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BLOOD LEAD CONCENTRATIONS OF WATERFOWL FROM UNHUNTED AND HEAVILY HUNTED MARSHES OF NOVA SCOTIA AND PRINCE EDWARD ISLAND, CANADA

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ABSTRACT: Blood lead concentrations of juvenile American black ducks (*Anas rubripes*) sampled in unhunted sanctuaries of Nova Scotia (NS) and Prince Edward Island (PEI), Canada, usually were <30 parts per billion (ppb). Based on gizzard content analyses of juvenile American black ducks from hunted areas, eight (24%) of 33 flightless birds contained ingested lead shot. Blood lead concentrations were ≥100 ppb in seven of eight juveniles with ingested shot; thus we adopted blood lead concentrations 100 ppb as our threshold indicating exposure to non-background lead. The proportion of both American black ducks and ring-necked ducks (*Aythya collaris*) with elevated blood lead concentrations (>100 ppb) exceeded 5% in hunted areas sampled in NS and PEI combined. The Canadian Wildlife Service draft policy is to consider replacing lead shot with non-toxic shot for waterfowl and snipe hunting if 5% of American black ducks exceed a blood lead concentration of 200 ppb. American black ducks significantly ($P < 0.05$) exceeded this threshold but ring-necked ducks did not. The source of lead in hunted areas may have been lead shot; we recommend that it be eliminated and replaced by an acceptable non-toxic shot for waterfowl hunting. Twenty four (96%) of 25 of American black ducks overwintering in Sullivans Pond, Dartmouth, NS, contained elevated (>100 ppb) blood lead concentrations and 19 (76%) had detrimental concentrations (>200 ppb). We believe that the source of lead at Sullivans Pond was automobile emissions.

Key words: American black duck, *Anas rubripes*, ring-necked duck, *Aythya collaris*, blood lead concentration, lead poisoning.

INTRODUCTION

Lead poisoning of waterfowl from spent lead shot is well documented, especially in the United States (Bellrose, 1959; Feierabend, 1983; U.S. Fish and Wildlife Service, 1986). Documentation of lead shot ingestion by waterfowl in two areas of Nova Scotia (NS), Canada (Schwab and Daury, 1989), has led to concern that the lack of information may be allowing lead poisoning of Atlantic Canada waterfowl. As a result, further study was initiated into whether lead shot bans should be implemented in that region.

Absolute blood lead concentration is a good short-term indicator of lead toxicosis since blood carries lead to other tissues (Anderson and Havera, 1985). Because 200 parts per billion (ppb) of lead in blood (wet weight) caused a significant inhibition of delta-aminolevulinic acid dehydratase in canvasbacks (*Aythya valisineria*), Dieter (1979) proposed that a 200 ppb blood lead concentration was physiologically detrimental. Sanderson and Bellrose (1986) reported blood lead concentrations >200 ppb to exceed background levels and the U.S. Fish and Wildlife Service (1986) accepted ≥200 ppb blood lead as indicating waterfowl exposure to a non-background source of lead. As a result of work done on lead poisoning of waterfowl due to ingesting spent lead shot, the U.S. Fish and Wildlife Service banned the use of lead shot for waterfowl hunting (U.S. Federal Register 29673, 20 August 1986).

The draft Canadian Wildlife Service (CWS) policy on lead shot use for waterfowl hunting is that if >5% of one indicator species, the American black duck (*Anas rubripes*), in Atlantic Canada contains blood lead concentrations >200 ppb, then the use of non-toxic shot for waterfowl hunting will be considered (Canadian

Wildlife Service, 1990). Ring-necked ducks (*Aythya collaris*) also ingest spent lead shot. To provide information for the consideration of lead shot bans, we determine the blood lead concentrations of both American black ducks and ring-necked ducks on both unhunted and hunted NS and Prince Edward Island (PEI) marshes. Our objectives were to determine background blood lead concentrations of American black ducks and therefore a threshhold level of exposure to non-background lead; to determine the pre-winter proportions of American black ducks and ring-necked ducks exposed to lead; and to determine the proportion of wintering American black ducks exposed to lead.

MATERIALS AND METHODS

Marshes were selected for waterfowl capture in consultation with federal (CWS) and provincial (NS Wildlife Division; PEI Fish and Wildlife) wildlife management personnel. Two marshes, each within a migratory bird sanctuary (MBS), served as controls and three hunted marshes served as experimental areas to determine background blood lead concentrations of ducks brooded in NS and PEI. The unhunted control sites were Amherst Point MBS, NS (45°40′N, 64°10′W), a fresh water marsh and Black Pond MBS, PEI (46°21′N, 62°10′W), a brackish water non-tidal marsh. The three experimental sites were Martinique and area, NS (44°40′N, 63°00′W), tidal salt marshes; Wallace Bay National Wildlife Area, NS (45°49′N, 63°31′W), fresh water marshes; and Fullerton's Marsh, PEI (46°14′N, 63°03′W), a fresh water wetland.

During the summer of 1988, 14 American black ducks, young of the year incapable of flight, were caught on control marshes and 33 were caught on experimental marshes, using retrieving dogs, night-lighting, or funnel traps baited with corn. Blood samples were collected by jugular venipuncture, ducklings were immediately euthanized by cervical dislocation, and gizzards collected to determine whether they contained ingested lead shot.

In addition to the three experimental (hunted) marshes, blood samples to determine prewinter proportions of American black ducks and ring-necked ducks with elevated blood lead levels were taken from three additional hunted marshes: East Amherst Marsh, NS (45°50′N, 64°10′W); Johnston's River, PEI (46°16′N, 63°01′W); and DeRoche Point Pond, PEI (46°25′N, 62°56′W). All additional hunted marshes were fresh water wetlands.

From 11 July to 22 August 1988, 46 American black ducks from NS hunted wetlands and 17 from PEI hunted marshes were sampled by brachial venipuncture, and released. From 11 August to 10 September 1989, we similarly acquired blood samples from 93 American black ducks and 69 ring-necked ducks in NS and from 33 American black ducks and 12 ring-necked ducks from hunted marshes in PEI. All prewinter blood samples were collected before the opening of waterfowl hunting seasons. Any ingested lead shot present would have been caused by shot deposited the previous autumn or before.

From 10 to 25 January 1989, blood samples were collected from wintering American black ducks at two locations in each province: Shubenacadie Wildlife Park (45°05′N, 63°23′W) and Sullivans Pond (44°40′N, 63°34′W) in NS; and North River (46°15′N, 63°11′W) and Vernon River (46°10′N, 62°53′W) in PEI. Both NS marshes were fresh water and both PEI wetlands were tidal salt marshes. Twenty-two blood samples were collected at Shubenacadie Wildlife Park, 25 at Sullivans Pond, 30 at North River, and 17 at Vernon River.

Blood samples were placed in heparinized vacutainers for trace element studies (Becton Dickinson Vacutainer Systems, Rutherford, New Jersey, USA) and mixed thoroughly. Samples were chilled 6 to 10 hr until frozen. Blood samples were analyzed for absolute amounts of lead using a Perkin Elmer Zeeman 5100 atomic absorption spectrophotometer equipped with a HGA-600 graphite furnace and an AS-60 autosampler (Perkin Elmer Canada Ltd., Analytical Instrument Division, Montreal, Quebec, Canada). Lead levels could not be reliably detected when concentrations were <30 ppb; residues were reported on a wet weight basis. Control samples from the National Wildlife Research Centre, Ottawa, Canada, were reliably analyzed prior to the analysis of wild duck samples.

Gizzard contents of juvenile ducks were analyzed using the methods Schwab and Daury (1989) described for gizzards from hunter-harvested waterfowl. A gentle flow of water allowed most of the vegetation in the lumen to be decanted. Contents remaining in the pan were examined under bright light to detect fragments of shot.

Statistical analyses involved tests between two proportions (Daniel, 1977).

RESULTS

None of the 14 flightless young of the year American black ducks collected from

Amherst Point MBS and Black Pond MBS contained ingested lead shot. Thirteen of these birds had blood lead concentrations <30 ppb ($\bar{x}$ = 10.2, SD = 6.7). The blood lead concentration from the remaining sample, collected from Amherst Point MBS, was 138 ppb; that duck may have ingested lead in the immediately adjacent hunted wetland, John Lusby Marsh (45°40′N, 64°10′W).

Six of nine local American black ducks collected from Fullerton's Marsh, PEI, contained ingested lead shot: five contained one pellet and the other two pellets. Three of the flightless young of the year birds containing ingested shot had blood lead concentrations >200 ppb; the other three ducks had blood lead concentrations >100 ppb, but <200 ppb. Two of 24 local American black ducks collected from NS marshes each contained one ingested lead shot. The blood lead concentration of one of these birds was 1,124 ppb, but the blood lead concentration of the other bird ingesting shot was 48 ppb and the shot was worn thin. The blood lead concentration of all flightless young of the year birds from hunted marshes that did not contain ingested shot was <43 ppb ($\bar{x}$ = 16.6, SD = 8.8).

Since the background blood lead concentration appeared to be <30 ppb, we used 100 ppb as a conservative threshhold level indicating exposure to non-background lead in waterfowl of NS and PEI. Since there were no data available on background blood lead levels of ring-necked ducks, >100 ppb was used as the threshhold value for them as well.

Overall, 31 (16%) of 189 pre-winter American black ducks from hunted areas contained blood lead concentrations >100 ppb (Table 1). This proportion was greater ($Z = 2.62$, $P < 0.01$) than 10%, twice the percentage at which CWS considers action necessary. In NS, ten (7%) of 139 American black ducks contained blood lead concentrations >100 ppb. In PEI, 21 (42%) of 50 American black ducks contained blood lead levels >100 ppb, a proportion greater ($Z = 7.07$, $P < 0.01$) than 10%. Overall, 21 (11%) of 189 American black ducks from hunted areas contained blood lead concentrations >200 ppb. This proportion also was greater ($Z = 3.80$, $P < 0.01$) than 5%. In NS, seven (5%) of 139 American black ducks contained blood lead concentrations >200 ppb. In PEI, 14 (28%) of 50 American black ducks contained blood lead levels >200 ppb, a proportion greater ($Z = 4.24$, $P < 0.01$) than 10%.

TABLE 1. The proportion of American black ducks and ring-necked ducks with elevated (>100 ppb) and deleterious (>200 ppb) blood lead concentrations collected from hunted marshes prior to the hunting season (July to September) in Nova Scotia (NS) and Prince Edward Island (PEI), during 1988 and 1989.

Location	Species	Number sampled	Percent elevated (>100 ppb[a])	Percent elevated (>200 ppb[b])
NS	Black duck	139	7.2	5.0
	Ring-necked duck	69	11.6[c]	5.8
PEI	Black duck	50	42.0[d]	28.0[d]
	Ring-necked duck	12	41.7[d]	25.0[c]
Total	Black duck	189	16.4[d]	11.0[c]
	Ring-necked duck	81	16.0[d]	8.6

[a] 100 ppb of lead in blood was determined to be a threshold level indicating exposure of American black ducks to non-background lead and may not be applicable to ring-necked ducks.

[b] 200 ppb of lead in blood determined to be elevated by U.S. Fish and Wildlife Service.

[c] 95% confident that the proportion is greater than 5%.

[d] 95% confident that the proportion is greater than 10%.

Thirteen (16%) of 81 ring-necked ducks had >100 ppb blood lead concentrations, a proportion greater ($Z = 1.80$, $P = 0.04$) than 10%. Eight (11%) of 69 ring-necked ducks in NS contained blood lead levels >100 ppb, a proportion greater ($Z = 2.52$, $P < 0.01$) than 5%. In PEI, only 12 ring-necked ducks were sampled but five (41%) contained lead >100 ppb. In 7 (8%) of 81 ring-necked ducks, blood lead concentrations were >200 ppb. Four (5%) ring-necked ducks in NS and three (25%) in PEI contained blood lead levels that were >200 ppb.

Four (18%) of 22 wintering American black ducks from rural NS and 7 (14%) of

47 from two rivers outside Charlottetown, PEI, contained blood lead concentrations >100 ppb. However, 24 (96%) of 25 wintering American black ducks from Sullivans Pond, in downtown Dartmouth, NS, had blood lead concentrations >100 ppb. Nineteen (76%) of 25 contained blood lead concentrations >200 ppb. Three American black ducks contained blood lead concentrations >500 ppb.

DISCUSSION

Based on blood samples collected before the hunting season, a large percentage of American black ducks contained elevated (>100 ppb) blood lead amounts at some sites, especially on PEI. Ring-necked ducks in hunted areas of both provinces combined contained elevated blood lead concentrations in proportions comparable to those we observed in American black ducks (16%). Since moderate densities of spent lead shot occur in the sediments of hunted marshes (Daury et al., 1992), and waterfowl from these marshes sometimes contain ingested lead shot (Schwab and Daury, 1989; R. W. Daury, unpubl.), we believe the source of lead contamination probably was ingested lead shot.

In NS, the proportion of ring-necked ducks containing elevated blood lead levels (11%) was approximately one-and-one-half times the number of American black ducks (7%). Others also report one-and-one-half to two times the prevalence of ingested lead shot in ring-necked ducks compared with that of American black ducks (Bellrose, 1959; Sanderson and Bellrose, 1986). In PEI, approximately 40% of each species had elevated blood lead concentrations. The differences in proportions of waterfowl with elevated blood lead concentrations between provinces and species may have resulted from the number of samples analyzed, different intensities of hunting activity on sampled marshes, and species specific feeding behaviour.

Most (76%) of the wintering American black ducks from Sullivans Pond, Dartmouth, NS, had deleterious blood lead concentrations (>200 ppb). The highest percentage of waterfowl with >200 ppb blood lead, outside of urban areas, was the 27% found in the pre-winter sample from heavily hunted marshes of PEI. We cannot positively identify the source of lead contamination because gizzard contents were not examined nor were waterfowl x-rayed. But lead contamination from ingesting lead fishing sinkers or spent lead shot from nearby wetlands was unlikely as there are few game fish in the ponds and gizzards from hunter harvested waterfowl in the surrounding area seldom contained ingested shot (R. W. Daury, unpubl.). Lead additives in gasoline now are illegal in Canada, but residual lead from gasoline has resulted in contamination of urban pond sediments (Shepard, 1992). American black ducks may spend a large proportion of time ingesting water, sediment and food containing lead that originated in leaded gasoline. The high proportion of American black ducks with deleterious blood lead concentrations has prompted further investigation of lead poisoning of waterfowl at Sullivans Pond by the CWS and NS Department of Natural Resources.

Pre-hunting season blood samples from waterfowl utilizing heavily hunted marshes indicate that 16% of both American black ducks and ring-necked ducks in NS and PEI have been exposed to non-background lead. Further, 11% of American black ducks and 9% of ring-necked ducks ingested sufficient lead to produce deleterious effects. The source of ingested non-background lead probably was hunters' spent lead shot. Using similar data the U.S. Fish and Wildlife Service (1986) has banned the use of lead shot for waterfowl hunting in the United States. Based on our data, we believe that waterfowl survival would be improved if non-toxic shot zones were established, at least on heavily hunted marshes of NS and PEI.

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