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LEAD POISONING IN CANADA GEESE ON PLUM ISLAND, MASSACHUSETTS

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ABSTRACT: During December 1983 and early January 1984, about 200 Canada geese (*Branta canadensis*) died of lead poisoning at Parker River National Wildlife Refuge on Plum Island, Massachusetts. In an effort to determine the source of lead, 100 bottom samples were taken from a refuge impoundment where much of the mortality/morbidity occurred. An average of 157,150 pellets/ha was found with a range of 64,582 to 322,910 pellets/ha. Water levels in this impoundment were low when Canada geese arrived, making shot more readily available to the geese and contributing to the outbreak. To minimize the risk of Canada geese being exposed to lead shot poisoning at this location in the future, we recommend several corrective manipulations of habitat.

Key words: Lead poisoning, Canada geese, *Branta canadensis*, lead shot deposition.

INTRODUCTION

A variety of waterfowl species migrate through the Plum Island area including the Parker River National Wildlife Refuge (NWR) near Newburyport in northeastern Massachusetts. Although as many as 10% of the waterfowl shot at Parker River were reported to have ingested lead shot (White and Stendell, 1977), mortality from lead poisoning has not been documented at the refuge. Waterfowl mortality occurred in 1981 at the Merrimac River north of Plum Island and in 1972 at the Parker River NWR. These were attributed to starvation and dinoflagellate (paralytic shellfish) poisoning, respectively. This report describes the loss of about 200 Canada geese (*Branta canadensis*) to lead poisoning during the winter of 1983–1984 at Parker River NWR and subsequent shot deposition studies conducted at that refuge.

STUDY AREA AND HISTORY

Parker River NWR (1,800 ha) occupies the southern two-thirds of Plum Island and is characterized by ocean beach, sand dunes, tidal marsh, and three man-made freshwater pools (105 ha). The topography varies from a barrier beach-dune complex to kettle-hole depressions that support upland environments. The barrier beach-dune complex (330 ha) protects the 1,200 ha of salt marsh and mud flats on the refuge.

The refuge is a valuable resting and feeding area for American black ducks (*Anas rubripes*), green-winged teal (*A. carolinensis*), and Canada geese. Peak usage in 1982 included 5,000 green-winged teal in October plus 8,000 black ducks and 2,400 Canada geese in December. Waterfowl counts for the 1983–1984 season were not available, but are probably similar to the preceding year. Canada geese feed mainly on salt meadow grass (*Spartina* sp.) in the salt marsh and on vetch (*Vicia* sp.) in upland fields, and roost primarily in the Stage Island Pool (Fig. 1).

Stage Island Pool, a 40 ha impoundment, is one of three that was constructed from a pocket of salt marsh in the late 1950's when an earthen dike was built across the main channel to contain the marsh. Since its purchase in 1942, Stage Island Pool has been closed to hunting, but adjacent to the pool is Sandy Point State Reservation (administered by the State of Massachusetts) that traditionally has been

open for hunting. Because of the excellent waterfowl hunting, a firing line along the refuge boundary of Stage Island Pool has existed since the installation of the impoundment.

In an effort to encourage emergent vegetation, an experimental water management plan for Stage Island Pool was undertaken in 1983. The pool was drawn down in stages from March through late June. Precipitation, the only source of fresh water for the impoundment, averages 106 cm per year. Precipitation from July through September 1983 was below normal, creating drought-like conditions in the impoundment. When migrating Canada geese arrived in late September, the pool had standing water only in old creek channels. During October and early November, occasional rain moistened and softened the soil. By late November, heavy rains filled the pool to near normal levels, approximately 25 to 30 cm.

Refuge personnel observed sick Canada geese on the impoundment in early December. A search of the area revealed 22 sick or dead geese. During the following 6 wk, 194 sick and dead geese were found. Geese too weak to fly were captured and euthanized. Sixty-one Canada geese, one snow goose (*Chen caerulescens*), one mallard (*Anas platyrhynchos*), and one black duck were necropsied and gizzards examined visually for lead and steel shot.

MATERIALS AND METHODS

Following necropsy, tissues for microscopic examination were fixed in 10% formalin and stained with both hematoxylin-eosin and Ziehl-Neelsen acid-fast stains. Livers (kidney from the one snow goose) were analyzed for lead on a Perkin-Elmer Model 2380 atomic absorption spectrophotometer (Perkin-Elmer Analytical Instruments, Norwalk, Connecticut 06856, USA) as described by Locke et al. (1982). Lead concentrations are expressed in ppm, wet weight, unless otherwise noted. Liver lead concentrations greater than 6 ppm were used as indicative of lead toxicity when accompanied by pathology.

We sampled sediment from Stage Island Pool and examined it for lead shot using methods similar to those of Longcore et al. (1982). Four sampling points were selected at regularly spaced intervals on the refuge adjacent to the part of the state hunting area that receives the heaviest shooting (Fig. 1). Sediment samples (n = 100) were collected at 10 m intervals along each parallel transect that runs perpendicular to the hunting area. An iron framed box 30 × 30 × 10 cm deep with two sliding bottom doors was forced into the substrate to collect sediments. When the top of the box was level with the substrate, sharpened steel plates were slid or hammered into place to close the bottom of the box. The sample was then lifted, the sediments pushed out on a plywood board and placed in a plastic bag. In addition, six sediment samples were taken to determine distribution of shot within the sediment. Four samples at depths of 2.5, 5.0, 7.5, and 10.0 cm were taken at each of these six sites.

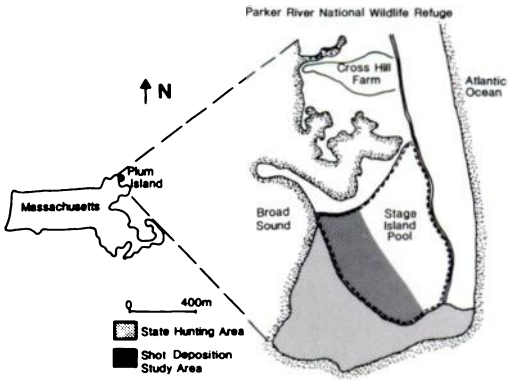

FIGURE 1. Canada goose mortality area (Stage Island Pool) and shot deposition study area to determine incidence of shot deposition at Parker River National Wildlife Refuge, Massachusetts, 1983–1984.

Lead pellets were found by washing sediment samples in boxes (61 × 61 × 122 cm) that were divided into levels of progressively smaller hardware cloth; 1.5 cm, 0.7 cm, and window screen, respectively. The remaining debris was then placed in a plastic container which was filled with water, allowing any lead or steel shot to fall to the bottom. This sediment was rewashed through the window screen and any shot in the sample was removed, placed in a plastic bag, and kept with the original sediment sample tag.

RESULTS

By early January 1984, 194 Canada geese, one snow goose, one mallard, and

TABLE 1. Ingested lead shot and liver lead concentrations (wet weight) of 57 Canada geese dying of lead poisoning at Parker River NWR from December 1983 to January 1984.

Number of ingested lead shot	Number of geese (%)	Mean liver lead concentrations (ppm)	Range (ppm)
0	11 (19)	16.1 ± 6.0	8.3–29.0
1	6 (10)	16.1 ± 4.4	9.0–20.0
2	5 (9)	22.9 ± 12.2	12.4–42.0
3	5 (9)	20.8 ± 4.3	16.2–26.5
4	8 (14)	16.6 ± 8.8	8.0–33.4
5	6 (10)	22.2 ± 9.2	7.5–32.9
6	4 (7)	19.8 ± 4.4	16.0–26.2
7	1 (2)	15.3	—
8	2 (4)	22.7 ± 2.1	21.2–24.2
>8	9 (16)	24.1 ± 13.7	16.0–44.4

one black duck (the latter two were gunshot victims) were recovered. Of the 61 Canada geese examined at the National Wildlife Health Center (Madison, Wisconsin 53711, USA) 57 cases (93%) of lead poisoning were diagnosed. Another Canada goose died of suspected lead poisoning, two were gunshot victims, and one died of undetermined causes. The only snow goose recovered also died of lead poisoning.

Lesions observed in the 57 lead poisoned Canada geese included breast muscle atrophy and reduction of subcutaneous, mesenteric, and coronary fat (75% of birds examined), bile staining of gizzard lining (93%), gizzard hyperkeratosis (72%), distended gallbladder (88%), and cephalic edema (12%). Esophageal and/or proventricular food impaction, with almost exclusively *Spartina* sp., was noted in 41 (72%) of the geese. Six geese suffered from acute lead poisoning with moderate to good deposits of fat and little or no atrophy of the pectoral muscles. Four of these had myocardial infarcts (Karstad, 1971). All six had well-worn short (3 to 42) in their gizzards and had liver lead concentrations well above toxic levels (range = 15.3 to 30.4 ppm).

Ingested lead shot was found in gizzards of 46 (81%) of the Canada geese. Nineteen (41%) of the gizzards with lead shot contained steel shot also. A total of 301 lead pellets, all moderately to well-worn, and 28 steel pellets were recovered.

The average lead concentration in livers of poisoned geese was 20.0 ± 8.3 ppm with a range of 7.5 to 44.4 ppm (Table 1). The average dry weight concentration was 78.9 ± 32.5 ppm with a range of 31.8 to 198 ppm. One Canada goose suspected to have died of lead poisoning had a liver lead concentration of 15.5 ppm which is well within the toxic range, but lesions typical of lead poisoning were absent and the gizzard did not contain lead shot.

Among birds not diagnosed as lead poisoned, a Canada goose that drowned following a gunshot injury had a liver lead concentration of 0.78 ppm. The second goose killed by gunshot had a liver lead concentration of 1.5 ppm, and the goose that died of undetermined causes had 2.5 ppm lead in its liver. The liver of the snow goose was missing and apparently was eaten by a scavenger, but the lead concentration of 25.5 ppm in its kidney supports the necropsy findings of lead toxicity.

Most of the dead and sick birds (80%) were associated with the Stage Island Pool, although Canada geese moved from that area into the salt marsh and to nearby upland grass fields of Cross Farm Hill (Fig. 1) or adjacent salt marsh grass.

The 100 sediment samples taken in Stage Island Pool contained 146 lead shot and 11 steel shot; an average lead shot density of 1.46 pellets/30.5 cm^2 or 157,150 pellets/ha (range = 64,582 to 322,910 pellets/ha). Subsampling showed 18 of 19 (95%) lead shot and 2 of 2 (100%) of the steel shot was in the upper 5 cm of the sediment.

DISCUSSION

Cook and Trainer (1966) found that Canada geese died in 39 to 72 days when force-fed 10 or fewer number 4 lead pel-

lets. Birds fed 25 or more pellets died within 10 days of acute lead poisoning and exhibited few or none of the external signs of lead poisoning.

Lead-poisoned geese on Plum Island probably ingested shot from early October to late November. This period coincides with the arrival of migrant Canada geese (late September to early October) as well as with periods of low water at Stage Island Pool. The decline in mortality would likewise correlate to reduced ingestion of shot during a period corresponding to increasing water depth at Stage Island Pool. This indicated that the lead probably was ingested at Stage Island Pool. Additional support for on site ingestion came from the relationship between the ratio of lead to steel shot found in gizzards of sick and dead geese (91.5% lead) with shot found in Stage Island Pool sediment (92.9% lead).

Longcore et al. (1982) reported that the lead shot density of 99,932 shot/ha at Merrymeeting Bay was relatively high compared to the results of other studies. The shot density at the Stage Island Pool study area was almost twice that reported by Longcore et al. (1982). The greatest density of lead shot deposition found by Bellrose (1959) was 291,672 shot/ha at Lake Puckaway, Wisconsin.

MANAGEMENT IMPLICATIONS

We conclude that the lead poisoning of Canada geese on Plum Island was a consequence of the high density of lead shot in sediments in Stage Island Pool. The sequence of events leading to the outbreak began with drought conditions which forestalled the refilling of the pool with fresh water. The availability of food (seed and plant growth from the emergent vegetation) then attracted geese into the area of high lead shot densities in sediments, and the October–November rains softened the soil so that the geese could probe into soils and ingest the lead shot. Because it is important that Parker River NWR be able to manage this impoundment for waterfowl production and for wintering habitat, it is not appropriate to continue water management practices of the past.

One possible corrective technique to reduce future mortalities is to turn over the substrate in Stage Island Pool, thus burying the lead shot deposited prior to the conversion to steel shot. This action involves a three-phase approach, including vegetation management. First, a herbicide would be applied to the phragmites and purple loosestrife (*Lythrum salicaria*) stands in the impoundment. This is necessary because these plants thrive in disturbed soil, are of limited value to waterfowl, and inhibit desirable plants. The impoundment then would be plowed using a high flotation crawler or tractor pulling a disk plow burying the lead shot to a depth of 30 to 40 cm (Fredrickson et al., 1977). Finally, planting of fast growing, moist-soil plants in the impoundment could produce food and compete with phragmites and purple loosestrife for open space. Because this area falls within a recently established steel shot zone, active hunter education and aggressive law enforcement should minimize future lead shot deposition in this impoundment. This will allow refuge managers the flexibility of changing water management practices as needed.

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LETTER TO THE EDITOR . . .

Goussia-Like Coccidium in Crocodiles

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In their article in the Journal of Wildlife Diseases on a *Goussia*-like coccidium in crocodiles, Gardiner et al. (1986) made the statement, "this preliminary report establishes the fact that *Goussia*-like organisms can be found in non-picine definitive hosts." It does not. They have apparently missed *Goussia flaviviridis* (Setna and Bana, 1935) Levine, 1983 (a synonym is *Eimeria flaviviridis* Setna and Bana, 1935) in the gall bladder of *Hemidactylus flaviviridis*; *Goussia hyalina* (Léger, 1898) Levine, 1983 originally described as *Coccidium hyalina* (Léger, 1898) and *Eimeria hyalina* (Léger, 1898) Reichenow, 1921 from the Malpighian tubules of an unidentified aquatic beetle; and *Goussia lacazei* (Labbé, 1895) Levine, 1983 previously described as *Bananella lacazei* (Labbé, 1895), *Coccidium schneideri* Schaudinn and Siedlecki, 1897 and *Eimeria lacazei* (Labbé, 1896) Moroff, 1908 in the chilopods *Lithobius forficatus* and *L. martini*. In addition, they have failed also to mention the following species of "*Eimeria*" which may eventually turn out to be the same species as they saw: *Eimeria crocodyli* Lainson, 1968 in *Crocodylus acutus*; *E. kermorganti* (Simond, 1901) Braun, 1908 (a synonym is *Coccidium kermorganti* Simond, 1901) from the spleen of *Gavialis gangeticus*; and *E. pintoi* Carini, 1932 in *Caiman* sp.

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