

Radiocaesium in moose in Finland

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Abstract. The areal variation of the ^{137}Cs contents in moose meat during 25 years was studied and the ingestion radiation dose from ^{137}Cs in moose meat was assessed in the game management districts in Finland. The level of radiocaesium contents in moose (*Alces alces alces*) has been monitored annually in Finland after the Chernobyl accident in 1986. Since 1986 the ^{137}Cs concentrations have decreased on average up to 50 percent by the beginning of the 2000s. Measurements of moose meat, liver and kidney originating from the same animals indicated that the fresh weight content of ^{137}Cs was in liver on average 0.84 times and in kidney about 1.5 times as high as in meat. The ^{137}Cs concentrations in meat of Finnish moose in 2010 are well below the level 600 Bq kg^{-1} which is the level recommended to be respected for placing on the market of wild game (2003/274/Euratom). In 2007, the average annual ingestion dose from moose meat for hunter households varied from 0.01 mSv a^{-1} to 0.13 mSv a^{-1} in various game management districts.

KEYWORDS: (^{137}Cs , moose, radiation dose)

INTRODUCTION

Moose (*Alces alces alces*) is the most significant game animal in Finland. In the 2000s, the annual bag of moose has varied from 60 000 to 80 000 individuals (RKTL, 2010). Moose meat yield of the entire game bag is about 75 percent in Finland. The proportion of calf meat of all the moose meat was from the late 1980s to 1993 less than 25 percent and has increased since then to about 30 percent. The number of hunters in Finland was in the end of the 1980s about 270 000, and has increased by 2010 up to 300 000. Almost one-third of the hunters live in the two northernmost provinces of the country. In the 2000s the number of hunters taking part in moose hunting has been about 100 000. Nearly 98 percent of the moose meat is consumed in the households of these hunters. The median consumption of moose meat by moose hunters is $17 \text{ kg year}^{-1} \text{ person}^{-1}$ ($4.3\text{--}50 \text{ kg year}^{-1}$) and median consumption of moose liver among users of liver is 1 kg year^{-1} and among users of kidney consumption is 0.5 kg year^{-1} (Vahteristo et al, 2003). Of all the moose hunters 69 percent consumes moose liver and kidney is consumed by 23 percent of moose hunters.

Radiocaesium in moose meat originates mainly from the deposition after the Chernobyl accident in 1986 and small fraction from deposition after the nuclear weapons tests in the 1950s and 1960s. In 1985 the accumulated ^{137}Cs deposition in Finland was 1.8 kBq m^{-2} (STUK-A54, 1987). The ^{137}Cs deposition in 1986 was unevenly distributed (Arvela et al, 1990) (Fig. 1). The mean ^{137}Cs deposition in the game management districts varied from 1.8 kBq m^{-2} to 47 kBq m^{-2} (1.10.1987). About 40 percent of the annual bag of moose comes from the game management districts where the mean ^{137}Cs deposition was less than 5 kBq m^{-2} after the Chernobyl accident, and only 8 percent from the districts with the mean deposition more than 30 kBq m^{-2} .

^{137}Cs contents in Finnish moose meat were measured for the first time in 1979. The nationwide mean ^{137}Cs concentrations were then 34 Bq kg^{-1} varying areally from 22 to 52 Bq kg^{-1} (Rantavaara, 1982). After the ^{137}Cs deposition in 1986 the mean ^{137}Cs contents of moose meat varied from 40 to 500 Bq kg^{-1} in the game management districts, and the nationwide mean was 170 Bq kg^{-1} (Rantavaara et al, 1987). The mean ^{137}Cs contents of moose meat in Finnish Lapland, where the deposition was minor, remained in 1986 at the same level as in 1979 (Rissanen et al, 1987).

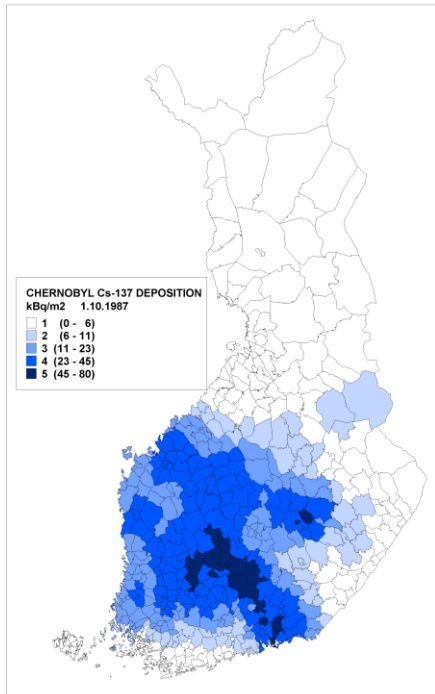


Fig. 1. ^{137}Cs deposition in Finland (1.10.1987).

MATERIAL AND METHODS

In 1986–2010 altogether 2 500 moose meat samples were collected of which about 650 were from calves and the rest from adults. Most samples were taken from moose shot during the hunting season, mainly in October–November. The number of samples varied from about 300 samples in 1986 decreasing to 100–200 by 2000 and down to 10–50 samples per year in later on. In the end of the 1980s and in the 1990s the sampling area covered all the game management districts in Finland and later in the 2000s fewer districts with varying deposition levels.

RESULTS AND DISCUSSION

^{137}Cs concentrations of moose meat in 1987–2010

Variation of ^{137}Cs concentrations of the moose meat samples in areas of low deposition ($< 5 \text{ kBq m}^{-2}$) and highest deposition ($> 30 \text{ kBq m}^{-2}$) in 1987–2010 is shown in Fig. 2 by two year intervals. The number of samples for the two-year periods varied, decreasing year by year. The sampling areas have not been the same during the years, which may have had some influence on the fluctuation of ^{137}Cs concentrations during the study period. In addition, the proportion of calves in the data varied, which increases the variation due to higher ^{137}Cs contents in calves than in adults (Nelin, 1994). In the areas of high deposition ($> 30 \text{ kBq m}^{-2}$) the decline in the ^{137}Cs concentrations is obvious; the contents have decreased since 1987 with the half-life of 15 years. The nationwide mean of ^{137}Cs contents in moose meat has decreased from 170 Bq kg^{-1} in 1986 down to 50 Bq kg^{-1} in 2010.

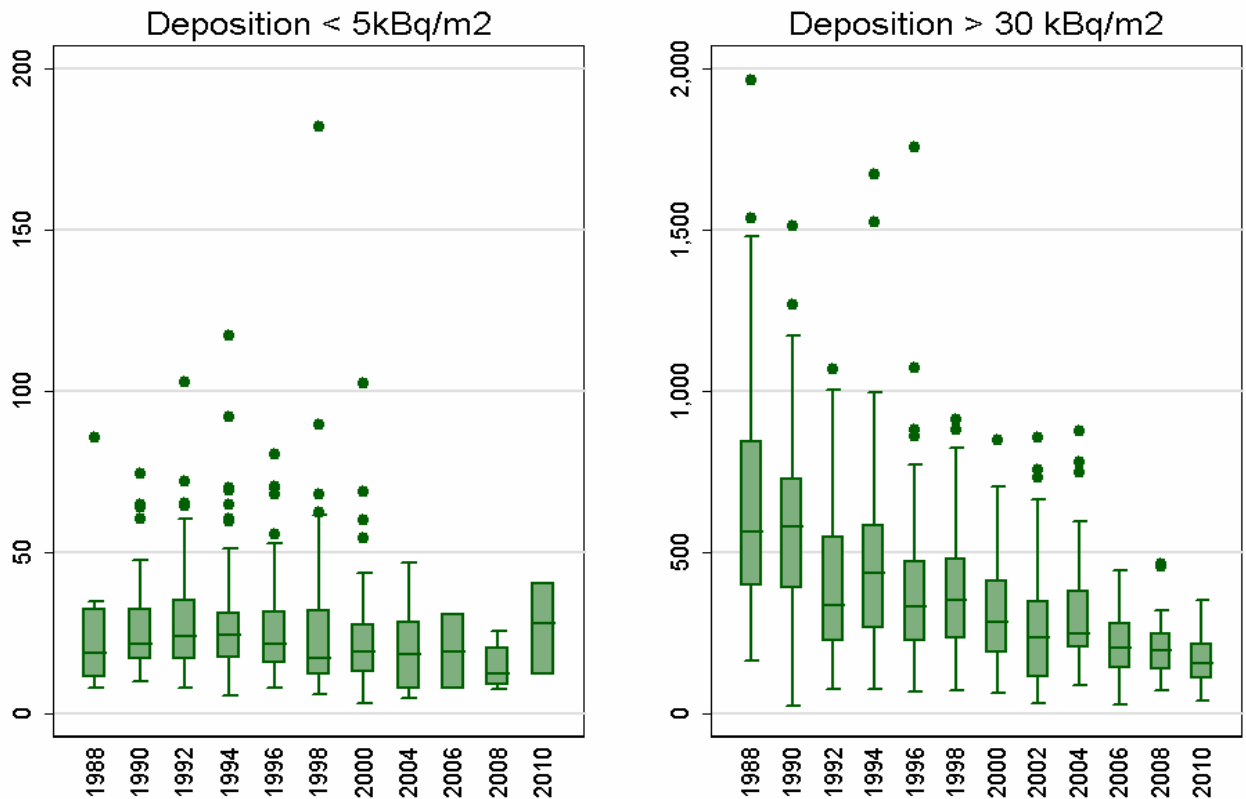


Fig 2. Variation of ^{137}Cs concentrations (Bq kg^{-1} f.w.) of moose meat (calves and adults) in areas with ^{137}Cs deposition (1.10.1986) less than 5 kBq m^{-2} and over 30 kBq m^{-2} . Boxes represent 25th and 75th percentiles with median values, whiskers upper and lower adjacent values and dots outside values.

The relationship between ^{137}Cs contents in moose liver and meat was estimated on 51 pairs of moose meat and liver samples, where both the liver and meat originated from the same animal. The fresh weight content of ^{137}Cs in meat was on average 1.2 times as high as in liver (median=1.15, mean= 1.22). In four sample pairs of moose meat and kidney, the ^{137}Cs concentrations (fresh weight) in kidney were 1.5 (1.1–1.8) times as high as in meat.

Effective radiation dose due to ingestion of moose meat

Nearly 98 percent of the moose meat is consumed by the approximately 100 000 hunter households in Finland, whereas only a minor amount of moose meat is available on the market. The annual moose meat yields vary in different game management districts as well as the number of moose hunters (Svensberg, 2008). The highest amounts of moose meat per household calculated from annual meat yields of the game management districts are well consistent with the maximum consumption rates (55 kg) found in the questionnaire made by Vahteristo et al. The amounts of moose meat per household and the average doses to these households in various game management districts were estimated in 2007 (Fig.3). The highest average dose per household was about $130 \mu\text{Sv}$ in 2007, which is $40 \mu\text{Sv}$ per person, if a household is assumed to consist of three persons. Inside the game management districts where the maximum deposition values are found, the highest annual dose due to ^{137}Cs in moose meat for a hunter consuming 55 kg per year may reach 0.3 mSv per year. The consumption of moose liver and kidney causes a minor increase to the dose due to low consumption rates.

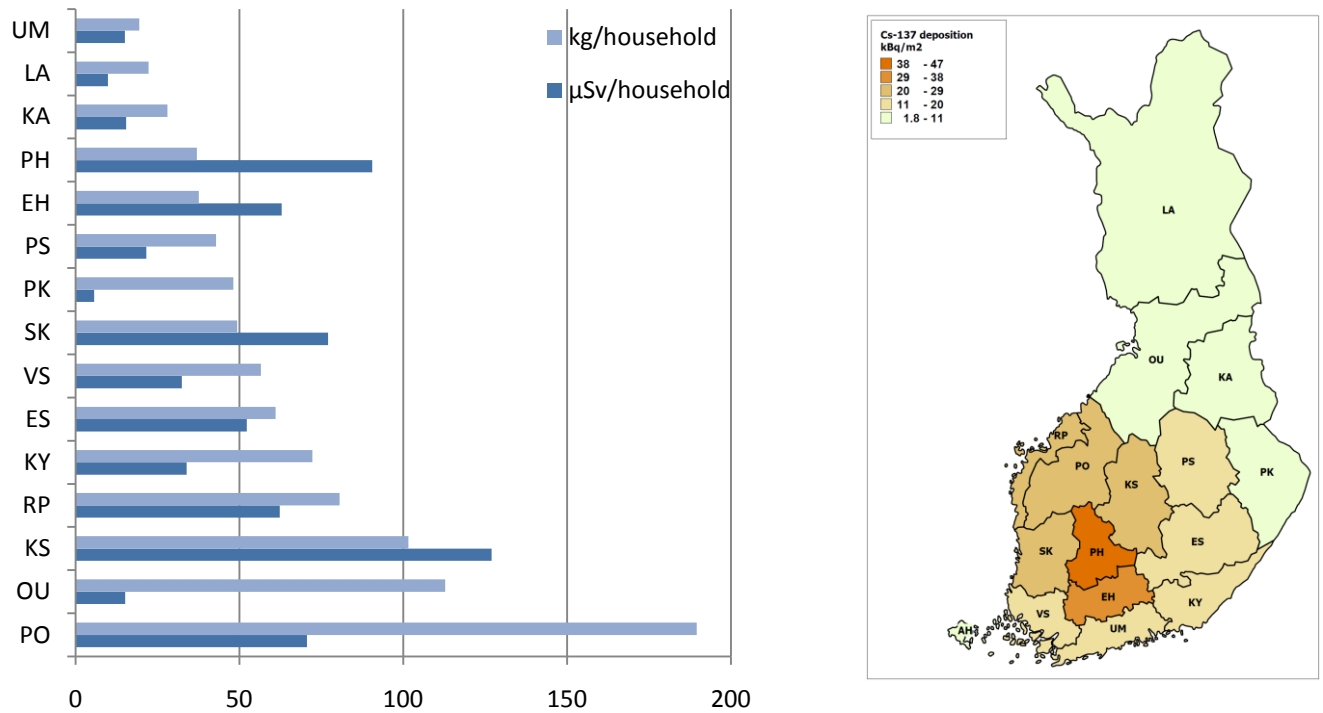


Fig. 3. The radiation dose ($\mu\text{Sv a}^{-1}$) per household in 2007 due to ^{137}Cs in moose meat in different game management districts. The moose meat yields (kg a^{-1}) per household are given. The game management districts in Finland and the mean ^{137}Cs deposition kBq m^{-2} (1.10.1987) in the districts.

CONCLUSIONS

The ^{137}Cs contents in moose meat correlate with the Chernobyl deposition. The ^{137}Cs concentrations in moose meat have decreased on average by a half-life of 15 years. The decrease of ^{137}Cs after 1986 has been not been uniform; the annual and areal variations are large. In 2010, even in the most contaminated areas in Finland, the ^{137}Cs concentrations in moose meat are well below the level 600 Bq kg^{-1} which is the level recommended to be respected for placing on the market of wild game (2003/274/Euratom).

REFERENCES

- Arvela, H., Markkanen, M., Lemmelä, H. (1990). Mobile survey of environmental gamma radiation and fallout levels in Finland after the Chernobyl accident. *Radiat. Prot. Dosimetry*, 32 (3), 177–184. 1990.
- Finnish Game and Fisheries Research Institute (2010). *Hunting 2009. Riista- ja kalatalous 6/2010*. Official Statistics of Finland – Agriculture, Forestry and Fishery. Helsinki 2010.
- Vahteristo, L., Lyytikäinen, T., Venäläinen, E.-R., Eskola, M., Lindfors, E., Pohjanvirta, R., Maijala, R. (2003). Cadmium intake of moose hunters in Finland from consumption of moose meat, liver and kidney. *Food Addit. Contam.*, 2003, 20, 5, 453-463.
- Nelin P. (1994) Chernobyl cesium in the Swedish moose population: Effect of age, diet and habitat selection. Department of Animal Ecology, Faculty of Forestry, Swedish University of Agricultural Sciences, Umeå. Dissertation 1994.

- STUK-A54 (1987). Studies on Environmental Radioactivity in Finland 1984–1985. Annual report. Helsinki.
- Rantavaara, A. (1982). Caesium-137 in moose meat in Finland. Suomen Riista 1982; 29: 5–13. (In Finnish, Summary in English.)
- Rantavaara, A., Nygrén, T., Nygrén, K., Hyvönen, T. (1987). Radioactivity of game meat in Finland after the Chernobyl accident in 1986. STUK-A62. Helsinki, 1987.
- Rissanen, K., Rahola, T., Illukka, E., Alfthan, A. (1987). Radioactivity of reindeer, game and fish in Finnish Lapland after the Chernobyl accident in 1986. STUK-A63. Helsinki, 1987.
- ICRP Publication 72. (1996). Age-dependent doses to members of the public from intake of radionuclides: Part 5. Annals of the ICRP 26 (1996) 75–77.
- Svensberg, M. (2008). Personal communication.