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Lead Levels in Primary Feathers of American Woodcocks Harvested by Hunters Throughout the United States Range

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Pesticides and heavy metals represent major components of environmental contamination and consequently are problems for wildlife populations. American woodcocks (*Philohela minor*) have been shown to accumulate lethal levels of heptachlor by feeding on heptachlor-contaminated earthworms (STICKEL et al. 1965). SANDERSON (1977:180) recommended a monitoring system for pesticides and other environmental contaminants to study the effects of environmental contaminants on woodcocks. Earthworms are the principal food source of woodcocks and these have been shown to accumulate substantial quantities of lead in roadside environments (GOLDSMITH and SCANLON 1977, SCANLON unpublished). To date, little or no information has been collected on the levels of heavy metals in woodcocks. Relatively little information exists on what might be considered normal levels of elements in either contaminated or uncontaminated environments. This paper is concerned with levels of lead in the wing feathers of woodcocks collected in 32 states of the United States range.

METHODS AND MATERIALS

Wings were collected from woodcocks killed by hunters during the 1976-77 hunting season. Samples were chosen from 32 states comprising the majority of the woodcock's range in the continental United States. States and number of wings per state are shown in Table 1. Forty wings were chosen from each state. Only wings undamaged by shot were chosen. These were equally divided between male and female and between juveniles and adults. When less than 40 wings were available from any state all available wings were included in the sample which totaled 1008 woodcocks. Feathers were used to determine age and sex of the woodcocks (MARTIN 1964, ARTMANN and SCHROEDER 1976). All 10 primary feathers from each wing were used to determine lead levels.

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Feathers were ovendried, weighed, ashed in a muffle furnace and the ash dissolved into solution in nitric acid and hydrochloric acid. Lead levels were determined for each sample by means of atomic absorption spectrophotometry using an Instrumentation Laboratories Model 351 Atomic Absorption Spectrophotometer. Lead levels were calculated in terms of µg/g dry weight of feathers.

Data analysis was done using the Statistical Analysis System (SAS) of BARR et al. (1976). Analysis of variance tests were conducted and where significant differences were discovered, Duncan's multiple range tests were used to locate the differences.

Data on human populations of states, amounts of roads, and highway vehicle use were also collected for each state and correlation tests were conducted to determine relationships between these data and lead levels in woodcocks. The statistics studied are listed in Table 3. The sources of these statistics were U. S. BUREAU OF THE CENSUS (1975) and U. S. FEDERAL HIGHWAY ADMINISTRATION (1975).

RESULTS

Data are presented in Table 1 on mean lead levels in feathers of woodcocks shot in the 32 states studied. Significant differences ($P<0.05$) among states were observed (Tables 1 and 2). No significant differences ($P<0.05$) were observed between age classes or between sexes (Table 2). Lead levels in feathers of individuals ranged from undetectable amounts to less than 60 µg/g d.w., generally. In 13 woodcocks (1.3%) extremely high levels were observed (range 113 to 485 µg/g d.w.).

Correlation coefficients between lead levels in woodcock feathers and human population of state, human population density percentage of population in urban areas, total length of road per state, total length of rural roads per state, total vehicle miles, rural vehicle miles total,traffic density and rural traffic density are presented in Table 3. All of these correlation coefficients were found to be nonsignificant.

DISCUSSION

The woodcock is a carnivorous bird, possessing a prehensile beak which it uses to probe fertile soils for soil organisms, primarily earthworms (ALDOUS 1939, SPERRY 1940). Recent data has shown that earthworms from contaminated soils are capable of accumulating high levels of lead (GISH and CHRISTENSEN 1973, GOLDSMITH and SCANLON 1977, SCANLON unpublished). It could be assumed that woodcocks would also tend to accumulate lead through feeding on contaminated earthworms. Shrew species, which probably feed in part on earthworms, trapped near highways had higher lead levels than those trapped from areas not adjacent to highways (GOLDSMITH and SCANLON 1977).

TABLE 1

Mean (± S.E.) lead levels (µg/g, d.w.) in woodcock primary feathers shot by hunters in 1976-1977 hunting season.

State	N	Mean (± S.E.)
Alabama	20	15.49(± 3.94)abcd
Arkansas	9	12.14(± 3.06) cd
Connecticut	40	26.88(±12.50)ab
Delaware	17	6.75(± 1.11) d
Florida	18	10.66(± 2.18) cd
Georgia	35	9.81(± 2.41) cd
Illinois	26	8.19(± 1.14) cd
Indiana	34	23.24(± 7.82)abc
Iowa	27	9.96(± 2.76) cd
Kentucky	6	17.29(± 3.67)abcd
Louisiana	34	10.75(± 1.74) cd
Maine	39	8.29(± 2.90) cd
Maryland	38	10.69(± 1.26) cd
Massachusetts	39	15.99(± 2.14)abcd
Michigan	40	8.93(± 1.77) cd
Minnesota	39	9.81(± 2.50) cd
Mississippi	35	15.01(± 1.68) bcd
Missouri	24	10.47(± 3.09) cd
New Hampshire	40	7.40(± 1.86) d
New Jersey	40	9.56(± 1.69) cd
New York	40	8.83(± 2.19) cd
North Carolina	32	13.30(± 4.00) bcd
Ohio	40	16.91(± 2.73)abcd
Pennsylvania	40	11.14(± 1.65) cd
Rhode Island	32	10.03(± 2.49) cd
South Carolina	25	16.75(± 2.20)abcd
Tennessee	23	5.35(± 1.00) d
Texas	29	4.51(± 0.63) d
Vermont	39	19.34(± 5.63)abcd
Virginia	33	29.79(±12.59)a
West Virginia	36	11.57(± 4.55) cd
Wisconsin	40	6.54(± 1.54) d

a, b, c, d: Means with different superscripts in the same columns are significantly different at the $P<0.05$ level.

TABLE 2

Analysis of variance of lead levels in woodcock feathers

Source	DF	Sum of Squares	PR>F
state	31	36391.27	0.01
sex	1	291.02	n.s.
age	1	163.24	n.s
state x sex	30	14302.86	n.s.
state x age	31	9206.84	n.s.
sex x age	1	15.85	n.s.
state x sex x age	26	18821.05	n.s.
Error	886	638584.56	n.s.

TABLE 3

Correlation coefficients, with α levels, between mean lead levels of woodcocks shot in 32 states and selected human population, highway mileage, and traffic volume statistics in those states.

Parameters	Correlation Coefficient	α level
Total Population/state	-0.177	0.332
Population density/mi^2	-0.045	0.806
% Population in urban areas	-0.179	0.326
Total miles of road	-0.293	0.104
Rural miles of road	-0.282	0.118
Number of vehicles/state	-0.182	0.320
Total vehicle miles	-0.187	0.306
Rural vehicle miles	-0.127	0.488
Total traffic density[a]	0.184	0.314
Rural traffic density[b]	0.158	0.388

a: Total Traffic density = $\frac{\text{Total vehicle miles}}{\text{Total miles of road per state}}$

b: Rural Traffic density = $\frac{\text{rural vehicle miles}}{\text{rural miles of road per state}}$

Little data are available on elemental contents of feathers of birds other than waterfowl. Lead levels in feathers of Illinois pheasants (*Phasianus colchicus*) ranged from 62 µg/g to 500 µg/g (d.w. ash) for 3 age groups from agricultural areas (ANDERSON and STEWART 1970). Lead levels in feathers of wild turkeys (*Meleagris gallopava*), a species normally inhabiting remote and presumably uncontaminated areas of Virginia, were extremely low (<10 µg/g feather d.w.) in 93 percent of the birds SCANLON et al. 1978). Based on these 2 studies, lead levels in woodcock feathers could not be considered excessive. Lead levels were low (<30 µg/g d.w.) in 92.6 percent of the birds studied and the overall mean for 1008 woodcocks was 12.93 µg/g (d.w.). High levels of lead in feathers may result from lead shot in the bird's system or from feeding on earthworms contaminated with high lead levels. In all probability lead shot in woodcock would more likely result from non-fatal shooting than from ingestion of spent lead shot. The lack of a significant difference between lead levels of adults and juveniles indicates that lead shot probably does not play a major role in lead levels in woodcock feathers as juvenile woodcocks would not have been exposed to shooting prior to feather growth. More information on woodcock use of lead contaminated habitats will be needed to determine the exact relationship between lead levels in earthworms and woodcocks.

Interpretation of differences between states in lead levels in woodcock feathers is rendered more difficult by the fact that woodcocks are a migratory species and those shot in any state may not have been produced, and thus grown their primary feathers, in that state. During the breeding season woodcocks are known to occupy the majority of states where harvesting took place. In many of those states in the southern portion of the range only sparce populations occur and the majority of birds shot probably originated from states other than those where collected.

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SUMMARY

Levels of lead were determined in primary feathers of 1008 woodcocks (*Philohela minor*) shot by hunters in 32 states of the species' United States range. Lead levels did not vary by sex or age but varied significantly ($P<0.05$) by state. Generally, levels were found to be low (<30 µg/g d.w.) in the birds examined. No significant correlations were found between mean lead levels and 10 human population, highway and highway traffic parameters examined.

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