Early season grazing effects on birch, grass, herbs and plant litter in coastal meadows used by reindeer: a short-term case study

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Abstract: The effects of short-term grazing by reindeer (*Rangifer tarandus tarandus*) on birch (*Betula pubescens*), grasses, herbs and plant litter in coastal meadows in spring were investigated in grazed and control plots in 1996 and 1997. The meadow contained 29 different plant species, all but one of which (*Deschampsia caespitosa*) were intensively grazed by reindeer. Young birch eaten by reindeer did not increase in mean height (9 cm), while birch protected from grazing grew from 9 to 22 cm ($P<0.05$) during the two years of the experiment. The ratio of grasses to herbs was higher ($P<0.05$) in the grazed plots than in the control plots, and the relative abundace of grasses increased during the summer in both years. The abundance of *Rumex asetosa* and *Alchemilla subcrenata* decreased ($P<0.05$) in response to grazing. From spring 1996, plant litter increased ($P<0.05$) on the control plots until the investigation came to an end in spring 1998, unlike grazed vegetation. Reindeer affects the coastal meadows in northern Norway in spring by browsing on birch and grazing on herbs and grass which in the long term might influence the cultural landscape in favour of the growth of grass species.

Key words: botanical composition, coastal meadow, *Rangifer t. tarandus*, spring grazing.

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Introduction

In northernmost Norway, semi-domesticated reindeer (*Rangifer tarandus tarandus*) migrate in late winter from inland pastures to the coast, peninsulas and islands (Paine, 1994) where they graze on grasses, herbs, trees and woody bushes during the summer (Gaare & Skogland, 1975; Skogland, 1980; Mathiesen *et al.*, 1999; 2000). When they reach the islands, they start grazing at sea level and follow the young vegetation close to the snow melt-line up to the mountain pastures. In North-Norway (the counties of Nordland, Troms and Finnmark) 25% of former farmland has been abandoned between 1959 and 1997 (Central Bureau of Statistics, 1960; 1997), much of this land being in the coastal region where meadows without herbivores have reverted from sward dominated by timothy grass (*Phleum pratense*) to a vegetation with a more heterogeneous composition of grasses, herbs and small birch (*Betula pubescens*) (Losvik, 1993; Alm, 1996). Such areas may subsequently be colonised by trees, and thus transformed into shrub lands (Gibson *et al.*, 1987a; Harrison, 1976; Mitchell *et al.*, 1997). During the spring and early summer, coastal meadows in early successional stages dominated by grass and herbs are characterised by a high protein content (crude protein as high as 30% of dry matter (DM)) and easily digestible water-soluble carbohydrates (26% DM) (Eilertsen *et al.*, 2000). Reindeer may consume as much as 131 g DM/kg body mass$^{0.75}$ per day of their dietary plants on such coastal meadows (Eilertsen *et al.*, 1999) in order to increase their body protein (Eilertsen *et al.*, 2001). Domestic sheep grazing on abandoned meadows in the north of England help to maintain a species-rich vegetation (Smith & Rushton, 1994). Sheep grazing has

increased the proportion of annual herbs (Gibson *et al.*, 1987b) and thus influenced the future botanical composition of the cultural landscape. A number of studies suggest that a dense accumulated litter layer may limit the diversity of productive habitats by inhibiting species establishment through the effects of shading and mechanical impediment (*e.g.* Goldberg & Werner, 1983; Carson & Peterson, 1990; Tilman, 1993; Facelli, 1994). We investigated whether early spring grazing by reindeer affects the dynamics of birch, grass and herbs in coastal meadows.

Material and methods

Area and design

At Søreidet, on the island of Reinøya (147.3 km^2) in Troms County (69°53'N, 19°46'E), 0.8 ha of abandoned meadow near the shoreline was surrounded by an electric fence. The meadow had previously been used for hay and silage production, but has not been used for traditional farming since 1990, having only sporadically been exposed to grazing by sheep and goats during the past few years. The sward was dominated by the grasses *Festuca rubra, Poa alpigenea, Agrostis tenuis, Phleum commutatum* and herbs such as *Achillea millefolium, Rumex acetosa, Ranunculus repens* and *Alchemilla subcrenata*. Inside the electric fence, five permanent enclosures (control plots) (1 m x 1 m) were established by dividing the area into a grid system (1 m x 1 m), and selecting plots at random. The enclosures were created by erecting steel fencing with a 10 cm mesh. The snow melted at the same time inside the enclosures as on the rest of the experimental vegetation. Adjacent to each enclosure an unfenced plot of the same size was established. In spring 1997 a further five plots were established in randomly selected squares and exposed to grazing.

Animals

Male yearling reindeer (n=12, 15 reindeer ha^{-1}) were allowed to graze in the fenced area from 7 June until 1 July in 1996, from 14 June until 7 July in 1997. Animals were released at equal phenological plant stages, immediately after the snow had disappeared from the fence and as soon as plant growth had started (Eilertsen *et al.*, 1999; 2000).

Occurrence of grass, herbs and plant litter

Vegetation cover was observed in grazed plots and in control plots one week after grazing started in 1996 and at the start of grazing in 1997. The plots were recorded weekly during the grazing period in both years. All plant species present on the sample plots were registered, and the proportion of each species was assessed visually as percentage cover according to the Domin cover-abundance scale (*e.g.* Evans & Dahl, 1955; Økland, 1990). Furthermore, in spring (8 June) 1998, vegetation cover was recorded in the grazed and control plots. Previously grazed plots were registered again in summer

Table 1. Plant species observed in the investigated plots at Reinøya.

Herbs	Grass	Bushes
Achillea millefolium pubescens	*Agrostis capillaris*	*Betula*
Alchemilla subcrenata	*Alopercurus geniculatus*	
Anthriscus sylvestris	*Carex* sp.	
Cardamine pratensis	*Descampsia caespitosa*	
Equisetum arvense	*Descampsia flexuosa*	
Euphrasia hyperborea	*Festuca ovina*	
Myosotis arvensis	*Festuca pratensis*	
Paris quadrifolia	*Festuca rubra*	
Plantago major	*Phleum alpinum*	
Ranunculus acris	*Poa annua*	
Ranunculus repens	*Poa pratensis*	
Rumex acetosa		
Solidago virgaurea		
Stellaria media		
Taraxacum sp.		
Trifolium repens		
Viola canina		

1998 (26 July). The same person made all the estimates of vegetation cover and all plots were photographed before the records were made, thus permitting the estimates of cover to be checked against the photos. In all plots, the percentage of plant litter covering the ground was assessed at the same time. In order to check the cover estimates, in spring 1996 samples of vegetation (n=10) were harvested after the observations of cover had been made. The vegetation was cut by one-hand garden clippers and sorted, each plant species was weighed separately. The proportions of the total weight of grass and of each species of herb were calculated, and the estimates of cover were checked.

Birch

The height of randomly selected young birches (*Betula pubescens*) (<0.5 m high) were measured on 10 birches in the grazed area, and on 10 adjacent birches protected from reindeer grazing by the electric fence. The birches were individually marked and each height was measured by ruler to the nearest cm from ground level to top of the meristem at the beginning of the grazing period in 1996 (7 June). The measurements were repeated on 8 July, 1997 after the two years of spring grazing. The leaves of the top meristem on the birches were inspected for any defoliation caused by the grazing reindeer.

Data analysis

The various herb and grass species were grouped into the generic groups "herbs" and "grasses". The data sampling carried out in June is referred to as "spring", while the July sampling is referred to as "summer" (Tables 2-4). Significant differences (P<0.05) between birch on grazed and ungrazed meadow were calculated by Student's t-test (two-tailed test assuming equal variances) (Bhattacharyya & Johnson, 1977). The assumption of equal variance was tested by the Folded Form F Statistic (SAS Institute Inc., 1989). Analyses of differences in the number of plant species, plant cover, plant litter, and grass:herbs ratio were performed by ANOVA in the General Linear Models procedure described by SAS Institute Inc. (1989).

Results

Plant species

Both grazed and control plots in the coastal meadow contained a total of 29 different plant species (Table 1), dominated by the grasses *Festuca rubra*, *Poa pratensis*, *Agrostis capillaris*, *Deschampsia caespitosa*, *Phleum alpinum* and the herbs *Achillea millefolium*, *Rumex acetosa*, *Ranunculus repens* and *Alchemílla subcrenata*. No significant changes in the total number of plant species were detected during the two years of the experiment. All plant species were visibly and intensively grazed, except *D. caespitosa*.

Botanical composition and cover of individual plant species

The differences in plant cover between grazed and control plots after one week of spring grazing in

Table 2. Percentage plant cover of grass, *Rumex acetosa*, *Alchemílla subcrenata* and *Ranunculus repens* in spring (June) and summer (late July) in meadow ungrazed and grazed by reindeer for 3.5 weeks in spring at Reinøya in 1996 and 1997. Significant differences (P<0.05) between grazed and ungrazed meadows each year and season is marked with '*', and different letters in superscript indicates differences (P<0.05) between years within grazed or ungrazed meadows. Standard deviation in parentheses.

		Spring			Summer	
	No.	1996	1997	1998	1996	1997
Grass						
Ungrazed	5	26 (8.2)^{A}	21 (7.4)^{A}	18 (17.9)^{*A}	73 (5.2)^{B}	66 (7.4)^{*B}
Grazed	5	23 (15.2)^{A}	31 (7.4)^{A}	49 (6.5)^{*B}	77 (8.4)^{C}	79 (2.7)^{*C}
R. acetosa						
Ungrazed	5	17 (4.5)^{A}	8 (6.8)^{B}	8 (2.0)^{B}	6 (0.5)^{B}	8 (1.9)^{*B}
Grazed	5	16 (4.5)^{A}	6 (1.5)^{A}	9 (5.5)^{A}	3 (5.4)^{B}	4 (1.5)^{*B}
A. subcrenata						
Ungrazed	5	9 (7.1)^{A}	5 (3.2)^{AB}	3 (1.8)^{B}	7 (1.5)^{AB}	8 (3.2)^{*AB}
Grazed	5	5 (1.3)	3 (1.5)	2 (3.4)	4 (3.6)	3 (1.5)*
R. repens						
Ungrazed	5	5 (3.1)^{A}	2 (0.8)^{B}	1 (0.9)^{B}	5 (0.5)^{A}	2 (1.8)^{B}
Grazed	5	4 (2.3)^{A}	3 (1.5)^{AB}	3 (1.2)^{AB}	4 (3.0)^{AB}	2 (0.9)^{B}

Fig. 1. Photo to the left, plots ungrazed for one week; photo to the right, plots grazed by reindeer for one week at Reinøya in mid June 1996.

1996 is illustrated in Fig. 1. Further, the cover of grass and of certain selected herbs is shown in Table 2. The cover of grass increased ($P<0.05$) from spring to summer in both grazed and control plots in 1996 and 1997. In comparison with the control plots, the grass cover was higher ($P<0.05$) in grazed plots in spring 1998 and in summer 1997. In contrast, cover of the herb *R. acetosa* decreased from spring to summer in grazed plots (Table 2). In summer 1997, the cover of *R. acetosa* was higher ($P<0.05$) in control plots than grazed plots. There were also significant differences between grazed and control plots for *A. subcrenata* in summer 1997 (Table 2). The dynamic changes in plant cover during the grazing period in 1997 is shown in Table 3. Grass cover increased ($P<0.05$) rapidly from spring to summer in 1997. In contrast, there were no significant changes in the cover of the various herbs. As a consequence of the increased cover of grass, the ratio of grass to herbs rose ($P<0.05$) during the grazing period in 1997 (Table 3).

In the summer observations in 1996 and 1997 and spring 1998, the grasses:herbs ratio in the grazed plots was higher ($P<0.05$) than the control plots (Table 4). Within the grazed plots, the ratio rose from 1996 to 1997 and 1998 in spring, and from 1996 to 1997 in summer (Table 4). Similar changes were observed in the control plots (Table 4).

Table 3. Percentage plant cover of grass, *Rumex acetosa, Alchemílla subcrenata, Ranunculus repens, Achillea millefolium , Taraxacum* sp. and *Equisetum arvense* in plots ($n=10$) grazed by reindeer for 24 days at Reinøya in 1997. Grass: herbs relationship is based on the cover estimates. Different letters in superscript indicates differences ($P<0.05$) in cover between dates. Standard deviation in parentheses.

	15 Jun	22 Jun	29 Jun	6 Jul	26 Jul
Grass	17 (6.4)^{A}	31 (7.4)^{B}	40 (3.5)^{C}	54 (6.5)^{D}	78 (2.6)^{E}
R. acetosa	7 (3.6)	6 (1.5)	6 (1.6)	7 (3.0)	4 (1.4)
A. subcrenata	2 (2.0)	3 (1.5)	2 (1.3)	2 (1.7)	3 (1.3)
R. repens	3 (1.7)	3 (1.5)	3 (3.3)	2 (1.8)	1 (0.8)
A. millefolium	4 (3.1)	3 (4.2)	6 (4.0)	5 (4.4)	3 (2.9)
Taraxacum sp.	0	0.4 (0.6)	0.6 (0.9)	0.4 (0.6)	1 (0.9)
E. arvense	0.1 (0.3)	0.4 (0.6)	0	0.2 (0.5)	0.2 (0.4)
Grass:herbs ratio	1.1 (0.6)^{A}	2.4 (0.9) ^{AB}	2.4 (0.5)^{A}	3.3 (0.3)^{B}	6.7 (2.4)^{C}

Table 4. Gras: Herbs relationship in spring (June) and summer (late July) based on percentage plant cover in meadow ungrazed and grazed by reindeer for 3.5 weeks in spring at Reinøya in 1996 and 1997. Significant differences ($P<0.05$) between grazed and ungrazed meadows each year and season is marked with '*', and different letters in superscript indicates differences ($P<0.05$) between years in grazed meadows. Standard deviation in parentheses.

	No.	Spring 1996	Spring 1997	Spring 1998	Summer 1996	Summer 1997	Summer 1998
Ungrazed	5	0.8 (0.37)^{A}	1.2 (0.51)^{AB}	1.1 (0.88)^{*AB}	2.3 (0.76)^{*BC}	2.8 (0.46)^{*C}	2.6 (0.43)^{C}
Grazed	5	0.9 (0.40)^{A}	2.4 (0.93)^{B}	2.7 (1.37)^{*B}	5.3 (1.05)^{*C}	6.7 (2.44)^{*C}	

Table 5. Mean height (cm) of birch (*Betula pubescens*) in a coastal meadow at Reinøya ungrazed and grazed for 3.5 weeks in spring (standard deviation in parentheses). Different letters in superscript indicates significant differences ($P < 0.05$) between grazed and ungrazed meadows.

	No.	Spring 1996	Summer 1997
Ungrazed	10	9 (1.6)	22 (3.4)a
Grazed	10	8 (1.2)	9 (1.4)b

Table 6. Amounts of litter (percentage cover) in spring in meadow at Reinøya in 1996-1998. The plots were either ungrazed or grazed by reindeer for 3.5 weeks in spring in 1996 and 1997. Significant differences ($P<0.05$) between grazed and ungrazed meadows each year is marked with '*', and different capitalised letters indicates differences ($P<0.05$) between years. Standard deviation in parentheses.

	No.	14 Jun 96	15 Jun 97	8 Jun 98
Ungrazed	5	8 (4.7)^{A}	49 (16.4)^{*B}	66 (20.4)^{*B}
Grazed	5	8 (2.5)	17 (11.8)*	19 (14.9)*

Shrub development

The mean height of the birches in the grazed area remained unchanged between 1996 and 1997 (Table 5), while it more than doubled in the control area ($P<0.05$) (Table 5). All leaves were intensively browsed by reindeer, whereas on the control plots a large number of large green leaves were observed.

Litter accumulation

Plant litter cover increased ($P<0.05$) in the control plots during the three years of observation (1996, 1997 and 1998) (Table 6). There was significantly less plant litter in the grazed plots than in the control plots in spring 1997 and 1998 (Table 6).

Discussion

Dynamic change in the vegetation in response to grazing

In spring and summer, herbs make up a considerable part of the diet for sheep and reindeer when they are available in the pasture (Gaare & Skogland, 1975; White *et al.*, 1975; Skogland, 1980; Garmo & Skurdal, 1989; Mathiesen *et al.*, 1999; 2000). Herbs previously exposed to herbivores or mechanical cutting seem to develop smaller leaves than ungrazed plants. Further, intensive sheep grazing reduced the occurrence of herbs (Bowns & Bagley, 1986; Häggström, 1990), and rare species could be extinguished (Augustine *et al.*, 1998). By the end of the grazing experiment, a few grass species were dominant, indicating that herbs seem to be intensively grazed by reindeer on the coastal meadows in northern Norway in spring. However, none of the herbs growing in the meadow were exterminated during the experimental two years.

The dominant grass species, such as *P. pratensis, A. capillaris, D. caespitosa*, are very common in old meadows in northern Norway (*e.g.* Nesheim, 1986; Sveistrup & Østgård, 1985). Traditional grazing by cattle, sheep and goats is common on these meadows and grasses tend to be more tolerant to grazing than herbs (Hester, 1996). Many grass species increased the number of tillers during recovery. Furthermore, in arctic grasses, species such as *Dupontia fisheri* can compensate for clipping by rapid regeneration (Wegener & Odaz, 1997). In grassland containing various proportions of herbs and grass species in Norway, Haugland (1999) reported that the biomass production of grasses was

greater than that of herbs in the second harvest. Nesheim (1986b) and Lemieux *et al.* (1987) have also reported that second yield harvest decreased as the amount of herbs increased.

In late summer the grazed vegetation had a higher protein content than the ungrazed vegetation (Eilertsen *et al.*, 2000). In recovered leaves of previously grazed vegetation the protein content and digestibility were both high in comparison with ungrazed plants at the flowering stage. Such grazing facilitation is discussed by e.g. McNorton (1976; 1984). Likewise, experimental clipping of sedges increased concentrations of nitrogen and minerals, improving quality of forage eaten by Canadian caribou (Ouellett, *et al.*, 1994). Furthermore, early summer grazing by sheep was capable of improving the nutritive value of forage plants compared to locations with ungrazed plants (Alpe *et al.*, 1999). Nesheim (1986a) and Haugland (1995a, b; 1999) demonstrated that the ratio of herbs to grasses in plant communities in Norway did not affect the dietary quality (protein content and digestibility) of the pasture as long as the plant species involved were at the same developmental stage.

The nutritive quality of forage vegetation used by reindeer in the meadows was not affected by the grass:herbs ratio, while a predominantly grassy vegetation seems to increase biomass production late in the growing season, compared to vegetation dominated by herbs.

Colonization of birch

During the last decades birch forests in northern Norway seems to have changed in response to a fall in the number of grazing ruminants (43 000 fewer dairy cattle and 200 000 fewer sheep) from 1959 to 1997, a ride of 31 000 ha in the area of abandoned farmland (Central Bureau of Statistics, 1960, 1997). Climatic conditions have also favoured the growth of pioneer birch plants (*e.g.* Hanssen-Bauer & Frøland, 1998; Talkkari, 1998; Kullmann, 2001; Niemela *et al.*, 2001). An invasion of shrubs and woody meadow vegetation would cause considerable changes in the landscape vegetation (Bjor & Graffer, 1963; Harrison, 1976; Mitchell *et al.*, 1997). In meadows at several places on Reinøya, where this experiment were carried out, pioneer birch plants seem to colonise what had previously been farmland. In our experiment, young birch leaves seemed to be highly selected by reindeer in early spring. Intensive browsing reduces the regeneration of palatable trees (Bjor & Graffer, 1963; Risenhoover & Mass, 1987; McInnes *et al.*, 1992) or might even eliminate all tree regeneration (Jordan, 1967; Marquis, 1974). Reindeer browsing on pioneer birches in the spring could prevent the coastal meadow from being colonised by bushes and subsequently being developing into shrub-land and woodland.

Accumulation of plant litter on abandoned meadows.

In spring 1997 and 1998, before grazing, accumulations of plant litter were lower in previously grazed vegetation than on control plots. First, reindeer remove a large proportion of the biomass (as much as 16 kg per animal per day) during the summer leaving less for senescence and litter production (Eilertsen *et al.*, 1999). Secondly, a decrease in plant litter may also be due to trampling by reindeer. The hoof and foot areas of reindeer are large (Nieminen, 1990), and these animals crush a lot of litter at each step. Moderate trampling may increase the rate of decomposition of litter caused by soil micro-organisms (*e.g.* Stålfelt, 1960; Larcher, 1983), with the result that the availablility plant nutrients might increase, in turn stimulating plant growth. Studies in South Georgia have demonstrated that intense reindeer trampling can transform the nature of the vegetation (*e.g.* Lindsay, 1973; Leader-Williams *et al.*, 1987). Likewise, in summer, dry lichen mats are rapidly destroyed by trampling (Bayfield *et al.*, 1981) in particular on migration routes (Boertje, 1990; Pegau, 1970). We did not detect any trampling damage on the vegetation in the meadow grazed by the reindeer. The hoof load of sheep (approximately 850 g/cm^2; Spedding, 1971) is more than three times as high as the hoof load of reindeer (approximately 250 g/cm^2; Nieminen, 1990). The trampling of the reindeer should therefore have little effect on the coastal vegetation that we investigated. Reduced utilisation of coastal meadows in northern Norway by ruminants may therefore increase the accumulation of plant litter in these locations.

On the basis of two years of investigation, plant species growing on coastal meadows are assumed to be tolerant of grazing in the northern Norwegian farming system, but the period of study may have been too short to have a detrimental impact on the species involved. The reindeer seems to have increased the dominance of grass species in the abandoned meadows which may lead to higher biomass production late in the growing season. Furthermore, browsing on birch seems to prevent the area from being colonised by pioneer trees and may thus support the maintenance of an open landscape in northern Norway.

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