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Variation of plasma protein parameters in four free-ranging reindeer herds and in captive reindeer under defined feeding conditions

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Abstract

Plasma total protein (TP), albumin (ALB) and globulin (GLOB) concentrations and albumin/globulin ratio (A/G) were analysed from blood samples collected from free-ranging reindeer (*Rangifer tarandus tarandus*) herds at varying times of year. The same parameters were followed in nine captive reindeer with varying protein and energy intake. Variation in the blood constituents of free-ranging reindeer was analysed in relation to different extrinsic and intrinsic factors and compared to findings from captive animals, allowing the analysis of effects of protein and energy intake. There was large overall variation in TP, ALB, GLOB and A/G ratio in the free-ranging animals, ranging between 36–110 g/L, 18–59 g/L, 17–59 g/L and 0.5–2.1. The variation between months and years was significant for all variables except the A/G ratio, where no year effect was noted. Increase in live body mass was associated with a small significant increase and pregnancy with a small significant decrease in all dependent variables, except for the A/G ratio. Age did not have a significant effect on any of the blood constituents when body mass was included in the same model. In captive animals, feeding lichens with low protein content was related to a significant decline in TP, ALB and GLOB, but not in the A/G ratio, whereas feeding commercial ration increased plasma TP, ALB and GLOB significantly. Extrinsic factors such as season and year explained majority of variation in the blood constituents of free-ranging reindeer, whereas body mass, pregnancy and age had only a minor influence. It is concluded that plasma TP and ALB, and to a lesser extent GLOB and A/G ratio may serve as nutritional biomarkers of reindeer.

Keywords: Albumin; A/G ratio; Body mass; Globulins; Nutrition; Reindeer; Total proteins

1. Introduction

Over-winter survival and efficient reproduction and growth of the reindeer in summer are essential for the productivity of reindeer management. Under natural conditions, changes in weather, pasture condition and feed availability may have adverse effect on these factors of productivity. During the past few decades, the decline in winter pasture quality related to overgrazing has become a growing problem in several parts of the Norwegian and Finnish reindeer herding areas (Johansen et al., 1996; Evans, 1996; Kumpula et al., 1997) and has reduced the productivity and profitability of reindeer herding (Kumpula et al., 2002). In Finland, this development has simultaneously favoured the use of commercial ratios with great economical costs as supplementary feeds on winter pastures (Nieminen et al., 1998). Therefore, parameters for monitoring the nutritional condition of reindeer are needed in studies where herd productivity levels in different pasture conditions and management systems are assessed. To be of practical value, these parameters should be easy to record in field conditions and relatively inexpensive to analyze in sufficient numbers. Blood samples can be obtained when semi-domesticated reindeer are gathered for slaughtering and counting, and most clinical laboratories employ automated techniques for the analysis of the selected chemical parameters.

In domestic ruminant management, plasma total proteins (TP) and albumin (ALB) have long been used as indicators of nutritional condition (Payne et al., 1970; Payne, 1987; Kaneko,

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1989). In the context of nutrition, albumin is probably the strongest indicator of protein nutrition (Payne, 1987). In sheep, the reference values for normal plasma TP and ALB concentrations are 60–79 g/L and 24–30 g/L (Kaneko, 1989), and concentrations below these are indicative of protein deficiency and undernutrition.

Lichens, which make up a considerable proportion of the winter diet of free-ranging reindeer, have low protein content, whereas summer forage has much higher protein and overall nutritive contents (Nieminen and Heiskari, 1989). The changes in the quality and/or quantity of diet are reflected as changes in several physiological parameters of reindeer, such as body mass, tissue protein and fat composition (Pösö et al., 2001; Soppela and Nieminen, 2002), and several blood parameters. The seasonal patterns in blood TP and ALB concentrations characterized by higher concentrations in autumn and a decrease over winter generally parallel the change in nutrition between summer and winter (Hyvärinen et al., 1975; Nieminen, 1980; Nieminen and Timisjärvi, 1983). Similar seasonal patterns and overall ranges in these protein parameters have also been described for other northern deer species such as white-tailed deer (DelGiudice et al., 1992). Several studies on captive reindeer have described an increase in blood TP and ALB concentrations during periods of high protein intake and a decline during periods of low protein intake (Bjarghov et al., 1976; Soppela et al., 1992; Soveri et al., 1992; Säkkinen et al., 1999), which has been considered to indicate a negative nitrogen balance.

Together with ALB, globulins (GLOB) account for most of total proteins in blood, acting as antibodies, enzymes and carrier proteins. The plasma GLOB concentration may increase in chronic infections caused by, for example, gastrointestinal parasites. These parasites can simultaneously cause a notable reduction in plasma ALB concentration due to loss of albumin from the host animal (Yakoob et al., 1983; Kaneko, 1989), leading to a reduction in the albumin/globulin ratio (A/G). High A/G ratios may occur in response to hyperalbuminaemia caused by dehydration. In reindeer, the blood A/G ratio shows seasonal variation with higher ratios in winter compared to summer and autumn, mainly as a consequence to changes in GLOB concentration (Hyvärinen et al., 1975; Nieminen and Timisjärvi, 1983).

Apart from nutrition, age and pregnancy may also affect the variation in the blood TP, ALB and GLOB of domestic ruminants, defined by lower concentrations in newborn and pregnant animals (Kaneko, 1989). In reindeer, less attention has been given to the age- or pregnancy-related differences in blood constituents (McEwan and Whitehead, 1969; Nieminen, 1980). What portion of the variation in blood chemical constituents is accounted for by these and other factors that could potentially confound the use of the blood constituents as nutritional indicators has not been studied until recently (Ropstad et al., 1997; Säkkinen et al., 2001; Milner et al., 2003).

This paper describes the sources of variation in plasma TP, ALB and GLOB concentrations and A/G ratio in free-ranging reindeer by taking into account several extrinsic and intrinsic factors, including year, season, age and pregnancy status. The variation in the studied parameters was also related to a conventional measure of animal's condition, namely live body mass (BM). Data collected from free ranging animals were compared to captive animals in defined feeding conditions, allowing an analysis of the effects of protein and energy intake on the studied blood constituents. Such knowledge is important for the evaluation of their usefulness as indicators of reindeer nutritional status.

2. Materials and methods

2.1. Free-ranging herds

Blood samples were collected from altogether four free-ranging reindeer (*Rangifer tarandus tarandus*) herds, three located in the Finnmark area in northern Norway (Seiland, Sørøy and Magerøy herds) and one in the Filefjell area in central southern Norway (Filefjell herd).

Female reindeer of the Seiland herd, named after its summer pasture on the island of Seiland in Altafjorden (70.25°N, 23.15°E), were followed during 2 consecutive years. The animals were blood sampled in March ($n=140$), May ($n=91$), June ($n=11$), October ($n=100$), November 1997 ($n=99$), and in March ($n=121$), May ($n=67$), July ($n=34$) and October 1998 ($n=102$). The blood samples were from mature animals, except in March 1998 when the sampled animals included 13 calves and 9 yearlings, in May 1998 when four calves were included, and in July 1998 when 1 yearling was included. The animals were divided into age classes based on their general appearance.

The lichen reserves on the winter pasture area in interior Finnmark in northern Norway were limited, but no supplementary feed was given to the animals in winter. In May, the herd was moved to the summer pasture. The pasture on the island was limited in spring and early summer, but improved considerably as summer progressed. The autumn pastures between October and late November, when the herd was moving to the winter pastures, were of moderate quality.

Blood samples were also collected from female reindeer in two other herds in Finnmark county, Norway (Sørøy: 70.36°N, 22.46°E; $n=219$ and Magerøy: 71.03°N, 25.45°E; $n=519$) during the winters of 1992 and 1994 (Sørøy) and 1992–1995 (Magerøy). All samples were collected in late January, except those in Magerøy in 1992, which were collected in early March. The herds were named after their summer pastures on two islands located on the northern coast of Finnmark. The animal density on Magerøy was about 10 reindeer/km^2 as compared to 4 reindeer/km^2 at Sørøy. In mid-September, the Magerøy herd was made to swim from the island pasture to the mainland, while the Sørøy animals were ferried to the mainland in mid-October. The migration to the central part of the Finnmark mountain plateau took about one to two months, with both herds covering a distance of about 250 km. Pasture quality varied considerably during the migration, but was generally regarded as satisfactory. During the winter, the herds were kept on a pasture in interior Finnmark, generally regarded to be of moderate quality.