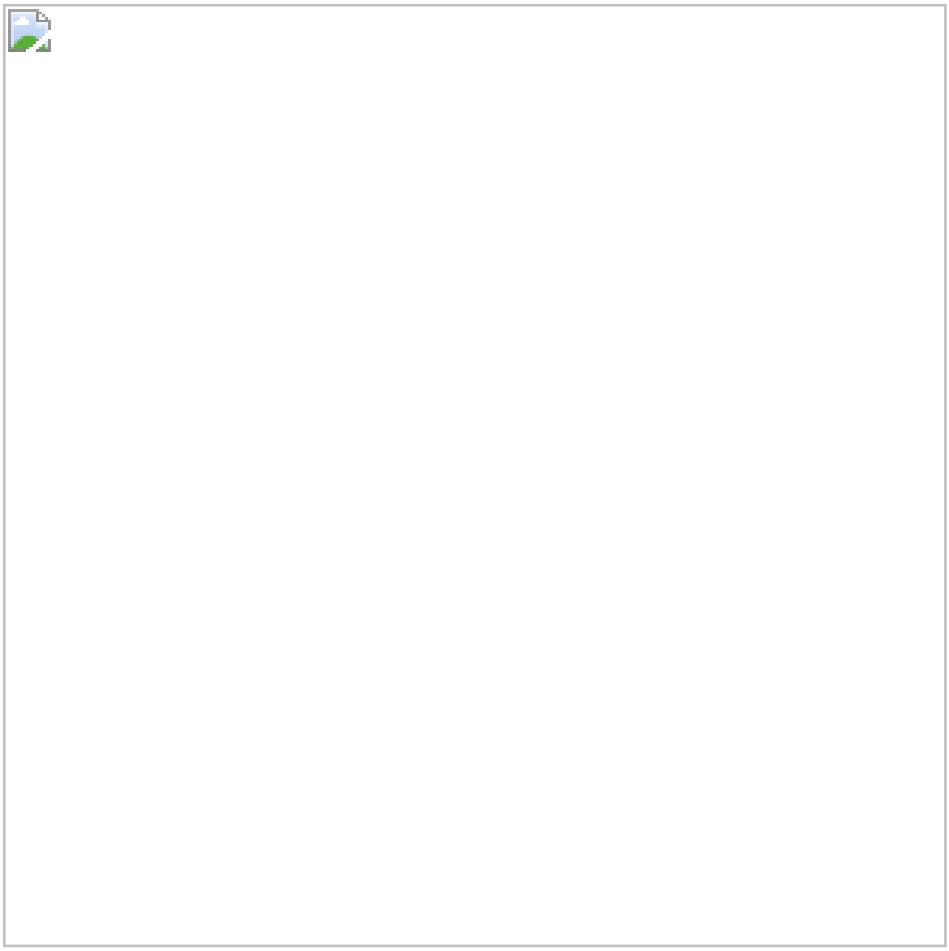

Deadly Gastroliths: Eurasian Siskins Carduelis spinus Poisoned by Road Salt Grains

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Source: Ardea, 102(1) : 101-104

Published By: Netherlands Ornithologists' Union

URL: https://doi.org/10.5253/078.102.0116

Deadly gastroliths: Eurasian Siskins *Carduelis spinus* poisoned by road salt grains

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Töpfer T., Mazánek L. & Bureš S. 2014. Deadly gastroliths: Eurasian Siskins *Carduelis spinus* poisoned by road salt grains. Ardea 102: 101–104.

We describe a case of winter mass mortality of Eurasian Siskins *Carduelis spinus* caused by large road salt grains that birds apparently had mistaken for potential gizzard stones (gastroliths). Clinical evidence revealed acute salt intoxication as the cause of death. We recommend using only small-sized salt grains (<2 mm) for de-icing roads in order to save wintering birdlife from a potentially hazardous substance.

Key words: road salt, salt toxicosis, grit, gastroliths, road casualties

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The use of road salt for de-icing roads is widespread in countries with long frost periods. For example, in the USA 15 to 18 million tons of road salt are applied every year, causing long-term contamination of groundwater and soil as well as intoxicating plants and animals (Jackson & Jobbágy 2005, IAPPO 2007). Birds are affected when salt is ingested: i) directly as salt granules (Meade 1942, Trainer & Karstad 1960, Baker 1965, Oeser 1977, Bennetts & Hutto 1985, Glutz von Blotzheim 1997, Mineau & Brownlee 2005, Environment Canada 2011), ii) indirectly as a salt solution when drinking (Windingstad *et al.* 1987, Stolley & Meteyer 2004, Töpfer 2010), or iii) during foraging and preening (Meteyer *et al.* 1997, Gordus *et al.* 2002). Since, to our knowledge, no observational and clinical confirmation of direct lethal salt poisoning exists to date, we describe a case of mass mortality of Eurasian Siskins *Carduelis spinus* apparently caused by ingestion of granular road salt.

Observations

The incident took place on 25 January 2005 in the village of Lošov near Olomouc in the Czech Republic (49°37'20"N 17°21'52"E; 320 m a.s.l.) when a flock of 38 Eurasian Siskins *Carduelis spinus*, observed by Mr. Příza, was seen feeding on Black Alder *Alnus glutinosa* seeds close to a salt-treated road. The weather was windy, with passing snowfall and air temperature at about –5°C. Subsequently, the Siskins settled on the road. Within 5–10 minutes their behaviour changed completely, as all of them were immobilised almost instantly. When the eyewitness returned after fetching his camera, all the birds had actually died within 5 minutes. A number of birds, as well as some salt granules, were collected for later analyses. The next day, Mrs. Příza found a female Siskin in ataxia on the road surface. The bird appeared uninjured externally, but died within several minutes.

Analysis

Five randomly chosen victims (two males, three females) from the incident were dissected at the Laboratory of Ornithology at Palacky University by SB and Viktor Tukač of the Veterinary University Brno. Because of apparent symptoms of acute intoxication, the behaviour of the Siskins on the road, and the sudden mortality, we performed an anatomical-pathological dissection of the digestive tract. The brains were

not dissected. We visually compared a digestive tract of a healthy female Siskin (roadkill, found in a suburb of Olomouc shortly before the described incident) with those of the Lošov birds, using a stereo-microscope.

Among the dissected birds we found symptoms in the digestive tract typical of acute toxic shock. All birds had oedema and distension of the gizzard and intestines, which were partly hanging off the hyperaemic mucous membrane. The contents of the intestines were very dark and irritation and haemorrhaging of the intestine's mucous membrane were evident. The analysis of the salt granules taken from the road revealed that granules consisted of 96% sodium chloride (NaCl). According to the regional road authority, non-toxic potassium ferrocyanide ($C_6N_6FeK_4$; E536) or sodium ferrocyanide ($Na_4Fe(CN)_6$; E535) were used as anti-caking additives in concentrations of less than 200 mg/kg (Olomouc regional centre of road service, pers. comm.). The size of the collected salt granules was 2.0–5.0 mm (n = 16), their average weight 0.035 g (0.007–0.1 g).

Discussion

The symptoms recorded during the dissection of the dead birds and the observation of confused and physically impaired birds were similar to those mentioned in the literature (Trainer & Karstad 1960, Bollinger *et al.* 2005), but with stronger evidence of acute intoxication. Road salt can be a direct agent of mortality because of its dose-dependent toxicity (Mineau & Brownlee 2005). The lethal dose (LD_{50}) of NaCl for House Sparrows *Passer domesticus* was established at 3.0–3.5 g/kg of water-deprived birds (Bollinger *et al.* 2005). Thus, for the much lighter European Siskin (mean body mass 13.0–13.5 g, Dunning 2008), only one salt grain suffices to almost reach this value (0.035 g/salt grain, dose 2.6–2.7 g/kg). Considering that water deprivation of European Siskins during prolonged freezing conditions is likely, and that birds may swallow several salt granules without recognizing the salty taste, acute toxic shock is likely to occur, causing a rapid deterioration of body condition and mobility. While only five salt grains of 2.4 mm diameter represent the LD_{50} for the House Sparrow (Bollinger *et al.* 2005), the bigger salt grains found in Olomouc clearly must have had an even more intense effect on the smaller Siskins.

Many fringillid birds actively take up salt and other minerals (particularly calcium nitrate), sometimes on a regular basis. Sources are efflorescences on masonry constructions and rocks, road salt, salt licks, and even natural urine accumulations (Bleitz 1958, Dawson *et al.* 1965, Oeser 1977, Flaxmann 1983, Bennetts & Hutto 1985, Glutz von Blotzheim 1997). Moreover, for many seed-eating passerines grit or gizzard stones (gastroliths) play an important role in the digestion of coarse food items, at least seasonally when seeds are the predominant food component (Meade 1942, Glutz von Blotzheim 1997). Apparently, the consumption of grit and minerals is a functional combination of food trituration and mixing ('gastric mill') and physiological needs (Wings 2007).

We assume that the Siskins mistook road salt granules for suitable gizzard stones that might have become temporarily unavailable because of the snow cover. This is also suggested by Allen (in Meade 1942) and Trainer & Karstad (1960). The incident described here bears a striking resemblance to salt-related incidents among North American and European fringillids. Meade (1942), Allen (in Meade 1942) and Baker (1965) report Pine Siskins *Carduelis pinus* and crossbills *Loxia* spp. to have died under virtually the same circumstances as the Eurasian Siskins at Lošov: after having swallowed grains of salt from iced roads, the birds appeared disorientated and were unable to rise, which lead to deadly collisions with cars. Oeser (1977), who found dead crossbills under similar conditions (dense snow cover, road salt use), does not conclude that road salt was the direct cause of death. He argued that pure NaCl is a non-toxic substance to birds and therefore placed greater weight on collisions with vehicles as cause of mortality. Obviously, in his case road salt also must have attracted the birds in the first place.

Unlike regular gizzard stones, of which in House Sparrows 80% will be replaced within five days (Best 1995), road salt rapidly dissolves in the gizzard, causing hazardous physiological effects. Best (1995) shows that the mean volume of gizzard stones is about eight times larger in birds fed on large-grained grit. This implies that consumption of large road salt crystals would instantly lead to a massive multiplication of the salt volume in the birds' gizzards compared to the amount of salt taken up with the same number of small salt granules. As shown experimentally (Dawson *et al.* 1965), Red Crossbills *Loxia curvirostra*, for example, cannot excrete more than 18% of concentrated salt loads within six to seven hours. Thus, fringillids, having no functional glands for salt excretion, will inevitably suffer massive salt shock after having consumed large amounts of road salt.

The consumption of road salt may also be stimulated by the shape and colour of salt granules. In experiments, House Sparrows preferred angular or oblong grain shapes to rounded or spherical shapes (Best 1995), and the former is exactly the shape of

granular road salt. The whitish colour of salt granules may be an additional attraction to birds since light yellowish or white is also the colour of quartz grains, i.e. the predominant natural gizzard stone material in many bird species (Best 1995, Best & Gionfriddo 1991, Bureš 1993).

There are no data pertaining to what extent the use of road salt contributes to bird mortality on roads, the latter conservatively estimated to claim millions of casualties each year in Europe (Erritzøe *et al.* 2003). However, road salt poisoning and subsequent collisions with traffic are widespread only in regions with severe winter conditions. In the Czech Republic in the winter of 2004/05, about 52 tons of road salt were applied per km on governmentally maintained motorways and about 18 tons/km on first level roads (Road and Motorway Directorate of the Czech Republic 2013). During the same period, in the Olomouc region, with its slightly warmer annual average temperature, about 8 tons/km were used on first class and 6 tons/km on second and third class roads (source: Olomouc regional centre of road service). Picking up grit from roads might be dangerous in general, as reported from exceptional highway mortality of songbirds during summer (Smith 1981). Nonetheless, the incident discussed above clearly documents the risks of road salt to birdlife, further aggravated by the recent tendency towards using bigger salt grains which persist on roads for a longer time. This increases the risk of consumption by birds as gastroliths. Moreover, excessive amounts of salt are used not only on main roads, but also on footpaths and in parks.

We recommend using road salt more responsibly and only in grain sizes not exceeding 2 mm in diameter. Although smaller grain sizes will not overcome the problem of contamination of soil and water, we are convinced that at least a direct hazard to wintering birds could be minimised if small-grained salt is applied. Alternatively, the use of sand as a substitute for salt should be considered.

We would like to thank Mr. and Mrs. Příza and V. Tukač for documenting the case and for collecting material for our analyses. Our thanks go to the Olomouc regional centre of road service for information on road salt use, to S. Rick for her comments on the manuscript and to D. Voeten for providing the Dutch summary. The study was supported by the Grant Agency of Palacký University (B.S., IGA PrF-2014-018).

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Samenvatting
We beschrijven een geval van massale wintersterfte onder Sijzen *Carduelis spinus* die klaarblijkelijk werd veroorzaakt doordat grote korrels strooizout door de vogels werden verward met potentiële maagstenen (gastrolieten). De vogels, die eerst hadden gefoerageerd op zaad in elzenproppen, waren binnen luttele minuten dood nadat ze op de naastgelegen weg waren geland en van het strooizout hadden gegeten. Klinisch onderzoek heeft acute zoutvergiftiging aangewezen als doodsoorzaak. Wij adviseren het gebruik van uitsluitend kleine strooizoutkorrels (<2 mm) voor het ijsvrij maken van bestratingen om overwinterende vogels te behoeden voor deze potentieel gevaarlijke substantie. (RGB)

Corresponding editor: Rob G. Bijlsma
Received 19 September 2013; accepted 27 March 2014