Changes in plant densities in a mesic species-rich grassland after imposing different grazing management treatments

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Abstract

Changes in plant density were evaluated monthly in the first three vegetation seasons after imposing different grazing management treatments on abandoned semi-natural grassland in the Czech Republic. There was no agricultural management in the 5 years before the start of the experiment in 1998. A completely randomized block experiment was established with the following five treatments: unmanaged control, intensive continuous grazing, extensive continuous grazing and a harvest in June followed by either intensive or extensive continuous grazing for the rest of the growing season. The sward was maintained at a target height of 5 and 10 cm under the intensive and extensive grazing managements respectively. An almost immediate increase in the densities of all sward components, especially grass tillers, occurred after the introduction of grazing on the previously abandoned grassland in comparison with the unmanaged control treatment. *Trifolium repens* was able to colonize and increase the number of its stolon growing-points in all managed treatments, particularly in intensively grazed patches during the second and third experimental seasons. Delay to defoliation in both treatments containing a harvest in June resulted in an increase in the number of forb plants, particularly in the number of *Taraxacum* spp. plants, most probably due to an enabling of its seed production. It is evident that increases in plant density as a function of intensive defoliation are not restricted to the frequently documented effect on grass tillers but also can occur in many legume and forb species in species-rich grasslands.

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Introduction

In recent years the number of studies experimentally evaluating the effect of management on sward structure and composition has increased considerably (e.g. Krahulec *et al.*, 2001; Marriott *et al.*, 2002; Matějková *et al.*, 2003; Pavlů *et al.*, 2003; Hofmann and Isselstein, 2004; Kohler *et al.*, 2004). The majority of these studies have focused on how changes in plant species diversity are affected by a change in grassland management. A need for this kind of research has arisen because of changes in landscape management, agricultural technologies, socio-economic conditions and the public concern for the decline in wildlife over the whole of Europe in recent decades (Marriott *et al.*, 2004).

Structure, as well as the density of grazed swards, can be influenced by grazing intensity, grazing systems and grazing species. Extensive grazing promotes selective patch grazing which increases the heterogeneity and spatial diversity in species distribution. Selective grazing results in the uneven distribution of grazing pressure, both within and between plant communities, and between and within plant species (Tainton *et al.*, 1996).

Cover estimation of plant species in permanent plots is the most frequently used method in grassland management studies due to its rapidity. This method allows determination of changes in species richness and relationships among species, but is weak in investigating morphological plasticity of sward components under grazing. Although the use of single-species responses gives important information, a functional analysis of vegetation may help to understand and predict the impact of management in a more general way (Louault *et al.*, 2005). To study sward structure in detail, the number of grass tillers, stolon growing-points of white clover or number of other plants are often used (e.g. Laidlaw *et al.*, 1995; Brock *et al.*, 1996; Pavlů and Velich, 2001). These characteristics are mostly observed in sown grass monocultures or simple grass-clover swards only. It has been shown that the density of grass tillers increases and their size decreases with increasing intensity of livestock grazing (Laidlaw and Steen, 1989; Orr *et al.*, 1990; Matthew *et al.*, 1995). Jones *et al.* (1982), for example, reported that tiller density increased fivefold in a sward of *Lolium perenne* managed by continuous grazing, compared with an infrequently cut sward. These differences had already developed in the first grazing season. Johnson and Parsons (1985) described how intensity of grazing had a considerable positive effect on the total number of tillers, but a negative effect on the number of reproductive tillers of *L. perenne* in a pure grass pasture. Different grazing management treatments caused no differences in plant structure between *L. perenne* and *Dactylis glomerata*, but did affect the size of their organs, and hence the size of the plants (Brock *et al.*, 1996). Despite large differences in tiller size or tiller density between two grass species, the plastic responses of swards, mediated by the trade-off between size and density of tillers, do not necessarily affect the frequency at which individual tillers are defoliated (Lemaire and Chapman, 1996). The differences could be explained by the principle of size–density compensation in grasslands (Matthew *et al.*, 2000). This theoretical relationship describes how at low grazing heights a higher population density of smaller tillers optimizes sward leaf area index (LAI) and, conversely, at higher grazing heights a lower population density of larger tillers optimizes sward LAI. Steady-state tiller density reflects the tillering capacity of the different species, which is linked to their leaf appearance rate (Lemaire and Chapman, 1996).

Little attention has been paid to tillers, stolon growing-points and plant densities under various defoliation regimes in species-rich grasslands up to now. With regard to the wide range of grazing intensities, or combination of cutting in spring and grazing in summer and autumn commonly practised in Central Europe, it was investigated how imposition of grazing and its combination with cutting affects sward density of previously unmanaged semi-natural grassland. The aim of this study was to reveal changes in densities of sward components as a function of various defoliation regimes.

Materials and methods

Study site

The experiment was undertaken in the Jizerské Mountains in the northern part of the Czech Republic, 10 km north from the township of Liberec (50°50′N, 15°06′E). The site is underlain by granite bedrock and a medium-depth brown soil (cambisol) with the following attributes: pH/KCl, 5·1; C_{ox}, 3·9%; available P content, 64 mg kg^{-1}; available K content, 95 mg kg^{-1}; and available Mg content, 92 mg kg^{-1}. The altitude is 420 m, the average annual precipitation is 803 mm and the mean annual temperature is 7·2°C (Liberec Meteorological Station). The experimental area was drained, ploughed and reseeded with a highly productive grass/clover mixture in the early 1980s and was intensively managed by cutting and grazing. In the early 1990s mulching was applied once a year only (in August) and then the grassland was abandoned. There was no agricultural management in the 5 years before the start of the experiment in 1998. According to phyto-sociological nomenclature (Moravec *et al.*, 1995), the vegetation, before introduction of the experimental treatments, was classified as upland hay meadow (*Arrhenatherion*). Nomenclature of vascular plant species was taken from Kubát *et al.* (2002). The dominant species of the unmanaged sward were *Agrostis capillaris*, *Alopecurus pratensis*, *Festuca rubra agg.*, *Aegopodium podagraria* and *Galium album*. No fertilizers had been applied since the 1980s.

Design of the experiment

The experiment was established in the spring of 1998 and was arranged in two completely randomized blocks. Treatments applied were: intensive grazing (IG), harvest of primary growth in June followed by intensive grazing (ICG), extensive grazing (EG), harvest of primary growth in June followed by extensive grazing (ECG), and unmanaged grassland (U) as the control. Each grazed plot was approximately 0·35 ha and the unmanaged control was 0·12 ha. Detailed descriptions of the treatments applied are outlined in Table 1. Sward height was measured weekly using the first contact method (modified point-quadrat method). Measurements are derived from the first perpendicular contact of a long needle at 0·20 m intervals (Pavlů and Velich, 1997). Sward height was calculated as a mean of 100 records on a 20-m linear transect across each paddock. To maintain the target sward height, an additional non-sampling area with the required sward height was added in the course of the grazing season. All treatments were grazed continuously by young

Table 1 Detailed description of treatments.

Treatment	Description	Target sward height (cm)	Date of harvest	Start of grazing	Stocking rate (kg ha^{-1})
U	Unmanaged control	No grazing	No harvest	No grazing	–
IG	Intensive grazing	5	–	Beginning of May	1000
ICG	Harvest of primary growth followed by intensive grazing	5	Start of June	Middle of June	1000
EG	Extensive grazing	10	–	Middle of May	500
ECG	Harvest of primary growth followed by extensive grazing	10	Start of June	End of June	500

heifers with an initial live weight of 150–220 kg in each grazing season. Grazing was applied from early May to the end of October and the productivity of the pasture varied from 2 to 4 t DM ha^{-1} year^{-1}.

Data collection

Density of all vascular plant species was visually estimated in 100 cm^2 circles. The term, plant density, used in this experiment refers to the number of individual tillers for grasses, the number of stolon growing-points for *Trifolium repens* (Davies, 1993), and the number of single primary stems or rosettes for other forbs. Across the experimental plot two samples were taken randomly every month. Each sample was composed of five circles (five treatments × two blocks × two replicates per plot × five individual circles) from May to October during the years 1997–99. To eliminate trampling of vegetation during the making of observations, data in control unmanaged plots were collected in May only. Baseline data were collected in May 1998 before the first application of treatments. The number of all plant species present, with the exception of grasses, was recorded. To avoid any mistakes in the identification of grazed grasses (*A. capillaris*, *A. pratensis*, *Holcus mollis*, *Poa pratensis*, *P. trivialis* and *Trisetum flavescens*), they were classified into one group. Only the easily identifiable grass, *F. rubra*, was evaluated separately.

Functional groups

Based on descriptions of vascular plants for the regional flora (Kubát *et al.*, 2002), all plant species within the study area were *a priori* categorized into functional groups. The following categories were used: grasses, legumes, prostrate forbs (dicotyledonous perennial species with creeping or prostrate growth), annuals and biennials (annual and biennial monocotyledonous and dicotyledonous species) and other species (Table 2). The proportion of gaps as a proportion of the soil surface without vegetation was also estimated visually.

Data analysis

Data were collected in the form of repeated measures, thus a repeated-measures redundancy analysis (RDA, Lepš and Šmilauer, 2003), followed by the Monte Carlo permutation test, was used. The CANOCO program (Ter Braak and Šmilauer, 2002) was used to evaluate multivariate data. Redundancy analysis is a direct gradient analysis method based on the assumption of a linear response and was used because the data set was relatively homogeneous. A total of 499 permutations were used in all analyses. A split-plot design was used and permutations were performed within each of the two experimental blocks. Whole plots were records of sample repeated in time and were permuted completely at random; the split-plot level was not permuted. Default parameters were used in the CANOCO program. After obtaining a significant RDA analysis result, a repeated-measures ANOVA was used to evaluate univariate plant density data and block was used as a random factor.

Results

Seasonal sward development

A significant effect of month in 1998 and 2000 on plant density in the sward was found (Table 3, An. 1). Month × treatment interactions were significant in all the seasons that were studied, indicating an obvious non-parallel development of at least one treatment (Table 3, An. 2) during each season.

Grass functional group

At the beginning of the experiment, the structure of abandoned grassland was similar on all treatments (Figure 1). A relatively low number of grass tillers (about 2000 m^{-2}) was detected from the baseline data collected in the spring of 1998. During the first season of grazing there was a gradual increase in grass tillers

Table 2 Functional groups of the sward.

Grasses	Legumes	Prostate forbs	Forbs	Annuals and biennials
Agrostis capillaris	*Lathyrus pratensis*	*Alchemilla* spp.	*Achillea millefolium*	*Capsella bursa-pastoris*
Alopecurus pratensis	*Lotus uliginosus*	*Plantago major*	*Aegopodium podagraria*	*Cirsium vulgare*
Dactylis glomerata	*Trifolium pratense*	*Ranunculus repens*	*Alchemilla* spp.	*Veronica arvensis*
Elytrigia repens	*Trifolium repens*	*Taraxacum* spp.	*Anthriscus sylvestris*	
Festuca pratensis	*Vicia cracca*	*Trifolium repens*	*Campanula patula*	
Festuca rubra	*Vicia sepium*		*Cardamine pratensis*	
Holcus mollis			*Cerastium holosteoides*	
Poa pratensis			*Cirsium palustre*	
Poa trivialis			*Cirsium vulgare*	
Trisetum flavescens			*Galium album*	
			Glechoma hederacea	
			Hypericum maculatum	
			Lychnis flos-cuculi	
			Ranunculus acris	
			Ranunculus repens	
			Rumex acetosa	
			Rumex obtusifolius	
			Stellaria graminea	
			Taraxacum spp.	
			Veronica chamaedrys	
			Veronica serphyllifolia	

recorded on all treatments. The mean tiller number was around 6000 m^{-2} at the end of the first grazing season and this was maintained during the next two experimental seasons. The lowest tiller number was on the EG treatment, followed by the ECG and ICG treatments. The maximum tiller number was recorded under intensive grazing (treatment IG) during all months studied with the exception of September 1998, and May and June 1999. The effect of month and treatment was significant in all seasons, and the interaction of month and treatment was significant in 1999 and in 2000 (Table 4). No interaction was found in the first experimental season in 1998 as the development of all treatments was relatively similar with the exception of October when the highest tiller density arose was found on treatment IG. Tiller densities in 2000 were a function of defoliation intensity during the grazing season as can be seen from Figure 1. *Festuca rubra* was positively influenced mainly by the IG treatment (Figure 2).

Legume functional group

The mean number of legume plants was close to zero before application of the different treatments in May 1998. The increase in legume plants was evident in the subsequent experimental years without significant seasonal development or evidence of treatment effects, or interactions between month and treatment (Table 4). High fluctuations of legumes between consecutive months without any effect of the applied treatments are visible from Figure 1. The functional group of legumes was composed of species with different environmental requirements. *Lotus uliginosus* and *Lathyrus pratensis* were found on the unmanaged treatment. *Trifolium repens* (Figure 2) and *Vicia cracca*, on the other hand, were never recorded but were abundant in the other treatments, especially in 1999 and 2000.

Forb functional group

The mean number of forb plants ranged from 500 to 1000 plants m^{-2} in the first grazing season (Figure 1) without a significant effect of month in comparison with the following 2 years (Table 4). Gradually significant increases were revealed in the following grazing seasons. In 2000, significant treatment differences were recorded but there were no month effects. The highest number of forb plants was recorded in the ICG and ECG treatments for the whole grazing season. The number of forbs was lowest in the unmanaged treatment in all grazing seasons. *Urtica dioica* increased in the unmanaged control and in the extensively grazed treatment during the course of the experiment. *Glechoma hederacea*, on the other hand, was never recorded in the unmanaged control treatment and *Ranunculus acris* increased in the unmanaged control treatment and

Table 3 Results of the redundancy analysis of plant density performed within three consecutive seasons (1998, 1999 and 2000).

			1998			1999			2000		
An.	Explanatory variables	Co-variables	Proportion of variation explained	*F*-ratio	*P*-value	Proportion of variation explained	*F*-ratio	*P*-value	Proportion of variation explained	*F*-ratio	*P*-value
1	M	PlotID, M * IG, M * ICG, M * EG, M * ECG	0·241	28·5	*0·0008*	0·018	1·65	0·272	0·083	8·19	*0·012*
2	M * IG,M * ICG, M * EG, M * ECG	Plot ID, M	0·077 (0·088)	7·60 (2·90)	*0·018* (*0·026*)	0·169 0·182	0·184 6·69	*0·002* (*0·002*)	0·281 (0·335)	35·2 (15·1)	*0·002* (*0·002*)

An., number of analysis; M, month; IG, ICG, EG, ECG, treatment abbreviations, see Table 1; plot ID, plot identifier; proportion of variation explained, species variability explained by one ordination axis (measure of explanatory power of the explanatory variables); *F*-ratio, *F*-statistics for the test of particular analysis; *P*-value, corresponding probability value obtained by the Monte Carlo permutation test. Significant *P*-values are in italics.

decreased in the other treatments. *Stellaria graminea*, *Rumex acetosa*, *Cirsium palustre* and *Ranunculus repens* were more abundant in the other treatments.

Prostrate herb functional group

This functional group revealed few changes following changes in management. Some species in this functional group overlapped with other functional groups. The significant effect of month in all three grazing seasons is shown in Table 4. The effect of treatment and the interaction of treatment and month were not significant in either case. The lowest number was recorded in unmanaged plots over the course of the experiment (Figure 1); the number increased in managed treatments during the whole experiment, and was highest at the end of third grazing season. *Alchemilla* spp. were the most common prostrate herbs in the unmanaged plots, *R. repens* (Figure 2) was the most common herb species on treatment IG, *Taraxacum* spp. were the most common herb species on the ICG and ECG treatments, and *T. repens* was the most abundant in both treatments with intensive grazing by the end of the experiment.

Annual and biennial functional groups

Capsella bursa-pastoris and *Veronica arvensis* were the only annuals and *Cirsium vulgare* was the only biennial recorded (Figure 1). No ANOVA analysis of this functional group was conducted because of low plant numbers and because no plants were recorded in the unmanaged control treatment during the whole experiment. No annuals were recorded in any of the treatments during the first experimental season. Up to ten plants m^{-2} were recorded during the second grazing season in 1999. The highest variation in annuals and biennials of up to thirty-five plants per m^2 was revealed in the third experimental season in 2000. These peaks were detected in the IG and ICG treatments.

Gaps

The estimated percentage cover of bare soil without vegetation was highest under the unmanaged treatment in all three seasons, although a decrease in the second and third seasons was evident. Bare ground decreased in treatments IG and ECG by approximately 0·20 at the end of the first grazing season (Figure 1). During the second season a decrease in gaps was recorded with the exception of the EG treatment where the opposite trend was observed. Share of gaps was relatively stable during the third vegetation season with the exception of the IG treatment where

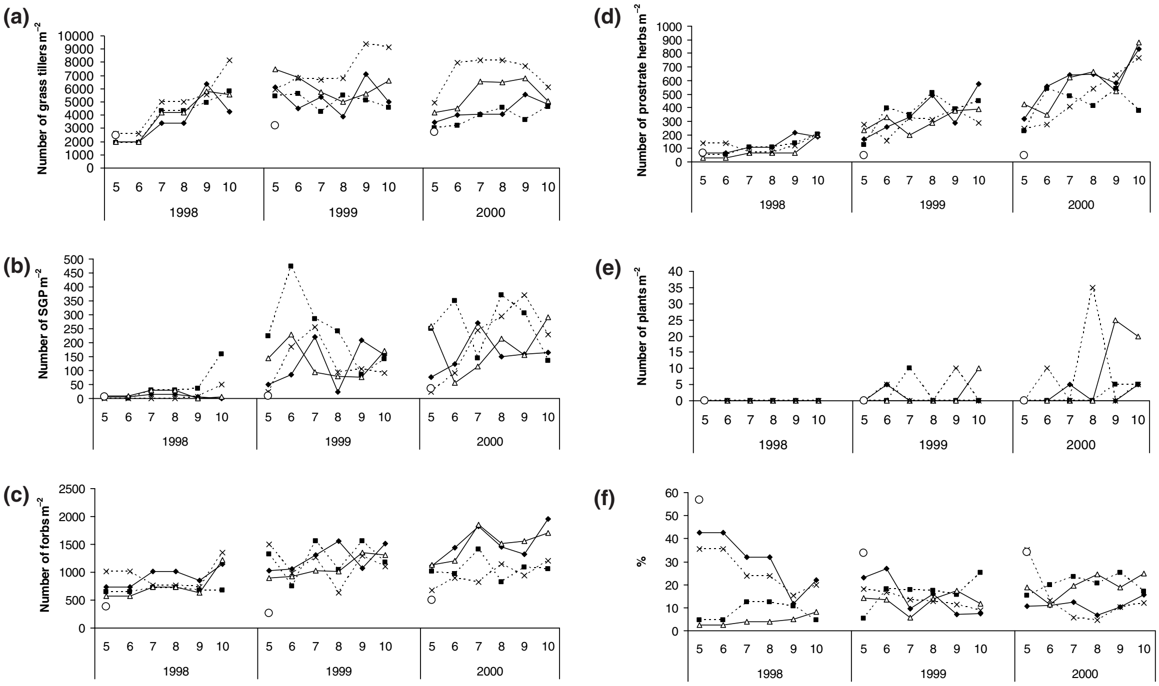

Figure 1 Density of plants per m^2 of functional groups: (a) grasses, (b) legumes, (c) forbs, (d) prostrate herbs, (e) annuals and biennials and (f) cover as gaps for treatments U (○), IG (×), ICG (△), EG (■), and ECG (◆) in the months of 1998, 1999 and 2000 when measurements were made.

Table 4 Results of repeated-measures ANOVA analyses for seasonal development for months (M, from May to October) of plant density in relation to management treatments (T). Significant results are in italics.

		Grasses		Legumes		Forbs		Prostrate herbs		Gaps	
Year	Effect	*F*-ratio	*P*-value	*F*-ratio	*P*-value	*F*-ratio	*P*-value	*F*-ratio	*P*-value	*F*-ratio	*P*-value
1998	M	39·08	*<0·001*	1·77	0·130	2·11	0·074	4·73	*0·001*	30·54	*<0·001*
	T	6·14	*0·001*	2·05	0·114	2·61	0·058	1·62	0·193	4·79	*0·004*
	M × T	1·58	0·103	1·19	0·303	0·58	0·880	0·63	0·845	1·85	*0·044*
1999	M	3·03	*0·015*	1·33	0·261	3·48	*0·007*	2·94	*0·018*	2·90	*0·019*
	T	16·99	*<0·001*	1·94	0·131	1·49	0·224	0·91	0·439	0·41	0·745
	M × T	2·70	*0·003*	0·73	0·752	2·32	0·009	0·89	0·574	1·18	0·311
2000	M	7·80	*<0·001*	0·56	0·734	6·14	*<0·001*	5·14	*<0·001*	6·58	*<0·001*
	T	44·11	*<0·001*	0·80	0·497	20·95	*<0·001*	2·44	0·071	3·74	*0·015*
	M × T	1·93	*0·034*	0·73	0·749	1·35	0·199	0·95	0·512	4·29	*<0·001*

there was a continuous decrease from the spring peak.

Discussion

The counting of plant numbers in species-rich swards has been frequently used for only specific sward components, such as the number of stolon growing-points of *T. repens* (Pavlů and Velich, 2001), numbers of seedlings in studies of gap dynamics (Hofmann and Isselstein, 2004; Špačková and Lepš, 2004) or numbers of modules in fine-scale studies of semi-natural grasslands (Herben *et al.*, 1995). Little attention has been paid to the investigation of the densities of all sward components in species-rich semi-natural grasslands up until now. The majority of researchers have focused only on evaluation of plant cover or biomass production (e.g. Gaisler *et al.*, 2004; Lepš, 2004), most probably due to the lower time requirements for the collection of data on cover and also due to the difficulties with definitions

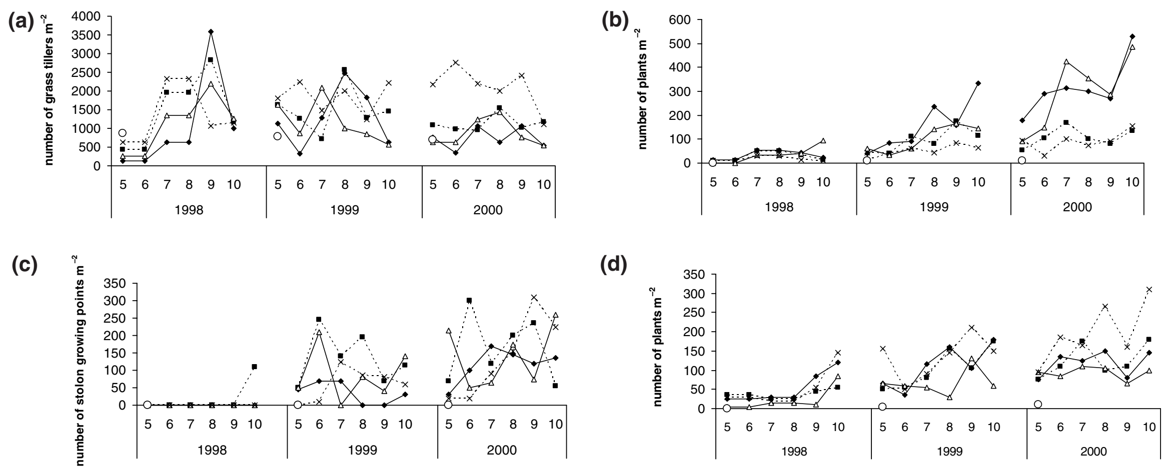

Figure 2 Density per m^2 of (a) *Festuca rubra*, (b) *Taraxacum* spp., (c) *Trifolium repens* and (d) *Ranunculus repens* for treatments U (○), IG (×), ICG (△), EG (■), and ECG (◆) in the months of 1998, 1999 and 2000 when measurements were made.

of individuals in various clonal plant species. Up to now, increases in tiller densities of grasses as a function of intensive defoliation have been published from sown or species-poor grasslands composed of one or a few plant species only (Johnson and Parsons, 1985; Brock *et al.*, 1996). In grass monocultures, tiller population density can be obtained if herbage mass is divided by individual tiller weight, thus counting all tillers in the field is not necessary. To do this in species-rich swards in this study was impossible because of the high labour requirements for counting in the field.

The response of unmanaged grassland to the introduction of grazing management was investigated in two ways in this experiment: changes in dominance of single species, extinction of defoliation-sensitive species, or emergence of new species in some plots, and, on the other hand, changes in the growth forms of the species present. Substantial increases were found in plant densities within the first growing season after the introduction of grazing and the grasses showed the most flexible response of all sward components, especially *F. rubra*. Decreases in tiller size were recorded and more than a doubling of their density between June and July after the introduction of grazing treatments. This is in accordance with the results of Johnson and Parsons (1985) who used a model of vegetative grass grow under continual grazing. Grazing intensity in *L. perenne* swards had a considerable effect on the number of grass tillers as was found in this study in a more species-rich sward.

At the end of the first grazing season, tiller densities were more than three times higher than those in May before the application of continuous grazing in intensively grazed plots. It is concluded that changes in plant density are a function of the defoliation intensity as the effect on tiller density in extensively grazed treatments was not significant in contrast to intensively grazed treatments. This conclusion has long been known for forage grasses in sown monocultures (Langer, 1963; Bircham and Hodgson, 1983; Matthew *et al.*, 1995) but this is the first evidence from a semi-natural species-rich grassland. It is evident that increases in plant density as a function of defoliation were not only restricted to grasses only but also to legume and forb species in semi-natural grasslands. Results of this study indicate the validity of the size/density compensation principle frequently documented in sown grass monocultures (see Matthew *et al.*, 2000) even for many dicotyledonous plant species.

The density of legume plants was close to zero before application of the different grazing regimes in the spring of 1998. *Trifolium repens* substantially increased on the EG treatment by the end of the first grazing season and became common on all the managed treatments in the next two grazing seasons. The extensively grazed treatments were composed of patches grazed little, moderately or intensively. Thus, the spread of *T. repens* can be misleading if it is analysed without respect to patchiness. *Trifolium repens* preferentially colonizes intensively grazed patches with favourable light conditions (Adler *et al.*, 2001; Correll *et al.*, 2003). It was evident that the seed bank was responsible for establishment of *T. repens* in the spring of 1999. Its relatively quick spread in the third season was perhaps further supported by germination of seeds among faeces in the spring of 2000. The appearance and subsequent expansion of *T. repens*, observed in all grazed treatments, is in accordance with grazing studies performed in comparable climatic and soil conditions (Pavlů and Velich, 2001; Correll *et al.*, 2003). This is in contrast to studies performed in Western Europe where *T. repens* under heavy grazing can become more suppressed by dense *L. perenne* in more suitable conditions (see Davies, 2001). Similar to *T. repens*, *V. cracca* was not recorded in the unmanaged control treatment. Tall vegetation was evidently not favourable for growth of light-demanding species. *Lotus uliginosus* and *L. pratensis* were legumes able to survive in the unmanaged control treatment, although they were more abundant in the managed plots. Hejcman *et al.* (2005) recorded the spread of *L. pratensis* after cessation of management in the Giant Mountains of the Czech Republic showing high plasticity to defoliation.

The most favourable treatments for growth of forbs were the ICG and ECG treatments in the third season of the study. *Taraxacum* spp. were the most positively influenced species. Plants of these species were clearly favoured by a delay in the first defoliation in the grazing season as they were able to produce seeds in the ICG and ECG treatments but not in the treatments grazed from the early spring.

The prostrate functional group was employed to test the hypothesis that intensive defoliation supports species of low growth as is discussed in many current ecological studies (see Bullock *et al.*, 2001; Diaz *et al.*, 2004; Gaisler *et al.*, 2004). Increases in prostrate herbs were recorded during the course of the experiment in all managed treatments but the effect of different grazing intensities was not so obvious, most probably due to the patchiness created in the extensively grazed treatments.

The highest peaks for annuals were in both the intensively grazed treatments which may have provided more suitable conditions for germination and seedling survival. This is in accordance with grazing studies performed in temperate zones indicating the creation of a regeneration niche by grazing (e.g. Bullock *et al.*, 2001; Pavlů *et al.*, 2003).

The highest cover of gaps was recorded in the unmanaged control treatment in all 3 years at the May recording. It was evident that the increase in plant density was a consequence of bare ground decreasing in managed plots. This is in accordance with the results of Hofmann and Isselstein (2004) who found that infrequent defoliation resulted in a more open sward compared with frequent defoliation. According to many authors, grazing increases gap dynamics due to trampling and makes the sward more suitable for seed germination and survival of seedlings (Stammel and Kiehl, 2004). Substantial increases were recorded in the number of perennials under grazing and thus in these treatments the sward appeared to have become more resistant to trampling.

Synthesis

The patchiness aspect of the grazed swards needs to be taken into account. However, to extend the number of samples with respect to the patches is difficult due to the time-consuming nature of the sampling. Almost immediate increase in densities of all sward components, especially grass tillers, in comparison with the unmanaged control was a characteristic change after introduction of grazing on the previously abandoned grassland. *Trifolium repens* was able to colonize and increase its number of stolon growing-points in all managed treatments, particularly in intensively grazed patches during the second and third experimental seasons. Delay in defoliation in both treatments, in which harvests of primary growth were taken, resulted in a rise in the number of forb plants, principally in the number of *Taraxacum* spp. individuals, probably due to enabling its seed production. It is evident that increases in plant density as a function of intensive defoliation are not only restricted to the frequently documented effect on grass tillers but also can occur in many legume and forb species in species-rich grasslands.

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