Agriculture, Ecosystems and Environment 202 (2015) 243–250

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Little grazer species effect on the vegetation in a rotational grazing system

Jana Sabrina Jerrentrup [a,b,*], Melanie Seither [c], Ute Petersen [b], Johannes Isselstein [a]

[a] Georg-August-Universität Göttingen, Department of Crop Sciences, Grassland Science, 37075 Göttingen, Germany
[b] Thünen-Institute of Biodiversity, Bundesallee 50, 38116 Braunschweig, Germany
[c] Agricultural Centre of Baden-Württemberg, Grassland Botany and Ecology, Atzenberger Weg 99, 88326 Aulendorf, Germany

ARTICLE INFO

Article history:
Received 13 December 2014
Accepted 5 January 2015
Available online 21 January 2015

Keywords:
Plant diversity
Mixed grazing
Sward structure
Permanent grassland
Grazing management
Vegetation composition
Plant species richness

ABSTRACT

To maintain and enhance phytodiversity of complex permanent swards, the choice of livestock is still being debated. In this study, vegetation composition, diversity and sward structure of permanent grassland were investigated in response to cattle, sheep or mixed grazing on two sward types differing in composition. The study was conducted in the Solling Uplands in Lower Saxony, Germany, in a triplicate randomized block design. The experimental site belongs to the plant association Lolio-Cynosuretum and is moderately species-rich. One half of the paddocks was treated with herbicides to achieve grass-dominated, species-poor swards (2007: 6.9 ± 1.5 species m^{-2}, means ± sd) in contrast to the diverse controls (10.3 ± 2.9 species m^{-2}). Paddocks were grazed rotationally in three grazing cycles per year from 2007 to 2011; the vegetation was analyzed from 2007 to 2012. Vegetation composition showed a clear effect of herbicide-treatment, but was not significantly influenced by grazers within or after five years of grazing. With respect to vegetation composition and sward structure, there was no indication of complementary grazing between cattle and sheep in mixed stocking. The effects of grazers in this study were relatively minor and not consistently found. Sward structure, measured as coefficient of variation of sward height, was more heterogeneous in the second grazing cycle 2011 under cattle grazing in contrast to sheep grazing. In addition, the cattle-grazed diverse swards contained more species than the sheep-grazed ones in 2012. These results point toward a slight advantage of cattle grazing for the diversity of European grasslands in common agricultural practice.

1. Introduction

Grasslands belong to the most biodiverse agroecosystems in Europe (Rook et al., 2004). Management affects grassland diversity (Wrage et al., 2011) and in the past, species richness declined due to agricultural intensification on the one hand or abandonment on the other (Henle et al., 2008). For the maintenance and restoration of diversity, an appropriate management aiming at the sustainable use as well as fulfilling farmer's interests, is mandatory (Watkinson and Ormerod, 2001).

As a management option, grazing is seen as one of the most important tools promoting grassland diversity (Rook et al., 2004; Vickery et al., 2001; Wrage et al., 2011) and can enhance vegetation dynamics and (re-) establishment of plant species more than other management practices (Kahmen et al., 2002). Livestock influences pastures in several ways, in particular by selective defoliation, trampling and excreta deposition (Wrage et al., 2011). Selective foraging exerts a local control on competitive plant species enabling subordinate species to coexist (Grime and Mackey, 2002), whereas trampling and subsequent small-scale soil disturbances can be beneficial by creating niches for gap-colonizing species (Hofmann and Isselstein, 2004). Cattle and sheep differ in their selectivity and forage quality requirements and can thereby influence vegetation composition and diversity (Fraser et al., 2011; Rook et al., 2004; Wrage et al., 2011). Sheep bite with their incisors and are, therefore, able to graze close to the ground and to select single plants or even preferable plant parts of high quality and palatability. In contrast, cattle wrap forage with their tongues. Due to their body size and demand for a larger forage quantity, they cannot display this scale and degree of selectivity, but are able to cope with forage of a lower quality in return (Illius and Gordon, 1987; Rook et al., 2004). Compared to cattle, grazing with sheep may lead to an increase in grasses (Dumont et al., 2011; Sebastià et al., 2008), while forbs and legumes decrease (Nolan et al., 2001) due to higher selectivity of

* Corresponding author at: Georg-August-Universität Göttingen, Department of Crop Sciences, Grassland Science, Von-Siebold-Str. 8, 37075 Göttingen, Germany. Tel.: +49 551 39 4363.
E-mail address: sabrina.jerrentrup@agr.uni-goettingen.de (J.S. Jerrentrup).

http://dx.doi.org/10.1016/j.agee.2015.01.007
0167-8809/

sheep for these plants. As a result of selective grazing, sheep might utilize vegetation more unevenly and consequently cause lower plant diversity. In this context, Sebastià et al. (2008) found sheep to decrease vegetation heterogeneity but to facilitate the presence of plant species with conservation value. However, grazing behavior is also affected by the abundance of preferred plants like forb density for instance (Stejskalová et al., 2013) and at low occurrence of these plants foraging costs might become too high (Dumont et al., 2002). The increase of sward heterogeneity usually created by cattle grazing is seen as a key issue in preserving grasslands biodiversity (Rook et al., 2004). Cattle avoid foraging around their dung pats (Forbes and Hodgson, 1985) and perform patch grazing (Adler et al., 2001) thereby creating different habitat types and subsequently promoting the coexistence of different plant compositions (Marion et al., 2010).

The utilization of pastures might be maximized when livestock species are combined in mixed grazing, which has been investigated in many studies (e.g., Abaye et al., 1997; Critchley et al., 2008; Fraser et al., 2013; Loucougaray et al., 2004; Murphy et al., 1995; Nolan et al., 2001). Complementary grazing of cattle and sheep could be beneficial from an agronomic point of view: sheep are indeed more selective, but graze closer to cattle dung pats than cattle do (Forbes and Hodgson, 1985). This complementarity should allow a better utilization of pastures resulting in a structurally more homogeneous sward (Forbes and Hodgson, 1985).

Grazer effects on diversity were often found in observational studies (Sebastià et al., 2008; Socher et al., 2013) and compositional changes detected on sown or relatively species-poor swards (Abaye et al., 1997; Nolan et al., 2001; White and Knight, 2007; Wright et al., 2006). There is only little knowledge about these effects in relation to controlled, replicated experiments, considering complex permanent swards in particular (Stewart and Pullin, 2008). This study aims at filling this gap and compares the effect of cattle and sheep grazing alone or together over five years on permanent grassland swards differing in diversity and composition. To achieve different sward types, one half of the paddocks was treated with herbicides to remove dicotyledonous plants (forbs and legumes) thereby creating swards of poor species richness and composition comparable to intensive grasslands. As suggested by Petersen et al. (2012), this method is recommended to create swards differing in diversity, as there are little disturbances of the natural sward composition in the years after treatment. The sprayed sward is, therefore, comparable to an intensified part of the diverse sward but still representative for agriculturally used grasslands in Europe (Petersen et al., 2012).

We addressed the following hypotheses:

1. Species composition differs between sheep- and cattle-grazed paddocks. This effect is more severe on diverse paddocks since selectivity is a function of the abundance of preferred plant species.
2. Sheep paddocks are, as a result of the high selectivity of sheep, expected to display a lower diversity and evenness, particularly on diverse paddocks.
3. Due to stronger dung avoidance and patch grazing of cattle, the beta diversity is supposed to be higher on cattle than on sheep paddocks.
4. The sward structure on both sward types is expected to be more uniform with mixed grazing indicating complementary grazing. Cattle create structurally more heterogeneous swards.

2. Material and methods

The experimental site, 9 ha in total, is a moderately species-rich Lolio-Cynosuretum, located in the Solling Uplands, Germany (51°46′47N, 9°42′11E; the altitude of the total area ranges from 184 to 209 m above sea level). The site had been managed as a mown pasture with varying proportions of cattle and sheep for more than 16 years before the start of the experiment. Light manure was applied regularly to the total area; however, not all parts of the site were completely accessible for mowing or application of manure. Swards were dominated by *Dactylis glomerata* (22%), *Lolium perenne* (15%) and *Taraxacum* sect. *Ruderale* (13%; yield proportions assessed according to Klapp and Stählin (1936), respectively). The soil type is a pelosol with a texture of silty/clay loam. The average annual precipitation is 879 mm and the average temperature 8.2 °C (1961–1990, Deutscher Wetterdienst, DWD, location: Dassel – 3 km from the experimental site). To characterize initial soil conditions, composite soil samples (consisting of eight subsamples) were taken around five randomly distributed permanent plots per paddock (also used for vegetation analyses) to a depth of 10 cm (P, K, Mg; July 2007) and 30 cm (mineral N analysis; October 2007). The pH of the soil (in $CaCl_2$ suspension) as well as the availability of P, K (extracted with calcium acetate lactate, continuous flow analyzer [CFA]), Mg ($CaCl_2$ extraction, CFA) and mineral N (KCl extraction, CFA) showed the large variability typical for pastures (pH: 6.8 ± 0.3; in mg 100 g^{-1} dry matter: P: 7.9 ± 3.2 [very low to optimal], K: 17.4 ± 4.9 [low to very high], Mg: 35.8 ± 8.4 [high to very high; categorization of the nutrient availability, respectively], NO_3^-[high to very high; categorization of the nutrient availability, respectively]: 0.5 ± 0.1, NH_4^+: 0.2 ± 0.01, means ± standard deviation, sd).

The experimental variants were implemented on eighteen paddocks of 0.5 ha in size that were arranged in three blocks. Two factors were introduced: the botanical composition and the species of grazer. The initial composition of the sward was manipulated in summer 2006, prior to the start of the experiment, by the use of a herbicide against dicotyledonous plants (Starane Ranger and Duplosan KV, active components fluroxypyr/triclopyr and mecoprop-p) on half of the paddocks of each block, resulting in a grass-dominated (gd) sward (2007: 6.9 ± 1.5 species m^{-2}, means ± sd) compared to the untreated diverse (div) sward (10.3 ± 2.9 species m^{-2}) (referred to as 'sward types' in the following). In autumn 2009 gd-swards were treated with herbicides again to maintain sward differentiation.

Both diversity treatments were either grazed by sheep (S), cattle (C) or both (CS) (referred to as 'grazers' in the following) in the years 2007–2011, starting each year in May. Grazing cattle were suckler cows and calves of the breed German Simmental. Ewes with lambs were Blackheaded and Leine sheep in comparable proportions. The combination of both experimental factors resulted in six treatments (gdC, gdS, gdCS, divC, divS, divCS) replicated three times in blocks that were rotationally grazed three times per year. Animals were assigned to the paddocks on a live weight basis using 3000 kg each (12 LU ha^{-1}, LU = livestock units: 500 kg) for the first grazing cycle. For mixed grazed paddocks, sheep and cattle were used in equal weight proportions. Grazing was continued with the same livestock in the second grazing cycle and reduced to 2000 kg (8 LU ha^{-1}) in the third grazing cycle to adapt to slower vegetation growth. The grazing period typically lasted from beginning of May–September/October with a break in between after the second grazing cycle for animal mating varying yearly between 5 and 11 weeks. The grazing time in each rotation cycle depended on the herbage on offer (Table 1).

Compressed sward heights were measured 50 times using a rising plate meter (Castle, 1976) in a zigzag-walk on each paddock before and after each grazing cycle. Based on these measurements, the coefficient of variation of sward heights (CV) was calculated as a measure of sward structure (Zhu et al., 2012) resulting in one CV for each paddock and grazing cycle.

Five permanent subplots per paddock were established for vegetation analysis and soil sampling following the generation of