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RENAL EXCRETION OF UREA IN REINDEER

EFFECT OF NUTRITION

By

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HOVE, KNUT and ENDRE JACOBSEN: *Renal excretion of urea in reindeer. Effect of nutrition.* Acta vet. scand. 1975, *16*, 513—519. — Renal reabsorption of urea was studied in 8 9-month old reindeer calves fed low protein (19—34 g crude protein, mostly lichens) and high protein (68—69 g crude protein, lichens + soybean meal) diets. Low protein diets fed for a 3-month period resulted in an average renal reabsorption of 93 % of the filtered urea, while only 50 % was reabsorbed on the high protein ration. It was calculated that if the reabsorbed urea was used completely for protein synthesis in the rumen, 4 g crude protein could be made daily in the lichen fed animals. This amount would be a very significant contribution to the nitrogen economy of animals which are usually in a negative nitrogen balance when lichens are the main food consumed.

urea; kidney reabsorption; reindeer protein intake.

Protein deficiency is a prominent problem of arctic herbivorous animals. During the winter the reindeer eats mostly lichens (*Skjenneberg et al.* 1972) which are so low in protein that it often excretes more nitrogen than it consumes (*Nordfeldt et al.* 1961, *Jacobsen & Skjenneberg* 1972). Amino acids are synthetized from inorganic nitrogen by rumen microorganisms. These amino acids become in term available to the ruminant after digestion of the microorganisms (*Houpt* 1970, review). Recent observations indicate that the transfer of urea to the digestive tract is of considerable magnitude in reindeer (*Wales et al.* 1972). A low urinary excretion of urea will increase the amount of nitrogen available for recycling and consequently for microbial amino acid synthesis. *Schmidt-Nielsen et al.* (1957) and *Schmidt-Nielsen & Osaki* (1958) found that more than 95 % of the filtered urea was reabsorbed in the kidneys of camels and sheep on low protein diets. The present study was undertaken to investigate urea excretion in reindeer on diets with a high and a low protein content.

MATERIALS AND METHODS

Animals and diets

Eight male calves aged about 6 months were divided into 2 groups. For 2½ months group 1 was fed a pelleted reindeer feed (13.7 % crude protein) which maintained the animals in a positive nitrogen balance. A diet of lichens and protein supplements was fed during the clearance measurements. The adaptation of the animals to this diet was carried out in 2 steps: First lichens were fed for an 8-day period, then supplements were added for the last 10 days before the measurements were carried out.

The group 2 animals consumed a low protein diet which secured a negative protein balance for 3 months before the clear-

Table 1A. Diets fed to the animals at the different stages of the experiment.

Group	2½—3-month pre-experimental period	Experimental period
1 (high protein)	diet 1	diet 2
2 (low protein)	diet 3	diet 3

Table 1B. Composition and protein content of the diets.

Diet	Daily food ration	Crude protein intake g/day
1	1.0 kg reindeer feed (barley, oats wheatbran, grass meal and soybean oil)	120
2	0.67 kg lichen dry matter 100 g soybean meal 40 g crushed barley	68—69
3	0.87 kg lichen dry matter In addition: 150 g crushed barley (animal no. 4 only) 30 g minerals* (2 animals)	19—23 (animals nos. 1—3) 34 (animal no. 4)

* Commercial supplement with the following composition (%): Calcium phosphate 37.7, calcium carbonate 7.1, sodium chloride 8.3, sodium phosphate 5.5, magnesium oxide 5.1. Trace elements 1.3, crushed wheat 11.0, ground hay 4.0, molasses 10.0, water 10.0.

ance was measured. Table 1 gives a summary of the diets fed to the animals at the different phases of the experiment, and the composition of the diets. The daily food ration was divided into equal parts and fed at 8 a. m. and 4 p. m. The effects of the diets were followed by measuring plasma and urine concentrations of urea and creatinine. The animals were kept in individual cages which permitted separate collection of faeces and urine.

Blood and urine collection

Blood was taken from the jugular vein. Heparinized plasma was separated and stored frozen until it could be analyzed. Five samples were taken between 8 a. m. and 12 p. m. in group 1, 4 samples between 8 a. m. and 4 p. m. in group 2. In group 1 4 consecutive days were used for blood and urine collection, while 2 24-hr. periods were studied with 1 day interspersed in group 2. The urine was either collected in small portions and frozen, or collected once per 24 hrs. using hydrochloric acid as preservative.

Analytical procedures

Urea in blood and urine was measured spectrophotometrically by an automated modification of the diacetyl monoxim reaction (Technicon autoanalyzer file Nl-C). Urine creatinine was measured by an automated spectrophotometric method after reaction with alkaline picrate. Plasma creatinine was either extracted from plasma with ionic-exchange resin (*Polar & Metcoff* 1965), eluted and finally measured with the alkaline picrate reaction, or measured directly by the picrate reaction. Similar values were obtained by both methods. The chemical analyses of the diet constituents were performed according to official procedures for the Norwegian agricultural control stations.

Calculations

Clearance values were calculated for each 24-hr. period using the mean of the plasma concentrations of that day. These means are probably good estimates for the 24-hr. creatinine averages, since the plasma concentrations of creatinine were practically constant from hour to hour. During the day-hours plasma urea increased 5—10 mg/100 ml in the animals fed soybean meal. The contribution of newly fermented proteins to the blood urea level is lower during the night-hours. Twenty-four-hr. urea clearances consequently tend to be underestimated when calculated from day-time plasma samples on high protein intakes. The percentages of filtered urea reabsorbed were calculated on the assumption that the creatinine clearances were true estimates of the glomerular filtration rates in reindeer. Although *Vogel* (1962) claims to have found higher creatinine than inulin clearances, other workers using both methods simultaneously have not observed significant discrepancies between the 2 clearances in ruminants (*Schmidt-Nielsen et al.* 1957, *Schmidt-Nielsen & Osaki* 1958).

RESULTS

About 50 % of the filtered urea was reabsorbed in the high protein group. The low protein diet resulted in a much higher urea reabsorption (Table 2). Judged by the ratio between the

Table 2. Effect of diet on plasma urea concentration and urea excretion (mean and range).

Experimental ration	Protein intake g/24 hrs.	Plasma urea mg/100 ml	Urea clearance 1/24 hrs.	Percentage of filtered urea reabsorbed	Creatinine U/P ratio*	Creatinine clearance 1/24 hrs.	Urine volume 1/24 hrs.
high protein (group 1)	68 (68—69)	54.9 (49.2—60.0)	21.6 (18.0—23.3)	50 (47—53)	31 (26—34)	41 (36—46)	1.4 (1.2—1.5)
low protein (group 2)	24 (19—34)	5.1 (3.4—6.3)	1.8 (0.9—4.0)	93 (84—97)	33 (22—53)	25.4 (23.3—28.0)	0.9 (0.5—1.1)

* $\frac{\text{Urine concentration}}{\text{Plasma concentration}}$

concentrations of creatinine in urine and plasma 2—5 % of the fluid filtered in the kidneys appeared as urine in both the high and the low protein group. The creatinine clearances and consequently the 24-hr. urine outputs were about 50 % higher in the high than in the low protein group. The creatinine excretion showed considerable constancy from day to day in the same animal. (Mean excretion within the same animal: 0.85 ± 0.06 g/24 hrs., in 4 24-hr. periods from 4 animals in group 1).

DISCUSSION

The animals in the present investigation excreted a smaller fraction of the filtered urea on low protein diets than on high protein diets. In the low protein group a urea reabsorption as high as 97 % of the filtered amount was recorded in 1 animal. These results are in accordance with previous findings in non-cervid ruminants such as the sheep and the camel (*Schmidt-Nielsen et al.* 1957, 1958, *Schmidt-Nielsen & Osaki* 1958, *Gans* 1966, *Scott & Mason* 1970). Consequently, reindeer are among the ruminant species which are able to minimize their urinary urea loss, and thus increase the availability of nitrogen for the synthetic processes in the rumen during periods of low protein intake.

Schmidt-Nielsen (1958) emphasized that this effect of protein intake on renal reabsorption of urea only appears on low or moderate urine flows (inulin or creatinine U/P ratios greater than 10). The creatinine U/P ratios of the reindeer fed low protein diets were between 20 and 50. According to *Schmidt-Nielsen* somewhat more urea could have been reabsorbed if the urines had been more concentrated. Too little is known about the concentration of urine on natural pastures to indicate whether this affects urea conservation when reindeer are grazing normal vegetation in the winter.

The concentrations of plasma urea found in the low protein group are of the same magnitude as from red deer and sheep fed diets comparably low in proteins (*Lewis* 1957, *Schmidt-Nielsen & Osaki, Maloyi & Scott* 1969).

Lichens (Cladonia alpestris) have a fairly high energy content (mainly carbohydrates, *Nordfeldt et al.* 1961, *Jacobsen & Skjenneberg* 1972). Protein synthesis from inorganic nitrogen requires energy from readily fermentable carbohydrates, and lichens are probably favourable in this respect. If it is postulated that all the urea nitrogen reabsorbed in the kidneys are used for protein synthesis, about 4 g crude protein could be made daily from this nitrogen source in the animals kept long term on low protein rations (about 0.25 $g/kg^{0.75}$). When reindeer are fed lichens only, protein losses from the body exceeds protein intakes by from 3—6 g/kg lichen dry matter digested (*Nordfeldt et al., Jacobsen & Skjenneberg*). This means that without the urea-recycling daily protein losses would probably have been in the magnitude of 6—10 g in the calves of the present experiment.

A recycling of urea of the observed magnitude therefore seems to be a significant contribution to the nitrogen economy of the reindeer.

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SAMMENDRAG

Renal ekskresjon av urea hos rein. Effekt av ernæring.

Nyrenes reabsorpsjon av urea ble studert hos 8—9 måneder gamle reinkalver foret en lavprotein diett (19—34 g råprotein, hovedsaklig reinlav) eller en høyprotein diett (68—69 g råprotein, reinlav + soyamel).

Foring med lav proteindiett i 3 måneder resulterte i en gjennomsnittlig reabsorpsjon på 93 % av den filtrerte ureamengde, mens bare 50 % ble reabsorbert på høyprotein dietten. Beregninger viser at den reabsorberte ureamengde forutsatt fullstendig utnyttelse til proteinsyntese i rumen tilsvarer ca. 4 g råprotein pr. dag hos de lavforede dyr. Denne proteinmengde vil være et signifikant bidrag til reinens nitrogen balanse i perioder hvor reinlav er hovedføden.

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