The Occurrence of Lead in Tissues of Wild Birds

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Lead poisoning has been recognized as a factor in waterfowl mortality since the turn of the century. Lead, once believed to be foreign, or accidental at most in its occurrence, is now known to be a regularly occurring constituent of plant and animal tissues (1). Although there is a relatively large amount of information on the concentration of lead in tissues of birds that have succumbed to lead poisoning, there is a conspicuous need for a record of naturally occurring levels in certain tissues. All birds are constantly exposed to sublethal quantities of lead in their food. Such exposure results in measurable amounts in the bones, soft tissue, and liver. No biological requirement for lead has been established.

Cases of lead poisoning are well documented in the literature. Beer and Stanley (2) reported lead to be an important cause of death among 32 species of captive wild birds at Slimbridge, Gloucestershire, England. Bellrose (3) presented a thorough documentation of lead poisoning in waterfowl in the United States. Irby et al. (4) reported on pen-raised mallards (Anas platyrhynchos) fed lead shot, and Locke and Bagley (5) discussed lead poisoning in a black duck (Anas rubripes).

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Upland birds are also susceptible. Hunter and Rosen (6) reported on lead poisoning in a wild pheasant (Phasianus colchicus). Locke and Bagley (7) documented lead poisoning in a sample of mourning doves (Zenaidura macroura) from Maryland, and Westemeier (8) discussed lead poisoning in a wild bobwhite quail (Colinus virginianus).

Lead poisoning usually results from the ingestion of spent shot deposited in lakes and marshes by hunters. Shot in various stages of erosion are usually, but not always, present in the gizzards of affected birds. Trainer and Hunt (9) recovered as many as 201 shot from the gizzard of a single whistling swan (Olor columbianus). They found an average of 50 shot per bird in 45 swans examined. A diagnosis of lead poisoning was made on 41 of these birds. Only 2 of the lead poisoned birds contained no shot in their gizzards.

This paper reports the concentrations of lead found in certain normal tissues of selected species of wild birds. An exhaustive search of the literature failed to offer any substantial data for comparison.

Materials and Methods

Most of the birds analyzed were obtained from their natural habitat and were in apparently good physical condition when collected. Some were raised in captivity at the Patuxent Wildlife Research Center, Laurel, Maryland, and a few, although found dead,

had none of the lesions or signs typical of abnormal exposure to lead (10). The gizzards of all birds were free of lead shot at necropsy. Tissues were kept frozen prior to preparation for chemical analysis. Liver and bone were selected for analysis because of the significant increase of lead deposition in these tissues when birds are exposed to abnormal amounts of lead in their diets (11, 12).

Chemical Analyses -- Tissues were weighed then dried at 110° C to constant weight. Organic matter was removed by ashing at 550° C. The carbon-free ash was dissolved in 10 ml of concentrated nitric acid, evaporated to dryness, then redissolved and diluted to appropriate volume with 0.1 N hydrochloric acid. The Perkin-Elmer atomic absorption spectrophotometer, Model 303, was used for all determinations. Instrument settings were essentially those recommended in the Analytical Methods for Atomic Absorption Spectrophotometry (13). The standard burner head was replaced with the three slot Boling burner head.

Extreme care was exercised to avoid contamination of samples. Glassware was cleaned with a laboratory detergent, rinsed thoroughly with distilled water and hot nitric acid, and given a final rinse in de-ionized water. Reagent grade nitric and hydrochloric acids did not require further purification. The lead content of the acids was estimated by evaporating 100 ml to dryness, dissolving the residue in 5 ml of de-ionized water,

and determining the percentage absorption for lead by atomic absorption spectrophotometry. The lead reference standard (No. So-L-21) was obtained from Fisher Scientific Company.

Results and Discussion

The lead levels obtained are recorded in Tables I and II. With the exception of the rock ptarmigans (Lagopus mutus) from Iceland, all birds were collected in the Eastern United States, from Florida north to New England.

TABLE I

The concentration of lead in the liver of birds based on wet wt.

	Average ppm	Range ppm	No. of Samples	Source*
American coot (Fulica americana)	2.0	2.0	1	3
American scoter (Oidemia nigra americana)	0.5	0.3-0.9	10	2
Bald eagle (Haliaeetus leucocephalus)	0.6	0.6	1	2
Black duck (Anas rubripes)	0.5	0.4-0.6	2	2
Brant (Branta bernicla)	1.3	0.9-1.9	11	2
Brown pelican (Pelecanus occidentalis)	0.8	0.4-1.3	16	2
Canada goose (Branta canadensis)	0.5	0.3-0.8	11	1
Canvasback (Aythya valisineria)	0.5	0.5	4	2

TABLE I (Continued)

	Average ppm	Range ppm	No. of Samples	Source*
Cowbird (Molothrus ater)	3.7	2.0-5.0	4	2
Domestic goose (Anser cygnoides)	0.6	0.3-0.8	4	1
Dusky grouse (Dendragapus obscurus)	1.1	1.1	1	1
Great blue heron (Ardea herodias)	0.7	0.7	1	2
Green wing teal (Anas carolinensis)	1.5	1.5-1.6	2	3
Hooded merganser (Lophodytes cucullatus)	0.9	0.6-1.2	3	2
King rail (Rallus elegans)	2.0	2.0	1	2
Mallard (Anas platyrhychos)	0.9	0.3-2.0	16	1
Mourning dove (Zenaidura macroura)	3.3	0.4-7.0	37	2
Osprey (Pandion haliaetus)	1.5	1.5	1	2
Pintail (Anas acuta)	0.9	0.9	1	3
Ring-necked pheasant (Phasianus colchicus)	0.5	0.2-1.0	21	1
Rock ptarmigan (Lagopus mutus)	2.1	2.0-3.0	7	3
Sandhill crane (Grus canadensis)	0.7	0.7	1	2

TABLE I (Continued)

	Average ppm	Range ppm	No. of Samples	Source*
Shoveler (Spatula clypeata)	1.1	1.0-1.2	3	3
Snow goose (Chen hyperborea)	1.2	0.8-1.8	18	2
Surf scoter (Melanitta perspicillata)	0.9	0.4-2.0	23	2
Whistling swan (Olor columbianus)	0.8	0.8	1	2
White-winged scoter (Melanitta fusca)	0.8	0.3-1.8	18	2
Wood duck (Aix sponsa)	1.5	0.7-2.0	5	2

*1. Pen raised
2. Captured or shot
3. Found dead

TABLE II

The concentration of lead in the tibia of birds based on wet wt.

	Average ppm	Range ppm	No. of Samples
American coot (Fulica americana)	3.0	3.0	1
American scoter (Oidemia nigra americana)	6.0	2.0-19.0	13

TABLE II (Continued)

	Average ppm	Range ppm	No. of Samples
Canada goose (*Branta canadensis*)	2.0	0.2- 4.0	11
Dusky grouse (*Dendragapus obscurus*)	3.0	3.0	1
Great blue heron (*Ardea herodias*)			
Mallard (*Anas platyrhynchos*)	10	6.0-14.0	6
Osprey (*Pandion haliaetus*)	9.0	9.0	1
Pheasant (*Phasianus colchicus*)			
Rock ptarmigan (*Lagopus mutus*)	7.1	3.0-12.0	7
Snow goose (*Chen hyperborea*)	13	4.0-26.0	18
Surf scoter (*Melanitta perspicillata*)	3.8	2.0-12.0	18
Whistling swan (*Olor columbianus*)	8.0	8.0	1
Wood duck (*Aix sponsa*)	4.4	2.0- 8.0	5

These data clearly indicate that lead is a regularly occurring constituent in liver and bone tissues of wild birds. The degree of active exposure to lead is indicated by concentrations of the metal

in the liver tissue while exposure of a chronic nature is reflected in concentrations in the bone tissues. Levels of lead in the liver are low (Table I). Bone levels are much higher (Table II) reflecting the effect of continued lead absorption. The behavior of lead in following calcium to the bones and its mobilization therefrom under conditions of stress is well known in mammals (14) and highly probable in birds. This creates the danger of lead intoxication if more than the "normal" amount is ingested at the same time as lead is released suddenly from the bones.

In order to evaluate any incidence of suspected lead poisoning "normal" levels of lead for the species involved must be known, and the levels above normal which tend to produce injury on the one hand or no apparent harmful effect on the other must be recognized. It can be suspected that these levels will vary from species to species. We believe the values derived from this study will provide guidance to the problem and a base line above which abnormal exposures to lead can be recognized.

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