# Evaluation of Bird Shield as a blackbird repellent in ripening rice and sunflower fields

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# Evaluation of Bird Shield™ as a blackbird repellent in ripening rice and sunflower fields

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**Abstract** Chemical repellents sometimes can provide a nonlethal alternative for reducing wildlife impacts to agricultural production. In late summer and autumn 2002, we evaluated Bird Shield™ (active ingredient: methyl anthranilate, Bird Shield Repellent Corporation, Spokane, Wash.) as a blackbird (Icteridae) repellent in Missouri rice fields and North Dakota sunflower fields. We selected 5 pairs of ripening rice fields in southeastern Missouri and randomly allocated treatments (treated and control) within pairs. The repellent was aerially applied by fixed-winged aircraft at the recommended label rate and volume (1.17 L Bird Shield/ha and 46.7 L/ha, respectively); 1 field received 2X the label rate. We observed no difference in average bird activity (birds/minute) between treated and control fields over the 3-day post-treatment period ($P = 0.503$). We used reversed-phase liquid chromatography to quantify methyl anthranilate residues in treated fields. The maximum concentration of methyl anthranilate in rice samples was 4.71 µg/g. This concentration was below reported threshold values that irritate birds. In North Dakota we selected 6 pairs of sunflower fields used by foraging blackbirds. We randomly selected 1 field from each pair for 2 aerial applications of Bird Shield at the label-recommended rate ~1 week apart. The remaining 6 fields served as controls. Daily bird counts, starting the first day of application and continuing for 5–7 days after the second application, showed similar numbers of blackbirds within treated and control fields ($P = 0.964$). We observed no difference in sunflower damage within treated and control fields ($P = 0.172$) prior and subsequent to the treatment. Bird Shield was not effective for repelling blackbirds from ripening rice and sunflower fields.

**Key words** *Agelaius phoeniceus*, brown-headed cowbird, chemical repellent, common grackle, methyl anthranilate, *Molothrus ater*, *Quiscalus quiscula*, red-winged blackbird, wildlife damage management, *Xanthocephalus xanthocephalus*, yellow-headed blackbird

Several blackbird (Icteridae) species are abundant summer residents and migrants in central and southern regions of North America (Meanley 1971, Dolbeer 1978), including red-winged blackbirds

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(*Agelaius phoeniceus*), common grackles (*Quiscalus quiscula*), yellow-headed blackbirds (*Xanthocephalus xanthocephalus*), and brown-headed cowbirds (*Molothrus ater*). After breeding, these species aggregate in large flocks that feed on agricultural crops. The flocking behavior continues from late summer into early spring. Blackbirds can cause economic losses during this period to seeded and ripening rice in the southern regions of North America and sunflower and corn in central regions (Besser 1985, Dolbeer 1990, Linz et al. 1993, Homan et al. 1994, Cummings et al. 2002). Direct economic losses have been estimated per annum at $11.5 million (US) for rice (Besser 1985), $25 million for corn (Wywialowski 1996), and $4–11 million for sunflowers (Hothem et al. 1988, Peer et al. 2003). These losses have led to use of various bird damage management practices, including chemical repellents.

Methyl anthranilate was identified as a candidate bird repellent in the early 1960s (Kare 1961). Several field studies and controlled experiments have been conducted with methyl anthranilate and dimethyl anthranilate to reduce bird impacts at feedlots (Mason et al. 1985, Glahn et al. 1989, Mason et al. 1991); repel waterfowl from valued grasses, corn, and water impoundments (Cummings et al. 1991, 1992, 1995; Askham 1995; Belant et al. 1996); deter birds from fruit crops (Askham 1992, Avery 1992, Avery et al. 1996); decrease bird exposure to contaminants (Clark and Shah 1993, Cummings et al. 1998); and protect orchids from bird depredation (Cummings et al. 1994). Avery et al. (1995) also evaluated methyl anthranilate as a rice-seed treatment to reduce red-winged blackbird impacts to sprouting rice.

No large-scale manipulative experiments have been published to document the efficacy of methyl anthranilate as a blackbird repellent in ripening rice and sunflower fields. Whereas effective repellents presently are needed, our objective was to evaluate a commercially available methyl anthranilate product (Bird Shield™, Bird Shield Repellent Corporation, Spokane, Wash.) under conditions encountered by rice and sunflower producers near harvest, when blackbird pressure on these crops is at its peak.

## Methods

### *Missouri rice*

The study sites (A–E) consisted of 5 pairs of fields selected based on willingness of growers to participate and the extent of bird pressure. All fields were in the farming region in the vicinity of Morehouse, Missouri. We selected 1 field from each field pair for treatment with Bird Shield, and the other was untreated (control field). Treated fields and control fields ranged from 15–61 ha and 16–36 ha, respectively, and were separated geographically by 20 m to 10 km. At each site soybean and rice fields adjacent to study fields provided abundant feeding and loafing habitat. Rice was in the late milky-dough stage (i.e., phenology subsequent to spikelet formation) when treatments were applied.

Beginning 4 September 2002, we estimated relative blackbird abundance within treated and control fields at study sites A and B. Between 0700 and 1000 hours we initiated bird observations in each field by estimating and recording number of blackbirds within a field. We subsequently recorded number of birds entering and departing each field (and the associated time of immigration and emigration) for 1 hour. We made abundance estimates using binoculars at several vantage points on the perimeter of each field.

We aerially applied Bird Shield on sites A and B in the late afternoon (1730–1930 hours) of 6 September. The application rate and volume followed label instructions (1.17 L Bird Shield/ha and 46.7 L/ha, respectively). The repellent was diluted 1:40 with water according to recommendation of the manufacturer. We set the aircraft spray apparatus to produce the smallest possible droplet size: 0.32-cm nozzle orifice with 45° deflection. After we applied the repellent, we sprayed the untreated fields at sites A and B with water (46.7 L/ha). Bird observations continued for the next 3 mornings. Blackbird abundance estimates commenced on 3 October, and we aerially applied Bird Shield on 5 October at study sites C–E. We applied twice the recommended amount of Bird Shield on site D and applied nothing to control fields associated with sites C–E; methodology was otherwise identical among sites A–E.

We used a repeated-measures analysis of variance (PROC Mixed; SAS 1999) to analyze differences in bird activity prior and subsequent to aerial spraying in treated and control fields. The dependent measure for this analysis was relative blackbird abundance (birds/min) in treated and control fields based upon the initial abundance of birds in each field and numbers recorded entering and leaving fields during the subsequent 1 hour of observations. Blackbird abundance data were square-root transformed to improve normality prior to the analysis (Sokal and Rohlf 1981). The independent variables were sites, treatments (treated and control fields), and days (1–3 pretreatment, 4–6 post-treatment). We used the treatment-by-day interaction to examine differences in blackbird activity between paired fields prior to and following application of Bird Shield. We used descriptive statistics (mean± SE) to illustrate differences in blackbird activity between treated and control fields.

### *Methyl anthranilate analyses*

We took 2 samples each of undiluted Bird Shield and 1.17 L/ha and 2.34 L/ha Bird Shield solutions prior to application. We collected rice panicles at 5 locations within each treated and untreated field before application and at 1, 20, 72, and 120 hours post-application to determine the quantity of methyl anthranilate residues on rice. We refrigerated samples and transported them to the National Wildlife Research Center for analysis. We used descriptive statistics (mean±SE) to examine differences in methyl anthranilate residues among collection times.

We prepared quality control samples at 0.0, 3.8, and 29% technical grade methyl anthranilate (Aldrich, St. Louis, Mo.) in deionized water. We analyzed the control samples with samples of undiluted Bird Shield and 1.17 L/ha and 2.34 L/ha dilutions. The methods of methyl anthranilate extraction and analysis otherwise followed those of Primus et al. (1995).

We analyzed rice panicles by grinding 10 g of each sample in a liquid nitrogen homogenizer (SPEX, Certiprep 6,850 Freezer Mill; Metuchen, N.J.). We placed subsamples of 0.50–0.55 g of the resultant powder in 25-ml test tubes that contained a 10.0-ml aliquot extraction solution. The extraction method was validated for homogenized ripening rice fortified at 0.50 and 150 µg/g methyl anthranilate. The tubes were capped, vortex mixed, mechanically shaken for 10 minutes, placed in an ultrasonic bath for 10 minutes, and then hand shaken for 5 seconds. We repeated the ultrasonic bath step 2 more times to ensure a high rate of extraction.

We centrifuged the sample tubes for 5 minutes at ~2,500 rpm to separate the rice matrix from the extraction solution. We drew a 1-ml portion of the extract through a 0.45-µm Teflon syringe filter and analyzed it by high performance liquid chromatography (Table 1). We quantified the concentration of methyl anthranilate from a linear calibration curve. For extracts with methyl anthranilate concentrations ≤1.00 µg/g, we used the fluorescence detector response. We used the UV detector response at greater concentrations. We used a concentrated standard with methyl anthranilate at 1,000 µg/ml and an intermediate standard at 100 µg/ml (in methanol) to fortify the control matrix and evaluate analyte recovery.

Table 1. Typical high performance liquid chromatography conditions used to determine methyl anthranilate residue concentration. Rice samples were collected within ripening rice fields previously treated with Bird Shield bird repellent near Morehouse, Missouri in September–October 2002.

| Parameter | Operating conditions [a] |
|---|---|
| Mobile phase | 55 ACN: 45 water |
| Flow rate | 1.0 mL/min |
| Injection volume | 10 µL |
| Column | Keystone ODS/H (C18), 5 µm, 250 mm × 4.6 mm i.d. or equivalent (guard column contained identical HPLC packing) |
| Column temperature | 30°C |
| Detector | Ultraviolet @ 248 nm<br>Fluorescence: excitation =338 nm, emission =424 nm |
| Runtime | 16 min |

[a] Operating conditions were adjusted to obtain optimum response and reproducibility. For the mobile phase shown, retention time of methyl anthranilate was approximately 6.7 min.

### *North Dakota sunflower*

In late August 2002, we selected 6 pairs of sunflower fields with blackbird feeding activity in Stutsman County, North Dakota. We paired the fields according to their proximity to one another and randomly assigned them to treatment (i.e., treated with Bird Shield or untreated controls). Treated and control fields ranged in size from 30–65 ha. Each treated field received 2 aerial applications of Bird Shield by fixed-wing aircraft. The applications were separated by ~1 week, per label instructions. We applied Bird Shield at the label-recommended rate and volume using standard polypropylene CP® nozzles (CP Products Company, Inc., Tempe, Ariz.) on the No. 3 setting (0.32-cm orifice) at 2.1 kg/cm$^2$ pressure and 30° deflection. The first series of applications were between 28 August–3 September, followed by the second series between 5–10 September. This time frame encompassed the major migration period for blackbirds in North Dakota when bird damage was heaviest.

We estimated pretreatment bird damage within each treated and control field the day before or the day of the first application. Post-treatment estimates were made 5–7 days after the second application. We made damage estimates by randomly selecting 1 row per stratum from 4 strata containing an equal number of rows. The location of the first sample plot of 5 consecutive sunflower heads was a randomly selected distance in paces (~1 m) between 0–100 m. After establishing the first plot, we systematically sampled plots of 5 consecutive sunflower heads every 100 m until the end of the field. For sunflower heads with bird damage, we measured the diameter (±1 cm) of the head and undeveloped center (light-colored, immature achenes) by averaging 2 perpendicular tape measurements. We estimated the amount of missing achenes by placing a template with 5-$cm^2$ grids over the damaged area of the head (Dolbeer 1975). Undamaged heads were left unmeasured and 0% damage was recorded. We derived percent damage on each head by dividing total area of bird damage (i.e., missing achenes) by the total area of achenes potentially available (minus the area of undeveloped centers) and multiplying by 100. We calculated percent damage for each field by averaging percent damage from all plots among strata (Cochran 1977).

We counted the number of blackbirds in treated and control fields beginning the day a treated field received its first application. The last counts were completed 5–7 days after the second application. We made counts using binoculars at several vantage points on the perimeter of the field. We closely monitored the immigration and emigration of birds within fields and added to or subtracted from the initial estimate made at the start of the count. We completed a count in 10–15 minutes, with 2–4 counts repeated per field per census. We averaged counts to derive a single estimate of bird abundance. Barring inclement weather, we conducted a census daily following the first application of Bird Shield. We counted fields in random order, with counts alternating between 0.50–2.0 hours after sunrise and 3.0–0.50 hours prior to sunset (i.e., prime feeding times for blackbirds).

We used a 2-factor (treatment and day) repeated-measures analysis of variance (RMANOVA), with day as the repeated measure, to test the null hypothesis of no difference in average numbers of birds using treated and control fields. To assess treatment effects on bird damage, we used a 2-factor RMANOVA, repeating on damage assessment (i.e., pretreatment and post-treatment assessments). For both analyses we used the interaction of the treatment factor with the repeated measure factor to determine presence or absence of an effect (Cody and Smith 1997). We used Pearson correlation coefficients to test the relationship between average bird counts and the difference in damage between pre- and post-treatment assessments. We used a 1-way ANOVA to compare pretreatment damage assessments between treated and control fields. Statistical significance was accepted at $\alpha$= 0.10. The sole purpose of the initial pairing of fields was to randomly assign treatments to the fields as they serially entered the experiment between 28 August–3 September; thus, we analyzed the data in a completely randomized design. Before analyses, the count data and damage data were square-root transformed and arcsine square-root transformed, respectively (Sokal and Rohlf 1981).

## Results

### *Missouri rice*

We observed blackbirds moving freely among study sites. Flocks in study fields were almost entirely red-winged blackbirds, many of which exhibited short, stubby tails and gaps in their wing feathers, indicating that the birds were molting. We observed flocks of brown-headed cowbirds on roads and plowed fields adjacent to study fields but not within rice fields.

Repellent applications were concurrent with presence of thousands of blackbirds within treated and adjacent fields. We detected no repellency among birds as the chemical was applied to the fields. In general, birds flew up as the plane approached, swarmed in and out of the spray, and then resettled within the rice field. Few birds (<25%) left the fields during the spray operation.

Relative to control fields, there was an apparent reduction in bird activity in treated fields (Figure 1), particularly during the 2 days following application of Bird Shield. Statistical analysis, however, revealed no overall differences in bird activity between treated and control fields ($F_{1,4}$=0.54, $P$= 0.503) or among days of the study ($F_{5,20}$=0.51, $P$= 0.767). We observed no treatment-by-day interaction ($F_{5,20}$=0.71, $P$=0.622). Thus, blackbird activity

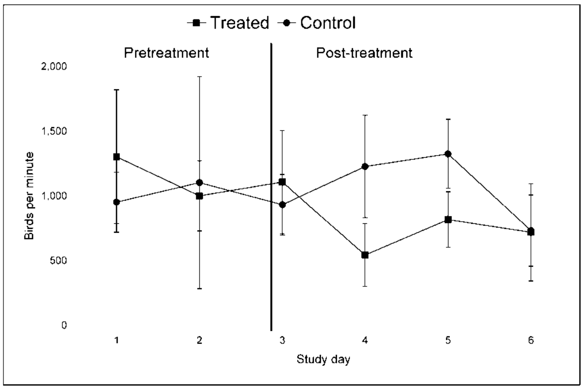


Figure 1. Relative blackbird abundance (±SE) within treated and control rice fields prior and subsequent to aerial application of Bird Shield bird repellent near Morehouse, Missouri. Bird Shield was applied in early September and early October 2002. Each treated field received one aerial application at the label recommended rate and volume.

was similar in treated and control fields prior and subsequent to treatment.

## *Methyl anthranilate analyses*

The maximum concentration of methyl anthranilate among collected rice samples was 4.71 µg/g (ppm methyl anthranilate). The concentration of methyl anthranilate in samples of undiluted Bird Shield averaged 26.4% (wt/wt; $n = 10$; SE = 0.11%) prior to dilution for aerial application in Missouri. The dilutions averaged 1.2% ($n = 9$; SE = 0.01%) in the 1.17 L/ha and 1.6% ($n = 9$; SE = 0.02%) in the 2.34 L/ha solutions. Methyl anthranilate residues on rice panicles collected 1, 20, 72, and 120 hours post-application were 1.09 µg/g ($n = 24$; SE = 0.253), 1.26 µg/g ($n = 25$; SE = 0.217), 1.50 µg/g ($n = 25$; SE = 0.245), and 1.31 µg/g ($n = 25$; SE = 0.230), respectively. At 2 times the label rate, residues of methyl anthranilate ranged from 1–4 µg/g among the collection periods.

We analyzed more than 180 rice samples in duplicate for methyl anthranilate residues. The mean recovery of methyl anthranilate in quality-control samples averaged 91±14% ($n = 28$) over the 7 days of analyses for all fortification levels. For the individual fortification levels of 0.50, 5.0, and 180 µg/g, the recoveries averaged 93±19% ($n = 14$), 89.1 ±6.4% ($n = 14$), and 94.1±2.9% ($n = 4$), respectively. The high fortification level of 180 µg/g was not needed for the samples analyzed, and the mean value reported demonstrates the range of analysis that is possible for this method. A chromatogram of a blank control sample, a control sample fortified at 0.46 µg/g, and an actual sample that was positive for methyl anthranilate are shown in Figure 2.

For the analysis of methyl anthranilate in formulated product and related solutions, 5 replicates of each of the 8 samples were analyzed. The mean recovery of methyl anthranilate in quality-control samples averaged 99.8±1.7% for all fortification levels. For the individual fortification levels of 3.6 and 29% the recoveries averaged 100±1.5% and 99.2± 2.1%, respectively.

## *North Dakota sunflower*

Daily census estimates indicated that blackbird numbers were similar between treated and control fields ($F_{18,102} = 0.47$, $P = 0.964$). Fields treated with Bird Shield averaged 1,166 (SE = 233.8, $n = 83$) blackbirds per census, whereas control fields averaged 798 (SE = 186.5, $n = 83$). The highest numbers recorded in a single census were 12,333 (SD = 5,507.6, $n = 3$ counts) and 9,950 (SD = 70.7, $n = 2$) for treated and control fields, respectively. Blackbird numbers differed among days ($F_{18,102} = 1.76$, $P = 0.040$), with numbers tending to be higher between 4–10 September. Prior to application of Bird Shield, damage estimates were similar between treatments ($F_{1,10} = 0.45$, $P = 0.517$), averaging 5.1% for control fields and 4.1% for treated fields. The amount of bird damage increased between the pre- and post-assessments for treated and controls, with an average increase of 2.4% (SE = 0.84, $n = 6$) in control fields and 5.7% (SE = 2.57, $n = 6$) in treated fields but was not significant ($F_{1,10} = 2.17$, $P = 0.172$). We detected a positive correlation between the difference between pre- and post-treatment damage assessments, and average counts per field ($r = 0.560$,

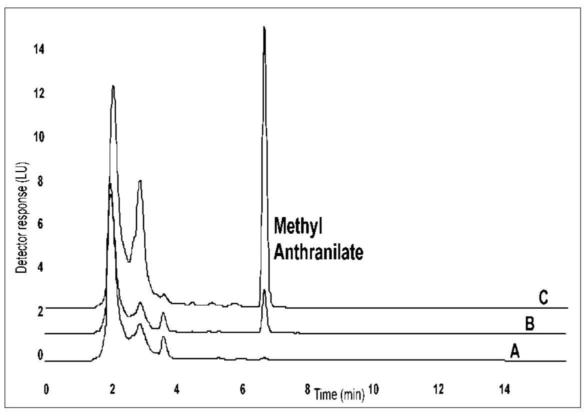


Figure 2. Comparative chromatograms of (A) control rice extract; (B) control rice fortified at 0.46 µg/g methyl anthranilate; and (C) a rice sample collected 5 days subsequent to the aerial application of Bird Shield bird repellent in Missouri rice fields (September–October 2002; the sample contained 2.80 µg/g methyl anthranilate).

$P = 0.058$, $n = 12$). This correlation indicated that increased amounts of damage were associated with larger counts of birds.

## Discussion

Blackbird species compositions in rice and sunflower fields were not the same, with red-winged blackbirds the most abundant species in rice and yellow-headed blackbirds the most abundant in sunflower. Neither species responded with significant numerical decreases, compared to control fields, following treatment with Bird Shield, even at 2 times the recommended rate in rice and 2 applications per field in sunflower. Although the experimental designs and response variables measured in the rice and sunflower studies differed, the results from both studies concurred on their findings of no repellent effect. Our methyl anthranilate residue analyses provided additional chemical evidence that supports the behavioral data, including the count and activity observations for both crop types and the damage assessments for sunflower. Although residues were not measured in the sunflower study, we believe that residue analyses would have provided results comparable to those reported for rice. Bird Shield was applied to sunflower at nearly the same settings as those used in the rice experiment.

The irritation threshold for European starlings (*Sturnus vulgaris*) in captivity was 8% (vol/vol; 80,000 µg/g) methyl anthranilate (Stevens and Clark 1998). An "irritation threshold" is operationally defined as the repellent concentration necessary to elicit frequent bill wiping, gagging/vomiting, head shaking, piloerection, and quick-preening (Stevens and Clark 1998). Whereas the maximum concentration of methyl anthranilate among collected rice samples was less than 5 µg/g in our study, we would not expect blackbird repellency within fields treated with 1.17 L Bird Shield/ha. Costs, however, prohibit field applications of bird repellents that contain effective concentrations of methyl anthranilate.

The aerial application of Bird Shield in our study cost approximately $30/ha (US). Assuming that applicators follow label recommendations and use similar spray settings as those used in our experiments, Bird Shield likely will not be cost-effective for protecting either ripening rice or sunflower from blackbird depredation. We conclude that Bird Shield was not effective for repelling blackbirds from ripening rice and sunflower fields in this study.

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