Feed intake, gastrointestinal system and body composition in reindeer calves fed early harvested first cut timothy silage (*Phleum praténse*)

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Abstract: Early harvested first cut (EFC) timothy silage was fed to five reindeer calves (*Rangifer tarandus tarandus* L.) taken from their natural summer pasture and brought to Tromsø for feeding trial. The calves were housed indoors in metabolism cages and fed EFC timothy silage *ad lib.* during the trial, which lasted from late November 1994 until the end of February 1995, when animals subsequently were slaughtered. Daily feed intake, gastrointestinal (GI) anatomy, body weight and body composition of the animals were examined. Timothy silage (*Phleum praténse*) was harvested 21 June, 1994 in Tromsø, prewilted and stored as round bales containing 97% leaves. The EFC silage contained 42.1% dry matter (DM), and 18.1% crude protein, 20.7% cellulose, 16.9% hemicellulose and 28.0% water soluble carbohydrates (WSC) of DM. Mean feed intake (DM) 24 hours after the trial started (day 1) was 9.4 g/kg body mass (BM) (S.D.± 3.9), while the mean daily DM intake during days 15-74 comprised 24.2 g/kg BM (S.D.± 6.1). All animals except one gained body weight during the trial. The median (range) BM at start and at slaughter was 48.5 kg (34.5-58.0 kg) and 50.0 kg (42.0-53.5 kg), respectively. Median (range) carcass weight % of BM was 58.0% (51.2-58.7%) and muscle index value 0.0132 (0.0106-0.0176). The median reticulo-rumen (RR) content wet weight (WW) was 4601 g (range 2697-5000 g) comprising 9.3% of the BM, and 85.1% of the total gastrointestinal wet weight content. The median (range) gastrointestinal tract weight was 14.1% of BM (10.7-16.4%). Based on feed intake during the trial and body composition at slaughtet we conclude that first cut timothy silage is suitable as emergency feed to reindeer, as long as it is harvested in early growth stage with high proportion of leaves.

Key words: *Rangifer tarandus tarandus*, feed quality, growth stage.

Rangifer, 18 (2): 65–72

Introduction

The distribution of reindeer (*Rangifer tarandus tarandus L.*) in Eurasia is wide and ranges between many different habitats according to geology and topography, the seasonal abundance of vegetation and annual migrations of animals. In Northern Norway semidomesticated reindeer migrate traditionally between distinct winter and summer pastures (Skjenneberg, 1989). In summer reindeer graze in the areas where the vegetation is dominated by protein rich vascular plants, e.g. along the coast, and during autumn different species of mushrooms are highly preferred in their diet. In winter reindeer eat a mixed diet dominated by lichens, which in some areas in Scandinavia may constitute even 80 % of the rumen content (Nieminen & Heiskari, 1989; Nieminen, 1994; Mathiesen, S.D., unpubl.). In comparison, introduction of reindeer from Norway to South Georgia demonstrates that reindeer do not necessarily need lichen in winter. Graminoid plants dominate in the diet of reindeer in South Georgia throughout the year (Leader-Williams *et al.*, 1981), and the main plant eaten is the tussock-grass (*Paradiocola flabellata*) which contains 15% crude protein, 24% cellulose, 26% hemicellulose and 29% water soluble carbohydrates (WSC) of dry matter (DM) (Mathiesen, S.D., unpubl.).

According to Hofmann (1989) reindeer can be classified as an adaptable intermediate feedet expressing its ability to use mixed diet with low fibre content. Aagnes & Mathiesen (1996) and Aagnes *et al.* (1996) have demonstrated that reindeer are highly adaptable feeders, but with strong limitations to digest rough first cut timothy silage containing 27% leaves and 30% cellulose.

In situations when supplementary feeding is necessary it is important to focus on the quality of supplemental feed. To be suitable, feed must have high palatability and it must not cause any digestive disorders when eaten by animals that are already starving (Aagnes & Mathiesen, 1995). Starvation has been shown to reduce animals ability to digest food because of it's negative effects on both the number and the species composition of bacteria in the rumen of reindeer (Aagnes *et al.*, 1995).

In Finland where herds graze in closed geographical units throughout the year (Nieminen, 1993) supplementation of the natural winter diet of reindeer with hay is common (Nieminen & Autto, 1989). However, also round baled grass silage has become more popular in corral feeding during last years. Several studies of the suitability of grass silage as feed for reindeer have been conducted (e.g. Syrjälä-Qvist, 1982; Aagnes & Mathiesen, 1995; Olsen *et al.*, 1995). The results have indicated high palatability of examined silages, but low digestibility and low tuminal volatile fatty acid (VFA) production leading to inadequate nutrition of animals. Still, also good results of feeding reindeer solely with grass silage have been achieved. Aagnes *et al.* (1996) concluded that first cut (FC) timothy silage containing a high proportion of stems and only few leaves was of limited value in supplying the energy requirements of reindeer while leaf-rich (89% leaves) regrowth (RG) timothy silage instead could be recommended as feed for reindeer. The RG silage contained 14% crude protein, 19% cellulose and 30% WSC of DM, while corresponding values for FC silage were 12%, 30% and 6%, respectively. The higher content of WSC in RG silage is likely to stimulate a higher ruminal fermentation enabling adequate production of essential VFA's to satisfy energy requirements of reindeer (Aagnes *et al.*, 1996).

The nutritive quality of gtass silage, as well as natural forage plants, is dependent on the growth stage and weather conditions at harvest. In this study we examined the quality and suitability of early harvested first cut timothy silage (EFC) as supplemental feed to teindeer calves.

Material and methods

Animals and experimental procedure

Five male reindeer calves were taken from theit natutal summer pasture on the island Reinøya in Northern Norway (70°N, 20°E), and brought to the Department of Arctic Biology, University of Tromsø. Animals A and B arrived on 23 September and animals C, D and E on 20 October, 1994. After arrival calves were kept in outside pens and fed mixed reindeer lichens (*Cladina* sp.) and commercial pelleted food (RF-80®, Stormøllen, Balsfjord, Norway) until the beginning of feeding expetiment. Watet or snow was freely available. On 23 November the calves (age 6 months, body mass (BM) 34.5-58.0 kg) were raken inside for feeding trial, and placed in a light and temperature-regulated (between 0 and 5 °C) room where they were exposed to a natural photoperiod. The calves were housed in metabolism cages (60 cm wide x 140 cm long x 96 cm high) and offeted silage and water *ad lib.* twice per day. Feed intake was measured daily by removing and weighing the residues (mean 26.9% ±14.7(S.D.)). The mean daily feed intake was calculated over 60 days (days 15-74). At day 42 all calves except animal C were treated against parasites with doramectin (Dectomax®, Pfizer; 200 µ/kg BM). Animals A, B, C, D and E were slaughtered 98, 77, 98, 84 and 84 days after the start of the experiment, respectively. The examination of body composition and GI tracr was carried out following the slaughter.

Feed and chemical analysis

The silage was made of locally grown (69°40'N, 19°00'E) timothy (*Phleum praténse*) which consisted almost purely of leaves (97%). Timothy was harvested on the 21 June, 1994 and was subsequently wilted and prepared to round bale silage. Methods for preparing silage and examining the chemical composition of silage are described earlier by Aagnes & Mathiesen (1995).

Body mass, gastrointestinal system and body composition
BM of calves were weighed to 0.5 kg on days 1, 12, 22, 29, 42 and on slaughter day by using an electronic weighing system (Farmer Tronic, Give, Denmark). Carcass weights were measured to 0.5 kg with spring balance immediately after slaughtet. Total, tissue and content wet weights of different sections of GI tract, including reticulo-rumen (RR), omasum, abomasum, small intestines, caecum and colon, were weighed to 1 g and samples of contents from each section were dried at 105 °C at least 17 hours for determining the dry weight (DW) of digesta. The combined values of caecum and proximal colon were defined as values of distal fermentation chamber (DFC). In order to examine body composition and condition, carcass weight in percent of BM, muscle index, liver weight, kidney fat weight and rump fat depth were measured. For

Table 1. Chemical composition of early first cut (EFC) timothy silage (*Phleum praténse*) harvested 21 June, 1994, Tromsø, Norway (69°40'N, 19°00'E).

	EFC timothy silage (97 % leaves)
Dry matter (DM), %	42.1
Chemical composition, % of DM:	
Ash	6.7
Crude protein	18.1
True protein	10.3
Ethet extract	4.2
Cellulose	20.7
Hemicellulose	16.9
Lignin	1.2
Water soluble carbohydrates	28.0
Formic acid	0.17
Acetic acid	0.55
Propionic acid	<0.03
Butyric acid	<0.03
Lactic acid	7.03
NH_4-N, % of tot. N	5.6
pH	4.1

calculating muscle index (Tylet, 1987) *Musculus gluteobiceps* and femur were dissected from left hind leg, following the drying of muscle tissue to constant DW (see Equation 1).

Muscle index = DW of *M. gluteobiceps* (g) / (length of femur (cm))^3 (eq. 1)

Statistical methods
The results of GI tract and body composition measurements ate given as medians and range. Feed intake values are given as means and standard deviations. The possible body weight change of calves during the feeding trial was tested using the matched pairs *t*-test (Ranta *et al.,* 1991).

Results

Feed
The chemical composition of timothy silage is presented in Table 1. The fibre fraction (cellulose, hemicellulose and lignin) constituted only 39% of dry matter (DM). The ratio of true protein and crude protein was 1:1.8. The proportion of DM in silage was high (42.1%) and both percentage of ammonium nitrogen of total nitrogen and pH indicated good preservation of silage.

Feed intake
The mean daily feed intake (± S.D.) of five reindeer calves increased from 996 g (±303) fresh weight (FW) at day 1 to 2919 g (±538) FW at day 8. The mean daily feed intake after two weeks feeding (days 15-74) was slightly less (2839 g FW±701), and showed large short-term and long-term fluctuation tanging from 1562 g (±376, day 50) FW to 3710 g (±582, day 65) FW (Fig. 1b). The long-term mean in feed intake (DM) compared to the body weight of animals was 24.2 (±6.1) g/kg BM/day (days 15-74). The maximal individual daily feed intake was 4890 g FW (day 66, animal A).

Body mass and body composition
The BM of the calves remained fairly constant throughout the trial (Fig. 1a), and there was no statistical diffetence in body weights in the beginning of feeding trial on day 1 and on slaughter day (P>0.1). The carcass weights ranged from 21.5 kg to 30.5 kg, which comprised the median 58.0% (range 51.2-58.7%) of BM on slaughter day. The median muscle index was 0.0132 g/cm^3. Weights of *M. gluteobiceps,* liver and kidney fat, as well as the

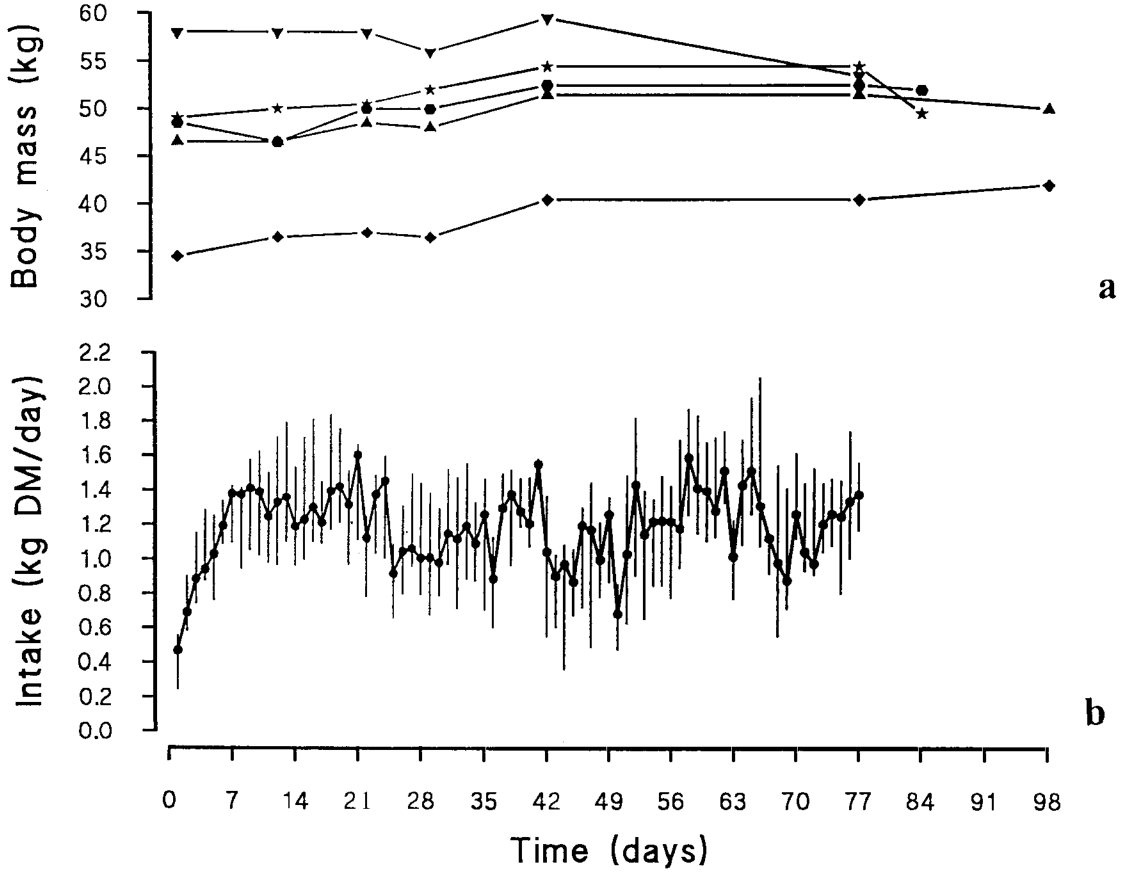

Fig 1a. Live body mass (BM; days 1-untill slaughtered) development of five reindeer calves (animals A (▲), B (▼), C (◆), D (★) and E (●)) fed early harvested first cut timothy silage (Phleum praténse).

Fig 1b. Feed intake (kg dry matter (DM)/day; median and range; days 1-77) of five reindeer calves. The feeding experiment started 24 November, 1994 (day 1).

length of femur and rump fat depth, are presented in Table 2.

Gastrointestinal system

The weights of tissues and contents of the GI tract are presented in Table 3. The total GI tract tissue and content wet weight (WW) was 14.1% of BM, which of RR tissue with contents (WW) consisted 79.7% (range 69.2-81.4%). Corresponding values (% of total GI mass) for omasum, abomasum, small intestine, caecum and total colon were 1.2%, 2.8%, 8.9%, 2.4% and 4.6%, respectively. The percentage of contents in RR, omasum, abomasum, small intestine, caecum, proximal colon, colon coil and distal colon compared to the total gastrointestinal fill consisted 85.1%, 0.7%, 2.1%, 5.9%, 2.4%, 1.9%, 1.2% and 0.7%, respectively. The contents of DFC consisted 4.5 % (range 3.8-6.1%) of total GI fill and 5.7% (range 4.4-7.3%) of reticulo-rumen fill. The ratio between DFC content (WW) and RR content (WW) was 1:17 (range 1:14-1:23). Dry matter % of digesta was highest in distal colon being 24.9% and lowest in RR being 8.4%. In omasum, abomasum, small intestine, caecum, proximal colon and colon coil corresponding values were 17.3%, 14.9%, 14.5%, 15.6%, 16.5% and 19.3%, respectively. In total GI tract fill the DM % was 10.9% (range 7.6-11.3%).

Discussion

The chemical composition of EFC timothy silage used in this experiment was very similar to that of tussock-grass which is the main plant supporting

Table 2. Body composition of male reindeer calves fed early harvested first cut (EFC) timothy silage (*Phleum praténse*) (median and range; $n=5$).

Body mass (g):	50 000	(42 000-53 500)
Carcass weight (g):	29 000	(21 500-30 500)
Carcass weight % of BM:	58.0%	(51.2-58.7%)
M. gluteobiceps:		
wet weight (g):	653	(476-672)
dry weight (g):	164	(124-180)
Femur length (cm):	23.1	(21.7-23.7)
Muscle index (g/cm^3):	0.0132	(0.0106-0.0176)
Livet weight (g):	705	(632-856)
Kidney fat weight (g):	70	(15-119)
Rump fat depth (mm):	6	(2-10)

teindeer over winter on South Georgia (Leader-Williams *et al.*, 1981; Mathiesen, S.D., unpubl.). It seems evident that high WSC level in the feed together with low fibre and moderate protein content is necessary to maintain tuminal fermentation and energy production which satisfies the metabolical requirements of reindeer in winter.

The proportions of protein, fibre and WSC in grass prepared for silage are dependent on the weather conditions during the growing season in summer and the time of harvest. At early growth stages protein levels are at their highest and fibre levels at their lowest values. Concerning the natural diet of reindeer, growth stage and time of the season have effects on the quality and palatability of food plants and, thus, selective feeding behaviour of reindeer (e.g. Hofmann, 1989; Nieminen & Heiskari, 1989; Danell *et al.*, 1994; Norberg *et al.*, 1995). Syrjälä-Qvist (1982) observed that also grass silage harvested at earlier growth stage was mote palatable for reindeer compared to later growth stages, supporting our results on the EFC timothy silage.

According to Wilson & Kennedy (1996) high voluntary feed intake and animal liveweight gain are difficult to achieve by ruminants grazing high fibre forages because of slow passage of the fibrous digesta from the rumen. The EFC silage offered in this experiment was well accepted and did not cause any digestive disorders during the trial. The high feed intake level of 26.2 g DM/kg BM/day was observed already after one week feeding while the mean daily feed intake aftet two weeks feeding was slightly less. The mean daily feed intake remained high compared to 16 g DM/kg BM in adult males observed by Syrjälä-Qvist (1982) and 15.7 g DM/kg BM in reindeer calves observed by Aagnes & Mathiesen (1995). Aagnes *et al.* (1996) observed higher feed intake in reindeer calves fed high quality second cut (regrowth) timothy silage (89% leaves) compared to calves eating fibrous first cut timothy silage (27% leaves). In reindeer calves fed first cut timothy silage in wintet the daily feed intake ranged from 13.2-13.5 g DM/kg BM compared to 18.1-22.6 g DM/kg BM in reindeer calves fed regrowth timothy silage. Based on these results the EFC silage used in our experiment seems to be comparable to the high quality second cut (regrowth) timothy silage used by Aagnes *et al.* (1996).

Accotding to Nagy & Regelin (1975) animals with a small rumen must select forage lower in fibre and higher in digestibility than animals with a large rumen in order to satisfy their energy needs. Reindeer, as well as fallow deer (*Dama dama*) and red deer (*Cervus elaphus*), has been classified as adaptable intermediate feeder among ruminants while roe deer (*Capreolus capreolus*) instead prefer even more selective strategy (Hofmann, 1989). In roe deer, fallow deer and red deer reticulo-rumen contents comprised 8.5%, 11.6% and 8.3% of total BM, respectively (Nagy & Regelin, 1975). According to Aagnes & Mathiesen (1996) rumen wet weight content of reindeer calves from natural pasture in wintet comprised 9.5-11.5% of BM, while in calves fed fibrous first cut timothy silage (27% leaves) rumen content comprised 25.4-33.3% of BM. Reindeer seems to have strong limitations in utilizing silage containing as much as 30% cellulose of DM (Aagnes *et al.*, 1996). When teindeer calves were fed leaf rich second cut timothy silage containing 30% WSC and 39% cell wall contents (cellulose, hemicellulose and lignin) of DM, rumen content comprised 10.4-18.3% of BM (Aagnes & Mathiesen, 1996). The wet weight content of reticulo-rumen in reindeer calves fed EFC timothy silage in our study was similar to that in calves from natural pasture, and comprised only 5.2-10.9% of BM. In addition to low percentages of RR digesta load of BM also low values of ratio DFC content (WW)/RR content (WW) (median 1:17) indicated good quality of the EFC timothy silage and animals' adaptations to selective feeding sttategy with low fibre in the diet.

Table 3. Total, tissue and contents wet weight , wet weight % of body mass (BM), dry weight and dry weight % of BM of the gastrointestinal (GI) tract in male reindeer calves fed early harvested first cut timothy silage (*Phleum praténse*) (median and range; n=5). Distal fermentation chamber (DFC) represents the summarised values of caecum and proximal colon.

		Wet weight (g)		Wet weight % of BM		Dry weight (g)		Dty weight % of BM	
GI tract:	Total	6974	(5579-7524)	14.1	(10.7-14.8)				
	Tissue	1639	(1440-1975)	3.3	(3.0-3.8)				
	Contents	5462	(3604-5872)	10.9	(6.9-13.0)	446	(409-607)	1.0	(0.8-1.1)
Reticulo-rumen:	Total	5676	(3860-6066)	11.5	(7.4-12.9)				
	Tissue	1075	(855-1163)	2.0	(1.8-2.2)				
	Contents	4601	(2697-5000)	9.3	(5.2-10.9)	305	(271-465)	0.7	(0.5-0.9)
Omasum:	Total	84	(79-135)	0.2	(0.2-0.3)				
	Tissue	47	(44-65)	0.1	(0.1-0.1)				
	Contents	37	(31-70)	0.1	(0.1-0.1)	7	(5-13)	0.01	(0.01-0.02)
Abomasum:	Total	209	(165-275)	0.4	(0.3-0.5)				
	Tissue	95	(78-122)	0.2	(0.2-0.2)				
	Contents	112	(79-153)	0.2	(0.2-0.3)	17	(12-19)	0.03	(0.02-0.04)
Small intestine:	Total	628	(590-832)	1.3	(1.1-1.6)				
	Tissue	293	(280-412)	0.6	(0.5-0.8)				
	Contents	335	(307-420)	0.7	(0.6-0.8)	47	(46-58)	0.10	(0.09-0.11)
Caecum:	Total	165	(130-278)	0.3	(0.3-0.7)				
	Tissue	36	(31-52)	0.1	(0.1-0.1)				
	Contents	129	(78-234)	0.3	(0.2-0.6)	19	(12-33)	0.04	(0.02-0.08)
Colon:	Total	340	(294-386)	0.7	(0.6-0.7)				
	Tissue	128	(118-161)	0.3	(0.2-0.3)				
	Contents	200	(176-250)	0.4	(0.4-0.5)	38	(34-46)	0.08	(0.07-0.09)
DFC:	Total	307	(270-417)	0.6	(0.5-1.0)				
	Tissue	74	(63-108)	0.2	(0.1-0.2)				
	Contents	244	(162-335)	0.5	(0.3-0.8)	39	(27-49)	0.07	(0.05-0.12)

Heiskari & Nieminen (1992) concluded that long and short term feeding with concentrates affect the absolute and relative sizes of the digestive organs of reindeer calves. When pellered RF-80 concentrate was fed to reindeer calves in winter rumen wet weight content ranged from 8.1-10.9% ofı BM (Mathiesen, S.D., unpubl.). Aagnes & Mathiesen (1996) concluded that teindeer have ability for anatomical Gl-tract adaptation when forage quality change. The constant BM throughout the feeding period in our experiment is used as evidence that EFC timothy silage did not increase the reticulorumen digesta load (Fig. 1a).

Investigation of body composition after slaughtering revealed a good condition of carcass detected by high muscle index and carcass % of BM (Table 2). In reindeer calves from natural pastute in wintet the muscle index tanged from 6.9-8.4 x 10^{-3} g/cm^3, while in reindeer calves fed first cut (FC) fibrous timothy silage and second cut (RG) timothy silage muscle index tanged from 6.5-7.8 x 10^{-3} g/cm^3 and 9.4-12.7 x 10^{-3} g/cm^3 , respectively (Aagnes &

Mathiesen, 1996). In the present study the muscle index values were higher than in earlier studies (Table 2). In addition to positive effects on muscle condition the silage used in the present experiment had also positive effects on liver and kidney fat weights. Weights of kidney fat and liver in reindeer calves fed FC and RG timothy silages were 12 g and 365 g, and 164 g and 671 g, respectively (Aagnes & Mathiesen, 1996). In teindeer calves fed EFC timothy silage the liver weight and kidney fat weight were comparable to those of reindeer calves fed high qualiry RG timothy silage. Taking account that our experiment was carried out in indoor metabolism cages, which restrict enetgy expenditure, the EFC timothy silage obviously enabled high enough feed intake and good utilization of the feed to gain or maintain body reserves (Table 2).

Several studies on feeding reindeer on grass silage have been conducted (e.g. Syrjälä-Qvist, 1982; Nilsson, A., 1994; Aagnes & Mathiesen, 1995; Aagnes *et al.,* 1996), but with results of limited nuttitional values when used as emergency feed for reindeer. Early harvested first cut timothy silage (EFC) used in this trial indicated good suitability in respect of palatability and adequate nutrition of animals. We conclude that EFC silage could be used as emergency feed to reindeer after starvation in winter.

Acknowledgements

This work was supported by the Norwegian Reindeer Research Fund under the auspices of Norwegian Ministry of Agriculture.

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Manuscript received 20 June, 1997
accepted 2 June, 1998