Bull. Environ. Contam. Toxicol. (1985) 34:291–294

Bulletin of Environmental Contamination and Toxicology

Lead in Tissues of Cats Fed Pine Voles from Lead Arsenate-Treated Orchards

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Lead arsenate has been used for many years for control of insects in apple orchards in the United States. In an earlier study, it was shown that such orchard soils may contain very high concentrations of lead (Kenyon et al. 1979; Elfving et al. 1978) and that orchard voles and mice inhabiting such soils accumulate inordinately high levels of lead (Elfving et al. 1978; Scanlon et al. 1983).

It is of interest to learn the possible extent of deposition of lead in higher carnivores that may consume such orchard animals. In the work reported, cats were fed pine voles (Microtus pinetorum) captured in lead arsenate-treated orchards located in the vicinity of New Paltz, New York. Following sacrifice, the lead content of cat tissues was determined.

MATERIALS AND METHODS

Pine voles (Pitymys pinetorum) were captured during 1982 and 1983 in several orchards in the Hudson Valley apple growing area in the vicinity of New Paltz, New York. The entire voles were thoroughly minced in a Hobart Food Cutter with Hill's Prescription p/d Feline Diet in the ratio of 2 voles per 15 ounces (425 grams) of diet and the blend was mixed. Subsamples of the minced voles, control diet and diets containing the voles were taken for the determination of lead.

Six, three-month old male SPF kittens were removed from the cat colony at the New York State College of Veterinary Medicine and transferred to individual stainless steel cages. They were acclimated for one week during which time all were fed the prescription diet. Then 3 cats were fed the prescription diet for 86 days to serve as controls while the remaining 3 were fed the diet containing the voles. Each cat was allowed to consume 212.5 grams of its respective diet per day or equivalent to 1 vole per cat daily. At the end of the period each cat was euthanised and kidney, liver and bone (tibia) were taken for the determination of lead. The liver and kidney samples were freeze-dried, milled and mixed. The flesh remaining on the tibia was removed by dermestid beetles. The bone samples were cut in half with a wire cutter and then reduced to a fine powder using a mortar and pestle. Subsamples of the kidney, liver and bone were then wet-ashed with perchloric acid. After dilution of the digests with water, lead was determined by conventional stripping voltammetry using a Princeton Applied Research Corp. Model 174 Polarographic Analyzer (Gajan and Larry 1972).

RESULTS AND DISCUSSION

The concentration of lead in the voles and diets are listed in Table 1. Orchard voles presumably absorb lead during consumption of plant roots and soil insects with inadvertent ingestion of lead-ladened soil particles from which assimilation of lead is apparently possible (Dacre and Ter Haar 1977).

Table 1. Concentrations of lead in voles and diets.

Sample	Lead ppm[a] (dry wt)
Voles	60.3 ± 1.9
Control cat diet	3.20 ± 0.11
Diets containing voles	5.68 ± 0.48

[a]Mean ± standard error based on analysis of seven subsamples.

The concentrations of lead found in the kidney, liver and bone (tibia) of the cats are listed in Table 2. The concentration of lead in each of the tissues in the cats fed the voles was significantly higher ($p < 0.01$) than the respective control tissues. No gross abnormalities were seen in the cats in either treatment group during autopsy.

Table 2. Concentrations of lead in tissues of cats.

Dietary treatment	Lead ppm (dry wt)[a] Kidney	Liver	Bone (tibia)
Control	0.16 ± 0.01[x]	0.08 ± 0.00[x]	0.89 ± 0.10[x]
Vole	1.34 ± 0.07[y]	0.51 ± 0.03[y]	4.96 ± 0.47[y]

[a]Mean ± standard error.

[x,y]Column within a tissue having dissimilar superscripts are significantly different ($p < 0.01$).

It would appear that the lead contained in the voles was readily assimilated by the cats in this study. The completeness of digestion of the vole tissues and therefore availability of lead may have been enhanced by the preliminary mechanical mincing of the animals as compared ot the normal mastication and consumption of voles by cats in the field. The absorption of dietary lead by animals and its toxicity is also influenced by other dietary constituents. Diets deficient in calcium (Jacobson and Snowden 1976); phosphorus (Barton and Conrad 1981; Kostial et al. 1971); iron (Flanagan et al. 1979); magnesium (Cerklewski 1983); zinc (Bushnell and Levin 1983; El-Gazzar et al. 1978); fat (Bell and Spickett 1983); and protein (Shah 1980) are reported to cause enhanced absorption of ingested lead in animals. Protection against various toxic effects of lead in animals by dietary supplementation with calcium, iron (Carpenter 1982); ascorbic acid (Suzuki and Yoshida 1979a,b) and vitamin E (Levander et al. 1975) has been reported.

The practical significance of the data in this study as regards possible toxicity to predacious wildlife is speculative. The number of voles consumed daily by a typical field cat frequenting orchard areas may be more or less than the equivalent of one vole per day consumed in the investigation. The consumption of voles and absorption of lead by cats may more closely resemble that by weasels or foxes, for instance, than by raptorial birds that regularly regurgitate indigestible animal parts that may be high in lead concentration. The pH and enzymatic activity of the digestive fluids and residence time of food in the gastrointestinal tract of such predators would also be important. Other modifying factors are the lead concentration in the soil and the percentages of different orchard animals that are consumed by predators since various species of prey may differ in their lead burden. Thus, in an earlier study (Elfving et al. 1978), the extent of accumulation of lead appeared in the order: pine voles > meadow voles (*Microtus pennsylvanicus*) > white-footed mice (*Peromyscus leucopus*) which correlates with their degree of sub-surface feeding and movement. The possible deleterious effects of lead on the progeny of wildlife would also have to be considered since lead has been reported to be excreted in the milk of animals and transferred to their suckling offspring (Keller and Doherty 1980; Hejtmancik et al. 1982).

Although the use of lead arsenate as an insecticide in orchards is diminishing, residues of lead are rapidly immobilized in the upper soil surface and would expectedly remain there indefinitely. Contamination of animals inhabiting such orchard soils can therefore be expected to continue.

Acknowledgments. The authors thank R. Dembinski, W. H. Gutenmann and L. Roth for their assistance during this investigation.

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Received June 1, 1984; accepted July 9, 1984