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Grazing repellency of methyl anthranilate to snow geese is enhanced by a visual cue

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Methyl anthranilate (Rejex-It AG-36) is formulated as a commercial goose repellent. Frequent reapplications of this product are often necessary, and the cost/application is high (⩾ $300.00/ha). The present experiment tested the possibility that the repellency of methyl anthranilate might be enhanced by the addition of visual cues. Twelve 0.4 ha plots were assigned randomly to three treatment groups. Plots in the first group (n = 4) were sprayed with 10% Vapor Guard (an agrochemical adhesive). Plots in the second group (n = 4) were treated with a mixture of methyl anthranilate (3.4 kg/ha) and Vapor Guard. Plots in the third group (n = 4) were sprayed with a mixture of methyl anthranilate, white paint pigment (titanium oxide, TiO_3, 0.9 kg/l) and Vapor Guard. From 28 November 1994 to 19 December 1995, all plots were visited at 7 day intervals to collect snow goose (*Chen caerulescens*) droppings along transects. Examination of feces weights/transect meter at 7 days post-treatment showed that both methyl anthranilate formulations reduced goose activity. At 14 and 21 days post-treatment, however, dropping weights were significantly lower in plots treated with methyl anthranilate and TiO_3 than in plots treated with formulated methyl anthranilate alone. These results show that visual cues can enhance the durability of methyl anthranilate repellency.

Keywords: *Chen caerulescens*; damage; goose; grazing; methyl anthranilate; mimicry; Rejex-It; repellent

Populations of Canada geese (*Branta canadensis*) and snow geese (*Chen caerulescens*) are increasing in many areas of North America (Williams and Bishop, 1990; Gauthier and Bedard, 1991). Not surprisingly, reports of crop damage and nuisance complaints also are increasing (Hunt, 1984; Knittle and Porter, 1988; Mason, Clark and Bean, 1993; Mason and Clark, 1994a, 1994b). Because geese are a vector for the transmission of agriculturally important parasites and pathogens (Mason *et al.*, 1993), even farmers without substantial goose damage to their crops complain of geese in their fields.

Existing management strategies include hunting and harassment, planting unattractive cover and lure crops (Owen, 1978, 1990; Gauthier and Bedard, 1991), and using auditory and visual repellents (e.g. Timm, 1983; Conover and Chasko, 1985; Knittle and Porter, 1988; Heinrich and Craven, 1990; Taylor and Kirby, 1990; Mason *et al.*, 1993; Mason and Clark, 1994b). In practice, the use of these techniques is constrained by cost, logistics and effectiveness. Such constraints have stimulated efforts to develop chemical repellents that are effective, economical and ecologically safe. Methyl anthranilate (CAS 134-20-3), an effective bird repellent (Mason, Adams, and Clark, 1989; Cummings, Mason, Otis and Heisterberg, 1991), was registered in 1994 by the U.S. Environmental Protection Agency (EPA REG. No. 58035-9) as a goose repellent. This substance is the active ingredient in Rejex-It AG-36 (PMC Specialities Group, Cincinnati, OH), and the formulated product is effective against snow geese (Mason and Clark, 1995). However, formulated methyl anthranilate is also expensive (⩾$300.00/ha including labor and equipment for application, John Floyd, USDA/APHIS/ADC, pers, comm.), and measurable repellency may require reapplication at 3–4 day intervals. One method to extend the effectiveness of methyl anthranilate may be the use of visual cues. Birds readily associate such cues with unpleasant feeding experiences (Mason, 1988), and they continue to avoid them even in the absence of the causes of underlying unpalatability.

In the present experiment, we compared the goose repellency of formulated methyl anthranilate mixed with a white paint pigment (titanium oxide, TiO_3), to that of formulated methyl anthranilate alone. Titanium oxide was selected as the cue because similar paint pigments (e.g. calcium carbonate) have been used as visual cue additives to aerially applied methiocarb formulations (Dolbeer, Woronecki and Bullard, 1992).

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Materials and methods

Study sites

We selected 12 0.4 ha study plots on four farms (three plots/farm) in Cumberland and Salem Counties, NJ, USA. The minimum distance between farms was 10 km (range: 10–40 km). All four farms had histories of extensive snow goose grazing (Mason and Clark, 1994b, 1995; Mason *et al.*, 1993).

Our criteria for selection were (a) evidence of goose activity, e.g. feces, footprints, feathers, grazing damage; and (b) agronomic similarity, e.g. planting date, crop, barriers to the wind. Winter wheat (*Triticum aestivum*) was planted in six plots, and Kentucky blue grass (*Poa pratensis*) was planted in the remaining six. We marked the corners of each plot with 0.5 m survey stakes.

Procedure

We randomly assigned the three study plots on each farm to three treatment groups (across farms, n = 4/ treatment group), and then established a diagonal transect across each plot. The mean length (± standard error) of these transects was 97.4 ± 3.1 m. We removed all debris within 0.3 m of the transect midline on 29 September 1994 with a rake.

Beginning in October 1994, we visited all plots every few days to search for signs of goose activity (i.e. goose droppings along transects). All plots showed signs of goose activity by mid November. On 28–29 November 1994, we again raked the transects to remove goose feces and debris within 0.3 m of the midlines. Treatment formulations were then applied with a Solo Model 410 Backpack Mist Blower. First, we sprayed plots in the control group with an aqueous solution containing 10% Vapor Guard (Miller Chemical Corp., Hanover, PA). Next, we applied formulated methyl anthranilate (3.4 kg^{-1} ai/ha) in a 10% aqueous solution of Vapor Guard to plots in group MA. Finally, we treated the remaining four plots with formulated methyl anthranilate (3.4 kg/ai/ha) in an aqueous solution containing 10% Vapor Guard and 0.9 kg of TiO_3 (Buten Paints, Philadelphia, PA). This group is referred to below as MA/TiO_3.

Starting at 7 days post-treatment, we visited all plots at 1 week intervals for 3 weeks. During each visit, we collected all feces within 0.3 m of the midline of each transect. Sampling visits occurred between 0630 and 0900 h, generally prior to the arrival of geese. After collection, droppings were dried for 72 h at 37°C. Dry weights (g) were used as measurements of goose activity within plots (Mason and Clark, 1994b).

To provide an index of the presence or absence of methyl anthranilate, 75 × 25 mm glass slides were dipped in the treatment formulations on the day of application, and then placed at the midpoint of feces collection transects. Beginning on the day of treatment, four slides were retrieved at weekly intervals for 3 weeks.

Analyses

To determine levels of goose activity as a function of treatment, we calculated mean post-treatment feces mass/transect meter for each plot. Means were evaluated in a two factor analysis of variance (ANOVA). We considered treatment groups as an independent factor in this analysis and collection dates as a repeated factor. Tukey *post-hoc* tests (Winer, 1962: 193) were used to isolate significant differences among means ($P < 0.05$).

The concentrations of methyl anthranilate residue were determined by standard spectrophotometric techniques (Clark and Shah, 1993; Mason and Clark, 1995). Briefly, each slide was immersed in 100 ml of methanol for 5 days. The methanol samples were sonicated for 30 min and then passed through a 5 μm filter to remove encapsulation materials. Filtered solutions were assayed for methyl anthranilate by ultraviolet spectroscopy. Ultraviolet absorbance was measured at 300 nm, and assays of pure methanol served as the control.

Results

There were significant differences between treatment groups ($F = 34.5$; 2,6 df; $P < 0.001$) and among dates ($F = 9.2$; 2,6 df; $P < 0.01$). Also, the interaction between these terms was significant ($F = 6.6$; 4,12 df; $P < 0.005$).

Examination of the main effect for groups showed that mean feces dry mass was lower for MA/TiO_3 plots than for MA or control plots. Examination of the main effect for dates indicated that feces dry mass was lowest at 7 days post-treatment. Examination of the interaction term revealed the following pattern of effects. At 1 week post-treatment, feces dry masses in MA and MA/TiO_3 plots were significantly less than in control plots. However, only MA/TiO_3 plots had a lower dry mass at 2 and 3 weeks post-treatment. Mean feces masses in MA and control plots were approximately the same (*Figure 1*). Weights in MA/TiO_3 plots at 2 and 3 weeks were not significantly greater than those recorded at 1 week.

Residue analyses showed that the mean concentration of methyl anthranilate per slide on the day of treatment was 436.5 ± 8.9 mg for MA, and 402.8 ± 6.9 mg for MA/TiO_3. At the end of the post-treatment period, the concentration per slide had declined for both groups to 87.7 ± 25.6 mg and 13.1 ± 5.6 mg per slide, respectively.

Discussion and management implications

Goose activity levels (i.e. mean feces/transect meter) are indicative of grazing damage (Mason and Clark, 1994b, 1995). Accordingly, both MA and MA/TiO_3 reduced damage for 7 days post-treatment. Only MA/TiO_3 continued to prevent damage throughout the post-treatment period, however, suggesting that the visual cue was a useful additive to the formulation. This difference in effectiveness (≥300%) is important, because the cost of methyl anthranilate applications is high.

While it is conceivable that TiO_3 alone conferred some repellency, we believe that this is unlikely. Firstly, pilot tests suggested that TiO_3 alone does not deter grazing by geese (Mason, unpubl. data).

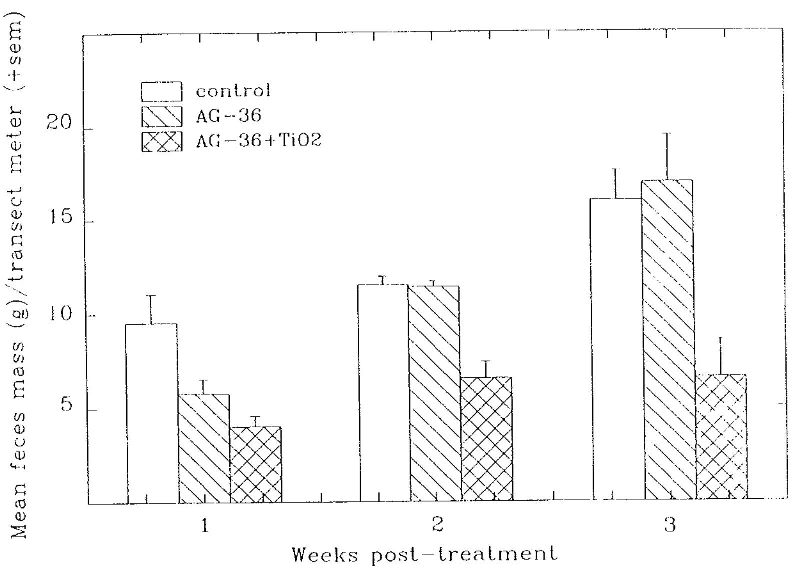

Figure 1. Mean feces mass g/transect meter in plots treated with methyl anthranilate (A636), methyl anthranilate plus titanium oxide (A6–6 + TiO_2) or left untreated

Secondly, in other field experiments, simple applications of white paint pigment (i.e. calcium carbonate) were not avoided (Dolbeer *et al.*, 1992).

We suspect that any visual cue that contrasts against background vegetation would serve at least as well as TiO_3. Colors that serve biological warning functions (so-called aposematic cues) may be the most effective (Mason, 1988). Colored plastic flags might also enhance methyl anthranilate repellency. In fact, flagging may be even more effective than color additives, *per se*, because flags are inherently repellent to geese (Mason and Clark, 1994b, 1995). This hypothesis is readily testable. Finally, an intriguing possibility is that methyl anthranilate/visual cue applications might be coupled with applications of visual cues (pigments, flags) alone. Analogous to automimicry effects (Mason, 1988), the methyl anthranilate/visual cue combinations (i.e. models) may confer significant protection to vegetation treated with the visual cue alone.

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