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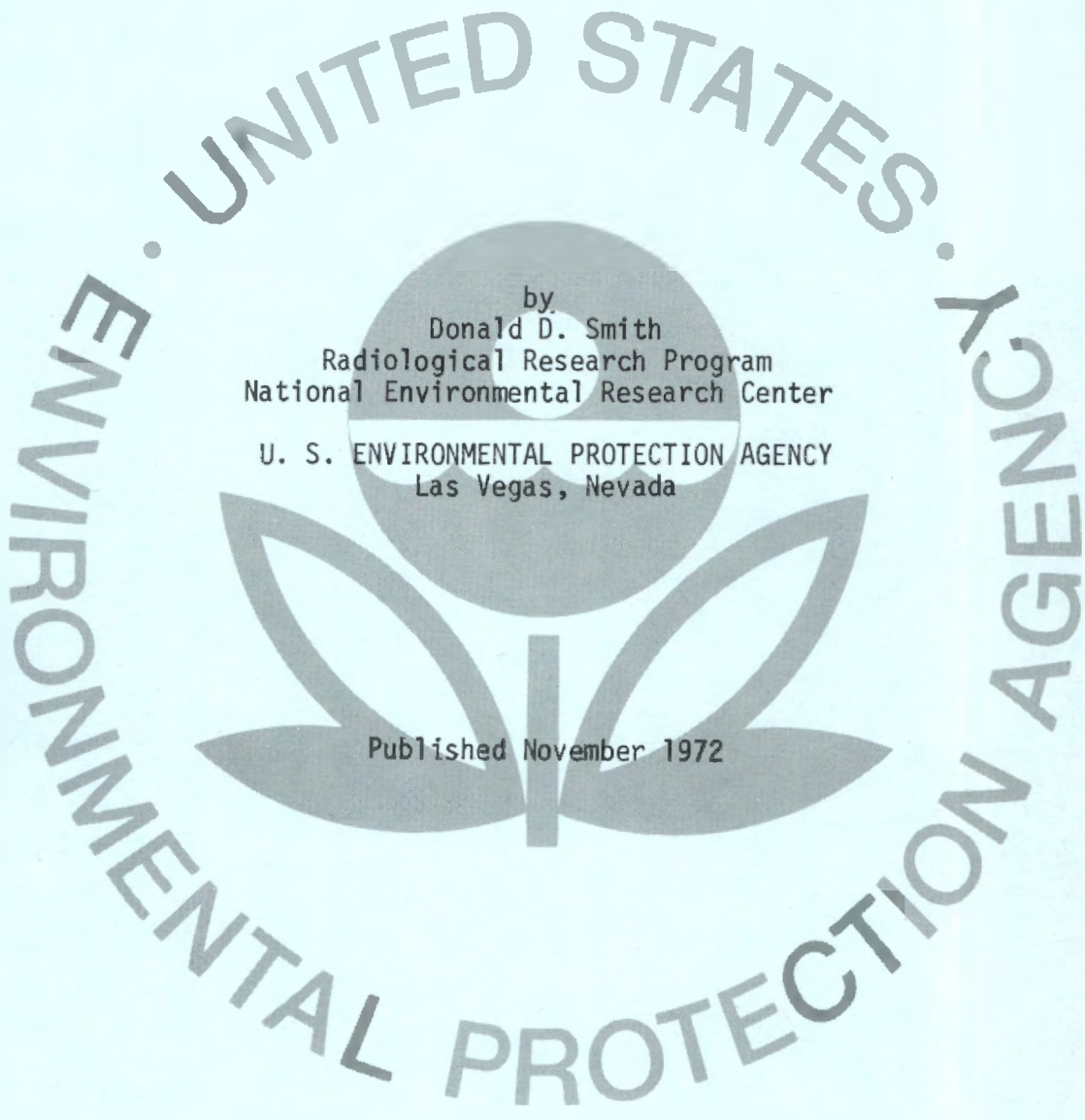
RADIATION SURVEILLANCE OF RUMINANTS ON AND ABOUT THE NEVADA TEST SITE



by
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Radiological Research Program
National Environmental Research Center

U. S. ENVIRONMENTAL PROTECTION AGENCY
Las Vegas, Nevada

Published November 1972

This study performed under a Memorandum of
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1. The following informational note should be added to the title page of NERC-LV-539-18, *Radiation Surveillance of Ruminants on and about the Nevada Test Site*, (November 1972):

This report is an updated version of the report of the same title which appeared in Desert Bighorn Council 1971 Transactions, a compilation of papers presented at the 15th Annual Meeting, April 7 through 9, 1971, at Santa Fe, New Mexico. Desert Bighorn Council, 1500 N. Decatur Blvd., Las Vegas, Nevada.

2. The following change should be made on page 3, Table 1, the third item under Isotope should be changed to ^{95}Zr.

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ABSTRACT

The National Environmental Research Center-Las Vegas is engaged in various radiation research and surveillance activities. A portion of this work is concerned with the metabolism and tissue burdens of radionuclides in domestic and wild ruminants.

The ^{90}Sr levels in bones from three species of ruminants grazing on or near the Nevada Test Site have shown a steady decline since the cessation of atmospheric testing in 1962. Levels of ^{90}Sr observed in desert bighorn sheep (*Ovis canadensis nelsoni*) ranged from 3.9-13.4 pCi/g of ash in 1964 (average of 9.7 pCi/g of ash) and from 1.0-12.0 pCi/g of ash in 1971 (average of 5.8 pCi/g of ash).

Levels of gamma emitting radionuclides found in the Nevada Test Site beef herd remain low, with the liver as the edible organ containing the highest levels of radioactivity.

In addition, the operation of an experimental dairy farm, the maintenance of an experimental beef herd, and the use of the dairy herd in controlled metabolism studies are discussed.

INTRODUCTION

The National Environmental Research Center-Las Vegas (NERC-LV), is engaged in various research and surveillance activities. Much of this work is concerned with the metabolism and tissue burdens of radionuclides in domestic and wild ruminants. This research requires three types of support activities on the Nevada Test Site (NTS). These are: (1) the maintenance of an experimental beef herd, (2) the conduction of wildlife surveillance, and (3) the operation of an experimental dairy farm.

During 1957 an Animal Investigation Program was established by the Atomic Energy Commission (AEC). In 1964 this program was assigned to the NERC-LV. The objectives of the Animal Investigation Program are:

1. To determine tissue concentrations of fresh and/or aged fission and activation products in biological samples obtained from bovine on the NTS and from off-site ranches, if required.

2. To develop and conduct wildlife studies on and near the NTS in cooperation with State and Federal wildlife agencies in order to assess radionuclide content of various edible wildlife species.

3. To maintain veterinary relations with the off-site population.

4. To investigate alleged damage to domestic animals from the AEC's activities.

The research reported was performed as part of the Animal Investigation Program and was supported by the U. S. Atomic Energy Commission under a Memorandum of Understanding.

Experimental Beef Herd

Since 1957 a beef herd has grazed on the NTS [1]. The original herd was purchased from area ranches. The descendants of this herd now number 80 grade or nonpurebred Herefords. They routinely graze the natural vegetation growing in the fallout zones of three atmospheric tests which were detonated in the early sixties. This herd is maintained in the same manner as herds neighboring the NTS.

Twice a year the herd is rounded up and six beef animals are sacrificed. The animals are necropsied and samples collected for radioanalysis and histopathology. No gross or microscopic lesions have been noted that can be directly attributed to radiation [2, 3]. In 1970 the calving was 96% and the average weight gain was 1.5 pounds per day between May and October.

Table 1 presents a summary of the analytical data from the tissues collected from beef animals grazing on the NTS that were sacrificed on October 29, 1970. As shown in the table, certain radionuclides (^{95}Zr, ^{106}Ru) detected in the ingesta in the ruminants are not readily absorbed through the gut but are passed out of the animals in the feces. The ^{131}I levels found in the thyroids are believed to have resulted from an atmospheric nuclear detonation that was conducted by a foreign nation on October 14, 1970. The International Commission on Radiological Protection (ICRP) recommended biological parameters and radiation protection guides in ICRP Reports 2 and 10. Cesium is biologically similar to potassium, and is, therefore, incorporated into the soft tissues of the body. Thus, the radiation dose from ^{137}Cs is evaluated based on the total body dose. The highest concentration of ^{137}Cs (80 pCi/kg) in an edible tissue was found in the liver of one of the cattle. Assuming an adult was to consume one pound of this liver per week, for a year, his dose commitment could be calculated as shown on page 4.

Table 1. Summary of Analytical Results of Tissues from Beef Animals, October 29, 1970 (reported on wet weight basis)

Isotope	Rumen Content	Liver	Lung	Muscle	Thyroid	Bone Femur Wet Weight	Bone Femur Ash
K g/kg	0.8(7) 0.5-1.9	1.6(7) 1.0-2.5	1.3(7) 1.0-1.9	1.9(7) 1.1-3.7	<0.3	NA	NA
^{90}Sr pCi/g	NA	NA	NA	NA	NA	1.0(7) 0.4-1.9	4.3(7) 1.5-8.3
^{95}Sr pCi/kg	45(5) 45-50	<25	<25	<25	<25	NA	NA
^{106}Ru pCi/kg	250(2) 200-300	<250	<250	<250	<250	NA	NA
^{131}I pCi/g	<0.025	<0.025	<0.025	<0.025	6.2(6) 4.3-9.7	NA	NA
^{137}Cs pCi/kg	<25	80(1)	230(1)	45(3) 30-50	<25	NA	NA
^{144}Ce pCi/kg	500(7) 300-800	300(3) 250-400	<250	<250	<250	NA	NA

First number is average, number in parenthesis is number of samples with detectable activity, third set of numbers is the range.

NA = Not analyzed.

Dose Calculation

$$80\ \text{pCi/kg} \times \frac{\text{kg}}{2.2\ \text{lbs}} \times 1\ \text{lb/wk} \times \frac{52\ \text{wk}}{\text{yr}} \times \frac{0.061\ \text{rem}}{\mu\text{Ci-intake}}$$

$$\times \frac{10^{-6}\ \mu\text{Ci}}{\text{pCi}} = 122 \times 10^{-6}\ \frac{\text{rem}}{\text{yr}} \simeq 0.1\ \text{mrem/yr of consumption.}$$

This level of approximately 0.1 mrem would be about three orders of magnitude below the radiation protection guides recommended by the Federal Radiation Council and the ICRP.

Wildlife Surveillance

In addition to the beef surveillance, the Animal Investigation Program is charged with conducting surveillance of wildlife which may enter the food chain of man. Samples are collected from at least one mule deer every three months. These samples are usually collected from road killed animals but are occasionally hunted under the provisions of a collection permit issued by the Nevada Fish and Game Commission. Rabbits and game birds are also collected.

Samples from desert bighorn sheep are also collected through the cooperation of personnel of the Desert National Wildlife Range and the participants in the annual hunt in this area. In recent years, the levels of gamma emitting radionuclides in the tissues have been of low magnitude and are usually below detectable limits of the Center's analytical equipment.

In the fall of 1970, water samples were collected from seven natural springs on the Desert National Wildlife Range. The results of gamma spectroscopy analysis were negligible on all samples and the tritium levels did not exceed 400 pCi/l.

Figure 1 presents the average ^{90}Sr content of the ash of bones collected from deer on or near the NTS, from cattle on the NTS and from desert bighorn sheep on the Sheep Range. The data presented were collected from 1964 to 1971.

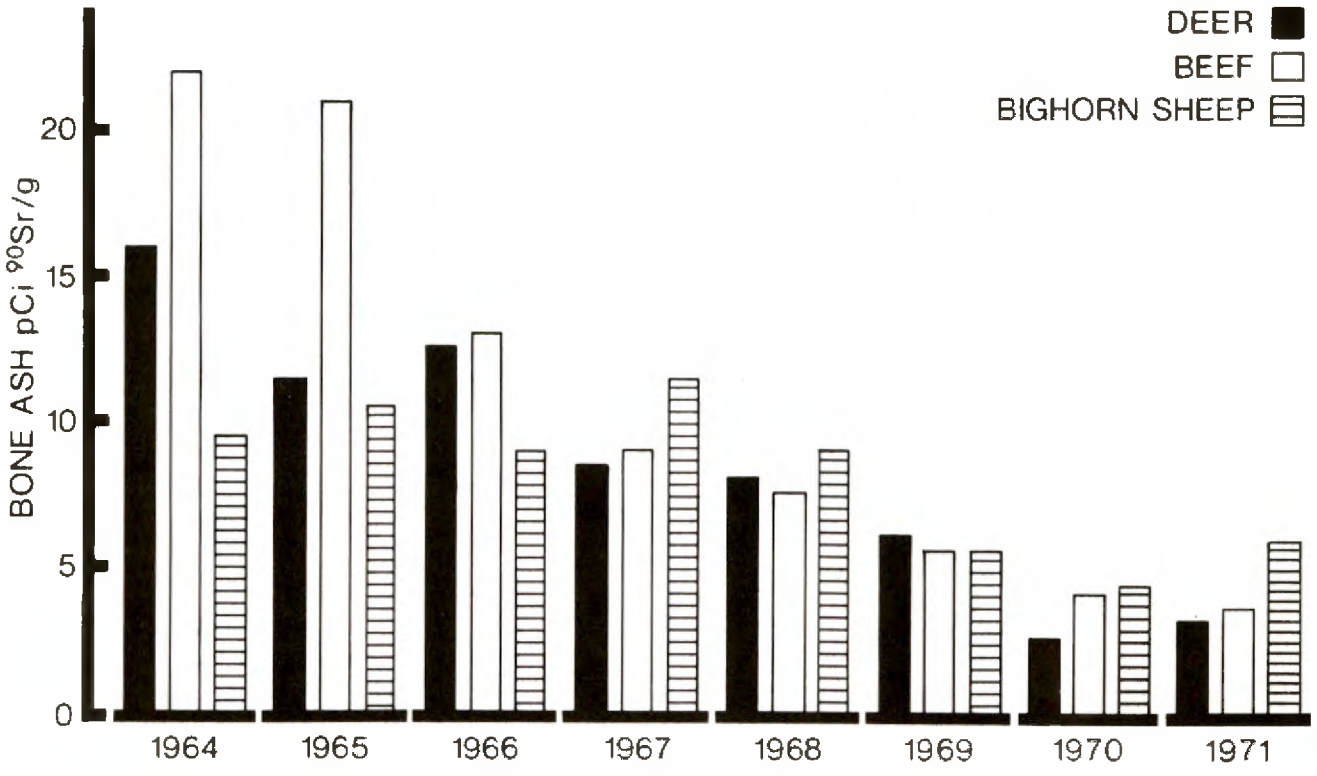

Figure 1. Comparison of ^{90}Sr in Bones of Deer, Beef and Bighorn Sheep

The ^{90}Sr data on the three species through 1963 were reported previously (4, 5). In general, all three species have shown a downward trend since 1964 and this is assumed to be directly associated with the cessation of atmospheric testing in 1962. In 1964 the range in bone ash samples from desert bighorn sheep was 3.9-13.4 pCi/g of ash with an average of 9.7 pCi/g of ash and in 1971 the range was 1.0-12.0 pCi/g of ash with an average of 5.8 pCi/g of ash.

Strontium-90 has a long half-life (27.7 years) and resembles calcium in its biological behavior, so the critical organ is bone. As it decays by beta emission, there may be damage to the bone marrow, which is one of the blood-forming sites within the body.

Radiation protection guides have not been specifically established for desert bighorn sheep, but have been established for man. These standards may be applied if it is assumed that desert bighorn sheep are no more sensitive to the effects of radiation than man. The radiation protection guide for ^{90}Sr in man has been established by the National Committee for Radiation Protection as 2 μCi in the critical organ, i.e. bone, for occupational exposure. The radiation protection guide for members of the general population is 1/30th of this value or 6.7×10^4 pCi. Standard man contains 7,000 grams of bone in his body which will yield approximately 2,330 grams of ash. For standard man 6.7×10^4 pCi of activity corresponds to 28 pCi per gram of ash.

As shown in Figure 1, levels of ^{90}Sr found in the bone ash of desert bighorn sheep and other ruminants living on and around the NTS are a fraction of the 28 pCi/g of ash level.

Experimental Dairy Farm

The experimental dairy farm was established in 1964 to study the transport of radioiodine through the soil-forage-cow-milk-food-chain. Data obtained from studies conducted there were used to formulate a model for calculating

the dose to man drinking milk from cows exposed to fresh fission products under a variety of conditions and exposure levels.

The research dairy farm is located in the northern end of the NTS, 120 miles by road from Las Vegas. It consists of 16 1/2 acres of croplands which are irrigated from a 5,400-foot well. Crops grown are alfalfa and rye, which furnish forage for the dairy herd of 30 animals (26 Holstein and 4 Jersey cows). Standard irrigation, fertilization, and harvesting practices are used [6]. During 1970 the croplands provided 170 tons of green chop and 50 tons of hay.

The cows are maintained in a dry lot the year around. They are not allowed to graze; all forage is brought to them. Commercial husbandry practices are followed with the dairy herd, except that individual bucket milkers are used to prevent cross contamination and to allow the collection of data from individual cows. The cows are milked on a 9- and 15-hour schedule, in order to reduce the manpower requirement [7, 8].

Despite the unusual milking hours and extensive participation in experiments, the cows average over 13,000 pounds of milk per lactation with an average butterfat percentage of 3.5. The Nevada Dairy Herd Improvement Association's monthly ratings have placed the herd as high as No. 1 on butterfat percentage and third on milk production.

In addition to furnishing feed for the cows, the crops are used for experimental purposes. They were used for studying the uptake and retention of radionuclides by the plants and for the investigation of the uptake of radionuclides by the cows from ingestion of the plants. Aerosols of radioiodine were generated over the crops which were then harvested in the normal manner. A weighed amount of this forage was fed to the cows in the experimental feeding pens. A sample of each cow's ration was analyzed for radionuclide content prior to feeding. The uneaten residue was also weighed and the total radionuclide intake of the cow was determined. At each milking, each cow's production was weighed and sampled for analysis. The percentage of the radionuclide transferred to the milk was then derived.

Other experiments were carried out in association with Plowshare cratering experiments. Forage was placed downwind of these experiments and subsequently returned to the farm and fed in the same manner as above, except that baled hay was chopped before feeding to ensure that a homogeneous ration was fed and that a representative sample was collected.

There is a microplot area at the farm with 1/8 to 1/4 acre study plots which are used to grow a variety of forage, grain and vegetable crops. The wheat yield in 1970 was approximately 40 bushels per acre. Vegetables that have been grown include onions, radishes, potatoes, beets, sugar beets, lettuce, Swiss chard, beans, English peas, cow peas, melons, sweet corn, and tomatoes. These plots have been used to study the uptake of aged radionuclides by the crops from the soil which contains ejecta from the Sedan crater. The leaching effect of irrigation water on these radionuclides has also been studied.

The dairy cows have been used for metabolism studies of various radionuclides. In these studies, following the oral or intravenous administration of the selected radionuclide, the cows were placed in special metabolism stalls for a period of 8 to 14 days. During this time, milk and blood samples were collected every six hours. The entire fecal and urinary output was collected and sampled every 12 hours and the thyroids were counted periodically. In this way the pathways of excretion for the radionuclide were determined. In addition, cull cows and steer calves were given similar doses and after varying periods of time they were sacrificed. Each organ and all tissues were sampled to determine the distribution of the radionuclide within the body. Radionuclides studied in this manner have included: ^{3}H; ^{123}I; ^{131}I; ^{7}Be; ^{181}W; ^{202}Tl; ^{203}Hg; ^{86}Rb; ^{59}Fe; ^{187}W; and ^{203}Pb.

CONCLUSION

The radionuclide burdens found in the tissues of domestic and wild ruminants on and near the NTS continue the decline observed each year since the cessation of atmospheric testing. On the basis of guidelines currently used, levels found present no significant hazards to the animals themselves or to humans consuming their flesh. Surveillance activities will be continued in order to determine any changes in the present situation.

Studies defining critical metabolic pathways of ingested radionuclides which are likely to appear in the environment following nuclear detonations provide valuable data for use in hazard evaluation. Such studies are of particular importance when conducted with dairy cows as dairy products contribute a significant portion of the total diet for infants and children.

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