

Deer truffles – the dominant source of radiocaesium contamination of wild boar

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Abstract. In some regions of Germany radiocaesium contamination of wild boar (*Sus scrofa*) is either staying fairly constant or slightly increasing on average, concurrently exhibiting an extraordinary variability. The reasons for this peculiar contamination pattern were investigated from 2002 to 2004 in an area located in the Bavarian forest. The microscopic analyses of 70 stomachs gave detailed information on the food composition. Potential food items sampled in the investigation area were measured for their radiocaesium level. Deer truffles (*Elaphomyces granulatus*), a preferred delicacy of wild boar, turned out to play a key role. This fungus showed contamination levels exceeding those of edible mushrooms and other food components by an order of magnitude and more. Despite their low weight proportion of about 6% of the stomach content on average, more than three quarters of the radiocaesium uptake can be ascribed to deer truffles. Their irregular consumption and the dynamics of radiocaesium in forest soil explain the peculiar contamination pattern of wild boar. Predictive modelling of radiocaesium contamination of wild boar should always take into account deer truffles, especially their occurrence, contamination levels and irregular consumption.

1. INTRODUCTION

Radiocaesium contamination of wild boar (*Sus scrofa*) still achieves several ten thousands Bq kg⁻¹ fresh weight (FW) in some areas of Germany, concurrently exhibiting an extraordinary variability. In the Bavarian Forest, for instance, activity levels ranged between 82 and 40,000 Bq kg⁻¹ FW in 2004, with maximum and minimum values occurring at almost the same location within one week [1]. Whereas radiocaesium levels of roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*), apart from seasonal variations, are continuously decreasing, those of wild boar are either remaining fairly constant or even increasing [1–3].

Wild boars take up radiocaesium *via* their fodder. Because of their high radiocaesium levels, deer truffles (*Elaphomyces granulatus*), a delicacy for wild boar but unfit for human consumption, have repeatedly been discussed as one of the reasons for the unexpected contamination pattern (e.g. [4]). The abundance and amount of different food items in wild boar stomachs and their potential contribution to the radiocaesium intake of these animals have not yet been systematically investigated. Therefore, the German Federal Office for Radiation Protection initiated a research project aiming at understanding the dominant factors governing the contamination pattern of wild boar. This contribution focuses on the importance of deer truffles with regard to the radiocaesium intake of wild boar and the consequences for predictive modelling.

2. MATERIALS AND METHODS

2.1 Investigation area

The area investigated is located in the Bavarian Forest (49°04' N latitude, 13°06' E longitude) at altitudes between 550 and 1,450 m a.s.l. The soils are classified as cambisol (FAO classification). They are partly podsollic and show a 2–8 cm thick moder layer.

The uppermost mineral soil (0–5 cm) is characterized by a grain size distribution of 59% sand, 27% silt and 13% clay, a pH (CaCl₂) of 3.4 and a CEC of 144 mmol_c kg⁻¹. The average annual temperature is 5 °C and the mean annual precipitation is about 1,200 mm. The dominating trees are Norway spruce (*Picea abies*) and beech (*Fagus sylvatica*). The spare understorey vegetation essentially consists of bilberry (*Vaccinium myrtillus*), spinulose wood fern (*Dryopteris carthusiana*), lady fern (*Athyrium filix-femina*), blackberry (*Rubus fruticosus*) and moss (*Polytrichum* sp.). With a mean ¹³⁷Cs inventory of about 54,000 Bq m⁻² (corrected to 1 May 1986, n = 59) and peak values exceeding 100,000 Bq m⁻², this site belongs to the areas most heavily affected by the Chernobyl accident.

2.2 Sampling, sample preparation and gamma spectrometric measurement

From 2002 until 2004, samples of potential food items were collected during four field trips taken each year. Leaves of each forage plant species were collected from 20–40 individual plants and pooled. Roots were carefully excavated, cut off and adhering soil particles were removed by rinsing. Fungal fruit bodies were sampled according to their natural occurrence. In the case of deer truffles, which often occur in aggregations, the entire aggregation was dug out and pooled. All plant and fungal samples were dried at 105 °C to constant weight and milled.

For each soil profile, 10 drilling cores were taken down to a depth of 30 cm. The drilling cores were divided into slices of 2 cm thickness and slices belonging to the same depth were pooled. After drying at 105 °C to constant weight, the pooled samples were sieved to 2 mm. The soil skeleton fraction (> 2 mm) was weighed and discarded. The fine soil fraction (< 2 mm) was milled.

From 2002 until 2004, a total of 206 wild boars were shot. Muscle tissue was taken from the forearm (*Musculus flexor digitorum profundus/superficialis*). After removing tendons, fat and connective tissue, the meat was minced.

The ¹³⁷Cs activity of soil (fine fraction), plant, fungi and meat samples was determined at the Laboratory for Radioisotopes of the Georg August University Göttingen using HPGe detectors. The counting statistical uncertainty was below 5% with a confidence level of 95%.

2.3 Stomach content analyses

From a subset of 102 animals, whole stomachs were taken and deep-frozen until analysis. In the laboratory, the stomachs were opened, emptied and the remaining feed was carefully removed from the stomach wall. The stomach content was weighed and microscopically analysed. First, larger parts of leaves, grasses, ferns, fruit bodies or other constituents were attributed to their species and removed. After sieving with mesh sizes of 1 mm and 0.2 mm, the smaller constituents were identified. Although stomach liquids predigest leaf tissue, the epidermises often remain. The size, structure and arrangement of different cell types, hairs and wax layers are characteristic of a plant species. Animal constituents were identified on the basis of the characteristic structure of the animal tissue or, in the case of mammals, the peculiarities of the kemp. The animal and plant species were identified *via* comparison to permanent specimens and by using identification keys. Deer truffles were identified by the ochre brown pointed warts of their peridium, i.e. their “rind”, and by their specific spores. The amount of mineral soil in the stomach was indirectly determined from the quantity of soil skeleton material. The total amount of mineral soil was calculated from the amount of soil skeleton material in the stomachs and the skeleton fraction of the soil layer rummaged for food. In a similar way, the amount of organic soil was derived from the dark, fine residue passing through the sieves.

3. RESULTS AND DISCUSSION

3.1 ¹³⁷Cs Levels in potential food items

The radiocaesium level in the leaves of green forest plants was below 1,000 Bq kg⁻¹ FW in most cases. Only few species, e.g. the spinulose wood fern (*Dryopteris carthusiana*, maximum 4,300 Bq kg⁻¹ FW)

and bilberry (*Vaccinium myrtillus*, maximum 1,900 Bq kg⁻¹ FW), showed higher activities. The contamination of fungal fruit bodies developing above ground varied from a geometric mean of 24 Bq kg⁻¹ FW for *Macrolepiota procera* to a geometric mean of 6,300 Bq kg⁻¹ FW for *Cortinarius hercynicus*. With an average radiocaesium level of 25,000 Bq kg⁻¹ FW (minimum 5,000 Bq kg⁻¹ FW, maximum 122,000 Bq kg⁻¹ FW), the fruit bodies of deer truffle (*Elaphomyces granulatus*) were by far the most contaminated food item. The comparatively low radiocaesium level of beech nuts, an important food component in autumn, ranged between 8 and 23 Bq kg⁻¹ FW, with a geometric mean of 19 Bq kg⁻¹ FW. As expected for Central European agricultural products, the ¹³⁷Cs levels of supplementary feed and bait, e.g. maize, did not exceed a few Bq kg⁻¹ FW.

3.2 Composition of feeding stuffs

Wild boars are omnivores with a high potential to adapt to locally and seasonally varying food supplies. A total of 102 stomachs were collected between May 2002 and August 2004 and analyzed for the composition of their content [1]. The average mass was 1,450 g FW (minimum 395 g, maximum 4,170 g). In about one third (32 stomachs), agricultural products originating from supplementary feed and bait, such as maize and fodder beet, accounted for more than 95% of the stomach content. Obviously, these animals had been fed just before being shot and were excluded from further consideration being unrepresentative.

The diet composition as deduced from the analyses of 40 stomachs collected between May 2002 and June 2003 is depicted in Fig. 1. On average, green forest plants, feed (supplementary feed and bait), soil and deer truffle contributed to about 56%, 24%, 11% and 6% of the stomach content, respectively. The weight proportion of the remaining food items was below 4%. The diet composition changed completely in the second half of 2003 owing to a beech mast event. From September 2003 until February 2004, beech nuts dominated the food spectrum.

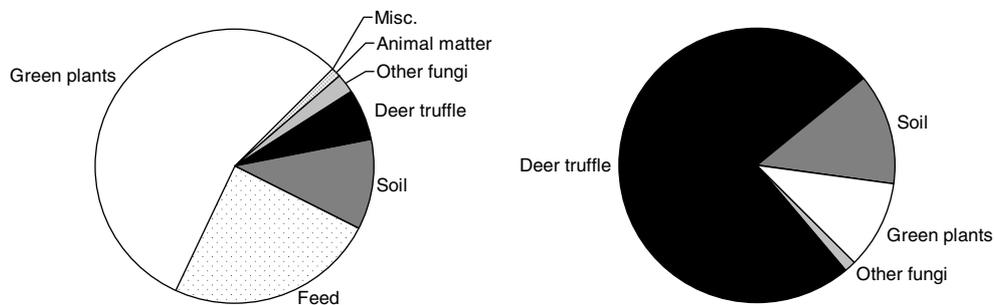


Figure 1. Diet composition of wild boars shot between May 2002 and June 2003 (40 stomachs) according to weight (left) and radiocaesium intake (right).

Deer truffles (*Elaphomyces granulatus*) turned out to play a key role because of their exceptionally high contamination levels. Despite their low weight proportion of an average of only about 6% of the stomach content, more than three quarters of the radiocaesium intake could be ascribed to this fungus (see Fig. 1). Soil contributed about 13% and all other food items together less than 12% to the ¹³⁷Cs intake of wild boar (average values).

3.3 Time trends and consequences for modelling

The 126 aggregations of deer truffle were found in depths between 1 and 16 cm, the mean depth being about 6 cm. In 2002, the vertical profile of ¹³⁷Cs in soil, expressed on a volume basis, peaked between 6 and 8 cm depth, i.e. the peaks of the vertical distributions of radiocaesium and deer truffle fairly

coincided. Consequently, the contamination of deer truffle and, hence, its contribution to the ^{137}Cs intake of wild boar should have attained its maximum.

Irregular consumption of this highly contaminated food component and the short biological half-life of about 20–40 days for radiocaesium in wild boar result in extremely variable radiocaesium levels in meat, even within a short time span and small area. Moreover, the slow vertical migration of radiocaesium in forest soil and the deep mycelium of deer truffle explain the previously observed trend of the constant or increasing activity levels of wild boar. In the future, the contamination of meat is expected to decrease slowly in the investigated area.

4. CONCLUSIONS

Deer truffles were identified as the dominant source of ^{137}Cs for wild boar. More than three quarters of the radiocaesium intake could be ascribed to this fungus, giving rise to the peculiar contamination pattern of wild boar. Therefore, predictive modelling of radiocaesium contamination of these animals should always take into account deer truffles, especially their local abundance, depth distribution in soil, contamination level and irregular consumption. Long-term predictions should further consider the slow migration of radiocaesium to deeper soil layers. The stochastic nature of feeding deer truffle suggests explicitly modelling the contamination pattern of wild boar as the result of a stochastic process.

Acknowledgments

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