Comparison between grass-silages of different dry matter content fed to reindeer during winter

Anna Nilsson, Ingemar Olsson & Per Lingvall

Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management, Kungsängen Research Center, S-753 23 Uppsala, Sweden.

Abstract: A study was made of whether the dry matter content of silage influenced performance when 17-month-old male reindeer were fed solely silage outdoor during winter. Two kinds of round-baled silages with different wilting times were offered to the animals; low dry matter (LDM silage) with a mean of 39% DM, or high dry matter (HDM silage) with a mean of 53% DM. The 115 reindeer were allotted to slaughter at the start of the experiment in October or to be fed until slaughter in January or March. During the first three weeks of the experiment small amounts of lichens were mixed with the silages and the reindeer adapted to the feeding without problems. The daily intake of DM did not differ significantly between reindeer fed the LDM or the HDM silage despite a highly significant difference in daily silage intake. This resulted in small but significantly higher gains in live weight for animals fed the LDM silage, caused by increased weight of the rumen content. All groups of reindeer either retained or lost carcass weight during the experiment, and no improvements or differences were obtained between the kinds of silages in carcass assessment or gains in fat in the abdominal cavity. Animals slaughtered in January had a lower carcass weight and dressing percentage than reindeer slaughtered in October and March. Environmental conditions during the experiment were good but nonetheless mobbing and illness still occurred. The present results concur with those of earlier studies suggesting that it seems to be the bulk of the ration rather than the dry matter content of the silage that limits the intake.

Key words: *Rangifer tarandus tarandus*, round baled, feed intake, weight gain, dressing percentage.

Rangifer, 16 (1): 21–30

Introduction

Forage in the form of silage and hay is commonly given in addition to concentrate when feeding reindeer. Based on previous experiences, neither hay (Syrjälä-Qvist, 1985) nor silage (Syrjälä-Qvist 1982a; 1982b) are recommended as sole feeds to reindeer, while others (Aagnes *et al.*, 1993; 1994; Moen, 1994; Aagnes & Mathiesen, 1995) have demonstrated that silage served well as sole feed for short feeding periods. One advantage of silage as a feed to reindeer is its moisture content. Reindeer have difficulties in saving water by concentrating the urine during periods of water shortage (Valtonen & Eriksson, 1977). When water supply is limited it is important to have a balanced water and N-intake as excessive N-intake will increase the urinary losses of water (Valtonen, 1979; 1980). The dry matter (DM) content of the silage can be controlled by wilting. Grass of earlier growth stages with higher nutritional value can preferably be preserved as silage rather than hay. This makes it possible to produce feed with fairly high moisture content and nutritional value close to the reindeer herding areas. Obviously, it seemed appropriate to study whether the DM-content of the silage influenced the performance when fed to reindeer.

The purposes of this experiment were to compare silages with different DM contents and to investigate the effect of silage as the sole feed to male reindeer intended for slaughter during the winter.

Material and methods

Animals, feeds and feeding

A total of 115 semi-domesticated male reindeer *(Rangifer tarandus tarandus)*, about 17 months old, were bought from the herd of Vilhelmina Södra at a gathering on October 10, 1993 and were kept in a grazing pen for two days. They were taken by truck to the research station in Vuolda, Arjeplog, about 300 km away on October 13. The station is situated in the coniferous forest area at latitude 66° N. The animals were allowed to graze in one pen of about 6 ha for the first nine days. On October 22 all animals were weighed and divided into two weight classes, < 66 kg (57 animals) and > 66.5 kg with 58 animals. Within the weight classes they were randomly divided into five groups. Eight of the ten groups, each comprising 12 animals, were randomly alloted to the experimental pens and to a silage ration with high (HDM) or low (LDM) dry matter content. Four of the eight groups, balanced for weight class and silage, were randomly assigned to be slaughtered on January 21 and four on March 22. The remaining two groups with 9 "light" and 10 "heavy" animals, respectively, were slaughtered at the start of the experimental period (October 22) in order to record the initial status of the animals.

The area of each experimental pen was about 5000 m^2. Initially, only about one-third of the area was allowed for the reindeer but they were given free access to the whole area after 12 days. During the first three weeks of the experiment the reindeer were given a mixture of lichens (*Cladonia* spp.) and silage. On the first day, 0.4 kg DM lichens and 0.4 kg DM silage were offered per animal. The silage allowances were increased by 0.03 kg DM per animal and day, whereas the lichens were decreased by 0.02 kg DM. After three weeks, the rations solely consisted of silage and the amounts of silage were adjusted in order to obtain about 10 % residues. The silage consisted mainly of grass, meadow-fescue and timothy, with a minor amount of red-clover. Both kinds of silages were made from the same pasture, first-cut growth harvested at the same place and time in Northern Sweden and preserved as plastic-wrapped big bales with 8 layers of plastic. The silage with high dry matter content (HDM) was wilted for 6-7 hours longer in the field than the silage with low dry matter content (LDM). No preservative was added to the grass at ensiling.

The big bales were stored outdoors. After thawing for one day in a temperated room, the silage was cut into pieces with about 10 cm stem-length with a tractor-powered bale shredder. The reindeer were fed twice daily and refusals were removed daily and recorded. The feed was offered in two wooden cribs with a total number of sixteen feeding-places in each pen. The silage was supplemented with 25 g per kg DM of a mineral and vitamin mixture (Mineral Låg, Lactamin, Stockholm, Sweden). Each pen had access to a lick-stone with salt and minerals (Viltsten, AB Hanson & Möhring, Halmstad, Sweden). The animals had free access to temperated water (about 10-18° C).

Chemical analysis

The chemical composition of the silage was analysed from frozen daily samples of the silage fed during one or two weeks. The DM content of the frozen silage was determined by drying samples for 16 h at 65° C followed by 5 h at 105° C and corrected for volatiles (Lingvall & Ericson, unpubl.). This correction is based on the difference between two step drying and toluene distillation followed by Karl Fisher titration of the distillate. The factor found for more than 300 silages was +1.4% units. Ash was determined by heating 2 g dried samples for 2 h at 600° C. Crude protein (CP) was determined by a Kjeldahl technique (Bremner and Breitenbeck, 1983). Ammonia-nitrogen was determined by direct distillation on a Kjeltec Auto System 1030. Metabolisable energy (ME) was calculated from in vitro digestibility, and crude protein digestibility from the (CP) content of DM (Lindgren, 1979). Watersoluble carbohydrates (WSC) were determined in the dried samples. Three g samples were extracted in 100 ml boiling water. Extracts were filtered and hydrolyzed with 0.074 M H_2SO_4 (200 ml extract + 200 ml H_2SO_4, 70 min at 80° C). Glucose and fructose were determined enzymatically (Larsson and Bengtsson, 1983). Silage pH was measured in silage juice by a Methrom 654 pH-meter. The content of neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined as described by Goering & Van Soest (1970).

Outdoor temperature
The outdoor temperature was recorded daily at 10 a.m. from a thermometer placed in the shade. Records of maximum and minimum temperature during the previous 24 hours were made at the same time.

Live weight
All weighings of the animals took place at the same time of the day, starting at 11 a.m. using an electronic scale. At the first weighing session, on October 21, all the animals were weighed and then again on October 22. During the experiment, the live weight (LW) was recorded every two weeks with additional weighings prior to slaughter. The LW at slaughter was estimated from the LW one or two days before slaughter and changes in LW during a three-week period prior to slaughter.

Slaughter
The animals were slaughtered at a specialized reindeer slaughter plant. They were loaded together with their pen-mates and transported by truck for about one hour. Before slaughter they had to wait another one or two hours. After slaughter, the weight of the reticulo-rumen and its content were measured. The kidneys, liver, lungs and heart were examined and weighed. Samples from organs with divergent appearance were examined histologically. The weights of the kidney-knob and the omentum were recorded and their sum is referred to as fat in the abdominal cavity. The carcasses were classified according to the EUROP-system. The carcasses were weighed two days after slaughter (cold weight). The dressing percentages for animals slaughtered in October and January were used to calculate the carcass weight (CW) from LW for animals still in the experiment at those times of the study. The pH-value in *M. longissimus dorsi* was measured two days after slaughter using a KNICK Portamess 651-2 pH-meter (Knick Elektronische Mess-geräte Gmbh & Co, Germany) equipped with a Xerolyte electrode (lot 406 M-6, Ingold Messtechnik AG, Switzerland).

Statistical methods
The statistical analysis was performed using the General Linear Models procedure described by SAS (1988). Differences in nutrient content and quality between the two kinds of silage were tested with Student's *t*-test. All tests concerning animal performance were based on pen averages. When testing for differences in feed intake and gain in live weight and carcass weight the following model, where r_i is the effect of ration (LDM and HDM silage), t_j is the effect of slaughter time (January and March) and e_{ijk} is the random error, was applied:

$$Y_{ijk} = \mu + r_i + t_j + e_{ijk}$$

As there were no real replications and no obvious interactions, the interactions and the effect of weight class were pooled into the error term, which gave a total of 5 df to the error term. Results are presented as means with least significant differences (LSD) for $p=0.05$.

A similar model, where t_j is the effect of slaughter occasion (October, January and March) was applied when testing for differences in the weight of the animals, the fat in the abdominal cavity, the reticulo-rumen and the rumen content and also in the dressing percentage and the pH of *M. longissimus dorsi*. Contrasts were calculated for the effect of initial status compared with status after a feeding period (October *vs.* January and March), effect of time on feeding (January *vs.* March) and for the effect of the DM content of silage (LDM *vs.* HDM).

Results

Nutritional value of the silages
The DM and chemical composition of the silages are presented in Table 1. The mean DM content of the LDM silage, 39 %, was significantly ($p< 0.001$) lower than the DM content of the HDM silage, 53 %. The content of ME in the LDM silage was slightly but significantly ($p< 0.001$) lower than for the HDM silage and the values of CP and digestible CP (DCP) were significantly ($p< 0.001$) higher. The content of WSC was much higher in the HDM silage ($p< 0.05$) but the content of NDF and ADF were similar in the LDM and HDM silage. Both kinds of silage were of good hygienic and preservative quality.

Animal health and behaviour
Two reindeer fell ill and died during the experiment. The first one, that died on November 24, had been fed the HDM silage and belonged to the heavy weight class. The *post mortem* investigation revealed a combined action of different bacterial

Table 1. Dry matter (DM), crude protein (CP), digestible CP (DCP), ash, water soluble carbohydrates (WSC), neutral detergent fibre (NDF), acid detergent fibre (ADF) and metabolisable energy (ME) content and pH and ammonia-N of total nitrogen (TN), as mean ± standard deviation of silages with high dry matter (HDM) and low dry matter (LDM) content.

	LDM-silage	HDM-silage
Number of analysis	16	16
DM, %	38.7±2.4	52.6±3.6
CP, g/kg DM	120±6	106±6
DCP, g/kg DM	81±6	68±6
Ash, g/kg DM	57±3	60±2
WSC, g/kg DM*	76±27	135±21
NDF, g/kg DM*	567±33	540±8
ADF, g/kg DM*	310±19	290±6
ME, MJ/kg DM	11.3±0.2	11.6±0.2
Ammonia-N, g/kg TN	58±8	32±7
pH	5.3±0.2	5.4±0.1

* Based on 5 analyses for each kind of silage.

infections secondary to an infection of herpes virus. The other (fed LDM-silage, light weight class), died on December 27 and the *post mortem* showed starvation in combination with an infection of herpes virus. Five reindeer fell ill from November 26 to December 2, with signs of emaciation and mobbing and had to be excluded for the remaining part of the experiment. Three of the animals were fed HDM silage, two of which belonged to the heavy weight class. Two animals were fed LDM silage and belonged to different weight classes. After feeding for about five weeks in the experiment, all the reindeer in one pen (HDM-silage, heavy weight class) became extremely inert and spent most of the time lying down. The group was moved to another pen that had not previously been used and with better opportunities for digging. After the change of environment the animals became more alert.

Feed intake

The gradual increases of feed allowances during the first weeks of the experiment were followed by a continued increase in feed intake (Fig. 1). After about eight weeks of feeding the feed intake curve slightly decreased and the animals had reached their

Table 2. Number of reindeer per treatment, daily feed and metabolisable energy (ME) intake per animal and daily dry matter (DM) intake per kg live weight (LW) in reindeer fed silage with low (LDM) or high (HDM) dry matter content. Means and least significant difference (LSD) for $p=0.05$

Kind of silage		LDM-silage		HDM-silage		Main effects			
Slaughter time		Jan.	Mar.	Jan.	Mar.	Silage		Slaughter time	
		940121	940322	940121	940322	$p\leq$	LSD	$p\leq$	LSD
Number of animals		22	22	21	24				
Number of groups		2	2	2	2				
Silage, kg:	Start-slaughter	3.30	3.35	2.01	2.21	0.001	0.48	NS	0.48
	931022-940121	3.30	3.20	2.01	1.95	0.002	0.52	NS	0.52
	940122-940322	–	3.58	–	2.60	NS	1.28	–	–
DM, kg:	Start-slaughter	1.23	1.32	1.09	1.19	NS	0.18	NS	0.18
	931022-940121	1.23	1.20	1.09	1.05	NS	0.19	NS	0.19
	940122-940322	–	1.51	–	1.39	NS	0.54	–	–
DM, g/kg LW:	Start-slaughter	18.7	19.4	16.9	18.8	NS	1.6	NS	1.6
	931022-940121	12.6	11.8	11.3	11.0	NS	1.1	NS	1.1
	940122-940322	–	14.8	–	14.8	NS	1.4	–	–
ME, MJ:	Start-slaughter	13.8	15.0	12.5	13.7	NS	2.1	NS	2.1
	931022-940121	13.8	13.5	12.5	12.1	NS	2.2	NS	2.2
	940122-940322	–	17.2	–	16.3	NS	6.2	–	–

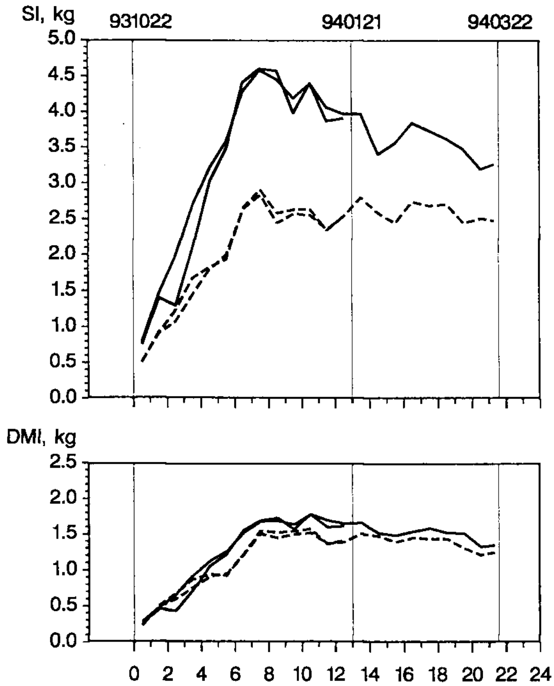

Fig.1. Daily silage intake (SI) and dry matter intake (DMI), respectively, of reindeer fed silage with high (-----) or low (——) dry matter content. The slaughter occasions are indicated by vertical lines.

maximum intake of silage. The daily intake of the LDM silage was significantly higher in the first period of the experiment from October to January and for the entire experimental period (Table 2). In the latter period of the experiment, from January to March, the intakes of silage were not significantly different. However, the daily intakes of silage DM or ME were only slightly, but not significantly, higher in animals fed the LDM silage (Table 2).

Gain and losses in live weight and carcass weight

There were no significant differences in mean LW between the treatments at the start of the experiment (Table 4). The reindeer fed the LDM silage had a daily LW gain of ca 80 g during the first five weeks of the experiment when the silages were gradually introduced to the animals (Fig. 2). This was more than the animals fed the HDM silage, which gained ca 10 g per day. Until January, the animals fed the HDM silage lost LW whereas the reindeer fed the LDM silage maintained their LW (Fig. 2 and Table 3). The difference between the silages was significant. The weights of the carcasses in January were less than in March or October (Table 4). Both the group fed the LDM silage and the group fed the HDM silage lost CW during the experiment, but there was no significant difference in the losses between the two kinds of silage (Table 3). The losses were greatest from October to January. No significant differences in dressing percentage between reindeer fed the LDM or the HDM silage were found (Table 4). The dressing percentage of the reindeer slaughtered in January was, on average, about 43 %, which was significantly lower than the 47 % obtained in October and March (Table 4).

Reticulo-rumen and its content

The weight of the reticulo-rumen and its content per kg CW were not significantly different between animals fed the LDM or the HDM silage. The reindeer slaughtered in January and March had significantly higher weight of the reticulo-rumen content than animals slaughtered at the start of the experiment in October. In the comparison between reindeer slaughtered in January or March the reticulo-rumen content was significantly heavier in January (Table 4). The relative weights of the reticulo-rumen and its content from reindeer in different weight classes were similar.

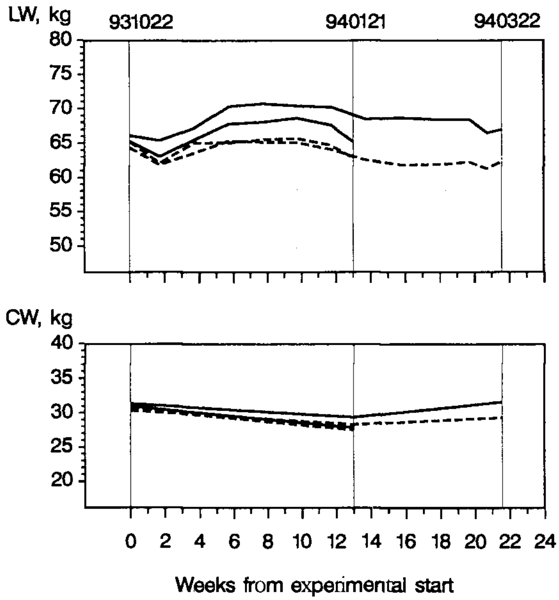

Fig. 2. Developmenr of live weight (LW) and carcass weight (CW), respectively, for reindeer fed silage with high (-----) or low (——) dry matter content. The slaughter occasions are indicated by vertical lines.

Table 3. Number of reindeer per treatment, live weight gain (LWG) and carcass weight gain (CWG) for reindeer fed silage with low (LDM) or high (HDM) dry matter content. Means and least significant difference (LSD) for p=0.05

Kind of silage		LDM-silage		HDM-silage		Main effects			
Slaughter time		Jan.	Mar.	Jan.	Mar.	Silage		Slaughter time	
		940121	940322	940121	940322	$p\leq$	LSD	$p\leq$	LSD
Number of animals		22	22	21	24				
Number of groups		2	2	2	2				
LWG, g/day:	Start-slaughter	0	5	-25	-13	0.02	12	NS	12
	931022-940121	0	31	-25	-13	0.0002	7	0.005	7
	940122-940322	–	-35	–	-12	0.003	2	–	–
CWG, g/day:	Start-slaughter	-35	1	-32	-8	NS	14	0.004	14

Fat in the abdominal cavity

The amount of fat in the abdominal cavity per kg CW did not differ significantly between animals fed the LDM or the HDM silage or between different slaughter occasions (Table 4). The relative amounts of fat were similar in the weight classes.

Kidneys, liver, lungs and heart

The absolute weights of the liver, the kidneys, the lungs and the heart or related to kg CW from reindeer fed the LDM or the HDM silage did not differ significantly. Neither did the relative weights of the organs compared between weight classes show significant differences. As a mean for all animals the relative weights of liver, kidneys, lungs and heart were 27.6, 5.5, 24.5 and 17.8 g/kg CW respectively. Histological examination of 14 kidneys, 6 livers and 4 lungs with divergent appearance showed that the injuries were caused by healed parasite attacks and thus did not appear to be caused by the handling or feeding.

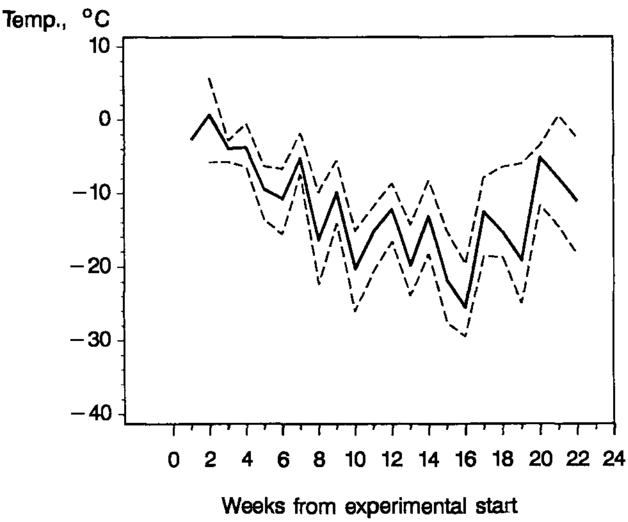

Fig.3. Weekly means of outdoor temperature (°C) recorded at 10 a.m. (——), and minimum and maximum (-----) temperature during the experimental period with reindeer fed silage out-doors at the research station in Vuolda, Arjeplog.

Carcass assessment

No differences were found in the classification of carcasses between reindeer fed the LDM or the HDM silage. Most of the carcasses were classified as class "O". All carcasses were estimated in the lowest fat-group, 02. The ultimate pH-value of the *longissimus dorsi* was not found to be significantly different in reindeer fed either the LDM or the HDM silage or between the weight classes (Table 4).

Outdoor temperature

During the experimental period, the outdoor temperature at 10 a.m. varied between -31.8° C and 5.0° C, with the lowest temperatures in December, January and February (Fig. 3). The minimum daily temperature was usually 5 to 10 degrees lower.

Discussion

A previous experiment had showed that silage was unsatisfactory as a sole feed when fed to reindeer calves (Nilsson, 1994). Thus, it seemed suitable to use older animals with a fully developed rumen in investigations of the influence of the DM content of silage. The choice fell on 17-month-old male reindeer as these animals still had the capacity to grow and had probably not lost as much weight during the rut period as older animals.

Table 4. Number of reindeer per treatment, live weight at start and slaughter, carcass weight (CW) and slaughter data for reindeer at start of experiment (October) and for reindeer fed silage with low (LDM) or high (HDM) dry matter content until slaughter in January or March. Fat in the abdominal cavity is the sum of the kidney-knob and the omentum. Means and least significant difference (LSD) for p=0.05

Kind of silage		LDM-silage		HDM-silage		LSD	Contrasts		
Slaughter time	Oct. 931022	Jan. 940121	Mar. 940322	Jan. 940121	Mar. 940322	p=0.05	LDM *vs* HDM $p\leq$	Oct *vs* Jan., Mar. $p\leq$	Jan. *vs* Mar. $p\leq$
Number of animals	19	22	22	21	24				
Number of groups	2	2	2	2	2				
Live weight at start, kg	66.7	65.4	65.7	65.7	64.3	2.1	NS	NS	NS
Live weight at slaughter, kg	66.7	65.4	66.5	63.4	62.4	2.1	0.005	0.02	NS
CW, kg	31.6	27.8	31.4	28.2	29.3	2.5	NS	0.03	0.02
Dressing percentage	47.4	42.5	47.4	44.4	47.2	3.8	NS	NS	0.02
Content in reticulo-rumen, g/kg CW	215	436	312	363	327	54	NS	0.0007	0.004
Tissue of reticulo-rumen, g/kg CW	48	56	45	54	47	10	NS	NS	0.02
Kidney-knob, g/kg CW	2.4	3.9	3.6	4.6	2.7	1.2	NS	0.02	0.02
Fat in the abdominal cavity, g/kg CW	6.5	7.1	8.0	8.1	5.9	2.7	NS	NS	NS
pH, *M. longissimus dorsi*	5.63	5.69	5.66	5.67	5.69	0.14	NS	NS	NS

The daily DM intake was not affected by the DM content of silage and none of the treatments led to gained CW or abdominal fat weight. The reindeer spent most of the daytime around the feeding place and always seemed hungry when new silage was offered, although the feed was offered with 10 % residues. These results and results from earlier experiments (Syrjälä-Qvist 1982a; 1982b; Aagnes *et al.*, 1994; Moen, 1994; Nilsson, 1994, Aagnes & Mathiesen, 1995) indicate that reindeer have a limited capacity to digest silage in such large amounts as those required. As no significant differences were found in the weights of the reticulo-rumen or its content between reindeer fed the LDM or the HDM silage, it would appear that it is not the DM content of the silage that limits the intake but rather the DM intake and the capacity of the rumen. This is in agreement with the assumption by Syrjälä-Qvist & Salonen (1983) that the bulk of ration may be the factor limiting forage intake by reindeer. Since the reindeer are known to be very selective in their choice of plants (Jacobsen & Skjenneberg, 1979; Trudell & White, 1981), it was important for the evaluation of the silages that the amount of residues was kept to about 10 %. This amount of residues strongly restricted the possibility for the animals to select freely. A higher percentage of residues might have given the reindeer the possibility to select more nutritious parts of the silage and thus influence the digestibility and the rate of outflow from the rumen.

The results from the three slaughter occasions showed that the length of the feeding period and possibly the time of year were of importance. From the start of the experiment in October until slaughter in January the reindeer hardly maintained their LW and lost CW. The difference between the gains in LW and CW can mainly be explained by the increased weight of the rumen content. This also explains the lower dressing percentage in January compared with the other two slaughter occasions. In the second part of the experiment, from January to March, the reindeer lost LW and weight of the rumen content, but increased their CW. These data are in agreement with the results by Aagnes & Mathiesen (1995) and clearly illustrate that it is very important that a gain in LW is not necessarily understood as a gain in C.W. It should be stressed that the gains and losses in C.W in the present experiment were small and that the carcasses had about the same weight at the start in October as in March. Since there were no differences in carcass assessment between the thtee slaughtering occasions it is hard to see any economic profit from this type of feeding. Instead, the successful period of adaptation may be interpreted as a positive experience of the experiment. Reindeer in earlier experiments suffered problems during the first three weeks of feeding (e. g. Jacobsen & Skjenneberg, 1979; Rognmo & Bye, 1990). The reindeer in the present experiment started to eat the silage and lichen mixture without delay and there were no signs of ill-health during the first five weeks of feeding. These results are in agreement with earlier experiments with individually silage-fed reindeer kept indoors (Aagnes *et al.*, 1993; 1994; Moen, 1994) and out-doors (Aagnes & Mathiesen, 1995).

Although loss of LW and body fat reserves during the winter is normal for reindeer under natural conditions when access to pasture is restricted (e.g. Ryg & Jacobsen, 1982; Larsen *et al.*, 1985), gains in LW have been recorded in experiments (Åhman, 1996). Gains in LW during the winter period are also observed when reindeer are fed commercial pelleted feeds in order to reduce the activity of ^{137}Cs in their body mass prior to slaughter (Åhman, pers. comm.). The failing gain in LW, C.W and abdominal fat despite the good environmental conditions during the present experiment therefore must be considered. The reindeer were kept in small groups of animals with about the same body size and had access to about 400 m^2 per animal. Nonetheless mobbing among the animals still occurred and in some cases the mobbed reindeer became emaciated and ill. The competition for feed would probably be harder in a conventional feeding situation with a larger group of animals and with greater variation in body size, age and sex. It may be especially difficult for low-ranked animals to get enough time at the feeding place. In this aspect, the silage has limitations since the reindeer needs to spend so much time eating.

The outdoor temperature recorded during the experiment reflected an average winter in this area of Sweden (Alexandersson *et al.*, 1991). No severe problems with handling of either of the two kinds of silage were observed. However, the possibilities to thaw and store the silage indoors certainly facilitated the handling, especially with the LDM silage. Since the silage rations were divided into two feedings per day, the reindeer were offered thawed silage continuously and problems with frozen feed in the cribs were avoided.

Animal health during the experiment was stable, with the exception of a period from five to eight weeks from the start of feeding. The veterinarians consulted could not explain the apathy of some reindeer during this period. Earlier investigations have demonstrated that herpes virus may develop and break out in animals under stress (Rockborn *et al.*, 1990). Deprivation of food, mobbing among the animals, or difficulties to adapt to life in a pen may act as stressors. Since the reindeer in this experiment developed clinical signs of herpes virus infection, this may indicate that the animals were not in a sufficiently good condition.

Based on Moen (1973), Åhman (1977) calculated the daily maintenance requirements for a reindeer of 65 kg LW to 11 MJ ME. The reindeer in the present experiment, reasonably, had limited expenses for energy since they had free access to temperated water and thus were spared from eating and melting snow. Neither were they forced to dig or walk to obtain feed. Still, they did not gain C.W or increase the amount of fat in the abdominal cavity, although their ME intake was clearly above the estimated maintenance requirements. A possible explanation might be that the content of ME in the silages as calculated for cows and sheep (according to the VOS method) is overestimated for reindeer.

From this experiment it was concluded that the DM content of the investigated silage did not influence performance when fed as the sole feed to 17-month-old reindeer with free access to water during winter. The length of the feeding period affected the results in feed intake and body composition. Thus, in agreement with earlier investigations, silage cannot be recommended as the sole feed to fattening reindeer in winter, but it has advantages during the first period of feeding and may serve as a good complement to concentrate feeds.

Acknowledgements

We greatly appreciate the help of Professor Rehbinder and his staff at the National Veterinary Institute (SVA) for fruitful discussions and advice and for histological investigations. We also wish to thank the Division of Meat Science of the Department of Food Science for lending us the pH-equipment. This work was supported by grants from the Swedish Council for Forestry and Agricultural Research, the Saami foundation, the Swedish Board of Agriculture and the County administrations of Z-, AC- and BD counties.

References

Aagnes, T. H., Olsen, M. A. & Mathiesen, S. D. 1993. Utprøvning av rundballeensilert silo som krisefôr til rein. – *Reindriftsnytt* 1: 18–20 (In Norwegian).

Aagnes, T. H., Olsen, M. A. & Mathiesen, S. D. 1994. Digestive limitations in reindeer fed timothy silage. – *In: Proceedings of the Society of Nutrition Physiology,* p. 209. Edited by D. Giesecke. Willingen, Germany.

Aagnes, T. H. & Mathiesen, S. D. 1995. Round baled grass silage as food for reindeer in winter. – *Rangifer* 15 (1): 27-35.

Alexandersson, H. K., Karlström, C. & Larsson-McCann, S. 1991. Temperature and precipitation in Sweden 1961–90. Reference normals. – *Meterologi 81, SMHI,* Norrköping, 88 pp.

Breimner J.M. & Breitenbeck, G.A. 1983. A simple method for determination of ammonium in semimicro Kjeldahl analysis of soils and plant materials using block digester. – *Communication in Soil and Plant Analysis* 14: 905-913.

Goering, H. K. & Van Soest, P. J. 1970. Forage Fibre Analysis. *USDA Agricultural Research Service Handbook,* Nr 379.

Jacobsen, E. & Skjenneberg, S. 1979. Experiments with different diets to reindeer – feeding value of reindeer feed (RF-71). – *Meldinger fra Norges landbrukshøgskole* 34 (58): 1–11 (In Norwegian with English Summary).

Larsen, T. S., Blix, A. S., Nilssen, K. J. & Belfrage, P. 1985. Mechanisms involved in fat mobilization during winter in reindeer. – *Acta Physiol Scand.* 124 suppl., 542: 50.

Larsson, K. & Bengtsson, S. 1983. Determination of non structural carbohydrates in plant material. – *Method description no. 22, National Laboratory for Agricultural Chemistry, Uppsala.* (In Swedish).

Lindgren, E. 1979. The nutritional value of roughages determined in vivo and by laboratory methods. – *Report 45, Swedish University of Agricultural Sciences, Department of Animal Nutrition,* Uppsala (In Swedish with English Summary).

Moen, A. N. 1973. *Wildlife Ecology – an analytical approach.* Cornell University. 458 pp.

Moen, R. 1994. *Cellulose fordøyelse i vom og blindtarm hos reinkalver* (Rangifer tarandus tarandus) *føret ensilert og tørket timotei* (Phleum pratense). – Hoveduppgave (Cand. Agric.) i Husdyrfag (In Norwegian). 38 pp.

Nilsson, A. 1994. *Feeding of reindeer during the winter – performance of reindeer calves fed silage diets and silage-based diets.* – Examensarbere Nr. 60, Sveriges Lantbruksuniversitet, Institutionen för husdjurens utfodring och vård, Uppsala. 60 pp (In Swedish with English Summary).

Rockborn, G., Rehbinder, C., Klingeborn, B., Leffler, M., Klintevall, K., Nikkilä, T., Landén, A. & Nordkvist, M. 1990. The demonstration of a herpesvirus, related to bovine herpesvirus 1, in reindeer with ulcerative and necrotizing lesions of the upper alimentary tract and nose. – *Rangifer,* Special Issue No. 3: 373–384.

Rognmo, A., & Bye, K. 1990. Palatability of two artificial feeds for reindeer. – *Rangifer,* Special Issue No 4: 61–62.

Ryg, M. & Jacobsen, E. 1982. Seasonal changes in growrh rate, feed intake, growth hormone, and thyroid hormones in young male reindeer (Rangifer tarandus rarandus). – *Can. J. Zool.* 60: 15–23.

SAS. 1988. *SAS/STAT User's Guide* Release 6.03 Edition. SAS Institute, Inc., Cary, N.C. 1028 pp.

Syrjälä-Qvist, L. 1982a. Comparison of grass silage utilization by reindeer and sheep. 1. Palarability, feeding values and nutrient supply. – *J. Scient. Agric. Soc. Finl.* 54: 119–126.

Syrjälä-Qvist, L. 1982b. Comparison of grass silage utilization by reindeer and sheep. 2. Rumen fermentation and rumen microbiota. – *J. Scient. Agric. Soc. Finl.* 54: 127–135.

Syrjälä-Qvist, L. 1985. Hay as the feed for reindeer. – *Rangifer* 5(2): 2–5 (In Swedish with English Summary).

Syrjälä-Qvist, L. & Salonen, J. 1983. Effect of protein and energy supply on nitrogen utilization in reindeer. – *Acta Zool. Fenn.* 175: 53–55.

Trudell, J. & White, R. G. 1981. The effect of forage structure and availability on food intake, biting rate, bite size and daily eating time of reindeer. – *Journal of Applied Ecology.* 18: 63–81.

Valtonen, M. H. 1979. Renal responses of reindeer to high and low protein diet and sodium supplement. – *J. Scient. Agric. Soc. Finl.* 51: 387–419.

Valtonen, M. H. 1980. Effects of dietary nitrogen and sodium chloride content on water intake and urine excretion in reindeer. *In: Proceedings of the 2nd International Reindeer and Caribou Symposium,* p. 274–277. Edited by Reimers, E., Gaare, E., Skjenneberg, S. Direktoratet for vilt og ferskvannsfisk, Trondheim.

Valtonen, M. & Eriksson, L. 1977. Responses of reindeer to water loading, water restriction and ADH. – *Acta Physiol.* Scand. 100: 340–346.
Åhman, G. 1977. *Renens energibalans under svåra vinterförhållande.* – Stencil, Sveriges Lantbruksuniversitet, Uppsala. 12 pp (In Swedish).
Åhman, B. 1996. Effect of bentonite and ammonium-ferric(III)-hexacyanoferrate(II) on uptake and elimination of radiocaesiun in reindeer. – *Journal of Environmental Radioecology.* (in press).

Manuscript received 15 July, 1995
accepted 15 February, 1996