NO9700056

Effects of the Chernobyl Accident on Radioactivity in Swedish Reindeer

BIRGITTA ÅHMAN[1], GUSTAF ÅHMAN[2]

[1]*Swedish University of Agricultural Sciences, Department of Clinical Nutrition, PO Box 7036, S-750 07 Uppsala, Sweden*
[2]*Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management, PO Box 7024, S-750 07 Uppsala, Sweden*

Large areas of reindeer pasture in Sweden were contaminated with radioactive material after the accident at the Chernobyl nuclear power plant in Ukraine in April 1986. The deposition of radioactive caesium was over 100 kBq per m^2 in some areas. Activity concentrations up to 7 kBq per kg in reindeer muscle were recorded during the summer after the accident (Åhman, 1994). The levels increased during the autumn. In the winter, reindeer meat from the southern parts of the county of Västerbotten contained up to 96 kBq ^{137}Cs per kg fresh weight.

Following the Chernobyl accident, the Swedish authorities decided upon an upper limit, 300 Bq kg^{-1}, for food products intended for sale on the open market. This restriction had a serious impact on reindeer meat production. From August 1986 until April 1987, 78% of all reindeer slaughtered in Sweden were excluded from sale for human consumption. The restriction for reindeer meat, game, freshwater fish, wild berries and mushrooms was changed in July 1987, to an upper limit at 1500 Bq kg^{-1}. The change was based on the fact that these food products were considered to constitute only a small part of the diet of the average Swedish consumer. As a consequence of the changed limit, less reindeer meat (29%) was excluded from the market during the following year.

Radiocaesium contamination of reindeer pasture land after the Chernobyl accident raised interest in collecting facts with the purpose of predicting radiocaesium levels in reindeer in the future. It was demonstrated (Åhman and Åhman 1994) that the levels of radiocaesium in reindeer are well correlated to the ground deposition. The average aggregated transfer factor (^{137}Cs per kg reindeer meat in relation to deposition of ^{137}Cs per m^2) for the first winter after the accident was 0.76 m^2 kg^{-1}. This may be compared to a ratio around 1.5 m^2 kg^{-1} for activity concentrations in reindeer muscle to activity per m^2 of lichens that was observed after the nuclear weapons test (Svensson and Lidén, 1965).

A large seasonal variation of radiocesium in reindeer from the same area, with up to 20 times higher levels during winter than during summer (Fig. 1), was observed after the Chernobyl accident (Åhman and Åhman 1994). A considerably lower aggregated transfer factor was also observed in September 1986 (0.12 m^2 kg^{-1}) than later during winter. The seasonal variations are explained by the shift in diet from summer (mainly green vegetation) to winter (a lichen dominated diet), resulting in a considerable change of radiocaesium intake. A shorter biological half-life of radiocaesium during summer (Holleman *et al.*, 1971) may reduce the activity in the body in relation to intake and further increase the seasonal difference. Seasonal migrations between ranges with different ground contamination may also affect the seasonal variations of radiocaesium levels in the reindeer.

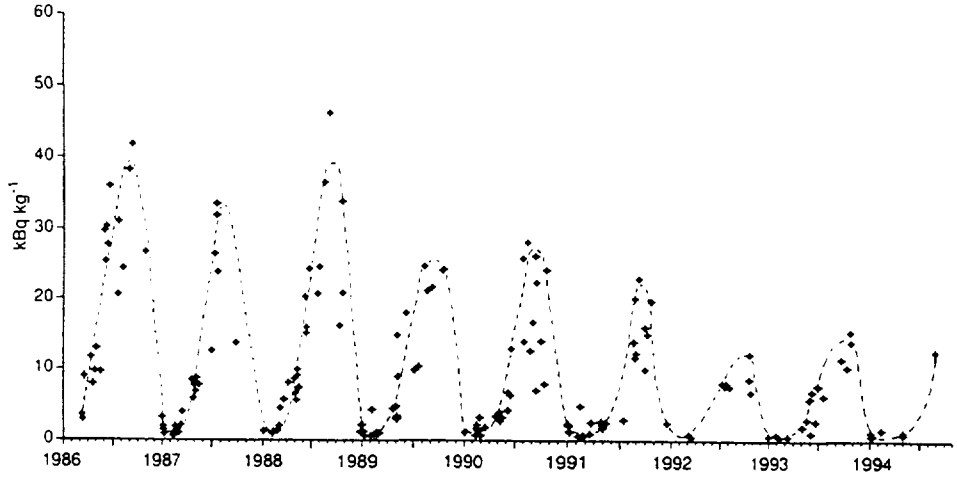

Figure 1. Activity concentrations of ^{137}Cs in reindeer meat from Vilhelmina Norra from 1986 to 1995; mean values from separate slaughter occasions (n≥10 animals)

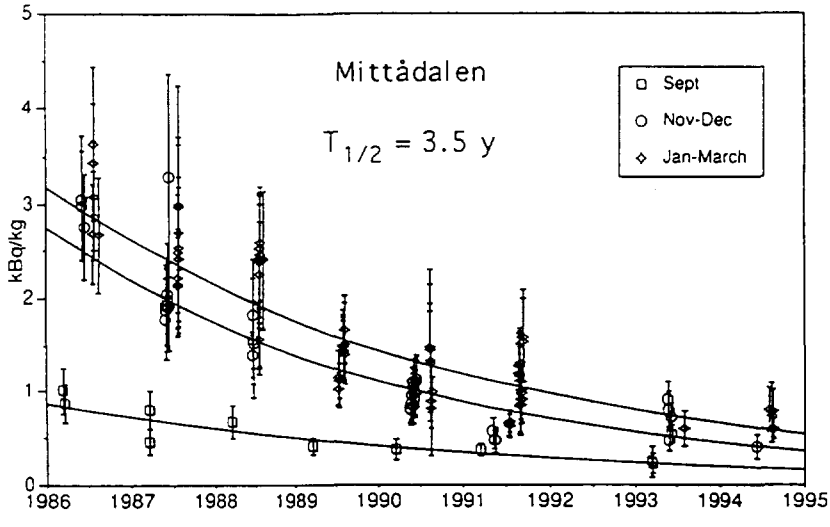

Figure 2. The decrease in activity concentrations of ^{137}Cs in reindeer meat from Mittådalen from 1986 to 1995; mean ± S.D. from separate slaughter occasions (n≥10 animals)

In most areas of Sweden the radiocaesium levels in reindeer have decreased from 1986 to 1992, with an effective ecological half-life from 2 to 5 years. The average effective ecological half-life (Fig. 2) was shorter, 3.2 years, for the period September to December than corresponding half-life, 4.2 years, for January to April (Åhman and Åhman 1994). The decline has been considerably faster than the corresponding decline, 6-7 years half-life, observed from 1965 until 1983 or 1986 (Westerlund *et al.*, 1987; Rissanen and Rahola, 1990). However, additional fallout after 1965 may have resulted in a longer half-life. A trend towards a slower decline during later years than during the first years after the Chernobyl accident, may indicate that the effective ecological half-life will be longer in the future.

Two main countermeasures have been used in Swedish reindeer husbandry, to prevent contamination of food products after the Chernobyl accident. The most simple method has been to slaughter reindeer earlier in the autumn, before radiocaesium levels rise too high. The other one has been to decontaminate the reindeer by providing uncontaminated feed for about two months prior to slaughter. These two methods have been very successful, and during the last slaughter season (July 1994 to June 1995) only 3% of the slaughtered reindeer had to be excluded from the market because of too high radiocaesium levels.

CONCLUSIONS

Fallout radiocaesium is effectively transferred to reindeer and the transfer is highly dependent on the season. The reduction of radiocaesium from the soil-pasture-reindeer ecosystem has occurred with a faster rate after the Chernobyl fallout than after the nuclear weapons tests. Effective countermeasures have helped to prevent contamination of reindeer meat intended for human consumption. Nevertheless, the fallout from Chernobyl will probably remain a problem for reindeer husbandry in the contaminated parts of Sweden for at least 20 more years.

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