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Effects of soil temperature and moisture on the feeding activity of soil animals as determined by the bait-lamina test

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ABSTRACT

The aim of the study was to determine the effect of soil temperature and moisture on the feeding activity of soil fauna. To measure this activity, we conducted two short-term (14 days) experiments using the bait-lamina method. In experiment 1, the enchytraeid *Cognettia sphagnetorum* was added to defaunated mor humus. The experiment included incubations at four temperatures (−4, 5, 14, and 24 °C) and three moisture regimes (220, 260, and 300% of dry weight). No feeding activity was detected at −4 °C, but at other temperatures the bait-laminae were perforated, and the number of baits consumed increased with time. Because of variable animal survival and because of the rather low bait consumption, the effect of temperature and moisture on the feeding activity was unclear. In experiment 2, intact soil cores were either pre-treated at −21 °C or were not treated until being placed at −4, 5, 14 and 24 °C and two moisture regimes. The pre-treatment at −21 °C killed all meso- and macrofauna except collembolans and mites. Despite high densities of collembolans and moderate densities of mites at 24 °C in the pre-treated cores, there was no bait perforation. In the non-frozen cores, there was no feeding activity at −4 °C, but the activity increased with temperature up to 24 °C. The study showed that the bait-laminae were perforated by the activity of soil-living animals. Bait perforation seemed to be dependent on animals like enchytraeids and lumbricids and to a lesser degree collembolans and mites. The feeding activity measured by the bait-laminae increased with temperature, whereas the effect of soil moisture was less evident.

1. Introduction

Plant litter decomposition is a key process in carbon and nutrient cycling. Litter decomposition involves both micro-organisms and soil fauna (Swift et al., 1979), and litter fragmentation performed by soil meso- and macrofauna will often increase decomposition rate (Anderson and Bignell, 1980; Hanlon, 1981; Gunnarsson et al., 1987; Hättenschwiler et al., 2005).

A relatively new screening method to estimate soil faunal activity is the bait-lamina test (von Törne, 1990). This method has been found to be a suitable tool in various ecological and

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ecotoxicological studies (Larink, 1994; Kratz, 1998; Kula and Römbke, 1998; Keplin and Hüttl, 2000; Filzek et al., 2004; Hamel et al., 2007), and its use has been suggested for international test standardisation purposes (Römbke et al., 2006). The feeding activity measured by this method is strongly dependent on large soil animals such as earthworms and enchytraeids and not much on microarthropods (springtails and mites) (Helling et al., 1998; van Gestel et al., 2003; Förster et al., 2004). The outcome of the bait-lamina test is also influenced by soil moisture and temperature (Larink, 1993; Meyer, 1996). This was supported by a comparison of bait-lamina perforation in different climatic regions of Russia (Gongalsky et al., 2004). This study indicated that animal numbers and feeding activity were affected by soil temperature and moisture.

In the present study, we hypothesised that the feeding activity of soil biota measured as disappearance of bait in the bait-lamina method is controlled by soil temperature and moisture.

To test this hypothesis and to determine the optimal temperature and moisture for feeding activity, we carried out two laboratory experiments in which either the enchytraeid *Cognettia sphagnetorum* (Vejd.) or the indigenous community of soil fauna were exposed to various combinations of soil temperature and moisture levels.

2. Materials and methods

2.1. Site description

We performed two experiments, and for both experiments soil samples were taken in a mixed Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst.) forest with *Vaccinium myrtillus* L., *V. vitis-idaea* L. and feather mosses, predominantly *Pleurozium schreberi* (Brid.) Mitt. The forest (lat. 59° 40′N, long. 17°40′E) was growing in a till area with shallow soil on granitic rocks 10 km south of Uppsala, central Sweden.

2.2. Experiment 1

In the first experiment, which was considered as a pilot study, the feeding activity of *C. sphagnetorum* was assessed in the laboratory using bait-lamina strips and humus layer materials from the field. Soil sampling was done in late February 2002, when the snow had already melted, and the average daytime temperature approached 5 °C. Five-cm thick humus layer samples were taken, and a part of the humus layer collected was frozen at −21 °C for 48 h to kill all meso- and macrofauna. After thawing for another 48-h period, the soil was mixed and sieved through a 5-mm mesh. Soil moisture content was determined in four subsamples after drying at 105 °C for 24 h.

Another part of the soil collected from the field was kept at 10 °C for 48 h to acclimatise enchytraeids to experimental procedures. The enchytraeids used in the experiment were extracted from this soil for 3 h in modified Baermann extractors (O'Connor, 1962) just before the beginning of the experiment. Enchytraeid worms were selected as a model group, because a strong relationship between enchytraeid number and feeding activity had been demonstrated in previous studies (Helling et al., 1998; Förster et al., 2004). *C. sphagnetorum* specimens were selected for the experiment as this is the dominant enchytraeid species in the area. Fifty individuals were added to each "animal" jar within 6 h after extraction. This number corresponded to an abundance of 62,500 individuals m^{-2}, which is a representative abundance in the field (Persson et al., 1980). All jars (with and without animals) were kept at 15 °C for 24 h before the experiment started.

For the experiment, 24 plastic jars (10 cm high, 8 cm upper diameter) were used. Each jar had a plastic lid with three openings of 5 mm diameter. In each jar, 150 g of the defaunated soil was placed. The general set-up of the experiment consisted of 12 jars with and 12 jars without animals. The 12 jars were placed at four temperature levels (the jars were kept in climate chambers at −4, 5, 14 and 24 °C) and three moisture levels leaving only one replicate jar per treatment. The water contents were 220% (similar to that in the field), 260% and 300% of dry weight, the latter levels being obtained after addition of distilled water. No gradual acclimation of samples was applied, because the temperature shift (ca. 15 °C) was within daily fluctuation.

The bait-laminae used in this experiment were 16 cm long and 0.5 cm wide strips made of PVC with 16 openings of 15 mm diameter each. They were placed at a distance of 5 mm from each other. The upper 4-cm end of each lamina was left intact without openings for handling. For a bait-lamina image, see Kratz (1998). The openings were filled with a wet mixture of finely ground cellulose and nettle (*Urtica dioica* L.) leaves (ratio 7:3) and were dried for 2 days at room temperature (20–22 °C). Three bait-lamina units were placed in each jar, which was covered by a lid. The openings in the lids were covered with paper stickers to prevent evaporation. The bait-lamina units were distributed in the jars according to the method described by von Törne (1990). To test for mechanical damage, a control strip was inserted into the soil and then removed at the start of the experiment. The strips were checked on day 3, 5, 7, 10 and 14 of exposure to the soil. On each occasion, each strip was pulled out of the soil, whereby perforated holes were counted, and the strips were inserted into the soil again at the same place as before. In total, 72 bait-lamina units were used.

After the experiment was finished, enchytraeids were extracted from the soil. To note the stratification of animal distribution within the jars, the upper and lower 4 cm soil layers were extracted separately. The number of surviving enchytraeids was counted, and the presence of nematodes was noted.

2.3. Experiment 2

For experiment 2, which was performed to determine optimum temperatures for the meso- and macrofaunal community, undisturbed soil cores were taken from the same pine-spruce forest as in experiment 1. The soil cores had a 4-cm diameter and were 10–15 cm long including litter layer (1–2 cm), humus layer (4–5 cm) and E (3–4 cm) and upper B (2–4 cm) horizons. The cores were placed in cylinders made of hard plastic with open tops and bottoms. Immediately after sampling, the cylinders were covered by sheets of aluminium foil to avoid loss of animals and soil. In total, 80 soil cores were collected, and 40 of the cylinders were frozen at a temperature