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MORTALITY OF WATERFOWL ON A HYPERSALINE WETLAND AS A RESULT OF SALT ENCRUSTATION

G. Wobeser[1] and J. Howard[2]

ABSTRACT: Approximately 300 geese, primarily lesser Canada geese (*Branta canadensis parvipes*) were found unable to fly or dead on a small hypersaline lake (conductivity 77,000–90,000 μmhos/cm) in western Saskatchewan in September 1985. The birds were heavily encrusted with sodium sulfate crystals. Dead birds that were necropsied had aspirated lake water and had evidence of acute muscle degeneration. The live geese (155) were captured and moved to nearby freshwater wetlands where most apparently survived. Some birds died of severe myopathy after translocation. Five northern shovelers (*Anas clypeata*) were found encrusted with salt and unable to fly on the lake approximately 10 days later. Salt encrustation apparently occurred when rapid cooling of the lake resulted in supersaturation and crystallization of the dissolved salt. A local resident recalled similar events occurring on the lake in autumn on at least two other occasions during the past 50 yr.

INTRODUCTION

Wetlands containing a high concentration of dissolved salts are common in western North America and many of these "alkali" or "bitter" marshes are utilized by waterfowl. Most systems for classification of wetlands define saline waters as those with a salt concentration greater than 3,000 parts per million (Hammer, 1978). Hypersaline waters are those with a salt content greater than that of the ocean and specific conductivity in excess of 45,000 (Millar, 1976) or 60,000 μmhos/cm (Cowardin et al., 1979).

Saline wetlands are likely to comprise a greater proportion of total wetland area and to become increasingly important for waterfowl on the prairies in the future as they are generally not drained because of their low agricultural potential. It is thus important to understand both the potential and limitations of these marshes for waterfowl use. This report describes mortality as a direct result of crystallization of salt on the plumage of waterfowl using a hypersaline lake in Saskatchewan.

MATERIALS AND METHODS

Sherlock Lake (52°47′ latitude, 109°59′ longitude) is a small (ca. 1 km^2) terminal wetland, with no outflow or major inflow streams, located near the junction of the grassland and aspen parkland regions of Saskatchewan directly adjacent to the border with Alberta. The land immediately surrounding the lake is native grassland, while the adjacent area is comprised of mixed cropland and pasture. Several small freshwater seeps occur around the edges of the lake. The basin has a gently sloped shoreline with a flat bottom; the maximum depth in September 1985 was 65 cm. There is no emergent vegetation except in the immediate area of the freshwater seeps. The lake water is extremely saline, with sodium the dominant cation and sulfate the dominant anion (Table 1).

On 19 September 1985 local residents noted geese, primarily Canada geese (*Branta canadensis*) with a few lesser snow (*Anser caerulescens caerulescens*) and Ross' geese (*A. rossi*), unable to fly or dead on the shore and in the shallow water at the southern end of Sherlock Lake. The following day 155 geese that were unable to fly were captured by members of the local wildlife federation, local farmers and personnel of Saskatchewan Parks and Renewable Resources and released on nearby freshwater wetlands. Capture of these birds was facilitated by use of an airboat supplied by Ducks Unlimited Canada. These birds were heavily encrusted with salt crystals, and some were estimated to have at least 3 kg of tightly adherent crystals

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TABLE 1. Concentrations (mg/liter) of selected elements in water from Sherlock Lake, Saskatchewan.

Element	Collection date May 1985[a]	30 September 1985[b]
Sodium	36,950	30,800
Potassium	133	N.A.[c]
Calcium	56	N.A.
Magnesium	39	20
Sulfate	53,040	26,700
Chloride	6,980	9,570
Carbonate	9,344	15,600
Bicarbonate	3,636	1,200

[a] Data supplied by Saskatchewan Energy and Mines, Regina, Saskatchewan.
[b] Analyses by Analytical Services Laboratory, Saskatchewan Research Council, Saskatoon, Saskatchewan.
[c] N.A. = no analysis done.

FIGURE 1. Accumulated crystals of sodium sulfate on the shore of Sherlock Lake, Saskatchewan, 21 September 1985. A salt encrusted dead Canada goose is visible in the middle distance (arrow).

on the feathers of the wings, ventral body and neck. Dead birds were not counted or collected; many carcasses had been fed on by scavengers, with an unknown number having been dragged out of sight on the shore. A propane exploding device ("scare cannon") and a scarecrow were placed on the lake to discourage use by geese. On 21 September about 0.8 km of the southern shore was searched by the senior author. This represented approximately one-fifth of the total shoreline, but included the major portion of the downwind side, as the wind direction had been consistently from the north or northwest from 17 to 21 September.

The lake was surrounded by an exposed mudflat 10–15 m wide, the upper portion of which was covered by 1–2 cm of powdery white crystals. The shore area closer to the water was covered by 2–6 cm of clear to white granular crystals that had been piled into windrows by wave action (Fig. 1). This thick layer of crystals extended on the bottom underwater and was sufficiently firm to support a walking person in many areas. Conductivity of the water measured with a temperature-compensated meter was approximately 90,000 μmhos/cm.

No live geese were seen on the lake, but about 200 northern shovelers (*Anas clypeata*) were present in the central area and some of these birds were seen to land and take off. The intact carcasses of 79 Canada, three lesser snow, and two Ross' geese, and one American avocet (*Recurvirostra americana*) were found on the shore or in the shallow water within a few meters of shore. These birds were heavily encrusted with salt crystals (Fig. 2). Six Canada geese and one each of the lesser snow, Ross' and avocet carcasses were collected for necropsy. A water sample containing a small number of crystals was collected.

Ten of the Canada geese moved on 20 September had been placed on a 18 × 20 m freshwater farm pond. The carcasses of two of these that had died overnight were collected for necropsy. The remaining eight birds appeared bright and alert, but seemed reluctant to move. When approached, three of the birds attempted flight, rising to about 3 m before sinking back to the ground. No salt crystals were visible on these birds, and they were not harassed further. On 25 September six of these geese were still present on the pond and were unwilling to fly.

On 30 September the lake was revisited and the basin was examined from a canoe. No live geese were present on the lake. The salt crust observed on the bottom near shore on 21 September was found to extend under the entire basin and four dead Canada Geese were found firmly embedded within the salt crust on the bottom of the pond. No intensive search was made for carcasses, but an additional 10 dead Canada geese were seen on the shore. A cursory examination in the field suggested that these birds had been dead since the time of the earlier incident.

Approximately 200 northern shovelers were present on the lake in midmorning on 30 September and birds of this species were landing and taking off continuously. These ducks were feeding actively, probably on brine shrimp (*Artemia salina*) that were numerous and conspicuous in the water. Many of the ducks made frequent lateral head shakes. This is a behavior common in ducks drinking saline water, and clears drops of salt gland secretion from the nares. Six of the ducks were unable to take off when approached. These birds flapped along the surface with their wings and dove when approached more closely; one appeared to have very limited use of its legs. Three of these were captured in the water; two went on shore when chased, but moved only a few meters on land before attempting to hide in the short grass. All of these birds had extensive salt encrustation on the breast, neck and bill (Fig. 3). Blood samples were taken from these birds, and they were then killed for necropsy.

Water depth, temperature, and conductivity were measured throughout the basin between 9:00 and 10:30 A.M., 30 September. Probes for the latter two measurements were suspended about 15 cm below the water surface. The weather at the time was bright and sunny with the air temperature rising from 0.5 C at 9:00 A.M. to 3.0 C at 10:30 A.M. During this period the water temperature in the central, deepest (45–65 cm) part of the lake was 1.5–1.8 C; whereas that in a sheltered bay on the upwind side of the lake was 3.1 C and in a downwind side of the bay was 0.0–0.3 C. The conductivity in all areas was approximately 77,000 μmhos/cm. A sample of water was collected from the central area of the lake for chemical analysis.

Blood and tissue fluid were analyzed in the clinical pathology laboratory, Western College of Veterinary Medicine. Osmolality was determined by freezing point depression, sodium concentration was measured by ion selective electrodes. Creatine phosphokinase (CPK) was measured using the modified Oliver-Rosalki method, and aspartate aminotransferase (AST) was measured by the modified IFCC method, using a Coulter Dacos Analyzer. Salt crystals were analyzed in the Analytic Services Laboratory, Saskatchewan Research Council, Saskatoon using inductively coupled, argon plasma-emission spectroscopy and ion chromatography.

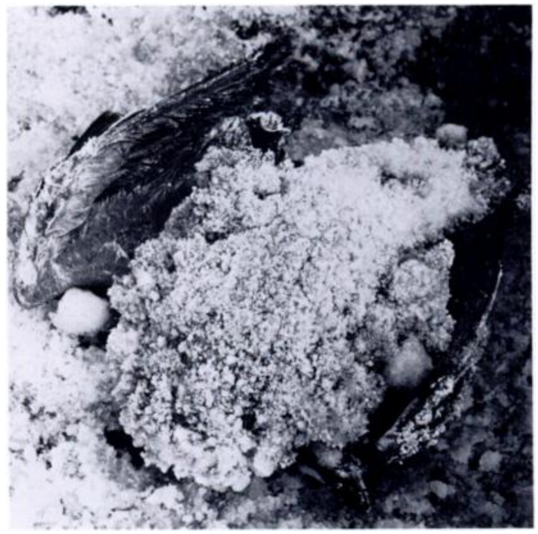

FIGURE 2. Salt encrusted dead Canada goose found on the shore of Sherlock Lake, Saskatchewan. Note size of crystal agglomerates.

Selected tissues collected at necropsy were fixed in neutral buffered 10% formalin, processed routinely, sectioned at 5 μm and stained with hematoxylin-eosin.

RESULTS

The six dead Canada geese collected on 21 September consisted of three juvenile females, a juvenile male and two adult females. The size of these indicated that they were lesser Canada geese (*B. c. parvipes*) of the short-grass prairie population that migrates through the area (Bellrose, 1976). The lesser snow goose was a juvenile male. The Ross' goose and avocet had gunshot wounds and will not be considered further. The juvenile geese had little body fat; the adults had abundant fat. Consistent findings in all geese were heavy encrustation of salt on the feathers, with individual large crystals formed around frayed feather filaments (Fig. 4), severe diffuse pulmonary edema (Fig. 5), cardiac dilatation, and absence of ingesta in the alimentary tract. Four of the Canada geese and the snow goose had 20–40 ml of sanguineous fluid in the abdomen. This fluid contained a high concentration of sodium

FIGURE 3. Salt encrustation on northern shoveler found unable to fly on Sherlock Lake, Saskatchewan, 30 September 1985.

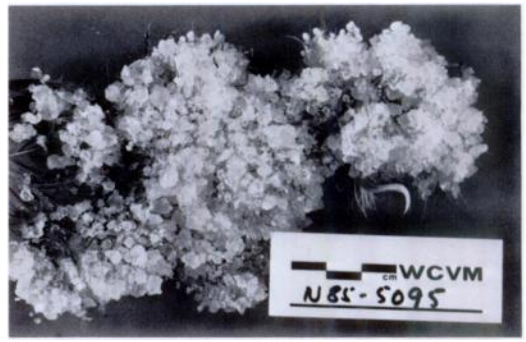

FIGURE 4. Sodium sulfate crystals formed around feather filaments from wing of Canada goose from Sherlock Lake, Saskatchewan.

(522 to 1,034 mmol/liter) and had a high osmolality (1,137 to 1,494 mosmol/kg). The supra-orbital salt glands in all geese were very small and appeared inactive. Microscopically, there was severe pulmonary edema, with numerous small birefringent foreign bodies evident in the lungs. Occasional muscle fibers in skeletal and cardiac muscles were swollen with an hyaline appearance indicative of early degeneration. The salt glands were very inactive in appearance. The conclusion was that the proximate cause of death was pulmonary edema, at least partially as a result of aspiration of lake water. The location of the abdominal fluid was not determined at the time of necropsy, and much of this may have been aspirated water within the abdominal air sacs, rather than true ascites. The muscle and cardiac changes were those of early myopathy. Crystals from the feathers were identified as sodium sulfate.

The two geese that died after translocation were adult females in moderate body condition. The lungs of both were mildly edematous and congested, with grey-brown discoloration of the ventral portions. The heart was dilated and flabby in both; the myocardium was pale and streaked in one bird. The liver of this bird was severely congested. Microscopically, there was severe diffuse myopathy, characterized by swelling, hyalinization and fragmentation of individual fibers (Fig. 6) in all skeletal muscles examined (superficial and deep pectoral muscles, extensor muscles of leg) from each bird. There was no mineralization or phagocytosis visible in these muscles, indicating the changes were acute in nature. There were distinct foci of necrosis of myocardial fibers in the papillary muscles of the heart of the goose with gross evidence of myocardial changes, and less obvious hyaline swelling of fibers in the heart of the other bird. The

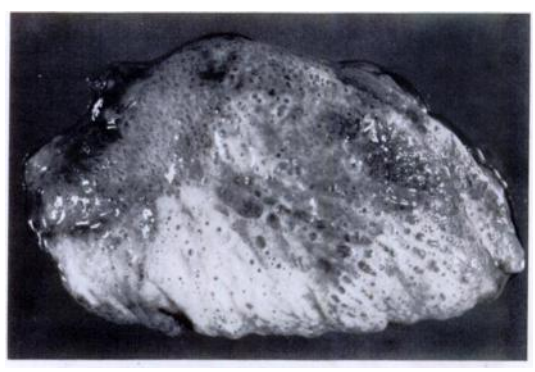

FIGURE 5. Severe pulmonary edema, Canada goose found dead on Sherlock Lake, Saskatchewan.

lungs were congested and edematous; the grey-brown material evident grossly was foreign material within air spaces. There was no cellular reaction to this material. It was concluded that these birds died of acute skeletal and cardiac myopathy and that the material in the lungs was the result of aspiration. The latter was probably not of primary significance in the death of the birds.

The salt crystals within the water sample collected 21 September went into solution when the water sample was warmed to room temperature and the conductivity of this water increased to 100,000 μmhos/cm. The crystals remained in solution until the water was cooled to approximately 3 C, at which temperature crystallization occurred suddenly, with the formation of large crystal agglomerates that sank to the bottom of the container. The conductivity of the water following crystallization was 77,000 μmhos/cm; similar to that of the lake water on 30 September.

There were no significant gross lesions in the five northern shovelers examined. All were juveniles, fully fledged and in good general body condition. The amount of salt adhering to two of the ducks was determined at the time of necropsy. In each case 74 g of salt were removed, which was equal to 12.3 and 12.6% of the body weight of the birds, respectively. This was a very conservative estimate of the amount of salt present when the birds were captured, as a considerable amount had fallen off during capture and subsequent handling.

One duck had many brine shrimp in the proventriculus; only a few seeds were found in the other birds. The salt glands of all of these ducks were enlarged markedly, and were approximately twice the size of those from the much larger geese. Serum from these birds had an elevated concentration of sodium (154 to 169 mmol/liter) and high osmolality (326 to 346 mosmol/kg) when compared to that of four shovelers of similar age that had been raised in captivity on commercial duck food (140 to 150 mmol/liter, 303 to 325 mosm/kg, respectively). The concentration of CPK (963 to 2,511 U/liter) and AST (27 to 162 U/liter) in the serum of these birds also was elevated. Serum from the ducks was negative when tested for botulinum toxin by mouse inoculation. Microscopically, the bird with the highest concentration of CPK and AST had multifocal degeneration of muscle fibers in the deep pectoral and several leg muscles, but not in the superficial pectoral muscle. Two of the other ducks had less severe myopathy. The salt glands in all had evidence of marked hyperplasia and hypertrophy of acinar cells.

FIGURE 6. Skeletal muscle from Canada goose that died after translocation from Sherlock Lake to a farm pond in Saskatchewan. Swelling, hyalinization and fragmentation of fibers are evident. Hematoxylin-eosin, ×85.

The chemical composition of water collected 30 September is shown in Table 1; daily maximum and minimum temperatures measured at a weather station at Artland, Saskatchewan approximately 10 km from Sherlock Lake from 1 to 25 September are shown in Figure 7.

DISCUSSION

The total number of birds involved in this incident is unknown, but at least 252 geese (97 found dead and 155 translo-

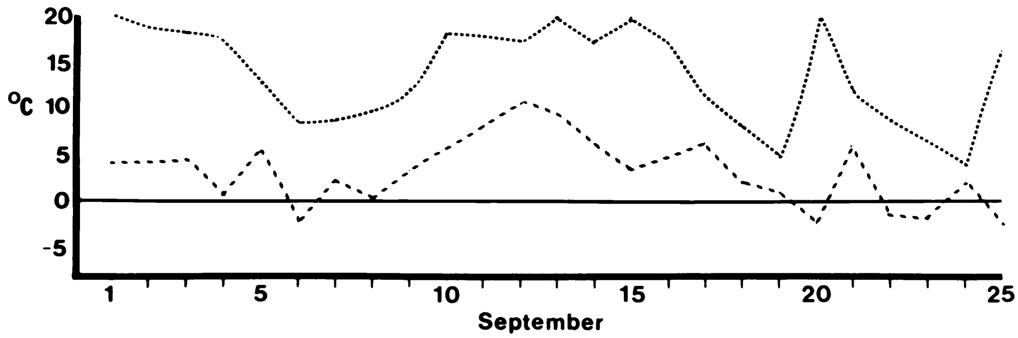

FIGURE 7. Daily maximum and minimum temperature during September 1985 measured at a weather station approximately 10 km from Sherlock Lake, Saskatchewan.

cated) were affected. This is a conservative estimate as no complete search was made for carcasses and an unknown number were removed by predators/scavengers. No pre-existing or coincident disease was identified in the sample of birds examined, and we conclude that these were normal geese that became encrusted with large amounts of salt and were unable to leave the lake. The birds found dead appeared to have died after aspiration of lake water, probably as a terminal event. These birds had early degenerative changes in skeletal muscle, that could be related to the exertion of trying to fly while salt-encrusted. The role of electrolyte imbalance, particularly hypernatremia from ingestion of lake water, is unknown but may have been significant. The small quiescent salt glands in the geese indicates that they were not conditioned to consuming and excreting excess salt.

The fate of the translocated geese is unknown although 11 of the 155 were found dead subsequently. The two birds necropsied had severe myopathy of the type seen in geese with "capture" or "exertional" myopathy (Wobeser, 1981), and the weakness and inability to fly seen in one group of these birds were compatible with signs we have observed in other geese with that condition. The muscle lesions were likely the result of exertion involved in trying to move and fly while salt encrusted, together with the exertion and stress associated with capture and movement. The latter was an unavoidable risk, as it seems likely all the geese would have died had they been left on Sherlock Lake.

No cause other than salt encrustation was found to account for the inability of some northern shovelers to fly on 30 September. It is not clear why only a few of the estimated 200 ducks on the lake should have been affected. The affected birds may have become salt encrusted about 18 September, but been able to survive on the lake because they had a source of food (brine shrimp) and had active salt glands that allowed excretion of excess sodium. It is unlikely that these ducks could have survived with lake water as their only source of drinking water, but they may have utilized the freshwater seeps for this purpose. (On 25 September, a group of avocets feeding along the shore was observed to fly to a freshwater seep and drink for several minutes prior to roosting on a "salt bar".) Three of these ducks had myopathy and all had elevated concentrations of CPK and AST in their serum when compared to published values for "normal" ducks (Wobeser, 1981; Franson, 1982; Franson et al., 1985). The concentrations of these enzymes were comparable to those reported in trapped mallards (*Anas platyrhynchos*) (Driver, 1981) in which the elevations were attributed to muscle injury during capture and handling, and to those from a Ross' goose with capture myopathy (Wobeser, 1981). It is difficult to evaluate what portion of the elevation of these enzymes was a direct result of capture. All blood samples were collected within 90 min of capture; however, we have found that the concentration of these enzymes can increase markedly within 2 hr after handling waterfowl (Wobeser, unpubl. data).

The major salt in the water and on the birds was sodium sulfate; that on the birds was likely the decahydrate or "Glauber's" salt. The solubility of this salt is directly related to water temperature; rapid cooling of the water overnight on 18 September when the mean daily air temperature fell to 2 C could have resulted in supersaturation and rapid crystallization as occurred in the water sample cooled in the laboratory. The presence of dead geese entrapped in the salt crystal layer on the bottom of the lake, and the formation of crystals around feather filaments is good evidence for sudden crystallization and formation of agglomerates. Precipitation of salt in autumn is a normal occurrence on hypersaline lakes, and is the basis for industrial recovery of sodium sulfate from some larger water bodies in Saskatchewan. We were told that in the past local farmers harvested crystallized salt from Sherlock Lake and sold it to an industry in Edmonton, Alberta.

In July 1985, approximately 250 m^3 of "drilling mud" containing 23,960 ppm sodium and 36,700 ppm chloride was dumped into Sherlock Lake by an oil well drilling company. There was a great deal of public and media concern that the death of geese approximately 3 mo later was a direct result of this action. Addition of this mud would have increased the overall salinity of the lake slightly, but we feel that the two events were not directly related. The water of Sherlock Lake was so saline that it would have become supersaturated when cooled, even without this addition of further salt.

Most of the affected geese were concentrated along the downwind shore. Some of these birds may have drifted there because of wind action; however, crystallization may also have occurred there first because of differential cooling of the water. The temperature readings taken 30 September illustrated the variability in water temperatures that can occur in a small wetland. At that time the coldest water was found on the downwind side of the lake. We assume this occurred because water reaches its maximum density at about 4 C; cooler water would remain at the surface where it could be moved by wind action.

The number of waterfowl affected at Sherlock Lake was not large in terms of continental populations, but this appears to be a form of natural mortality that has not been reported previously. A farmer who lives adjacent to Sherlock Lake recalled similar incidents occurring in approximately 1973 and during the 1930's on this lake, and an incident of similar nature occurred on a lake in the Provost area of Alberta in September 1981. Approximately 200 Canada geese were involved in the latter incident, and the salt was identified as sodium sulfate (Rippen, pers. comm.). The occurrence in 1985 was likely related to unusually cold weather in September during the time that migrating geese were present in the area.

Marked fluctuations of temperature, as often occur on the prairies during autumn, could result in repeated occurrences of the phenomenon in a single year. The only "control" methods evident would be to either discourage waterfowl usage of hypersaline lakes during autumn, which because of the number of such basins is not practical, or to "rescue" sick birds when salt encrustation occurs. The experience at Sherlock Lake suggests that the latter may be only partially successful because of occurrence of exertional myopathy in rescued birds.

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LITERATURE CITED

BELLROSE, F. C. 1976. Ducks, Geese and Swans of North America. Stackpole Books, Harrisburg, Pennsylvania, 544 pp.

COWARDIN, L. M., V. CARTER, F. C. GOLET, AND E. T. LAROE. 1979. Classification of wetlands and deep water habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C. Biol. Serv. Progr. FWS/OBS/79/31, 103 pp.

DRIVER, E. A. 1981. Hematological and blood chemical values of mallard, *Anas p. platyrhynchos*, drakes before, during and after remige moult. J. Wildl. Dis. 17: 413–421.

FRANSON, J. C. 1982. Enzyme activities in plasma, liver and kidney of black ducks and mallards. J. Wildl. Dis. 18: 481–485.

———, H. C. MURRAY, AND C. BUNCK. 1985. Enzyme activities in plasma, kidney, liver, and muscle of five avian species. J. Wildl. Dis. 21: 33–39.

HAMMER, U. T. 1978. The saline lakes of Saskatchewan III. Chemical characterization. Int. Rev. Ges. Hydrobiol. 63: 311–335.

MILLAR, J. B. 1976. Wetland classification in western Canada: A guide to marshes and shallow open water wetlands in the grasslands and parklands of the prairie provinces. Canadian Wildlife Service Report, Ottawa, Canada, Series No. 37, 38 pp.

WOBESER, G. 1981. Diseases of Wild Waterfowl. Plenum Publ. Corp., New York, 300 pp.