Effect of breed of cattle and season on diet selection and defoliation of competitive plant species in semi-natural grasslands

A. Hessle*, J. Wissman†, J. Bertilsson‡ and E. Burstedt§

*Department of Animal Environment and Health, Swedish University of Agricultural Sciences, Skara, Sweden, †Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden, ‡County Administration Board of Västra Götaland, Skara, Sweden, and §Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Uppsala, Sweden

Abstract

To maintain biodiversity in semi-natural grasslands, the choice of breed of livestock and season of grazing can be important. The objective was to determine the effects of breed and season on the composition of plant fragments in the faeces of cattle grazing a heterogeneous semi-natural grassland. Twelve heifers of the traditional Swedish Väneko breed (live weight 309 kg) and twelve heifers of the Charolais breed (live weight 431 kg) were allocated to three pastures per breed. Faeces samples were collected in spring, summer and autumn for micro-histological examination of plant fragments. On the same occasion, defoliation of four competitive plant species was recorded. Faecal plant fragments mainly consisted of grasses but also herbs, whereas Cyperaceae, despite their abundance on the pastures, only composed a small proportion of fragments. Season affected the composition of plant fragments in the faeces, with a higher proportion of Cyperaceae and herbs in spring than later in the grazing period ($P < 0{\cdot}001$), and the heifers ingesting more grasses and woody plants in autumn. In spite of a clear difference in live weight between the two breeds, no effects of breed on the composition of plant fragments in faeces were observed, although Väneko heifers defoliated more *Filipendula ulmaria* in spring than the Charolais heifers ($P < 0{\cdot}01$). In addition, defoliation of *Alnus glutinosa* increased later in the grazing period ($P < 0{\cdot}05$), especially for the Väneko heifers, indicating control of pernicious brushwood by grazing may be more effective in autumn.

Correspondence to: A. Hessle, Department of Animal Environment and Health, Swedish University of Agricultural Sciences, PO Box 234, 532 23 SE Skara, Sweden.
E-mail: anna.hessle@hmh.slu.se

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Introduction

The semi-natural grasslands of northern Europe have a wide diversity of plant and animal species of which a number are under threat of loss (Smart *et al.*, 2000; Bernes, 2001; Luoto *et al.*, 2003). The largest threat to grassland diversity is from the cessation of grazing. In areas where a decrease in the grazing of grasslands is forecasted, there is a need to develop strategies of grazing management that maintain the biodiversity of semi-natural grasslands.

In addition to factors, such as live weight and previous grazing experience, breed of livestock has often been suggested as a tool for obtaining specific grazing effects (Rook *et al.*, 2004; Van Wagoner *et al.*, 2006). Historically in Europe, forests and marginal grasslands with nutrient-poor vegetation were generally used for grazing (Myrdal, 1998). Therefore, it is possible that certain adaptive foraging traits in livestock may differ between traditional breeds developed in nutrient-poor environments and breeds developed in more fertile environments and under intensive production systems (Sæther and Vangen, 2001; Rook *et al.*, 2004). A less selective diet is synonymous with an increased proportion of plant species generally avoided for defoliation. Plant species avoided in grasslands, such as a number of species of rough grasses, Cyperaceae and brushwood species, are often competitive and this may lead to a reduction in the biodiversity in species-rich grasslands. Therefore, defoliation of competitive species is desirable when managing semi-natural grasslands. Using specific types of livestock may be one way to control their spread (Steinheim *et al.*, 2005; Sæther *et al.*, 2006; Scimone *et al.*, 2007). Previous studies have also demonstrated that cattle grazing can be more selective at the beginning of the grazing season (Dumont *et al.*, 2007) whereas less preferred species, such as sedges, rushes and woody plants, are ingested to a greater extent later in the grazing season (Roath and Krueger, 1982; Ganskopp *et al.*, 1999; Evans *et al.*, 2004; Pelster *et al.*, 2004). In this study, the effect of cattle breed and season of grazing on the composition of plant fragments in the faeces and the extent of defoliation of competitive plant species found in wetter areas of the grassland from a semi-natural grassland was examined.

Materials and methods

Animals and pre-experimental feeding

Spring-born weaned heifer calves, of which fourteen were of the Swedish traditional breed Väneko (Hallander, 1993) and fourteen of the Continental commercial breed Charolais, were brought from eight commercial suckler cow herds in November 2003 at, on average, 8 months of age. All calves had been reared on semi-natural grasslands together with their dams. All grasslands consisted of dry, mesic and wet areas, and the pastures were supplemented by grazing of leys, mainly in autumn. During the pre-experimental indoor period, all heifers were offered wilted grass-clover silage containing 0·90–0·95 of grass (*Lolium perenne*, *Festuca pratensis* and *Phleum pratense*) and 0·05–0·10 of clover (*Trifolium repens* and *Trifolium pratense*) *ad libitum*. The Väneko heifers had low initial live weights, so they were also fed daily 1·5 kg oats and 0·2 kg soya bean meal per heifer during the first 2 months of the indoor period. Heifers were weighed every 2 weeks during both the pre-experimental indoor period and the experimental grazing period. Average live weights at turn-out for the Väneko and Charolais heifers were 309 and 431 kg respectively.

At turn-out, the heifers were arranged according to their live weights to obtain similar stocking rates, in terms of kg live weight per hectare (average 494 kg ha^{-1}) on the experimental plots. Twelve heifers of each breed were included in the experiment with four Väneko heifers and four Charolais heifers in each of three plots. The remaining two heifers of each breed were used as ''put-and-take'' animals to maintain similar average pasture heights among the six plots and a light to moderate stocking rate.

Study site

The experiment was conducted on 18 ha of semi-natural grasslands at the Götala Research Station, the Swedish University of Agricultural Sciences, Skara, in south-western Sweden (13°21′E, 58°42′N, elevation 150 m) from 4 May to 18 October 2004. Historically, the grassland had been used as pasture, meadow and arable land but during the last 50 years all of it had been continuously grazed by cattle during the growing season. The grass-dominated pasture was mainly open and had a varied topography and moisture gradient. Dry, mesic and wet areas in the grasslands were visually determined and mapped by a global positioning system (GPS), equipped with a receiver for signals from DGPS correction stations resulting in an accuracy of within 1 m (Trimble Pro XR, Trimble®, Sunnyvale, California, USA). Areas were calculated using the GIS software (ArcMap; ESRI®, 2002). When dividing up the grassland by fences before the experiment started, similar proportions of wet, mesic and dry areas were attained in each plot averaging 0·20 (s.d. 0·05) of dry, 0·62 (s.d. 0·07) of mesic and 0·18 (s.d. 0·06) of wet areas. The six plots (2·2–4·1 ha) were located side by side in a row. Every second plot was grazed by Väneko heifers and every second plot by Charolais heifers. Water, salt and minerals were available in the mesic area of each plot.

In the dry areas, the predominant grass species were *Festuca ovina*, *Deschampsia flexuosa*, *Nardus stricta* with several herb species such as *Lathyrus linifolius*, *Galium verum*, *Galium borale* and *Hieracium pilosella*. Mesic areas were dominated by the grasses *Festuca rubra* and *Deschampsia cespitosa* and herbs, such as *Ranunculus acris*, *Veronica chamaedrys*, *Ajuga pyramidalis* and *Succisa pratensis*. *Deschampsia cespitosa*, *Juncus effusus* and *Carex* spp., were prominent in wet areas together with the herbs *Filipendula ulmaria* and *Ranunculus repens*. The principal woody plant species were *Juniperus communis*, *Betula* spp. and *Quercus robur* in dry and mesic areas, and *Alnus glutinosa* in wet areas.

The pasture heights were measured in all plots every second week throughout the grazing period to ensure the same height in each plot. Sward height measurements were made by following a W-shaped route in each plot, as recommended by Frame (1993). Pasture height measurements were performed with a rising plate meter (0·3 m × 0·3 m with a weight of 430 g) with 24 to 40 recordings in each plot.

At the end of the grazing period, visual assessments of the grazing intensity status of the plots were made. Inspections were conducted according to a Swedish national protocol developed to accommodate management status for obtaining agri-environmental support for pastures (Swedish Board of Agriculture, 2004; Persson, 2005). Areas assessed as having had a satisfactory management implied a well-grazed area with no deleterious litter accumulation or pernicious brushwood, moderate management implied a less well-grazed area with obvious litter accumulation and/or spreading brushwood, whereas weak management implied insignificant grazing, considerable litter accumulation and widely spreading brushwood.

Weather

Weather data were collected continuously every hour by an automatic station about 500 m from the plots. During the experimental grazing period, the precipitation was higher than average, especially in July when it was 180 mm and three times higher than the average values. Average 24-h temperatures were 11°C, 13°C, 14°C, 17°C, 12°C and 7°C in May, June, July, August, September and October, respectively, which were close to the long-term average temperatures of each month.

Sampling and chemical analyses

Herbage was sampled in spring (2–3 June), summer (26–27 July) and autumn (16–17 September). The samples were used to estimate herbage quantity and chemical composition. In each of the six plots, all herbage in five randomly selected 0·5 m × 0·5 m quadrats was cut to a height of 3 cm above ground level in dry, mesic and wet areas respectively (i.e. fifteen quadrats per plot). For the three seasons (spring, summer and autumn), herbage quantity was estimated for each area (dry, mesic and wet) in all six plots, whereas samples for chemical analysis were combined to one sample per season and area for all six plots together.

Herbage samples were analysed for content of dry matter (DM), and concentrations of ash, crude protein (CP), neutral-detergent fibre (NDF) and *in vitro* organic matter digestibility (Lindgren, 1979). The DM content was determined at 105°C for 24 h. The concentration of CP was determined in a Tecator Kjeltec Auto Sampler 1035 Analyzer (Tecator Inc., Höganäs, Sweden) and the concentration of NDF was determined according to Goering and Van Soest (1970). Metabolizable energy concentration was calculated from *in vitro* organic matter digestibility (Lindgren, 1979).

Composition of plant fragments in faeces

Samples of faeces were collected from each heifer in spring (29 May to 2 June), summer (17–24 July) and autumn (7–13 September) respectively. Samples were collected immediately after defecation, labelled and put in a freezer (−18°C) within 30 min, where they were stored until further analysis. Faecal samples were prepared for micro-histological analyses by boiling them in nitric acid followed by sieving and conserving them according to the procedures of Garcia-Gonzalez (1984). All fragments intersecting a 1-mm wide line along 40-mm long transects were examined. The transects were placed 3 mm apart. Identification of fragments was conducted by the same individual and a minimum of 200 fragments was identified to main components on each slide, with completion of the last transect after reaching 200 fragments.

The seventy-two faecal samples were analysed for fragments from thirty plant species and plant groups and for total number of fragments. In addition, a further four plant groups were constructed; total grass (*F. rubra*, *F. pratensis*, *F. ovina*, *Festuca* spp., *D. cespitosa*, *D. flexuosa*, *Poa* spp., *N. stricta*, *Agrostis* spp., *Molinia caerulea*, *Anthoxanthum odoratum*, *Alopecurus* spp., *Phalaris* sp., *Glyceria* sp., *Phleum pratense*, *Dactylis glomerata*, unidentified grasses), total herbs (*F. ulmaria*, unidentified herbs), total sedges and rushes (*Carex* spp., Cyperaceae) and total woody plants (*Betula* spp., *A. glutinosa*, *Calluna vulgaris*, *Vaccinium myrtillus*, *Pinus sylvestris*, *J. communis*, unidentified woody plants).

Defoliation

To study defoliation intensity, 15 areas of *F. ulmaria*, 15 areas of *Juncus effusus*, 15 areas of *A. glutinosa* and 30 areas of *D. cespitosa* in each of the six plots were marked with a 5-cm wooden stick prior to onset of grazing. All the areas, 0·5 m × 0·5 m, were located in wet areas of the enclosures and positions of the plots were recorded using GPS (Trimble Pro XR, Trimble®). Defoliation intensity was recorded three times during the grazing period – in spring, summer and autumn (starting on 7 June, 31 July and 27 September, respectively) – and the recording periods lasted 1–2 weeks. During the experiment, proportionately 0·07 of the sticks were lost and replaced by new sticks, which were applied at the GPS position of the former area. Of the areas, 0·05 had to be moved briefly during the summer and autumn recordings because of trampling, withering or flooding of herbage.

In *F. ulmaria* areas, the numbers and average heights of grazed and ungrazed main shoots and side shoots were recorded. *Alnus glutinosa* was investigated in the second year of growth, when at the onset of grazing, main shoots were <1 m high and had side shoots from roots and stems. Numbers and heights of grazed and ungrazed main shoots and side shoots of *A. glutinosa* were recorded and the numbers of grazed shoots were corrected for shoots browsed by wild herbivores before the experiment started. For *J. effusus* and *D. cespitosa*, proportions of grazed and ungrazed shoots were estimated for the entire area and the average heights of the grazed and ungrazed shoots were measured.

Statistical analysis

The composition of faecal plant fragments as well as the proportions of defoliated shoots and heights of shoots were investigated using a nested model (animal nested within plot) with one fixed factor (breed) and repeated measurement (season) by using the procedure Mixed (SAS, 2001) according to the model:

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + c_{ijk} + e_{ijkl}$$

where α_i is the fixed effect of breed, β_j is the fixed effect of season, $\alpha\beta_{ij}$ is the interaction between breed and season, c_{ijk} is the random effect of plot and e_{ijkl} is the error term. Data for plant species constituting, on average, proportionately <0·01 of the fragments were excluded from the statistical analyses. To correct for false significant effects, further Bonferroni tests were conducted for multiple tests of plant fragments and defoliation data respectively (Hochberg, 1988; SAS, 2001). The proportions of areas visited were investigated by a logistic model with adjustment for overdispersion in the Genmod procedure with Pearson's chi-square test (SAS, 2001). Confidence intervals (CI; $P < 0{\cdot}05$) were analysed for differences in pasture height and herbage mass in the enclosures using a *t*-test (SAS, 2001). Differences among the means for breed and season means were considered significant at $P < 0{\cdot}05$.

Results

Pasture

The pasture height of plots was similar for the two breeds throughout the grazing period. The pasture was higher in summer (4·7–5·3 cm) than in autumn (3·9–4·3 cm; $P < 0{\cdot}001$), which was higher than in spring (3·4–4·0 cm; $P = 0{\cdot}05$). Herbage mass showed the same pattern with higher values in summer and lower values in spring (Table 1) and with no season × plot interaction. The grazing pressure at the end of the grazing season, according to the official classification (Persson, 2005), had been at a satisfactory high level in the dry and mesic areas, whereas it had been weak in the wet areas (E. Isaksson, personal communication). Mean daily liveweight gains of the heifers during the grazing period were similar in the two breeds (0·51 *vs.* 0·63 kg).

Composition of plant fragments in faeces

Faecal samples included on average 448 (s.d. 24) plant fragments per sample. On average over breeds and seasons, the plant fragments were mainly composed of grasses (0·75 of the fragments), dominated by *D. cespitosa* (0·34 of the grasses) and *F. rubra* (0·28 of the grasses), but there was also fragments of herbs (0·18), and, to a minor degree, sedges and rushes, woody plants and mosses (Table 2). Plant species constituting <0·01 of fragments were *F. ovina*, *D. flexuosa*, *M. caerulea*, *A. odoratum*, *Alopecurus* spp., *Glyceria* sp., *P. pratense*, unidentified Cyperaceae, *Equisetum* spp., *Betula* spp., *A. glutinosa*, *C. vulgaris*, *V. myrtillus*, *P. sylvestris*, *J. communis*, unidentified woody plants and *F. ulmaria*. Of the plant species, where defoliation intensities were also investigated, *D. cespitosa* composed 0·26 of the total fragments, whereas the other three species were present to a minor extent (*F. ulmaria,* 0·001, Cyperaceae excluding *Carex* spp. 0·004 and *A. glutinosa*, 0·001 of fragments).

A higher proportion of fragments of herbs was found in spring ($P < 0{\cdot}001$) and summer ($P = 0{\cdot}005$) than in autumn (Bonferroni corrected; Table 2). Also, a higher proportion of fragments of Cyperaceae was found in spring than in summer ($P < 0{\cdot}001$).

No main effect of breed on the composition of plant fragments was found. For the Väneko heifers but not the Charolais heifers the proportion of grasses was lower in spring than in summer ($P = 0{\cdot}001$) and autumn ($P = 0{\cdot}002$). For the Väneko heifers, the proportion of Cyperaceae was higher in spring than in autumn ($P = 0{\cdot}008$), which was higher than in summer ($P < 0{\cdot}001$). For the Charolais heifers, the proportion of woody plants was higher in autumn than in spring ($P = 0{\cdot}006$) and summer ($P = 0{\cdot}001$).

Table 1 Herbage mass, dry matter (DM) content and concentrations of metabolizable energy (ME), crude protein (CP) and neutral-detergent fibre (NDF) of herbage in dry, mesic and wet areas of semi-natural grassland in spring, summer and autumn.

	Area				Season			
	Dry	Mesic	Wet	Level of significance	Spring	Summer	Autumn	Level of significance
Herbage mass (t DM ha^{-1})	$0{\cdot}8^{c}$	$1{\cdot}1^{b}$	$1{\cdot}6^{a}$	***	$0{\cdot}9^{c}$	$1{\cdot}4^{a}$	$1{\cdot}1^{b}$	***
DM content (g kg^{-1})	270	272	265	NS	312^{a}	229^{c}	265^{b}	***
ME concentration (MJ kg^{-1}DM)	9·9	9·4	9·0	NS	$11{\cdot}5^{a}$	$8{\cdot}5^{b}$	$8{\cdot}4^{b}$	***
CP concentration (g kg^{-1}DM)	140^{a}	124^{b}	122^{b}	*	152^{a}	114^{b}	121^{b}	**
NDF concentration (g kg^{-1}DM)	53^{b}	600^{a}	608^{a}	*	480^{b}	654^{a}	627^{a}	**

NS, not significant. Means in a row with different letters differ significantly ($P < 0{\cdot}05$) according to $LSD_{0{\cdot}05}$ test.
*, $P > 0{\cdot}05$; **, $P < 0{\cdot}01$; ***, $P < 0{\cdot}001$.

Table 2 Proportion of plant fragments and plant groups in faecal samples from Väneko (n = 12) and Charolais heifers (n = 12) grazing semi-natural grasslands in south-western Sweden in spring, summer and autumn; plant species constituting on average <0·01 of the total fragments are excluded. Level of significance of effects of breed, season and interaction of breed × season (B × S) is also presented.

	Väneko			Charolais			s.e. of mean		Level of significance		
	Spring	Summer	Autumn	Spring	Summer	Autumn	Breed	Season	Breed	Season	B × S
Festuca rubra	0·179	0·170	0·284	0·163	0·154	0·294	0·015	0·014	NS	***	NS
Festuca pratensis	0·034	0·042	0·039	0·039	0·048	0·033	0·004	0·004	NS	NS	NS
Festuca spp.	0·016	0·021	0·000	0·007	0·024	0·003	0·004	0·004	NS	***	NS
Deschampsia cespitosa	0·256	0·262	0·262	0·288	0·258	0·208	0·028	0·023	NS	NS	NS
Poa spp.	0·010	0·024	0·019	0·018	0·022	0·015	0·003	0·003	NS	*	NS
Nardus stricta	0·056	0·086	0·035	0·063	0·083	0·057	0·009	0·009	NS	***	NS
Agrostis spp.	0·025	0·019	0·013	0·021	0·020	0·018	0·002	0·002	NS	**	NS
Phalaris arundinacea	0·009	0·008	0·015	0·010	0·006	2·1	0·002	0·002	NS	***	NS
Dactylis glomerata	0·011	0·005	0·004	0·014	0·006	0·5	0·002	0·002	NS	**	NS
Poaceae spp.	0·086	0·100	0·086	0·099	0·093	8·7	0·003	0·003	NS	NS	NS
Carex spp.	0·049	0·023	0·035	0·038	0·038	4·2	0·008	0·008	NS	*	*
Bryophyte spp.	0·004	0·013	0·019	0·006	0·009	1·5	0·002	0·002	NS	***	NS
Total grasses	0·701	0·766	0·760	0·750	0·736	77·1	0·013	0·013	NS	*	*
Total herbs	0·217	0·185	0·167	0·185	0·204	14·4	0·024	0·019	NS	**	NS
Total Cyperaceae	0·057	0·025	0·037	0·044	0·040	4·5	0·008	0·008	NS	**	0·020
Total woody plants	0·016	0·010	0·013	0·012	0·010	2·3	0·003	0·003	NS	*	0·030

Levels of significance are from statistical analyses testing the species separately, where NS = not significant (P > 0·10). Tests with bold figures are significant (P < 0·05) also after Bonferroni correction.
*, P > 0·05; **, P < 0·01; ***, P < 0·001.

Defoliation

The majority of areas of *F. ulmaria* (0·98) and *A. glutinosa* (0·87) and half of those of *J. effusus* (0·51) and *D. cespitosa* (0·42) were defoliated at some point during the grazing period. The proportion of defoliated areas of the species varied among the plots (0–1·00). A higher proportion of *F. ulmaria* areas was defoliated in autumn than in spring (P = 0·040). Consequently, the proportion of *F. ulmaria* shoots defoliated was higher in autumn than in spring and summer (P < 0·001; Table 3). A higher proportion of *A. glutinosa* areas was defoliated in autumn than in spring (P = 0·035). Accordingly, the proportion of grazed main shoots and side shoots of *A. glutinosa* increased during the grazing season (Table 3). The proportion of *D. cespitosa* areas grazed was lower, and the proportion of shoots grazed in these areas was lower (P < 0·001) and the height of the grazed shoots was higher (P = 0·012 and 0·010) in summer than in spring and autumn (Table 3).

All tests for significance of defoliation intensity were significant after Bonferroni corrections. No main effects of breed on defoliation intensity were found. However, in spring, the Väneko heifers grazed a higher proportion of shoots in the *F. ulmaria* areas (P = 0·009) than the Charolais heifers (Table 3). For *A. glutinosa*, the Väneko heifers increased their proportion of grazed shoots during the grazing season more than the Charolais heifers (breed × season: P < 0·001; Table 3).

Discussion

In this study no attempt was made to predict quantitatively the diet composition of the heifers from plant fragments in the faeces because of the potentially differential rate of digestion of the different species in the diet. Seasonal and breed effects on the composition of faecal plant fragments could have been biased by changes in digestion across the grazing season and between breeds. It is considered, however, that these latter effects were small as there is little evidence for differences in digestibility of the same diet between seasons and within breeds of cattle (Johnson and Pearson, 1981; Badsberg *et al.*, 2003).

Few differences were found between the breeds in the several variables measured associated with grazing. Scimone *et al.* (2007) and Wallis De Vries *et al.* (2007) reported that breed effects on diet preference were generally small, and possible breed differences could be related to differences in live weight (Dumont *et al.*, 2007). Here, no main effects of breed for any of the variables measured could be observed in spite of a 120 kg difference in live weight between the two cattle breeds. In studies where some breed effects have been

Table 3 Proportions of defoliated shoots and heights of *Filipendula ulmaria* (90 areas), *Juncus effusus* (90 areas), *Alnus glutinosa* (90 areas) and *Deschampsia cespitosa* (180 areas) in semi-natural grasslands in south-western Sweden, grazed by Väneko and Charolais heifers in spring, summer and autumn in 2004. Levels of significance of effects of breed, season and interaction of breed × season (B × S) are presented.

		Väneko			Charolais			s.e. of mean		Levels of significance†		
		Spring	Summer	Autumn	Spring	Summer	Autumn	Breed	Season	Breed	Season	B × S
Filipendula ulmaria												
Main shoots	Proportion	0·35	0·20	0·46	0·08	0·12	0·43	0·047	0·037	NS	***	***
	Height (cm)	11	15	15	12	20	19	1·5	1·2	NS	***	NS
Side shoots	Proportion	0·002	0·004	0·010	0·002	0·004	0·012	0·005	0·004	NS	NS	NS
	Height (cm)	15	13	30	13	18	33	–	–	NS	NS	NS
All shoots	Proportion	0·35	0·21	0·47	0·08	0·012	0·45	0·046	0·036	NS	***	***
Juncus effusus												
All shoots	Proportion	0·07	0·02	0·05	0·12	0·19	0·19	0·065	0·049	NS	NS	NS
	Height (cm)	22	40	30	26	40	45	4·4	3·6	NS	***	NS
Alnus glutinosa												
Main shoots	Proportion	0·003	0·31	0·84	0·15	0·23	0·61	0·12	0·085	NS	***	***
	Height (cm)	20	52	51	47	25	36	7·1	5·6	NS	NS	***
Side shoots	Proportion	0	0·04	0·02	0	0·03	0·01	0·006	0·006	NS	***	NS
	Height (cm)	–	53	72	–	19	50	13·5	12·2	NS	NS	NS
All shoots	Proportion	0·003	0·35	0·86	0·15	0·25	0·62	0·12	0·086	NS	***	***
Deschampsia cespitosa												
All shoots	Proportion	0·10	0·003	0·09	0·06	0·01	0·06	0·026	0·020	NS	NS	NS
	Height (cm)	15	20	16	18	24	17	1·1	1·3	NS	*	NS

NS, not significant; –, missing value.

†Tests are significant also after Bonferroni correction.

*, $P > 0{\cdot}05$; ***, $P < 0{\cdot}001$.

found, traditional breeds of ruminants have ingested higher proportions of plants with low nutrient concentrations than other breeds (Osoro *et al.*, 1999; Steinheim *et al.*, 2005; Dumont *et al.*, 2007). In this study, there were also indications that the Väneko heifers might be more inclined than the Charolais heifers to explore more plant species in spring, including less preferred and less nutritious ones found in wet areas, such as Cyperaceae and *F. ulmaria*. When nutrient concentrations in the herbs decreased in autumn, higher proportions of plant fragments associated with grasses were found in the faeces of the Väneko heifers than in spring, whereas the Charolais heifers replaced the herbs by increasing the proportion of woody plants as well as increasing the proportion of grasses in the plant fragments in the faeces (Tables 2 and 3). On the other hand, the woody species, *A. glutinosa*, was more defoliated over the grazing season in the plots containing the Väneko heifers than the Charolais heifers.

The heifers had proportionally more plant fragments of Cyperaceae and herbs (not *F. ulmaria*) in the faeces in spring and more grasses, woody plants and mosses in autumn. Although fragments of woody plants were found in the faeces only to a minor extent, there was an effect of season on the proportion of defoliated *A. glutinosa* shoots. The defoliation was highest in autumn when as much as 0·74 of the *A. glutinosa* shoots were grazed. A higher proportion of woody plants in the diet in late season has been attributed to the lower nutritive value of grasses and herbs (Ganskopp *et al.*, 1999). However, defoliation of the herb, *F. ulmaria*, increased during the grazing season, but *F. ulmaria* differs from many other herbs by growing in wet areas and having a woody-like morphology. A lower herbage mass in autumn can also be the reason for a less-selective foraging behaviour (Roath and Krueger, 1982) but in this study herbage mass was higher in autumn than in spring. Consequently, the effect of grazing livestock on pernicious brushwood is greater and, hence, may be more important in autumn than in spring, although the impact of grazing on subsequent growth of the plant species may be greater in spring. The present Swedish recommendation for management of semi-natural grasslands is an early onset of grazing (Sandberg and Thylén, 1999).

In heterogeneous semi-natural grasslands with abundant herbage, cattle graze herbage with a high nutritive value (Launchbaugh and Howery, 2005). In this study, herbage from Cyperaceae-rich wet areas had a higher NDF concentration than herbage from herb-rich dry areas (Table 1) which may be a reason for only half of the areas of the two dominating plant species in the wet areas, *D. cespitosa* and *J. effusus*, being grazed. As reported elsewhere (Hessle *et al.*, 2007), the heifers spent only 0·09, 0·05 and 0·08 of their foraging time in the wet areas in spring, summer and autumn respectively. Consequently, at the end of the grazing season, a majority of the wet areas were judged as having had too little grazing pressure to be optimal for maintaining the biodiversity (E. Isaksson, personal communication). *Deschampsia cespitosa* and *J. effusus* are tufty species with low digestibility in early season which declines further during the growing period with advancing maturity (Hagsand and Anier, 1978; Andersson, 1999; Lifvendahl, 2004). The avoidance of these species by grazing animals may, in the long run, result in them becoming dominant in wet semi-natural grasslands (Krahulec *et al.*, 2001).

Results from this short-term study with a limited number of plots indicate that cattle may prefer to graze herb-rich areas in spring and summer, whereas the period of browsing *A. glutinosa*, often found in wet areas, is mainly in autumn. Generally, biodiversity is higher in dry, herb-rich areas than in wet areas (Table 1) but valuable herb species also are more nutritious and preferred (Garmo, 1986). For restoration of grasslands, a high grazing pressure in early spring may risk damaging valuable herbs when the livestock, given a choice, may prefer to graze herbs instead of browsing shoots of pernicious brushwood. Herbs become less preferred compared to brushwood later in the grazing season. Directing livestock to pastures later in the season may be a way of controlling brushwood without risking the extinction of rare herb species by allowing them to flower and produce seeds. Instead, in early spring livestock might be directed towards *D. cespitosa*- and *J. effusus*-dominated areas by fencing or other measures, resulting in a delayed maturation and accompanying decline in digestibility of these plants and, thereby, a better control of them. Taken together, these practices may diminish the need for manual clearance to prevent the risks of succession towards scrub and, finally, woodland.

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