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Metals in Soft Tissues of Mule Deer and Antelope

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The Northern Great Plains is one of the few remaining areas in the United States containing large numbers of free roaming big game animals. Because of increasing fossil fuel development in this region and the potential for trace metal environmental hazards associated with this development (ERDMAN et al. 1978), a closer look at metal levels in wildlife is desirable. The effects of elevated concentrations of trace metals upon laboratory animals, fish and man have been studied and many articles and reviews published (NRC 1972, 1975, 1977) but almost nothing has been said of increases in trace metals in the diets or tissues of wild terrestrial herbivores. In only a few cases has mention even been made of the levels of different elements in wildlife tissues (SCHROEDER AND BALASSA 1961, LYNCH 1972).

Most heavy metals are selectively concentrated in the liver and kidneys. These organs are, therefore, the preferred heavy metal reservoirs in studies of animal burdens and were used in this investigation.

METHODS AND MATERIALS

Thirty mule deer *(Odocoileus hemionus)* and 21 pronghorn antelope *(Antilocapra americana)* were collected in Southeastern Montana with the cooperation of the State Fish and Game Department. These animals were aged from lower jaw tooth structure by Kenneth R. Greer, supervisor of the Montana Fish and Game Wildlife Laboratory. Liver and kidneys were removed in the field, placed in plastic bags and refrigerated until transfer to a freezer. Frozen tissues were transferred to the laboratory where membranes were removed from the kidneys and the entire organ or half of the organ was masticated in a stainless steel blender. Exposed surfaces of liver samples were excised with a stainless steel knife and the remaining tissues homogenized. All samples were then lypholyzed.

Aliquots of the freeze dried tissues were digested in a mixture of nitric:perchloric acids (GORSUCH 1970). The digested solutions were filtered, brought to volume with double distilled water and analyzed for zinc, copper, manganese, lead, cadmium, nickel and molybdenum. A Varian Techtron AA6, atomic absorption spectrophotometer with automatic background correction was used to determine metal concentrations in the solutions.

All analytical standards were prepared from reagent or ultra-high purity grade chemicals. Standards and blanks were carried through the sample digestion procedure. Analysis of National Bureau of Standards, Standard Reference Material, Bovine liver was performed concurrently with the other samples. Table 1 gives comparative accuracy and precision data for this procedure.

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TABLE 1

Analysis of Standard Reference Material, Bovine Liver (µg/g freeze dried wt.)

Element	Certified Values	This Procedure
Zinc	130 ± 10	122 ± 3
Copper	193 ± 10	188 ± 6
Manganese	10.3 ± 1.0	9.9 ± 0.1
Cadmium	0.27 ± 0.04	0.34 ± 0.01
Lead	0.34 ± 0.08	0.33 ± 0.11

Oven dried tissues are not identical to freeze dried materials, however they are similar in that water has been removed by both treatments. Our studies have found that bovine kidney and liver tissues contained approximately 79 and 70 percent water respectively when oven dried to constant weight. Therefore to convert concentrations in this report to approximate wet weight levels, multiply kidney values by 0.21 and liver concentrations by 0.30.

RESULTS AND DISCUSSION

Nickel and molybdenum levels in digested solutions were near or below the sensitivity limits for flame atomization atomic absorption. All molybdenum concentrations in the tissues were below 2 µg/g and although nickel levels ranged up to three, most levels were less than 0.5 µg Ni/g tissue. Means and standard deviations for concentrations of the other five metals in deer and antelope liver and kidney samples are found in Table 2.

The large standard deviations found in this study were reflective of the wide variation of elemental levels found from animal to animal. This large range appears to be a natural phenomenon and has been reported by several investigators in other animals (PAGENKOPF and NEUMAN 1974, MUNSHOWER 1977, HOWARD 1964).

Some of the lead data has been omitted because of obvious contamination. The deleted tissue levels were one to two orders of magnitude higher than the mean lead values in Table 2.

UNDERWOOD (1977) indicated that animal tissue concentrations of lead were about the same level as concentrations found in humans. A report by HAMILTON et al. (1972) and other investigators have indicated lead liver levels increasing with age and generally ranging from 1 to 2 µg Pb/g wet weight. These levels are much higher than the results found in this survey. Since these animals were collected 30 miles from any major highway and in an area devoid of any large source of pollution the lead concentrations in these organs may be indicative of the pristine nature of the study area.

Bioaccumulation of lead in livers of older antelope was consistent with other investigations in man and domestic animals (SCHROEDER and TIPTON 1968, BOYER and CHISOLM 1972). Accumulation with age, was significant at $P = 0.005$. Deer liver samples, however, did not show any significant accumulation with age.

TABLE 2

Trace metal content of mule deer and antelope kidney and liver tissues (μg/g freeze dried wt.)*

	Antelope		Deer	
	Kidney	Liver	Kidney	Liver
Zn	96.5 ± 27.2 (21)	84.8 ± 28.4 (20)	97.4 ± 16.2 (24)	113.3 ± 24.6 (30)
Cu	13.3 ± 2.8 (21)	26.9 ± 12.8 (20)	29.5 ± 16.4 (24)	46.3 ± 29.1 (29)
Mn	6.0 ± 1.4 (21)	7.3 ± 3.2 (20)	8.2 ± 2.2 (23)	9.4 ± 2.5 (29)
Cd	1.27 ± 1.06 (21)	0.30 ± 0.15 (20)	2.70 ± 3.00 (24)	0.51 ± 0.53 (30)
Pb	0.8 ± 0.6 (19)	0.6 ± 0.5 (19)	0.7 ± 0.4 (21)	0.9 ± 0.7 (27)

*Mean ± 1 standard deviation, number of animals in paranthesis

The accumulation of cadmium in human kidneys as a function of age has been demonstrated (SCHROEDER and BALASSA 1961). A similar relationship developed in deer and antelope kidneys. Analysis of deer kidney cadmium concentrations and age yielded an "r" value of 0.903. This was significant at P = 0.001 (see Figure 1). Antelope kidneys showed a similar but weaker trend of accumulation of cadmium with age. In this species accumulation with age was significant at P = 0.10. Correlations between liver cadmium and age were not found in either species. There were no obvious species differences in the concentrations of cadmium or lead although deer tissue levels were usually higher than corresponding tissue concentrations in antelope.

Age and species differences in liver copper concentrations were noted by UNDERWOOD (1977) as occurring in man and many domestic animals. This study found deer liver and kidney copper concentrations were higher than corresponding values in antelope. Liver copper levels in both species decreased with age but only in deer were these changes significant (P = 0.10). High liver copper concentrations in new born domestic and laboratory animals have been previously reported and a decrease in this elemental level with age has been known for many years (CUNNINGHAM 1931). Kidney copper concentrations although showing species differences did not reveal any significant decreases with age.

Species differences were not found in zinc concentrations for the two organs analyzed, nor were there any significant changes in

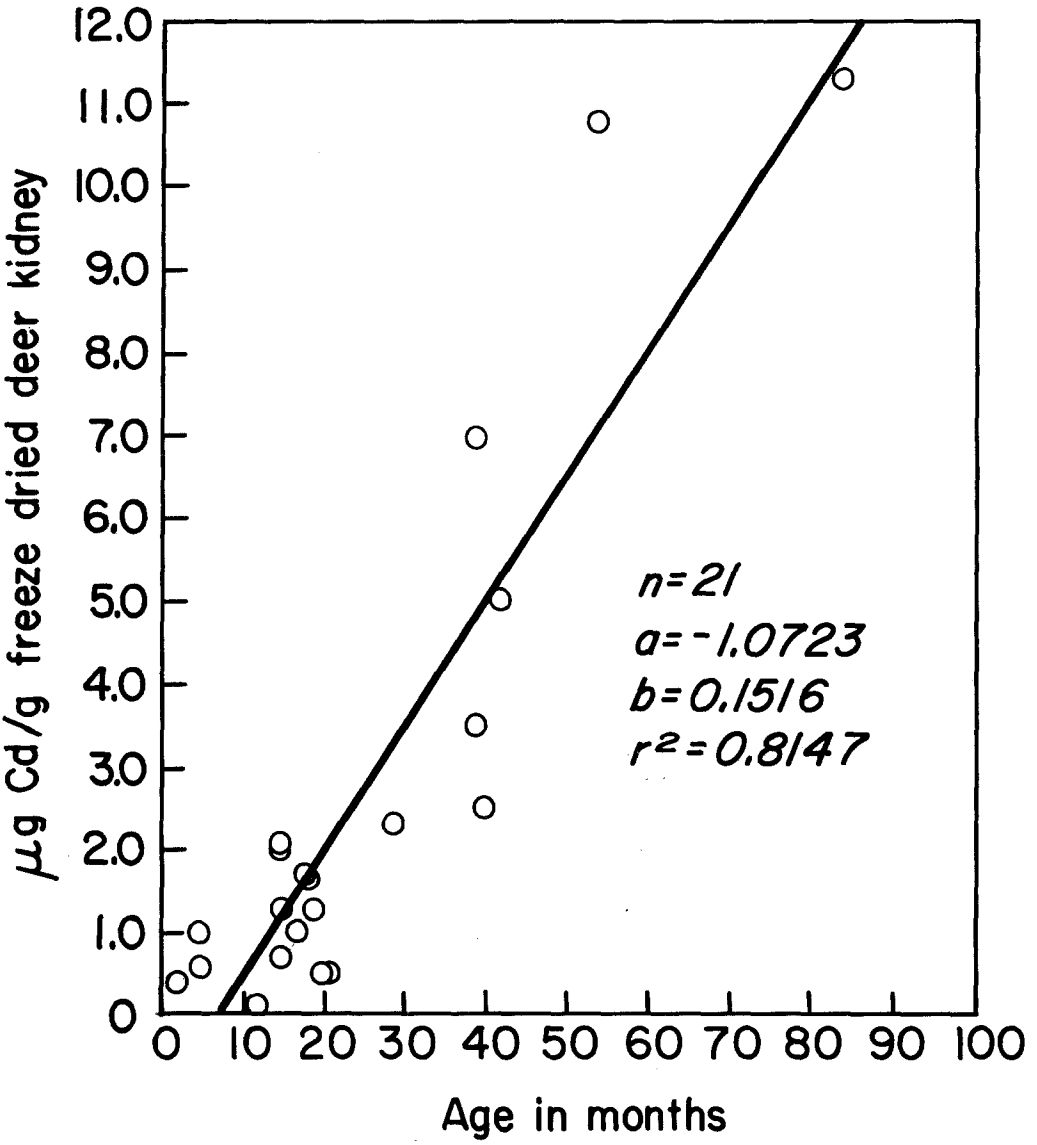

Figure 1. Mule Deer Kidney Cd Level

organ zinc concentrations with age. Mule deer showed higher average levels of zinc in the liver while pronghorn antelope revealed higher levels in the kidneys. A positive relationship between zinc and manganese concentrations was found in deer liver and kidneys and in antelope liver ($P = 0.01$). The meaning of this relationship is unclear.

Manganese concentrations did not show any relationship with age. Species differences were observed but they were very small and non-significant. Manganese values found in this study were very similar to concentrations listed by FORE and MORTON (1952) for a wide range of species.

Vegetation samples were collected in the same area as the antelope and deer tissues. Analyses of these plant tissues indicated a rather pristine area free from gross pollution effects (MUNSHOWER et al. 1978). Cadmium and lead levels in browse and forage species were lower than most literature values; common concentrations were 0.01 to 0.15 µg Cd/g and 1-2 µg Pb/g of plant tissue. Manganese in these plant tissues was more than adequate for cattle nutrition (20-40 µg/g). The elements copper and zinc on the other hand were marginally deficient in most of the range grasses (MUNSHOWER and NEUMAN 1978).

It is impossible to state whether the values found in these animals were reflective of normal, healthy animals because of the paucity of comparable data. The general conditions of the animals and the general wildlife population when these samples were collected, however, would indicate that these sample elemental levels were reflective of levels in healthy deer and antelope in the study area.

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