LABORATORY EVALUATION OF A METHYL ANTHRANILATE BEAD FORMULATION ON MALLARD FEEDING BEHAVIOR

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Abstract: We applied methyl anthranilate (MA) bead formulation coded JR930413 to bottom sediment in a simulated pond setting to evaluate its repellency to captive mallards (*Anas platyrhynchos*). We applied JR930413 at a rate of 21.7 kg/ha or 7 bead/cm^2 to bottom sediment. Methyl anthranialte bead formulation JR930413 was effective in reducing time mallards spent in pools ($P \leq 0.01$). Application of JR930413 to contaminated waterfowl feeding areas at 21.7 kg/ha could reduce feeding and mortality and warrants further testing in the field.

JOURNAL OF WILDLIFE MANAGEMENT 62(2):581–584

Key words: *Anas platyrhynchos*, avoidance, feeding behavior, food flavor, mallard, methyl anthranilate, remediation, white phosphorus.

Since 1945, the U.S. Army has used Eagle River Flats on Fort Richardson, Alaska, as an impact area for artillery shells, mortar rounds, rockets, grenades, illumination flares, and U.S. Army–Air Force door-gunnery exercises. In August 1981, hunters discovered large numbers of duck carcasses in Eagle River Flats. Since that time, the U.S. Army and other federal and state agencies have been involved in identifying the cause of the waterfowl mortality problem. On 8 February 1990, the Army temporarily suspended firing into the Eagle River Flats due to the suspected correlation between explosives and duck deaths (W. A. Quirk, III. 1991. Environmental assessment for resumption of firing in the Eagle River Flats impact area, Fort Richardson, Alaska, unpublished report. U.S. Department of Army, Fort Richardson, Alaska, USA). In July 1990, a sediment sample collected from Eagle River Flats was suspected of containing white phosphorus. By February 1991, it was confirmed that white phosphorus at Eagle River Flats was the cause of waterfowl mortality (Cold Regions Research and Engineering Labortory 1991).

Eagle River Flats is an important spring (Apr–May) and fall (Aug–Oct) waterfowl staging area, but white phosphorus has represented a hazard to migrating waterfowl at this location (Cold Regions Research and Engineering Laboratory 1991). This concern has stimulated efforts toward the development of an effective remediation action to reduce or eliminate waterfowl mortality caused from white phosphorus in Eagle River Flats. One action might be use of MA in waterfowl feeding areas that are contaminated with white phosphorus. Methyl anthranilate is a food flavoring approved for human consumption by the U.S. Food and Drug Administration that has been found to be offensive to birds (Avery et al. 1992, Cummings et al. 1992). Methyl anthranilate produces a negative response in most birds by affecting the trigeminal receptors in the mouth (Mason et al. 1989).

In 1992, laboratory studies were conducted to evaluate the repellency of 2 MA bead formulations to captive mallards (Cummings et al. 1993). Methyl anthranilate bead formulation coded DP920324B applied at 5.4 kg/ha was ineffective in reducing the number of duck entries into simulated test pools. Examination of the test pools indicated that the structure of the beads was pliable and would not break under duck bill pressure. However, experiments with MA bead formulation coded SE920326 at application rates of 5.4 and 10.8 kg/ha showed slight treatment effects. These application rates provided marginal bottom coverage and precluded ducks from encountering sufficient numbers of beads during each feeding bout to deter them from the pools. An application of SE920326 at 21.7 kg/ha to bottom sediment was needed to cause almost complete avoidance of treated simulated ponds and indicated that ducks were likely to continue to avoid ponds on subsequent treatment days.

Field studies conducted in 1992 indicated a loss of the effectiveness of MA after 10 days (Clark et al. 1993*b*). Two possibilities existed for this reduced performance in the field: (1) the bead wall may have been permeable to MA, and (2) MA may not have dissolved in the oil formulation. Because MA has a higher affinity for oil than water, MA is more likely to stay within the capsule, as long as the oil does not permeate the alginate outer wall. Hence, changing the outer wall to decrease permeability to oil and reincorporating the core to an oil–MA mix should retard leaching from the capsule. An effective bead formulation might then contain a 15% concentration of methyl anthranilate and a half-life of 10 days. If the above MA bead formulation could be achieved, the beads should retain their effectiveness in the field for the duration of the spring or fall waterfowl staging period at Eagle River Flats, where only 1 additional application may be required during the fall migration period.

This study tested a modified MA bead formulation that was encapsulated at 15% methyl anthranilate by mass in a food-grade material coated with a water–oil impermeable material. The MA bead formulation was evaluated in a simulated pond setting to determine the effects on feeding behavior of mallards.

METHODS

We obtained a bead formulation, JR930413, containing 15% entrapped MA in a food-grade material from PMC Specialties Group, Cincinnati, Ohio, USA (Use of a company name does not imply U.S. Government endorsement of their product). The material was formed into beads about 3–4 mm in diameter and coated with an impermeable polymer. Beads were structured to release at minimum mallard bill pressure (1 psi; Cummings et al. 1993).

We obtained adult mallards from a captive wild mallard population housed at the Denver Wildlife Research Center, Denver, Colorado, USA. Captive mallards were banded with U.S. Fish and Wildlife Service numbered bands and weighed at periodic intervals. The mallards were housed in 1 of 2 holding pens (54 and 96 m^2) at the Denver Wildlife Research Center and quarantined for at least 14 days before testing. We followed criteria outlined by the Animal Welfare Act and the National Wildlife Research Center Animal Care and Use Committee.

After quarantine, we randomly selected 8 mallards (4 M, 4 F) of similar masses and housed them in a 2- × 2- × 2-m test pen in an indoor aviary. We acclimated birds for 4 days before collecting pretreatment data. The mallards had free access to food (mixture of corn, wheat, barley, duck chow) and water. The floor of each pen was elevated about 20 cm and covered with Dri-deck matting (Monarch Pools, Denver, Colorado, USA). A circular pool 1 m in diameter and 20 cm deep was inserted into the floor so that water height was the same as the floor. Mallards were able to enter the pool directly from the floor. The bottom of the pool was covered with 3 cm of sand, which encouraged foraging off the bottom of the pool. Throughout the experiment, we placed food in a pan on the Dri-deck outside the pool.

We conducted the experiment between 0800 and 1600 for a 7-day pretreatment and a 10-day treatment period. The bead matrix was designed to settle to the bottom of the pool and only release MA when broken by feeding mallards. The bead formula was applied to the pool at 21.7 kg/ha or about 7 beads/cm^2 so that mallards would encounter it when feeding from the bottom.

The number of entries each mallard made into the pool was recorded with a Trailmaster motion detector (Goodson and Associates, Lenexa, Kansas, USA). Each day, the motion detector was turned on to the data gathering mode when the duck was outside of the pool to ensure that the first event recorded was an entry. We recorded data from the motion detector at the end of each treatment day. We used a 2-factor repeated measures analysis of variance with day as the repeated factor (treatment × sex × day) to assess whether time spent in the water varied among groups. We used Duncan's multiple-range test to isolate differences ($P < 0.05$) among means.

Before treatment, we collected 1 20-g sample of the MA bead formulation for subsequent verification of the chemical concentration. In addition, we collected 1 sample of water (20 mL) per pool for MA analyses during each treatment day. All samples were shipped to Monell Chemical Senses Center (Philadelphia, Pennsylvania,

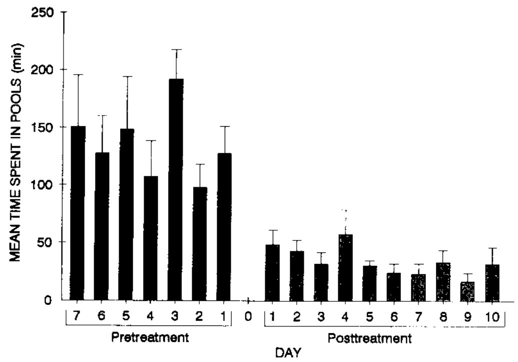

Fig. 1. Mallard use of aviary pools treated with methyl anthranilate bead formulation JR930413 (15%) applied at 21.7 kg/ha, Denver, Colorado, 17 May–3 June 1993. Capped vertical lines represent standard errors of the means.

USA) and analyzed with a method described by Clark et al. (1993*a*).

RESULTS

The average number of minutes mallards spent in pools decreased ($F_{6,16}$ = 7.64, $P <$ 0.01) to below pretreatment levels on day 2 posttreatment and remained at this level until the completion of the study (Fig. 1). We found no differences between sexes ($F_{1,6}$ = 0.04, P = 0.84) and sex × day interaction ($F_{1,16}$ = 1.17, P = 0.31).

Analysis of MA bead formulation JR930413 was 13.9–14.5%. No MA was detected in any of the water samples collected from the test pools.

DISCUSSION

Methyl anthranilate bead formulation, JR930413, was sufficient to cause almost complete avoidance of treated pools. Data also indicated that ducks encountering MA continued to be repelled on subsequent treatment days. The number of entries into the pools also decreased over the treatment period, suggesting there were residual effects from previous encounters with MA beads, and limited observations suggested that the learned avoidance of the pools was associated with MA beads. The MA repellency threshold for waterfowl is >2% (Cummings et al. 1993). In this experiment, the higher application rate increased the possibility that ducks would encounter beads in sediment when feeding, and the greater concentration prolonged the effectiveness of the MA beads.

While several waterfowl feeding areas on Eagle River Flats are contaminated with white phosphorus, only certain areas have high enough white phosphorus concentrations that could be lethal to waterfowl. Exposure data from penned mallards placed over these highly contaminated sites at Eagle River Flats indicate that mortality usually occurs after prolonged feeding bouts (J. L. Cummmings, unpublished data). Thus, waterfowl feeding in sites contaminated by white phosphorus and treated with MA beads are likely to be repelled from the site before ingesting a lethal dose of white phosphorus. Hence, use of MA could be an effective management tool to reduce duck use of contaminated areas, but field tests on Eagle River Flats are warranted.

ACKNOWLEDGMENTS

We thank S. A. Bird, U.S. Army Environmental Center, and W. A. Gossweiler, U.S. Army, Fort Richardson, for funding and support for this project, and the National Wildlife Research Center Animal Care Section for technical assistance.

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Received 22 April 1996.
Accepted 23 July 1997.
Associate Editor: Fairbrother.