The Chronic Toxicity of Methiocarb to Grackles, Doves, and Quail and Reproductive Effects in Quail

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SUMMARY

Methiocarb (4-methylthio-3,5-xylyl N-methyl carbamate, Mesurol,** Bay 37344), a bird repellent, was fed in concentrations of 100 to 1,000 ppm to common grackles (*Quiscalus quiscula*), mourning doves (*Zenaida macroura*), and breeding pairs of coturnix quail (*Coturnix coturnix*) to investigate the possibility of cumulative intoxication. Although aversion to treated diets was readily apparent in most of the tests, the 28- to 30-day median lethal concentration (LC_{50}) was determined to be >100 ppm for grackles, 630 ppm (95% confidence limits, 480-830 ppm) for doves, and >1,000 ppm for coturnix quail. Methiocarb appeared to be noncumulative when measured by an index of chronicity: birds consumed several LD_{50} doses during a day's feeding, and when deaths occurred, they appeared to be due to acute intoxication. Egg production and live chick production were not affected in coturnix fed 100 ppm but were reduced at 316 and 1,000 ppm.

INTRODUCTION

The effective uses of the chemical, methiocarb, for protecting crops from bird damage have recently been reviewed by GUARINO (1972), and several registrations are being sought for bird repellent or insecticidal uses. Since birds feeding in crops treated to prevent bird damage could be exposed to methiocarb residues for periods of 7 days (for sprouting seeds) to 6 weeks (for ripening grains), the possibility of chronic intoxication exists. In addition, some repellent applications (on sprouting seeds and ripening fruits) are made during the breeding season of temperate climate birds, and therefore effects on reproduction are also of interest. This paper presents data on these two aspects.

METHODS

All tests were conducted by feeding small groups of birds various levels of methiocarb in their standard laboratory diet

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(Purina Game Bird Breeder Layena). Treated food was prepared by thoroughly blending the standard diet with technical methiocarb in acetone and pelleting. Treated food, and water were always available *ad libitum*; however, because of the aversive nature of methiocarb (SCHAFER and BRUNTON 1971), alternate food sources were not provided during treatment periods.

Common Grackles

Three groups, each consisting of two wild-trapped adult female grackles, were held in wire mesh cages. Environmental conditions were: 12 h light:12 h darkness, temperature of 19° to 23°C, and 20% to 40% relative humidity. After a 7-day pretest period, two groups were fed a diet containing 100 ppm methiocarb for 30 days, while the third group remained on an untreated diet. Body weights of each bird and food consumption of the group were measured every 4 to 7 days throughout the 7-day pretest and 30-day test periods.

Mourning Doves

Eight groups, each consisting of three wild-trapped doves of unknown age and sex, were held, fed, and observed under the same conditions described for grackles. After the pretest period, the eight groups were randomly assigned to four treatments of six birds each. The treatments were 0, 100, 316, and 1,000 ppm methiocarb.

Coturnix Quail

Four groups, each consisting of six breeding pairs of quail (Random Line 926 from the University of California at Davis), were caged in pairs in standard quail-breeding racks (GQF Manufacturing Co.). Environmental conditions were 16 h light:8 h darkness, temperature of 21° to 27°C, and 20% to 50% relative humidity. The birds were tested for four consecutive 2-week periods: pretreatment, first treatment period (T1), second treatment period (T2), and posttreatment. During the two treatment periods, birds were offered food containing 0, 100, 316, or 1,000 ppm methiocarb. During all four periods, egg production was recorded daily, and food consumption and body weight were recorded weekly. In addition, eggs were collected daily, stored through the week in a constant-temperature cooler, and incubated and hatched in a Jamesway Incubator in weekly groups. Hatched chicks were brooded for 10 days. Embryonic mortality, eggshell weakness, hatchability, and 10-day chick mortality were recorded for each of the eight weekly periods of the test.

Data Analysis

Food consumption, weight, and reproductive data were analyzed by multi-way or two-way analysis of variance followed by Scheffé's S test of the means at $P = 0.10$. LC_{50}'s (median lethal concentrations) were determined by the moving-point interpolation method of THOMPSON (1947), THOMPSON and WEIL (1952), and WEIL (1952).

RESULTS AND DISCUSSION

Common grackles appeared to be the most sensitive of the three species to chronic ingestion of methiocarb (Table 1). Although an LC_{50} could not be calculated from the limited data, 100 ppm is probably close to the LC_{50} since one of the four birds treated at this level died, exhibiting acute intoxication symptoms typical of cholinesterase-inhibiting chemicals like methiocarb. Body weight and food consumption of grackles fed 100 ppm methiocarb were less than those of control birds for the entire treatment period, indicating an aversion to the treated food (SCHAFER and BRUNTON 1971). Although the acute oral LD_{50} of methiocarb to common grackles is 10 mg/kg (SCHAFER 1972), most treated birds ingested more than this each day (Table 1). Average consumption was 1.9 LD_{50} doses a day during the 30-day test.

TABLE 1

Effects of feeding methiocarb to adult female common grackles

Methiocarb treatment	No. of birds	Treatment period (days)	Mean body weight (g)	Mean consumption Food (g/day)	Mean consumption Methiocarb (mg/kg/day)	Deaths
Control (0)	2	Pretest	88	23.3	--	0
		1- 4	100	24.4	--	0
		5-11	104	23.1	--	0
		12-18	114	20.3	--	0
		19-25	107	14.2	--	0
		26-30	112	19.0	--	0
Mean for treatment period			107	19.9	--	-
100 ppm	4	Pretest	86	24.7	--	0
		1- 4	78	5.3	6.8	0
		5-11	69	14.7	21.3	1
		12-18	62	15.9	25.6	0
		19-25	68	6.7	9.9	0
		26-30	67	17.9	26.7	0
Mean for treatment period			68	12.4	18.6	-

The calculated LC_{50} of methiocarb for mourning doves was 630 ppm (confidence limits at P = 0.05, 480-830 ppm), and progressive aversion was observed at all three treatment levels. Food consumption dropped significantly after 18 days of treatment for the 100-ppm group, after 4 days of treatment for the 316-ppm group, and within the first 4 days for the 1,000-ppm group. However, body weights were significantly affected by the reduced food intake only in the 1,000-ppm group. As with grackles, mourning

TABLE 2

Effects of feeding methiocarb to adult mourning doves (sex unknown)

Methiocarb treatment	No. of birds	Treatment period (days)	Mean body weight (g)[1]	Mean consumption Food (g/day)[1]	Mean consumption Methiocarb (mg/kg/day)	Deaths
Control (0)	6	Pretest	108a	13.1a	--	0
		1- 4	105a	13.4a	--	0
		5-11	110a	13.0a	--	0
		12-18	118a	16.4a	--	0
		19-25	120a	13.5a	--	0
		26-30	123a	14.1a	--	0
Mean for treatment period			116A	14.1A	--	-
100 ppm	6	Pretest	86a	13.9a	--	0
		1- 4	96a	13.8a	14.4	0
		5-11	100a	12.6a	12.6	0
		12-18	105a	12.6a	11.9	0
		19-25	113a	9.2b	8.1	0
		26-30	110a	6.8b	6.2	0
Mean for treatment period			105A	11.0B	10.6	0
316 ppm	6	Pretest	94a	14.1a	--	0
		1- 4	105a	14.5a	43.6	0
		5-11	98a	9.1b	29.3	0
		12-18	103a	9.0b	27.6	0
		19-25	115a	8.6b	23.6	0
		26-30	112a	5.5b	15.5	0
Mean for treatment period			106A	9.1B	27.2	-
1,000 ppm	6	Pretest	110a	13.5a	--	0
		1- 4	92a	2.0c	22.0	0
		5-11	70b	3.9c	55.7	2
		12-18	65b	7.8b	120.0	3
		19-25	65b	4.7bc	72.3	0
		26-30	61b	7.4b	121.0	0
Mean for treatment period			76B	4.0C	61.1	-

[1] Values followed by different lower case letters are significantly different ($P \leq 0.10$) within treatments. Values followed by different capitol letters are significantly different ($P \leq 0.10$) between treatments.

TABLE 3

Effects of feeding methiocarb to breeding pairs of coturnix quail (six pairs per treatment level)

Methiocarb treatment	2-week period	Mean body weight (g)[1]		Mean consumption		Deaths	Mean egg production (%)[1 2]	Mean live chick production (%)[1 3]
		Males	Females	Food (g/day)[1]	Methiocarb (mg/kg/day)			
Control	Pre	122a	141a	15.6a	--	0	64a	57a
	T1	123a	142a	17.3a	--	0	80a	48a
	T2	127a	144a	17.2a	--	0	79a	61a
	Post	127a	142a	19.1a	--	0	83a	53a
100 ppm	Pre	120a	143a	15.6a	--	0	74a	61a
	T1	118a	144a	18.6a	14.2	0	79a	53a
	T2	119a	151a	19.0a	14.1	0	86a	62a
	Post	120a	149a	19.9a	--	0	70a	54a
316 ppm	Pre	118a	144a	14.6a	--	0	67a	48a
	T1	115a	140a	14.6a	36.1	1♂	75a	38a
	T2	121a	142a	14.5a	34.8	1♀	77a	32b
	Post	119a	142a	19.5b	--	0	58a	32b
1,000 ppm	Pre	118a	142a	14.6a	--	0	81a	66a
	T1	111a	133a	7.9b	64.8	2♀	43b	27b
	T2	111a	124b	10.2b	86.8	1♂ 1♀	17c	0c
	Post	116a	132a	19.5a	--	0	41b	53a

[1] Values followed by different letters are significantly different ($P \leq 0.10$) within treatments.
[2] Percent of 84-egg potential per 2-week period. Eggs laid after death of male not included.
[3] Percent of eggs laid hatching live chicks that survived for 10 days.

doves usually ingested considerably more than an acute oral LD_{50} (10 mg/kg; SCHAFER 1972) of methiocarb daily. Doves fed 316 ppm survived 30 days with an average daily intake of 2.7 LD_{50} doses a day. In the 1,000-ppm group, five of six birds died within 13 days, showing typical symptoms of acute methiocarb intoxication. These five birds ingested an average of 5.6 LD_{50} doses a day before death. The surviving bird ingested as many as 12 LD_{50} doses a day and exhibited only minor disturbance of the motor nerves. This response is typical of reversible cholinesterase inhibiting carbamates such as methiocarb.

The indicated LC_{50} of methiocarb for coturnix was >1,000 ppm for the combined sexes. However, at 1,000 ppm, three of six females and one of six males died (Table 3), suggesting that 1,000 ppm was close to the actual LC_{50}. Weight and food consumption at the 100- and 316-ppm levels were not significantly different from pretest values; however, food consumption in the 316-ppm group was significantly less during the posttest period, probably resulting from less than optimum food consumption during the two treatment periods. One male died on day 5 and one female on day 15. At the 1,000-ppm level, females weighed significantly less during the second 2 weeks of treatment (T2), and food consumption was significantly lower during both treatment periods (T1 and T2). Deaths in this group occurred from 7 to 26 days after treatment began. As with grackles and doves, all mortality appeared to be due to acute intoxication. Since our unpublished data show that the acute oral LD_{50} of methiocarb to coturnix (combined sexes) is 9.50 mg/kg (95% confidence limits, 8.55-10.6 mg/kg), birds fed at 100 ppm consumed an average of 1.5 LD_{50} doses a day; those fed at 316 ppm, 3.7 LD_{50} doses a day; and those fed at 1,000 ppm, 7.9 LD_{50} doses a day.

Although a number of reproductive parameters in coturnix quail were measured, only two--egg production and live chick production (a composite including embryonic mortality, hatchability, and 10-day chick mortality)--were significantly reduced from pretest values, and then only at 316 and 1,000 ppm (Table 3). There was no significant change in any parameter for birds fed 0 or 100 ppm. Birds fed 316 ppm showed no significant change in egg production but produced significantly fewer live chicks during the last 4 weeks (T2 and posttreatment). Birds fed 1,000 ppm were more severely affected: both egg and live chick production in this group were significantly depressed during both treatment periods, and egg production remained depressed through the posttreatment period.

Although methiocarb caused mortality when fed to birds at high levels for 28 to 30 days, the "Index of Chronicity"* (KENAGA 1973) for grackles was <0.54, for doves 0.23, and for coturnix

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* Defined as $\frac{LD_{50}\ mg/kg/day\ (acute\ oral)}{LD_{50}\ mg/kg/day\ (dietary\ feeding)}$

<0.13, indicating that it should not be considered a cumulative toxicant. To calculate these values, we used the average mg/kg/day of methiocarb ingested by grackles at 100 ppm, by coturnix at the 1,000-ppm level, and a projected LD_{50} of 44.2 mg/kg/day based on the LC_{50} of 630 ppm for doves. Deaths showed no pattern in time, and all were apparently due to the ingestion of an acute lethal dose during a single feeding period.

Because of the aversive nature of methiocarb, it was difficult to determine which of the observed effects were due to chemical intoxication or food deprivation. However, it appears that, under field conditions, it would be almost impossible for birds to consume lethal doses of methiocarb, even if minimal alternate food sources were available.

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