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Sustainable meat and milk production from grasslands

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Soil faunal and plant diversity of dairy and semi-natural grasslands on peat

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Abstract

Peat wetlands are of major importance for ecosystem services such as carbon storage and maintenance of biodiversity. However, peat drainage for farming leads to CO_2 emission and biodiversity losses. In the peat areas in the Netherlands, solutions are sought in reducing drainage and converting productive dairy grasslands to less intensively managed semi-natural grasslands. Our objective was to compare the soil faunal and plant diversity of dairy and semi-natural grasslands on peat soils. Taxonomic richness of earthworms, enchytraeids, nematodes, microarthropods and plants were measured in 20 dairy and 20 semi-natural sites. Mean soil faunal taxonomic richness per site (alpha diversity) was higher in dairy grasslands compared to semi-natural grasslands but no difference was found for plant species richness. However, the total observed number of taxa (gamma diversity) in dairy grassland was 21% lower for soil faunal and plant species together. We conclude that spatial scale is of crucial importance for biodiversity and management strategies. In dairy grasslands, between-farm diversification may increase biodiversity at landscape scale. Similarly, diversity in (semi) natural grasslands is needed to keep a high gamma biodiversity in this land use type.

Keywords: grassland, terric histosols, soil biodiversity, botanical diversity

Introduction

Peat wetlands worldwide deliver important ecosystem services such as carbon storage and maintenance of biodiversity. Approximately 80% of the peat area in the Netherlands is drained and used for grassland-based dairy farming. Apart from CO_2 emission and soil subsidence, peat drainage for farming leads to loss of floral and faunal biodiversity, including meadow birds. Current policy, therefore, focuses on increasing the area of (semi-)natural grasslands and promoting 'nature-inclusive' agriculture including reduced drainage (Erisman *et al.*, 2016; Van den Born *et al.*, 2016). However, for effective policy and land management, it is necessary to know how a less intensive land use affects soil functioning. Effects on delivery of several soil-related ecosystem services of dairy and semi-natural grasslands on peat is presented in Deru *et al.* (2018). In the present paper, we focus on biodiversity. Our aim was to provide a comparison of the plant and soil species diversity of peat grasslands either used for grass production or for nature restoration and conservation.

Materials and methods

In the western peat district of the Netherlands, we selected 20 grasslands on dairy farms ('dairy grasslands') and 20 grasslands in areas managed for nature conservation ('semi-natural grasslands'). All grasslands had a minimum sward age of ten years. Dairy grasslands had an average ditch water level of 49 cm below soil surface (Table 1), and a conventional management with a history of mixed grazing and cutting. In the semi-natural grasslands, mean ditch water level was 9 cm higher than in dairy grasslands. Most of the semi-natural grasslands were extensively grazed, cut once or twice a year after the chick season of meadow birds and had low manure input, mainly as solid cattle manure. At each site, an experimental plot was laid out in February 2010, which remained unfertilized, ungrazed and unmown until soil sampling in April 2010. In each plot, nematodes, enchytraeids, earthworms and microarthropods were sampled and identified as described in Deru *et al.* (2018). Botanical composition was assessed in June 2010 according to the Braun-Blanquet cover-abundance method. Statistical analysis was carried out in Genstat (18th edition), using a one-way ANOVA to test for land use effect ('dairy' versus 'semi-natural'). Additionally, gamma diversity was calculated as the sum of taxa found in all samples per land use type. Full method description can be found in Deru *et al.* (2018).

Results and discussion

The mean number of plant species did not differ between grassland types (Table 1). However, plant gamma diversity in dairy grassland was lower than in semi-natural grassland: 34 vs 64, respectively (Figure 1).

Soil faunal taxonomic richness was higher in dairy than in semi-natural grasslands. Mean earthworm abundance of dairy grasslands was about twice that of semi-natural grasslands. At the scale of grassland, positive influence of nutrient input on soil biodiversity and a lack of correlation between aboveground and belowground biodiversity is in line with studies of grasslands on clay soils (Van der Wal *et al.*, 2009). Dairy grasslands have a higher input of easily decomposable organic matter to the soil via manure and primary production (plant residues, root exudates), next to drier (thus also warmer) soil conditions in spring due to drainage. These factors together may contribute to a higher abundance and diversity of soil biota (Cole *et al.*, 2005; Plum and Filser, 2005; Yeates, 1987).

Table 1. Management and biodiversity of 20 dairy and 20 semi-natural grasslands on peat.

Parameter	Unit	Dairy		Semi-natural		*P*-value
		mean	s.d.	mean	s.d.	
Management						
Ditch water level (summer)	cm below soil surface	49	8	40	14	0.009
N from organic manure	kg N ha^{-1} yr^{-1}	216	55	43	50	< 0.001
Biodiversity						
Monocotyledon soil cover	%	82.5	10.6	55.1	21.1	< 0.001
Number of plant species	N	15.2	3.2	14.8	5.3	0.104
Number of soil faunal taxa	N	71	4	61	12	< 0.001

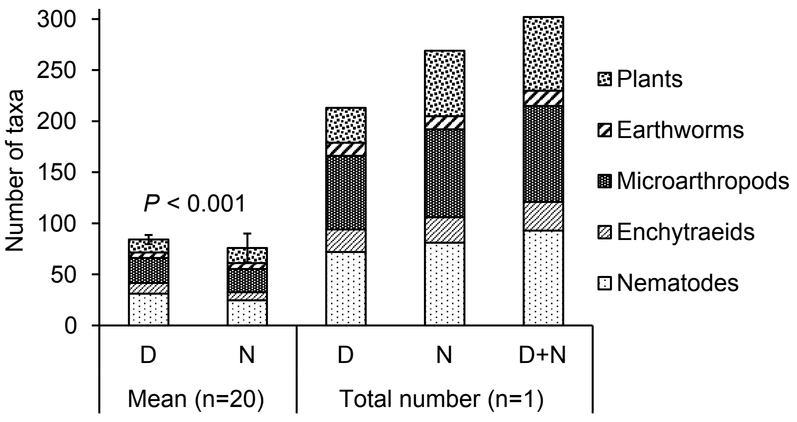

Figure 1. Number of plant and soil faunal taxa in dairy (D) and semi-natural (N) grasslands on peat: grassland mean (alpha diversity) and total number (gamma diversity) (adapted from Deru *et al.* (2018)).

In contrast, the soil faunal gamma diversity was higher in semi-natural grassland: of the 230 taxa found in all 40 sites, 78% was present in dairy grasslands and 89% in semi-natural grasslands (Figure 1). The difference in gamma diversity indicates that the botanical and soil faunal taxonomic composition was more homogeneous across dairy grasslands and more diverse across semi-natural grasslands. This could well be related to a lower diversity in land management of dairy grasslands. Our findings have implications for nature conservation in managed peat areas at field and landscape scale. First, the trend towards low between-farm diversity should be reversed. Second, the lower diversity of individual semi-natural grasslands (alpha diversity) may imply that many (semi-)natural grasslands are needed to increase the total nature value. Finally, our results emphasise the importance of considering spatial scale when evaluating ecological observations.

Conclusion

Spatial scale is of crucial importance in maintaining biodiversity and considering biodiversity strategies. In dairy grasslands, diversification in management between farms may increase biodiversity at a larger geographical scale. Similarly, diversity in types and management of (semi-) natural grasslands is needed to keep a high biodiversity at landscape scale.

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