Radiocesium metabolism in reindeer

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Abstract: Early in the era of atmospheric nuclear weapon tests, the reindeer was found to be an interesting animal concerning the transfer of environmental radioactive contaminants to man via the production of contaminated reindeer meat. The reason for the high transfer factors for some radionuclides is the feeding habits of the reindeer with a substantial intake of lichens, especially in the wintertime. One effect of the seasonal changes in feeding is also a considerable cyclic, seasonal variation in radiocesium content of soft tissues. The effective half-life of radiocesium was determined to about 30 days in an experiment where a herd of reindeer was moved form a high (>20 kBq/m^2 ^{137}Cs) to a low (<3 kBq/m^2 ^{137}Cs) contamination area. The fractional transfer of ^{137}Cs, during natural grazing, was determined to about 0.65 d/kg during wintertime on the low- contamination area and about 0.30 d/kg in summertime grazing in a more contaminated area. The radiation dose received by reindeers in Sweden after the Chernobyl accident was calculated to <200 mSv/a. The dose rate would be highest during the later part of winter but would not exceed 1 mSv/d.

Key words: reindeer, Chernobyl accident.

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Introduction

Radioactive pollutants from nuclear weapons tests were early detected in reindeer meat and the lichen-reindeer pathway was recognized as being interesting and important in the transfer of environmental radioactivity to man (Lindén & Gustafsson 1967; Miettinen 1967; Nevstrueva *et al.* 1967).

The reasons for this are mainly the feeding habits of the reindeer with a substantial intake of lichens high in radioactive contaminants (e.g. strontium, cesium and actinides) and a high transfer factor for radioactivity from reindeer-feed to meat. The grazing of lichens is high in wintertime, giving a substantial and typical seasonal variation in the radiocesium content of soft tissues with the highest concentration in late winter (Feb.-Mar.) (Lindén & Gustafsson 1967; NFA 1987). The disappearance of contaminants from the lichen plants is slow, which also adds to the long-term importance of reindeer meat as a potential contaminant of human foods (Westerlund *et al.* 1987).

Radioactive material, mainly ^{134}Cs and ^{137}Cs, from the Chernobyl nuclear power plant caused substantial contamintion of reindeer grazing areas in the middle part of Norway and Sweden. The total deposition in Sweden of the long-lived nuclide ^{137}Cs has been estimated to 3.4 PBq. Some 70,000 semi-domestic reindeer are normally kept by the local Sami families in the most contaminated ares. Wild game animals living in these areas have also been contaminated by radiocesium (Danell *et al.* 1989). A limited number of farmers have also been affected by contamination of their pasture mainly used for grazing of sheep and goats.

The level of radiocesium contamination, which was determined by aerial surveys already during the first month after the initial contamination and earlier studies of radiocesium transfer in reindeer (Ekman & Greitz 1967), showed that reindeer meat would contain ^{137}Cs well above the action level of 300 Bq/kg initially decided by the National Food Administration (NFA). The high radiocesium levels in reindeer meat will also persist for many years (Westerlund *et al.* 1987; Miettinen 1967). Several studies were therefore initiated in Sweden to find practical means to reduce the transfer of radioactivity to man from the reindeer forage - reindeer food chain.

The present study reports the results of moving about 5000 reindeer from their highly contaminated traditional winter grazing area in the middle part of Sweden to a less contaminated area further south where reindeer normally are not allowed to graze.

Material and methods

In late November 1986, the normal time for migration to the winter grazing area, about 5000 reindeer were moved by truck from the Gäddede area (lat. N 64° 15' - 64°55', long. E 12°) about 400 km south to Älvdalen (lat. N61°10', long. E 13°). The animals were allowed to graze in this area until late April 1987 when they were moved back to the normal spring grazing and calving area near Gäddede.

At monthly intervals, yearling bull calves were slaughtered both in the Älvdalen area and in the Gäddede area.

Samples were obtained form the flexor muscles of the fore limbs and from the ruminal content. All samples were analysed for radiocesium content and the ruminal samples were also analysed for potassium content by ^{40}K determination. Muscle samples were analysed as wet weight but plant material and ruminal samples were dried and analysed as dry matter (d.m.). To follow the seasonal changes of radiocesium in different plants, plant material was sampled in the area where the animals were grazing when slaughtered. These results will be presented elsewhere (Eriksson 1989).

The botanical composition was determined in the ruminal samples (Eriksson et al. 1981). The fractional transfer (f_m, d/kg) of ^{137}Cs from reindeer forage to meat was determined from the results of ^{137}Cs determination in meat and ruminal content.

Results and discussion

The average ^{137}Cs content of reindeer from the herd slaughtered in early November was 12 kBq/kg meat. Animals kept in the area throughout the winter had the same level or even increased levels in February - March when the highest levels normally are seen (Lidén & Gustafsson 1967; NFA 1987). These high levels are mainly due to the radiocesium contamination of lichens (e.g. *Cladina rangiferina)* which is the dominating feed in winter grazing conditions, which last from October to April in this area. Lichens grazed by these animals contain at least 10-15 kBq ^{137}Cs/kg d.m. (Eriksson et al. 1987).

The ^{137}Cs content of muscular tissue decreased, in this study, with an effective half· time of about 30 d when the animals had been moved to the low- contaminated area and were grazing lichens with a contamination level of <2 kBq/kg d.m. During the first week after tran-

Table 1. Measured content of ^{137}Cs in reindeer meat and calculated fractional transfer, f_m, of ^{137}Cs from natural grazing to meat. The daily potassium intake at different sampling times and the relative compositon of the ruminal contents are also shown.

Sampling time	^{137}Cs in meat kBq/kg	f_m d/kg	Daily K intake g/d	Lichen intake %	Vascular plant intake %
Nov	12	n.d.	n.d.	n.d.	n.d.
Jan	3	0.95	7	67	25
Feb	2.6	0.65	7	65	24
Mar	3.9	0.77	7	58	31
Apr	2.5	0.61	9	66	28
Jul	2.1	0.36	33	8	89
Aug	2.6	0.29	30	17	80
Sep	3.6	0.24	28	14	82

n.d. not determined

sportation of the reindeer the decrease was faster because they were fed uncontaminated hay in corrals.

The calculated fractional transfers, f_m, for different sampling times are shown in Table 1. Due to the seasonal changes in feeding habits of the reindeer its radiocesium metabolism will never be at steady state under natural grazing conditions. The calculated transfer factors therefore have to be evaluted together with the change in the body burden of radiocesium. The most reliable results will be seen in late winter and late summer, just before the major changes in forage selection occur (Eriksson 1989). The effects of these changes will be an overestimation of f_m in periods of decreasing radiocesium intake and an underestimation in periods of increasing intake, i.e. spring and autumn respectively, periods that are not specifically studied in this work. This effect is, however, indicated by the high f_m seen in January when these animals were still decreasing their body content of radiocesium after moving to the low-contamination area. If these effects are kept in mind the transfer of radiocesium to reindeer meat from a contaminated pasture can be estimated with reasonable accuracy if the radiocesium content of some specific forage plants are known. This type of information is valuable to the reindeer herders when planning grazing areas and slaughter times in a situation of substantial radiocesium contamination, such as after the Chernobyl accident.

The daily potassium intake of the reindeer, measured as ^{40}K, varies considerably through the year (Table 1). These variations reflect the different levels of potassium found in plants grazed by the reindeer. Lichens have a constant low potassium content throughout the year, about 2 to 4 g/kg d.m. (Åhman 1984) while most vascular plants which dominate summer feed intake have variable and in most cases substantially higher potassium levels, 20 to 35 g/kg d.m. (Hyvärinen et al. 1977; Wielgolaski et al. 1975). These differences are also confirmed by the present results, with a considerably higher potassium intake in the summer. The potassium intake of the reindeer in summer is similar to the intake of other herbivorous animals while the intake in winter is substantially lower. Earlier laboratory studies of cesium metabolism have not always shown clear effects of potassium suplementation within reasonable limits (Comar 1961) but in other studies incre-

ased potassium intake had decreased the body burden of radiocesium (Holleman et al. 1971). It is, however, possible that the considerable differences observed in potassium intake of reindeer can lead to effects on uptake, and f_m, of radiocesium under natural grazing conditions (Holleman et al. 1989).

The results of the botanical studies in this experiment will be reported in detail elsewhere (Eriksson 1989). The present study shows that natural grazing on low-contaminated pasture rapidly decreases the radiocesium content of reindeer and can be used as one effetive means of producing meat with, from a radiological point of view, acceptable levels of radiocesium.

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