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Liver Lead Concentrations of Several Bird Species from the Western James Bay Region of Northern Ontario, Canada: Do the Data Support the Canadian Nontoxic Legislation?

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In 1999, the use of lead shotshell for the hunting of all migratory game birds was banned nationwide in Canada, due to the toxic nature of lead (Environment Canada 2000). It should be emphasized that until recently, only limited data existed on lead poisoning of birds in Canada (Scheuhammer and Norris 1995). Even though a larger database now exists for some regions of Canada (e.g., Kennedy and Nadeau 1993; Scheuhammer and Norris 1995), data are scarce concerning the prevalence of lead poisoning of birds in Ontario (Dickson and Scheuhammer 1993). More data are required to justify the banning of lead shot for migratory bird hunting in Ontario. If more information is not made available, hunter cooperation will be limited, as was seen in Alaska's Yukon-Kuskokwim Delta after the American nationwide ban on the use of lead shotshell for the hunting of waterfowl in 1991 (Balogh 1999). Moreover, enforcement of the nontoxic shotshell legislation will be difficult in remote regions of Canada, especially when considering the fiscal constraints imposed on government enforcement agencies (Scheuhammer and Norris 1995).

Lead poisoning data for Ontario consists mainly of lead pellet ingestion studies (e.g., Dennis 1993; Tsuji et al. 1998) with a limited database existing for tissue-lead levels (Dickson and Scheuhammer 1993; Braune et al. 1999). Although lead pellet ingestion data give some indication of lead poisoning problems, only tissue lead levels provide an accurate account of actual lead uptake by individuals (Friend 1985).

In this paper, we determine liver lead concentrations for several bird species in a heavily hunted region of Canada, the western James Bay region of northern Ontario, to examine whether the data collected for this area supports the recent nontoxic shotshell legislation. Results are compared to two levels of concern established by the Canadian Wildlife Service (Canadian Wildlife Service [CWS] 1990) with respect to lead pellet ingestion in birds, the 5% level (lead poisoning may be a problem but more data are required) and the 10% level (establishment of a non-toxic zone is warranted).

MATERIALS AND METHODS

The western James Bay region of northern Ontario, Canada, is populated by First Nation Cree. Harvesting of waterfowl is a way of life to the Cree (Tsuji et al. 1999). During the period 1993-1996, Cree of the western James Bay region allowed our research team to recover livers from game birds harvested as food. Age distribution of sampled birds was not considered because only acute lead exposure was measured (liver lead). If a chronic indicator of lead exposure were to be measured, such as bone lead, only hatch-years birds would have been collected.

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Liver lead levels of 6 μg/g wet weight (ww) or 20 μg/g dry weight (dw) are diagnostic of lead intoxication in birds (Friend 1985). A total of 385 livers were collected from four groups of birds: grouse, spruce *(Dendragopus canadensis)* and sharp-tailed (*Tympanuchus phasianellus*); shorebirds, common snipe (*Gallinago gallinago*) and Hudsonian godwit (*Limosa haemastica*); ducks, mallard (*Anas platyrhynchos*), northern pintail (*A. acuta*), and green-winged teal (*A. crecca*); geese, Canada (*Branta canadensis*), and snow (*Chen caerulescens*).

Stainless steel blades were used to cut livers (whole livers were used when available) from the game birds. Subsequently, samples were individually sealed in marked, plastic, zip-lock bags and stored frozen until further processing.

Tissue samples were oven-dried to constant weight at 70°C and ground in a spice mill with stainless steel blades. Subsamples of 1.00 g of dried tissue were digested in trace-metal grade HNO_3 (JT Baker, Ultrex), 0.5 mL of HNO_3 for every 0.10 g of tissue. The tissue-acid mixture was digested overnight at room temperature followed by heating at 100°C for 6 hrs. Samples were diluted with distilled deionized water (DDW) to a final acid concentration of 2.5% v/v. This mixture was then filtered through Whatman 42 ashless filter paper. A blank (trace-metal grade HNO_3) and bovine liver Standard Reference Material 1577b (US National Institute of Standards and Technology) were included with each digest run. Samples were analyzed for lead with a Perkin-Elmer Model 460 flame atomic absorption spectrometer. Calibration standards were dilutions of Delta Scientific high-purity multi-element (100±0.5 mg/L) standard made to the same chemical matrix as the samples. The detection limit for lead was 1.0 μg Pb/g dw corresponding to 0.3 μg Pb/g ww. A total of 19 bovine liver reference samples were digested and recovery of lead from them, on average, was within 5% of the expected value.

Frequencies of liver lead concentrations for species found to have liver lead concentrations ≥20 μg/g dw were tested against an expected lead exposure rate of 5% and 10% (levels of concern) using Chi-square goodness-of-fit tests. The extremely high liver lead levels from specimens of snow (516 μg/g dw) and Canada geese (718 μg/g dw; 28,072 μg/g dw) are not included in statistical analysis (or Table 1), because the probable upper limit for liver lead concentrations in livers of waterfowl that have ingested lead shot (natural or dosed - Szymczak and Adrian 1978) is 283 μg/g dw. Concentrations exceeding this value are most likely the result of lead pellets and/or lead fragments being embedded in the tissue (Frank 1986).

RESULTS AND DISCUSSION

Percent of individuals with liver lead levels ≥20 μg/g dw are given in Table 1. There were no detectable liver lead levels for the grouse and shorebirds examined. Although grouse and shorebirds sampled were found not to be lead intoxicated, using liver lead level as the criterion, the data collected are limited. By contrast, data for northern pintails and geese harvested in the western James Bay region confirm lead uptake and intoxication in these birds. In all instances of species found to have detectable liver lead levels, the frequency of lead poisoning was not significantly different from an expected frequency of 5% ($x^2 \leq 1.103$, df=1, $P>0.05$). Thus, the frequency of lead poisoning in northern pintails, snow, and Canada geese warrants concern. Further, in northern pintails and snow geese, the frequency of lead poisoning was not significantly different from an expected frequency of 10% ($x^2 \leq 3.764$, df=1, $P>0.05$), while in Canada geese, the frequency of lead poisoning was significantly different from an expected frequency of 10% ($x^2=8.002$, df=1, $P<0.005$). Thus, the frequency of lead poisoning in northern pintails and snow geese

Table 1. Lead content in livers of birds harvested in the western James Bay region of northern Ontario, Canada.

	Pb[a]	n[b]	%[c]	range[d]
Grouse				
Spruce	0	4	0	<dl[e]
Sharp-tailed	0	10	0	<dl
Shorebirds				
Common Snipe	0	4	0	<dl
Hudsonian Godwit	0	4	0	<dl
Ducks				
Mallard	0	85	0	<dl
Northern Pintail	3	33	9.1	40-162
Green-winged teal	0	18	0	<dl
Geese				
Snow	2	68	2.9	25
Canada	5	156	3.2	50-276

[a]The no. of birds with lead levels diagnostic of poisoning, ≥20 μg/g dry weight.
[b]The no. of birds examined for that species.
[c] The percent of birds with lead levels diagnostic of poisoning.
[d]Liver lead values of samples with detectable levels of lead.
[e]The detection limit of 1 μg/g dry weight.

support the established nontoxic zone in the western James region of Ontario. Data for Canada geese do not support the legislation, although some concern is warranted.

Lead exposure of birds in the present study is presumed to have been from the ingestion of lead pellets by these birds since, lead pellet ingestion has been confirmed for these species in this region (Tsuji et al. 1998). Thus, using the CWS criteria (CWS 1990), liver lead concentrations for northern pintails and snow geese support the legislation that made the western James Bay region of Ontario a nontoxic zone. Although similar evidence supporting this legislation for some other regions of Canada is lacking (Scheuhammer and Norris 1995), the nationwide ban on the use of lead shotshell for the hunting of all migratory game birds can be supported from a human health perspective.

The CWS has stated that "if a risk to human consumers of waterfowl were identified, this would be of primary importance in establishing further restrictions on lead" (Wendt and Kennedy 1992; p.66). In the western James Bay region, Tsuji and Nieboer (1997) have shown in First Nation Cree that approximately 15% of randomly selected radiographic charts (abdominal and kidney, ureter, bladder views) examined at the regional hospital had evidence of pellets localized in the gastro-intestinal tract. Lead pellets located in the gastrointestinal tract can add to an individual's body burden of lead (see for e.g., Madsen et al. 1988). Indeed, elevated tissue lead levels

in newborns, children and adults of the region have been reported (Hanning et al. 1996; Tsuji et al. 1997; Tsuji et al. 2001). Further, approximately 10% of edible meat sampled from game birds harvested in Canada with lead shot have been shown to contain lead ≥0.5 μg/g ww (Scheuhammer et al. 1998; Tsuji et al. 1999), the human consumption level set by Health Canada for fish protein; no guidelines exist for game birds (Health Canada and Ontario Ministry of Health 1995). Radiography has confirmed that game birds harvested with lead shot can become contaminated through the embedding of whole lead pellets and/or pellet fragments generated from the disruption of lead shot upon impacting with hard tissue (Scheuhammer et al. 1998; Tsuji et al. 1999). Tsuji et al. (2002) have also shown that the dissolution of lead pellets in saliva can be a significant source of lead exposure in humans. Lastly, Levesque et al. (1998) showed using stable lead isotope ratios that the source of lead exposure for Inuit newborns in northern Quebec, Canada, was leaded ammunition. Thus, the data in the present study support the Canadian nontoxic legislation with respect to the western James Bay region, while recent environmental health studies support the nationwide ban on the use of lead shotshell for the harvesting of all migratory game birds, from a human health perspective.

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