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# Evaluation of chemical repellents for reducing crop damage by Dickcissels in Venezuela

(*Keywords:* anthraquinone, bird repellent, crop damage, Dickcissel, rice, *Spiza americana*, Venezuela)

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**Abstract.** In Venezuela, lethal control of wintering Dickcissels (*Spiza americana*) is considered a threat to the species survival. To help farmers protect their rice and sorghum crops from depredations by Dickcissels and to minimize the killing of large numbers of these birds, alternative non-lethal crop protection measures are needed. To that end, the responses of captive Dickcissels to three bird-repellent chemicals applied to rice seed were evaluated. In one-cup feeding trials, treatments of methiocarb (0.05% g $g^{-1}$, applied as Mesurol® 75% wettable powder) and anthraquinone (0.5%, applied as Flight Control®) reduced consumption of rice by 70% relative to pretreatment consumption. Other anthraquinone treatments (0.05, 0.1%) and methyl anthranilate (0.05%) were ineffective. In two-cup trials, with untreated millet as the alternative food, consumption of rice treated with 0.05 and 0.1% anthraquinone was reduced by 90% relative to pretreatment levels. Overall, Dickcissels responded to the repellents similarly to the red-winged blackbird (*Agelaius phoeniceus*). Because Flight Control® has been used successfully to reduce blackbird use of rice fields in the USA, the prospect is good for successful reduction of damage to ripening rice by Dickcissels in Venezuela, particularly if repellent use is coupled with the establishment of alternative feeding sites.

## 1. Introduction

The Dickcissel is a small (30–40 g) grassland bird that breeds throughout the central USA into southern Canada, and winters principally in Venezuela. On its wintering ground, the species consumes great quantities of ripening rice and sorghum, and some farmers resort to killing roosting birds with organophosphate pesticides to protect their crops (Basili and Temple 1999a). A single winter roost can contain up to 3 million Dickcissels—possibly 30% of the entire species population—so spraying such a huge roost with toxic pesticides could have a substantial negative impact on the world's Dickcissel population. Such a mortality rate probably contributed to a 40% decline in Dickcissel breeding populations in the USA during the 1960s and 1970s (Basili and Temple 1999a). Although the population has been stable in recent years, illegal killing continues as Venezuelan farmers attempt to protect their crops from bird damage (Basili and Temple 1999b). Reducing the illegal killing of this species means alleviating the economic pressure on Venezuelan farmers due to crop depredations by Dickcissels.

A method of bird damage control for rice not currently available to farmers in Venezuela is the use of chemical repellents. One candidate formulation that holds promise as a bird repellent in crops is Flight Control® (Environmental Biocontrol International, Wilmington, DE, USA). This product contains 9,10-anthraquinone (50% g $g^{-1}$, CAS no. 84-65-1) as the active ingredient. Anthraquinone has been recognized as an avian-feeding deterrent since the 1950s (Neff and Meanley 1957). It is currently used in Europe as a bird-repellent seed treatment, but it has never been registered as a bird repellent in the USA or Venezuela. In laboratory studies, birds given rice treated with anthraquinone vomited and exhibited signs of post-ingestional discomfort (Avery *et al.* 1997). Thus, anthraquinone is a secondary repellent, and birds acquire an avoidance response through associative learning (Rogers 1974). Recently, a number of studies involving several bird species have corroborated the repellency of both non-formulated anthraquinone (Avery *et al.* 1998a) and the formulated product, Flight Control® (Avery *et al.* 1998b, Dolbeer *et al.* 1998, Blackwell *et al.* 1999).

In the present study, captive Dickcissels were tested to document the birds' responses to rice seed treated with Flight Control®. The objective was to determine the potential for Flight Control® to be effective in reducing rice crop depredations by Dickcissels wintering in Venezuela. The trials with captive Dickcissels were needed because, despite other recent studies involving Flight Control®, only the red-winged blackbird has been tested with rice seed treated with this formulation (Avery *et al.* 1998c). Furthermore, no study has evaluated any avian repellent as a potential management method for Dickcissels. It is unreasonable to expect Venezuelan farmers to adopt this management approach without having some data specific to the target species. For comparative purposes in the present study, two other compounds previously documented as blackbird repellents were included: methiocarb and methyl anthranilate (Holler *et al.* 1982, Mason *et al.* 1991, Avery *et al.* 1995).

## 2. Materials and methods

### 2.1. Test birds

Dickcissels were mist-netted in a rice-growing region near Acarigua, north-western Venezuela. The birds were kept in a group aviary in Caracas for several days before being shipped

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by air to the USA. All birds arrived in good health. Birds were immediately placed 12 to a cage in four holding cages (1.2 × 1.2 × 1.8 m), in a roofed outdoor aviary. Free access to drinking and bathing water, grit, and a mixture of commercial wild birdseed, quail starter, and rice was provided. Birds were euthanized with carbon dioxide after the study.

### 2.2. Seed treatment

For each treatment, 1 kg rice seed was placed in a rotating mixer and the appropriate amount of chemical and commercial sticker was added in 50 ml water. Mixing continued for 5 min until the treated seed was dry. After treatment, the seed was stored in an air-conditioned laboratory.

Three compounds were evaluated. Anthraquinone was in the form of Flight Control® bird repellent, a 50% aqueous slurry. Technical-grade methyl anthranilate (MA, 99% purity, CAS no. 134-20-3) was obtained from Aldrich Chemical Co. (Milwaukee, WI, USA). Methiocarb (CAS no. 2032-65-7) was in the form of Mesurol® 75% wettable powder (Gowan Co., Yuma, AZ, USA).

### 2.3. Test procedures

Feeding trials were conducted in a roofed outdoor aviary, where test cages (45 × 45 × 45 cm) were visually isolated and equipped with automatic waterers. Four days before the start of a trial, birds were removed from the holding cages, were weighed, and assigned randomly to individual test cages. Each bird was tested once. Treatment groups of six birds each were formed by randomly assigning cages to treatments. During the 4-day acclimation period, test birds were given a mixture of untreated rice seed and commercial quail starter in clear plastic cups (8.2 cm diameter, 3.8 cm height).

Throughout the feeding trials, maintenance food was removed at 07 : 30 hours and put in the test food cups 1 h later. Aluminium trays suspended from test cages under each cup caught spilled seed. Cups containing test food not exposed to birds were placed in vacant cages to determine mass changes due to moisture uptake. After 3 h, test food was removed and the birds' maintenance food was again provided. The contents of test food cups were weighed and consumption was determined by subtraction after appropriate adjustments for spillage and moisture gain.

Following acclimation, for one-cup tests there was a 5-day test period. On day 1, each food cup contained 30 g untreated rice seed. Then, for the next 4 days, each bird received its randomly assigned treatment. There were six birds per treatment group. To compare the relative effectiveness of the three blackbird repellents, anthraquinone, methyl anthranilate (MA) and methiocarb were tested, each at a treatment rate of 0.05% (g $g^{-1}$). To determine if anthraquinone could reduce consumption of rice to near zero, two additional groups (six birds each) were included at higher anthraquinone rates, 0.1 and 0.5%.

For the two-cup trial, the acclimation period was followed by a 4-day pretreatment during which each bird received one cup of rice and one cup of white millet. For each cage, the location of the rice (left or right side) was randomly determined, which remained fixed thereafter. After the 4-day pretreatment, each bird received rice treated with Flight Control® at either 0.05 or 0.10% anthraquinone (g $g^{-1}$). Millet remained as an untreated alternative food. Treatment lasted for 4 days. There were five birds per treatment group.

### 2.4. Data analysis

In the one-cup trial, two-way ANOVA was used with seed treatment as the independent factor and repeated measures across days. For the two-cup trial, a three-way ANOVA was used, with anthraquinone level (0.05 and 0.1%) and seed type (rice and millet) as independent factors and repeated measures across days. The Tukey test was applied to separate means (Steel and Torrie 1980).

## 3. Results

### 3.1. One-cup trial

Overall, rice consumption varied by treatment group ($F_{5,30}$=12.58, $p<0.001$), with the 0.5% anthraquinone ($\bar{X}$= 0.39 g/bird, SE=0.12) and 0.05% methiocarb ($\bar{X}$=0.40 g/bird, SE=0.07) groups displaying lowest daily consumption. Across all groups, mean rice consumption varied ($F_{4,120}$=3.71, $p$=0.007) with test day. Mean consumption was greatest on the pretreatment day ($\bar{X}$=1.03 g/bird, SE=0.11) and least on the first treatment day ($\bar{X}$=0.69 g/bird, SE=0.08).

The treatment × day interaction ($F_{20,120}$=5.82, $p<0.001$) reflected divergent patterns of consumption among test groups during the five-day trial (figure 1). On the pretreatment day and the initial treatment day, rice consumption did not vary ($p<0.05$) among groups. Thereafter, rice consumption increased in the untreated and 0.05% methyl anthranilate groups, remained steady in the 0.05 and 0.1% anthraquinone groups, and declined in the 0.5% anthraquinone and 0.05% methiocarb groups (figure 1). Vomitus was found in the spill pans of some birds in the 0.05% methiocarb group.

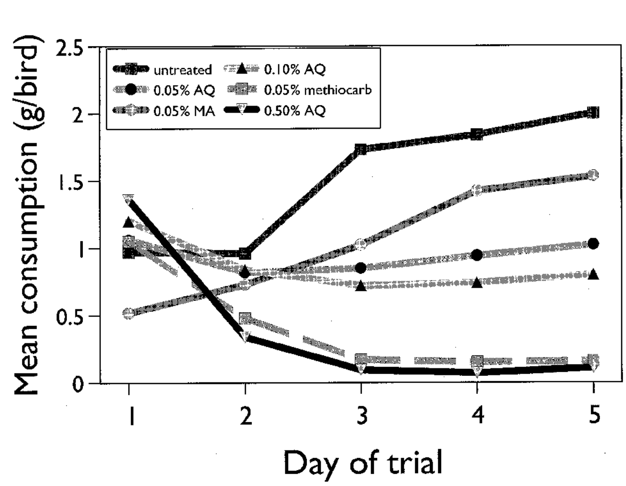


*Figure 1. Mean consumption of rice by singly caged Dickcissels during 3-h trials on 5 consecutive mornings. Consumption did not differ among groups on day 1 (pretreatment) and day 2 (first treatment). On days 3–5, consumption by the 0.5% anthraquinone (AQ) and 0.05% methiocarb groups was suppressed (p<0.05) relative to the untreated, methyl anthranilate (MA) and other AQ groups. There were six birds/treatment.*

### 3.2. *Two-cup trial*

Seed consumption was not affected by anthraquinone treatment level ($F_{1,8}$=1.22, $p$=0.302) or by type of seed ($F_{1,8}$=2.33, $p$=0.165). Consumption did vary with test day ($F_{7,56}$=7.63, $p<0.001$), being lowest on day 1 ($\bar{X}$=0.32 g/bird, SE=0.13) and greatest on day 4 ($\bar{X}$=0.94 g/bird, SE=0.24). The interaction between day and seed type ($F_{7,56}$=19.80, $p<0.001$) reflected that rice and millet were eaten in equal amounts (Tukey test statistic ($\omega$=0.67, $p>0.05$) through the 4-day pretreatment and on the first treatment day (figure 2), but on each of the next 3 days, millet consumption exceeded that of rice ($p<0.05$). There was no three-way interaction ($F_{7,56}$=1.50, $p$=0.185) indicating that the relative amounts of rice and millet consumed daily were independent of anthraquinone treatment level. Inspection of results from the one- and two-cup trials reveals that Dickcissel consumption of rice treated with 0.05 and 0.1% anthraquinone was suppressed when millet was provided as an alternative (table 1).

## 4. Discussion

Often, the presence of an untreated alternative food greatly increases the effectiveness of a chemical feeding deterrent. This was exemplified by the behaviour of Dickcissels in the present study. When presented with no alternative, Dickcissels consumed rice treated with 0.05 and 0.1% anthraquinone at levels similar to when rice was untreated (table 1). At these same rates of treatment, when untreated millet was available as an alternative food, rice consumption markedly declined from pretreatment levels (figure 2). This finding is important because crop damage in the field always includes alternative sources of food for birds, principally in the form of small-seeded, weedy grasses similar to millet.

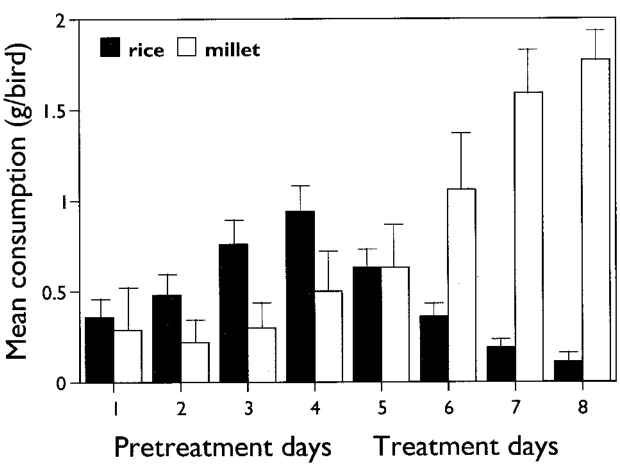


*Figure 2. Mean consumption of rice and millet by individually caged Dickcissels during 3-h trials. Rice was treated with anthraquinone (Flight Control® bird repellent) at rates of 0.05 or 0.1%. Because there was no effect of the rate of treatment (p>0.05), combined results from both groups (n=10) are depicted. Capped bars denote 1 SE.*

In the one-cup trial, there was clear separation of effects on consumption among the three repellents tested. At the 0.05% rate, methyl anthranilate, a primary repellent or contact irritant (Clark 1998), was not effective. The 0.05% anthraquinone treatment did not reduce consumption below pretreatment levels ($p>0.05$), but feeding did appear suppressed compared with the methyl anthranilate treatment (figure 1). Anthraquinone produces post-ingestional distress that often leads to vomiting (Avery *et al.* 1997), but the effects of the 0.05% treatment were apparently tolerable, or at least preferable to not eating. Conversely, methiocarb at 0.05% virtually eliminated rice consumption. Methiocarb produces post-ingestional distress and malaise by inhibiting acetylcholinesterase activity. In many cases, this causes temporary paralysis in addition to repeated vomiting (Schafer 1991). Such direct effects on the bird's nervous system represent the direst consequences of the three chemicals tested, and gram for gram methiocarb was the most effective feeding deterrent.

Nevertheless, by increasing the treatment rate 10-fold, the effects on rice consumption of anthraquinone were indistinguishable from the 0.05% methiocarb treatment. Mean daily consumption of treated rice (0.15 g/bird) by the 0.5% anthraquinone group was reduced 89% from pretreatment (1.36 g/bird). This reduction was identical to that recorded in similar one-cup trials with the red-winged blackbird (Avery *et al.* 1998c).

Consistency between captive Dickcissels and red-winged blackbirds in their responses to anthraquinone treatments suggests that results in the field will also be similar. Aerial application of 18.3 l ha$^{-1}$ Flight Control® to ripening rice in Louisiana resulted in rapid and substantial reductions in blackbird activity on the test fields (Avery *et al.* 1998b). Anthraquinone residues from those trials approximated the 0.05% treatment rate used in the present study. In the presence of an untreated alternative food, the 0.05% treatment rate on rice seed was very effective. A similar response by Dickcissels to aerial applications in Venezuelan rice fields will provide growers with a non-lethal alternative for management of a serious depredation problem. Clearly, field evaluations in Venezuela are needed to verify the effectiveness of Flight Control® and possibly other repellents.

Successful management of Dickcissel depredations will probably require an integrated strategy that includes such factors as the natural history of the bird, the phenology of the crop and large-scale land-use patterns as well as application of feeding deterrents such as Flight Control®. As demonstrated here, a chemical repellent is more effective when an alternative

*Table 1. Mean (SE) consumption of rice seed by captive Dickcissels on the pretreatment day immediately before the treatment period and on days 1 and 4 of the treatment period, with and without an untreated alternative food (millet) present*

| | Without millet | | | With millet | | |
|---|---|---|---|---|---|---|
| Anthraquinone | Pretreatment | Day 1 | Day 4 | Pretreatment | Day 1 | Day 4 |
| 0.05% | 1.06 (0.30) | 0.82 (0.17) | 1.02 (0.09) | 1.07 (0.21) | 0.79 (0.18) | 0.19 (0.12) |
| 0.10% | 1.20 (0.27) | 0.84 (0.18) | 0.80 (0.13) | 0.82 (0.20) | 0.46 (0.10) | 0.03 (0.03) |

food is available. Rice fields typically contain abundant weed seeds eaten by granivorous birds (Rodriguez and Avery 1996). But rather than rely on the natural availability of alternative food, a large-scale integrated management approach might include establishment of reserve areas planted with rice or other grains and maintained for use by wintering Dickcissels. Another option would be to alter the timing of the rice crop within a region to reduce exposure to large populations of wintering birds. Additional research is needed to develop a long-range, ecologically based plan for management of Dickcissel depredations that will protect agricultural interests in Venezuela as well as reduce potential threats to the viability of the species.

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