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Methyl anthranilate formulations repel gulls and mallards from water

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Two formulations of methyl anthranilate (MA), one (ReJex-iT™ TP-40 [TP-40]) containing a surfactant, the other (ReJex-iT™ AP-50 [AP-50]) a miscible, free-flowing powder, effectively repelled captive mallards (*Anas platyrhynchos*) from pools of water in pen tests, and/or free-ranging gulls (*Larus delawarensis* and *L. argentatus*) from pools of water in field trials for 4–11 days. With one exception, pool entries and bill contacts with water were reduced ($p \leq 0.02$) in pools treated with both formulations compared with untreated pools. Overall gull activity was reduced ($p \leq 0.01$) when all available water was treated with AP-50. Effectiveness of TP-40 (v/v) was similar to the previously reported effectiveness of powdered formulations where MA concentrations were 1.6–3.0 times (g/g) greater, a consequence of the surfactant concentrating MA at the surface. These tests indicate that MA-based formulations might have utility at airports and perhaps other locations where it is desirable to reduce bird activity in temporary pools of water.

Keywords: *Anas platyrhynchos*; *Larus*; methyl anthranilate; repellent, water

There are numerous agricultural and non-agricultural situations in which it is desirable to discourage birds from entering bodies of water. Waterfowl and blackbirds feeding on rice crops can cause substantial economic loss (Bird Pest Control Group, 1988; Wilson *et al.*, 1989). Also, avian depredation of fish at hatcheries is of major economic concern (Parkhurst, Brooks and Arnold, 1987; Hoy, Jones and Bivings, 1989). Federally protected waterbirds are sometimes attracted to settling and tailing ponds containing oil or toxic chemicals (Sturgess *et al.*, 1989; Hallock, 1990). Also, many bird species often flock to temporary pools of water at airports after heavy rains, creating a hazard to aircraft (Blokpoel, 1976; Buckley and Gurien, 1986). The development of an environmentally safe chemical formulation that could be added to water to repel birds should have wide utility.

Methyl anthranilate (MA), a chemical with demonstrated bird repellent properties (Mason, Adams and Clark, 1989; Mason *et al.*, 1991; Cummings, Otis and Davis, 1992), appears suitable for such use. Previous studies (Dolbeer *et al.*, 1991; Dolbeer, Belant and Clark, 1993; Avery, Decker and Nelms, 1992) have indicated that MA has potential as a repellent for keeping birds out of small temporary pools of water. During field trials at John F. Kennedy International Airport in May 1991, Dolbeer *et al.* (1993) evaluated a soybean oil-based formulation of MA (TP-250). Although this formulation appeared effective in repelling birds, the material did not disperse uniformly over the water surface. Rather, the material coalesced in globules 1–5 cm in diameter and drifted to the leeward side of the ponds.

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PMC Specialties Group, Cincinnati, Ohio, USA developed and provided us with two new MA formulations: one containing a surfactant to improve dispersal over the water surface (ReJex-iT™ TP-40, hereafter referred to as TP-40), the second a free-flowing powder completely miscible in water (ReJex-iT™ AP-50, hereafter referred to as AP-50). These products are formulated from food grade ingredients that meet or exceed US Food Chemical Codex and US Pharmacopeia specifications. The acute oral LD_{50} in rats for these two formulations is >5000 mg kg^{-1} body weight (PMC Specialties Group, unpublished data). Our objective was to evaluate the effectiveness of these formulations to repel birds from pools of water in pen and field situations.

Methods

Pen test

Four 8 × 4 m corrals, each with an attached 2.5 × 2.5 m holding pen, were established on grass at Plum Brook Station, operated by the National Aeronautics and Space Administration, Erie County, Ohio. In each corral we placed two 1 m diameter light-blue plastic swim pools with 40 l water. Mallards were acclimated to corrals and pools for more than one week before tests were conducted. On day 1 (8 October 1991) at 0800, 20 ml TP-40 (40% MA, 0.02% v/v) were added to one randomly chosen pool in each corral. Remaining pools served as controls. Two mallards (1 male, 1 female) were then released from the holding pens into the corrals from 0800 to 1600. Mallards were provided food and drinking water while in the holding pens, but were not allowed into the holding pens from 0800 to 1600. The corrals had no water except in the pools.

Two observers stationed 11–14 m from the corrals concurrently observed mallard activity in the pools for 80 min immediately after the birds were released into the corrals. Each observer monitored mallards in two corrals, alternating between corrals every 20 s. Thus, each pair of mallards was observed for 120 20-second intervals during the 80-minute period. During each 20-second interval, the observer recorded for each pool the number of bill contacts with water and the presence of each mallard in the pool. The schedule for the two-choice test was repeated on days 2–4. On days 5–6, the mallards were kept in their holding pens with food and water. On days 7–10, the schedule was repeated, except that control pools were removed, leaving only the pools that had been treated with TP-40 on day 1.

Analysis of variance (ANOVA) with repeated measures (days) was used to compare pool entries and bill contacts in TP-40-treated and untreated pools during the two-choice test, and to determine any day effect or day–treatment interaction. Paired t-tests were used to compare combined (treated and untreated, days 1–4) pool entries and bill contacts (i.e. control data) with those from the TP-40-only test (days 7–10). This latter test was also used to assess the longevity of effectiveness of TP-40 (1–4 days old versus 7–10 days old). Because the use of two or more related response variables (i.e. pool entries and bill contacts) to address a single hypothesis increases the probability of committing a type I error, we used the Bonferroni inequality technique to ensure that the experimental type I error rate was ≤ 0.05 (Beal and Khamis, 1991). To maintain this probability level, alpha (0.05) was divided by the number of response variables tested. Thus, differences between response variables in this experiment were considered significant at $p \leq 0.05$, if test statistics exceeded tabled values at 0.025.

Field tests

TP-40. Eight 1 m diameter plastic swim pools were located in a line with 4 m spacing between pools at the Erie County, Ohio Landfill on 12 November 1991 in a low-traffic area of bare ground about 100 m from the main dumping pit. Pools were placed in the ground so that the tops of the pools were flush with the ground surface. Each pool contained 50 l water. Four randomly chosen pools were treated with 20 ml TP-40 (0.016% v/v) on 13 November; remaining pools served as controls. Ring-billed gulls and herring gulls often loafed during daylight hours in the area where the pools were located.

Two observers stationed in a vehicle 50 m from the pools watched gull activity in the pools daily from 13 to 16 November and on 18 November. The landfill was closed on 17 November. Observations took place for two 40-minute periods each day, once at 1030 and again at 1430. Each observer used binoculars to watch two pairs of adjacent pools, alternating observations between pairs every 20 s (for a daily total of 40 min per pair). During each 20-second interval, observers recorded the number of gulls either in or entering each pool, and the number of bill contacts with water in each pool. Approximate number of gulls present at the landfill was counted and recorded for each 40-minute session.

Repeated measures (day) ANOVA were used to compare pool entries, bill contacts with water, and the number of gulls using treated and untreated pools, and to determine any day effect and day–treatment interactions. Differences were considered significant at $p \leq 0.05$, if test statistics exceeded tabled values at 0.017.

AP-50. Eight 1.2 m diameter plastic swim pools were set into the ground in the same area used nine months earlier during the TP-40 trials in two parallel lines (4 pools per line) with 12 m spacing between pools within a line and 10 m spacing between lines. Respective pools in each line were paired. Each pool contained 100 l water.

Observers monitored pools as in the TP-40 test during two 5-day and two 7-day periods (weeks 1–4: 11–15 August, 17–21 August, 9–12 and 14–16 September, and 17–18 and 21–25 September 1992). Observations took place for four 20-minute periods each day, beginning at 1330 until about 1500, the time of maximum gull use of the site. Each observer watched two pairs of pools, alternating between individual pools every 20 s (20 min per pool each day). Gull use of pools (pool entries, bill dips) and approximate numbers present at the landfill were recorded as during the TP-40 test.

To compare gull use of treated versus untreated pools during week 1, one pool from each pair was randomly selected and treated with 75 g (0.075% g/g, 50% MA) AP-50. Remaining pools served as controls. During week 2, we added 75 g AP-50 to pools untreated during week 1 to compare gull use of pools freshly treated with AP-50 and pools with AP-50 7–11 days after treatment.

During week 3, all pools were replaced with new pools and 100 l water was added without AP-50. Observations and data collection during week 3 were identical to weeks 1 and 2. All eight pools were treated with 75 g AP-50 during week 4. This test was done to assess whether overall gull activity and numbers would decline near the pools as a consequence of all available water being treated.

We used repeated measures (day) ANOVA to compare pool entries, bill contacts with water, and the number of individual gulls using treated and untreated pools during weeks 1 and 2, and to determine any day effect or day–treatment interactions. We used paired t-tests to compare the same gull activities between weeks 3 (all pools untreated) and 4 (all pools treated), using data collected during weeks 3 and 4 from each pool for the paired differences. Differences between response variables were considered significant at $p \leq 0.05$, if test statistics exceeded tabled values at 0.017. An independent t-test used to compare the mean number of gulls present at the landfill between weeks 3 and 4.

Results

Pen test

TP-40 was effective ($p \leq 0.02$) in reducing mallard entries and bill dips in treated pools in the 4-day two-choice test (*Table 1*). Mean number of entries was 176 times more frequent in untreated pools than in treated pools. Mean number of bill contacts occurred 17 times more frequently in the untreated pools. Overall, 99% of pool entries and 95% of bill contacts during the two-choice test were into untreated pools.

Mean pool entries in the combined treated plus untreated pools (53.1 ± 20.6 [s.e.]) during the two-choice test were higher ($t = 5.11$; 3 d.f.; $p \leq 0.02$) than during the one-choice test when only treated pools (1.1. ± 1.7) were available. Also, mean bill contacts were greater ($t = 7.59$; 3 d.f.; $p < 0.01$) in the combined treated plus untreated pools (109.8 ± 31.3) during the two-choice test than during the one-choice test when only treated pools (15.6 ± 9.7) were available.

Table 1. Mean number of pool entries and bill contacts by penned mallards with ReJeX-iT[TM] TP-40-treated (40% methyl anthranilate, v/v) water and untreated water in two-choice tests, 8–11 October, 1991

	Pool entries		Bill contacts	
Date	Treated	Untreated	Treated	Untreated
8 Oct	1.0	50.0	8.0	113.8
9 Oct	0.0	81.8	7.8	133.0
10 Oct	0.0	32.8	4.0	105.8
11 Oct	0.0	47.0	4.3	62.8
$\bar{x}$ ± s.d.	0.3[a] ± 0.8	52.9[a] ± 39.3	6.0[b] ± 6.3	103.8[b] ± 44.9

[a]Means are different ($F = 9.9$; 1,3 d.f.; $p = 0.02$); day effect and day–treatment interactions are not significant ($F = 3.3$ and 3.3; 3,18 d.f.; $p = 0.05$ and 0.05, respectively); [b]means are different ($F = 38.6$; 1,6 d.f.; $p < 0.01$); day effect is significant ($F = 4.3$; 3,18 d.f.; $p = 0.02$); day–treatment interaction is not significant ($F = 3.5$; 3,18 d.f.; $p = 0.04$)

Field tests

TP-40. TP-40 was also effective ($p \leq 0.01$) in reducing gull entries and bill dips in treated pools at the Erie County Landfill (*Table 2*). Untreated pools received 96% of gull entries and 94% of bill contacts during the 5-day test. Day effects and day–treatment interactions were significant ($p < 0.01$) for pool entries and bill contacts. The mean numbers of individual gulls using (entries and/or bill contacts) untreated and treated pools were similar ($p = 0.07$).

Gulls abandoned the landfill on day 4 of the test when they began feeding 6 km NE of the landfill on a large concentration of gizzard shad (*Dorosoma cepedianum*) in the Huron River (*Table 2*). When gulls returned to the landfill one week later, water in the pools had frozen and the experiment was terminated.

AP-50. The number of gull entries in pools treated with AP-50 were 83% less ($p = 0.01$) than that observed in untreated pools during week 1 (*Table 3*). Bill contacts were also 83% lower ($p = 0.04$) in treated pools than in untreated pools. There was a significant ($p \leq 0.01$) day effect and day–treatment interaction for

Table 2. Mean number of gulls at landfill and mean number of pool entries, bill contacts with water, and individual gulls using four ReJeX-iT[TM] TP-40-treated (40% methyl anthranilate, v/v) and four untreated pools at Erie County, Ohio Landfill during 120 20-second observations conducted on each of five days in November 1991

		Number of pool entries		Number of bill contacts		Individual gulls using pools	
Date	Gulls at landfill	Treated	Untreated	Treated	Untreated	Treated	Untreated
13 Nov	1400	0.5	27.5	3.0	172.5	1.3	11.3
14 Nov	2480	0.0	9.3	5.0	155.3	4.3	7.3
15 Nov	1375	2.0	17.3	26.5	207.5	6.0	16.5
16 Nov	150[a]	0.0	0.0	0.0	0.0	0.0	0.0
18 Nov	0[a]	0.0	0.0	0.0	0.0	0.0	0.0
$\bar{x}$ ± s.d.	1351 ± 825	0.5 ± 1.4[b]	10.8 ± 13.6[b]	6.9 ± 12.0[c]	107.1 ± 101.2[c]	2.3 ± 4.0[d]	7.0 ± 8.1[d]

[a]Gulls abandoned landfill on these days, apparently to feed on gizzard shad in Huron River 6 km away; [b]means are different ($F = 13.2$; 1,3 d.f.; $p = 0.01$); day effect and day–treatment interactions are significant ($F = 8.8$ and 7.6; 4,24 d.f.; $p < 0.01$); [c]means are different ($F = 30.0$; 1,3 d.f.; $p < 0.01$); day effect and day–treatment interactions are significant ($F = 28.4$ and 20.8; 4,24 d.f.; $p < 0.01$); [d]means are not different ($F = 4.82$; 1,3 d.f.; $p = 0.07$); day effect is significant ($F = 12.78$; 4,24 d.f.; $p < 0.01$); day–treatment interaction is not significant ($F = 12.78$; 4,24 d.f.; $p = 0.04$)

Table 3. Mean number of gulls at landfill and mean number of pool entries, bill contacts with water, and individual gulls using four ReJeX-iT[TM] AP-50-treated (0.075% g/g, 50% methyl anthranilate) and four untreated pools at Erie County, Ohio Landfill during 60 20-second observations conducted on each of five days (11–15 August 1992)

		Number of pool entries		Number of bill contacts		Individual gulls using pools	
Date	Gulls at landfill	Treated	Untreated	Treated	Untreated	Treated	Untreated
11 Aug	3500	2.0	2.5	32.0	98.5	12.3	23.8
12 Aug	1700	0.0	2.0	14.5	50.5	3.5	10.3
13 Aug	5000	0.0	4.3	13.8	161.5	5.3	26.8
14 Aug	2300	0.0	1.3	7.3	96.5	3.3	13.5
15 Aug	1700	0.0	1.8	3.8	28.3	1.3	4.8
$\bar{x}$ ± s.d.	2840 ± 1414	0.4 ± 1.0[a]	2.4 ± 2.2[a]	14.3 ± 17.0[b]	87.1 ± 77.2[b]	5.1 ± 5.6[c]	15.8 ± 13.0[c]

[a]Means are different ($F = 11.55$; 1,3 d.f.; $p = 0.01$); day effect and day–treatment interactions are not significant ($F = 2.05$ and 1.78; 4,24 d.f.; $p = 0.12$ and 0.17, respectively); [b]means are not different ($F = 6.74$; 1,3 d.f.; $p = 0.04$); day effect and day–treatment interactions are significant ($F = 5.10$ and 3.94; 4,24 d.f.; $p < 0.01$ and = 0.01, respectively); [c]means are not different ($F = 5.45$; 1,3 d.f.; $p = 0.06$); day effect is significant ($F = 8.56$; 4,24 d.f.; $p < 0.01$); day–treatment interaction is not significant ($F = 2.47$; 4,24 d.f.; $p = 0.07$)

bill contacts. The mean numbers of individual gulls using untreated and treated pools were similar ($p = 0.06$).

The mean number of bird entries and bill contacts with water in pools containing 1- to 5-day-old AP-50 was similar ($p \geq 0.17$) to that in pools with 7- to 11-day-old AP-50. There was a significant ($p < 0.01$) day effect for bill contacts, however. The mean number of gulls using each of the AP-50 treatments was similar ($p = 0.98$; *Table 4*).

The mean ($\pm$ s.d.) number of gulls present at the landfill during weeks 3 (3357 $\pm$ 378) and 4 (3671 $\pm$ 1247) was similar ($t = -0.64$; 12 d.f.; $p = 0.54$), allowing comparisons between gull use of the eight pools when they were untreated (week 3) and when they were all treated with AP-50 (week 4). Mean number of bill contacts and pool entries was reduced ($p \leq 0.01$) by 55 and 86%, respectively, after treatment with AP-50. The mean number of gulls using the pools after treatment was also lower ($p < 0.01$) than the mean number of gulls using the pools during the untreated period (*Table 5*).

Discussion

With TP-40, repellency of gulls and mallards from water was demonstrated at MA concentrations (v/v) of only 0.016–0.02%. With AP-50, gulls were repelled at MA concentrations (g/g) of 0.038%. These concentrations of MA are 10–60 times lower than concentrations needed to repel European starlings (*Sturnus vulgaris*) and red-winged blackbirds (*Agelaius phoeniceus*) from livestock feed (Mason *et al.*, 1991) or mallards and Canada geese (*Branta canadensis*) from maize kernels (Cummings *et al.*, 1992). Water may be a more effective medium than solid foods for delivering MA to trigeminal, olfactory and taste nerve receptors in the oral and nasal cavities of the birds (Kare, 1961; Mason *et al.*, 1989). Also, as suggested by Rogers (1978), differences in the desirability or need for materials (water versus food) may influence the effectiveness of repellents. Our results indicate that much lower levels of MA are needed to repel birds from water than from food. This may be particularly true for formulations such as TP-40 that disperse evenly over the water surface, concentrating MA at the water surface where bill contacts occur.

Significant day effects observed during field tests were attributed primarily to variable numbers of gulls present at the landfill. Precipitation also may explain some of the variation, as gull use of test pools appeared inversely related to availability of natural pools of water.

The longevity of effectiveness of TP-40 and AP-50 ($\geq$10–11 days) may prove advantageous in various agriculture and aquaculture programmes. For example, MA may be suitable for repelling blackbirds or waterfowl from rice fields during the germination and seedling growth period. Application of MA to rearing ponds and raceways at hatcheries may be of value in deterring birds from feeding on fish. Lower concentrations of MA during repeated applications may be adequate as there is evidence supporting learned avoidance of anthranilate compounds by birds (Glahn, Mason and Woods, 1989).

Gulls and mallards displayed no aberrant behaviour after swimming in or drinking water treated with either MA formulation. No non-target vertebrates were observed near the pools during either field test, although raccoon (*Procyon lotor*) tracks were seen

Table 5. Mean number of pool entries, bill contacts with water and individual gulls using eight pools of water during 60 20-second observations conducted each day during two 7-day test periods. Pools were left untreated and observed on 9–12 and 14–16 September; pools were then treated with ReJeX-iT™ AP-50 (0.075% g/g, 50% methyl anthranilate) and observed on 17–18 and 22–25 September 1992

Response variable	Untreated period (9–16 Sep)		Treated period (17–25 Sep)	
	$\bar{x}$	s.e.	$\bar{x}$	s.e.
Pool entries	0.7[a]	0.2	0.1[a]	0.0
Bill contacts	60.1[b]	5.7	27.1[b]	4.6
No. of gulls	12.8[c]	1.0	7.0[c]	0.9

[a]Means are different (paired t-test, $t = 3.33$, 7 d.f., $p = 0.01$); [b]means are different (paired t-test, $t = 6.56$, 7 d.f., $p < 0.01$); [c]means are different (paired t-test, $t = 6.25$, 7 d.f., $p < 0.01$)

Table 4. Mean number of gulls at landfill and mean number of pool entries, bill contacts with water, and individual gulls using four pools treated with ReJex-iT™ AP-50 (0.075% g/g 50% methyl anthranilate) on 11 August and foor pools treated with AP-50 (0.075% g/g) on 17 August at Erie County, Ohio Landfill during 60 20-second observations conducted on each of five days (17–21 August 1992)

Date	Gulls at landfill	Number of entries in pools treated on:		Number of bill contacts in pools treated on:		Number of individual gulls using pools treated on:	
		11 Aug	17 Aug	11 Aug	17 Aug	11 Aug	17 Aug
17 Aug	3000	0.0	0.0	0.0	0.0	0.0	0.0
18 Aug	1500	0.3	0.0	0.5	7.5	0.5	3.0
19 Aug	4300	0.0	0.0	7.8	21.0	1.5	5.3
20 Aug	5000	0.3	0.0	24.3	6.0	7.5	2.0
21 Aug	5000	0.3	0.0	50.5	64.0	17.8	17.3
$\bar{x}$ $\pm$ s.d.	3760 $\pm$ 1504	0.2 $\pm$ 0.4[a]	0.0 $\pm$ 0.0[a]	16.6 $\pm$ 26.5[b]	19.7 $\pm$ 28.4[b]	5.5 $\pm$ 8.5[c]	5.5 $\pm$ 7.2[c]

[a]Means are not different ($F = 2.45$; 1,3 d.f.; $p = 0.17$); day effect and day–treatment interactions are not significant ($F = 0.53$; 4,24 d.f.; $p = 0.72$); [b]means are not different ($F = 0.17$; 1,3 d.f.; $p = 0.69$); day effect is significant ($F = 13.71$; 4,24 d.f.; $p < 0.01$); day–treatment interaction is not significant ($F = 1.14$; 4,24 d.f.; $p = 0.35$); [c]means are not different ($F = 0.00$; 1,3 d.f.; $p = 0.98$); day effect is significant ($F = 20.30$; 4,24 d.f.; $p < 0.01$); day–treatment interaction is not significant ($F = 1.33$; 4,24 d.f.; $p = 0.29$)

around the pools at the landfill during tests with both formulations. However, there were some effects on invertebrates. Numerous moths (Lepidoptera) were attracted to and drowned in the TP-40-treated pools during the pen trials.

Our demonstration of reduced use of MA-treated water by birds in an area of high bird abundance indicates that MA formulations could be effective in reducing bird activity in shallow water areas such as rice fields, aquaculture facilities or at airports. We recommend that operational trials be conducted at rice fields and aquaculture facilities to determine the efficacy of MA in repelling birds.

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Calendar

Event	Date and venue	Details from
	1995	
SIMA – SIMAGENA 95	26 February–2 March *Paris, France*	Michèle Jackson or Catherine Chittock, Promosalons (UK) Ltd, The Colonnades, 82 Bishops Bridge Road, London W2 6BB. Tel: 071 221 3660; Fax: 071 792 3525
Pesticide Movement to Water	3–5 April *Coventry, UK*	Symposium Secretariat, Conference Associates & Services Ltd, Congress House, 55 New Cavendish Street, London, W1M 7RE, UK (Tel: +44 (0)71 486 0531; Fax: +44 (0)71 935 755)
International Symposium on Weed and Crop Resistance to Herbicides	3–6 April *Cordoba, Spain*	Prof Dr J Jorrín, Dept de Bioquímica y Biología Molecular, ETS Ingenieros Agronomos y Montes, Universidad de Cordoba 14080, Cordoba, Spain (Tel: +34-57-218439; Fax: +34-57-218830)
11th International Reinhardsbrunn Symposium on Modern Fungicides and Antifungal Compounds	14–20 May *Thuringia, Germany*	Professor Dr H Lyr, Biologische Bundesanstalt Fr Land und Forstwirtschaft, Institut fur Integrierten Pflanzenschutz, Stahnsdorfer Damm 81, O-1532 Kleinmacknow, Germany

This calendar of forthcoming events is based on information provided by the respective organizers and from secondary sources. *Crop Protection* welcomes information on relevant meetings. Copy deadlines are three months ahead of cover dates and information should be sent to:
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