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Regional Variation in Metals in Livers of White-Tailed Deer in Illinois[1]

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ABSTRACT

Concentrations of nine heavy metals found in livers of white-tailed deer (Odocoileus virgineanus) in Illinois exhibited significant regional variation. The findings illustrated both the utility of white-tailed deer to monitor environmental quality and also the need for at least regional, and perhaps site specific surveillance. Grouping on a regional ecological basis was useful for surveillance of Co, Cr, Cu, Mg, Mn, Ni, Pb, and Zn. Cadmium had a greater variability in distribution within the regional groupings suggesting that more site specific monitoring is needed for this trace element.

INTRODUCTION

Woolf et al., 1982 reported heavy metal concentrations found in liver samples from white-tailed deer collected from 15 areas of Illinois. The utility of using deer for such monitoring was shown and the baseline data were useful for comparison with other published findings. However, retrospectively there appeared to be a need to further define the geographical variation within Illinois based on a larger sample. Hence, more data were collected with the objectives of: 1) determining heavy metal concentration variability between distinct geographical regions in Illinois; and 2) identifying areas of the state for proposed monitoring in time and space.

MATERIALS AND METHODS

Liver tissue was collected from 441 white-tailed deer in 1980 and 1981 harvested in 26 counties plus Crab Orchard National Wildlife Refuge (CONWR) in William-son County (Fig. 1). All but 32 samples were obtained from hunters at

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mandatory deer check stations; the remainder were collected from road-killed deer by cooperators in the west-central Illinois region. Samples were placed in plastic "whirl-pacs" and identified by county of collection; specific site of harvest was unknown. Samples were frozen within 12 hours then transported to the laboratory and stored in a freezer (−10C) until processed for analysis. Samples from CONWR were handled similarly except hunters were interviewed to determine kill locations which were plotted on a 7.5′ topographic map.

Methods of collection did not permit choice of liver tissue nor did they include safeguards against contamination. During laboratory processing, a 4-6 g subsample was taken by trimming away superficial areas with a scalpel. Samples were then digested with nitric and sulfuric acids; blanks of all chemicals were processed concurrently with tissue digestions and were used to determine levels of background contamination. A Jarrell-Ash Model 975 Plasma Atom Comp Direct Spectrometric System was used to analyze digestates and the blank matrices as previously described (Woolf et al, 1982).

Data were grouped into four regions for analysis; CONWR was treated as a separate region although it is located in southern Illinois. The assignment of counties to regions was based on Illinois deer management units and approximated natural ecological divisions identified by Schwegmen (1973). Sex and age classes were grouped for analysis so sample sizes would permit statistical analysis at the county level. The General Linear Models Procedure in the SAS package (Helwig and Council, 1979) and Southern Illinois University at Carbondale computing facilities were used to do the ANOVA and Duncan's Multiple Range Test which would detect mean differences of each element within and between the four groupings. Levels of significance for all tests were $P < 0.05$.

RESULTS

Significant regional differences were found in mean liver concentrations (μ g/g dry wt.) for all nine elements evaluated (Table 1). CONWR had the highest concentration of every element except Co and Mg. In the case of Co, the mean was not significantly different than that in the region with the highest concentration.

The validity of the regional groupings was examined by assessing intraregional variation statistically. The 15 counties grouped as west central Illinois did not have significant differences in liver levels of Mg, Ni, Pb, or Zn. Significant differences existed in Co, Cu, and Mg levels, but 12, 14, and 13 counties, respectively, were similar.

There was significant variation of Cd levels within the region suggesting that this element requires more site specific surveillance than afforded by the regional grouping. Seven counties were similar with levels ranging from 0.13-0.28 ppm; eight others were similar with smaller concentrations from 0.01-0.12. Further, there was overlap in the mid-range with six counties not significantly different.

The northern and southern Illinois regions were more uniform than the west central region. Significant intra-regional differences were found only for Co, Ni, and Zn in southern Illinois; in all cases, the same four of five counties were similar.

DISCUSSION

These data illustrate the importance of determining regional variability and considering such in any geographical monitoring scheme. The baseline data previously reported by Woolf et al (1982), while useful for comparison with metal concentrations reported for deer or similar species in other areas, were biased by a large proportion of samples (69%) from CONWR. Likewise, the mean values in this study (Table 1) are biased if viewed as a group rather than regionally because CONWR data comprises 34% of the total sample. The necessity for regional monitoring is apparent. In the case of Cd. the intra-regional variation suggests the need for even more site specific monitoring.

Data on intra-regional variation must be evaluated with caution because of the uneven, and sometimes small sample sizes (Figure 1). Further, sex and age classes were combined for these analyses although Woolf et al. (1982) and others have noted sex and/or age influences on tissue concentrations of some metals. We accepted this potential additional source of variation because there was no significant difference in the age-structure (fawn, yearling, and 2 1/2 year old and older) of the samples representing each region ($X^2 = 5.61$ w/6 d.f.; $P < 0.50$). While there was a significant difference ($X^2 = 9.88$ w/3 d.f.; $P < 0.02$) in the sex structure of the samples (50.5, 54.8, 38.6 and 68.9% males for CONWR, west central, southern, and northern Illinois regions, respectively) these may have influenced only Cr, Cu, and Mg levels (Woolf et al. 1982). Also, the magnitude of differences between regions far exceeded those previously noted between sexes. However, we do recommend that this potential source of experimental variation be eliminated by limiting sampling to a single sex/age class.

The need to monitor environmental levels of heavy metals in time and space is well established and the regional differences found in this study illustrate the utility of such efforts. For example, CONWR samples had comparatively high concentrations of most metals. Especially noteworthy were the levels of Cd and Pb which are among those elements reported to constitute the greatest hazard to human health (Jenkins, 1981). The Cd levels at CONWR are nearly two-fold greater than elsewhere in southern Illinois, and about 4.5 times greater than other regions. Lead levels at CONWR ranged from 2.6 to 18.6 times greater than other regions (Table 1). While we do not imply that any hazard exists, clearly the findings indicate the value of such data, especially if the findings are then followed by an effort to determine the sources, actual extent, and biological significance of given levels of heavy metals in the environment.

The geographical dispersion of trace metals and the natural and man induced factors that influence flow and storage in ecosystems clearly need definition and understanding. Baseline data as presented identify status and provide a useful basis for further study. White-tailed deer, a widely distributed species, are useful for broad monitoring that can then form the basis for more site specific studies focused on soils, plants, and more sedentary animals.

ACKNOWLEDGEMENTS

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Fig. 1. Collection sites for livers of white-tailed deer, 1981-82. Numbers of livers collected from each area are as follows: (1) Jo Daviess Co., n = 21; (2) Boone Co., n = 4; (3) McHenry Co., n = 5; (4) DeKalb Co., n = 11; (5) Rock Island Co., n = 15; (6) Henry Co., n = 3; (7) Mercer Co., n = 5; (8) Henderson Co., n = 6; (9) Warren Co., n = 14; (10) Knox Co., n = 8; (11) Peoria Co., n = 8; (12) Marshall Co., n = 12; (13) Woodford Co., n = 7; (14) Tazewell Co., n = 33; (15) Fulton Co., n = 30; (16) McDonough Co., n = 16; (17) Schuyler Co., n = 2; (18) Hancock Co., n = 4; (19) Adams Co., n = 8; (20) Pike Co., n = 10; (21) Washington Co., n = 3; (22) Jackson Co., n = 2; (23) Williamson Co., n = 29; (24) Saline Co., n = 4; (25) Union Co., n = 19; Crab Orchard National Wildlife Refuge, n = 151.

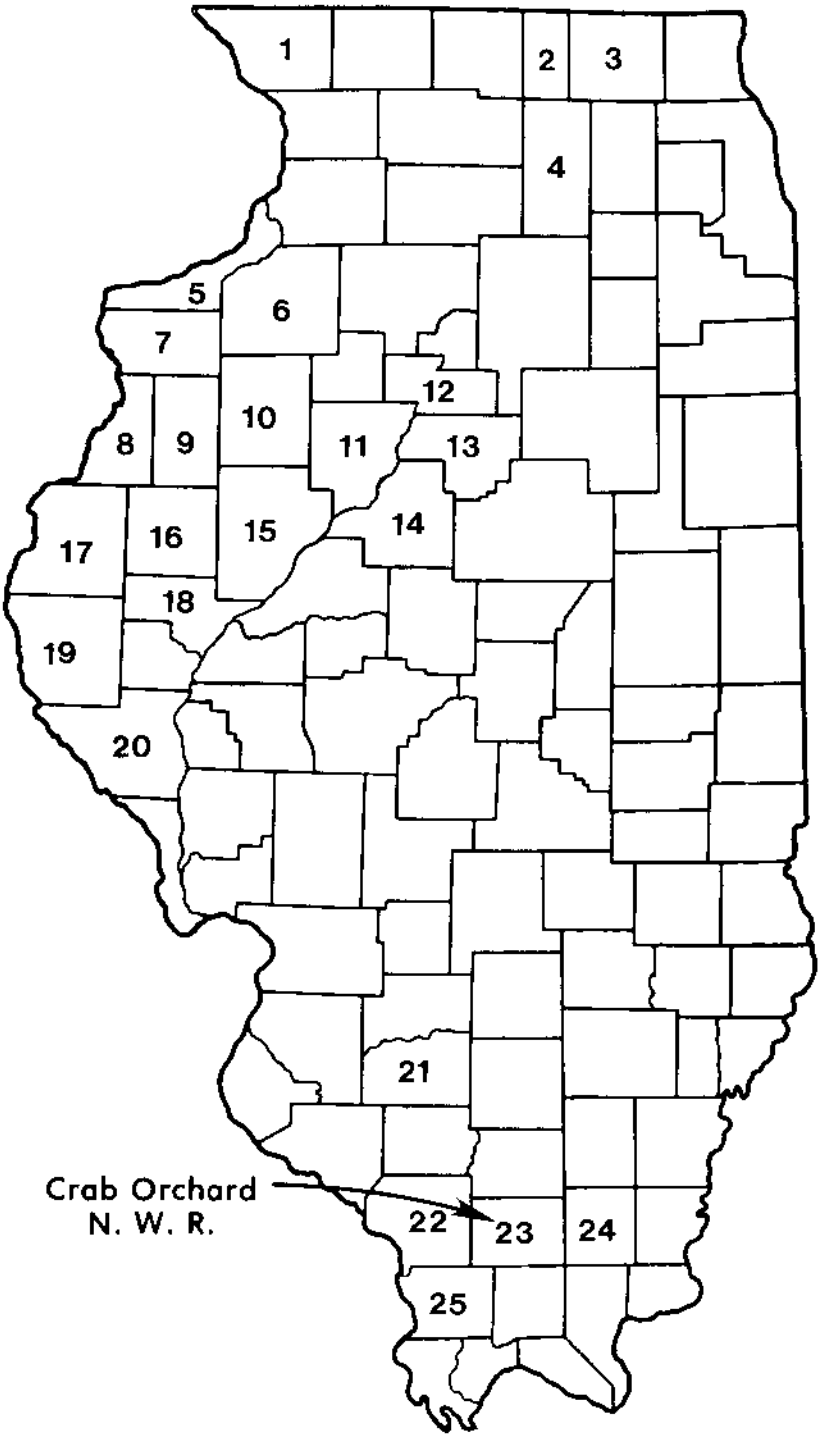
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Table 1. Regional mean trace metal content of Illinois white-tailed deer liver tissue, 1980 and 1981 (ug/g dry wt.).

Element	Total (n = 441) $\bar{X} \pm SE$	Crab Orchard[a] NWR (n = 151)	W. Central[b] Ill. (n = 188)	S. Ill.[c] (n = 57)	N. Ill.[d] (n = 45)
Cadmium	0.23 ± 0.02	0.43 (a)[e]	0.10 (c)	0.25 (b)	0.09 (c)
Cobalt	0.20 ± 0.02	0.36 (a)	0.05 (b)	0.45 (a)	0.04 (b)
Chromium[f]	2.7 ± 0.1	3.1 (a)	2.3 (b)	1.0 (c)	
Copper	76 ± 3	115 (a)	56 (b)	49 (b)	55 (b)
Magnesium	206 ± 3	211 (b)	212 (b)	154 (c)	235 (a)
Manganese	5.9 ± 0.2	8.4 (a)	5.0 (b)	3.9 (b)	4.0 (b,c)
Nickel	2.5 ± 0.3	4.5 (a)	1.7 (b)	0.8 (b)	1.0 (b)
Lead	2.8 ± 0.2	5.6 (a)	1.3 (b,c)	2.1 (b)	0.3 (c)
Zinc	65 ± 2	69 (a)	61 (a,b)	55 (b)	67 (a)

[a]Crab Orchard National Wildlife Refuge located in Williamson Co., Southern Illinois
[b]15 counties represented
[c]5 counties represented
[d]6 counties represented
[e]Means with the same letter are not significantly different (Duncan's Multiple Range Test)
[f]Chromium only tested for in 1980 samples. n = 205