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Effect of long term defoliation by cattle grazing with and without trampling on soil compaction and plant species composition in temperate grassland

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Abstract. Here we report the results for soil compaction and plant species changes in mesotrophic temperate Central European grassland after 12-years of grazing management with and without cattle trampling. Five grazing treatments (including intensive and extensive grazing, cutting and grazing with no trampling under permanent fencing), with two replicate blocks, have been applied since 1998. In 2010 species richness, the cover of vascular plant species and bryophytes, sward height and soil penetration resistance were recorded. Long term grazing by large herbivores had a significant effect on soil compaction with the lowest values in the "not trampled" treatment. Legumes and short forbs were supported by intensively defoliated and trampled treatments, whereas tall forbs prevailed under the extensive ones. The cover of tall and short graminoids was not dependent on applied treatments. The "not trampled" treatment had the highest prevalence of bryophytes (with more than 95% domination of *Rhytidiadelphus squarosus*) and was also the richest in a number of vascular plant species, on the other hand had the least Hill's evenness index. Long-term defoliation by grazing animals without trampling does not lead to the creation of a typical pasture community. Species forming pasture communities are essentially dependent on both types of disturbances: (i) regular defoliation by grazing and (ii) regular trampling by hooves, which causes a high degree of soil compaction as well as sward disruption.

Keywords. Grazing – Trampling – Soil compaction.

Effet à long terme de la défoliation par le pâturage du bétail (avec et sans piétinement) sur le compactage et sur la composition des espèces végétales dans les prairies tempérées

Résumé. *Nous présentons les résultats du compactage des sols et des changements d´espèces végétales dans les prairies mésotrophes tempérées d'Europe centrale après 12 ans de gestion du pâturage avec et sans piétinement. Cinq types de pâturages (pâturage intensif et extensif, coupe et pâturage sans piétinement sous clôture permanente) ont été appliqués depuis 1998 et répétés sur deux blocs. En 2010, la diversité des espèces, la couverture des espèces de plantes vasculaires et de bryophytes ainsi que la résistance à la pénétration du sol ont été mesurées. Le pâturage à long terme par les grands herbivores a eu un impact significatif sur le compactage du sol. Le compactage du sol le plus faible a été enregistré dans le traitement « non piétiné ». Les légumineuses et les herbacées dominaient dans les traitements intensifs défoliés et piétinés, alors que c'était les hautes plantes herbacées dans les traitements extensifs. Le couvert des hautes et courtes graminées ne dépend pas du type de traitement appliqué. Le traitement « non piétiné » présente la plus forte prévalence de bryophytes (avec de 95% de* Rhytidiadelphus squarosus*) et était également le plus riche en quantité d'espèces de plantes vasculaires, mais avait le plus faible indice de régularité de Hill. La défoliation à long terme par les animaux pâturant sans piétinement ne conduit pas à la naissance d'une communauté de pâturage typique. Les espèces composant les communautés de pâturage dépendent essentiellement des deux types de perturbations: (i) la défoliation régulière par pâturage et (ii) le piétinement régulier par les sabots; ce qui conduit à un degré élevé de compactage du sol ainsi qu´à la perturbation du couvert végétal.*

Mots-clés. *Pâturage – Piétinement – Compactage du sol.*

I – Introduction

The sward under grazing management is mainly affected by (i) defoliation, (ii) manipulation of nutrient availability by removal of biomass or by defecation, and (iii) trampling (Wallis De Vries, 1998). Studied effects of grazing management are often interpreted as results of only defoliation and manipulation of nutrient availability, and trampling effects are frequently underestimated or ignored. Only a few studies have underlined the impact of trampling (e.g. Curll and Wilkins, 1983) on vegetation, and these have shown the marked impact of these disturbances on plant species patterns.

To date, the majority of studies dealing with the effects of cattle trampling have been short-term, and so the results can only show the typical temporary changes that mostly follow after introduction of a new management treatment, or they reflect an inter-seasonal dynamic (Kohler *et al*., 2004). Through the following questions we analysed how the absence of cattle trampling affects soil and vegetation in species-rich temperate grassland with a 12-year history of grazing: (i) how does the absence of trampling affect vegetation height, plant species richness and composition; and (ii) can the long term effects of no trampling be detected by differences in soil compaction?

II – Materials and methods

The study was performed in the long-term Oldřichov grazing experiment (OGE) in 2010. The OGE is situated in the Jizera Mountains, 10 km north of the city Liberec (the Czech Republic). The trampling study was established and conducted in 2010 after 12 years of different management under OGE (yearly continuously grazed with heifers from May to October). Five following treatments with two replicate blocks have been applied since 1998: intensive (IG) and extensive (EG) grazing; cut for hay in June followed by intensive (ICG) or extensive (ECG) grazing, and intensive grazing with no trampling under permanent electric fencing (GNT). The stocking density in the different treatments was adapted to the target sward height. See Pavlů *et al.* (2007) for details about the study site.

The penetrometer was used to measure soil penetration resistance (MPa) among studied treatments. Prior to grazing in May samples were collected in the study data set plots using a grid of 0.33 m x 0.33 m subplots in 5 distant triplet plots along the permanent fence. The percentage canopy cover for all vascular species and bryophytes was visually estimated. The compressed sward height of each subplot was measured. To show the effect of the absence of trampling on the species richness of the community the Hill's N_1 diversity index and evenness index expressed as Hill's ratio (Hill, 1973) were calculated for each treatment. One-way ANOVA followed by *post-hoc* Tukey comparison was performed to identify significant differences in soil penetration resistance, sward height, Hill's diversity and evenness indices. To reveal the effects of grazing intensity and trampling on plant species composition a redundancy analysis (RDA) followed by a Monte Carlo permutation test in the CANOCO program (ter Braak and Šmilauer, 2002) was used.

III – Results and discussion

Soil compaction expressed as penetration resistance showed significant differences among investigated treatments. The subsurface layer of the soil under trampled treatments had significantly higher penetration resistance up to c. 30 cm in comparison with the GNT treatment. Significantly lower soil compaction was also observed under the EG and ECG treatments in comparison with IG and ICG treatments, especially in upper soil layers. This is in accordance with the study by Novák (2009), where the penetration resistance was higher under higher stocking rates even in a short term experiment. Measurements of the actual mean sward heights showed significant differences among the treatments (GNT < IG < ICG, EG < ECG).

The Hill's N_1 diversity index and Hill's ratio N_1/N_0 (in brackets) for plant species richness were 7.02 (28.63), 7.48 (43.32), 8.08 (44.50), 8.26 (53.62) and 8.96 (48.13) for GNT, IG, ICG, EG and ECG treatments, respectively. The differences among the treatments were not significant for N_1 (F = 2.23, P = 0.078) but were significant for N_1/N_0 (F = 17.01, P < 0.001). The GNT treatment was found to be the least equitable. The percentage cover of bryophytes in the treatments shows Fig. 1a. The lowest coverage of vascular plant species and significantly highest cover of bryophytes occurred in the GNT treatment, where more than 95% of bryophytes were represented by *Rhytidiadelphus squarrosus*. The RDA showed significant differences in plant species composition among treatments (explained variability by axis 1 and all axes = 16.8 % and 30.4 % resp.). Species became associated with three groups according to defoliation by grazing and trampling intensities: EG with ECG, IG with ICG and intensive defoliation by grazing and no trampling (GNT) (Fig. 1b). Bryophytes as a major component of the vegetation in the GNT treatment were observed to form 'a carpet' with a sparse density of vascular plants. Similarly, Chappell *et al.* (1971) found that *R. squarrosus* was reduced with increasing trampling pressure on chalk grassland. Although bryophytes are considered to be poor competitors with vascular plants (van Tooren *et al*., 1988), they can prevent seed germination or seedling survival (Kotorová and Lepš, 1999). In particular, if there is an absence of any bare ground disturbance, which would create germination, then bryophytes can prevail over vascular plants. However, during grazing in the GNT treatment cattle could pull up bryophytes with their mouths together with vascular plants. This factor probably causes small disturbances, which can lead to the formation of germination gaps. The prevalence of bryophytes in the 'not trampled' treatment resulted in the lowest compressed sward height in this treatment. A previous study (Kobayashi *et al*., 1997) found that trampling itself significantly suppresses vegetation height, but the trampling in this study was not separated from grazing. Therefore these results are consistent only with our IG treatment, where vegetation was defoliated by grazing and trampled.

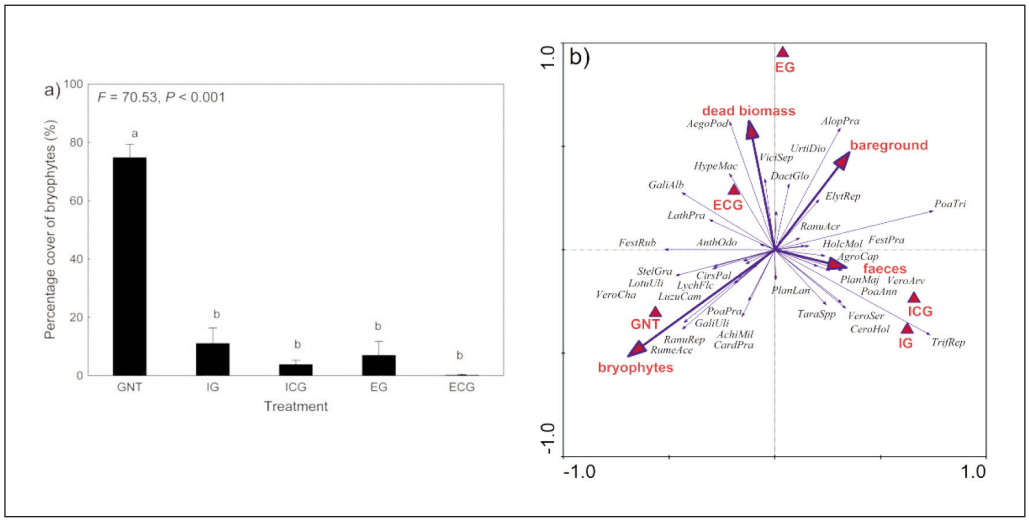

Fig. 1. (a) The mean percentage cover of bryophytes, (b) Ordination diagram showing the results of RDA of plant species composition data.

F = F statistics in one-way ANOVA, and P = probability value. Significant differences (P < 0.05) according to Tukey's post hoc test are indicated by different letters. Error bars represent standard errors of the mean. Abbreviations: for treatment abbreviations see Chapter II. Species names are abbreviated with the 4+3 letters.

The species that benefited from the absence of trampling (GNT treatment) were mostly bryophytes and e.g. *Ranunculus repens* or *Lychnis flos-cuculi*. In the EG and ECG treatments the species with the highest abundance were *Aegopodium podagraria* or *Hypericum maculatum.* In the IG and ICG treatments the species with the highest abundance was *Trifolium repens* (Fig. 1b). From previous studies performed in comparable conditions it can be concluded that *T. repens* is restricted to intensively grazed swards with good light conditions (e.g. Hejcman *et al*., 2010). From our study it appears that not only an intensive defoliation is important for the prevalence of *T. repens*, but also the disturbances associated with trampling. Kohler *et al.* (2004) and Kobayashi *et al.* (1997) also acknowledged that the abundance of legumes was related to trampling. Furthermore, short graminoids (including *Agrostis capillaris*) were negatively correlated with the GNT treatment. In general *A. capillari*s is described as a species promoted by regular defoliation in low-production temperate grasslands (Louault *et al*., 2005). However, the present study demonstrates that only the interaction of defoliation with trampling promotes the abundance of such species.

IV – Conclusions

In conclusion, long-term defoliation by grazing animals without trampling does not lead to the creation of typical pasture communities. We demonstrated that the species present in pastures do not profit only from regular defoliation but they also need bare ground disturbances and sward compaction which favour them in strong intraspecific competition. This means that not only defoliation by itself, but also the disturbance associated with trampling is one of the key factors responsible for supporting typical pasture species.

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References

Chappell H.G., Ainsworth J.F., Cameron R.A.D., Redfern M., 1971. The effect of trampling on a chalk grassland ecosystem. *J Appl Ecol*, 8: 869-882.

Curll M.L. and Wilkins R.J., 1983. The comparative effects of defoliation, treading and excreta on a *Lolium perenne-Trifolium repens* pasture grazed by sheep. *J Agric Sci*, 100: 451-460.

Hejcman M., Schellberg J. and Pavlů V., 2010. Long-term effects of cutting frequency and liming on soil chemical properties, biomass production and plant species composition of Lolio-Cynosuretum grassland after the cessation of fertilizer application. *Appl Veg Sci*, 13: 257-269.

Hill M.O., 1973. Diversity and evenness: A unifying notation and its consequences. *Ecology*, 54: 427-432.

Kobayashi T., Hori Y. and Nomoto N., 1997. Effects of trampling and vegetation removal on species diversity and micro-environment under different shade conditions. *J Veg Sci*, 8: 873-880.

Kohler F., Gillet F., Gobat J-M. and Buttler A., 2004. Seasonal vegetation changes in mountain pastures due to simulated effects of cattle grazing. *J Veg Sci*, 15: 143-150.

Kotorová I. and Lepš J., 1999. Comparative ecology of seedling recruitment in an oligotrophic wet meadow. *J Veg Sci*, 10: 175-186.

Louault F., Pillar V.D., Aufrère J., Garnier E., Soussana J.-F. 2005. Plant traits and functional types in response to reduced disturbance in a semi-natural grassland. *J Veg Sci*, 16: 151-160.

Novák J., 2009. *Trávne porasty po odlesnení a samozalesnení* (Grasslands after deforestration and self-reforestration). Brno: Tribun EU, 166 p.

Pavlů V., Hejcman M., Pavlů L. and Gaisler J., 2007. Restoration of grazing management and its effect on vegetation in an upland grassland. *Appl Veg Sci,* 10: 375-382.

ter Braak C.J.F. and Šmilauer P., 2002. CANOCO reference manual and CanoDraw for Windows user's guide, Software for Canonical Community Ordination (version 4.5). Microcomputer Power, Ithaca, NY.

van Tooren B.F., den Hertog J. and Verhaar J., 1988. Cover, biomass and nutrient content of bryophytes in Dutch chalk grasslands. *Lindbergia,* 14: 47-54.

Wallis De Vries M.F., 1998. Large herbivores as key factors for nature conservation. In: Wallis De Vries MF, Bakker JP, Van Wieren SE (eds), *Grazing and Conservation Management*. Dordrecht: Kluwer Academic Publishers, p. 1-20.