next 50–100 years (Schär et al., 2004). As a long-term consequence of the altered climate, a change in the composition of native forest ecosystems can be expected (Kölling and Zimmermann, 2007; Pompe et al., 2009). The impact of increasing drought stress can already be observed in some forest sites in southern Hesse, Germany, where native tree species such as *Fagus sylvatica* and *Quercus robur* show strong water-deficit damage, intensified by human-induced groundwater drawdown (pers. comm.: Forestry Office Hesse). To prevent further forest degradation and to maintain sustainable forest ecosystems, a long-term study is ongoing to evaluate the potential of more drought tolerant Mediterranean oak species such as *Quercus pubescens*, *Quercus frainetto* and *Quercus ilex*, among others, as future forest trees in these Central European sites (cf. Brüggemann et al., 2009; Holland and Brüggemann, 2011).

Leaf litter decomposition is an important process in the nutrient cycle of forests (Chew, 1974; Swift and Anderson, 1989). The feeding activity of saprophagous macroarthropods, such as earthworms, diplopods and isopods, and the associated fragmentation of plant litter material plays an essential role in the incorporation of organic matter into soils. As a result of planting foreign tree species, the leaf litter composition and thus the food resources of the native soil macrofauna will change. To ensure that the introduction of foreign tree species into local forests does not affect primary decomposition processes, it is therefore necessary to assess how foreign leaf litter affects the feeding activity of the local macrofaunal decomposers.

Results of a previous experiment, in which the consumption rate of local populations of the abundant diplopod species *Glomeris marginata* (Villers, 1789) from the experimental forest sites in southern Hesse was measured, indicate that consumption of introduced Mediterranean-oak leaf litter takes place at equivalent or even higher rates than that of domestic leaf species (Gerlach

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et al., 2012). It could thus been shown that this diplopod species does feed on the introduced leaf litter, at least in the absence of other food resources.

These first results gave rise to the question how other native decomposer species respond to the changed nutrient resources caused by the altered litter sources. Terrestrial isopods also feed predominantly on fallen leaf litter and soft, decaying plant material (Gruner, 1966) and are also abundant in the forest study sites in question. Additionally their selective feeding behaviour (Hassall and Rushton, 1984; Ihnen and Zimmer, 2008; Loureiro et al., 2006; Zimmer et al., 2002) and sensitivity towards changes in diet (Caseiro et al., 2000; Farkas et al., 1996; Hornung et al., 1998) render isopods suitable test organisms for such experiments. The aim of the study was therefore to determine whether local isopod populations will feed on Mediterranean leaf litter, which litter species is preferred when given the choice between leaf litter of introduced (*Q. pubescens*, *Q. frainetto*, *Q. ilex*) and comparable native (*F. sylvatica*, *Q. robur*) tree species, and whether isopod consumption of the various litter species differ.

Fig. 1. Setup of the chambered containers used in the feeding preference experiments.

2. Material and methods

Feeding-preference experiments were carried out with four isopod species obtained from forest sites in southern Hesse, Germany, where Mediterranean oak species are being introduced. *Trachelipus rathkii* (Brandt, 1833), *Porcellio scaber* Latreille, 1804 and *Oniscus asellus* Linnaeus, 1758 were collected from mixed forests near Rüsselsheim (N49°57′16.5″, E8°24′58.4″) and *Trachelipus ratzeburgii* (Brandt, 1833) from deciduous forests near Lampertheim (N49°35′7.2″, E8°34′42.3″). In the laboratory, the animals were kept species-specifically in round transparent containers (diameter: 14 cm; height: 7 cm) with a bottom coating of a plaster of paris and activated charcoal mixture (20:1; 1 cm layer) and above that a 1 cm high soil mixture (obtained from the same forest sites from which the animals were collected), which was moistened bi-weekly. deadwood, bark, mosses and especially moistened field-collected litter (*Q. robur*, *F. sylvatica*, *Tilia cordata*, *Carpinus betulus*, *Acer platanoides* and more rarely *Q. rubra*) were added to the containers as food resources as well as concealment possibilities. The litter was provided ad libitum. Maximally 30 individuals of single species were kept in one container. The containers with the animals were maintained in a climate chamber with a 13:11-h light:dark rhythm and a diurnal temperature regime of 12 °C (nighttime) to maximally 20 °C (daytime).

For the experiments, freshly fallen litter of the tree species *F. sylvatica*, *Q. frainetto*, *Q. robur* and *Q. pubescens* was collected in October and November 2008 from the Palmengarten and Botanical Garden in Frankfurt am Main (Hesse) as well as the Botanical Garden in Tharandt (Saxony) and air dried. Due to the low leaf abscission of the evergreen *Q. ilex* and resulting lack of litter in Germany, litter of this species was collected from its natural distributional area in southern France. Freshly fallen litter is decidedly less consumed than microbially pre-decomposed litter (Bertrand and Lumaret, 1992; Dunger, 1958; Gerlach et al., 2012; Hassall and Rushton, 1984). The litter was therefore exposed in litterbags (mesh size: 5 mm) for six months in the same woodlands from which the animals were obtained. After this, the litter was returned to the laboratory, air dried and stored dried until use in the experiments. For the experiments, litter was then used that showed no macroscopic signs of advanced decomposition. Parallel studies on field decomposition showed a litter decomposition rate of, on average, ca. 15% after six months, with the Mediterranean species being somewhat more decomposed than the Central European species (unpubl. data).

The feeding-preference experiments were carried out under the same climatic conditions in plastic containers of the same size and treated as mentioned above (however, without added organic material). For each of the four isopod species, six replicates (=containers) with isopods and six replicates without isopods (=controls) were studied (24 replicates + 24 controls total). The mass of the isopod individuals was, on average, 44.4 ± 13.0 mg (*O. asellus*), 23.9 ± 5.9 mg (*P. scaber*), 31.9 ± 10.8 mg (*T. rathkii*), and 20.0 ± 11.4 mg (*T. ratzeburgii*). In each replicated container, 400 mg ± 2 mg air-dried litter of each tree species, which was steeped in water for 24 h before beginning the experiments, and five previously weighed individuals of the respective isopod species (absent in the controls) was added. The interior space of the containers was divided into five chambers (Fig. 1), which ensured that the different litter species did not become mixed. To determine the initial dry weight of the litter, a portion (ca. 100 mg) of the air-dried litter of each species was dried at 60 °C to constant mass and weighed. All experiments continued for 10 days. After this period, the remaining litter was collected species-specifically, dried at 60 °C to constant mass and weighed.

The calculation of consumption by isopods (=mass loss) was performed according to the formula of David (1998):

$$C = \frac{\left(W_i - W_iD - W_f\right)}{(\mathrm{SQRT}(1-D))}$$

$$D = \frac{\left(W_i - W_f\right)}{W_i}$$

whereby C is the consumed litter in mg, W_i the initial dry weight of the litter sample before soaking in water, W_f the dry weight of the litter sample after the experiment and D the respective mass loss of the litter in the controls without animals. Consumption was calculated as per day values and was based on the total mass of the isopod individuals in the respective container.

Since the palatability of the different litter species was expected to be limited by more indigestible components, the C/N-ratio and lignin content was quantified for each litter species used in the experiments. For this characterization, a portion of the litter exposed in the field for six months was first dried at 60 °C and ground to a particle size of <1 mm. For each litter species, 6–7 mg of ground litter was sealed airtight in zinc capsules (8 replicates per species) and the total carbon and nitrogen contents measured in a vario PYRO cube element analyzer (Elementar Analysensysteme