Blood Lead Concentrations and Ingested Shot in Ring-necked Ducks at Catahoula Lake, Louisiana

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Abstract: We analyzed blood lead concentrations and prevalences of ingested lead and steel shot in 93 ring-necked ducks (*Aythya collaris*) at Catahoula Lake, Louisiana. Blood lead concentrations were higher for immatures than for adults, but did not differ between sexes or between randomly collected and hunter-shot birds. Blood lead concentrations were elevated (≥ 0.20 ppm) in 18 of 31 immatures (58%) and 13 of 61 adults (21%), and were toxic (≥ 0.50 ppm) in 11 immatures (35%) and 5 adults (8%). Prevalences of ingested lead shot were higher for immatures (7 of 32 birds, 22%) than for adults (3 of 61 birds, 5%), but did not differ between sexes or collection methods. Prevalences of ingested steel shot did not differ between sexes, but were higher for hunter shot (10 of 39 birds, 26%) than for randomly collected birds (2 of 54 birds, 4%), and tended to be higher for immatures (8 of 32 birds, 25%) than for adults (4 of 61 birds, 7%). We recommend continued monitoring of lead exposure in ring-necked ducks at Catahoula Lake to evaluate management techniques used there to reduce lead poisoning.

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Waterfowl mortality associated with ingestion of lead shot has been documented throughout the United States and in several other countries (Sanderson and Bellrose 1986, Pain 1992). Sublethal physiological effects of lead poisoning in waterfowl also have been described (e.g., Mautino and Bell 1986, Hohman et al. 1990*a*, Havera et al. 1992, Samuel et al. 1992). Although lead shot currently is prohibited for waterfowl hunting in the United States, shot deposited in prior seasons can remain available to foraging birds for many years in some habitats (Mudge 1984, Anderson 1986, Pain 1991). Monitoring of lead exposure is necessary to determine the effectiveness of nontoxic shot regulations or other management techniques used to reduce lead poisoning of waterfowl (Havera et al. 1992).

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Most investigators have relied on prevalences of ingested lead shot in gizzards of hunter-shot birds to assess lead exposure in waterfowl (Anderson and Havera 1985). However, this technique has been questioned because birds with ingested lead shot may be more vulnerable to hunting and thus may be more likely to be included in gizzard surveys than are birds without ingested shot (Samuel et al. 1992). Moreover, prevalence of ingested lead shot in gizzards is less sensitive for detecting lead exposure than are blood analysis techniques (Anderson and Havera 1985).

Catahoula Lake has been a popular waterfowl hunting area since at least the turn of the century and is one of the most intensively hunted areas in Louisiana (Wills 1965). The density of lead shot in sediments of Catahoula Lake is extremely high, exceeding most other major waterfowl staging areas in the United States (Hohman et al. 1990*a*). Consequently, lead poisoning of waterfowl has been a recurring problem at Catahoula Lake (Yancey 1953, Wills and Glasgow 1964, Smith 1981, Zwank et al. 1985, Hohman et al. 1990*a*). Use of lead shot was prohibited on 90% of the lake in fall 1987 and on the entire lake in fall 1988. Despite conversion to nontoxic shot, an estimated 10,000 ducks died of lead poisoning at Catahoula Lake during fall and winter 1989–90 (R. Helm, pers. commun.). A recent experiment indicated that deep tillage is a viable management option for reducing availability of lead shot to foraging waterfowl on the lake (Peters and Afton 1993*b*).

Our objectives were to: (1) estimate lead exposure of ring-necked ducks at Catahoula Lake following conversion to nontoxic shot but before deep-tillage treatments; (2) compare blood lead concentration and prevalence of ingested shot in the same sample of birds; and (3) investigate the effects of sex, age, and collection method (random vs. hunter shot) on lead exposure estimates.

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Methods

We collected ring-necked ducks at Catahoula Lake, a 12,000-ha wetland basin located in the Mississippi River floodplain of central Louisiana (31°30'N, 92°08'W).

The area has been described in detail by Wills (1965), Woolington and Emfinger (1989), and Hohman et al. (1990*a*). We collected 54 ring-necked ducks by shooting (with steel shot) from a boat at night with the aid of lights (hereafter random sample) from 31 November to 9 December 1990 (20 adult males, 17 adult females, 9 immature males, 8 immature females). We shot 30 ring-necked ducks over decoys, and obtained 9 from hunters (hereafter hunter-shot sample) from 1 January to 10 January 1991 (20 adult males, 4 adult females, 9 immature males, 5 immature females). During our study, the hunting season at Catahoula Lake opened on 17 November 1990 and closed 6 January 1991. For the random sample, only birds in flocks of ≥3 were collected to reduce the chance of inadvertently selecting lead-poisoned birds. Age (immature = <1 year; adult = ≥1 year) of birds was determined by plumage and cloacal characteristics (Hochbaum 1942, Carney 1964, Hohman and Cypher 1986).

Within 15 minutes of collection, blood was removed from the heart with a 3-ml syringe equipped with a heparinized, 20-gauge needle. Blood samples were transferred immediately to a vial (3-ml vacutainer) containing EDTA anticoagulant. The amount of time between death and blood extraction for the donated, hunter-shot birds could not be determined, but probably was <4 hours. Blood was not obtained from 1 donated bird (immature male). Blood lead concentrations decline after death (Havera et al. 1989); thus, lead concentrations from donated birds were conservative. Blood was analyzed for lead concentration following procedures outlined in Joselow and Bogden (1972) and Anderson and Havera (1985). Blood lead concentrations ≥ 0.20 ppm were considered elevated (Friend 1985) and those ≥0.50 ppm were considered toxic (Sanderson and Bellrose 1986).

Gizzards were removed from fresh carcasses and inspected for shot entry and exit wounds as described by Anderson and Havera (1985). Contents of gizzards with shot wounds were searched for shot-in pellets. (Steel shot without erosion or with attached feathers were identified as shot-in pellets). All shot-in pellets were excluded from analyses. Gizzard contents were examined radiologically; those testing positive for metal particles were placed in a white pan, and water was used to flush vegetation and other organic material from the heavier particles, thus aiding in the detection of shot (Montalbano and Hines 1978).

We used 3-way ANOVA to investigate the effects of sex, age, and collection method (random or hunter shot) on blood lead concentrations (PROC GLM, SAS Inst. 1987). Blood lead concentrations (ppm) were ranked prior to analysis. We examined the effects of these same factors on ingested lead and steel shot (presence or absence) separately using the linear model (PROC CATMOD, SAS Inst. 1987) approach of Grizzle et al. (1969).

Results

Blood Lead Concentration

Blood lead concentrations did not differ between sexes or collection methods; however, immatures had higher concentrations than did adults (Table 1). None of

Table 1. General linear models investigating the effects of sex, age, and collection method (random or hunter-shot) on blood lead concentrations and ingested lead and steel shot (presence or absence) in ring-necked ducks at Catahoula Lake, Louisiana, 1990–91.

	Blood lead				Lead shot			Steel shot		
Source	df	MS	*F*	*P*	df	X^2	*P*	df	X^2	*P*
Sex (S)	1	213.79	0.37	0.55	1	1.03	0.31	1	0.09	0.76
Age (A)	1	6952.49	12.00	0.0008	1	3.86	0.0494	1	2.90	0.0883
Method (M)	1	1067.60	1.84	0.18	1	0.02	0.88	1	6.17	0.0130
S × A	1	419.35	0.72	0.40	1	0.10	0.76	1	0.05	0.83
S × M	1	754.26	1.30	0.26	1	0.63	0.43	1	0.01	0.91
A × M	1	1968.21	3.40	0.0688	1	0.10	0.75	1	0.15	0.70
S × A × M	1	8.36	0.01	0.90	1	0.10	0.75	1	0.04	0.84
Residual	84	579.27								

the interaction terms were significant. Mean blood lead concentrations (ppm) for immatures (N = 31) and adults (N = 61) were 0.77 (SE = 0.21, Median = 0.25, Range = 0.01–4.12) and 0.21 (SE = 0.07, Median = 0.05, Range = 0.01–3.64), respectively. Blood lead concentrations were ≥0.20 ppm in 18 of 31 immatures (58%) and 13 of 61 adults (21%), and were ≥0.50 ppm in 11 immatures (35%) and 5 adults (8%).

Ingested Shot

Prevalences of ingested lead shot were higher for immatures (7 of 32 birds, 22%) than for adults (3 of 61 birds, 5%), but did not differ between sexes or collection methods (Table 1). Prevalences of ingested steel shot did not differ between sexes, but were higher for hunter shot (10 of 39 birds, 26%) than for randomly collected birds (2 of 54 birds, 4%), and tended to be higher for immatures (8 of 32 birds, 25%) than for adults (4 of 61 birds, 7%) (Table 1). The interaction terms were not significant in either analysis.

Gizzards with ingested lead shot had a mean of 1.40 (SE = 0.16, N = 10, Range = 1 to 2) lead pellets, whereas those with ingested steel shot had a mean of 1.25 (SE = 0.18, N = 12, Range = 1 to 3) steel pellets. All of the 10 birds with ingested lead shot had elevated blood lead concentrations; however, 21 of 31 birds (68%) with elevated blood lead concentrations did not have lead shot in their gizzards. Seven of 12 birds (58%) with ingested steel shot had elevated blood lead concentrations, and 2 of them (17%) had lead shot in their gizzards.

Discussion

Catahoula Lake provides important winter and migration habitat for waterfowl in the Mississippi Flyway, with peak numbers exceeding 400,000 birds in recent years (Woolington and Emfinger 1989). In fall and early winter when water levels are low, large numbers of northern pintails (*Anas acuta*) and mallards (*A. platyrhynchos*) use the lake, and are the most common species in lead poisoning

die-offs (Yancey 1953, Wills and Glasgow 1964, Zwank et al. 1985). Recent mid-winter waterfowl inventories have recorded 26% of the continental canvasback (*Aythya valisineria*) population at Catahoula Lake, with a peak estimate of 78,000 in January 1988 (Wookington and Emfinger 1989). Numbers of ring-necked ducks on Catahoula Lake and the adjacent Catahoula NWR have averaged 34,000 in recent years (Peters and Afton 1993*a*). Because of their diets and foraging behavior, canvasbacks and ring-necked ducks are prone to ingest shot (Sanderson and Bellrose 1986; Hohman et al. 1990*a, b*; Havera et al. 1992; Peters and Afton 1993*a*; this study). Dabbling ducks disperse from the lake when water rises after closure of the hunting season; however, diving ducks remain to forage and may ingest shot throughout winter.

Our analysis of collection method is confounded with slight differences (e.g., 3 weeks) in dates of collection. Blood lead concentration and prevalence of ingested lead shot did not differ between collection methods, but the prevalence of ingested steel shot was higher in the hunter-shot sample. The higher ingestion of steel shot by hunter-shot ducks may have resulted from an increase in the availability of steel shot near the end of the hunting season. Pellet density of steel shot was much lower than that of lead shot in sediments of Catahoula Lake; core samples (6.7-cm diameter, $N = 720$) collected in October of 1989 and 1990 revealed 24 lead pellets and 0 steel pellets in the top 10 cm of sediments (Peters 1992, unpubl. data). Although ring-necked ducks consumed primarily subterranean tubers (70% dry mass of diet, Peters and Afton 1993*a*), the high prevalence of ingested steel shot suggests that ring-necked ducks foraged primarily near the soil surface and ingested recently deposited shot (Roscoe et al. 1989).

Despite conversion to nontoxic shot, our results indicate that ring-necked ducks are still exposed to lead on Catahoula Lake. Blood lead concentrations were elevated in 58% of immature and 21% of adult birds. Our analysis of ingested lead shot also indicated age differences in lead exposure, but estimated percentages of exposed birds were lower than those determined from blood analysis. Elevated blood lead concentrations decrease to background levels in ring-necked ducks within 4 to 7 weeks after shot ingestion (Mautino and Bell 1986). If ring-necked ducks remain on Catahoula Lake for longer than 7 weeks, the probability of their ingesting shot should be higher than our percentages indicate; therefore, our estimates of lead exposure are likely conservative.

The age differences in lead exposure that we observed may have resulted from (1) differential sensitivity to lead intoxication or (2) differences in foraging rates. Lead has less effect on young birds up to about 7 months of age than on older birds (Sanderson and Bellrose 1986). If survival of adults was lower than for immatures after lead ingestion, the probability of sampling a lead exposed adult also would be lower. Hohman et al. (1990*a*) suggested that a higher prevalence of ingested lead shot by immature canvasbacks, as compared with adults, may have resulted from greater time spent feeding by immatures. Immature ring-necked ducks gain mass at a higher rate than adults throughout winter (Hohman et al. 1988); a higher rate of mass gain probably is facilitated by increased foraging time.

Species differences in diet and foraging behavior prevent sound inferences concerning species variation in lead exposure at Catahoula Lake. Thus, it is necessary to monitor species commonly found on the lake for trends in lead exposure. Prevalence of ingested shot is useful for comparisons among years and with different study areas; however, prevalence of ingested shot is less sensitive in detecting lead exposure than are blood analysis techniques (Anderson and Havera 1985, this study). Anderson and Havera's (1985) conclusion regarding sensitivity of various techniques was based on comparisons of different samples of birds from the same areas. Our comparison of techniques in the same sample of birds confirms their conclusion. Finally, we recommend continued monitoring of lead exposure in ring-necked ducks at Catahoula Lake to evaluate management techniques used there to reduced lead poisoning.

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