PROJECT REPORT

Project Title: Concentration-response Relationship of Anthraquinone-treated Lettuce Seedlings for Horned Larks.

Research Agency: National Wildlife Research Center

Principal Investigator: Scott J. Werner

Background:
Several bird species cause monetary losses to agricultural production throughout the world. For example, horned larks (Eremophila alpestris) severely damage lettuce, carrots, beets, spinach, turnips, and peas in California (Neff 1948). California's lettuce crop (Lactuca sativa) is economically important; it comprised approximately 77,000 ha of lettuce valued at $735 million in 1996 (California Farm Bureau Federation web page, 1998), 101,000 ha valued at $1.3 billion in 2002 (cfbf.com, 2002), and $1.6 billion in 2010 (CDFA.ca.gov/statistics 2011–12). In 1974, approximately 45% of survey respondents regarded bird damage as a serious problem among California lettuce growers (DeHaven 1974). Bird damage to newly-planted lettuce remains a major problem in several production areas in California, including the San Joaquin Valley, the central coast, and southern California (Hueth et al. 1998; Gebhardt et al. 2011).

York et al. (2000) suggested that horned larks cause the majority of damage to California lettuce production. Horned larks consume lettuce seeds, uproot seedlings, and graze seedling leaves (cotyledons). Damaged lettuce seedlings are typically stunted or disfigured, and thus disrupt harvest schedules. Horned larks are most abundant and cause most damage to lettuce seedlings from November–January in the Central Valley of California (York et al. 2000). Lettuce seedlings are most susceptible to bird damage during the two weeks subsequent to seedling emergence, unless cold weather delays growth (York et al. 2000). Lettuce damage typically continues until seedlings are approximately 8 cm tall, and severe damage caused by horned larks typically occurs first near the center of lettuce fields (Cummings et al. 2006). These damages have motivated the use of several bird damage management techniques, including chemical repellents.

Although methiocarb-based chemical repellents effectively reduced horned lark damage to lettuce seedlings during an aviary test (Cummings et al. 1998) and a field enclosure study (York et al. 2000), methiocarb is no longer registered as a bird repellent for use on food crops. Cummings et al. (1998) also concluded that foliar repellent treatments including methyl anthranilate or lime significantly reduced consumption of lettuce seedlings among horned larks during aviary tests. Although methyl anthranilate is currently registered as an avian repellent, Werner et al. (2005) concluded that Bird Shield™ bird repellent (a.i. methyl anthranilate) was not effective for repelling blackbirds from ripening rice and sunflower fields.

Anthraquinone-based repellents have also been previously tested with horned larks and lettuce seedlings. York et al. (2000) observed 60% damage (505 of 841 lettuce seedlings "destroyed") among field enclosures that contained horned larks and lettuce seedlings treated with "2.79 kg ha^{-1}" Flight Control™ (a.i. 50% 9,10-anthraquinone; Arkion Life Sciences, New Castle, DE). Cummings et al. (2006) observed 8% damage (44 of 522 lettuce seedlings consumed) among field enclosures that contained horned larks and lettuce seedlings treated with 10 L Flight Control™ per ha. For the purpose of reconciling efficacy of varying repellent concentrations, we recently investigated the concentration-response relationship of an anthraquinone-based repellent for Canada geese (Branta canadensis), red-winged blackbirds (Agelaius phoeniceus), ring- necked pheasants (Phasianus colchicus; Werner et al. 2009), and common grackles (Quiscalus quiscula; Werner et al. 2011). The present study was designed to evaluate repellency of foliar applications of an anthraquinone-based repellent on emergent lettuce seedlings and develop an anthraquinone concentration-response relationship for horned larks in captivity.

Results:

Preference testing with treated lettuce seedlings.

Horned larks consumed fewer than 10 lettuce seedlings during the first day of the preference test (i.e., from treated and untreated pans, combined). For the purpose of developing an anthraquinone concentration-response relationship for horned larks in captivity, we therefore terminated the lettuce seedling preference test and completed a concentration-response test with anthraquinone-treated wheat seeds.

Concentration-response testing with treated wheat seeds.

We observed 38–100% feeding repellency among horned larks offered wheat seeds treated with target concentrations of 0.02–0.5% anthraquinone (Figure 1). Actual anthraquinone concentrations for our 0.02%, 0.035%, 0.05%, 0.1%, 0.25%, and 0.5% anthraquinone seed treatments were 168, 323, 312, 716, 2150, and 3010 ppm anthraquinone, respectively. Lark repellency was not related to actual anthraquinone concentrations ($r^2 = 0.55$; $P = 0.091$). However, we observed 100% feeding repellency among horned larks offered wheat seeds treated with 3,010 ppm anthraquinone; we previously targeted ≥75% repellency for our concentration-response experiments (Werner et al. 2008a,b, 2009, 2010, 2011). Thus, horned larks were effectively repelled from wheat seeds treated with a target concentration of 0.5% anthraquinone (Figure 1). Subsequent field efficacy testing is recommended for horned larks exposed to lettuce seeds (i.e., preplant seed treatments) and lettuce seedlings (i.e., foliar applications to emergent seedlings) treated with ≥3,000 ppm anthraquinone.