Utilization of old meadow by reindeer in spring in northern Norway

Svein M. Eilertsen[1], Ivar Schjelderup[1] & Svein D. Mathiesen[2,3]

[1] The Norwegian Crop Research Institute, Holt Research Centre, N-9292 Tromsø, Norway (svein.eilertsen@planteforsk.no).
[2] Department of Arctic Veterinary Medicine, The Norwegian School of Veterinary Science, Stakkevollveien 23, N-9292 Tromsø, Norway.
[3] Department of Arctic Biology and Institute of Medical Biology, University of Tromsø, N-9037 Tromsø, Norway.

Abstract: Utilization of abandoned coastal meadows in northern Norway by reindeer (*Rangifer tarandus tarandus*) were investigated for 25 days in spring 1996 (n = 12, 40-57 kg body mass (BM)) and 24 days in 1997 (n = 12, 39-61 kg BM). Grass production on grazed and ungrazed meadow was measured both years. Faecal dry matter (DM) production and ruminal *in vitro* DM digestibility (IVDMD) of selected plants were measured in the reindeer 15-22 days after the grazing experiment started each year. During the grazing period mean, standard deviation (s), temperature was 8.7, s = 2.8, °C in 1996 and 11.0, s = 3.0, °C in 1997, while temperature the first week was significantly higher in 1997 (P < 0.05). Mean herbage mass, on ungrazed meadow (control), after one week of plant growth in 1996 (408, s = 166, kg DM ha^{-1}) was significantly different (P < 0.05) from 1997 (576, s = 110, kg DM ha^{-1}). We believe the low temperature the first week in 1996 affected the plant production, and was the main reason for the significant (P < 0.05) difference in mean daily plant DM production on the grazed meadow between 1996 (57, s = 16, kg DM ha^{-1}) and 1997 (81, s = 16, kg DM ha^{-1}). Mean ruminal IVDMD of a mixture of meadow plants, differed (P<0.05) between 1996 (72.4, s = 1.0, %) and 1997 (83.9, s = 1.3, %), and mean daily food intake in 1996 (82, s = 13.5, g DM/kg$^{0.75}$) was significantly lower than the intake in 1997 (131, s = 15.8, g DM/kg$^{0.75}$). Daily digestible energy intake in reindeer was estimated to 0.96 MJ/kg$^{0.75}$ X d^{-1} in 1996 and 1.85 MJ/kg$^{0.75}$ X d^{-1} in 1997, which was 1.3 and 2.5 times the resting metabolic rate in reindeer, respectively. We therefore assume the difference in food intake could be due to the initial difference in herbage mass.

Key words: digestibility, food intake, plant production, *Rangifer,* utilization.

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Introduction

In northern Norway, semi-domesticated reindeer (*Rangifer tarandus tarandus*) are herded between seasonal pastures in a transhumant nomadic grazing system. In winter they stay inland and graze lichens, dead plant material and woody plants. In spring, they migrate, as long as 300 km, to the coastal areas, peninsulas and to the archipelago where they forage on graminoids and herbs during the summer (Gaare & Skogland, 1975; Skogland, 1980; Mathiesen *et al.*, 1999a). The winter climate inland is dry continental (mean annual precipitation 315 mm; Bruun, 1962), while the coastal Atlantic climate has high precipitation (mean annual precipitation 1000 millimetre; Bruun 1962). When reindeer arrive at the coastal pasture in early spring, snow might cover most of the pastures, sometimes down to sea level. The snow melting and vegetative

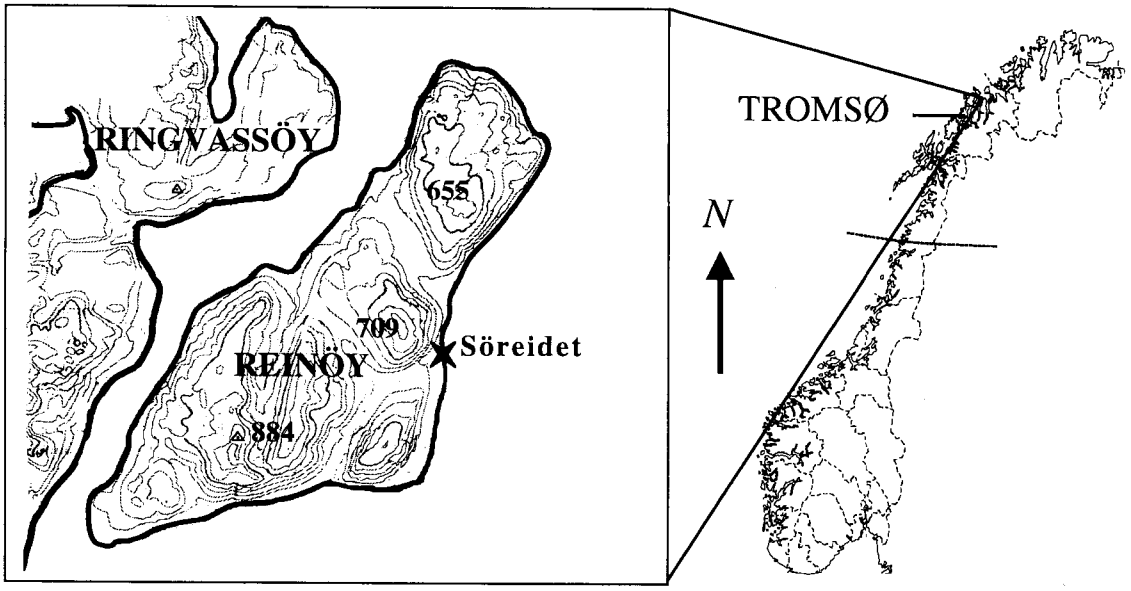

Fig. 1. The study area Søreidet, 40 km north of Tromsø, Norway.

growth starts along the coast and reindeer graze the young, green spring vegetation intensively. Traditional agriculture takes place in the coastal region, and, when reindeer forage on farmers' meadows, they create conflicts between farmers and reindeer herders. During the last 30 years, however, large areas of coastal meadows in northern Norway have been abandoned (Centrau bureau of statistics, 1960; Statistisk sentralbyrå, 1997). These old meadows are unused as energy and protein source, and could be utilized by reindeer in spring. To investigate this possibility, a coastal meadow at Reinøya in Troms County was used in a grazing experiment with male reindeer yearlings in spring in 1996 and 1997. The aim of this investigation was to characterise and assess these meadows as a nutrient supply for reindeer in spring. The influence of ambient temperature, precipitation and snow melting on plant production and food intake are discussed.

Materials and methods

Study area

This investigation was carried out on the island Reinøya (147.3 km^2; Fig. 1), in Troms county, northern Norway (69°53'N, 19°46'E) between June and July in 1996 and 1997. An area of 0.8 ha of old meadow (4-13 meter above sea level), sloped toward east, was fenced with an electrical fence. The area was former shoreline, sandy silt dominated the soil, and mean soil pH was 4.9, s = 0.2. The sward was dominated by the grasses *Festuca rubra, Poa alpigenea, Agrostis tenuis, Descampsia caespitosa, Phleum commutatum* and herbs like *Achillea millefolium, Rumex acetosa, Ranuculus repens* and *Alchemilla subcrenata.* A wet area with a brook flowing through it was dominated by *Betula pubescens* (bushes up to 4 m high).

Animals

Twelve, male yearling reindeer grazed the old meadow both in 1996 (body mass (BM) 40-57 kg (range)) and 1997 (BM 39-61 kg). The reindeer were transported from winter pasture near Kautokeino in Finnmark to the city of Tromsø in April, where they were kept in a pen (sized 0.5 hectare for about 40 days) and fed commercial reindeer feed (RF-80; Sletten & Hove, 1990), and accustomed to handling. Treatment against parasites was given orally as standard doses ivermectin (Ivomectin®, MS AGVET, Holland) when the reindeer arrived at the pen, and albendazol (Valbazen vet.®, Smith Kline Beecham, England) at the start of the grazing period. All animals were transported to the old meadow at Reinøya when the sward started to grow. Fig. 2 shows the start and length of the grazing periods in 1996 and 1997. To facilitate

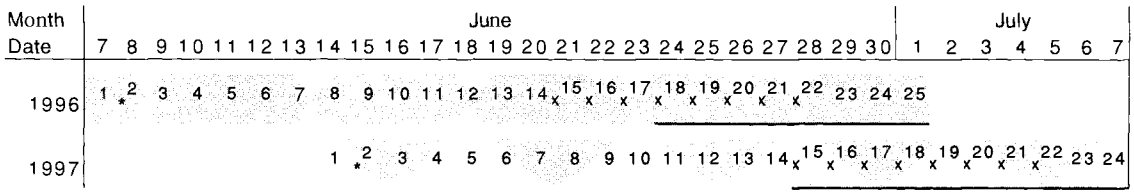

Fig. 2. Length and date for grazing , snow melt *, faecal collection ▬, experimental grass harvesting period x, and day no. 1 in the grazing periods for 1996 and 1997.

comparison of results, the first day of the grazing period was considered as day 1 of the trial in both 1996 and 1997.

Herbage production

Growth on ungrazed pasture was estimated using exclosures (1 X 1 m) throughout the experimental site during fixed periods (days 1-7, 8-14, 15-22 and 1-25) (Fig. 2) both years. Initial herbage mass of the grazed meadow in each of the periods was measured by harvesting the plant material within 5 random (the meadow was divided in to a grid system, and the squares were randomly selected) squares of 0.85 X 0.85 m on the pasture. At the same time 5 exclosure cages were placed randomly on the old meadow. Harvested squares were not used twice. After the fixed period, the herbage mass under each of the 5 exclosures was sampled. Corresponding squares to each of the 5 exclosures, were located close by, on sward exposed to reindeer grazing. The plant material in these squares was also harvested. The exclosures were moved, and placed randomly on the grazed meadow. The procedure was repeated throughout the whole grazing period. All samples were cut with hand-held garden clippers to 3 cm stubble height. Dead plant materials and litters were removed, the plant materials were dried and DM weight ha^{-1} was calculated. Food intake during a 7 days (day 15-22) period was estimated as the difference in dry matter (DM) herbage mass between grazed and ungrazed meadow on day 22.

Plant sampling, chemical and energy content

Three days before the end of the grazing period which was 28th of June in 1996 and 4th of July in 1997 (Fig. 2), samples of plants were harvested according to the procedure described from the grazed meadow. One sample consisted of a mixture of the different plants growing on the meadow. Subsequently, pure samples of grass, yarrow (*Achillea millefolium*) and common sorrel (*Rumex acetosa*) were sorted out for additional analysis. Chemical composition was determined in the plant samples both years. The samples with mixture of plants were analysed for DM, ash, nitrogen, water-soluble carbohydrates (WSC), fibre, phosphorus, potassium, calcium and magnesium. DM was determined after heating for 48 h at 60 °C and then heating at 105 °C for 4 h. The samples were ashed at 550 °C for 12 h (Horwitz, 1980). Nitrogen (N) was determined using the Kjeldahl method (Horwitz, 1980) and crude protein estimated as N X 6.25. Fibre and WSC were determined as described by Olsen *et al.* (1994) and Aagnes & Mathiesen (1995). The ash was dissolved in a mixture of concentrated HNO_3/HCl (1:3) on a hot plate and evaporated to dryness, dissolved again in diluted HCl and diluted to a fixed volume before the measurements. Phosphorus was determined spectrophotometrically by the Molybdenum-Vanadium method, while potassium, calcium and magnesium were determined was determined by AA-spectrophotometry (Horwitz, 1980). Energy in faeces collected at the end of the grazing period (days 21-25 in 1996 and days 20-24 in 1997) (Fig. 2) and in the mixture of plant material was determined using a CBA-301 automatic adiabatic bomb calorimeter with a CVM-3000 microprocessor (Gallenkamp, London). Digestible energy was calculated by subtracting faecal energy from energy intake (estimated food intake multiplied by energy content). Samples were analysed in duplicate.

Food intake

To measure faecal output, trained reindeer were selected (n = 3 in 1996 and n = 4 in 1997) and fitted with dung bags the last week of the grazing period (Fig. 2). The dung bags were emptied twice a day at 12 h intervals. The faeces were weighed, dried and the DM was determined. The reindeer with dung bags were slaughtered at the end of the grazing period (day 25 in 1996 and day 24 in 1997, Fig. 2). Rumen digesta samples were obtained from the reindeer within 10 min. after death and treated

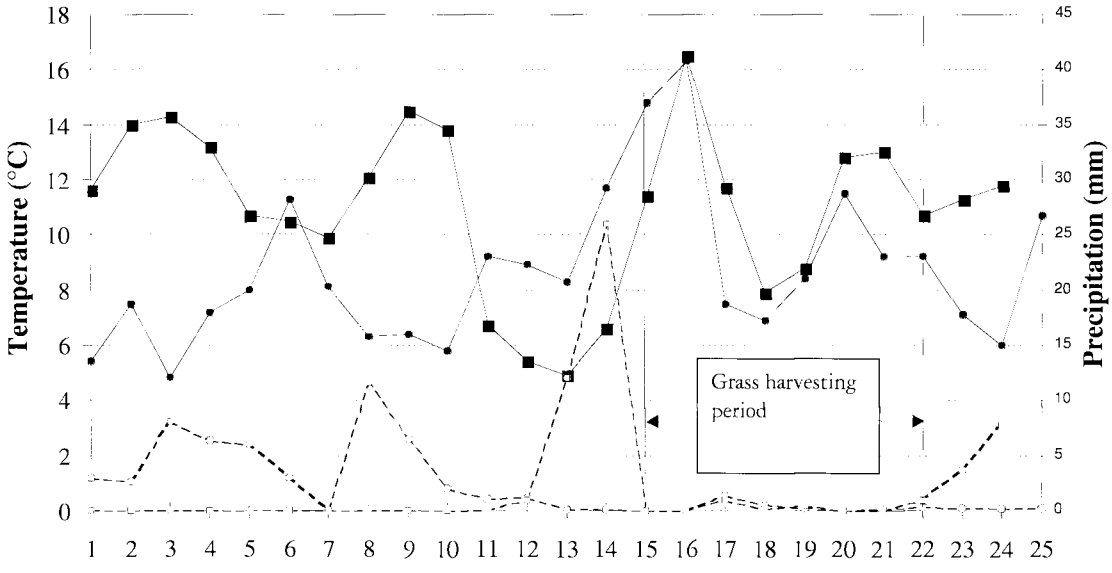

Fig. 3. Mean daily temperature and precipitation during the grazing period (7th of June to 1st of July in 1996 and 14th of June to 7th of July in 1997) at Reinøya. Day 1 represents the start of the grazing period. Temperature for 1996 —●—; 1997 —■—; Precipitation for 1996 ···○··· and 1997 ···□···.

according to the method described by Aagnes & Mathiesen (1995). The IVDMD of the selected plants was determined using rumen fluid from the slaughtered reindeer. The IVDMD values of standard qualities of timothy hay (*Phleum pratense*) (high and poor quality) were recorded using the same rumen fluid. The 2-stage method of Tilley & Terry (1963) as modified by Aagnes & Mathiesen (1995) was used in quadruplicate determinations. Intake of DM plant material by different reindeer was calculated by total daily faecal production and IVDMD at 24 h on an individual basis (food intake = faecal DM/(1-IVDMD/100)) (Table 2).

Temperature and precipitation

Temperature and precipitation were recorded at the Tromsø Weather Station (Det norske meteorologiske institutt, 1996; 1997) (Fig. 1). Temperature recordings (°C) are presented as means per day (one measurement every hour), while precipitation (mm) represents the total amount per day.

Statistical analyses

Significant differences in faecal production and intake were calculated by the Student *t*-test ($P < 0.05$). Analysis of difference in faecal production between reindeer were performed using the Student-Newman-Keuls multiple range test in General Linear Models procedure described by SAS Institute Inc. (1989).

Results

Climate

The temperature when the grazing period started was 5.4 °C and 11.6 °C for 1996 and 1997, respec-

Table 1. Mean daily dry matter (DM) plant production (kg DM/ha) on ungrazed (control), and grazed meadow at Reinøya 1996 and 1997. Standard deviation in parenthesis.

	1996	1997
Mean daily plant production on ungrazed old meadow:		
Days 1-25/24 (1996/1997)	101.0 (9.4)	93.0 (7.8)
Days 1-7	56.8 (16.0)*	81.0 (15.7)*
Mean daily plant production on grazed old meadow:		
Days 1-25/24 (1996/1997)	49.5 (10.0)*	62.0 (7.0)*

* $P < 0.05$.

Table 2. Mean herbage mass (kg DM/ha) on day 7, 14 and 21 on grazed and ungrazed meadow at Reinøya 1996 and 1997. Standard deviation in parentheses.

	1996	1997
Herbage mass on day 7, ungrazed meadow (control)	408 (166)	576 (110)
Herbage mass on day 14, ungrazed meadow (control)	1836 (216)	1362 (379)
Herbage mass on day 22, ungrazed meadow (control)	2222 (134)	1867 (195)
Herbage mass on day 7, grazed meadow	101 (37)	193 (90)
Herbage mass on day 14, grazed meadow	153 (64)	224 (34)
Herbage mass on day 22, grazed meadow	123 (32)*	333 (128)*

* $P < 0.05$.

Table 3. Faeces production and ruminal *in vitro* digestibility of meadow plants 24 h after inocularion and esrimated daily (d) food intake (faeces DM/(1-IVDMD/100)) in male reindeer yearlings (body mass (BM) 40.0-51.5 kg, $n = 3$, and BM 48.5-61 kg , $n = 4$) grazing on old meadow in spring 1996 and 1997, respectively. Mean with standard deviation in parentheses.

Year	Reindeer no.	Faeces production (g DM/kg$^{0.75}$ X d^{-1})	*In vitro* digestibility (%)	Intake (g DM/kg$^{0.75}$ X d^{-1})
1996	A	24.7 (3.5)*a*	71.6 (0.3)	86.9
1996	B	17.6 (1.9)*b*	73.5 (0.4)	66.2
1996	C	25.5 (1.6)*a*	72.1 (0.5)	91.5
mean		22.6 (4.4)	72.4 (1.0)*	81.6 (13.5)*
1997	D	22.2 (0.5)*ab*	82.7 (0.4)	128.3
1997	E	21.9 (2.4)*ab*	85.7 (0.8)	152.7
1997	F	20.2 (1.0)*b*	83.9 (1.0)	125.2
1997	G	19.2 (3.2)*b*	83.4 (0.4)	115.7
mean		20.9 (1.4)	83.9 (1.3)*	130.5 (15.8)*

a, b Different letters in italics indicate significant differences ($P < 0.05$) between reindeer in and between years.
* Significanr differences of means between years ($P < 0.01$).

tively. The first week of the experiment mean temperature was significantly ($P < 0.05$) different between the two years (Fig. 3). Mean temperature throughout the grazing period was 8.7, $s = 2.8$, °C in 1996 and 11.0, $s = 3.0$, °C in 1997, while the precipitation was 54.5 and 53.0 mm, respectively (Fig. 3). Mean daily temperature from day 15 to 22 was 10.9, $s = 2.8$, °C in 1996 and 11.7, $s = 2.3$, °C in 1997, while total precipitation was 2.5 mm both years (Fig. 3). All snow had disappeared from the meadow by 8th June in 1996 and 15th June in 1997.

Plant production

There was no significant difference in mean daily plant production, on ungrazed meadow (control), through the entire grazing period between 1996 (days 1-25) and 1997 (day 1-24) (Table 1). In contrast, mean daily plant production on grazed meadow was significantly ($P < 0.05$) lower in 1996 than 1997 (Table 1). Likewise, daily DM plant production the first week of the grazing period (days 1-7) was significantly ($P < 0.05$) higher in 1997 compared to 1996 (Table 1). At the end of the grazing experiment, there were no significant differences in herbage mass, on ungrazed meadow (control), between 1996 and 1997 (Table 2). Contrasting, from day 7 to 22 the herbage mass on grazed meadow in 1997, was significantly ($P < 0.05$) higher than 1996 (Table 2).

Chemical composition in plants

Nutrient content in mixtures of plant species, collected at day 22, are shown in table 4. There were small differences in the chemical composition of plant samples between 1996 and 1997 (Table 4).

Food and energy intake

Daily food intake estimated as the difference between ungrazed and grazed meadow was 175, $s =$

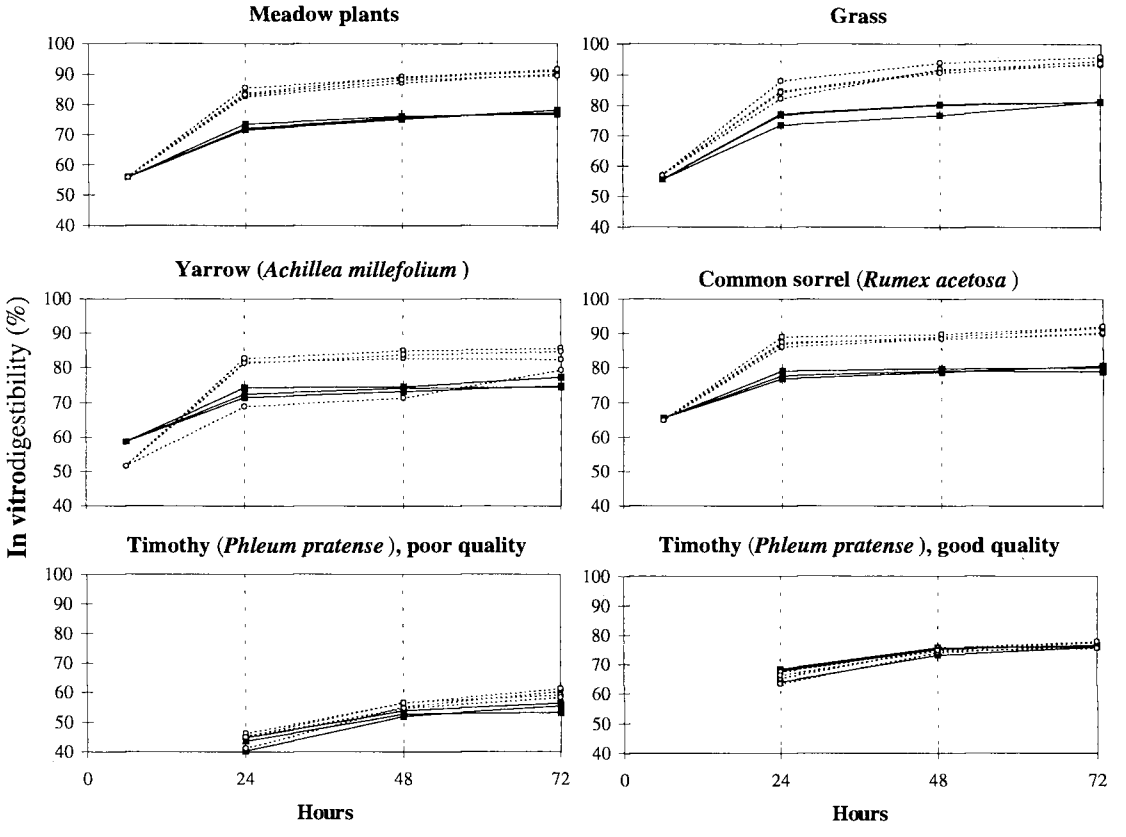

Fig. 4. Mean ruminal *in vitro* dry matter digestibility of various meadow plants, grass, yarrow (*Achilléa millefólium*) and common sorrel (*Rumex acetóca*) from old meadow in early summer in 1996 (n = 3) and 1997 (n = 4), and control timothy (*Phleum pratense*) of good and poor quality, in rumen fluid from reindeer yearlings. Reindeer A-C 1996–■–; -G 1997··⊙··.

55, g DM/kg$^{0.75}$ in 1996 and 112, s = 55, g DM/kg$^{0.75}$ in 1997. There were no significant differences in daily food intake between 1996 and 1997.

Digestibility (IVDMD) of selected plant material and for a mixture of meadow plants are shown in Figure 4 and Table 3. The IVDMD of all plants in 1997 was significantly (P < 0.05) higher for 24, 48 and 72 hours of microbial digestion, compared to 1996, while there were no significant differences in IVDMD between 1996 and 1997 of the standard grasses timothy of good and poor quality, respectively (Fig. 4). All plant samples from the old meadow had significantly (P < 0.05) higher IVDMD compared to the standard timothy samples (Fig. 4). There were no significant differences in mean daily faeces DM production between 1996 and 1997 (Table 3). Food intake based on IVDMD and faecal production is shown in Table 3. In 1997, food intake was 60% higher compared to 1996 (P < 0.05).

The energy content in the daily faecal production was not significant different between years (Table 5). The mixture of plants from the meadow contained 16.7, s = 0.1, KJ/g in 1996 and 17.1, s = 0.1, KJ/g in 1997, the difference was significant (P < 0.05). Total energy in food consumed and apparent digestible energy is shown in table 5.

Discussion

Climate-plant growth

In northern Norway the time for snow melting and start of vegetative plant growth is between early May and mid June, dependent on years. The snow melting will therefore influence total plant production (Andersen, 1988; 1989). In our investigation the snow melted the first part of June, and the grazing experiment started two days before the final snow had disappeared from the meadow, one week later in 1997 than in 1996. We therefore assume

Table 4. Chemical composition of meadow plants harvested at Reinøya 27th of June 1996 and 4th of July 1997.

Chemical composition (% of DM)	1996	1997
Crude protein	22.0	21.1
Phosphorus	0.4	0.4
Potassium	2.3	2.3
Calcium	0.3	0.4
Magnesium	0.2	0.2
Water-soluble carbohydrates	23.9	26.3
Cellulose	15.9	13.8
Hemicellulose	25.2	29.4
Lignin	2.1	1.8

that the soil was saturated with water in the beginning of the grazing experiment both years. Snow melting could therefore not explain the difference in plant DM production observed on grazed and ungrazed meadow the first week of the experiment the two years (Fig. 3, Table 1). Likewise, we assume that precipitation during the experimental period in 1996 and 1997 could not explain the observed differences in plant production between the two years (Fig. 3, table 1). According to Andersen (1979) no significant correlation was shown between plant production and precipitation during spring and early summer in northern Norway on an experimental meadow dominated by *Poa pratensis.*

The initial increase in ambient temperature at the beginning of the experiment in 1997 (Fig. 3), was associated with a significantly greater daily plant biomass production during this first week (day no. 1-7) (Table 1). The production of dry matter for vascular plants starts at about 5 °C, and the temperatures for optimal photosynthesis and dry matter production range between 10 and 15 °C (Larcher, 1983). The temperature the first week in this investigation in 1997 (Fig. 3) was therefore optimal. In the experimental meadow dominated by *Poa pratensis*, increased ambient temperature effected plant production in summer significantly (Andersen, 1979). Mean daily plant production in our experiment, during the whole experimental period on ungrazed meadow (control), was however not different between years. This could be explained by the relative higher temperature later in 1996 (days 10-16) (Fig. 3). The daily DM plant production of approximately 100 kg DM ha^{-1} (Table 1) on ungrazed meadows (control) is about half of the daily mean DM production (ca 200 kg DM ha^{-1}) on intensively fertilized meadows in northern Norway (Schjelderup, 1980). This indicates a relatively high potential for plant production on the unfertilised old meadow.

We assume that the higher herbage mass observed on grazed old meadow (day 15, 22) in 1997 compared to 1996 (Table 2) was strongly influenced by the ambient temperature during the first week of the experiment. When reindeer were grazing old meadows in spring 1996, the plant production was low the first week, the herbage mass seem to be maintained low during the summer (Table 2). The higher herbage mass on grazed meadow in 1997, after one week, leads to an increased area of photosynthetic active leaves, and consequently increased plant production (King *et al.,* 1984; 1988; Frame, 1993). Therefore, we assume utilization of these abandoned coastal meadows by reindeer are optimal when the grazing starts after plant growth have been initiated by the temperature.

Digestibility

We have demonstrated that reindeer forage on plant species, including the grasses *Festuca rubra, Poa alpigenea, Agostis tenuis, Phleum commutatum,* and the herbs *Achillea millefolium, Rumex acetosa, Ranuculus* and *Alchemilla subrrenata* on the old meadow both in 1996 and 1997. The exception was the grass *Descampsia caespitosa,* which was not preferred (Eilertsen, unpubl.). The chemical composition in the plant samples from 1996 and 1997 indicated that the plant species selected were of high quality with regard to the content of crude protein and

Table 5. Total energy in faeces and apparent digestible energy in food eaten (estimated) by male reindeer yearlings grazing on old meadow in spring at Reinøya in 1996 and 1997. Mean with standard deviation in parentheses.

	1996	1997
Total energy in faeces ($MJ/kg^{0.75}$ X d^{-1})	0.40 (0.08)	0.38 (0.02)
Total energy in food consumed (estimated) ($MJ/kg^{0.75}$ X d^{-1})	1.36 (0.22)	2.23 (0.27)
Apparent digestible energy ($MJ/kg^{0.75}$ X d^{-1})	0.96 (0.14)	1.85 (0.25)

WSC (Table 4). The crude protein content was similar to high quality timothy hay harvested for sheep and cattle, while plant cell wall content was significantly less (Aagnes & Mathiesen, 1995). The high nutrient content of plant species, subsequently collected from the old meadow during the summer, confirm these data (Eilertsen *et al.*, unpubl.).

The vegetation sampled from the old meadow was highly digestible in rumen fluid from reindeer, especially in 1997 (Fig. 4), which correlates with the high content of easily digestible nutrients in the plants collected in both years (Table 4). The IVDMD of plant mixture sampled in 1996 was similar to IVDMD of high quality standard timothy hay harvested to cattle and sheep using rumen fluid from reindeer (Fig. 4). The IVDMD of graminoid species was as high as 83% in reindeer on South Georgia in summer (Mathiesen & Utsi, 1999), which was similar to the IVDMD in plant samples from the old meadow in 1997. The *in vitro* organic matter digestibility of *D. flexuosa* in winter was as high as 79% (Danell *et al.*, 1994). All plants from the old meadow investigated were about 10% more digestible in 1997 compared to 1996 after 24 hours incubation, while no differences in the digestibility of the control samples of timothy between the two years were found (Fig. 4). We therefore suggest the ability to degrade plant material in the rumen of reindeer was similar in 1996 and 1997. The difference in IVDMD of selected plants between the two years is not understood, but could be due to differences in plant chemistry.

Food intake

The exclosure technique used to estimate food intake in reindeer grazing old meadows is not recommended of numerous reasons. First, old meadows in northern Norway is heterogenously composed plant communities, and the exclosure technique is not accurate to represent this variation. This is reflected in the large standard deviation of estimated food intake obtained each year (up to 50% of the mean value), which confirms earlier investigation by Frame (1993). Secondly, DM plant production may be overestimated if the sampling period is too long (Frame, 1993; King *et al.*, 1984; Parsons *et al.*, 1984). Thirdly, reindeer are highly selective ruminants, able to forage on specific plant species (Mathiesen *et al.*, 1999). Consequently, when herbage mass is high, the exclosure technique do not account for selection between plants (Meijs *et al.*, 1982).

Food intake has not previously been estimated in reindeer grazing old meadow in spring. Captive Norwegian reindeer fed commercial pelleted food, however, show pronounced seasonal changes in appetite, daily voluntary food intake reaching a maximum of 134 g/kg$^{0.75}$ in summer and 62.6 g/kg$^{0.75}$ in winter (Nilssen *et al.*, 1984). The summer value is therefore similar to the maximum DM food intake estimated in our investigation (Table 3). In free ranging reindeer in northern Norway and South Georgia (*R. t. tarandus*) and in Svalbard (*R. t. platyrhynchus*) food intake was 68, 96 and 187 g DM/kg$^{0.75}$ in summer, respectively (White & Staaland, 1983; Mathiesen *et al.*, 1999b). The daily food intake on the old meadow in 1996 and 1997 represented 13% less and 35% more than the food intake on South Georgia in mid summer foraging on a vegetation dominated by graminoids.

Daily digestible energy intakes of 0.96 MJ/kg$^{0.75}$ in 1996 and 1.85 MJ/kg$^{0.75}$ in 1997, in our investigation, represent 1.3 and 2.5 times the resting metabolic rate in female Norwegian reindeer in summer (0.736 MJ/kg$^{0.75}$, Nilssen *et al.*, 1984), consuming 134g/kg$^{0.75}$ commercially reindeer feed daily. Our reindeer increased carcass mass from 48 to 52% of BM during the grazing period of 25 days both years. The results indicate that a diet containing low fibre, up to 30% crude protein, and 26% water soluble carbohydrates (Table 4; Eilertsen *et al.*, unpubl.) is highly utilized by reindeer. We assume the high utilization of the old meadow plants, indicates that such pastures could be used as reindeer pasture in spring.

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