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Abstract: Two commercial (ReJeX-iTR brand) formulations of methyl anthranilate (MA), at concentrations of 0.10 - 0.5096 (0 -0.32% active ingredient [a.i.]), were highly effective in repelling mallards *(Anal plaryrhynchos),* and ring-billed gulls *detawarensis)* from pools of water in pen tests. For mallards, pool entries and bill contacts with water in MA-treated pools 1.4 and 4.0% of the levels in untreated pools during a 2-choice test, and 4.2 and 8.8% of the levels in untreated pools during 1-choice test. For gulls, the repellency levels were even higher, with activity levels in treated pools being < 1% of levels untreated pools during I- and 2-choice tests. We recommend further pen tests to determine minimum effective concentrate levels and a field test to determine responses of free-ranging birds.

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In a variety of situations it is desirable to discourage birds from entering bodies of water. For example, gulls, waterfowl, and other bird species often flock to temporary pools of fresh water at airports after heavy rains, creating a safety hazard for aircraft (Blokpoel 1976, Buckley and Gurien 1986). Also, federally-protected waterbirds are sometimes attracted to settingandtailingpondscontainingoilortoxicchemicals(Sturgess etal.1989, Hallock 1990). The development of an environmentally safe compound that could be added to water to repel birds should have wide utility.

Methyl anthranilate (MA), a chemical with demonstrated birdrepellentproperties(Mason et al.1989), is a likely candidate for such use. MA, which has a grape-like odor, occurs in numerous plant species, is used in the perfume and food industries, and is GRAS [listed] (generally recognized as safe) by the United States Food and Drug Administration (Jenner et al. 1964,CodeofFederalRegulations 1988). Our objective was to evaluate 2 commercial formulations of MA (ReJeX-iTR brands) as bird repellents when added to pools of water, using captive, wild birds (mallards and ring-billed gulls).

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METHODS

The experiments were conducted during September and October 1990 at Plum Brook Station, a 2,200-ha fenced facility operated by the National Aeronautics and Space Administra tion in Erie County, Ohio. Birds used in the tests were cap in funnel traps or by rocket net in northern Ohio during J through September 1990.

Mallard Experiment

Eight 8-m x 4-m corrals, each with an attached 2.5-m x 2.5. m x 2.0-m shaded holding pen, were set up on mowed grass in an area isolated from human disturbance. Each corral had 20.8m-diameter or 21.0-m-diameter plastic pools filled with 40 L or 90 L, respectively, of water (10-12 cm deep). Two pinioned mallards were placed in each holding pen and released daily for 9 hours into the corral to acclimate to the test condition for 2 days. Each corral contained a pan of cracked corn, millet, and commercial duck food.

On test day 1,1 of 2 formulations of MA encapsulated into a food-grade starch or polymer matrix (ReJeX-iTR CN121 or ReJeX-iTR CN123, Table 1) was applied to fresh tap water (0.5% w/w) in a randomly selected pool in each corral at 0800. The water depth was measured to nearest ml and the 2 mallards were released in the corral. One of 4 observers (2 corrals per observer) watched each corral for 120 20-second intervals (40 min total) during the next 2 hours. The observer recorded the number of mallards in each pool (pool use) during each 20second interval and the total number of times a bill touched the water (i.e., drinking or bathing activity) in each pool. At 1600 hours, the water depth was remeasured and the mallards were returned to their holding pen where they were provided food, but no water. This routine was maintained on days 2, 3, and 4. The mallards were kept in their holding pens on day 5 (with drinking water and food). On day 6, they were released into the corrals with only the MA-treated pool available. Thebirds were observed as before and the experiment was then terminated.

Table 1. Mean number of mallards and mean number of bill contacts with water in each of 2 swimming pools, l with methyl anthranilate (MA)-treated water and 1 with untreated water, during 120 20-second observation periods on each of 4 consecutivedays,19-22 September 1990. Each pen held 2 mallards.

MA formulation	pens	Mean no. of mallards in pools No. of Day	Mean no. of bill contacts with water MA pool	Control pool	control pool
ReJeX-iTa 76.5	4	1	2.8	17.0	23.3
CN121' 158.8		2	0.5	38.8	3.0
	3		0.0	29.3	4.0
137.5					
	4		0.8	31.3	0.8
103.3					
	x		1.0"	29.1 [b]	7.9°
119.0°					
ReJeX-iTR 35.5	4	1	0.0	15.8	3.3
CN123' 130.3		2	0.0	50.3	1.5

' Approximately 16% MA, applied to pool at concentration of 1 part formulation (by weight) to 200 parts water (0.50% concentration of formulation; 0.08% concentration of MA).

[b] Treatmentmeans are significantly (P < 0.01) different, F=47.3,1 and 3 df; day effect and day x treatment interaction are not significant (P > 0.10), F = 0.3 and 1.3, 3 and 18 df.

° Treatment means are significantly (P < 0.01) different, *F = 47.*6, 1 and 3 df; day effect is not significant (P > 0.10, *F = 0.*8, 3 and 18 df); day x treatment interaction is significant (P < 0.01, *F = 6.*2, 3 and 18 df).

[d] Approximately 64% MA, applied to pool at concentration of 1 part formulation (by weight) to 200 parts water (0.50% concentration of formulation; 0.32% concentration of MA).

Treatment means are significantly (P = 0.04) different, *F = 12.*5, 1 and 3 df; day effect and day x treatment interaction are not significant (P > 0.05), *F = 3.*1 and 2.7, 3 and 18 df.

[f] Treatment means are significantly (P < 0.01) different, F = 42.9, 1 and 3 df; day effect and day x treatment interaction are not significant (P > 0.10), F = 0.9 and 2.0, 3 and 18 df.

Gull Experiment

Methods were the same as in the mallard experiment except that: (1) the tests took place in the holding pens (and not the corrals) because the gulls could fly; (2) only 1 MA formulation (ReJeX-iTR CN123) was tested; and (3) the 1-choice test with only MA-treated pools available lasted 4 days instead of 1 day. Following these tests, a 2-choice test with the ReJeX-iT" CN123 formulation at a concentration of 0.1% (20% of the level used in all previous tests) was run on 7 days over a 9-day period, using a new group of gulls. Four pens (replications) were used. The gulls were fed fresh fish daily.

Randomized block analyses of variance, with repeated measures (days), were used to compare pool use and bill contacts with water between MA-treated and untreated pools in the 2-choice tests. Efficacy of the 2 formulations was compared in the 2-choice test with mallards by a 2-way, repeated measures analysis of variance in which the response variable was the difference in pool use or bill dips between the treated and untreated pools in each pen on each day. Paired t-tests were used to compare the net change in water level between MAtreated and untreated pools, and to compare mean pool use during the 4-day period when treated pools were available and during the 1-day (mallards) or 4-day (gulls) period when only MA-treated pools were available. A square-root transformation was performed on the response variables to normalize the distribution of data.

RESULTS

Mallard Experiment

Both formulations of MA were highly effective (P< 0.04) in keeping the birds from swimming, drinking, orbathing in the MA-treated pools during the 4-day, 2-choice test (Table 1), and in the subsequent 1-day, l -choice test (Table 2). There was no difference (P >0.50, F = 0.3; 1 and 6 df) in effectiveness between the 2 formulations. During the 4-day, 2-choice test, 98.5% of the pool entries and 96.1% of the bill contacts with water (drinking or bathing activities) were in the untreated pools. There were no significant (P >0.05) day effects; the treatment x day interaction was significant (P <0.01) for bill contacts with water with ReJeX-iTR CN121 (Table 1). During the 1-day, 1-choice test, when only MA-treated water was available, pool use and bill contacts were only 3.8% and 8.8%, respectively, of the levels during the previous 4 days when untreated water was available.

Untreated pools averaged a 7- to 9-mm decline in water depth over the 4-day test period compared with an increase (due to rain) of 2 mm for the pools treated with either MA formulation. These significant (P <0.01) differences also indicated greater bird use of untreated pools compared with MA-treated pools (Table 3).

Gull Experiment

The repellency of the MA formulation was even more pronounced than in the mallard experiment. During the 4-day 2-choice test with 0.5% ReJeX-iTR CN123, more than 99% of the pool entries and bill contacts were in untreated pools (Table 4). Water depth also declined more (P = 0.03) in untreated pools (x = -16 mm) than in MA-treated pools, (x = -3 mm) during the 4-day period. During the subsequent 4-day, 1-choice test, only a single incidence of pool use and 83 bill contacts with water were recorded compared with 620 pool uses and 8,846 bill contacts with water (virtually all in the untreated pools) during the 4-day, 2-choice test (Table 5). In the following 7day, 2-choice test with the reduced (0.1 % w/w) concentration of ReJeX-iTR CN123 formulation, no pool entries and only 21 bill contacts with water were recorded in MA-treated pools

(Table 4). During both 2-choice tests, there were significant (P `_ 0.02) day effects, and treatment x day interactions for pool entries and bill contacts (Table 4).

Table 2. Mean number of mallards in swimming pools and bill contacts with water during 120 20-second observation periods on days 1-4 in which the birds had a choice between a control and a methyl anthranilate (MA)-treated pool, and on day 6 when the birds had only the MA-treated pool available, 19-24 September 1990. Each pen held 2 mallards.

			Mean no. of resnanseslday	
			MA and control pools	MA pool only
MA formulation`	No. of available pens	Response variable	(days 1-4)b	(dap 6)b
ReJeX-iTR CN121	4	No. of mallards in pools	30.1°	3.0`
		No. of bill contacts with water	127.(?	19.54
ReJeX-iTR CN123	4	No. of mallards in pools	39.9`	0.0°
		No. of bill	122.1'	2.8f

See Table 1 for concentrations. b Rainfall of 8 mm on days 1-4, 0 mm on day 6. ° Means are significantly (P = 0.02) different, t = 4.64, 3 df. d Means are significantly (P = 0.04) different, t = 3.62, 3 df. ` Means are significantly (P = 0.04) different, t = 3.60, 3 df. f Means are significantly (P < 0.01) different, t = 11.90, 3 df.

Both formulations were highly aversive t entries were recorded in ReJeX-iTR CN121-ti ing 5 days of testing with mallards compared in untreated pools during 4 days of testing. CN123,only 6 entries were recorded in treated l 20 days of testing with mallards and gulls comp; entries in untreated pools during 15 days of testi CN123 contained 4 times the methyl anthran weight) than did ReJeX-iTR CN121(16% by wt

The significant day effects and day x treatment measured during the tests with gulls were probal reduced gull activity in control pools during days (Table 4). There was no trend of increased gut treated pools over time.

Both formulations partially settled on the pa The water appeared only slightly cloudy on days 1 turned orange by day 4, making the bottoms of poc obscured. This color change may have enhanced the ness of the treatments, acting as an aversive agent (Lipcius et a1.1980). However, bird response to the M pools was also highly negative on days 1 and 2 when t no color change. Furthermore, although color can i bird use of water, the strong levels of repellency demography in this study have not been induced by color alone (Li a1.1980>.

In conclusion, ReJeX-iPfonnulations containing L M/ added to water at concentrations of 0.1-0.59'0, 1 highl repellent to mallards and ring-billed gulls in per Additional pe tests should be run with MA at lower concentra lions t determine the minimum effective level for repel In addition, field trial with free-ranging birds should conducted, perhaps a an airport with an established problem birds flocking t temporary pools of water.

Table 3. Mean water depth (mm) in pools either treated with methyl anthranilate (MA) formulation or left untreated in ! each with 2 mallards, over a 4-day period, 19-22 September 1990.

	Treatment pools								Control pools	
MA in formulatiorf	Mean No. of pens	can e depth at start of day 11`	Mean depth change after day: 2	3	4	depth in start of day 1	after day: 2	3	Mean depth i`	et 23 4 dept
ReJeX-iTR CN121	4	112	118	114	113	110	113	118	110	106b
									106	-7
ReJeX-iTR CN123	4	110	115	113	112	112°	110	115	107	103
									101°	-9

` Rainfall of 5 mm during day 1 and 3 mm during days 3 and 4. b Means are significantly (P < 0.01) different, t = 7.36, 3 df.

Means are significantly (P < 0.01) different, t =19.54, 3 df.

Table 4. Mean number of ring-billed gulls and mean number of bill contacts with water in each of 2 swimming pools, 1 with methyl anthranilate (MA)-treated water and 1 with untreated water, during 120 20-second observation periods on each of 4 consecutive days, 29 September-2 October 1990, and on each of 7 days over a 9-day period, 10-18 October 1990. Each pen held 2 gulls.

Percent ReJeX-iTR *CNI23* (MA) concentration	Day	Rainfall (mm)	Mean no. of gulls in pools (n = 4) MA pool	*(n = 41* Control Pool	Mean no. of bill contacts with water MA pool	Control pool
0.50 (0.32)	1	0	1.0	57.8	0.8	794.0
	2	5	0.0	17.3	0.0	285.0
	3	0	0.0	54.5	0.0	827.0
	4	0				
	X			**304.8**		
			0 3	38 5'	0.22	552y.7
0.10 (0.06)	1	16	0.0	0.0	0.0	0.0
	2	8	0.0	0.0	0.0	0.0
	3	0	0.0	4.0	1.3	84.5
	6	0	0.0	15.0	0.8	201.3
	7	0	0.0	17.8	2.5	193.8
	8	0	0.0	34.5	0.8	381.8
	9	12				-(~
	x		0(~	105	O.8a	l~d

' Treatment means are significantly (P < 0.01) different. *F = 61.2,* 1 and *3* df; day effect and day x treatment interaction are significant *(P S 0.02), F = 6.*1 and 4.6, *3* and 18 df. b Treatment means are significantly *(P < 0.01)* different, *F = 55.*7,1 and 3 df; day effect and day x treatment interaction are significant *(P S 0.02), F = 5.*3 and 5.0, 3 and 18 df.

Treatment means are significantly (P = 0.02) different, *F = 20.*2, 1 and 3 df; day effect and day x treatment interaction are significant (P < *0.01), F =11.0* and 9.6, 6 and 36 (if. d Treatment means are significantly (P = 0.02) different, *F* =18.7,1 and 3 df; day effect and day x treatment interaction are significant (P < *0.01), F = 9.*5 and 9.4, 6 and 36 df.

Table 5. Mean number of ring-billed gulls in pools and bill contacts with water during 120 20-second observation periods on days 1-4, when the gulls had a choice between a control and a methyl anthranilate (MA)-treated pool, and on days 6-9 when the birds had only the MA-treated pools available, 29 september October 1990. Each pen held 2 gulls.

Response variable	NO of pens	Mean no. of responses/day MA' & control pools available (days 1-4)b	MA' pool only available (days 6-9)b
No. of gulls in pools	4	38.8°	0.1`
No. of bill contacts with water	4	552 .9d	5.2d

' Approximately 64% MA, applied to pool at concentration of 1 part formulation (ReJeX-iTR CN123) by weight, to 200 parts water (0.50% concentration of formulation; 0.329'o concentration of MA).

b Rainfall of 5 mm on days 1-4, 18 mm on days 6 - 9.

Means are significantly (P <0.01) different, t =10.0, 3 df. d Means are significantly (P <0.01) different, t= 6.2, 3 df.

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