SHORT COMMUNICATIONS

REPELLENCY AND TOXICITY OF THREE BIRD CONTROL CHEMICALS TO FOUR SPECIES OF AFRICAN GRAIN-EATING BIRDS

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Birds damage thousands of tons of ripening cereal grains worth millions of dollars annually in Africa. In Sudan, Denver Wildlife Research Center (DWRC) personnel are working with the Ministry of Agriculture to reduce crop losses to depredating birds. Although the red-billed quelea (*Quelea quelea*) is the primary pest in most of the countries, many other species also cause severe damage (Anon. 1980). In Sudan these other species include village weavers (*Ploceus cucullatus*), golden sparrows (*Passer luteus*), red bishops (*Euplectes orix*), and occasionally masked weavers (*Ploceus taeniopterus*).

The control measures used by the Sudan Plant Protection Department are directed at population reduction of highly gregarious species (such as quelea) through the aerial application of the avicide fenthion (O,O-Dimethyl O-[3-methyl-4-(methylthio)phenyl]phosphorothioate). Because of the potential primary and secondary poisoning problems posed by fenthion, development and application of an alternate control chemical is desirable.

Our objective was to determine the susceptibility of 4 species of birds (which damage cereal crops in Sudan and certain other African countries) to 3 chemicals regularly used in bird damage control in the United States (Dolbeer 1980): the avicide, Starlicide (3-chloro-4 methylbenzenamine); the repellent, methiocarb (3,5-dimethyl-4-(methylthio)phenyl methylcarbamate); and the frightening agent, Avitrol (4-aminopyridine). Our laboratory tests were designed to indicate the potential of Starlicide as an avicide in Africa, help explain the variable results obtained with methiocarb, and provide a basis for initiating field trials with Avitrol.

Starlicide has not been investigated for use in Africa because of its apparent lack of toxicity to some African species (Schafer et al. 1973). Methiocarb has proven to be an effective repellent in many farming situations and is gaining increasing acceptance throughout Africa (Bruggers et al. 1981), the United States, and New Zealand. Inconsistent field results, however, possibly due to differences in susceptibility of the bird species (Bruggers 1979), has slowed its development in some countries. Avitrol has not been extensively integrated into crop protection programs in Africa.

METHODS

Fourteen village weavers, 38 golden sparrows, 20 red bishops, and 21 masked weavers were imported from Sudan to DWRC during 1980 and held under strict quarantine in an aviary (2.4 × 2.4 × 3.6 m) for 3 months, in compliance with U.S. Department of Agriculture requirements. All birds had access to water, grit, and a 1:1:1 mixture of whole millet, whole-grain sorghum, and Purina Game Bird Chow. A photoperiod of 12 L:12 D, with 15-minute "dawn" and "dusk" periods, was used continuously.

After quarantine, the birds were placed

by species in communal wire mesh holding cages (53 × 25 × 38 cm), with no more than 10 birds/cage. Each bird was leg-banded for identification. Food availability and photoperiod were the same as during quarantine. For the toxicity and repellency tests, individual birds were placed in wire mesh cages (15 × 23 × 30 cm) that were divided with a wire mesh wall to form 2 cages 15 × 23 × 15 cm.

Repellency Test

Test methods were similar to those described by Shumake et al. (1976) and were based on the original methods of Starr et al. (1964) and Schafer and Brunton (1971). Potential tests birds were fed only hulled prosso millet for 5 days, and then offered a choice of millet or a 1:1:1 mixture of sorghum, millet, and Purina Game Bird Chow for 2 days. After this conditioning period, each bird was pretested for 19 hours on about 40 millet seeds. Only birds that ate all the millet seeds were used for further testing. Birds had continuous access to water.

Millet for the repellency tests was prepared by adding the amount of methiocarb required to achieve the desired application level in 5 ml of acetone to 100 g of millet, shaking to mix and venting to evaporate the acetone. Individual pretested birds were offered 37 treated millet seeds for a 19-hour period (12 D:7 L), then returned to the communal cages containing their maintenance diet. The number of millet seeds remaining in each test cage was counted, and birds that consumed ≤18 seeds were considered repelled. If one-half or more of the birds at the initial treatment level were repelled, 2 additional one-half log step lower treatment levels (0.032 and 0.32%) were used. If less than one-half of the birds were repelled, the next treatment level was a one-half log step higher (0.32%). Depending on the results from these tests and the availability of pretested birds, treatment levels for additional birds were raised or lowered in increments of one-fourth log step. Four village weavers and 6 individuals of each of the other species were tested at each level. We calculated repellency indexes (R_{50}'s), median effective dose (ED_{50}), and 95% confidence limits (CL) by using the Thompson-Weil method (Thompson 1948, Thompson and Weil 1952, Weil 1952).

Toxicity Test

Test methodology was based on that previously described by Schafer et al. (1973). Two hours before dosing, each bird was weighed, classified as to sex, then fasted until the time of dosing. Acute oral LD_{50}'s were determined by gavage with propylene glycol solutions of technical grade chemicals prepared, so that the dose volume of liquid administered (in μl) was twice the bird's weight (in g). A microsyringe with a short length of polyethylene tubing attached to a hypodermic needle was used to administer the solutions. The tubing was introduced into the esophageal opening and the gastrointestinal tract until resistance was reached. Birds were individually caged and observed closely for 4 hours after dosing for signs of toxic effects, then given water and maintenance diet. They were observed during the next 5 days for mortality, immobility, and other signs of toxicosis; all survivors were returned to the communal cages.

Two birds per species were initially used at each treatment level. Two additional birds were tested at each level when they were available. Survivors were used again after a minimum rest period of 2 weeks. Initial LD_{50} treatment levels for Avitrol and methiocarb were 10 mg/kg, and for Starlicide 100 mg/kg.

Table 1. Feeding repellency of 5 species of African birds to methiocarb-treated millet seeds.

Species, avg wt and range (g)	Treatment level (%) Number of birds repelled/number tested (percent of food offered that was consumed)								R_{50} (%)	95% CI (%)
	0.010	0.018	0.032	0.056	0.100	0.178	0.316	0.562		
Village weaver 34.9 (27.0–40.0)			0/4 (83.8)	2/4 (64.9)	3/4 (46.6)				0.063	0.038–0.100
Golden sparrow 14.4 (13.0–16.5)					2/6 (64.9)	4/6 (41.9)	3/6 (45.1)	5/6 (14.0)	0.178	0.075–0.420
Red bishop 15.2 (12.4–19.2)					1/6 (82.9)	5/6 (28.3)	4/6 (31.1)		0.133	0.077–0.230
Masked weaver 20.1 (17.0–24.0)			2/6 (73.9)		3/6 (57.7)		6/6 (14.9)		0.076	0.029–0.200
Red-billed quelea[a] 21.5 (18.0–25.0)	0/5	4/5	4/5		4/5				0.015	0.011–0.021

[a] From Shumake et al. (1976).

Treatment levels were increased in progressive one-fourth log intervals until both birds of a species died and were decreased by similar intervals until none of the birds was dead or immobilized. We calculated LD_{50}'s and TI_{50}'s (temporary immobilization) by using the Thompson-Weil method (Thompson 1948, Thompson and Weil 1952, Weil 1952).

RESULTS AND DISCUSSION

Under laboratory conditions, *Ploceus* weavers, golden sparrows, and red bishops all showed differences in repellent sensitivity to methiocarb. These species were, however, 4.2–11.8 times less sensitive than red-billed quelea (Table 1). This may explain some of the inconsistent results obtained in methiocarb field trials in Sudan and other African countries involving these species. Some observations during other field trials in Africa suggest that these species may be more easily repelled by methiocarb than quelea (Bruggers 1979), indicating the importance of the many factors mentioned by Martin and Jackson (1977) to the successful use of repellents. It is possible that the smaller, less dense, and less cohesive social feeding patterns of these species, compared with those of red-billed quelea, may account for the greater field efficacy of methiocarb when these species are involved.

The LD_{50}'s of Avitrol for all 4 speces were less (1.78–4.22 mg/kg) than the LD_{50} previously determined for quelea (5.62 mg/kg; Table 2). All 4 species exhibited typical Avitrol distress behavior, and ED_{50}'s for distress were similar to the LD_{50}'s for all species except the golden sparrow. Similar distress reactions were observed during outdoor aviary tests in Senegal in 1976 with golden sparrows, red bishops, and village weavers (Bruggers, pers. observ.).

Only a few field tests have been conducted in Africa with Avitrol, principally because the lethal and distress-eliciting dosages for most of the pest species were unknown and because safe baiting procedures or chemical application procedures need development. Two preliminary tests in Chad and Kenya in 1973 showed that golden sparrows, red bishops, red-billed quelea, black-headed weavers (*Ploceus melanocephalus*), and chestnut weavers (*Ploceus rubiginosus*)

Table 2. Lethal and effective dosage levels of methiocarb, Avitrol, and Starlicide for 5 species of African birds.

Species	Methiocarb		Avitrol		Starlicide	
	2 birds/level	4 birds/level	2 birds/level	4 birds/level	2 birds/level	4 birds/level
Village weaver						
LD_{50} (mg/kg)	7.50	7.50	4.22		>316	
95% CL	NC[a]	2.93–19.2	NC		NC	
ED_{50}[b] (mg/kg)	7.50	5.11	3.16		>316	
95% CL	NC	3.06–8.52	1.78–5.62		NC	
Golden sparrow						
LD_{50} (mg/kg)	5.62	5.62	2.37	2.74	316	287
95% CL	3.16–10.0	3.32–9.51	NC[a]	NC	178–562	173–480
ED_{50} (mg/kg)	3.16	2.74	10.0	5.00	133	133
95% CL	1.78–5.62	2.05–3.65	1.00–100	NC	NC	NC
Red bishop						
LD_{50} (mg/kg)	5.62	7.50	1.78	2.37	237	215
95% CL	3.16–10.0	4.36–12.9	1.00–3.16	1.58–3.59	NC	167–278
ED_{50} (mg/kg)	3.16	3.89	1.78	2.37	237	215
95% CL	1.78–5.62	2.96–4.94	1.00–3.16	0.110–51.1	NC	167–278
Masked weaver						
LD_{50} (mg/kg)	7.50	4.87	4.22	4.87	>316	>316
95% CL	NC	3.14–7.55	NC	3.65–6.49	NC	NC
ED_{50} (mg/kg)	3.16	1.78	4.22	4.87	>316	316
95% CL	1.78–5.62	1.28–2.48	NC	3.14–7.56	NC	84–1,195
Red-billed quelea[c]						
LD_{50} (mg/kg)	4.22		5.62		31.6	
95% CL	NC		3.16–10.0		17.8–56.2	

[a] NC = not calculable.
[b] ED_{50} for methiocarb and Starlicide is temporary immobilization; for Avitrol it is distress.
[c] From Schafer et al. (1973).

would consume 2% Avitrol-treated grains when broadcast at 1 and 10 kg/ha in field edge shelterbelts (DeGrazio 1973). These birds exhibited typical Avitrol distress behavior, but flock mobbing action was not observed. The results of these tests, in conjunction with our laboratory data, indicate that further field investigations of Avitrol baiting techniques, such as spraying part of the crop (border rows) or alternative grain, may result in effective Avitrol-induced fright responses.

Starlicide was less toxic to the 4 species we tested than to red-billed quelea (Table 2). Because these species were relatively insensitive, Starlicide does not seem to offer a satisfactory alternative to other, more toxic avicides.

Acknowledgments.—We thank W. Bohl for collecting and shipping the birds from Sudan and B. Johns for organizing and supervising the importation and quarantine period for the birds. M. Fall, T. Hall, and M. Marsh assisted in dosing the birds. S. Shumake and P. Savarie reviewed the manuscript. The research was conducted with funds provided to the U.S. Fish and Wildlife Service by the Agency for International Development under the project "Control of Vertebrate Pests: Rats and Noxious Birds," PASA ID/TAB-473-1-67. Reference to trade names does not imply U.S. Government endorsement.

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Received 23 February 1981.
Accepted 12 July 1981.

POTENTIAL SECONDARY HAZARDS OF AVITROL BAITS TO SHARP-SHINNED HAWKS AND AMERICAN KESTRELS

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Avitrol® is the registered trade name of a number of proprietary bird control products containing the active ingredient 4-aminopyridine (4-AP). Several formulations of Avitrol are available to pest control applicators for use in agricultural areas. Although individual treated bait particles contain from 0.5 to 3.0% 4-AP, the amount present in the 14 federally registered products ranges from 0.3 to 1.0%, depending on the proportion of treated to untreated particles in the ready-to-use baits. Individual birds in depredating flocks ingesting 1 or more of the treated particles exhibit erratic behavior which frightens other birds in the flock. Numerous published references are available which describe the use and results of 1 or more of these products under a variety of conditions (Goodhue and Baumgartner 1965, DeGrazio et al. 1972, Stickley et al. 1972, Dolbeer et al. 1976, Stickley et al. 1976, Besser and Guarino 1977, Knittle et al. 1977, Mott 1977, Stickley et al. 1977, Besser 1978, Woronecki et al. 1979).

Acute oral toxicities of 4-AP to terrestrial vertebrates are high (Schafer et al. 1973), but the chemical is apparently tolerated when ingested or administered at subacute or chronic levels over extended periods of time (Schafer et al. 1974, 1975; Schafer and Marking 1975). Although the subacute and chronic toxicity data are not substantial, they indicate that secondary poisoning (intoxication resulting from the ingestion of the body tissues of prey species containing 4-AP or its metabolites) of a variety of avian and mammalian predators or scavengers should not occur.

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