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Lead Concentrations in White-tailed Deer Mandibles and Teeth

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Heavy metal contamination in the environment has become a major concern of the scientific community. Lead pollution is of particular interest because it enters the environment from several sources including automobile exhaust, industrial waste, lead arsenate pesticides, and phosphate fertilizers (GOLDSMITH 1976).

The accumulation of lead in the tissue of organisms residing in a given area has been used as an index to measure both the amount of environmental contamination and the potential hazard to these organisms (SCANLON et al. 1980). Numerous investigations on lead accumulation in hair, antlers, and soft tissue such as liver and kidney of large ungulates exist (MUNSHOWER et al. 1979, SAWICKA-KAPUSTA 1979, and FRANZMANN et al. 1975). Although adequate for studies of acute lead contamination, analysis of tissues that do not accumulate and store lead throughout life may not be a sensitive index to accurately measure chronic low-level lead contamination (UNDERWOOD 1971). SCHROEDER and TIPTON (1968) found that 90% of the mean total body burden of lead is in the skeleton. Consequently, measuring the amount of lead in bone tissue or dental tissue, as opposed to hair, antlers, or soft tissue of organisms residing in a given area may be a useful tool in determining chronic low-level lead contamination for the local environment.

Investigations of lead in the bone tissue of large ungulates is generally lacking and the authors are unaware of any existing data concerning lead concentrations in the mandible and teeth of such species.

The purpose of this investigation was to determine the lead content of white-tailed deer (Odocoileus virginianus) mandibles and teeth to develop baseline levels for future investigations on lead accumulation in the bone and dental tissue of large non-migratory mammals. The mandibles and teeth of white-tailed deer were chosen for several reasons: 1) teeth have been increasingly used to measure integrated lead contamination in humans (NEEDLEMAN and SHAPIRO 1974); 2) age of the deer could be obtained directly from the sample by tooth replacement and; 3) mandibles (with teeth) were easily obtained from harvested deer at butcher shops during the fall hunting season. White-tailed deer were used as an indicator species in this investigation because they exhibit a relatively large constant home range (MARCHINTON and JETER 1967) thereby reflecting the level of lead contamination in a wide area.

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MATERIALS AND METHODS

Mandibles and teeth were collected from 48 white-tailed deer which had been harvested from Adams, Cumberland, Dauphin, Lancaster, Lebanon, and York counties in Central and Southeastern Pennsylvania during the fall hunting season of 1979. Pennsylvania State Game Commission Biologist Fred Hartman aged all samples using tooth replacement and wear as criteria for age.

Digestion techniques used by GOLDSMITH and SCANLON (1977) on soft tissue were modified for use on bone and dental tissue. Mandible and teeth were separated, weighed, then ashed in a muffle furnace at 400°C for 12 h. Ashed samples (range 0.5 to 1.5 g) in duplicate were digested with 20 ml of concentrated nitric acid, cooled, diluted with distilled water and 1 ml of concentrated hydrochloric acid, filtered and evaporated to near dryness. Distilled water was added to reconstitute the samples, which were then diluted to 50 ml. Lead concentrations were determined by flame atomic absorption on a Perkin-Elmer Model 360 Spectrophotometer and expressed in $\mu g/g$ ash weight. Blank samples indicated no laboratory contamination and spiked samples yielded a mean of 90.4% lead recovery in this procedure.

A three way analysis of variances for unbalanced data sets with lead concentration as the dependent variable was used to determine if any significant difference was found among three factors: 1) county from which the deer were harvested; 2) age of the deer; and 3) sex. Analysis of data was performed using the Statistical Analysis System (SAS) version 79.5 of BARR et al. (1979). Analysis of variance is robust, but it assumes homogeneity of variance and normal distribution. Therefore, the data were tested for homogeneity of variance, skewness (g_1) and kurtosis (g_2). The calculated values of g_1 and g_2 for each data set fell within allowable error and a F max test found the variances to be homogeneous.

RESULTS AND DISCUSSION

There was no significant difference in the lead levels of mandibles compared to teeth ($P > 0.05$). Although data on lead concentrations in mandibles and teeth of deer is lacking, FRENCH and BISSEL (1963) found no significant difference in strontium-90 content in the teeth and mandible of California mule deer.

Mean lead concentrations for mandibles and teeth of deer from the six counties studied are presented in TABLE 1. Analysis of variance indicated that no significant difference occurs between lead concentration in deer from the six counties ($P > 0.05$). The counties in this investigation are found to be similar in percent land devoted to agriculture, industry, paved roadways, and suitable white-tailed deer habitat (PA. ABST., 1981). Although no data are available on lead distribution in the counties studied, our findings suggest that the distribution of lead in these counties is similar.

TABLE 1

Mean ± S E lead concentration (μg/g a.w.) of white-tailed deer mandibles and teeth by county.

County	N	Teeth	Mandible
Lebanon	8	34.8 ±1.5	34.6 ±1.5
Cumberland	8	35.7 ±1.5	36.4 ±0.9
Adams	8	36.1 ±1.4	36.3 ±1.4
York	8	37.1 ±1.7	36.7 ±1.2
Dauphin	8	37.2 ±1.3	37.1 ±1.1
Lancaster	8	37.7 ±1.1	36.0 ±1.3

Mean lead concentrations of mandibles and teeth for white-tailed deer by age class are shown in TABLE 2. Analysis of variance found no significant age effect in the mandibles and teeth ($P > 0.05$). There are conflicting data in the literature concerning lead content of teeth in humans. WILKINSON and PALMER (1975), and MALIK and FREMLIN (1974) found lead to increase in teeth with age. These findings were not supported by SHAPIRO et al. (1975) and MAULBETSCH and RUTISHAUSER (1936). Our results concur with the latter findings indicating no increase in lead content in teeth with age. However, it should be noted that deer older than 30 months were extremely hard to obtain for this study, consequently, the sample of deer over 30 months was limited.

TABLE 2

Mean ± S E lead concentration (μg/g a.w.) of white-tailed deer mandibles and teeth by age.

Age (months)	N	Teeth	Mandible
5 to 6	20	36.0 ±0.9	36.4 ±0.9
17 to 19	22	36.9 ±0.9	35.9 ±0.7
≥ 30	6	35.7 ±1.1	36.8 ±1.0

TABLE 3 indicates mean lead concentrations for mandibles and teeth of white-tailed deer by sex. Analysis of variance found no significant difference between sexes ($P > 0.05$). This finding is in agreement with that of WILKINSON and PALMER (1975) and MAULBETSCH and RUTISHAUSER (1936) who found no difference in human teeth lead levels between the sexes.

TABLE 3

Mean $\pm$ S E lead concentration (μg/g a.w.) of white-tailed deer mandibles and teeth by sex.

Sex	N	Teeth	Mandible
M	19	35.4 $\pm$0.8	36.1 $\pm$0.8
F	29	37.1 $\pm$0.8	36.3 $\pm$0.7

Data concerning mandible lead levels in regard to age and sex in humans are not available.

In conclusion, this study indicates little influence of age, sex, and county on lead levels in mandibles and teeth. Although direct comparisons between deer and human are not absolute, the literature cited concerning age and sex are generally in accordance with our findings.

Additional studies are needed to establish the reliability of using deer teeth and/or mandible as a suitable bioindicator for chronic low level lead contamination. These studies should include: a) age comparisons encompassing deer over 30 months old; b) kinetics of lead metabolism and distribution in teeth and mandibles; and c) formulation of indices between deer teeth and/or mandible lead levels and lead levels in the deer's home range.

Little variation in lead content in teeth and mandible i.e. small S E, suggest that white-tailed deer mandible and teeth lead levels may reflect contamination over a wide home range with little variation among individual deer within that home range.

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