

Consequences of the Chernobyl accident for reindeer husbandry in Sweden

Gustaf Åhman¹, Birgitta Åhman² & Axel Rydberg¹

¹Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Box 5097, S-900 05 Umeå, Sweden.

²Department of Clinical Nutrition, Swedish University of Agricultural Sciences, Box 7023, S-750 07 Uppsala, Sweden.

Abstract: Large parts of the reindeer herding area in Sweden were contaminated with radioactive caesium from the Chernobyl fallout. During the first year after the accident no food with activity concentrations exceeding 300 Bq/kg was allowed to be sold in Sweden. This meant that about 75% of all reindeer meat produced in Sweden during the autumn and winter 1986/87 were rejected because of too high caesium activities. In May 1987 the maximum level for Cs-137 in reindeer, game and fresh-water fish was raised to 1500 Bq/kg. During the last two years, 1987/88 and 1988/89, about 25% of the slaughtered reindeer has had activities exceeding this limit.

The effective long-time half-life of radiocaesium in reindeer after the nuclear weapon tests in the sixties was about 7 years. If this half-life is correct also for the Chernobyl fallout it will take about 35 years before most of the reindeer in Sweden are below the current limit 1500 Bq/kg in the winter. However, by feeding the animals uncontaminated food for about two months, many reindeer can be saved for human consumption.

Key words: Cs-137, half life, feeding

Introduction

A few days after the nuclear power plant accident in Chernobyl it was evident that reindeer herding areas in Sweden had been hit by appreciable radioactive deposition. Ground radiation measurements showed the highest levels in Southern Västerbotten, Northern Jämtland and Northwestern Ångermanland. Levels ranging from 60 to 80 kBq Cs-137 per m² were found in the worst affected areas (Figure 1), being 40 - 50 times the levels during the mid-sixties of ground radiation from the nu-

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clear weapon tests (Lidén & Gustafsson 1967).

Measurements of activity concentrations of radiocaesium in reindeer have been made in Sweden since 1961. Some values are shown in Table 1 (Åhman 1986). In Finland measured activity concentrations of Cs-137 in reindeer meat in the winter 1985/86, before the Chernobyl accident, was 300 Bq/kg on an average (Risänen et al. 1987). The level of radiocaesium in reindeer varies during the year, with high values in the winter when the reindeer eat lichens and

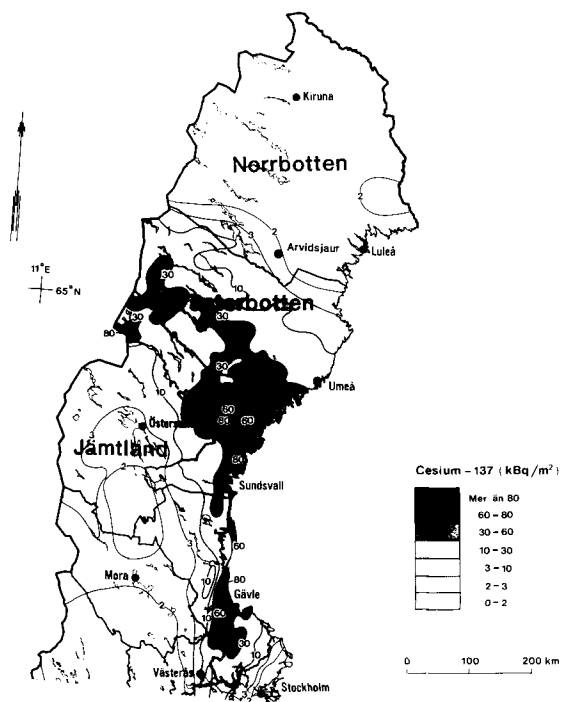


Figure 1. Ground radiation of Cs-137, kBq/m². Results from areal surveys, May to October 1986. Commissioned by the National Institute of Radiation Protection. Swedish Geological CO.

Table 1. The activity concentration of Cs-137, kBq/kg, in reindeer meat in the autumn and winter 1964/65, 1974/75 and 1985/86 (from Åhman 1986).

Year	Cs-137, kBq/kg	
	Autumn	Winter
1964/65	0.5-1	2-4
1974/75	0.3	1-2
1985/86	0.1	0.3

low values in the summer when they eat mainly green plants (grass, leaves, etc.) that are not so high in activity concentrations of radiocaesium (Lidén & Gustafsson 1967; Åhman et al. 1988).

The first year after Chernobyl, 1986/87

Soon after the Chernobyl accident an action level of Cs-137, 300 Bq/kg, was set by the Natio-

nal Institute of Radiation Protection in Sweden for all food, including reindeer meat, to be sold for human consumption. The Swedish Government declared that compensation would be paid for costs and loss of income because of the Chernobyl fall-out. According to this general promise the reindeer owners are paid for rejected reindeer meat, lower body weight and cost of labour when the time of slaughter has to be changed and also for costs when feeding reindeer to lower the radiocaesium content. The slaughter companies are refunded by the state for costs involved in slaughtering animals which are rejected.

During June and July 1986 a total of 102 reindeer were slaughtered and samples were taken from muscle, blood, rumen content, etc. for analyses of radioactive caesium (Åhman 1986). Some results are shown in Table 2. From an additional 132 live animals, blood samples were taken. The aim of the studies was to get an overview of the situation in different Saami (Lapp) villages and support for predicting radiocaesium levels in meat at the time of slaughter.

Table 2. Activity concentrations of Cs-137 in reindeer meat in June and July 1986 (6-10 samples from each area).

Area	Cs-137, kBq/kg in meat	
	June	July
<i>Norrbotten</i>		
middle	0.1-0.2	—
southern	0.4-1.9	0.1-0.3
<i>Västerbotten</i>		
middle	—	0.7-1.6
southern	3.1-6.6	1.8-4.3
<i>Jämtland</i>		
northern	5.4-7.6	0.9-3.2
southern	1.7-2.6	0.1-1.6

From these investigations it was clear that the majority of reindeer to be slaughtered in Jämtland and Västerbotten during September would

Table 3. Number of reindeer accepted for human consumption (<300 Bq Cs-137/kg in meat) and number rejected, from Norrbotten, Västerbotten and Jämtland in July 1986 to April 1987 (from Lantbruksnämnden i Jämtland län 1987 and Nilsson 1988).

	July–Sept.		Oct–Dec.		Total	
	accepted	rejected	accepted	rejected	accepted	rejected
Norrbotten	19013	2731	6902	32268	25915 (43%)	34999 (57%)
Västerbotten	134	5644	3	11217	137 (1%)	16861 (99%)
Jämtland	0	2342	1131*	12169	1131 (7%)	14511 (93%)
Total	19147	10717	8008	48837	27183 (29%)	66371 (71%)

* animals fed in corrals

be rejected because of Cs-137 levels exceeding 300 Bq/kg. A large proportion of the reindeer meat from Norrbotten was predicted to be below 300 Bq/kg. Slaughter during the autumn and winter season 1986/87 revealed, however, that almost 60% of the carcasses from Norrbotten were above 300 bq/kg and were rejected (Table 3). A few villages in Norrbotten were advised to slaughter earlier than normal, before the radiocaesium values started to increase because of high lichen intake. A couple of thousand carcasses were saved for human consumption in this way.

In Västerbotten only 137 reindeer (1%) were below 300 Bq/kg and the rest were rejected. In Jämtland about 1100 reindeer were taken into corrals and fed during January to March and thus saved for human consumption. During the slaughtering season 1986/87, 71% of all reindeer that were slaughtered in Sweden had activity concentrations of Cs-137 in meat exceeding 300 Bq/kg. The remaining 29% had values below 300 Bq/kg and were accepted for human consumption.

In samples taken after Chernobyl, Cs-137 from the sixties can be estimated by using the relation between Cs-134 and Cs-137 (Åhman 1986), since the Chernobyl fallout contained one-third of Cs-134 while the contamination from before Chernobyl is only Cs-137. Old Cs-137 estimated in this way was 0.06 - 0.25

kBq/kg in reindeer from Norrbotten during October and November 1986.

The second year after Chernobyl, 1987/88

In May 1987 the decision was taken by the National Food Administration to raise the action levels of Cs-137 in reindeer, game and fish from 300 to 1500 Bq/kg (see also Johanson, K.-J. in this publication). The increase of maximum level of Cs-137 had the effect that virtually all of Norrbotten and also a few villages in Jämtland were classified as 'safe' areas (all reindeer were considered to be below the new limit of 1500 Bq Cs-137/kg in meat and no analyses had to be made, except for a few test samples) during the bull slaughter in September of 1987. For the remaining part of the year, Norrbotten except the southernmost Saami villages were classified as safe.

In several villages in Jämtland reindeer were fed in corrals during the winter 1987/88. A total of 5500 reindeer were fed pelleted feed supplemented with 2.5% bentonite and 0.25% potassium. These animals were also given hay. The addition of bentonite to bind radiocaesium was considered necessary, as the reindeer had access to some pasture with high radiocaesium content in their corrals. They could also eat contaminated soil. The addition of potassium was made to speed up the degradation of caesium in the body.

From two Saami villages in Västerbotten and Jämtland (Vapsten and Frostviken mellersta), 10000 reindeer were transported to Älvdalen in northern Dalarna. In this area the radiocaesium contamination was not so high (1-2 kBq/kg DM in lichens, Eriksson et al., 1987). It was still not sufficiently low to reduce the levels of radiocaesium in the animals below 1500 Bq Cs-137/kg and about 2500 reindeer selected for slaughter had to be fed in corrals for some weeks. The other animals were transported back to their calving range in April.

During 1987/88 a total of 68000 carcasses (72%) were accepted for human consumption, out of 95000 slaughtered reindeer (Nilsson 1988). Figures from some Saami villages are shown in Table 4. Among those that were accepted, 5000 animals had been slaughtered early (before the normal bull slaughter in September) and 5500 had been fed in corrals during the winter. The remaining 57500 had not been treated in any special way.

Table 4. Activity concentration of Cs-137 (kBq/kg) in reindeer meat from some slaughters in the autumn of 1987.

Reindeer from	Date	No. of animals	kBq/kg $\bar{x} \pm SD$	Per cent <0.3	Per cent <1.5
<i>Norbotten</i>					
<u>Jäkkåskaska</u>					
Prinskullen	Aug 25	10	0.1	100	100
Tjapsåive	Sept 14	7	0.2	85	100
Sågudden	Dec 14	22	0.7 \pm 0.1	0	100
<u>Västra Kikkejaure</u>					
Dolpek	Nov 17	118	1.2 \pm 0.5	0	93
Solberg	Dec 15	60	0.6 \pm 0.2	0	100
<i>Västerbotten</i>					
<u>Umbyn</u>					
Biellojaur	Aug 20	377	0.5 \pm 0.3	5	99
"	Sept 5	172	1.1 \pm 0.5	0	90
"	Sept 19	244	1.0 \pm 0.5	0	92
"	Oct 25	244	3.6 \pm 1.1	0	0
<u>Vilhelmina norra</u>					
Gielas	Sept 5	333	1.0 \pm 0.4	0	86
"	Sept 15	218	3.9 \pm 1.1	0	0
"	Oct 21	127	8.5 \pm 3.5	0	0
<i>Jämtland</i>					
<u>Hotagen</u>					
Vinklumpen	Aug 23	112	0.8 \pm 0.2	0	100
"	Sept 8	184	1.4 \pm 0.5	0	71
"	Nov 30	163	6.0 \pm 1.4	0	0
<u>Mittådalen</u>					
Flatruet	Sept 16	10	0.8 \pm 0.2	0	100
Lossen	Nov 28	114	1.9 \pm 0.4	0	16

Prospects for the future

If there is no additional fallout the levels of radiocaesium in reindeer in the future will depend mainly on the effective half-time of radiocaesium in lichens. Lidén and Gustafsson (1967) estimated this half-time to 11 years. If grazing was taken into consideration they predicted the yearly decrease of radiocaesium in reindeer meat to be 10 - 15%, which corresponds to a effective half-time of 7 years. Holleman (1973/74) estimated the effective half-time of Cs-137 in lichens to be 8.3 years. From figures given by Westerlund et al., (1987) on Cs-137 in reindeer meat from 1965 to 1983, we have calculated the effective half-time of Cs-137 to be 7 years.

Even in one of the most contaminated Saami villages (Vilhelmina Norra in south Västerbotten) the values are below 1500 Bq/kg in July and August (Figure 2) but already in the be-

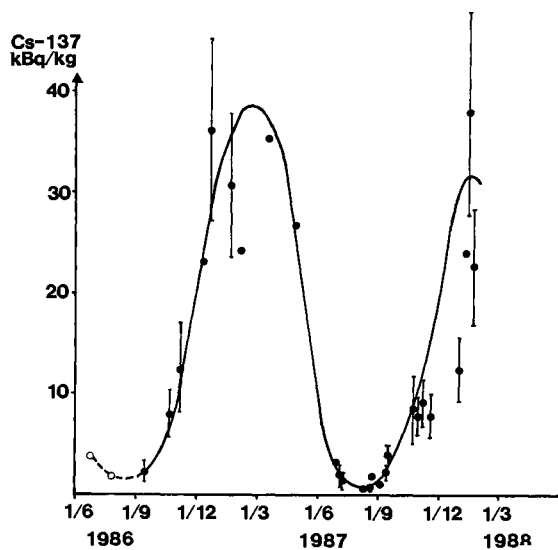


Figure 2. Yearly variation in activity concentration of Cs-137 in reindeer from the Saami village Vilhelmina Norra (south Västerbotten) from June 1986 to February 1988 (kBq/kg in meat).

ginning of September they start to increase rapidly. Before mid-September, the normal time for bull slaughter, most reindeer have

passed the limit 1500 Bq Cs-137 in meat. If the half-time of radiocaesium in most plants grazed by reindeer in late summer is the same as in lichens, it will take at least until the year 2000 before most of the reindeer in Vilhelmina Norra are below 1500 Bq/kg at the normal time for bull slaughter.

In the winter the highest activity concentrations of radiocaesium in reindeer in Vilhelmina Norra, as in the rest of southern Västerbotten and the most northern part of Jämtland, are at a level of 40 kBq Cs-137/kg in meat. It will take 5 half-times, 35 years, before most of the reindeer are below the 1500 Bq/kg level in the winter. In northern Västerbotten and middle Jämtland, where the activity concentrations are at a level of 10 kBq Cs-137/kg in the winter, it will take about 20 years before all reindeer fall below the 1500 Bq/kg limit.

If no measures are taken to reduce radiocaesium levels in reindeer before slaughter, nearly 30000 carcasses per year will be rejected during the next two years. Economically, early bull slaughter is the most efficient measure. Loss of income because of lower body weight and costs for extra labour amount to 20 - 30% of the value of the meat. It is, however, often difficult and some times impossible to round-up reindeer for slaughter in August. For this reason, most of the bull slaughtering will have to be done at the ordinary time in September.

There is great interest among the reindeer herders to move animals to areas with low radiocaesium contamination. Moving animals outside the normal pasture land for reindeer creates several legal and economical problems.

Lowering radiocaesium levels in reindeer by feeding had been used with success in most Saami villages in Västerbotten and Jämtland. To achieve a good live weight before slaughter the feeding has to be continued for 8 to 10 weeks. The half-time for radiocaesium in reindeer that are fed is normally 15 - 17 days. This means that most reindeer can be saved for hu-

man consumption by feeding. The total cost for feeding during 10 weeks is, however, almost as large as the price paid for the meat produced. New types of feed and new techniques that reduce the costs will be tried during forthcoming years.

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