High protein pastures in spring - effects on body composition in reindeer

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Abstract: In 1996 and 1997 three groups of reindeer from different nutritional origin and condition, (poor condition groups n=15 in 1996, n=7 in 1997, good condition group n=10 in 1997), were used to investigate effects of high protein pastures on body condition for 3.5 weeks in spring. Mean body mass (BM) of reindeer in the poor condition groups increased by 10% both in 1996 (P<0.05) and in 1997 (P<0.05), while there were no significant (NS) changes in BM of reindeer in the good condition group in 1997. The mean carcass weight as % of BM increased from 48 to 51% in both the poor condition group in 1996 (NS), and in the good condition group in 1997 (P<0.05). The reticulo-rumen wet weight in the poor condition group in 1996, tended to decrease from 15.1 to 11.9% of BM, while the reticulo-rumen wet weight decreased from 14.2 to 13.0% of BM (P<0.05) in the good condition group in 1997. Mean kidney fat decreased by 51% in the poor condition group in 1996 and by 40% in the good condition group in 1997 (P<0.05). Likewise, marrow fat decreased by 50% (P<0.05) in the good condition group in 1997. In both animal groups muscle mass and carcass mass increased in the reindeer, while fat deposits decreased when eating as much as 131 g dry matter/kg$^{0.75}$ on a high protein spring pasture containing as much as 30% crude protein of dry matter (DM). Much of the energy available from forage plants eaten and the body fat deposits therefore seem to support body protein growth in spring.

Key words: abandoned meadow, carcass weight, fat, *Rangifer*, reticulo-rumen.

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Introduction

In northern-Norway semi-domesticated reindeer (*Rangifer tarandus tarandus*) are herded between seasonal pastures. In spring they migrate to the coast, where the diet consists mainly of grass and dicotyledonous plants. Meadows at sea level, previously used as farmland are available for grazing early in the spring, but the reindeer follow the rapid initiation of plant growth as the snow melts on the mountains. In years with much snow or delayed snow melting, the reindeer are forced to remain on the coastal meadows until the initiation of new plant growth in the mountains. According to Eilertsen *et al.* (1999) male reindeer yearlings consumed in June up to 131 g DM/kg$^{0.75}$. Since food intake is much reduced in winter (Nilssen *et al.*, 1984; Larsen *et al.*, 1985), reindeer rely on the availability of good quality spring and summer pasture to gain body mass and condition (Tyler *et al.*, 1999). The plant composition in abandoned coastal meadows is reverted from timothy grass (Phleum pratense) to a more heterogeneous species composition (Eilertsen *et al.*, 1999; unpubl.). According to Eilertsen *et al.* (2000), the chemical composition of these meadows in spring is characterised by high quality (e.g. crude protein as high as 30% of dry matter). It is possible that these areas could be used as interim grazing lands for short periods in spring when snow covers the mountain pasture. A coastal meadow was therefore used in a grazing experiment with male reindeer yearlings in spring in 1996 and 1997 (Eilertsen *et al.*, 1999). We investigated the effects of high protein spring pasture on body composition in reindeer with different initial nutritional conditions.

Material and methods

Study area and grazing management

This investigation was carried out at Reinøy, Troms county in northern Norway. The site and its vegetation are described in detail in Eilertsen *et al.* (1999). In each year, grazing commenced as soon as the snow had melted (7 June 1996 and 14 June 1997). The grazing was ended after 25 days in 1996 (1 July) and 24 days in 1997 (7 July).

Animals and treatments

Fifteen male yearling reindeer (mean body mass (BM) 45 kg) in 1996, and 7 reindeer (mean BM 42 kg) in 1997 were obtained from a private herd. All the reindeer were in poor state of nutrition (poor condition groups), and were brought from winter pasture near Kautokeino in Finnmark to Tromsø in April. In 1997, 10 other male reindeer (mean BM 56 kg) from a private herd were fed commercial reindeer feed (RF-80; Sletten & Hove, 1990) during the winter until the grazing experiment started. These reindeer were therefore in a good state of nutrition (good condition group). In both years, just prior to the experimental periods, all the reindeer were held in a large outdoor pen, and were fed commercial feed. Three reindeer in 1996 (poor condition group) and five reindeer in 1997 (good condition group) were slaughtered immediately before the grazing started. The remaining reindeer in 1996 (n=12) (poor condition group) were used in the grazing experiment. Likewise, in 1997 the remaining reindeer (n=12) were used, 5 from the good condition group and 7 from the poor condition group. After the grazing period in 1996, animals (n=4) from the poor condition group and in 1997 animals from the good condition group (n=5) were subsequently slaughtered. All animals slaughtered were matched on the basis of BM within years. Remaining reindeer in both years were subsequently released on mountain pasture. The animals used are the same animals used to measure food intake in Eilertsen *et al.* (1999).

Body mass, body composition and nutritional status

The following measurements were made in the poor condition group in 1996 and in the good condition group in 1997:

(1) Body and carcass mass: live BM was measured with a mobile electronic balance (Hottinger Baldvin Messtechik, Germany) as described by Bye (1986), and carcass mass (after removal of the hide and evisceration) with a spring balance.

(2) Viscera mass: after slaughter, the digestive system was removed and the reticulo-rumen including contents were weight. The reticulo-rumen was emptied and the contents and tissue were reweight. Liver and kidney were removed and weight. All measurements were performed with a Farmer Tronic electronic balance (Give, Denmark).

(3) Muscle index: the femur, and *M. gluteobiceps* and *M. semitendinosus* were dissected out from the right hind leg of each the reindeer carcass. Femur length was the longest distance from the head to the distal extremity. *M. gluteobiceps* were weighed and stored cold until one slice of about 1 cm thickness was cut crosswise from the middle of each muscle about 6 hours later the same day. The slices were weighed, dried at 100 °C for 24 hours, and the muscle water content and dry weight calculated. The muscle index for each of the reindeer was calculated from dry weight of *M. gluteobiceps* and the length of the femur as described by Tyler (1987).

Five measurements of nutritional status were made in the good condition group in 1997:

(1) Rumen neutral detergent fibre (NDF) concentration (Brown *et al.*, 1995): rumen contents were

Table 1. Body mass (BM) and growth data in male reindeer yearlings before (7 and 14 June) and after grazing (1 and 7 July) coastal old meadow in spring in 1996 (poor condition group) and 1997 (poor and good condition groups), respectively. Standard deviation in parentheses.

	Condition group	*n*	BM (kg) Before	After		Daily BM Growth (g)
1996	Poor	12	45.3 (5.34)	50.0 (4.88)	$P<0.05$	188 (83.8)
1997	Poor	7	42.0 (4.41)	46.1 (4.22)	$P<0.05$	180 (95.3)
1997	Good	5	55.5 (5.27)	53.5 (6.21)	NS	-74 (242.1)

mixed, sampled and frozen. NDF was determined on thawed contents according to Goering & Van Soest (1970).

(2) Faecal N (Brown *et al.*, 1995): faeces were collected post mortem from the rectum of the reindeer slaughtered before the grazing period, and by pooling 2 consecutive days samples collected in faeces bags during the grazing period. Faecal nitrogen (N) was determined using the Kjeldahl method (Horwitz, 1980).

(3) Serum urea N: blood was obtained by jugular venipuncture from the animals slaughtered after the grazing period. The blood was allowed to clot, then centrifuged and the serum collected and frozen until urea nitrogen analysis (Tiffany *et al.*, 1972).

(4) Kidney fat index (Anderson *et al.*, 1972): measurements were made on fresh tissue obtained immediately after slaughter; both kidneys were used.

(5) Femur marrow fat (Torbit *et al.*, 1988): femurs were refrigerated (5 °C) until removal of marrow from the shank of the femur for analysis. Fat content was estimated by drying (Nieland, 1970).

Statistical analyses

Significant differences ($P\leq0.05$) were calculated within years by the Student t-test (two-tailed test assuming unequal variances) (Bhattacharyya & Johnson, 1977). To correct for differences in live weight when analysing for live weight change and body composition a covariance analysis was used, with initial live weight as the covariate (Kleinbaum *et al.*, 1987).

Results

Mean BM in the poor condition group in 1996 grazing high protein pasture increased by 10% ($P<0.05$) during the spring grazing period (Table 1). Likewise, mean BM of the 7 reindeer of poor condition group in 1997 increased by 10% ($P<0.05$) on these pastures. In contrast, mean BM in the good condition group in 1997 did not change (Table 1).

Carcass weight as % of BM tended to increase ($P=0.08$) in the poor condition group during the spring grazing periods in 1996, while the increased carcass weight in the good condition group in 1997 was significant (Table 2).

Mean weight of reticulo-rumen (tissue plus contents) tended to decrease ($P=0.06$) during the grazing period in the poor condition group in 1996, while the mean weight decreased in the good condition group in 1997 ($P<0.05$) (Table 2). As percent of carcass weight the reticulo-rumen wet weight contents in the poor condition group in 1996 tended to decrease ($P=0.09$), while the relative decrease in ruminal wet weight content in the good condition group in 1997 was significant.

Mean wet weights of *M. gluteobiceps* and *M. semitendinosus* tended to increase both in the poor and good condition group (Table 3). Likewise, the mean relative muscle index of the reindeer investigated tended to increase with 7% both in 1996 and 1997 (Table 3).

There were no significant changes in kidney fat in the poor condition group in 1996, while the decreased kidney fat in the good condition group during the grazing period in 1997 was significant (Table 3, 4). Furthermore, mean marrow fat (% fresh weight) decreased in the good condition group in 1997 ($P<0.05$) (Table 4). Conversely, liver weights increased during the grazing periods with 20% in both 1997, ($P<0.05$) and 1996 (Table 3).

In 1997, faecal N in reindeer offered commercial reindeer feed (containing 11% crude protein) before the experiment started increased significantly during the grazing experiment (Table 4). The mean concentration of blood serum urea

Table 2. Carcass weight, weight of reticulo-rumen (R-R) and femur length of male reindeer yearlings before (n=3, n=5) and after (n=4, n=5) a grazing period in spring on meadow in 1996 (poor condition group) and 1997 (good condition group), respectively. Standard deviation in parentheses.

Attribute	Before grazing	After grazing	
1996, poor condition group			
Live body mass (kg)	44.6 (6.99)	47.7 (5.38)	NS
Carcass weight (kg)	21.5 (4.49)	24.3 (3.16)	NS
Carcass weight (% of live weight)	47.9 (3.10)	51.2 (2.10)	NS
Total reticulo-rumen (kg)	7.83 (0.669)	7.12 (0.311)	NS
R-R contents (kg)	6.58 (0.726)	5.62 (0.288)	NS
R-R contents (% of live weight)	15.1 (3.29)	11.9 (1.71)	NS
R-R contents (% of carcass weight)	31.8 (8.85)	23.5 (4.19)	NS
Femur length (cm)	23.3 (1.20)	23.5 (1.10)	NS
1997, good condition group			
Live body mass (kg)	55.5 (5.27)	53.5 (6.21)	NS
Carcass weight (kg)	26.8 (2.38)	27.5 (3.37)	NS
Carcass weight (% of live weight)	48.4 (3.10)	51.4 (1.60)	*
Total reticulo-rumen (kg)	9.92 (1.621)	8.15 (0.902)	*
R-R contents (kg)	7.90 (1.345)	6.96 (0.808)	NS
R-R contents (% of live weight)	14.2 (1.460)	13.0 (0.41)	NS
R-R contents (% of carcass weight)	30.3 (3.64)	26.3 (1.73)	*
Femur length (cm)	24.9 (0.80)	25.1 (0.98)	NS

NS: not significant.
* P<0.05.

Table 3. Body composition and indices of nutritional status (mean with standard deviation in parentheses) of male reindeer yearlings slaughtered before (n=3, n=5) and after (n=4, n=5) a grazing period in spring on meadow in 1996 (poor condition group) and 1997 (good condition group), respectively.

Attribute	Before grazing	After grazing	
1996, poor condition group			
Liver, wetweight (g)	803 (183.0)	960 (166.4)	NS
Kidneys without fat (g)	140 (22.1)	174 (36.0)	NS
Kidneyfat (g)	47 (31.0)	23 (11.0)	NS
M. gluteobiceps (g)	436 (85.9)	497 (69.7)	NS
M. semitendinosus (g)	142 (46.9)	154 (20.4)	NS
Muscle index (mg/cm^3)	8.15 (0.497)	8.73 (0.749)	NS
1997, good condition group			
Liver, wetweight (g)	776 (207.6)	947 (138.0)	*
Kidneys without fat (g)	148 (25.6)	183 (22.9)	*
Kidneyfat (g)	32 (2.3)	19 (11.2)	*
M. gluteobiceps (g)	573 (44.8)	609 (109.3)	NS
M. semitendinosus (g)	205 (26.0)	216 (38.9)	NS
Muscle index (mg/cm^3)	8.83 (0.434)	9.48 (0.987)	NS

NS: not significant.
* P<0.05.

was 13.0, standard deviation (s) = 2.26, mMol in reindeer from the good condition group slaughtered after the grazing period in 1997.

Discussion

The observed difference in BM growth during the spring grazing between the poor condition

Table 4. Marrow fat, rumen NDF content (%), faecal N (% of DM) and kidney fat index in reindeer (good condition group) slaughtered before (n=5) and after (n=5) a grazing period in spring on old meadow at Reinøya 1997 (mean with standard deviation in parenthesis).

	Before grazing	After grazing	
Marrow fat (% fresh weight)	61.4 (21.13)	29.7 (8.95)	*
Rumen NDF content (%)	61.7 (3.68)	40.4 (2.42)	*
Faecal N (% of DM)	2.68 (0.202)	3.54 (0.142)	*
Kidney fat index	0.21 (0.029)	0.09 (0.050)	*

* $P<0.05$.

group of reindeer in 1996 and 1997 and the good condition reindeer in 1997 may be explained by compensatory growth. According to Jacobsen *et al.* (1977), reindeer yearlings grazing on natural winter pasture grew 114-180 g/day between April and September, while reindeer previously fed concentrates *ad lib.* in winter grew at only 96-114 g/day during the same period in spring and summer. As shown in the results, the reindeer from the good condition group (1997) did not increase their BM. In contrast, animals of the poor condition group in 1997 and 1996 increased their BM. Compensatory growth of previously undernourished animals has also been reported in reindeer by Ryg & Jacobsen (1982) and Espmark (1980) and in wapiti (*C. elaphus canadensis*) by Watkins *et al.* (1990).

In both groups animals were eating as much as 131 g DM/kg$^{0.75}$ per day of highly digestible plants with a low fibre content and thus reticulo-rumen wet weight content in these reindeer were much reduced (Table 2) (Eilertsen *et al.*, 1999). The reticulo-rumen wet weight content of reindeer calves fed baled timothy silage comprised 12.9% of BM when eating as much as 1.11 kg (DM) high quality timothy silage per day, and as much as 32.8% of BM when eating 0.69 kg (DM) poor quality timothy silage per day (Aagnes & Mathiesen, 1996; Aagnes *et al.*, 1996). In reindeer grazing on high protein meadow pastures in spring, reticulo-rumen wet weight content (12-13% of BM) was slightly lower than the relative reticulo-rumen wet weight content (13.5% of BM) in reindeer feeding on natural summer pastures (Staaland *et al.*, 1979). Reticulo-rumen wet weight fill therefore seem to have a powerful influence on BM of the reindeer, and explain why the reindeer in the good condition group in 1997 did not increase their BM.

The commercial reindeer feed (RF-80) contained 10.9% (of DM) crude protein. In contrast, crude protein concentration of herbage contents varied between 20 and 30% of DM during the grazing period (Eilertsen *et al.*, 2000). Faecal N (Table 4) in reindeer slaughtered after the grazing period were significantly higher compared to reindeer fed commercial reindeer feed. This indicates that the grazed diet may have had higher protein concentrations compared to the commercial feed (Bahnak *et al.*, 1979; Brown *et al.*, 1995). Furthermore, the serum urea values (13.0 mMol) in the animals grazing coastal meadow was significantly higher than the values (3.9, s=0.72 mMol) in reindeer of equal age, sex and size fed commercial reindeer feed before the grazing experiment started in 1997. This also indicates that the reindeer ate high-protein pasture dietary plants in 1997. In rusa yearlings (*C. timorensis*), consuming diets with 20 and 12% protein, blood ureas of 32 and 21 mMol were measured, respectively (Puttoo *et al.*, 1998).

Reduced marrow fat contents and kidney fat indexes (Table 3, 4) indicate that body fat stores decreased during the grazing period. This finding was unexpected since the forage (consuming up to 131 g DM/kg$^{0.75}$ per day (Eilertsen *et al.*, 1999)) eaten by the reindeer contained highly digestible energy (as much as 26% water soluble carbohydrates (Eilertsen *et al.*, 2000)). According to Torbit *et al.* (1988) and Hewison *et al.* (1996), kidney fat and marrow fat correlate to body fat storage's. The high intake of protein and energy rich dietary plants was confirmed by the increase in muscle protein mass during the experiment. Likewise, in domestic ruminants muscle mass may continue to increase when ruminants are fed a protein rich, energy restricted diet (e.g. Fattet *et al.*, 1984; Chowdhury *et al.*, 1997). It seems therefore that much of the available energy from feed and body reserves are utilised in a way to optimise muscle growth on the expense of fat deposits when the protein content in the diet eaten is very high. We therefore conclude that the body composition of male reindeer yearlings changes during a short grazing period in spring by decreasing the gut contents and fat tissues and increasing body protein.

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