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Source: Journal of Wildlife Diseases, 40(3) : 571-574

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-40.3.571

Journal of Wildlife Diseases, 40(3), 2004, pp. 571–574

Peracute Sodium Toxicity in Free-ranging Black-bellied Whistling Duck Ducklings

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ABSTRACT: From 23 to 25 July 2002, 98–103 newly hatched black-bellied whistling ducks (*Dendrocygna autumnalis*) were observed alive at an inland saline lake (La Sal Vieja) in Willacy County, Texas (USA). Seventy-one (71%) died after showing signs indicative of sodium toxicity within 5 hr of entering the water; some died within minutes. Six carcasses were sent to the United States Geological Survey, National Wildlife Health Center (Madison, Wisconsin, USA) for analysis, and brain sodium levels of all ducklings were above 2,000 parts per million wet weight. More black-bellied whistling duck ducklings are likely to have been affected, but they were not observed after hatching.

Key words: Black-bellied whistling duck, *Dendrocygna autumnalis*, duckling mortality, hypersaline lake, salinity, salt poisoning, sodium toxicity.

Sodium toxicity in free-ranging waterfowl is associated with the ingestion of hypersaline water or salt that has precipitated on feathers. This has been shown in waterfowl stranded on hypersaline lakes by storm conditions (Meteyer et al., 1997). Experimental sodium toxicity has been induced in mallard (*Anas platyrhynchos*) ducklings corralled on the shores of saline lakes (Swanson et al., 1984; Meteyer et al., 1997) and in captive Canada goose (*Branta canadensis*) goslings provided with only saline water to drink (Stolley et al., 1999b). During the summer of 2002, sodium toxicity occurred in free-ranging black-bellied whistling duck (*Dendrocygna autumnalis*) (BBWD) ducklings.

La Sal Vieja is a saline lake located in Willacy County, Texas (USA; 26°29′N, 97°54′W). Part of the land surrounding the lake is owned and managed by the Lower Rio Grande Valley National Wildlife Refuge. As the lake's name, "Old Salt," suggests, it was known historically for its salt deposits; salt was collected by the indigenous people of the area before the arrival of the Spanish, who mined it as well.

The salinity of the lake is primarily dependent on rainfall and evaporation. This area has been experiencing drought for many years, and, in 2002, lake levels were 2.9 m below the high-water line. During spring and summer of 2002, US Fish and Wildlife Service biologists monitored the BBWD using the lake. This species is primarily a cavity nester; however, the ducks nest on the ground in large numbers on three islands in the lake.

Studies of BBWD at La Sal Vieja began in April 2002. Over the next few months without rain, the lake level receded. Salt precipitate was visible on the bottom of the lake and the shoreline. No brine shrimp were observed in the water. Maximum lake depth was 0.33 m on 24 July 2002, and a water sample collected on that day was 386,595 parts per million (ppm) total dissolved solids. Total dissolved solids in sea water is approximately 35,000 ppm. Chemical analysis of the water was done by the Soil, Water and Forage Testing Laboratory (Texas Cooperative Extension Service at Texas A&M University, College Station, Texas, USA) using the methods of Clesceri et al. (1989) and Helrich (1990). Sodium and chloride are the primary ions in the lake water, with significant amounts of magnesium and sulfate (Table 1). In mid-September, the area received large amounts of rainfall that continued into October. The maximum lake depth was 0.89 m in November 2002. At that time, brine shrimp were visible in the water.

A sick bird was first observed on 25 April, when an eared grebe (*Podiceps ni-*

TABLE 1. Chemical characteristics of water collected from La Sal Vieja, Willacy County, Texas, on 24 July 2002.

Characteristic	Value
pH	7.50
Specific conductivity	220,000 μmhos/cm
Total dissolved salts	386,595 ppm[a]
Calcium (Ca)	18 ppm
Magnesium (Mg)	17,448 ppm
Sodium (Na)	130,146 ppm
Potassium (K)	2,147 ppm
Boron (B)	542 ppm
Carbonate (CO_3)	5 ppm
Bicarbonate (HCO_3)	16 ppm
Sulfate (CO_4^-)	72,969 ppm
Chloride (Cl^-)	163,300 ppm
Nitrate-N (NO_3-N)	0.01 ppm
Phosphorus (P)	3.43 ppm

[a] ppm = parts per million.

gricollis) was found to have salt encrusted on its face, especially around its eyes. No other birds were observed to be affected at that time; BBWD were rarely seen in the water. Using 10×40 power binoculars and 20–60× spotting scopes on 23 July, a recently hatched brood of 19 ducklings accompanied by two adults was observed coming off one of the islands and entering the water, presumably for the first time. By 19 min after entering the water, one duckling had died after convulsing; within 151 min, all but two ducklings were dead. Affected ducklings lagged behind the group, swam in circles, lost control of the head, had convulsions, and died. We assumed that affected ducklings were dead if they were motionless with the head in the water for several minutes.

During the morning, another five broods were spotted. Not all were seen before entering the water, so some ducklings may have died before the brood was first observed. Because of the distances involved and the visual distortion caused by heat refraction, it was not always possible to determine the exact number of ducklings per brood. At least 70 ducklings were observed alive; within 277 min, only two were observed alive, and another five had traveled out of viewing range (their fate was unknown). On 24 July, 18 ducklings were seen and 10 died; six carcasses were collected for necropsy. On 25 July, all but one of a brood of 10 ducklings died within 174 min.

During 3 days, at least 98 live ducklings were observed. Eleven of these reached the shoreline alive; five others were seen to swim beyond viewing range, for a possible survival of 16 (16%). There were 82 (84%) confirmed deaths. Of these, 71 had clinical signs of sodium poisoning. Four ducklings were killed directly by birds (laughing gull [*Larus atricilla*] or crested caracara [*Polyborus palncus*]) before they began showing clinical signs. The cause of death of six ducklings is unclear. The existence and fate of an additional five ducklings is uncertain.

Six carcasses were sent to the United States Geological Survey National Wildlife Health Center (Madison, Wisconsin, USA) for necropsy, histopathology, (lung, heart, liver, kidney, brain, eye) and bacterial cultures of liver and yolk sac using methods previously described (Meteyer et al. 1997). The brain sodium concentration was determined by inductively coupled plasma emission according to standard protocols (Windingstad et al., 1987; Meteyer et al., 1997). Individual brain sodium levels in the BBWD ducklings ranged from 2,440 to 4,050 ppm (mean, 3,015 ppm). In a previous study, 1,359 ppm was the average brain sodium concentration in mallards housed at hypersaline lakes and provided fresh drinking water (Meteyer et al., 1997). Because no established reference values were available for lethal levels of brain sodium in ducklings, we used the defined threshold suggested for lethal brain sodium, 2,000 ppm, which was established in studies that used similar methods for brain removal and brain sodium analysis in mature ducks (Windingstad et al., 1987; Meteyer et al., 1997). On the basis of this threshold, all of the BBWD ducklings were determined to have died of sodium poisoning.

The ducklings were in good body condition, with moderate-sized yolk sacs. The brains were congested. No food was found in the stomachs, and no significant bacteria were cultured. Microscopic changes in the brain were limited to congestion and mild multifocal perivascular hemorrhage. Bilateral or unilateral cataracts were seen at necropsy and confirmed microscopically in the five ducklings that had eyes examined. Cataracts and congested brains, with minimal lesions in other tissues and no evidence of infectious disease, is consistent with peracute sodium poisoning in waterfowl (Meteyer et al., 1997).

The rapid onset of clinical signs raises the question of when and how sodium exposure occurred. The emergence of young in most waterfowl usually takes 3–24 hr; young are then brooded at the nest for a few hours or days. Most broods leave the nest by early afternoon, and in only a few species do the young return to the nest for brooding (Afton and Paulus, 1992). Thus, it was assumed that the BBWD broods were hatched within the 18–36 hr of the first direct exposure to saline lake water. However, the ducklings may have experienced exposure to sodium through salt accumulated on the feathers of their parents or brought in during incubation or through windborne particles. Some ducklings were observed touching their bills to the surface of the water. The young may have been drinking the hypersaline water, which could be one explanation for salt exposure. The absorption of sodium and loss of body fluid across mucous membranes such as the cloaca may have contributed to sodium-associated dehydration. Either situation may have led to abnormal behavior, such as laying the bill in water, which may have resulted in a greater ingestion of sodium.

We have no estimate of the total number of eggs hatched on the islands in the lake, but many more ducklings than were observed are likely to have come off of the islands and been affected. More than 100 BBWD nests were observed, but on the basis of observation of adults, many others were assumed to exist. One island was searched carefully for nests, and 21 successful nests (evidence found of ≥1 hatched egg) were located. In these nests, direct sign was found of at least 105 hatched eggs. One densely vegetated island was partially searched, and 25 nests were monitored, of which nine (36%) were successful. Evidence of at least 46 hatched eggs was noted in these nine nests, and probably dozens more eggs hatched in other nests. A third island was not searched intensively, but some nests and evidence of hatched eggs were observed during a cursory search. After the first rains fell, duckling survival may have been greater, especially if low wind conditions allowed a lens of freshwater to float on top of the salt water. Almost all nests, according to the usual breeding phenology, would have hatched before the rains of mid-September.

The kidneys alone are incapable of excreting sufficient salts to ensure survival of a bird exposed to hypersaline drinking water (Bradley and Holmes, 1972). Adult ducks and geese are able to drink saline water because they possess nasal salt glands that function to excrete excess salt from the bloodstream. Experiments with adult ducks exposed to saline water showed increases in salt gland weight and the rate of secretion and concentration of sodium and chloride, allowing for significant tolerance to sodium chloride within 5 days. Salt gland efficiency continues to increase, but at a lower rate, for an additional 5 days. When salt water is removed after salt gland adaptation and only fresh water is provided to the ducks, the salt gland returns to its less active state but remains larger than before saltwater exposure (Peaker and Linzell, 1975). Ducklings and goslings that are exposed to saline drinking water develop fully functioning salt glands about 6 days after hatching (Riggert, 1977).

A single dose of 4 g of sodium chloride per kg of body weight was lethal for 5-day-old chickens with a mean weight of 32.5 g

(Quigley and Waite, 1932), and Pekin ducks are reported to be more sensitive than chickens to sodium chloride poisoning (Torrey and Graham, 1935). If 4 g of sodium chloride per kg of body weight is lethal for newly hatched BBWD ducklings that have minimal salt gland development and no freshwater ingestion, at a mean weight of 24 g (n=6; range, 22.1–27.5 g), these ducklings would have had to ingest only 0.1 g of NaCl for a lethal dose. Functioning salt glands, greater body mass, and the ability to leave the hypersaline lake for food and fresh water may explain why adult BBWD adults were not noticeably affected by the saline water.

Adult ducks may lead newly hatched offspring to freshwater inlets to drink (Riggert, 1977), and adult geese move broods to brackish ponds after hatching on hypersaline ponds (Stolley et al., 1999a). At La Sal Vieja, most ducklings did not survive long enough to reach the shore.

We thank R. Sohn for coordinating field submission, D. Finley for brain sodium analysis, B. Berlowski for bacterial cultures, N. Ramsay for technical assistance, and M. Neumann for field assistance.

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Received for publication 30 July 2003.