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Incidental Kill of Dunlin and Killdeer by Strychnine

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ABSTRACT: Strychnine poisoning of 36 dunlin (*Calidris alpina*) and two killdeer (*Charadrius vociferus*) in Yolo County, California (USA) was documented from 11 to 17 December 1990. Birds were found dead on a field containing treated wheat seeds (337 μg strychnine/g seed) in postures consistent with the known physiopathology of strychnine poisoning: rapid rigor mortis, wings folded over backs, straightened toes, and fecal material extruding from vents. Five dunlin and two killdeer were necropsied, and their crop and stomach contents were analyzed by high performance liquid chromatography for the presence of strychnine. The mean (± SD) actual unabsorbed strychnine concentration per amount stomach content for the five dunlin was 110 (± 108) μg/g and for the two killdeer, 210 (± 109) μg/g. Shorebirds have not been identified previously as victims of pesticides.

Key words: Strychnine poisoning, shorebirds, *Calidris alpina*, *Charadrius vociferus*, California, pesticides.

Human-produced chemicals toxic to avian species are abundant (Schafer et al., 1983), and commonly applied in ways detrimental to birds (O'Connor and Shrubb, 1986). Strychnine, an alkaloid extract of the plant dog button (*Strychnos nux vomica*) has been used for bird and mammal control (Hudson et al., 1984). Currently, its use generally is limited to below ground application for rodent control, but it has been ranked in California (USA) as one of the most hazardous pesticides for nontarget wildlife due to its toxicity and secondary persistence (Littrell, 1990). Strychnine significantly affects nontarget avian species, especially raptors and granivorous birds (Schmutz et al., 1989; Apa et al., 1991).

Here we report on an incidental kill of dunlin (*Calidris alpina*) and killdeer (*Charadrius vociferus*) that ingested strychnine-laced wheat seeds broadcast on a field for rodent control. Ingestion of grain by birds in the shorebird families (Charadriidae and Scolopacidae) rarely has been reported (Rahmani and Shobrak, 1992), and we know of no published accounts of shorebirds dying from strychnine poisoning.

On 11 December 1990, in Yolo County, California (38°41′N, 121°45′W), we observed dead dunlin and killdeer in a partially flooded grass field (hereafter referred to as the polo field). The polo field was approximately 25 m × 75 m, consisting of closely mowed grass surrounded by a weedy edge. Water covered about 30% of the field, and water depths did not exceed 8 cm. We searched the polo field and its surrounding edge each day from 11 to 17 December. Complete searches were conducted on and around the polo field, and it is doubtful that any birds were overlooked as the habitat was limited and open. Application rates of grain and acre-treatment estimates of strychnine were unknown. We collected samples of grain throughout the polo field including flooded portions. All dead birds found were placed in plastic bags and then put on ice until they could be transferred to freezers. We measured the length of the exposed culmen of each dunlin, and weighed the dunlins found on 11 December. Dunlin were aged according to the presence (juvenile) or absence (adult) of buff-color edges on their inner wing coverts (Page, 1974). The sex of each dunlin was determined as male if the exposed culmen was ≤ 37.7 mm, female if the exposed culmen was ≥39.8 mm, and as unknown if the exposed culmen length was between 37.8 and 39.7 mm (Page, 1974). Except for weight, the killdeer were not measured.

Five dunlin were necropsied at the Cal-

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TABLE 1. Shorebirds found dead on polo field in Yolo County, California, 11 to 14 December 1990.

	Dunlin			Killdeer		
	Juvenile	Adult	Unknown	Juvenile	Adult	Unknown
Male	3	17	0	0	0	0
Female	2	6	1	0	0	0
Unknown	1	6	0	0	0	2

ifornia Department of Fish and Game (CDFG) laboratory, Rancho Cordova, California. An additional five dunlin, two killdeer, and a grain sample were sent to the National Fish and Wildlife Forensics Laboratory (NFWFL), Ashland, Oregon (USA) for necropsy examination and quantitative analysis of strychnine concentrations. Quantitative analysis of strychnine was accomplished with high performance liquid chromatography (HPLC) using a HP 1090 HPLC with a diode array detector (Hewlett Packard Company, Wilmington, Delaware, USA) set to a wavelength of 254 nm. With this system we used a Merck LiChrospher 100 RP-18 (5 micron) (Hewlett Packard Company, Palo Alto, California) in LiChroCART 125. The solvent employed in HPLC was 20% CH_3CN and 80% KH_2PO_4. Operating parameters included an oven temperature of 35 C, a maximum pressure of 400 bar, and a solvent flow rate of 0.75 ml/min. The retention time for strychnine under the above conditions was 1.08 min. Diphenylamine was used as an internal standard. Retention time for diphenylamine was 2.29 min. A linear response for strychnine was established with five concentrations ranging from 5 to 100 μg/ml.

Approximate maximum numbers of birds observed feeding on the polo field on a given day included 300 dunlin, 200 black-bellied plover (*Pluvialis squatarola*), 50 killdeer, as well as 100 Brewer's blackbirds (*Euphagus cyanocephalus*) and 100 European starlings (*Sturnus vulgaris*). We found 36 dead dunlin and two dead killdeer (Table 1). Several birds appeared to have died while feeding, with bills inserted in the soil. This is consistent with the known physiopathology of strychnine poisoning where onset of symptoms is rapid, as is rigor mortis after death (Buck and Osweiler, 1982). Many of the birds had their wings folded over their backs, toes straightened, and fecal material extruding from the vent. Five of the dunlin had been partially scavenged, perhaps by a red-tailed hawk (*Buteo jamaicensis*) and a loggerhead shrike (*Lanius ludovicianus*) that we saw perched nearby.

Three of the five dunlin necropsied at the CDFG laboratory had undigested and recognizable treated wheat seeds in their gizzards. The other two birds had what appeared to be cellulose in the gizzard, and one had an earthworm in the proventriculus. All of the birds sent to NFWFL had freshly ingested grain in the stomach. A sample of grain from the field contained a concentration of 337 μg strychnine per gram of seed. All birds examined appeared to be healthy; based on the necropsies, there was no evidence that trauma or infectious disease caused their death. No histopathological lesions were reported. Four of the five dunlin examined had measurable amounts of strychnine in the gut contents ranging from 12 μg strychnine per 0.4 g actual stomach content to 244 μg per 0.9 g. The mean (± SD) strychnine concentration per gram actual stomach content for the five dunlin was 110 (± 108) μg. One killdeer necropsied had 106 μg strychnine per 0.8 g actual stomach content while the other had 86 μg strychnine per 0.3 g.

Hudson et al. (1984) found strychnine to be extremely toxic to birds with the mean doses at which 50% of animals tested died (LD_{50}) ranging from 2.0 μg strychnine per gram of body mass in mallard (*Anas platyrhynchos*) ducklings to 24.7 μg in adult, male pheasants (*Phasianus* sp.). Body mass may be a factor in susceptibility of shorebirds to strychnine poisoning. Dunlin, the lightest ($\bar{x}$ body mass ± SD = 57 ± 4 g, n = 12, this study) species of shorebird we observed feeding in the field, had the highest mortality rate, while we only

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found two dead killdeer ($\bar{x}$ body mass ± SE = 109 ± 5 g, n = 2, this study) and no black-bellied plovers ($\bar{x}$ body mass ± SE = 220 ± 24 g, n = 31, Dunning, 1993). Other factors also could have affected mortality rates. It is possible that dunlin fed more on grain than plovers, although this is not likely. Dunlin typically feed by probing the substrate while plovers pick at the surface, and much of the tainted grain was spread on the surface. It also is possible that dunlin have different susceptibilities to strychnine poisoning than do killdeer or black-bellied plover, but this is unknown.

Twenty-nine (81%) of the 36 dead dunlin were adults, mostly males (Table 1). It currently is unknown whether this is a representative sample of dunlin in the Central Valley of California. Perhaps smaller billed, male dunlin are more likely to leave coastal estuaries and feed in interior agricultural areas as done by smaller-billed, male curlew (*Numenius arquata*) in Europe (Townshend, 1981).

Interestingly, no starlings or blackbirds were found dead. Both species feed on grains, and both have been reported incidentally killed by strychnine (Schmutz et al., 1989). The LD_{50} of strychnine sulfate for starlings is less than 5.0 μg per gram of body weight (Schafer et al., 1983), or, using a conversion factor of 1.28 units strychnine alkaloid per 1.00 units strychnine sulfate as suggested by Hudson et al. (1984), 6.4 μg of strychnine alkaloid per gram of body weight; however, Hudson et al (1984) note this conversion does not work for all species. A starling with a mean mass of 80 g (n = 915; females; Dunning, 1993) would have needed to eat approximately 1.5 g of the treated seed (337 μg strychnine per gram seed) to reach the LD_{50} level. A Brewer's blackbird with a mean mass of 58 g (n = 15, females; Dunning, 1993) would have needed to ingest 1 g of the treated seed. This assumes the LD_{50} for Brewer's blackbird is 6.0 μg strychnine per gram of body weight, as found for the similar sized red-winged blackbird (*Agelaius phoeniceus*) (Schafer and Cunningham, 1972). Based on these results, we believe that starlings and blackbirds were not feeding on grain, but rather on other items such as invertebrates. It also is possible that grain was out of reach, perhaps under water, for starlings and blackbirds; however, we did not document where birds fed with respect to the water or where grain lay on the field.

The danger of secondary poisoning by strychnine of nontarget avian groups such as granivorous birds and raptors is well recognized. Shorebirds previously have not been considered to be at great risk to this type of toxin. In crop producing areas, such as the Central Valley of California, grain may be an important component of the diet of certain species of shorebirds, and this deserves further study. The use of poisoned grains in areas used by nontarget wildlife needs to be strictly discouraged to avoid incidences such as the one reported here.

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