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Metals in Livers of White-tailed Deer in Illinois

Alan Woolf, James R. Smith, and Linda Small

Cooperative Wildlife Research Laboratory, Southern Illinois University-Carbondale, Carbondale, IL 62901

The values of biological monitoring were clearly summarized by JENKINS (1981). White-tailed deer, Odocoileus virginianus, a widely distributed and abundant game animal, are especially suited for broad area surveillance because of the ease of obtaining specimens in conjunction with legal harvests. Levels of trace elements have been reported in deer, but not from the midwestern United States as represented by Illinois. The potential for trace metal environmental hazards has been indicated by others (ERDMAN et al. 1978, MUNSHOWER & NEUMAN 1979), and many regions of Illinois may be subject to such hazards. This study was conducted to establish baseline data for environmental monitoring and to compare trace element levels found with those reported in similar species from other regions.

Of the 14 trace elements or metalloids identified as potentially toxic (Sb, As, Be, B, Cd, Cr, Co, Cu, Pb, Hg, Ni, Se, Sn, V), only Pb, Cd, Hg, As, and Ni were indicated to constitute an important threat to humans (JENKINS 1981). These 5 elements were included in our analysis plus cobalt, chromium, copper, magnesium, manganese, and zinc. Liver was selected for analysis because of the availability of specimens from hunters at deer check stations.

MATERIALS AND METHODS

Samples of liver tissue were obtained from 190 deer representing 15 Illinois counties in 1980; all but 32 samples were from Nov.-Dec. harvested deer at check stations, the others came from automobile-killed deer throughout the year. Portions of livers were placed in plastic bags then transferred to the laboratory for frozen storage.

Samples were prepared for analysis by weighing a 4-6 g subsample to $\pm$0.0001 g on an analytical balance and drying at 70°C in a forced-air oven until a constant weight was obtained. Samples were then digested with nitric and sulfuric acids. Most analyses were done on a Jarrell-Ash Plasma Spectroscope Model 90-750 Atomcomp^{R}. Detection levels for all elements were at least 0.01 ppm. Because of varying viscosities of the digested samples, each was fortified 1:1(v:v) with 10 ppm (final concentration) reference standard titanium. The percent recovery of the titanium was used to adjust ppm (μg/mL) values of the other elements. The

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standardization procedure included analyzing standards (10 ppm) for each element and a titanium blank after every 7-12 samples. Analyses for arsenic and mercury were done on 29 samples at the Illinois Department of Agriculture Animal Diagnostic Laboratory, Centralia using atomic absorption spectrophotomety.

Sex and age of deer reported were obtained from Illinois deer check station data. Age determinations were made by the tooth replacement method to separate fawns, yearlings, and older deer (2.5 years-old and older). Data are presented as mean ($\bar{x}$) ppm $\pm$ standard error of the mean (SE) on a dry weight basis (µg/g) except where indicated otherwise (for arsenic and mercury). The effects of sex and age were tested by ANOVA using the SAS package (HELWIG & COUNCIL 1979) and SIU-C computing facilities.

RESULTS AND DISCUSSION

Arsenic was not detected (<0.01 ppm) in 21% (6/29) of the deer livers examined. The mean As level in deer with detectable levels was 1.4 µg/g wet wt. (0.60 - 4.8). These levels exceed those noted by DOYLE & SPAULDING (1978) and the normal reported tissue levels of 0.5 ppm or less (BUCK et al. 1976). JENKINS (1981) stated that comparatively few species of animals had been used to measure environmental gradients of arsenic; other reports of levels in white-tailed deer were not found. Without comparative data, little biological significance can be attached to these levels; they merely represent preliminary surveillance findings. Although it has been reported that acute or subacute poisonings may have as low as 2 ppm in liver of kidney, levels above 10 ppm are usually accepted to confirm arsenic poisoning (BUCK et al. 1976). Thus the levels, while apparently high, likely are sub-lethal. Further, toxicity depends on form as well as concentration. Elemental As per se is not toxic and the levels reported may just represent accumulation of elemental As.

The mean Hg level in deer with detectable amounts (>0.01 ppm) (10/29 or 35%) was 0.024 ppm wet wt. (0.010 - 0.057). The mean levels found are similar to those reported in livers of cattle, swine and dogs in the midwestern United States (PENUMARTHY et al. 1980). These levels are also similar to those found in kidneys of deer in Oklahoma (KOCAN et al. 1980).

The results of the analysis for other elements are listed in Table 1. MUNSHOWER & NEUMAN (1979) pointed out that their data, as well as those reported by others, reflected the wide variation of elemental levels found from animal to animal. The data in Table 1 substantiate that view. Tests of significance must be viewed with some caution in light of the wide ranges and resulting standard errors of the means of most elements. Further, 5 elements (Cr, Cu, Mg, Mn, Pb) also differed by county and/or region of Illinois (WOOLF, unpublished data, in preparation). Nevertheless, they do represent baseline data from a large sample of Illinois deer.

Table 1. Mean trace metal content of Illinois white-tailed deer liver tissue (µg/g dry wt.).

Element	Total (N=190) $\bar{X} \pm SE$ (range)	All Ages		Both Sexes			Sig.*
		Male (n=82)	Female (n=180)	Fawn (n=48)	1.5 (n=59)	2.5+ (n=83)	
Cd	0.37±0.03 (0.02-6.5)	0.36	0.38	0.24	0.32	0.49	Age
Co	0.18±0.01 (0.00-2.2)	0.18	0.18	0.17	0.19	0.18	
Cr	2.7±0.1 (0.32-9.0)	3.0	2.5	2.8	2.8	2.7	Sex
Cu	109±5 (0.00-456)	126	96	88	109	120	Sex & Age
Mg	205±4 (23-422)	214	198	219	202	200	Sex
Mn	8.4±0.3 (1.9-37)	8.6	8.2	9.7	8.2	7.7	Age
Ni	3.6±0.7 (0.00-97)	4.0	3.2	2.2	3.0	4.8	
Pb	4.4±0.2 (0.00-13)	4.8	4.0	4.4	4.6	4.2	
Zn	70±2 (21-252)	72	68	73	67	70	

*Significant effect noted for variable listed; $P<0.05$

Cadmium levels reported for midwestern domestic animals (PENUMARTHY et al. 1980) were similar to those found in this study. Levels were also similar to those reported for mule deer (Odocoileus hemionus) and pronghorn antelope (Antilocapra americana) collected in Southeastern Montana (MUNSHOWER & NEUMAN 1979). Accumulations significantly increased with age. MUNSHOWER & NEUMAN (1979) noted significant accumulations of Cd with age in mule deer and antelope kidneys, but they did not detect such a trend in livers from either species.

Cobalt is considered to be of low toxicity to humans and environmental gradients have been reported mainly in higher plants (JENKINS 1981). Levels found in this study did not vary by region, sex or age and likely reflect background environmental levels.

Chromium is an abundant, but not highly toxic element. Levels detected were within the range found in 25 mammalian species (0.0 - 5.0 ppm dry wt.; JENKINS 1981). Other reports of Cr levels in white-tailed deer were not found. There was a significant difference in levels detected by sex with males averaging higher concentrations (Table 1).

Mean Cu levels found were higher than the 73 ppm dry wt. mean reported in mule deer livers from Colorado (STELTER 1980), or mule deer (46 ppm freeze-dry wt.) and antelope (27 ppm) from Montana (MUNSHOWER & NEUMAN 1979). However, the levels were well below 150 ppm wet wt.; the level cited by BUCK et al. (1976) as associated with toxicity in ruminants. They were generally lower than the range of 200-300 ppm dry wt. reported in cattle livers by DOYLE & SPAULDING (1978). An extremely wide range was found, but significant sex and age differences appeared (Table 1). Locality differences also existed and these may account for the observed sex and age differences. MUNSHOWER & NEUMAN (1979) found decreasing levels of Cu associated with age in both mule deer and antelope in contrast to these findings.

Magnesium is not considered a toxic trace element and the levels found are merely reported without comparison. There was a wide range, but males had significantly higher levels. There was a nonsignificant trend toward decreasing levels with age (Table 1).

Manganese levels found in these analyses are similar to those values reported for mule deer and antelope in Montana (MUNSHOWER & NEUMAN 1979). Values are also similar to the range (8-12 ppm dry wt.) reported for cattle, sheep and swine livers (DOYLE & SPAULDING 1978). There was a significant trend toward lower levels with increasing age.

Mammal organs (liver) are considered a poor choice for biological monitoring of nickel (JENKINS 1981). He reported wet wt. ranges of 0.0 - 3.7 ppm in liver and kidney for 13 species. SCHRODER et al. (1962) found a range of 0.0 - 2.5 ppm wet wt. in deer livers from New England. We found a very wide range, but the mean (3.6

ppm dry wt.) was similar to other reported ranges. MUNSHOWER & NEUMAN (1979) stated that Ni levels in mule deer and antelope ranged up to 3, but most were less than 0.5 ppm freeze-dried wt. The wide range of Ni we found indicated higher concentrations in males and a strong tendency toward increasing levels with age, but the results were not significant (Table 1).

Lead levels in our sample were higher than those commonly reported for most species, but high levels in one area that constituted a large portion of the sample (n=131) was an important factor (WOOLF, unpublished data, in preparation). LYNCH (1973) reported a mean of 0.74 ± 0.32 SD (wet wt.) in Ohio deer livers. MUNSHOWER & NEUMAN (1979) found means of 0.6 and 0.9 ppm (freeze-dry wt.) in antelope and deer livers, respectively. Liver lead levels reported for Midwestern swine, cattle, dogs, and horses was generally less than 0.5 ppm with 2 ppm the maximum detected (PENUMARTHY et al. 1980). Levels of lead reported in deer kidneys by KOCAN et al. (1980) are also in this range.

Zinc levels found were somewhat lower than those reported for antelope and deer by MUNSHOWER & NEUMAN (1979). Also, the levels we found generally averaged lower than those reported for domestic animals in the US and other countries (DOYLE & SPAULDING 1978).

The sample elemental levels presented can only be viewed as preliminary baseline data generally comparable to that reported for similar species in other regions, or domestic animals. Since the samples were from 15 areas of Illinois, the mean values represent a broad, rather than site specific surveillance. In spite of obvious shortcoming (i.e. liver is not the tissue of choice for biological monitoring of all trace elements), the results do provide useful baseline information. The values found seemingly represent that present in healthy deer inhabiting the regions sampled. For the most part, the liver levels were similar to other published data. The higher than normal lead levels were attributable to a large sample from one area. Comparatively high arsenic levels are not explained and warrant further investigation.

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