*Journal of Zoo and Wildlife Medicine* 25(3): 438–445, 1994


# ZINC TOXICOSIS IN DIVING DUCKS

**Jacqueline M. Zdziarski, D.V.M., Mark Mattix, D.V.M., R. Mitchell Bush, D.V.M., and Richard J. Montali, D.V.M.**

*Abstract:* Zinc toxicosis was diagnosed in four species of diving ducks associated with the ingestion of pennies and fence clips containing zinc. Clinical signs included weight loss, depression, anorexia, and posterior paresis. A presumptive diagnosis of zinc toxicosis was made in one Bahama pintail (*Anas bahamensis bahamensis*) and two redhead ducks (*Aythya americana*) that had ingested metal fence clips. Diagnosis was based on complete recovery of the ducks after endoscopic removal of the clips, which contained 96% zinc. Assays for zinc and other minerals were performed on four Barrow's goldeneyes (*Bucephala islandica*) that died and one American merganser (*Mergus merganser americanus*) survivor. All of the animals had ingested one or two pennies. Two of four goldeneyes, from which serum was available, had elevated zinc concentrations of 12.6 and 13.1 μg/ml (normal range, 1.84–4.65 μg/ml, $n = 8$); all four goldeneyes had liver zinc concentrations ranging from 242 to 548 μg/g (normal, 35.9 μg/g, wet weight basis, $n = 1$). The American merganser from which a penny was removed endoscopically from the gizzard had an elevated serum zinc concentration of 16.6 μg/ml. Pertinent pathologic findings in the four goldeneyes included necrotizing ventriculitis. Pennies in various stages of dissolution were present in the ventriculus. The pancreas had degenerative lesions that resulted in acinar atrophy and ductular proliferation.

*Key words:* Toxicosis, toxicity, zinc, pancreas, ducks, *Bucephala islandica.*

## INTRODUCTION

Zinc is an essential, relatively nontoxic mineral.[3,11,15] Despite that, over the past 10 yr, cases of zinc toxicity have apparently been on the increase in both animals and humans[1,4,6,7,9–11,13,14,16] primarily as a result of ingestion of pennies minted since 1983, which contain 98% zinc.[1,6] Between late 1989 and early 1990, five diving ducks from the National Zoological Park (NZP) in Washington, D.C., and three diving ducks from the Conservation and Research Center (CRC) in Front Royal, Virginia, developed zinc toxicosis associated with the ingestion of zinc-containing objects. This report describes the clinical, pathologic, and analytical findings in these ducks.

From the Departments of Animal Health (Zdziarski, Bush) and Pathology (Montali), National Zoological Park, Washington, D.C. 20008, USA; and the Walter Reed Army Institute of Research, Division of Pathology, Washington, D.C. 20307-5100, USA (Mattix). Present addresses: the Brookfield Zoo, 3300 S. Golf Road, Brookfield, Il 60513, USA (Zdziarski); and the Department of the Army, Armed Forces Institute of Pathology, Washington, D.C. 20306-6000, USA (Mattix).

## CASE REPORTS

In November 1989, four male and seven female 6-mo-old Barrow's goldeneye ducks (*Bucephala islandica*) from a private breeder arrived at the quarantine facilities at the NZP. Samples were obtained for hematologic and serum biochemical analysis and fecal parasite screening. Prophylactic deworming was accomplished with fenbendazole (Panacur, Hoechst-Roussel, Somerville, New Jersey 08876, USA) and ivermectin (Ivomec, Merck Co., Rahway, New Jersey 07065, USA) for nematodes. After a 30-day quarantine period, they were released into an outdoor wetlands exhibit consisting of six pools. Each pool was separated by fencing that enclosed a 3.6- × 3.6- × 1.2-m area.

In mid-January 1990, a female goldeneye (211095, case 1) was hospitalized for depression and weakness. The duck was lethargic and had pectoral muscle atrophy. Bilateral motor movements were diminished, and the bird was unable to stand. No physical abnormalities of the limbs were present. Radiographic examination revealed a radiodense circular object consistent with a coin in the ventriculus (Fig. 1).

Anesthesia in the duck was mask induced, followed by intubation and maintenance on halothane (Fluothane, Fort Dodge, Fort Dodge, Iowa 50501, USA). A flexible fiberoptic endoscope with biopsy forceps (Richard Wolf Medical, Vernon Hills, Illinois 60018, USA) was introduced orally and passed to the level of the ventriculus. Once the foreign body was visualized, the biopsy forceps were extended past the scope and were manipulated to grasp and retrieve a penny. The penny had a pitted copper layer and an exposed zinc layer. The duck died during the anesthetic recovery period.

Three days later, a 9-mo-old female Bahama pintail (210966, case 2) (*Anas bahamensis bahamensis*) from the CRC was presented with weakness, depression, and reluctance to walk. After the duck took a few steps, it collapsed on its sternum, flapped its wings, and paddled its feet to move forward. A band-shaped metallic foreign body in the ventriculus was identified radiographically. A metal fence clip was retrieved from the ventriculus by the endoscopic procedure previously described. Within 24 hr, the duck was alert and swimming but was slightly ataxic. The duck's condition improved rapidly without further therapy. It was returned to the CRC 7 days later with a normal gait and activity.

Case 3 was a 7-mo-old female redhead duck (211036) (*Aythya americana*) from the CRC with signs similar to cases 1 and 2. A metal fence clip was removed via endoscopy. Within 48 hr, the duck was walking and swimming normally; however, its appetite was depressed and it continued to lose weight. It was hospitalized and tube fed a ground duck pellet (Purina Avian Maintenance Diet, Purina Mills, St. Louis, Missouri 63166-6812, USA) with a protein supplement (Gevral, Lederle Laboratories, New York, New York 01965, USA) gruel for 10 days. The duck's appetite improved, and it was released to the CRC. Another redhead duck (211006, case 4), a 6-yr-old male from the CRC, also had a metal fence clip ventricular foreign body. The duck recovered uneventfully after the metal clip was endoscopically removed. No additional cases of zinc toxicity were reported from the CRC.

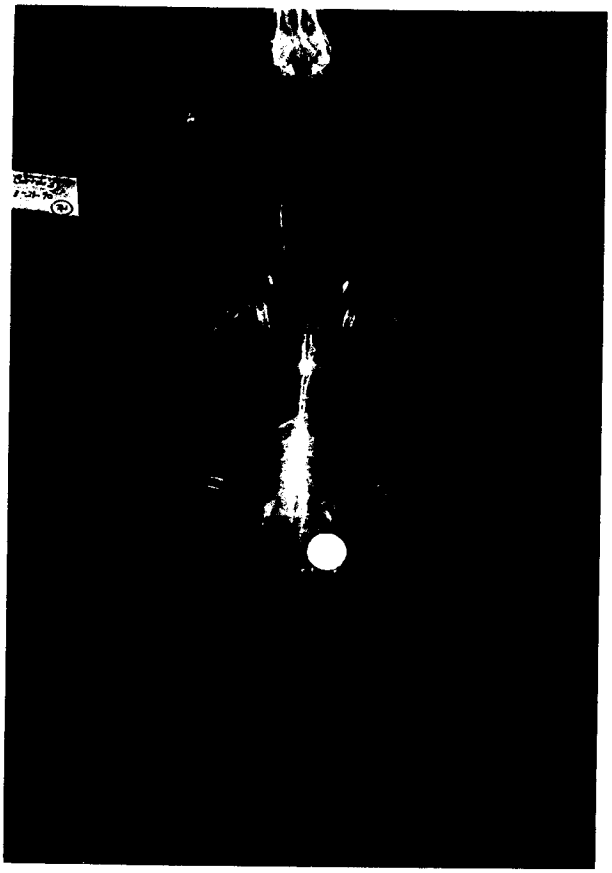

**Figure 1.** Radiograph of a female Barrow's goldeneye (case 1) with a radiodense ventricular foreign body.

In March 1990, three more ducks from the NZP were found radiographically or at necropsy to have metallic objects in their ventriculi. A depressed 3-yr-old male American merganser (*Mergus merganser americanus*) (210277, case 5) had a worn penny and a 58- × 1.5-mm metal rod. The metallic foreign bodies were removed endoscopically, and the duck recovered and was returned to its exhibit. A weak 10-mo-old male Barrow's goldeneye (211090, case 6) had two worn pennies removed endoscopically but died during recovery; another goldeneye, a 10-mo-old male (211092, case 7) was found dead with a worn penny within its ventriculus. In late May 1990, a 24-mo-old male Barrow's goldeneye (211089, case

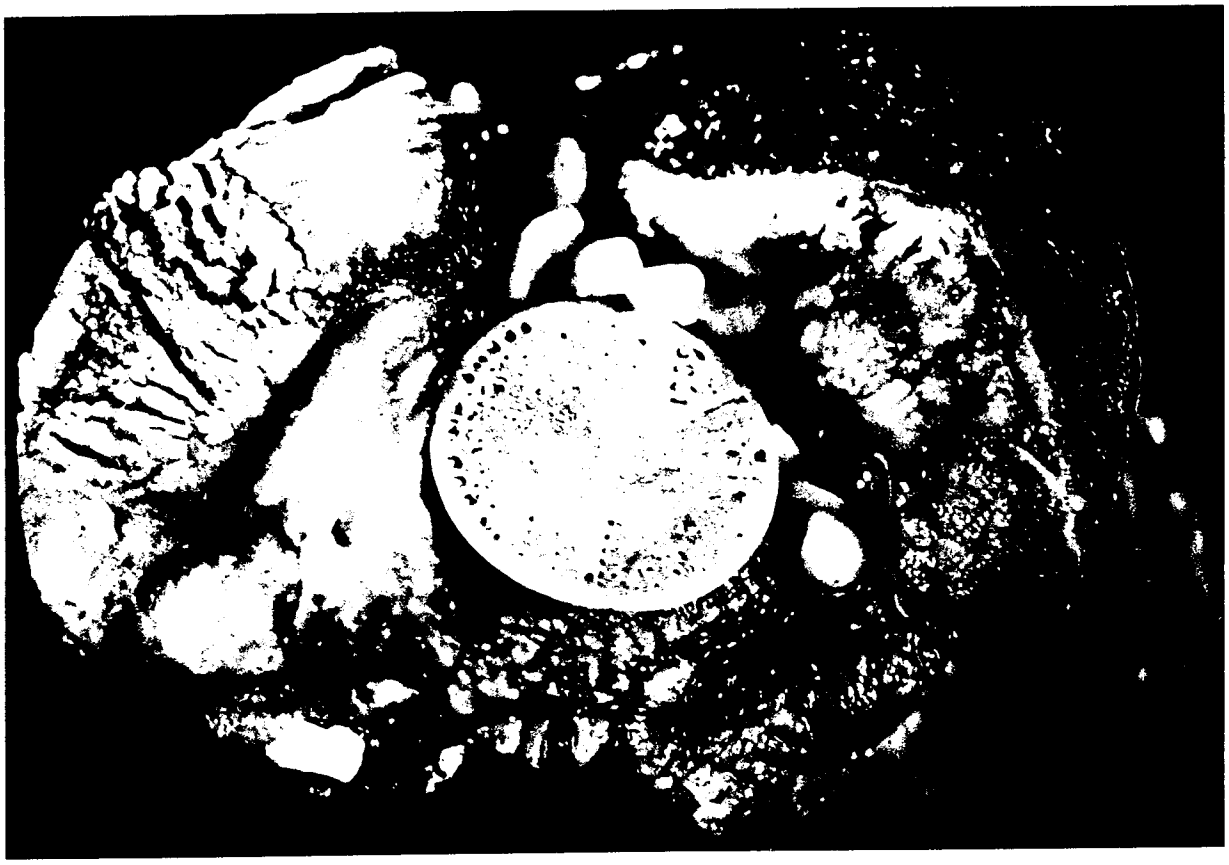

**Figure 2.** Gizzard from a Barrow's goldeneye (case 8) with zinc toxicosis containing a markedly eroded penny.

8) was found dead. A worn penny was found within its ventriculus at necropsy (Fig. 2).

Zinc toxicosis cases in two rosybill pochards (*Netta peposaca*) (208595 and 208583) from 1986 were retrieved from the NZP Department of Pathology archives and compared with the existing outbreak.

## MATERIALS AND METHODS

Antemortem blood samples were obtained from case 5 (2 days after endoscopic removal of ventricular metal) and case 6 (at time of presentation); a postmortem heart blood sample was taken from case 7 at necropsy. Plasma was submitted to the Michigan State University Animal Health Diagnostic Laboratory (AHDL) (East Lansing, Michigan 48824, USA). Inductively coupled argon plasma emission spectroscopy (ICAP)[12] was used to determine the concentrations of elements in sera, liver, and pennies removed from the ventriculus. A metal fence clip removed from case 2 was also analyzed for zinc. Additional blood samples were obtained from eight healthy goldeneyes that had no radiographic evidence of ventricular metal foreign bodies, and serum was submitted to establish normal mineral levels.

Four Barrow's goldeneyes were necropsied, and sections of frozen liver were also submitted to the AHDL for mineral analysis. Tissues were preserved in 10% buffered formalin, routinely processed, embedded in paraffin, sectioned at 5 $\mu$m, and stained with hematoxylin and eosin (H&E).

## RESULTS

### Pathologic and toxicologic findings

The four necropsied birds had a marked decrease in skeletal muscle mass and depleted subcutaneous and visceral fat depots, with up to 40% reduction in body weight.

**Figure 3.** Photomicrograph of the upper mucosa of the gizzard of a Barrow's goldeneye (case 1) with zinc toxicosis. Note necrosis of glandular epithelium with infiltration by heterophils (a) and koilin degradation (b). H&E, ×120.

The plumage in all birds was normal. The proventriculus from each duck was devoid of ingesta, and the gizzard lining was multifocally roughened and discolored (erosions). Two of the four ducks were found dead (cases 7 and 8); each contained within the gizzard a single eroded penny with an exposed zinc core (Fig. 2).

The left abdominal air sac of one bird (case 8) was thickened and opaque, and there were multifocal 2–4-mm white plaques on the serosal surfaces of the visceral organs. All other tissues from the four birds were grossly normal.

Sections of ventriculus from all four goldeneye ducks were similar microscopically. There was focally extensive to diffuse degradation, fragmentation, and loss of koilin. The epithelial lining of ventricular pits and superficial glands was necrotic and sloughed into glandular lumina. Moderate numbers of heterophils infiltrated the superficial ventricular mucosa (Fig. 3). The tunica muscularis of the gizzard in case 6 had severe, focally extensive coagulation necrosis of smooth muscle.

Pancreatic sections from three goldeneyes (cases 1, 6, and 8) were available for microscopic examination. Pancreatic lesions were present in all cases and differed only in severity. The normal acinar architecture of the exocrine pancreas was disrupted, with sparing of islets of Langerhans and pancreatic ducts (Fig. 4). Mildly affected acini were ectatic and lined by atrophic acinar cells with loss of zymogen granules and basal basophilia. More severely affected areas were composed of dissociated degenerative acinar cells that frequently contained granular, orange-brown, Periodic acid–Schiff-positive intracytoplasmic material, admixed with scattered necrotic acinar cells with

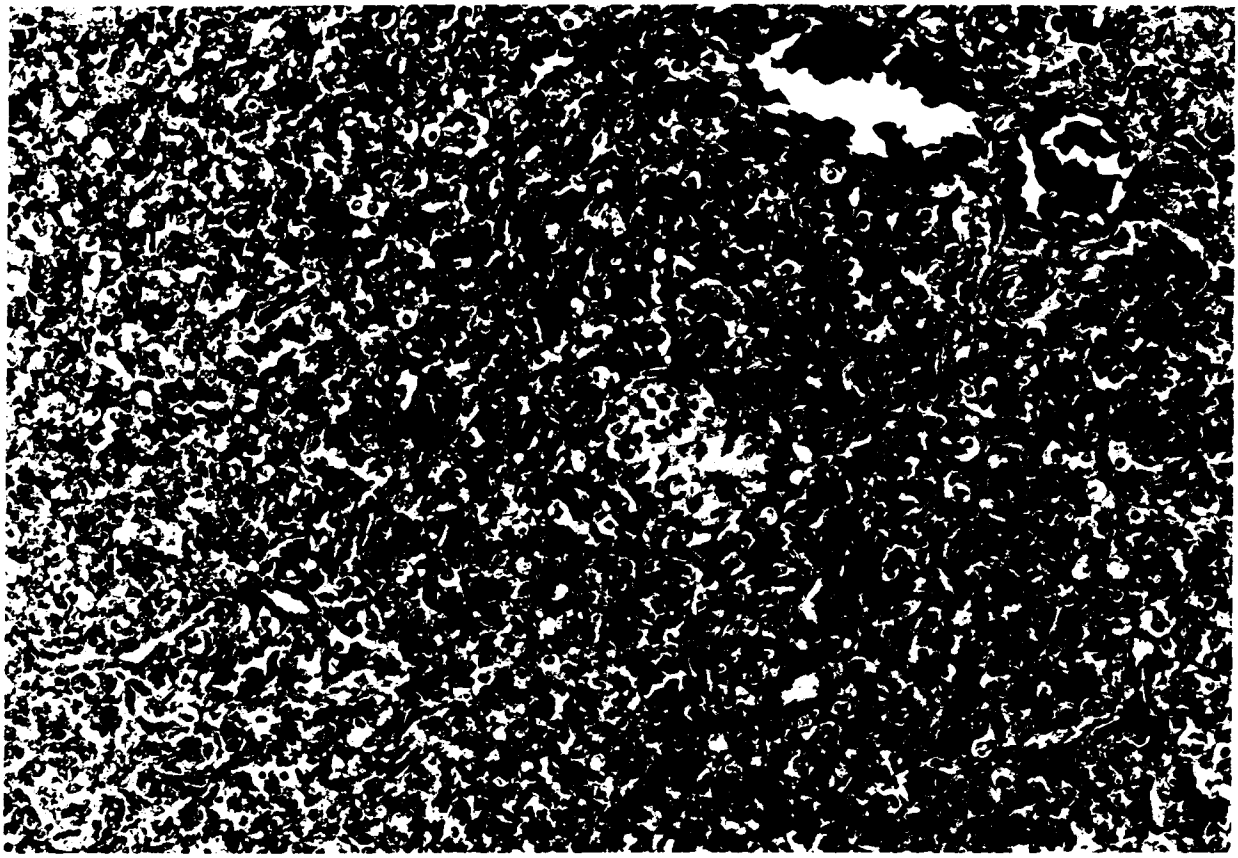

**Figure 4.** Photomicrograph of a pancreas from a Barrow's goldeneye (case 7) with zinc toxicosis. Note loss of normal acinar architecture with sparing of islets of Langerhans (c). H&E, ×200.

rounded hyalinized cytoplasm and nuclear pyknosis and karyorrhexis. Acini were separated by mild interstitial fibrosis and numerous small ductular structures lined by low cuboidal epithelial cells (Fig. 5).

The intestinal tracts from all birds had a spectrum of lesions that ranged from minimal degeneration and necrosis of enterocytes to acute necroulcerative enteritis with crypt abscesses. Renal lesions present in case 6 were characterized by mild degeneration and necrosis of tubular epithelial cells at the corticomedullary junction. Scattered tubules contained hyaline casts and sloughed epithelial cells. No microscopic lesions were found in serial sections of spinal cord examined from case 6.

Other histologic findings included disseminated aspergillosis (case 8), oral candidiasis (case 7), and intravascular *Trichobilharzia* species within the adrenal glands and intestine (cases 1, 6, and 8).

Serum and liver zinc concentrations were elevated in all affected birds tested (Table 1). Serum zinc concentrations ranged from 12.6 to 16.6 μg/ml (average, 14.1 μg/ml). The range of serum zinc concentrations in healthy goldeneyes from the NZP was 1.84–2.74 μg/ml (average, 2.71 μg/ml). The liver from one unaffected goldeneye contained 35.9 μg/g zinc (wet weight basis) as compared with 212–548 μg/g in affected ducks. The metal fence clips found in one pintail and two redhead ducks contained 96% zinc.

## DISCUSSION

Over a period of 5 mo, eight diving ducks belonging to three different species developed zinc toxicosis. All ducks ingested pennies or fence clips containing high concentrations of zinc. Common clinical signs included weight loss, depression, anorexia, ataxia, and muscular weakness. The weight

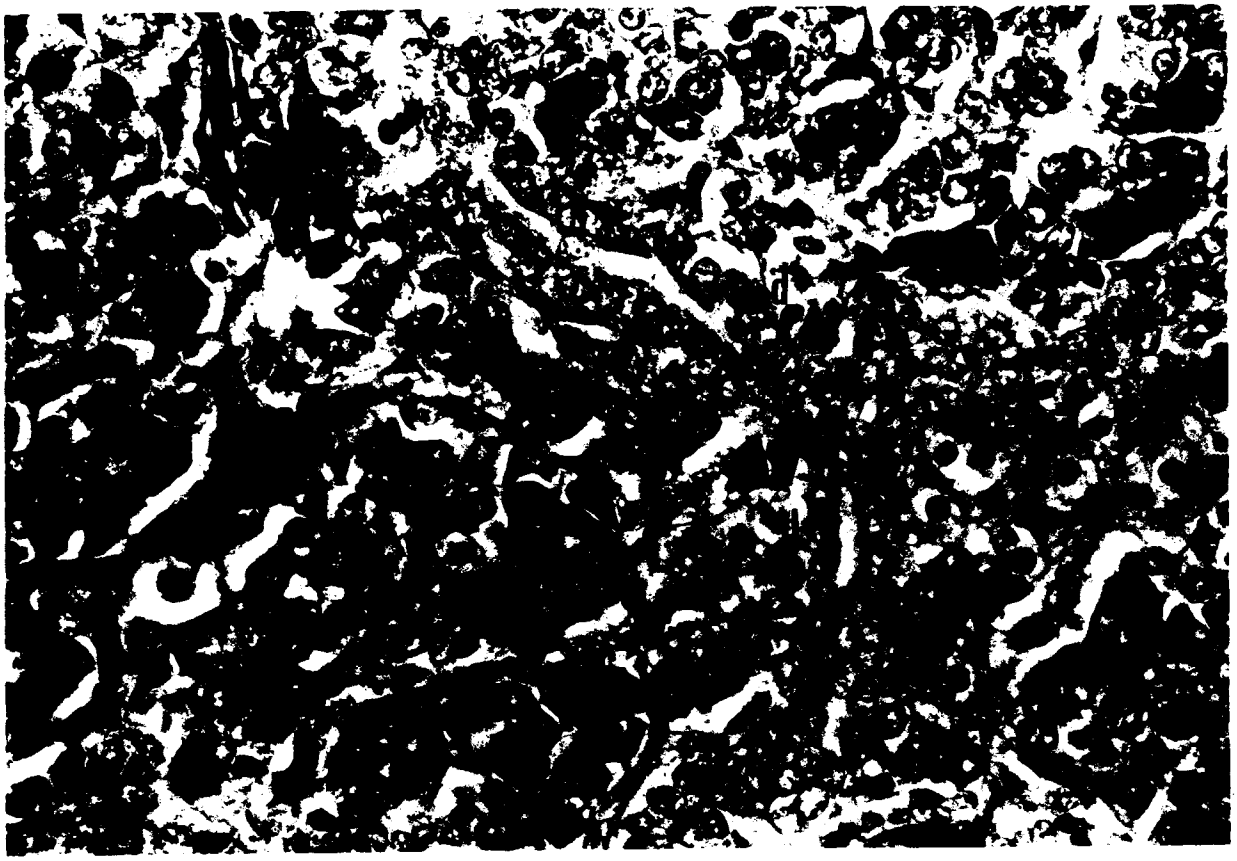

**Figure 5.** Photomicrograph of a pancreas from a Barrow's goldeneye (case 1) with zinc toxicosis. Note disrupted islands of degenerate acini, irregular, branching ductular structures lined by low cuboidal epithelium (d). H&E, ×480.

loss could be attributed to maldigestion due to pancreatic insufficiency, anorexia secondary to the pancreatic and gastrointestinal lesions, and muscular weakness affecting the animals ability to acquire food. Ataxia and recumbency due to zinc toxicosis have been reported in cockatiels.[2]

The presence of eroded pennies with the zinc core exposed in the ventriculus of four Barrow's goldeneyes and one American merganser led to a presumptive diagnosis of zinc toxicosis. This diagnosis was confirmed by discovery of elevated serum and/or liver zinc concentrations. Histopathologic examination revealed necrotizing ventriculitis and degeneration and necrosis of the pancreatic acini in the four goldeneyes compatible with lesions found in ducklings and chickens experimentally exposed to high levels of zinc.[3,5,17]

Zinc absorption primarily occurs in the proventriculus and small intestine in chicks.[15] Metallothionenes (metal binding proteins) bind zinc in the gut mucosa, pancreas, liver, and kidney.[15] Zinc is primarily excreted in the feces of mammals, with various percentages originating from pancreatic secretions.[4,8,17] The specificity of zinc for the pancreas correlates with the histologic lesions identified in birds[3,5,9,17] and suggests the pancreas is a target organ in zinc toxicity.

A diagnosis of zinc toxicity was made in one Bahama pintail and two redheads based on clinical signs and complete recovery following the removal of a metal object containing 96% zinc. Two unpublished zinc toxicosis cases in rosybill pochards were retrieved from the NZP Department of Pathology archives from 1986 and compared with these cases. Both ducks exhibited similar clinical signs, with radiographic evi-

**Table 1.** Serum and liver zinc levels (wet basis) in ducks with zinc toxicosis.

| Animal/ case no. | Species | Age (mo) | Status | Exposure | Serum zinc (μg/ml) | Liver zinc (μg/g) |
|---|---|---|---|---|---|---|
| 208595 (86-151) | rosybill pochard | 24 | found dead | 1 penny | NE[a] | 372 |
| 208583 (86-171) | rosybill pochard | 33 | found dead | 1 penny | NE | 212 |
| 211095 (Case 1) | Barrow's goldeneye | 8 | died postop | 1 penny | NE | 242 |
| 210277 (Case 5) | American merganser | 36 | alive | 1 penny | 16.6 | NE |
| 211090 (Case 6) | Barrow's goldeneye | 10 | died postop | 2 pennies | 12.6 | 548 |
| 211092 (Case 7) | Barrow's goldeneye | 10 | found dead | 1 penny | 13.1 | 414 |
| 211089 (Case 8) | Barrow's goldeneye | 24 | found dead | 1 penny | NE | 480 |

[a] NE = not examined.

dence of ventricular metallic foreign bodies identified as pennies. Liver zinc levels of 372 and 212 μg/g (wet basis) were documented for both rosybill pochards. The H&E-stained slides that were available from one of these birds revealed similar pancreatic lesions.

In late March 1990, all remaining goldeneyes were radiographically screened for evidence of ventricular foreign bodies. No metallic foreign bodies were identified on survey films. However in May, a 24-mo-old Barrow's goldeneye (case 8) was found dead with a worn penny in its ventriculus. Based on this information, it appears that in 2 mo the outer copper layer of a penny can be worn sufficiently to expose the zinc core, causing clinical signs or death in ducks. Cockatiels experimentally exposed to high levels of zinc developed clinical signs or died within 2 wk.[2]

Both the previous and the present cases involved species of diving ducks. The sources of zinc exposure in all cases were metal objects possessing high levels of zinc. Pennies were thrown into the duck ponds or dropped from pockets by visiting guests. Because these ducks dive to the bottom of pools or ponds to feed, shiny objects lying at the bottom may attract their attention and lead to ingestion. The fence clips found in ducks from the CRC may have been dropped by employees constructing the chain link fence surrounding the breeding pens. In zoos exhibiting diving ducks, preventive measures should include education of the public as to the hazards of foreign body ingestion as well as encouraging keepers to clean display pools as often as possible and to thoroughly examine newly constructed enclosures before allowing animals access.

## LITERATURE CITED

1. Ackerman, N., C. P. Spencer, S. F. Sundlof, and H. L. Partridge. 1990. Zinc toxicosis in a dog secondary to ingestion of pennies. Vet. Radiol. 31: 155–157.

2. Howard, B. R. 1992. Health risks of housing small psittacines in galvanized wire mesh cages. J. Am. Vet. Med. Assoc. 200: 1667–1674.

3. Kazacos, E. A., and J. F. VanVleet. 1989. Sequential ultrastructural changes of the pancreas in zinc toxicosis in ducklings. Am. J. Pathol. 134: 581–595.

4. Latimer, K. S., A.V. Jain, H. B. Inglesby, W. D. Clarkson, and G. B. Johnson. 1989. Zinc-induced hemolytic anemia caused by ingestion of pennies by a pup. J. Am. Vet. Med. Assoc. 195: 77–80.

5. Lu, J., and G. F. Combs. 1988. Effect of excess dietary zinc on pancreatic exocrine function in the chick. J. Nutr. 118: 681–689.

6. Luttgen, P. J., M. S. Whitney, A. M. Wolf, and

D. W. Scryggs. 1990. Heinz body hemolytic anemia associated with high plasma zinc concentration in a dog. J. Am. Vet. Med. Assoc. 197: 1347–1350.

7. Ogden, L., W. C. Edwards, and N. A. Nail. 1988. Zinc intoxication in a dog from the ingestion of copper-clad zinc pennies. Vet. Hum. Toxicol. 30: 577–578.

8. Pekas, J. C. 1966. Zinc 65 metabolism: gastrointestinal secretion by the pig. Am. J. Physiol. 211: 407–413.

9. Reece, R. L., D. B. Dickson, and P. J. Burrowes. 1986. Zinc toxicity (new wire disease) in aviary birds. Aust. Vet. J. 63: 199.

10. Shaw, D. P., J. E. Collins, and M. J. Murphy. 1991. Pancreatic fibrosis associated with zinc toxicosis in a dog. J. Vet. Diagn. Invest. 3: 80–81.

11. Stevens, M. D., W. F. MacKenzie, and V. D. Anand. 1977. Influence of cage material on amount of zinc in blood of the rhesus monkey (*Macaca mulatta*). Vet. Pathol. 14: 508–509.

12. Stowe, H. D., W. E. Braselton, M. Slanker, and J. B. Kaneene. 1986. Multielement assays of canine serum, liver, and kidney by inductively coupled argon plasma emission spectroscopy. Am. J. Vet. Res. 47: 822–827.

13. Straube, E. F., N. H. Schuster, and A. J. Sinclair. 1980. Zinc toxicity in the ferret. J. Comp. Pathol. 90: 355–361.

14. Torrance, A. G., and R. B. Fulton. 1987. Zinc-induced hemolytic anemia in a dog. J. Am. Vet. Med. Assoc. 191: 443–444.

15. Underwood, E. J. (ed.). 1977. Trace Elements in Human and Animal Nutrition, 4th ed. Academic Press, New York, New York. Pp. 196–242.

16. Van Sant, F. 1991. Zinc toxicosis in a hyacinth macaw. Proc. Assoc. Avian Vet. Pp. 255–259.

17. Wight, P. A. L., W. A. Dewar, and C. L. Saunderson. 1986. Zinc toxicity in the fowl: ultrastructural pathology and relationship to selenium, lead, and copper. Avian Pathol. 15: 23–38.

*Received for publication 13 May 1992.*