

ORIGINAL ARTICLE

Survey of blood lead levels in trumpeter swans (*Cygnus buccinator*) in Ontario, Canada

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Abstract

Lead toxicosis in waterfowl has been well documented for a century, with the majority of studies analysed from carcasses of dead birds. Lead can remain in the environment for decades; the sublethal effects of lead remain unknown in the once extirpated trumpeter swan (*Cygnus buccinator*) population in Ontario, Canada. The purpose of this study was to survey healthy, free-ranging trumpeter swans in Ontario to determine blood lead levels. Blood samples from 95 trumpeter swans in Ontario, Canada, revealed lead levels above 3.2 µg/dL in 90% of the birds, with 30% of the swans having blood lead levels exceeding 15 µg/dL. Furthermore, 11 birds from the population were admitted to wildlife rehabilitation centres with suspected lead toxicosis, with blood lead levels as low as 13.5 µg/dL. Three of the 11 birds were chelated for lead toxicosis, whilst the remaining eight received supportive care. These data show that lead toxicosis, even at low blood lead levels, could be a concern for the health and welfare of trumpeter swans in Ontario and for the potentially damaging ecological effects of lead ingestion by other animals. The long-term effects on the health of swans sampled in this study remain unknown.

Introduction

For decades, mortality of swans from lead toxicosis has been well documented, with the majority of studies based on dead birds and few studies on free-ranging trumpeter swans (*Cygnus buccinator*). The purpose of this research was to evaluate blood lead levels from healthy, free-living trumpeter swans brought into wildlife rehabilitation centres to better understand current blood lead levels in this population that was once extirpated in Ontario, Canada.

Sources of lead in the environment are vast ranging from ammunition; fishing weights and sinkers; mining and smelting operations; and other environmental sources (Blus et al. 1989). Whilst lead shot may be banned in some areas, lead persists in sediment for decades as metallic lead pellets and is neither chemically nor environmentally inert (Scheuhammer & Norris 1996; Thomas & Guitart 2005). Areas heavily hunted for waterfowl may contain more than 300,000 pellets per hectare (De Francisco et al. 2003). According to the Trumpeter Swan Society (2021), as few as three lead pellets can kill a trumpeter swan.

Avian species may ingest lead as they forage for food, with the lead source attributed to fishing sinkers or spent shotgun pellets ingested as grit (Blus 1994).

Keywords

Blood lead; lead toxicosis; trumpeter swan; waterfowl

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Abbreviation

EDTA: ethylenediaminetetraacetic acid

Trumpeter swans' large size and long neck allow them to feed from the bottom of ponds, where other birds may not be able to access (Bowes 1992; Katavolos et al. 2007). Once ingested, the lead shot is retained in the ventriculus, where the grinding action of this stomach coupled with an acidic environment can enhance the absorption of lead, where it will be distributed to soft tissues and stored in bones (Clemens et al. 1975).

Lead toxicosis is a common presentation of sick waterfowl admitted to wildlife rehabilitation centres. It can be a debilitating disease, depending on where lead is found in the body. Lead shot in muscle tissue or other areas outside the gastrointestinal tract may or may not cause significant clinical signs and is usually not a cause of systemic lead toxicosis (Routh & Sanderson 2009). In such cases, morbidity and mortality are often due to the traumatic effects of lead shot on the bones and soft tissue. Lead found in the proventriculus or ventriculus of birds, usually as a result of ingesting a lead sinker or shot whilst foraging, can result in more apparent clinical signs such as neurological (Degernes 1995), cardiovascular (Redig & Arent 2008), weakness (Degernes 1995), depression (Degernes 1995), abnormal faeces (Degernes 1995; Redig & Arent 2008), regurgitation and abnormal ventricular motility (Degernes et al. 1989) or other non-specific signs (Wismer 2016).

The diagnosis of lead poisoning is usually based on history, blood lead levels, clinical signs, radiology, blood chemistry, haematology and tissue analysis (Nakade et al. 2005; Redig & Arent 2008; Samour 2016). The level of lead in the blood and its impact from a toxicity standpoint have been reported with variation in the literature. It has been reported that birds with blood lead levels greater than 20 µg/dL in falcons (Samour & Naldo 2002) or 40 µg/dL in swans (Degernes et al. 1989; Sears et al. 1989) could be significantly impacted, and levels of 50 µg/dL or more confirm the diagnosis of lead toxicosis (Samour 2008). Acute signs of lead toxicosis may not be observed even if blood lead levels exceed 50 µg/dL (Eskildsen & Grandjean 1984). The differing opinion regarding significance supports species variation in terms of blood lead level tolerance (Beyer et al. 1988; Carpenter et al. 2003).

Methods

Blood was collected from two groups of trumpeter swans in Ontario, Canada: wild, free-ranging swans ($n = 84$) or swans that were admitted to wildlife rehabilitation centres ($n = 11$). Wild, free-ranging swans were captured by hand and manually restrained, ***whilst approximately 0.3 ml of blood via the medial metatarsal vein was collected and placed into an EDTA blood collection tube. Digital pressure to achieve haemostasis was successfully performed in all birds. All birds appeared healthy by the experienced bird bander who captured the birds. Birds that were admitted to wildlife rehabilitation centres after being found unable to fly or appeared ill were also manually restrained and blood collected in the same manner by trained wildlife medical staff.

Blood lead levels were tested using an in-house lead analyser (LeadCare II System, Meridian Bioscience, OH). Instructions were carefully followed according to the recommendations provided by the manufacturer. Specifically, 50 µL of whole blood placed into an EDTA blood collection tube was analysed within 24 hours when stored between 10°C and 32°C, or 50 µL of whole blood taken from an EDTA blood collection tube was placed into the provided reagent vial, refrigerated at 4°C, and analysed within seven days. Handling and temperature control were per the manufacturer's recommendation, and quality control procedures implemented with each new lot of reagents.

Results

Blood lead levels from 95 trumpeter swans were analysed. Eleven of these cases were admitted to a wildlife rehabilitation centre due to illness or injury (Table 1).

Out of the 11 cases, nine had lead in their blood as indicated with values greater than 3.2 µg/dL, and five cases had metal opacities in the ventriculus based on radiographs with the size of the foreign object ranging from 1 mm × 1 mm to approximately 3 mm × 2 mm. Three of the cases admitted to the wildlife rehabilitation centre were treated for lead toxicity based on clinical signs and blood lead levels.

From the 95 samples, 89.5% of birds had some levels of lead within their blood that was greater than 3.2 µg/dL (85/95) with 30.5% of the birds having lead levels greater than 15 µg/dL (29/95), 20% of birds have lead levels above 20 µg/dL (19/95) and 5% having lead levels greater than 40 µg/dL (5/95; Table 2). Of the 85 birds that had blood lead level values greater than 3.2 µg/dL, 39 birds were adults, and 44 birds were juveniles (two birds were listed as unknown sex or age; Table 3). Of the 10 birds that had blood lead levels less than 3.2 µg/dL, five were juvenile females, three were juvenile males and two were adult males (Table 4). Of the 29 birds that had blood lead level values greater than 15 µg/dL, 13 birds were adults, and 15 birds were juveniles (one bird was listed as unknown sex or age; Table 5).

Out of these 11 cases, nine had lead in their blood as indicated with values greater than 3.2 µg/dL, and five cases had metallic opacities ranging from one to three pellets in the ventriculus based on radiographs, with the size of the foreign objects ranging from 1 mm × 1 mm to approximately 3 mm × 2 mm. These metallic opacities along with elevated blood lead level concentrations were assumed to be lead, but further analysis was not conducted. Lead is not always visualized on radiographs (Samour & Naldo 2002) as was in the case with 67% of the birds in this study that were admitted to rehabilitation centres with blood lead levels greater than 3.2 µg/dL (6/9). Three of the cases admitted to the wildlife rehabilitation centre were treated for lead toxicity based on non-specific clinical signs of not flying, lethargy, neurologic deficits (head tilt, ataxia) and green faeces, along with elevated blood lead levels.

Whilst there is no specific value for which blood levels are known to be attributed to clinical signs in trumpeter swans, non-specific clinical signs (not flying and lethargy) were noted in three swans that were subsequently treated for lead toxicosis or had evidence of metal in the ventriculus with blood lead levels ranging 13.5–38 µg/dL. This study suggests that blood lead values greater than 13.5 µg/dL may be useful for diagnostic purposes when combined with clinical signs, with or without lead present in the ventriculus on radiograph in trumpeter swans.

It was interesting to note that three free-ranging, apparently healthy, wild trumpeter swans had blood lead levels that exceeded 55 µg/dL, where clinical signs would

Table 1 Trumpeter swans brought into wildlife rehabilitation centres due to an inability to fly or as a result of injury or illness.

Swan identification	Metallic opacity in ventriculus on radiograph	Blood lead level values	Treated with chelation therapy?	Presenting complaint
T49	Yes	25 µg/dL, 16 µg/dL after treatment	Yes	Unable to fly
V53	Yes	19.0 µg/dL	Yes	Unable to fly, green faeces
M80	Yes	13.2 µg/dL 38.3 µg/dL 20.1 µg/dL after 1st treatment 33.8 µg/dL two weeks later 25.3 µg/dL after 2nd treatment	No	Unable to fly, pododermatitis, thin body condition
K18	Yes	7.3 µg/dL before release	Yes	Unable to fly Unable to fly, shot, thin body condition
A66	Yes	13.5 µg/dL	No	Unable to fly, head tilt, possible head trauma
T05	No	14.6 µg/dL	No	Unable to fly, pododermatitis, lacerations on bill, walking down city street
M29	No	6.3 µg/dL	No	Unable to fly, fishing line wrapped around wing
K80	No	3.9 µg/dL	No	Unable to fly, fishing line entanglement
X16	No	5.8 µg/dL	No	Unable to fly
M26	No	Low	No	Unable to fly, pododermatitis, abnormal feather growth
Untagged cygnet	No	Low	No	

Table 2 Blood lead levels in trumpeter swans.

	Total number of birds sampled <i>n</i> = 95	% of birds sampled
Number of birds with lead present in blood	85	89.5
Number of birds with lead values > 15 µg/dL	29	30.5
Number of birds with lead values > 20 µg/dL	19	20
Number of birds with lead values > 40 µg/dL	5	5

Table 3 Number of male versus female, and adult versus juvenile trumpeter swans with blood lead values > 3.2 µg/dL.

	Juvenile	Adult	Total
Male	17	22	39
Female	27	17	44
Unknown sex or age			2
Total			85

have been expected. All three birds were located on the same pond, where the known father to two of the cygnets as well as another cygnet went missing. It is unlikely lab error for these values as blood was not taken on the same

Table 4 Number of male versus female, and adult versus juvenile trumpeter swans with blood lead values < 3.2 µg/dL.

	Juvenile	Adult	Total
Male	3	2	5
Female	5	0	5
Total			10

Table 5 Number of male versus female, and adult versus juvenile trumpeter swans with blood lead values > 15 µg/dL.

	Juvenile	Adult	Total
Male	8	7	15
Female	7	6	13
Unknown sex or age			1
Total			29

day for all of the swans, and the test was repeated the same day on the same blood sample with the same results and following the sampling procedures as described by the manufacturer of the blood lead level analyser.

It is possible that the blood lead level in swans will fluctuate depending on the chronicity of the lead toxicity.

The vast majority of lead is stored in the bone, and rebound effects in blood lead levels can be seen, as was attributed to swan K18 admitted to rehabilitation. This rebound effect is due to lead leaching out of the bones and into the blood (Scott 2016).

Mortality rates attributed to lead toxicosis may be underrepresented as they could be attributed to trauma, such as vehicle collision, power line collision or predation, whereas the animal may have been suffering from a sub-lethal dose of lead leading to a secondary cause of death. Kelly and Kelly (2005) note that in one study, mute swans (*Cygnus olor*) with intermediate levels of lead suffer an increased risk of collision with power lines and suggest that they may be too weak to fly with higher blood lead levels.

This study shows that lead toxicosis, even at low blood lead levels, may be a concern for the health and welfare of free-ranging trumpeter swans in Ontario.

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Author biography

Dr Sherri Cox is an Assistant Professor at the University of Guelph, and a wildlife veterinarian. She is the medical director of the National Wildlife Centre Canada, where she regularly provides diagnosis, treatment and surgical intervention for thousands of sick and injured wildlife across the country. As a board-certified specialist (ABVP, Avian), she and her medical team provide medical oversight for wildlife patients at four wildlife rehabilitation centres in Canada. Sherri holds a PhD from the University of Guelph, where her research is focused on lead toxicosis in free-ranging trumpeter swans in Ontario, Canada.

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