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Caffeine for reducing bird damage to newly seeded rice

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Abstract

The economic impact of blackbirds can be severe to rice producers in the United States. One approach to managing this damage is the application of bird-deterrent chemical to the crop. Previous pilot trials suggested that caffeine offered potential as a safe, economical bird repellent. In this study, cage feeding trials with female red-winged blackbirds and male brown-headed cowbirds confirmed that a treatment rate of 2500 ppm caffeine on rice seed reduced consumption as much as 76%. Trials with mixed species blackbird flocks in a 0.2-ha flight pen resulted in just 4% loss of caffeine-treated rice compared to 43% loss of untreated rice. Field trials of a 10,000 ppm caffeine treatment in Louisiana revealed $>90\%$ of caffeine-treated rice seed remained unconsumed on days 2 and 3 of the study whereas blackbirds consumed $>80\%$ of the untreated seed. As a rice seed treatment to deter blackbirds, caffeine appears to be effective, economical and environmentally safe, although additional aquatic toxicity testing is desirable. Improvements in formulation will be needed to make the compound practical for general agricultural spray applications and to extend the adherence of caffeine to rice seeds in field conditions.
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1. Introduction

In the United States, several species of blackbird, particularly red-winged blackbirds (*Agelaius phoeniceus*), grackles (*Quiscalus* sp.), and brown-headed cowbirds (*Molothrus ater*) inflict estimated damage worth \$11.5 million to newly planted and ripening rice (Besser, 1985). Damage is not uniformly distributed, but is localized and generally proportional to the size of nearby blackbird roosts. In Texas, losses in newly seeded rice are estimated at \$4.2 million (Decker et al., 1990). In Louisiana, locally severe blackbird damage to newly planted rice sometimes requires the crop be replanted (Wilson et al., 1989).

Application of a bird-deterrent chemical is one means for growers to reduce losses to birds. Despite extensive research and testing of many promising compounds, however, commercial development and regulatory agency approval of a safe, effective bird repellent remain elusive (Avery et al., 1995, 1998; Avery and Cummings, 2003).

We became interested in the possible bird-repellent uses of caffeine because previous screening trials with male red-winged blackbirds revealed it to have relatively low toxicity ($LD_{50} = 316\,mg\,kg^{-1}$) with a relatively high repellency rating (Schafer et al., 1983). Initial feeding trials with individually caged male red-winged blackbirds determined that caffeine applied at a rate of

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2500 ppm to rice seed reduced consumption of the seed by 76% (Avery and Cummings, 2003).

Caffeine is a powerful central nervous system stimulant that is widely distributed in nature and widely consumed by humans. Worldwide, it is estimated that humans ingest 120,000 tons of caffeine each year, principally through consumption of coffee and tea (Weinberg and Bealer, 2001). Other common sources of caffeine include soft drinks, chocolate, and various prescription and nonprescription medicines.

Caffeine is a purine alkaloid and is known chemically as 1,3,7-trimethylxanthine. It is moderately soluble in water at body temperature, and freely soluble in water $>80\,^{\circ}C$ (Windholz, 1983). Because caffeine is water-soluble, it readily passes through all cell membranes in the body. Thus, following ingestion, caffeine is absorbed rapidly from the stomach and intestines into the blood stream and then dispersed to all body organs, including the brain. Caffeine is not stored or sequestered within the body, and within 12 h of ingestion, 90% of the caffeine consumed has been metabolized and excreted (Weinberg and Bealer, 2001).

Dozens of plants contain caffeine, particularly those which produce coffee, tea, and cacao. In these plants, caffeine has antibacterial and antifungal properties. It also causes sterility in some insects. The insecticidal properties of caffeine prompted suggestions that the compound be developed for pest management purposes (Nathanson, 1984), including as a repellent or toxicant for slugs and snails (Hollingsworth et al., 2002).

In this study, we extend our earlier findings in cage feeding trials to female red-winged blackbirds and male brown-headed cowbirds, and we report on mixed-species blackbird feeding trials conducted with captive birds within a 0.2-ha flight pen and with free-flying birds on field plots in Louisiana, USA.

2. Methods

2.1. Trials with captive birds

2.1.1. Seed treatment

We prepared rice seed in 1-kg batches. We dissolved the appropriate amount of caffeine (Sigma Chemicals, St. Louis, MO, USA) in 60 ml of warm (60–65 °C) distilled water with 0.5 ml of a commercial agricultural spreader/binder (Latron CS-7, Rohm and Haas Company, Philadelphia, PA, USA). We slowly added this mixture to 1 kg of rice as it turned in a rotating mixer. Mixing continued for 5 min until the rice seed flowed freely in the mixer. We then air-dried and stored the treated seed in an air-conditioned laboratory.

2.1.2. Experimental subjects

For this study, we used 36 female red-winged blackbirds, 36 male brown-headed cowbirds, and 16 male red-winged blackbirds. We trapped birds locally in Alachua County, FL, USA and held them 1–3 months prior to testing. We housed birds in group cages ($1.2 \times 1.2 \times 1.6\,m^3$) in a roofed outdoor aviary and provided free access to water, grit and maintenance food (quail starter, Hillandale Farms, Lake Butler, FL, USA).

2.1.3. Individual cage trials

We conducted feeding trials in a roofed outdoor aviary, where test cages ($45 \times 45 \times 45\,cm^3$) were visually isolated and equipped with trigger-cup waterers. We presented food in clear plastic feed cups (8.2 cm diameter, 3.8 cm high) with a circular opening (3.1 cm diameter) in the top. Four days before the start of the trial, we removed birds from their holding cages, weighed them, and randomly assigned each to a test cage. Test groups (3 treatment and 1 untreated control group) of 5 birds each were formed by randomly assigning birds to receive either untreated rice or rice treated with caffeine at 1000, 1500, or 2500 ppm. During the 4-day acclimation period, we provided birds with a mixture of rice seed and commercial quail starter diet.

Following acclimation, there was a 4-day pretreatment period, a 2-day break, and a 4-day treatment period. During pretreatment, each bird's test cup held 20 g of untreated rice seed. During the 2-day weekend break, quail starter was provided. In the treatment phase, birds in the treatment cages received treated rice and the control group received untreated rice. During the treatment period, we videotaped one bird given treated seed to observe immediate and subsequent behavioral responses to the treatment.

During the pretreatment and treatment periods, we removed quail starter maintenance food at 07:00, and 1 h later placed the test food cups in the cages. Aluminum trays suspended from test cages under each cup caught spillage. The spillage information was used to estimate the proportion of rice seed removed from the cups that was actually eaten. Cups containing test food not exposed to birds were put in vacant cages to determine mass changes due to moisture. After 3 h, test food was removed and the birds' maintenance food again provided. Contents of test food cups were weighed and consumption determined by subtraction after appropriate adjustments for spillage and moisture gain. After the final treatment day, test birds were reweighed, banded, and released. The entire test sequence was completed with female red-winged blackbirds and male brown-headed cowbirds.

Consumption data for blackbirds and cowbirds were analyzed in separate 2-way analyses of variance with caffeine level as the independent factor and repeated