Macrominerals in free-ranging Swedish reindeer during winter

Birgitta Åhman[1], Axel Rydberg[2] and Gustaf Åhman[2]

Abstract: Samples of blood, rumen, and caecal contents were taken from 238 reindeer *(Rangifer tarandus)* slaughtered between September and March in two consecutive years. Levels of magnesium, calcium and phosphorus were measured to evaluate the extent to which levels of these minerals reflected changes in the grazing conditions through the winter. Twenty-one reindeer in poor conditon were included in the investigation and compared with normal animals with respect to the investigated minerals.

Serum values in September were within the normal range for domestic sheep *(Ovis* spp.) and cattle *(Bos* spp.) (Church, 1979). Magnesium was 0.9±0.1 mmol/l, calcium 2.8 ± 0.3 mmol/l and phosphorus 2.5 ± 0.5 mmol/l. Calcium values did not change very much through the winter while magnesium and phosphorus constantly decreased from September to February. Extremely low serum magnesium values (below 0.3 mmol/l in some animals were found in January and February. The majority of the animals in poor condition had low serum-magnesium values.

Key words: reindeer, *Rangifer*, nutrition, magnesium, calcium, phosphorus.

[1] Department of Clinical Nutrition, Swedish University of Acricultural Sciences, Box 7023, S-750 07 Uppsala, Sweden.

[2] Department of Animal Nutrition and Management, Swedish University of Agcricultural Sciences, Box 5097, S-900 05 Umeå, Sweden.

Rangifer, Special Issue No. 1, 1986: 31 - 38

Introduction

An important part of the reindeer *(Rangifer tarandus* spp.) winter diet is lichens, which can be as much as 70-85% of the total food intake (Eriksson *et al.*, 1981). Lichens are low in protein and minerals compared with forage plants available to reindeer during other times of the year (Table 1). Even when the winter food supply is adequate to meet the need for energy, protein and mineral content can still be inadequate.

Since 1978, we have extensively studied field-slaughtered reindeer from northern Sweden. These studies have focussed on various topics, including reproduction (Inga, 1984), foetal growth (Mossing and Rydberg, 1982), muscle fibre composition (Kiessling and Rydberg, 1983), meat quality and slaughtering strategy. One of the main objectives has been to evaluate the influence of nutritional factors on the condition of the reindeer from chemical analysis of blood, organs and content of the alimentary tract.

In this report we show how magnesium (Mg), calcium (Ca), and phosphorus (P) content in different parts of the body change during the winter. We gave special attention to animals that were weak and in poor condition and compared them with animals in normal condition.

Material and methods

Samples were taken from 217 reindeer slaughtered in September to March in 1979/80

Table 1. Macromineral and crude protein content (g/kg dry matter) in some reindeer forage plants (Isotalo, 1971).

Plant	Mg	Ca	P	Crude protein
Lichens:				
Cladonia and *Cladina*	0.3-0.8	0.6-1.4	0.4-0.8	1 - 4
Alectoria and *Usnea*	0.2-0.3	1.1-2.0	0.6-0.8	6 - 7
Leaves:				
Betula	2.8	5.7	2.8	20
Shrubs:				
Vaccinium and *Empetrum*	0.9-1.5	3.6-5.1	1.1-2.6	6 - 14
Grass:				
Deschampsia etc.	0.7-2.2	1.2-4.2	1.6-2.1	8 - 18

and 1980/81 (Table 2). The animals were from the same area around Arvidsjaur, Sweden. The animals were considered by the herdsmen to be in normal condition - they showed normal activity and normal behaviour. In February/ March 1981, 21 reindeer in poor condition (hereafter referred to as weak animals) were selected (Table 2). These were animals which tired while running in the corral and could not keep pace with the others.

At slaughter we weighed the carcasses, the liver and the contents of the digestive tract. Weight of omentum was used as an index of body fat. Samples were taken of mixed arterial and venous blood when bleeding the animal, from the liver and from rumen-reticulum and caecum content. Before sampling, rumen-reticulum content (hereafter referred to as rumen content) was carefully mixed. Blood samples were kept in 10-20°C and centrifuged after 3-8 h. Blood serum and liver were stored frozen in -20°C until analysed. Samples of rumen and caecum content for mineral analyses were dried (to ca. 90% dry matter DM) and stored dry until analysed.

Table 2. Numbers of animals by age, sex and condition slaughtered at different times.

Date of		Females		Males		Cast-	
slaughter	Calves	yearling	adult	yearling	adult	rates	Total
Animals in normal condition							
1979/80							
30 Aug — 26 Sept	-	-	-	2	30	3	35
23 — 26 Oct	2	-	6	-	-	-	8
19 Nov — 19 Dec	11	-	21	-	-	1	33
7 — 24 Jan	6	-	13	-	-	-	19
26 — 28 Feb	2	-	6	2	3	1	14
12 — 18 Mars	1	-	3	-	-	-	4
1980/81							
5 — 22 Sept	-	2	2	5	17	-	26
14 Nov — 17 Dec	4	10	9	13	1	3	40
8 — 26 Jan	6	4	5	6	2	-	23
9 — 27 Feb	1	3	6	3	-	2	15
Total	33	19	71	31	53	10	217
Weak animals in poor condition							
1981							
2 Feb — 17 Mar	6	3	-	11	1	-	21

Analyses of magnesium, calcium and phosphorus were made on blood serum and on acid digests of liver. Analyses of Mg and Ca were made on acid digests of rumen and caecum content. Mg and Ca were analysed on an atomic absorbtion spectrophotometer (Perkin Elmer 306). P was analysed according to Taussky *et al.*, (1953). On rumen and caecum content DM, pH and VFA (volatile fatty acids) were measured. The methods of sampling and preparing samples are described by Åhman and Åhman (1980).

Statistical analyses were carried out according to GLM (general linear models) procedure of the Statistical Analyses System (SAS Institute Inc., 1982). The model used tested effect of age and sex of animals, effect of time of slaughter and possible combined effect of these factors. When comparing weak and normal animals we used a model testing effect of conditon (weak - normal) and effect of age and sex. Only the animals slaughtered in February and March were used in the latter model.

Results and discussion

The four females slaughtered in September 1980 had the same body weights but lower omentum weights than those slaughtered in October to December (Table 3). No calves were slaughtered in September. Calves and females slaughtered in October to December weighed slightly more than those slaughtered later in the year. The omentum weights decrease relatively more than carcass weights. Males are known to

Table 3. Carcass weight (kg) and weight of omentum (% of carcass) in normal condition reindeer of different age and sex slaughtered at different times (mean±SD).

	Normal animals				Weak animals
	September	October - December	January	February-March	February-March
Calves					
n	-	17	12	4	6
Carcass, kg		21±2	18±4	19±4	15±2
Omentum, %		0.61±0.30	0.38±0.25	0.37±0.30	0.18±0.07
Yearling females					
n	2	10	4	3	3
Carcass, kg	24/29[1]	29±3	24±1	27±1	26±2
Omentum, %	0.57/0.55[1]	0.99±0.45	0.72±0.26	0.61±0.16	0.71±0.45
Adult females					
n	2	36	18	15	-
Carcass, kg	34/31[1]	35±5	33±4	33±4	
Omentum, %	0.44/1.09[1]	0.92±0.33	0.92±0.34	0.64±0.32	
Yearling males					
n	7	13	6	5	11
Carcass, kg	34±3	30±2	24±4	27±6	24±4
Omentum, %	0.48±0.16	0.35±0.23	0.54±0.40	0.34±0.23	0.46±0.32
Adult males					
n	47	1	2	3	1
Carcass, kg	55±10	36	39/31[1]	35±6	29
Omentum, %	0.83±0.18	0.04	0.45/0.46[1]	0.29±0.07	0.01
Castrates					
n	3	4	-	3	-
Carcass, kg	58±4	53±4		49±3	
Omentum, %	0.98±0.15	1.15±0.26		0.72±0.23	

[1] Sample values only.

loose up to 35% of their body weight during the 3-week rut in October (Rydberg, 1982) when they hardly eat at all (Skjenneberg and Slagsvold, 1968). As expected, males in this investigation had higher carcass weight and omentum weight in September, before the rut (Table 3). Later in the year weights for males were consederably lower.

The weak animals, except for yearling females, had significantly lower carcass weight ($P < 0.001$) than normal animals of the same age and sex at the same time of year (Table 3, the last two columns). Many of the weak animals, especially the weak calves, but also some of the normal animals had extremely low omentum weight, indicating that they had used almost all of their fat reserves. Dry matter and pH in rumen and caecum (15-20% DM and pH 5.5-7.0 in rumen and 15-19% DM and pH 6.0-7.0 in caecum) did not indicate any starvation or low intake of food prior to slaugther (Åhman and Åhman, 1980), nor did levels of VFA (80-180 mmol/l in rumen and 40-120 mmol/l in caecum). Weak animals did not differ from the other animals in this respect.

The changes in mineral values shown in Figs. 1, 2 and 3 through the winter differed between the two years. The first year there was a steady decline from September to February in the levels of minerals in serum and of Mg-levels in rumen and caecum. The serum values were higher in March. In the second year the decline came later and was less marked. Some of the differences between the two years could perhaps be explained by deeper snow in the area in late November and in December the first year (SMHI, 1979, 1980 and 1981). Snow deeper than 75 cm, as was the case in December 1979, could cause problems for reindeer when digging for food (Eriksson, 1976).

Animals slaughtered at different times were not of the same age and sex (Table 2). The statistical analyses showed that in general there were no significant effects of age and sex on the levels of minerals but castrates had non-significantly higher caecum-Mg values than other animals ($P > 0.05$) and calves had lower levels in serum of Ca ($P < 0.01$) and P ($P < 0.05$). It proved that applying the statistical model, where the values are adjusted in relation to age and sex, did not significantly change the curves in Figs. 1-3.)

The levels we have found of Mg in rumen and caecum are similar to levels found in lichen-fed

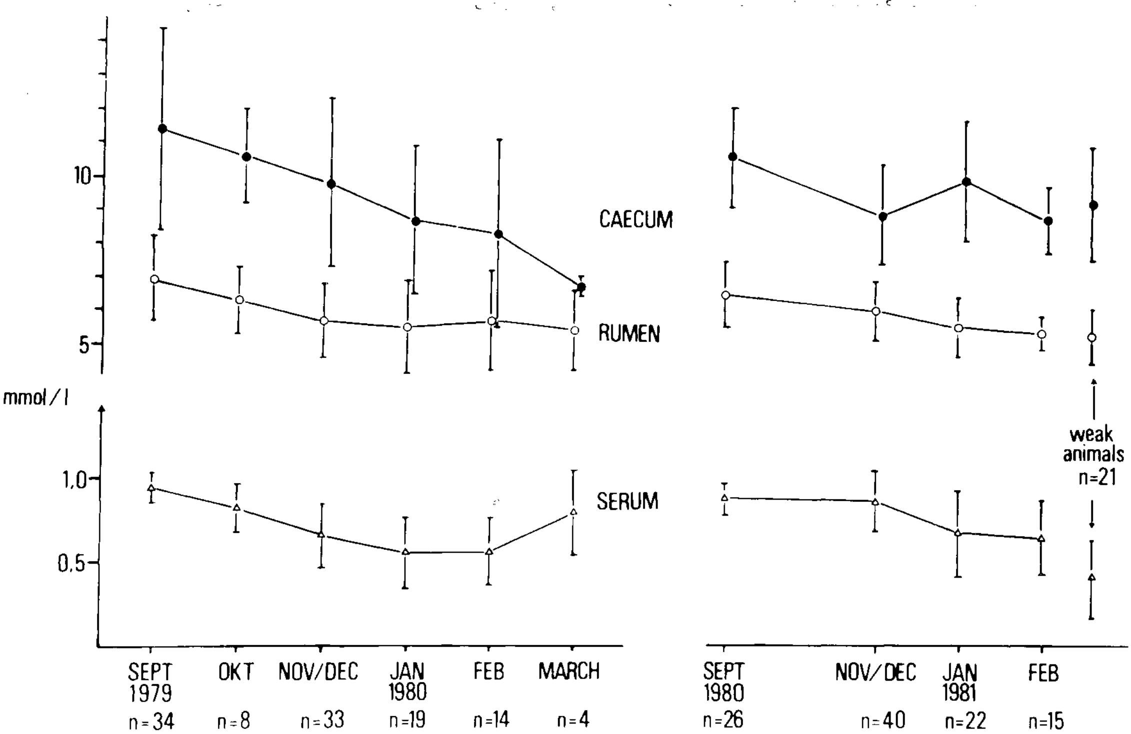

Fig. 1. Magnesium in serum (△) in rumen (○) in caecum (●) and content from free-ranging reindeer slaughtered at different times from September to March in 1979/80 and 1980/81 and from weak reindeer slaughtered in February/March 1981 (mean±SD).

Table 4. Magnesium levels in serum from reindeer slaughtered in February/March: comparision between animals in normal condition and weak animals (mean±SD).

	Normal animals			Weak animals		
	n	Mg mmol/l	no of animals with serum-Mg below 0.30	n	Mg mmol/l	no of animals with serum-Mg below 0.30
Calves	4	0.65±0.17	0	6	0.38±0.20	4
Yearling females	3	0.55±0.24	1	3	0.41±0.12	1
Yearling males	5	0.57±0.27	1	11	0.43±0.30	5
Adult males	3	0.52±0.28	1	1	0.29	1
Total	15	0.58±0.22	3(20%)	21	0.41±0.24	11(52%)

reindeer by Staaland *et al.* (1984). Their report also shows that Mg content of the digestive tract is markedly affected by mineral supplementation.

Serum Mg levels in reindeer in normal condition slaughtered in September of each of the two years (Fig. 1) were well within the normal range for sheep (*Ovis* spp.) and cattle (*Bos* spp.) (0.7 to 1.2 mmol/l, Church 1979). Among reindeer slaughtered in the first year, the values were lower from October and reached the lowest level (0.55 ± 0.20 mmol/l) in January and February. In the second year, the values stayed high throughout November and December (0.86 ± 0.18 mmol/l), but the values tended to be lower (0.66 ± 0.24 mmol/l) in reindeer slaughtered in January and February. The variation within groups was larger in the later part of the year. Most of the reindeer kept their serum-Mg values within the normal range while some had very low values (down to 0.2 mmol/l). In reindeer fed lichens for 4 months, Bjarghov *et al.* (1976) report similar Mg-levels. As in our study no symptoms of tetany were seen in the animals. Reindeer fed pelleted reindeer feed were reported by Bjarghov *et al.* to have serum-Mg values between 1.0 and 1.2 mmol/l.

The statistical analyses showed that weak animals had significantly lower serum-Mg values than normal animals ($P < 0.05$), with over one half of the weak animals having values below 0.30 mmol/l (Table 4). The animals did not show signs of tetany.

The levels of Ca in rumen (around 10-15 mmol/l) are somewhat higher than what Staaland *et al.* (1984) reports from four lichen fed reindeer, but lower than the values they report from reindeer fed mineral supplements (these had values above 20 mmol/l). In the caecum, we found varying levels of Ca during the first year (10-40 mmol/l). On the second year Ca levels increased from September to February, the mean value in September being 14 mmol/l compared to 31 mmol/l in February. An explanation for this could be mobilization of bone to meet the need for Mg and P when mineral content of the feed is low (Church, 1979). This could lead to excess of Ca in the blood and a secretion of Ca into the intestine, followed by high levels of Ca in caecum.

Serum Ca levels were very uniform throughout the year. There was a significant difference between the two years in the level of serum Ca ($P < 0.001$). This might be a genuine difference, or it could be due to some change in treatment of samples or method of analysis from one year to the next. Hyvärinen *et al.* (1977) and Nieminen and Timisjärvi (1983) report serum Ca values from reindeer slaughtered in October and February (2.3-2.8 mmol/l) that correspond well with the values we have from the winter 79/80. Serum Ca values reported by Bjarghov *et al.* (1976) from lichen-fed reindeer are at the same level. Our values from the second year, 80/81, are slightly higher with a maximum at 3.3 mmol/l. Normal values for domestic ruminats are 2.2 to 3.3 mmol/l (Church, 1979).

The consistent values for serum Ca through the year indicate a very good ability in reindeer to mobilize Ca from the bone to meet Ca requirements when Ca in the diet is low. Hyvärinen *et al.* (1977), however, claims that Ca deficiency at some times could be a problem.

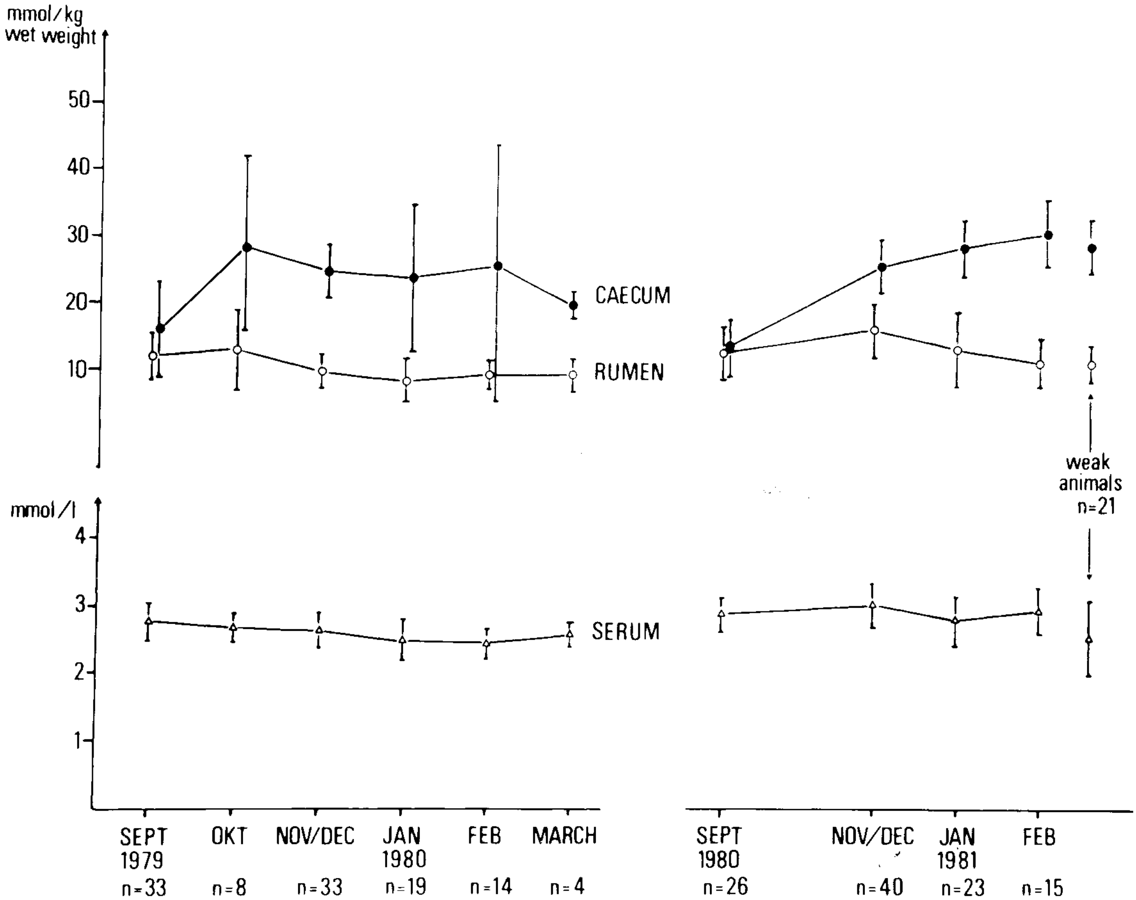

Fig. 2. Calcium in serum (△) in rumen (○) in caecum (●) and content from free-ranging reindeer slaughtered at different times from September to March in 1979/80 and 1980/81 and from weak reindeer slaughtered in February/March 1981 (mean±SD).

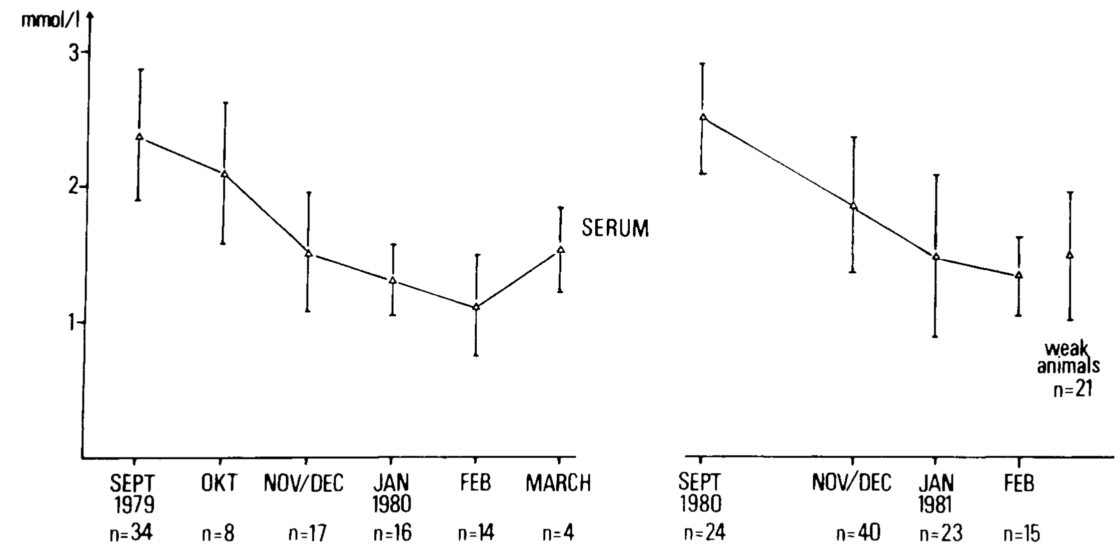

Fig. 3. Phosphorus in serum from free-ranging reindeer slaughtered at different times from Setember to March in 1979/80 and 1980/81 and from weak reindeer slaughtered in February/March 1981 (mean±SD).

They found extremely low serum-Ca values (1.7 ± 0.2 mmol/l) together with moderately low serum-Mg values (0.67 ± 0.12 mmol/l) in females living under poor nutritional conditions in February, and many reindeer from the same area died later and were reported to have had convulsions before death which indicates disturbances of grass tetany type.

The weak animals did not differ from animals in normal condition with respect to Ca-levels in rumen or caecum. In serum, the mean value of Ca was lower for weak animals: the difference was, however, not significant.

In serum-P there is a steady decline from autumn through winter. The same pattern was present in both years, though the values in January and February are slightly lower in the first year. P is often one of the most limiting minerals for many ruminants (Church, 1979) and probably also for the reindeer. This leads to low serum-P levels and a depletion of bone minerals (Church, 1979). No clinical signs of P-deficiency were shown in the reindeer investigated and the weak animals had serum-P values at the same level as animals in normal condition.

Our findings point to the conclusions that the winter conditions encountered in Scandinavia create difficulties for reindeer in meeting their mineral needs. This causes a magnesium and phosphorus deficiency and under the most difficult conditons a calcium deficiency. At some times Mg in serum drops to a level were the health of the animal is in danger.

Mg-deficiency along with deficiency in P and to some extent Ca are factors of considerable importance causing weakened condition in reindeer in the early spring.

References

Bjarghov, R. S., Fjellheim, P., Hove, K., Jacobsen, E., Skjenneberg, S. and **Try, K.** 1976. Nutritional effects on serum enzymes and other blood constituents in reindeer calves (*Rangifer tarandus tarandus*). — *Comparative Biochemistry and Physiology. 55A:187-193.*

Church, D. C. 1979. Digestive Physiology and Nutrition of Ruminants. Vol 2 — *Nutrition, Second edition. O & B Books Inc., Corvallis, Oregon. 452 p.*

Eriksson, O. 1976. Snöförhållandenas inverkan på renbetningen. (The effect of snow conditions on reindeer grazing). — *Medd. Växtbiologiska institutionen, Uppsala. 19 p. (Available from Växtbiologiska institutionen, Box 559, S-751 22 (Uppsala, Sweden).*

Eriksson, O. 1981. Renens vinterdiet. (Winter diet of reindeer). In: Renbetning vintertid. (Reindeer grazing in winter). — *Växtekologiska studier 13, Uppsala. 25-46. (Available from Sveriges Växtgeografiska Sällskap, Box 559, S-751 22, Uppsala, Sweden).*

Hyvärinen, H., Helle, T., Nieminen, M., Väyrinen, P., and **Väyrinen, R.** 1977. The influence of nutrition and seasonal conditions on mineral satus in the reindeer. — *Canadian Journal of Zoology 55:648-655.*

Inga, B. 1984. Rutting season in domestic reindeer — weight development and androgen variation. — *Rangifer 4(2):2-9.*

Isotalo, A. 1971. Porojen luonnonvaraisten rehukasvien ravintoarvosta. (The value of natural fodder plants on the reindeer feeding). — *Lapin tutkimusseuran vuosikirja XII:28-45.*

Kiessling, K-H. and **Rydberg, A.** 1983. Fibre composition and enzyme activities in six muscles of the Swedish reindeer (*Rangifer tarandus tarandus*). — *Rangifer 3(1):40-45.*

Mossing, T. and **Rydberg, A.** 1982. Reproduction data in Swedish domestic forest reindeer (*Rangifer tarandus* L.). — *Rangifer 2(2):22-27.*

Nieminen, M. and **Timisjärvi, J.** 1983. Blood composition of the reindeer. II. Blood chemistry. — *Rangifer 3(1):16-32.*

Rydberg, A. 1982. Preliminära resultat från slaktkroppsundersökningen av ren säsongen 1981 —82 inom Arvidsjaureområdet. (Preliminary results from studies of reindeer carcasses at slaughter, 1981 — 82 in the Arvidsjaur-area). — *Unpublished report 13 p. (Available from Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Box 5097, S-900 05 Umeå, Sweden).*

SAS Institute Inc. 1982. SAS User's Guide: Statistics, 1982 edition. — *SAS Institute Inc., Cary, N. C., 584 p.*

Skjenneberg, S. and **Slagsvold, L.** 1968. Reindriften og dens naturgrunnlag. (Reindeer husbandry and its ecological principals). — *Scandinavian University Books, Oslo/Bergen/Tromsø, Norway. 332 p.*

SMHI. 1979. Årsbok 1979 - månadsöversikter. — *(Available from SMHI, S-601 76 Norrköping, Sweden).*

SMHI. 1980. Årsbok 1980 - månadsöversikter. — *(Available from SMHI, S-601 76 Norrköping, Sweden).*

SMHI. 1981. Årsbok 1981 - månadsöversikter. — *(Available from SMHI, S-601 76 Norrköping, Sweden).*

Staaland, H., **Jacobsen, E.** and **White, R. G.** 1984. The effect of mineral supplements on nutrient concentrations and pool sizes in the alimentary effect of reindeer fed lichens or concentrates during the winter. — *Canadian Journal of Zoology 62:1232-1241.*

Taussky, H. H., **Shorr, E.** and **Kurzmann, G.** 1953. A microcolorimetric method for the determination of inorganic phophorus. — *Journal of Biolocal Chemestry 202:675-685.*

Åhman, B. and **Åhman, G.** 1980. Övergång från naturbete till kraftfoderutfodring av ren. (Changing from winter pasture to concentrate feeding of reindeer). — *Department of Animal Husbandry, Uppsala. Report 76. 65 p. (Available from Department of Clinical Nutrition, Swedish University of Agricultural Sciences, Box 7023, S-750 07 Uppsala, Sweden).*