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Investigation of Chlorophacinone-Related Goose Deaths in Monterey County, California

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ABSTRACT: In 2008, approximately 70 Canada geese were recovered dead in the Moro Cojo Slough area of Monterey County, California. Birds were necropsied and showed signs of abnormal internal bleeding. A total of 37 livers were analyzed for anticoagulants and 36 of these livers contained chlorophacinone. Death was attributable to chlorophacinone poisoning. Two turkey vultures and a barn owl also died, probably as a result of secondary chlorophacinone poisoning. The source of the chlorophacinone was not obvious, as chlorophacinone is used in several different forms on many different crops and also in commensal use. In addition, there often are several days between exposure and death, allowing the movement of the animal from the site of exposure. The ensuing investigations, which lasted several months, suggested that the exposure was due to expanded use of chlorophacinone pellets on artichokes used to control California voles. Subsequently, the label of the rodenticide product was modified to restrict its use when conditions favor goose presence in artichoke fields. No deaths have occurred since the label modification.

KEY WORDS: accidental poisoning, anticoagulant, *Branta canadensis*, California, Canada geese, chlorophacinone, non-target species, rodenticide

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INTRODUCTION

In July 2008, several Canada geese (*Branta canadensis*) were found dead in the Moro Cojo Slough area of Monterey County, California, adjacent to the Elkhorn Slough Ecological Reserve. The surrounding area is largely agricultural with fields of leafy greens and artichokes. Necropsy of the geese revealed abnormal bleeding, a sign of anticoagulant exposure. Over the next 2 months, more than 70 geese died in the same area, as well as 2 turkey vultures (*Cathartes aura*) and a barn owl (*Tyto alba*), apparently from secondary poisoning. An investigation was undertaken into the cause of death of the geese, in cooperation with the Monterey County Agricultural Commissioner's Office, the California Department of Pesticide Regulation, and the California Department of Food and Agriculture. Although chlorophacinone was quickly determined to be the cause of the goose deaths, the investigation was complicated by numerous sources of chlorophacinone, the lag time of several days between exposure and death, and the mobility of the animals. The published toxicity data for chlorophacinone to birds are for single-feeding exposures that do not accurately reflect effects that might occur as a result of multiple exposures over several days or weeks.

METHODS

Six livers from the first batch of geese were excised and sent to the DFG Water Pollution Control Laboratory for chemical analysis. As the die-off continued, 31 more goose livers were analyzed, as well as 4 livers from predators, 2 turkey vultures, a barn owl, and a bobcat (*Felis rufus*). All livers were analyzed for the anticoagulants brodifacoum, bromadiolone, chlorophacinone, diphacinone, coumatetralyl, and warfarin. Four stomach samples were also analyzed for phosphine gas, to rule out exposure to zinc phosphide as a cause of death. Necropsies were performed on all animals associated with the incident.

To help determine the formulation of chlorophacinone that was associated with the exposure, stomach contents from 18 geese were analyzed for the presence of paraffin. Chlorophacinone pellets contain paraffin, but not grain baits or the technical grade product. Samples of water in the Moro Cojo Slough were analyzed for chlorophacinone, to determine if water in the slough was a source of exposure.

RESULTS

All animals necropsied showed signs of abnormal bleeding. No signs of physical trauma were noted, and fluoroscopic examination was negative for the presence of radio-dense objects such as bullets, bullet fragments, or shotgun pellets. Of 37 goose livers analyzed chemically, 36 contained chlorophacinone (Table 1, Figure 1). Trace amounts of bromadiolone were detected in 2 of the livers, and brodifacoum was detected in another goose liver. Livers of both turkey vultures and the barn owl contained chlorophacinone. The liver of the bobcat contained diphacinone but no chlorophacinone (Table 2). Bromadiolone was also detected in the liver of one turkey vulture, and brodifacoum was detected in the liver of the other turkey vulture and the barn owl (Table 2). Water samples taken from Moro Cojo Slough contained no detectable levels of anticoagulants. Stomach samples from geese contained no phosphine gas. Eight of the 18 stomach content samples submitted for paraffin analysis contained paraffin.

DISCUSSION

Chlorophacinone was identified relatively early in the investigation as the cause of the bird loss, based on necropsy findings and chemical analyses. However, the source of chlorophacinone was more difficult to determine. Chlorophacinone, a first-generation anticoagulant, causes death through disrupting blood clotting. Death usually occurs several days after exposure.

Table 1. Chlorophacinone residues found in Canada goose livers, Monterey Co., Calif., summer 2008, by individual carcass sampled.

Date Found	Liver Chlorophacinone (ng/g)*	Date Found	Liver Chlorophacinone (ng/g)*
7/17/08	2,177	9/3/08	89.7
7/17/08	180	9/3/08	159
7/17/08	63.8	9/10/08	15.6
7/17/08	1,592	9/10/08	554
8/13/08	177	9/10/08	831
8/15/08	70.0	9/16/08	6.7
8/25/08	205	9/8/08	95.6
8/25/08	161	8/23/08	217
8/25/08	228	8/26/08	26.1
8/25/08	387	8/26/08	206
8/25/08	76.7	9/4/08	67.5
8/25/08	143	9/4/08	112
8/25/08	122	8/26/08	5.6
8/25/08	455	9/22/08	4.6
8/25/08	586	7/30/08	113
8/25/08	78.6	9/8/08	45.5
8/25/08	<2.0	9/8/08	202
8/25/08	249	9/8/08	167
9/3/08	356		

* fresh weight

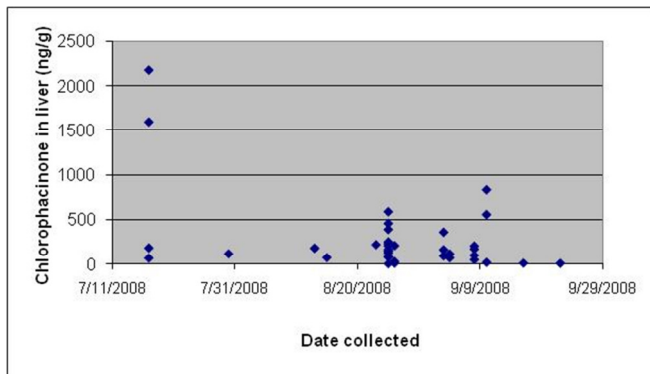


Figure 1. Chlorophacinone residues found in Canada goose livers, Monterey Co., Calif., summer 2008, with residue amounts plotted through time.

Table 2. Chlorophacinone and other anticoagulant rodenticide residues in livers of predators found dead, Monterey County, Calif., summer 2008.

Species	Date Found	Liver Chlorophacinone (in ng/g, wet weight)	Other Anticoagulants Detected (in ng/g, wet weight)
Bobcat	8/26/08	<2.00	diphacinone (340)
Turkey vulture	9/3/08	4.89	bromadiolone (1.09)
Turkey vulture	9/5/08	4.04	brodifacoum (436)
Barn owl	9/10/08	13.8	brodifacoum (4.52)

Geese typically fly around during the day and may feed at several different locations, making it difficult to pinpoint the source of exposure.

There were several formulations of chlorophacinone in use in the area, including grain baits, paraffin-coated pellets, and soaked artichoke bracts (Casey McSwiggin, Monterey Co. Agricultural Commissioner's Office, pers. commun.). There are also chlorophacinone products registered for use against commensal rodents. As Canada geese are often regarded as pests, the possibility of intentional poisoning also needed to be investigated. Chlorophacinone has been used largely without obvious incidents in California for a few decades, suggesting that the situation causing the goose mortalities was likely to be a new use or a misuse. The concentrated form of chlorophacinone that is used to soak artichoke bracts for California vole (*Microtus californicus*) control offered a potential means for intentionally poisoning the geese. The Monterey County Agricultural Commissioner's Office researched this possibility, but they were able to account for all stores of the concentrated product (Casey McSwiggin, pers. commun.).

Laboratory studies on chlorophacinone toxicity to birds generally use single-feeding exposure scenarios to generate acute toxicity (LD₅₀) values. Acute LD₅₀ values for chlorophacinone to birds are in the range of 200 to 500 mg/kg (US EPA 2008). Given the low concentration of chlorophacinone (0.005 - 0.01%) in field baits, an 8-lb bird would have to ingest about 3 lbs of rodenticide product to receive an acutely toxic dose.

There is a need to develop toxicity values that more accurately reflect field exposure scenarios. For example, the lethal dose for a goose feeding on chlorophacinone over several days to several weeks is unknown, but based on toxicity studies of anticoagulants to mammals and birds, it is likely to be substantially less than a single dose LD₅₀ value (US EPA 2004).

The use that was identified as the most likely source of the chlorophacinone was a paraffin-coated pellet used in artichoke fields. Due to the unavailability of an alternative product for vole control, the use of this pellet on artichokes had been extended later into the 2008 growing season. The rodenticide pellets were present on the ground at the time that artichoke plants were cut back, making them accessible to geese. The presence of paraffin in the stomach contents of 8 of the 18 geese tested support this explanation. The lack of paraffin in the stomachs of the other geese can be attributed to the lag time between exposure and death, allowing paraffin to pass from the digestive system.

It is a normal cultural practice, at the end of the growing season, to cut artichoke plants back to the bottom of the stem near the soil surface and dispose of the aboveground plant materials, allowing the plants to re-sprout from the root for the next season's production. California voles can be tremendously destructive to artichoke plants, and growers in Monterey County, California typically treat most of their fields annually in an attempt to control vole damage (Salmon and Gibson 2003).

As a result of the investigation, the registrant of the paraffin-coated pellet product submitted an amended 24(C) label specifying that the product was not to be applied to artichokes during the month preceding, and the month following, plant cutback. There have been no similar goose deaths in the area since the label was changed.

ACKNOWLEDGEMENTS

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