Gross anatomy of the gastrointestinal tract in reindeer, free-living and fed baled timothy silage in summer and winter

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Abstract: The gross anatomy of the gastrointestinal (GI) tract was investigated in reindeer calves (*Rangifer tarandus tarandus*), free-living and fed two different qualities of timothy silage in September 1992 (summer) and April 1993 (winter) and related to the body condition. At both seasons nine male reindeer calves were taken from a natural pasture. Three animals were slaughtered directly (NP reindeer), three offered first cut (FC) silage and three regrowth (RG) silage *ad lib.*, for 46 days. The FC silage contained 27 % leaves and 57.8 % dry matter (DM) cell wall content (CWC) and the RG silage 89 % leaves, and 38.7 % DM CWC. The reticulo-rumen (RR) digesta wet weight in the NP reindeer in summer was 6.7-7.7 % of body mass (BM), compared to 25.1-32.8 % and 9.6-12.9 % of BM, respectively, in the animals fed FC and RG silage. In winter the RR digesta wet weight relative to BM in the NP reindeer and in the animals fed FC and RG silages were 9.5-11.5 %, 25.4-33.3 % and 10.4-18.3 %, respectively. The distal fermentation chamber (DFC) digesta wet weight in the NP animals in summer was 0.48-0.80 % of BM, compared to 0.77-1.26 % and 0.57-0.65 % of BM, respectively, in the animals fed FC and RG silage. In winter the DFC digesta wet weight relative to BM in the animals fed FC and RG silage did not differ significantly from the summer values ($P>0.05$), while in the NP reindeer it was 1.0-1.2 % of BM which is significantly greater than in summer ($P\leq0.05$). The differences in relative weight of the fermentation chambers between the animals fed FC and RG silage both summer and winter were not reflected in total BM, which was similar in all groups fed silage. This is explained by a significantly lower carcass weight in the animals fed FC silage compared to the animals fed RG silage. Thus, the GI-tract gross anatomy in the silage fed animals seem to be highly affected by the plant structure and composition, and not by the season.

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Key words: *Rangifer*, grass silage, rumen fill, body condition.

Introduction

In ruminants there are variations in the capacity of the gastrointestinal (GI) tract, which is highly influenced by the amount, structure and the chemical composition of the food eaten (Hofmann & Stewart, 1972; Hofmann, 1989). In both grass and roughage eaters (GR) like sheep and intermediate opportunistic, mixed feeders (IM) like goats, living on a thornbush savannah in tropical Africa the forestomach fluid volume increased during the dry season when the plants available contained much fibre, compared to the green season when the plants available contained more digestible energy (Lechner-Doll *et al.*, 1990). The forestomach volume increased in sheep 55% compared to 29% in the goats reflecting the ability of GR to retain food particles in the forestomach to improve fibre digestion when feed quality is low. IM ruminants select a diet of high nutritive value as long as possible. An exceptionally large rumen fluid weight (31.6% of body mass (BM)) was found in sheep fed wheat straw and concentrates. These sheep could eat plenty of poor roughage and at the same time retain it in the rumen long enough for thorough digestion (Weyreter *et al.*, 1987).

Reindeer are classified as IM based on their ability to adjust to different diets, but with limitations to utilise fibrous grasses (Hofmann 1985, 1989; Aagnes *et al.*, in press *J. Agric. Sci.*). Semi-domesticated reindeer (*Rangifer tarandus tarandus*) in northern Norway select a mixed diet of vascular and woody plants of high quality in summer and in winter they include a substantial proportion of lichens and fibrous plants (S. D. Mathiesen, unpubl.). In winter, the pastures are covered by snow and in some areas the snow may be so deep and hard that it reduces the access to the plants beneath. In such situations emergency food is needed to ptevent loss of animals. The reindeers natural ability to adapt to different diets during the year may increase the animals ability to utilise grass as emergency food. When round bale silage of mixed grasses have been used as emergency food to previously lichen-fed and starved reindeer in winter, the reticulo-rumen (RR) digesta load was 19.6-23.7% of BM (Aagnes & Mathiesen, 1995), compared to 13.5% of BM in adult female reindeer feeding on summer pasture in Norway (Staaland *et al.*, 1979). It is not clear how much the GI-tract capacity in reindeer is genetically determined and how much it is influenced by the season, plant structure and composition. In this study we have investigated to what extent intake of high and low fibrous grass silage affect the GI-tract gross anatomy in reindeer both summer and winter and how GI-tract fill influence on body weight and body condition.

Materials and Methods

Animals and experimental procedure

Free living male reindeer calves (n=9), from a private herd kept on a natural pasture in northern Norway (68°N, 17°E) were rounded up in September 1992 (summer; age five months; BM 40.0 to 48.0 kg) and April 1993 (winter; age 11 months; BM 34.0 to 40.5 kg) and taken to Department of Arctic Biology, University of Tromsø, for studies of the GI-tract anatomy and the body condition. At both seasons, three animals were killed directly (NP reindeer) after arrival, three were offered first cut timothy (FC) silage harvested 10th July and three regrowth timothy (RG) silage harvested 24th August *ad. lib.*, for 46 days. The FC silage contained 27% leaves and 57.8% dry matter (DM) cell wall content (CWC) and the RG silage 89% leaves, and 38.7% DM CWC (Table 4, Aagnes *et al.*, in press *J. Agric. Sci.*). The silage fed animals were placed in a light and temperature regulated room where they were exposed to a natural photoperiod allowing expression of their normal seasonal appetite (Larsen *et al.*, 1985), and the temperature were kept between 0 and +5°C in both seasons. They were housed in metabolism cages (60 cm wide x 140 cm long x 96 cm high) offered silage and water twice a day in plastic tubs. On day 7 and 12 of the feeding period the animals were treated with albendazol. (Valbazen vet.® Smith Kline Beecham, plc, England) and fenbendazol (Panacur® Hoechst Veterinär, GmbH, München, Norske Hoechst a/s, Økern, Oslo), to clean the gastrointestinal system for parasites. At the end of the feeding period the animals were killed at the same time of the day. After killing all the animals were eviscerated, and the GI-tract removed and divided into six sections: reticulo-rumen, omasum, abomasum, small intestine (from the abomasum to the junction with the ceacum/colon), ceacum (the appendix from the junction with the small intestine) and colon (from the junction with the small intestine to the anus). Each section of the tract was emptied by squeezing the contents out by hand, and representative subsamples of the digesta were taken and dried at 100 °C to constant weight to determine dry matter (DM). The distal fermentation chamber (DFC) was defined as the combination of the digesta and tissue of the ceacum and proximal colon and the large intestine as the combination of the digesta and tissue of the ceacum and colon. One of the animals (no. 20), which was fed FC silage in winter, lost muscle mass at an abnormal rate and was therefore slaughtered after 25 days.

BM was measured to 1.0 kg using an electronic scale (Farmer Tronic, Give, Denmark) once a week in the animals fed silage before feeding in the morning and in all the animals at slaughtering. Carcass weight and rumen tissue and digesta weight were measured to 0.1 kg, by using a spring balance. The muscles *M. gluteobiceps*, *M. semitendinosus*, kidney fat, liver, tissue and digesta wet weight from the different sections of the GI-tract were measured to 1 g using an electronic scale (Sartorius, GMBH, Göttingen, Germany). The muscle index was calculated from dry weight of M. *gluteobiceps* (g) divided by femur length (cm^3) (Tyler, 1987). To determine muscle dry weight one subsample of the muscles were dried at 70°C to constant weight. The jaw (not including the front teeth) and femur length were measured to 1.0 mm. The digestive energy intake (DEI), nitrogen (N) balance and rumen fermentation in the animals fed FC and RG silage both summer and winter were investigated (Aagnes *et al.*, 1994; Aagnes *et al.*, in press *J. Agric. Sci.*).

Statistical methods

The results are present as median and range. The Wilcoxen rank-sum test for comparing two treatments was used when comparing values between the groups of animals (Johnson & Bhattacharyya, 1992). The null hypothesis was rejected at $P \leq 0.05$.

Results

The gastrointestinal tract gross-anatomy

The RR digesta wet weight in the NP reindeer in summer was 6.7-7.7% of BM, compared to 25.1-32.8% and 9.6-12.9% of BM, respectively, in the animals fed FC and RG silage. In winter the RR digesta wet weight relative to BM in the NP reindeer and in the animals fed FC and RG silages were 9.5-11.5%, 25.4-33.3% and 10.4-18.3%, respectively. In the NP reindeer and in the animals fed FC and RG silage in summer the RR digesta wet weight of total Gl-tract digesta wet weight (GIDW) were 71.4-76.3%, 87.0-90.7% and 80.4%-81.2%, respectively (Table 1). In winter the RR digesta wet weight relative to GIDW in the different groups of reindeer, did not differ significantly from the summer values ($P>0.05$). In summer the total RR digesta dry weight in the NP reindeer and in the animals fed FC and RG silage were 342-507g, 942-1051g and 351-633g, respectively (Table 2). In winter the total RR digesta dry weight in the animals fed FC and RG silage did not differ significantly from summer values ($P>0.05$), while in the NP reindeer the total RR dry weight was significantly greater than the summer value (590-933g) (Ws= 15, n_1 and n_2 = 3, $P \leq 0.05$). In summer the RR tissue wet weight in the NP reindeer was 34.4-42.7% of total GI-tract tissue wet weight (GITW) compared to 61.3-64.2% and 55.7-64.6% of GITW, respectively in the animals fed FC and RG silage (Table 1). In winter the RR tissue wet weight relative to GITW in the animals fed FC and RG silage did not differ significantly from the summer values ($P>0.05$), while in the NP reindeer it was 59.2-62.5% of GITW and significantly greater than the summer value (Table 1; Ws= 15, n_1 and n_2 = 3, $P \leq 0.05$)

In the NP reindeer in summer the digesta wet weight and tissue wet weight of omasum amounted to 0.86-1.7% of the GIDW and 3.5-4.6% of the GITW, respectively, and did not differ significantly from values in the animals fed FC and RG silage ($P>0.05$) (Table 1). In winter the omasum digesta wet weight relative to GIDW, and omasum tissue wet weight relative to GITW in the NP reindeer were 1.9-2.1% and 5.2-7.2%, respectively, and significantly greater than the values from the NP reindeer in summer and the animals fed FC and RG silage both summer and winter (Table 1; Ws= 15, n_1 and n_2 = 3, $P \leq 0.05$).

The abomasum digesta wet weight of GIDW in the NP reindeer and in the animals fed FC and RG silage in summer were 1.0-1.7%, 1.4-2.2% and 1.5-2.9%, respectively (Table 1). In winter the abomasum digesta wet weight relative to GIDW in the three groups of animals, did not differ significantly from summer values (P>0.05). The abomasum tissue wet weight of GITW in the NP reindeer and in the animals fed FC and RG silage in summer were 4.9-6,4%, 4.9-6.4% and 4.8-5.6%, respectively (Table 1). In winter the abomasum tissue wet weight of GITW in the animals fed FC silage and in the NP reindeer were not significantly different from the summer values, while in the animals fed RG silage it was 5.9-6.1% of GITW and significantly greater than the summer value (Table 1; Ws= 15, n_1 and n_2 = 3, $P \leq 0.05$).

The small intestine digesta wet weight in the NP reindeer was 13.3-13.9% of GIDW in summer, compared to 3.2-5.0% and 8.5-9.2% of GIDW in the animals fed FC and RG silage, respectively (Table 1). The small intestine tissue wet weight in the NP reindeer, and in the animals fed FC and RG silage were 34.1-43.8%, 17.4-20.5% and 19.4-26.4% of GITW, respectively (Table 1). In winter the small intestine digesta wet weight relative to GIDW and the tissue wet weight relative to GITW in the FC and RG silage fed animals did not differ significantly from the summer values ($P>0.05$), while in the NP reindeer both the digesta wet weight and the tissue wet weight were significantly smaller than in summer (Table 1; Ws= 6, n_1 and n_2 = 3, $P \leq 0.05$).

The DFC digesta wet weight in the NP reindeer in summer was 0.48-0.80% of BM, compared to

Table 1. Body mass, digesta and tissue wet weight (g) of the gastrointestinal (GI) tract of reindeer from summer and winter pasture fed first cut and regrowth baled timothy (*Phleum pratense*) silage (median and range; n=3).

		Reindeer from summer pasture			Reindeer from winter pasture		
		From pasture	Fed first cut timothy	Fed regrowth timothy	From pasture	Fed first cut timothy	Fed regrowth timothy
Body mass:		45000 (42500-48000)	46000 (44000-49500)	47000 (43500-50000)	38000 (34000-39500)	44500 (41000-49000)	47000 (46000-48000)
GI tract:	Total	6280 (5564-6844)	15296 (15027-18618)	8801 (7209-9167)	6315 (6242-7167)	15303 (12982-19532)	9435 (7469-11664)
	Tissue	1733 (1600-1757)	1870 (1632-2041)	1707 (1667-1859)	1469 (1281-1520)	1708 (1403-2014)	1546 (1498-1639)
	Digesta	4523 (3964-5111)	13664 (12986-16748)	6942 (5542-7460)	4961 (4795-5698)	13289 (11579-17824)	7796 (5971-10118)
Reticulo-rumen:	Total	4350 (3400-4200)	13400 (12600-16300)	6800 (5500-6950)	4700 (4500-5300)	13400 (11250-17400)	7350 (5800-9750)
	Tissue	700 (550-750)	1200 (1000-1300)	1000 (950-1200)	850 (800-900)	975 (850-1100)	975 (950-1000)
	Digesta	3450 (2850-3650)	12400 (11300-15100)	5600 (4500-6000)	3900 (3600-4400)	12300 (10400-16300)	6400 (4800-8800)
Omasum:	Total	101 (90-165)	153 (121-222)	116 (100-124)	200 (160-220)	150 (82-174)	70 (64-95)
	Tissue	61 (56-80)	63 (45-71)	61 (60-62)	101 (67-106)	63 (43-72)	51 (45-55)
	Digesta	40 (34-85)	108 (58-151)	54 (40-62)	99 (93-114)	87 (39-102)	30 (19-40)
Aboma-sum:	Total	153 (150-162)	375 (265-400)	275 (165-290)	166 (150-216)	268 (193-356)	251 (224-314)
	Tissue	100 (86-103)	116 (80-120)	90 (80-95)	72 (67-76)	93 (86-105)	92 (91-97)
	Digesta	63 (50-76)	255 (185-284)	180 (85-200)	90 (83-144)	175 (107-251)	159 (133-217)
Small intestine:	Total	1250 (1200-1320)	860 (820-1020)	1000 (820-1140)	655 (528-688)	785 (773-939)	836 (825-1017)
	Tissue	620 (600-700)	335 (325-375)	360 (350-450)	213 (196-272)	272 (224-605)	286 (200-346)
	Digesta	600 (550-700)	535 (458-645)	640 (470-690)	416 (332-442)	501 (334-561)	636 (539-671)
Ceacum:	Total	250 (200-300)	275 (235-490)	210 (200-220)	300 (213-311)	289 (200-378)	238 (141-251)
	Tissue	39 (31-42)	24 (19-32)	31 (27-36)	23 (20-25)	25 (23-26)	25 (24-39)
	Digesta	219 (158-261)	256 (211-458)	173 (164-189)	277 (193-286)	177 (174-352)	199 (117-226)
Colon:	Total	421 (417-559)	455 (440-510)	400 (395-482)	461 (425-531)	414 (380-475)	421 (371-550)
	Tissue	194 (160-218)	148 (130-160)	121 (120-139)	148 (126-158)	145 (142-150)	149 (131-152)
	Digesta	261 (199-365)	325 (292-350)	275 (261-361)	313 (299-373)	264 (235-333)	240 (269-401)

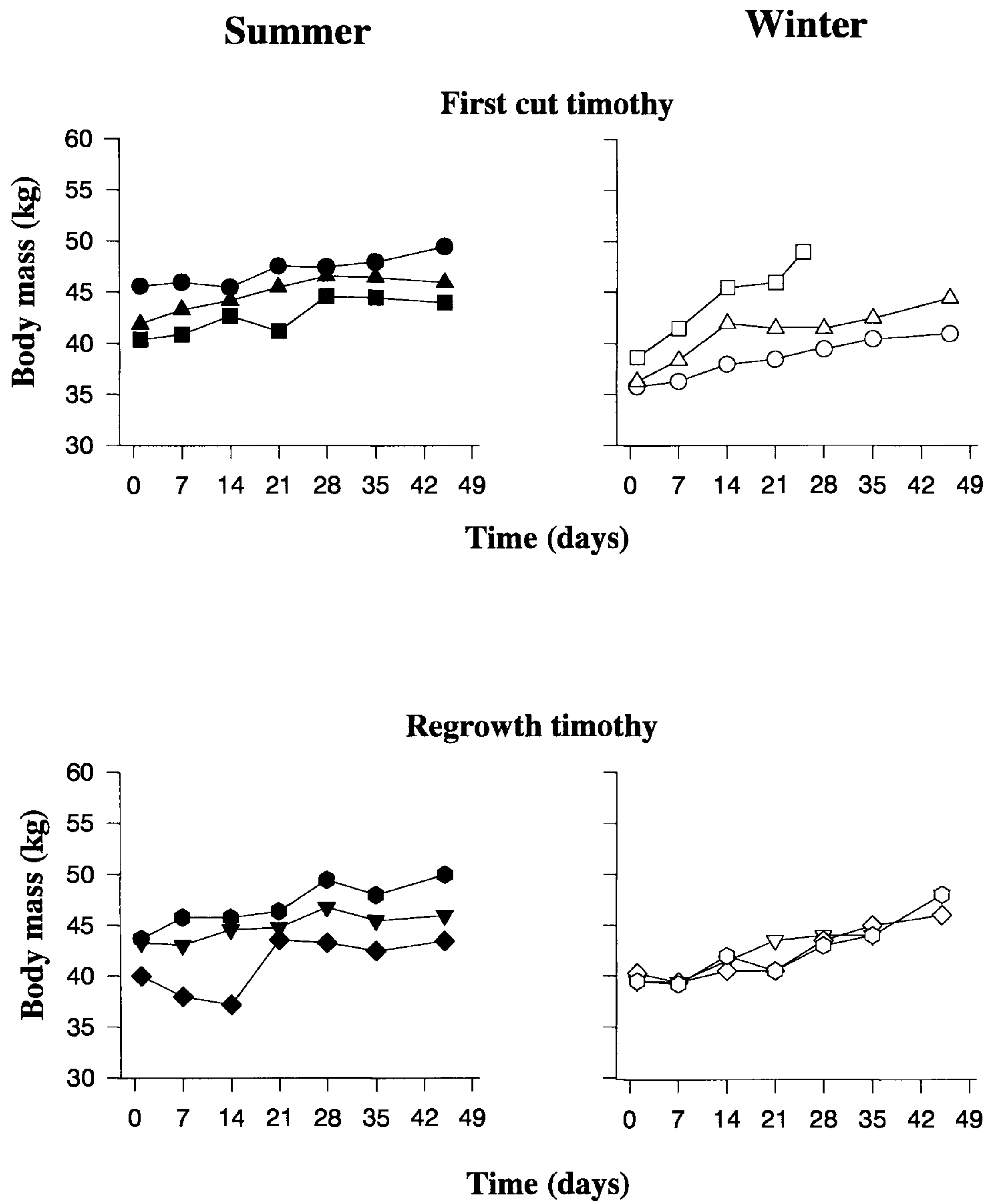

Fig. 1. Body mass of reindeer calves fed first cut and regrowth baled timothy silage *ad libitum* for 46 days, summer and winter Animal 4 (●); 5 (●); 6 (▲); 7 (▼); 8(◆); 9 (●); 19 (○); 20 (□); 21 (△); 16 (▽); 17 (◇);18 (⬡).

0.77-1.26% and 0.57-0.65 of BM respectively, in the animals fed FC and RG silage. In winter the DFC digesta wet weight relative to BM in the animals fed RG and FC silage did not differ significantly from the summer values (P>0.05), while in the NP reindeer it was 1.0-1.2% of BM and significant greater than the summer values (Ws= 15, n_1 and n_2 = 3, $P \leq 0.05$). The DFC digesta wet weight of GIDW in the NP reindeer and in the animals fed FC and RG silage in summer were 4.8-7.5%, 2.8-

Table 2. Dry matter digesta (%) of the gastrointestinal tract of reindeer from summer and winter pasture fed first cut and regrowth baled timothy (*Phleum pratense*) silage (median and range; n=3).

	Reindeer from summer pasture			Reindeer from winter pasture		
	From pasture	Fed first cut timothy	Fed regrowth timothy	From pasture	Fed first cut timothy	Fed regrowth timothy
Reticulo-rumen	13.7 (12.0-13.9)	7.6 (6.8-9.3)	9.2 (7.8-11.3)	19.5 (16.4-21.2)	7.9 (7.3-8.2)	8.5 (6.8-9.9)
Omasum:	19.9 (18.4-21.4)	19.1 (16.0-19.8)	17.6 (16.5-18.6)	23.4 (21.9-24.8)	20.1 (19.4-20.7)	16.2 (15.4-18.5)
Abomasum:	13.9 (13.2-15.9)	15.2 (13.3-15.7)	12.9 (9.5-15.1)	20.0 (15.4-24.0)	16.7 (16.3-17.1)	13.7 (13.0-14.0)
Small intestine:	15.5 (14.2-16.1)	10.5 (10.1-11.2)	13.1 (12.7-14.5)	14.1 (13.4-16.7)	8.4 (7.2-9.5)	13.9 (11.9-14.2)
Ceacum:	14.0 (13.1-14.8)	13.8 (11.9-16.9)	15.4 (13.7-16.0)	17.9 (17.7-18.2)	15.9 (14.8-17.1)	12.8 (12.5-16.9)
Colon:						
Proximal	16.5 (14.1-17.2)	14.5 (13.5-15.4)	15.0 (14.3-15.8)	19.0 (18.5-22.2)	14.6 (12.3-15.7)	17.1 (16.7-17.3)
Coil	19.1 (17.7-20.1)	18.1 (17.4-19.0)	18.2 (16.0-19.4)	23.4 (21.7-25.0)	20.0 (17.6-21.9)	18.8 (17.5-19.5)
Distal	28.3 (27.1-28.5)	27.8 (23.0-29.7)	23.5 (22.7-24.2)	32.1 (30.8-33.3)	25.0 (22.2-26.7)	26.1 (25.0-31.7)

Table 3. Body condition of reindeer from summer and winter pasture fed first cut and regrowth baled timothy (*Phleum pratense*) silage (median and range; n=3).

	Reindeer from summer pasture			Reindeer from winter pasture		
	From pasture	Fed first cut timothy	Fed regrowth timothy	From pasture	Fed first cut timothy	Fed regrowth timothy
Carcass weight (g)	25000 (23000-25500)	16700 (15800-18500)	24600 (21200-25000)	18900 (16000-20300)	17000 (16800-18800)	23900 (22000-24200)
Muscle index (g/cm^3)	(10.8 (9.3-14.5)) x 10^{-3}	(8.1 (7.6-8.6)) x 10^{-3}	13.5 (11.9-13.8)) x 10^{-3}	8.0 (6.9-8.4)) x 10^{-3}	(7.2 (6.5-7.8)) x 10^{-3}	(9.6 (9.4-12.7) x 10^{-3}
Kidney fat weight (g)	160.5 (91.6-196.4)	9.3 (3.6-15.0)	93.0 (83.9-150.3)	11.6 (8.8-28.8)	11.6 (10.0-20.2)	164.0 (54.0-172.0)
Liver weight (g)	942.0 (908.0-1025.0)	400.0 (400.0-400.0)	775.0 (750.0-800.0)	470.0 (425.0-475.0)	365.0 (350.0-384.0)	671.0 (583.0-774.0)
Femur length (cm)	22.2 (21.5-22.7)	22.2 (22.1-22.7)	22.4 (22.2-22.5)	23.4 (22.0-23.7)	22.6 (22.6-23.7)	23.7 (22.3-24.2)
Jaw length (cm)	20.0 (18.9-20.3)	19.9 (18.7-20.6)	20.5 (20.1-19.9)	20.8 (19.2-21.0)	21.1 (20.4-22.3)	22.3 (21.9-22.6)

Table 4. The effect of cell wall contents (CWC), crude protein (CP) and water soluble carbohydrates (WSC) in % of dry matter in first cut (FC) and regrowth (RG) timothy silage on digestive energy intake (DEI) in reindeer in summer and winter (median and range).

	Silage			Summer	Winter
	CWC	CP	WSC	DEI (MJ/d)	DEI (MJ/d)
FC 27% leaves	57.8	12.3	6.2	9.0 (8.8 - 9.6) n=3	8.7 (8.3 - 9.0) n=2
RG 89% leaves	38.7	14.3	30.0	15.9 (13.9 -17.2) n=3	14.0 (13.9 -16.0) n=3

Data from Aagnes *et al.* (in press, *J. Agric. Sci.*)

3.5% and 4.0-4.9%, respectively. In winter the relative DFC digesta wet weight to GIDW in the different groups of reindeer, did not differ significantly from summer values (*P*>0.05). In the NP reindeer, animals fed FC and RG silage in summer, the DFC tissue wet weight were 3.3-4.8%, 2.4-3.5% and 2.9-4.3 of GITW, respectively. In winter the DFC tissue wet weight relative to GITW in the three groups of reindeer did not differ significantly from the summer values (*P*>0.05). The ratio DFC digesta wet weight/RR digesta wet weight in the NP reindeer and in the animals fed FC and RG silage in summer were 1:10-16, 1:26-33 and 1:17-20, respectively and in winter 1:9-11, 1:28-38 and 1:21-24, respectively. In summer ceacum and coil colon DM digesta were 13.1-14.8% and 17.7-20.1%, respectively, in the NP reindeer and did not differ significantly from those of the animals fed FC and RG silage both summer and winter (*P*>0.05) (Table 2). In the NP reindeer in winter ceacum and coil colon DM digesta were 17.7-18.2% and 21.7-25.0%, respectively, and were significantly greater than the summer values ((Ws= 15, n_1 and n_2 = 3, *P*≤ 0.05).

Body mass and condition

The BM of the animals fed FC and RG silage in summer was 40.4-45.6 kg and 40.0-43.7 kg at the start of silage feeding, increasing to 44.0-49.5 kg and 43.0-50.0 kg, respectively, after 46 days (Fig. 1, Table 1). In winter the BM increased in the FC and RG silage fed animals from 35.8-38.7 kg and 39.5-40.3 kg at the start of silage feeding to 41.0-49.0 kg and 46.0-48.0 kg, respectively, after 46 days (Fig. 1, Table 1). In summer the carcass weight of the NP reindeer was 51.1-58.8% of BM compared to 34.3%-38.0% and 48.7%-52.3% of BM in the animals fed FC and RG silage, respectively. In winter the carcass weight relative to BM did not differ significantly from the summer values in any of the groups (*P*>0.05). The muscle index relative to BM was similar in the NP reindeer, summer and winter (*P*>0.05) while the kidney fat weight and liver weight relative to BM in the NP reindeer in summer were significantly greater compared to the NP reindeer in winter (Ws= 15, n_1 and n_2 = 3, *P*≤0.05) (Table 3). In the animals fed FC and RG silage the kidney and liver weights relative to BM were not different between summer and winter (*P*>0.05), but significantly greater in the animals fed RG silage compared to the animals fed FC silage (Ws= 15, n_1 and n_2 = 3, *P*≤ 0.05) (Table 3). In summer the DM content of the muscle *M. semitendinosus* was 23.5-26.4% in the NP reindeer and did not differ significantly from the NP reindeer in winter nor in the animals fed FC and RG silage both summer and winter (*P*>0.05).

Discussion

The relatively greater RR and omasum digesta wet weight of GIDW and the greater DM content in the reticulo-rumen in the NP reindeer in winter compared to summer (Table 1 and 2) indicate an adaptation towards a strategy known in GR ruminants with a high intake of fibre (Hofmann & Stewart, 1972; Hofmann, 1989). In adult female reindeer in Norway RR digesta wet weight increased in winter with increasing fiber content in the diet (S. D. Mathiesen, unpubl.) which support the data from the NP reindeer summer and winter (Table 1). The RR fill has shown to increase both in sheep (GR), goat (IM) and roe deer (concentrate selector (CS)) when the fibre content of the diet increase. (Lechner-Doll *et al.*, 1990; Holand, 1992). Staaland *et al.* (1979) and White *et al.* (1987), on the other hand, have reported a lower relative RR fill in winter than in summer in High-Arctic Svalbard reindeer (*Rangifer t. platyrhynchus*) and Alaska reindeer (*Rangifer t. granti*). White *et al.* (1987) pointed out that low food availability may limit daily intake and hence influence digesta fill.

The differences in kidney fat weight and liver weight between the NP reindeer from summer and winter pasture (Table 3) are probably due to naturally seasonal changes in food intake (Larsen *et al.*, 1985) and food quality and availability, which could affect their energy balance (McEven & Whitehead, 1970). Still, the total BM was lower in winter compared to summer in the NP reindeer the carcass weight and muscle index relative to BM were similar at both season.

The differences in Gl-tract fill and body condition in animals from summer and winter pastures are not reflected in the relative size of the different sections of the Gl-tract in reindeer fed silage both summer and winter. The changes in the Gl-tract capacity in silage fed reindeer seem rather to be caused by the DEI, structure and the chemical composition of the grass eaten and irrespective of season (Table 1).

The greater relative weight of the RR and DFC digesta of BM in the animals fed FC silage compared to the animals fed RG silage both summer and winter were not reflected in total BM, which was similar in all groups fed silage (Table 1). This is explained by a significantly lower carcass weight in the animals fed FC silage compared to the animals fed RG silage (Table 3). In the animals fed RG silage both summer and winter the RR digesta wet weight ranged between 9.6%-18.3% of BM, and was similar to the mean RR digesta wet weight of adult reindeer feeding on a natural summer pasture in Norway (13.5% of BM, Staaland *et al.*, 1979; 12.2% of BM, S. D. Mathiesen, unpubl.). The greater relative RR digesta wet weight of BM, and the greater ratio of DFC digesta wet weight/RR digesta wet weight in the animals fed FC silage compared to the animals fed RG silage are indications for an adaptation towards a strategy known in GR ruminants, with an intake of plants rich in cell walls (Table 1) (Hofmann & Stewart, 1972; Hofmann, 1989). The FC silage contained on a DM basis 57.8% CWC, compared to 38.7% in the RC silage. The fibre in plant tissue are more resistant to fragmentation during mastication and rumination (Van Soest, 1994). This will reduce the rate of particle fragmentation and contribute to a less particle density, which again increase rumen food particles retention time and increase RR fill (Lechner-Doll *et al.*, 1991). According to Campling *et al.* (1961), Van Soest (1994) and Forbes (1995) increased rumen fill and passage will suppress food intake and may explain the low DEI shown in the animals fed FC silage both summer and winter (Table 4; Aagnes *et al.*, in press *J. Agric. Sci.*). Limitations in ruminal cellulolysis may also be important in reducing the ability of reindeer to utilise roughage. Olsen *et al.* (1995) have found an exceptionally large rumen digesta wet weight in a reindeer fed high-quality leaf rich timothy silage, which might have been caused by failure in the rumen cellulolysis. When a round bale silage of mixed leaf rich grasses and similar chemical composition as the FC silage was used as an emergency food to reindeer calves which were first given lichens and then starved for two days in winter, the RR digesta wet weight was 19.6-23.7% of BM after six weeks of silage feeding (Aagnes & Mathiesen, 1995). This shows that even though the plant material is leaf rich the chemical composition of the diet may contribute to an increased RR digesta wet weight.

These results show that reindeer have ability for anatomical Gl-tract adaptation when forage quality change. The main factors effecting the Gl-tract anatomy in reindeer calves fed silages seem to be the plant structure and chemical composition and not season. Reindeer calves adapt easily to leaf rich high-quality timothy silage with a relatively small RR load and high DEI both summer and winter. The large increase in RR digesta load and low DEI in the animals fed roughage timothy both summer and winter show that reindeer have limitations in utilising roughage. These results suggest that reindeer should be classified as an intermediate opportunistic mixed feeder.

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