The effect of grassland management on enchytraeids (Oligochaeta) communities

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Abstract

Enchytraeids (small white earthworms between 3 to 35 mm) are important regulators of nitrogen turnover in grasslands, as their activities accelerate the decomposition and nutrient recycling processes. In this study, the effect of management on species composition, abundance and biomass of the enchytraeid community was determined at three sampling occasions (before slurry application in October 2010 and March 2011, and after slurry application in May 2011) in 1-yr-old grass-clover field with three managements: 1) cut without manure, 2) cut with cattle slurry, and 3) grazed by heifers. We observed a significant effect of management on the enchytraeid biomass and density but no significant changes in their species composition. The slurry plot had the significantly highest biomass for the three management practices, in particular when compared to the grazed plots. We suggest that the lower enchytraeids biomass and density of the grazed plots are due to compaction by grazing animals.

Keyword: grass-clover, cattle manure, grazing, cutting, soil-fauna

Introduction

Grasslands cover 20% of the agricultural area in Denmark and are used for conventional and organic dairy farming. Dairy production systems are to a large extent based on these highly productive temporary grasslands. A range of soil organisms are involved in the decomposition processes and the nutrient mineralization in grassland and it has been reported that enchytraeids can be important regulators of nitrogen (N) turnover in native grasslands (Didden, 1993). Their activity stimulates soil microbial activity and affects soil structure by ingesting and excreting soil particles and creating burrows that cause increased soil aggregation and porosity (Didden, 1993; Bardgett, 2005). Despite the widespread abundance of enchytraeids in agricultural grasslands their responses to different agricultural management practices has largely been neglected. Grasslands in Denmark are dominated by grass--clover, and typical managements are the removal of herbage through grazing or cutting and application of fertilizer through injection of cattle slurry (Eriksen *et al*., 2004). Those management practices are applied either alone or in combination and it is suspected that they can have different impacts on the enchytraeid communities.
Cutting grass can affect the below-ground soil food web by changing the carbon allocation from the roots as large amounts of organic matter are removed. Grazing is a combination of several factors that affect simultaneously the grassland ecosystem. Increased compaction can occur due to trampling, reduced input of organic matter due to grazing and a heterogenic input of nutrients and organic matter caused by the return of dung and urine (Bardgett, 2005). Soil compaction limits habitable pore space for soil fauna (Larsen *et al*., 2004) and to our knowledge only a few studies have examined the effects on enchytraeids. Long term slurry application may have a positive effect on the enchytraeid community (King

and Hutchinson, 1976) as it adds organic matter to the soil, which may result in increase food source for the enchytraeids. The objective of this study was to disentangle the effect on the enchytraeid community of different management practices applied to grassland used for dairy production.

Materials and methods

The experimental plots were located in an arable-ley rotation experiment at Aarhus University, Foulum (9°34′E, 56°29′N); mean annual rainfall is 770 mm and mean annual temperature is 7.7°C. The grass-clover swards consisted of *Lolium perenne*, *Trifolium repens* and *Trifolium pratense*. The study presents investigations conducted with three managements: 1) cut without manure, 2) cut with cattle slurry (200 kg total N per ha), and 3) grazed by heifers (Table 1).

Table 1. Managements in experimental grassland plots

Abbreviation	Management	Fertilizer amendment
CUT	Herbage removal	None
CUT-SLURRY	Herbage removal	200 kg N[1)]
GRAZED	Grazing[2)]	None[3)]

[1)] Total-N in cattle slurry injected in April and June.
[2)] Grazed by 9 heifers per ha from May to October (1250 grazing days/ha/season).
[3)] Except for urine and dung from grazing cattle.

Samples were collected on 25 October 2010, 21 March 2011 and 2 May 2011. The second sampling occurred two weeks before slurry injection, and the third within the month following slurry application. At the first sampling date, three subsamples were collected from the CUT, GRAZED, and CUT-SLURRY treatments in one field block, and during the second and third samplings three subsamples were collected in each treatment in four replicated field plots. However, it was not possible to collect all the samples in GRAZED during the last sampling occasion due to soil compaction. The samplings were performed with a soil corer (inner diameter 5.5 cm; depth 18 cm) and the samples were kept at 5°C until extraction, which was initiated within two weeks. The total density of enchytraeids (per m^2) and their biomass (dry mass per m^2) was determined by integrating the 0–9 cm depth for all samples. The data were 'log+1' transformed and analysed as a randomized ANOVA repeated block design using the SAS PROC MIXED procedure.

Results and discussion

The different management practices and dates of sampling both affected significantly the enchytraeid community in terms of abundance and biomass (Figure 1A and 1B). However, the species composition was not affected by management or season (data not shown). Both biomass and density varied with seasons ($P < 0.001$), with higher biomass and density of enchytraeids in all treatments in October 2010 compared to March and May 2011 (Figure 1A and 1B).

Enchytraeids are highly sensitive to drought and sub-zero temperatures (Maraldo and Holmstrup, 2009). Thus, the severe decrease in the enchytraeids community can be explained by the period with low soil moisture content between March 2011 and May 2011, where the soil water content decreased from 17% to 10%. The different management practices affected significantly the density ($P = 0.013$) and biomass ($P = 0.004$), with higher values in CUT plots compared to GRAZED but the effect varied between seasons. Both density

and biomass were 3 to 5 times higher in CUT compared to GRAZED plots in October. Values were lower during the following spring (Figure 1) but this pattern was still in visible in March 2011, where CUT-SLURRY both had significantly higher enchytraeid biomass and density compared to GRAZED, and significantly higher density compared to CUT. However, the effect of the management was not significant in May 2011. The negative effect of grazing may be explained by the compaction of the soil by the heifers, as both biomass ($P = 0.0083$) and density ($P = 0.0004$) were lower in the 0–9 cm compared to the 9–18 cm layer (data not shown). It can be speculated that the density might be higher in hotspots with cow dung that typically have little or no trampling, but to avoid bias we did not sample in these locations. The injection of cattle slurry showed a stimulation of the enchytraeid community, which is due to the increase in organic matter inputs, but more studies involving older grassland is needed to conclude if the effect persists in the long-term.

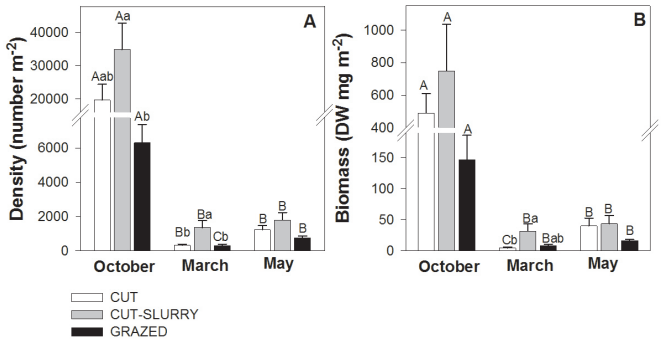

Figure 1. (A) Total density (individuals per m^2; mean ± S.E; N = 2–4) and (B) total biomass (mg DW per m^2; mean ± S.E; N = 2–4) of enchytraeids according to grassland managements and season. Small letters show significant differences between managements within dates (GLM), and large letter shows significant between dates but within the same management practice (repeated ANOVA)

Conclusions

The different management practices clearly affected the enchytraeid community in different directions in 1-yr-old grass-clover field, with a positive effect of the density of cattle slurry addition and a negative effect by heifer compaction. However, more studies are needed to determine if the observed effect persists over time and hence to quantify the contribution of the enchytraeids to the decomposition processes in agricultural grasslands with different management practices.

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