ANTHRAQUINONE FORMULATION (FLIGHT CONTROL®) SHOWS PROMISE AS AVIAN FEEDING REPELLENT

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Abstract: We evaluated the effectiveness of Flight Control® (FC), which contains 50% anthraquinone (AQ), as a grazing repellent for Canada geese (*Branta canadensis*) and as a seed-treatment repellent for brown-headed cowbirds (*Molothrus ater*) in northern Ohio in 1997. For the turf test, FC was applied at 4.5 L/ha in 6 18.3- × 30.5-m pens. There were 2.5 times more ($P < 0.01$) bill contacts/min observed on untreated plots (26.4 ± 6.0; $\bar{x} \pm$ SE) compared to treated plots (10.4 ± 3.8) during a 7-day test with captive geese. Mean numbers of geese per observation were also greater ($P = 0.02$) on untreated plots (2.6 ± 0.4) compared to treated plots (1.4 ± 0.4). Residue analyses indicated AQ declined from 2.02 kg/ha at application to 0.22 kg/ha after 1 week. Individually caged cowbirds were presented untreated millet or millet treated with FC at 0.1, 0.5 and 1.0% (g/g) levels in 1- and 2-choice tests for 3–4 days. Flight Control® was repellent to cowbirds at all levels in both 1- and 2-choice tests. In the 2-choice test, birds in the 1.0% treatment level lost body mass ($P = 0.04$), whereas birds at the other levels did not. Each group of treated birds in the 1-choice test lost mass ($P \leq 0.01$), whereas the control group did not. Birds in the 0.5 and 1.0% groups ate minimal amounts; 3 of 12 birds died. We conclude that FC was an effective foraging repellent for Canada geese in a 7-day pen experiment and for brown-headed cowbirds as a seed repellent in aviary experiments. Flight Control® shows promise as an avian feeding repellent. Further lab and field studies are needed to refine minimum repellent levels and to enhance retention of AQ on treated vegetation.

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Canada goose populations, particularly populations of resident giant Canada geese (*Branta canadensis maxima*), have increased dramatically in recent years in North America (Ankney 1996). These burgeoning populations have resulted in numerous goose–human conflicts in agricultural, recreational (e.g., parks, golf courses), and airport settings (Hunt 1984, Kahl and Samson 1984, Conover and Chasko 1985, Cleary et al. 1997). For example, 24 people were killed when a U.S. Air Force E-3 aircraft valued at $190 million crashed at Elmendorf Air Force Base, Alaska, after striking Canada geese on take-off in September 1995.

Other problem species include blackbirds (Icterinae), which cause substantial economic loss to various agricultural crops (Heisterberg 1983, Hothem et al. 1988, Wilson et al. 1989, Dolbeer 1990). For example, depredations by blackbirds on ripening field corn in the United States in 1981 was estimated at >272,000 metric tons worth $31 million (Besser and Brady 1986). In addition, blackbirds create human health and safety concerns when roosting in large numbers near airports or other urban areas (Cleary et al. 1997, Dolbeer et al. 1997).

Because large-scale killing of nuisance birds is often undesirable or impractical (Dolbeer 1986), there is considerable demand for effective nonlethal techniques to deter birds from problem sites. Numerous frightening and exclusion devices have been used in efforts to reduce bird–human conflicts (Dolbeer et al. 1995); however, many are ineffective or cost-prohibitive. Chemical repellents are a promising means of reducing avian damage; however, only 1 chemical, methyl anthranilate, is currently registered with the U.S. Environmental Protection

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Agency (EPA; Dolbeer et al. 1993, Belant et al. 1995, Cummings et al. 1995). Most foraging repellents evaluated recently have had short-term effectiveness or have been tested only in laboratory situations (Cummings et al. 1991, 1995; Belant et al. 1997*a,b*).

Environmental Biocontrol International (EBI, Wilmington, Delaware, USA) has developed a potential avian repellent, FC, which contains 50% AQ. Formulations of AQ have previously been used as a bird repellent for pine (*Pinus* spp.) seed (Royall and Neff 1961), but no products containing AQ currently are registered by EPA. Preliminary tests in 1996 with captive geese in 4 small (10 × 21 m) pens suggested FC had repellency (P = 0.10–0.11; J. L. Belant et al., U.S. Department of Agriculture, unpublished data). Our objectives were (1) further test FC as a grazing repellent for Canada geese by using larger (18.3 × 30.5 m) pens with increased replications (n = 6), and (2) quantify the effectiveness of 3 concentrations of FC as a feeding repellent for brown-headed cowbirds.

METHODS

Flight Control® contains 50% AQ, surfactants (2%), and a latex-based filler (48%). Flight Control® is a light-tan liquid, miscible in water, and has a pH of 7.5–8.5. The oral LD_{50} for rats is >10,000 mg/kg, and the dermal LD_{50} is 1,000 mg/kg (FC Material Safety Data Sheet, EBI, Wilmington, Delaware, USA).

Turf Test

Procedures involving animals were approved by the National Wildlife Research Center Animal Care and Use Committee. Canada geese of undetermined sex were captured during molt in northern Ohio on 20 June 1997 and transported to a 2-ha fenced pond in Erie County, Ohio. Grass and shade were available along the perimeter of the pond. Geese had primary feathers from 1 wing cut before being released onto the pond. Whole-kernel corn and poultry pellets were provided as food supplements. A 0.4-ha fenced holding area adjacent to the pond was used to separate experimental from nonexperimental geese. This holding area contained grass and shade and included about 20 m^2 of the pond. Geese maintained in this area also were provided corn and poultry pellets.

A fenced chute connected the holding area to the test site, which consisted of 6 18.3- × 30.5-m pens constructed in a grass area of 1.5-m-high fence. The area was sown with perennial rye and fertilized 4 weeks before testing. Pens were spaced 5–12 m apart. A 1.5-m-high heavy plastic fence was placed between adjacent pens to serve as a visual barrier. Each pen consisted of 2 15.2- × 18.3-m plots (treatment, control) delineated by a spray-painted line on the grass. A 0.5-m-diameter pan of water was positioned in the center of each plot. A rain gauge was placed at the test site to monitor precipitation.

Prior to pretreatment conditioning, 24 geese were herded from the pond to the holding area, and each was assigned randomly to 1 of 6 groups of 4 geese. We attached color-coded neck collars (1 color/group) to individuals in each group. Each group was assigned randomly to 1 of the 6 pens. Pens were mowed to a height of 5 cm on 10 July. For 8 days (11–18 Jul) prior to testing, each group of 4 geese was herded from the holding area to the appropriate pen at 0830. Geese were herded back to the holding area at 1530. This grazing schedule allowed geese to adjust to pen conditions and establish social hierarchies prior to testing.

Three 4-m-high scaffolds were positioned 16–26 m from the pens. One person conducted observations of geese from each scaffold daily starting at 0900, 30 min after geese were released into the pens. Each person observed geese in each of 2 pens for 1 hr, alternating observations between pens every 60 sec (daily total of 30 min/pen). During each 60-sec interval, observers recorded the number of geese seen initially in each plot and the total number of bill contacts with grass in each plot. To estimate fecal mass deposited daily on each plot, we established 4 permanent 1- × 15-m transects at 4.6-m intervals and collected feces daily at 1530. Feces were placed in a drying room at 38°C for 48 hr before weighing.

At the end of the final pretreatment day (18 Jul), we calculated the mean number of bill contacts per plot in each pen for the last 4 days of the pretreatment period (15–18 Jul) and assigned the plot with the highest feeding rate to be sprayed with FC. Immediately before we applied FC, grass in the pens was mowed to a height of 5 cm, and cut grass was removed. We then placed 20 glass slides (2.5 × 7.6 cm) in a 0.5- × 2-m area in 1 treatment plot to determine the amount of AQ present over time. We mixed FC with water and used a boom sprayer at 27.6 Newtons/cm^2 to evenly apply the formulation on 6 plots at a rate of 4.5 L/ha; remaining plots served as untreated controls. After treatment, slides were placed on a board on the ground outside 1 of the pens. We randomly selected 5 slides at 2 hr after application and at days 2, 5, and 7 for residue analysis (*u*g of AQ/slide). Residue analysis was performed by EBI personnel and converted to kilograms per hectare based on the surface area of the slides. We continued daily observations and feces collections for the 7 days following treatment (19–25 Jul), at which time the experiment was terminated. Test geese then had collars removed and all cut primary feathers pulled before being placed back in the holding pond. These geese were able to fly from the pond within 40 days.

Mean numbers of geese observed, mean numbers of bill contacts, and mean mass of fecal material collected were analyzed via randomized block analysis of variance with repeated measures (Statistix 1994). If main effects or interactions were significant ($P < 0.05$), we used Tukey tests to determine which means differed.

Aviary Tests

Adult male brown-headed cowbirds were captured in decoy traps in northern Ohio during March 1997 and transported to an outdoor aviary in Erie County. Cowbirds were held until testing in groups in 2.5- × 2.5- × 2.0-m holding cages containing millet and water. Experimentally naïve birds were used for each test. Tests were completed in April 1997.

Two-Choice Test.—Twenty-four adult male brown-headed cowbirds were randomly selected from the group-holding cages, banded, and placed individually in 1.0- × 1.5- × 0.5-m cages containing water, grit, and millet (see Woronecki et al. 1986). The birds were then randomly assigned to 4 groups containing 6 birds each. One group was used as a control to monitor body mass changes. The remaining 3 groups were used in the 2-choice test. For 4 days immediately preceding the experiment, birds were provided 2 cups (0.1 L) containing millet. Each cup was attached to a 24-cm-diameter pan to catch spillage.

On day 1 of the experiment, cowbirds were weighed at 0900, and 2 food cups were placed in each cage. One cup contained 20.0 g of millet, and the other contained 20.0 g of millet mechanically mixed with 1.0, 0.5, or 0.1% FC (g/g; see Belant et al. 1997*a*), or left untreated. For the next 3 days, cups were removed at 0900 and replaced with fresh millet and identical millet–FC mixtures. Positions of cups were randomized each day. Contents of removed cups, including spillage, were weighed to determine consumption. Final 24-hr consumption was adjusted for moisture gain or loss based on mass changes of control cups of millet and millet–FC placed adjacent to cages. Cowbirds were reweighed at the end of the test.

One-Choice Test.—A 1-choice test was conducted under identical conditions. We used a single food cup containing 20.0 g millet mixed with the same predetermined levels of FC. The 1-choice test was terminated after 3 days.

Due to small sample size within groups, and nonnormal data, we compared food consumption among treatments via the Kruskal-Wallis analysis of variance, followed by a pairwise comparison of mean ranks between treatment groups (Statistix 1994). We used repeated measures analysis of variance (SAS Institute 1988) to examine time effects within treatments. We used Dunnett's *t*-test (SAS Institute 1988) to conduct paired comparisons between groups at each level of time. Changes in body mass were examined with paired *t*-tests.

RESULTS

Turf Test

There were 2.5 times ($F_{1,10} = 25.86$, $P < 0.01$) more bill contacts/min observed on untreated plots (26.4 ± 6.0; $\bar{x}$ ± SE) compared to treated plots (10.4 ± 3.8) during the 7-day test (Fig. 1). This result was in contrast to the 4-day pretreatment period when untreated plots averaged only 0.6 times as many bill contacts/min (10.1 ± 3.1) as did plots that were subsequently treated (16.4 ± 3.6). There was no difference ($F_{6,60} = 2.11$, $P = 0.07$) in feeding rate among days, but there was an interaction of day × plot treatment ($F_{6,60} = 2.45$, $P = 0.03$). Day 2 had the greatest mean difference in feeding rate between untreated and treated plots, whereas days 6 and 7 had the least difference.

Mean numbers of geese per observation were also greater ($F_{1,10} = 8.43$, $P = 0.02$) on untreated plots (2.6 ± 0.4) compared to treated plots (1.4 ± 0.4; Fig. 1). Again, this result was in contrast to the 4-day pretreatment period when untreated plots averaged only 0.4 times as many geese per observation (1.0 ± 0.4) as did plots that were subsequently treated (2.8 ± 0.4).

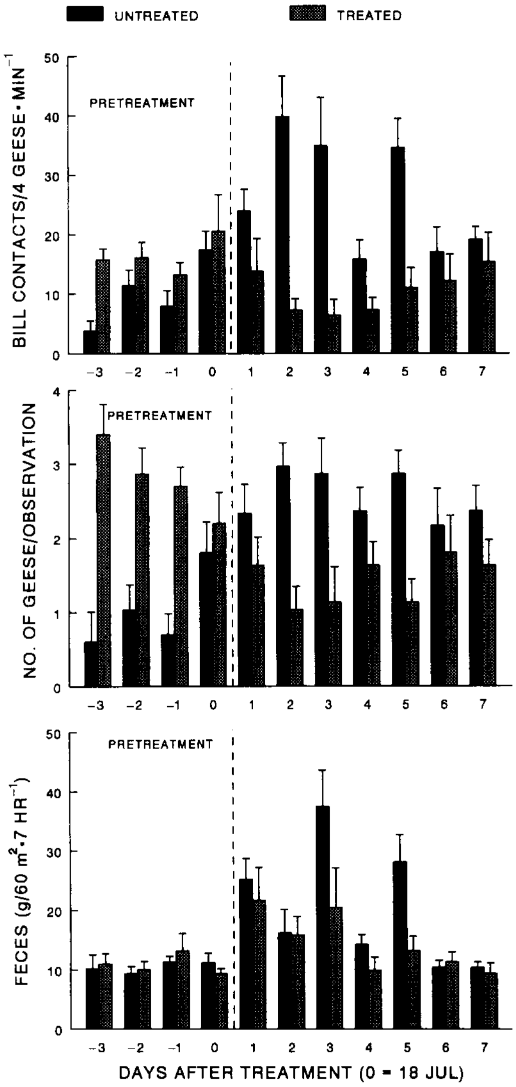

Fig. 1. Mean number of bill contacts, number of Canada geese, and fecal mass on grass plots in pens untreated or treated with Flight Control™ at an application rate of 4.5 L/ha, Erie County, Ohio, July 1997. Capped vertical lines represent 1 standard error.

There was an interaction ($F_{6,60}$ = 2.45, P = 0.03) between day and plot treatment: day 2 had the greatest mean difference in geese per observation between untreated and treated plots, whereas days 4, 6, and 7 had the least difference.

Mean fecal mass (g/60 m^2·7 hr^{-1}) collected on untreated (20.3 ± 12.6) and treated (14.5 ± 9.8) plots was similar ($F_{1,10}$ = 3.40, P = 0.09). Again, there was a day × plot treatment interaction ($F_{6,60}$ = 2.48, P = 0.03) for fecal mass. Days 3 and 5 had the greatest mean difference (Fig. 1).

The estimated amount of AQ (kg/ha) declined from 2.02 ± 0.06 on day 0 to 0.22 ± 0.03 on day 7. The major decline occurred between days 2–5 after treatment. We recorded 6.5 mm of rain on day 4 and 5.0 mm on day 6. There was no perceptible odor or grass discoloration associated with the treatment, even immediately after application.

Aviary Tests

Two-Choice Test.—Brown-headed cowbirds in treatment and control groups ate a similar combined amount of treated and untreated millet (χ^2_3 = 4.96, P = 0.15). Overall, birds consumed dissimilar (χ^2_3 = 137.01, P < 0.01) amounts of untreated and treated millet (Fig. 2). There was a time × treatment interaction ($F_{9,31.8}$ = 5.63, P < 0.01) for the 0.5% treatment level between days 1 and 4 ($F_{1,15}$ = 15.18, P < 0.01). Also, birds consuming the 0.5% treated millet decreased consumption over the 4 days by 80–100%.

Birds presented with the 1.0% treatment had a mean body mass loss of 0.8 g (t_5 = −2.87, P = 0.04; Fig. 2) during the 4-day test. The 0.5% treatment group had a greater mean mass loss; however, loss was due primarily to 1 bird, and overall mass loss was not significant (t_5 = −2.08, P = 0.09). Control and 0.1% groups also showed no mass loss (Control: t_5 = 0.51, P = 0. 63; 0.1%: t_5 = 1.11, P = 0.32).

One-Choice Test.—Brown-headed cowbirds consumed dissimilar (χ^2_3 = 43.88, P < 0.01) amounts of untreated and treated millet (Fig. 3). Cowbirds presented 1.0% treated millet consumed less (P < 0.01) than control birds or individuals fed 0.1% treated millet. The 0.5% and 1.0% groups consumed similar (P > 0.05) amounts of millet. Within treatment groups, there was a time effect ($F_{2,19}$ = 8.5, P < 0.01). On day 3, food consumption by the 0.1% treatment group was not different from the control group (P > 0.05). However, food consumption by the 0.5 and 1.0% groups was different from the control group (P < 0.05).

Control birds maintained (t_5 = −1.64, P = 0.16) body mass over the 3 days, whereas birds presented with 0.1%, 0.5%, and 1.0% treated millet lost mass (t_5 = 4.47, 8.71, and 11.32, respectively, P < 0.01; Fig. 3). The test was suspended on day 3 when 1 bird in the 1.0% treat-

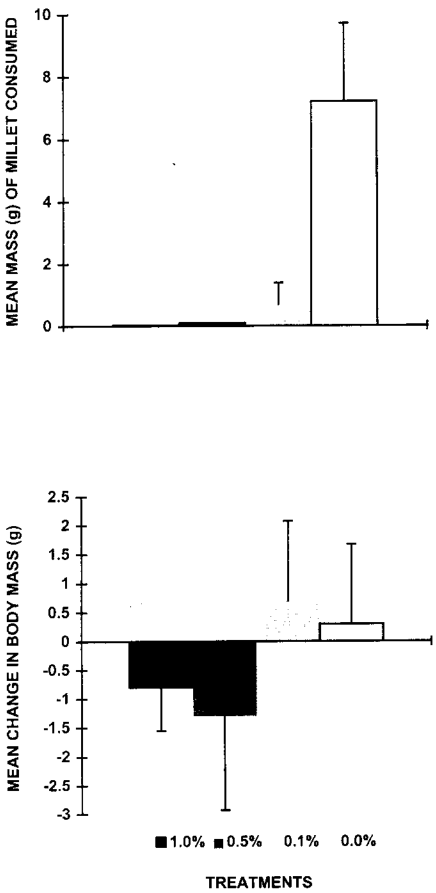

Fig. 2. Mean daily (24 hr) consumption of Flight Control®-treated and untreated millet by captive male brown-headed cowbirds and mean change in individual body mass during a 4-day 2-choice test in Erie County, Ohio, 1997. Capped vertical lines represent 1 standard error.

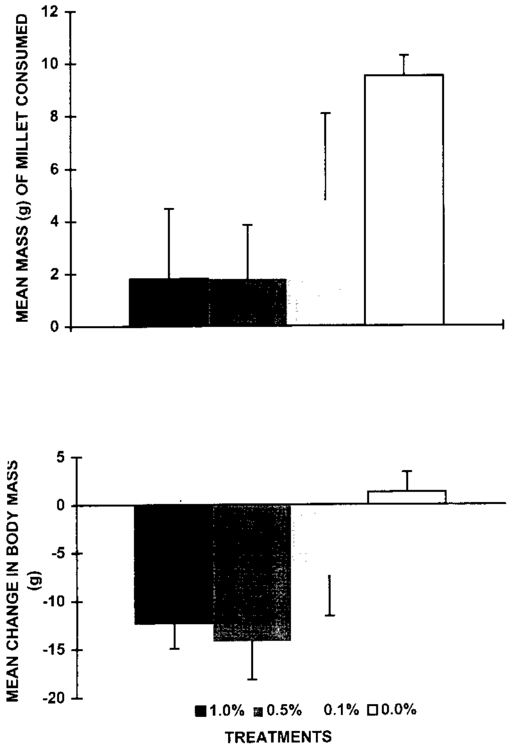

Fig. 3. Mean daily (24 hr) consumption of Flight Control®-treated and untreated millet by captive male brown-headed cowbirds and mean change in individual body mass during a 3-day 1-choice test in Erie County, Ohio, 1997. Capped vertical lines represent 1 standard error.

ment and 2 birds in the 0.5% treatment died due to apparent starvation.

DISCUSSION

Two preliminary tests in 1996 using captive geese in 4 small (10 × 21 m) pens suggested FC had some repellency, although the reduction in grazing was not significant (P = 0.10–0.11; J. L. Belant et al., U.S. Department of Agriculture, unpublished data). A reduction (P = 0.01) in goose occurrence on treated plots was measured over a 10-day period when FC was applied at 4.5 L/ha. Our test in 1997, with 2 additional pens (6 total) and pens 2.7 times larger than in 1996, clearly demonstrated a reduction in grazing and occupancy on treated plots over the 7-day treatment period. However, by days 6 and 7, feeding on treated plots increased to near levels on untreated plots, which was likely related to reduced residues of AQ (<0.3 kg/ha) at this time. The attractiveness of lightly grazed grass in treated plots on days 6 and 7, in contrast to the heavily grazed grass in untreated plots, also may have contributed to the increased feeding in treated plots.

Flight Control® was also repellent to brown-headed cowbirds in aviary tests. In the 2-choice test, each treatment level of FC was repellent over 4 days when compared to the control. We detected a time × treatment interaction between days 1 and 4 at the 0.5% level, but we suspect small sample size within groups was a contributing factor. However, because consumption of the 0.5% FC-treated millet declined by 80–100% for each bird over the 4 days, the repellent effect might not have been independent of time.

Further, in the 2-choice test, birds offered the 1.0% level of FC experienced significant loss of body mass even though birds consumed <1% of the treated millet available. This mass loss may indicate that even slight consumption of FC at the 1.0% level had adverse physiological effects or caused the birds to generalize the repellency to untreated food. Avery et al. (1997) demonstrated a similar generalized aversion to untreated rice seed by red-winged blackbirds (*Agelaius phoeniceus*) in a 2-choice test with rice treated with 0.5% (g/g) AQ. Other chemical repellents such as methiocarb also produce a conditioned aversion to treated food, but birds generally will continue to consume untreated food (Rogers 1974).

Under a 1-choice design, birds presented with millet treated at the 0.1% level began to feed by day 3, whereas birds offered 0.5 and 1.0% FC-treated millet consumed minimal amounts, and 3 apparently starved. Unlike the 2-choice test, however, birds receiving 0.1% FC-treated millet experienced significant mass loss, indicative that FC at the minimum level tested maintained a repellent effect. Our findings indicate that a minimum treatment level of 0.5% FC is sufficient to maintain repellency over 4 days.

MANAGEMENT IMPLICATIONS

We conclude that FC has potential as a grazing repellent for geese and seed treatment for blackbirds. However, we did observe some feeding on treated grain and occasionally extensive feeding on treated grass, especially 6–7 days after treatment. To be most effective as an avian repellent, FC applications will need to be combined with other harassment or cultural techniques in an integrated management program (e.g., Dolbeer 1990).

A major advantage of FC over other avian repellents such as methiocarb is the low toxicity of AQ (e.g., LD_{50} >100 mg/kg for red-winged blackbirds; Schafer et al. 1983). Methiocarb, an effective grazing repellent for geese (Conover 1985, 1989), has high avian toxicity (e.g., LD_{50} <5 mg/kg for red-winged blackbirds; Schafer et al. 1983), which makes registration by EPA difficult. Another advantage of FC over repellents such as methyl anthranilate (Cummings et al. 1995) or lime (Belant et al. 1997*b*) is that there is no odor or grass discoloration associated with applications. Furthermore, based on our findings, FC appears to have stronger repellency than other candidate grazing and seed repellents (e.g., lime, *d*-pulegone, mangone) that have been recently tested with geese and cowbirds (Belant et al. 1997*a*,*b*). In conclusion, we recommend field trials to further evaluate FC as a grazing and seed repellent for birds. The addition of an adhesive to the formulation to enhance retention of AQ to vegetation and seeds also should be investigated.

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LITERATURE CITED

ANKNEY, C. D. 1996. An embarrassment of riches: too many geese. Journal of Wildlife Management 60: 217-230.

AVERY, M. L., J. S. HUMPHREY, AND D. G. DECKER. 1997. Feeding deterrence of anthraquinone, anthracene, and anthrone to rice-eating birds. Journal of Wildlife Management 61:1359-1365.

BELANT, J. L., S. W. GABREY, R. A. DOLBEER, AND T. W. SEAMANS. 1995. Methyl anthranilate formulations repel gulls and mallards from water. Crop Protection 14:171-175.

———, S. K. ICKES, L. A. TYSON, AND T. W. SEAMANS. 1997*a*. Comparison of *d*-pulegone and mangone as cowbird feeding repellents. International Journal of Pest Management 43:303-305.

———, L. A. TYSON, T. W. SEAMANS, AND S. K. ICKES. 1997*b*. Evaluation of lime as an avian feeding repellent. Journal of Wildlife Management 61: 917-924.

BESSER, J. F., AND D. J. BRADY. 1986. Bird damage to ripening field corn increases in the United States from 1971 to 1981. U.S. Fish and Wildlife Service Leaflet 7.

CLEARY, E. C., S. E. WRIGHT, AND R. A. DOLBEER. 1997. Wildlife strikes to civil aircraft in the United States, 1992–1996. U.S. Department of Transportation, Federal Aviation Administration Serial Report-Number 3.

CONOVER, M. R. 1985. Alleviating nuisance Canada goose problems through methiocarb-induced aversive conditioning. Journal of Wildlife Management 49:631-636.

———. 1989. Can goose damage to grain fields be prevented through methiocarb-induced aversive conditioning. Wildlife Society Bulletin 17:172-175.

———, AND G. G. CHASKO. 1985. Nuisance Canada goose problems in the eastern United States. Wildlife Society Bulletin 13:228-233.

CUMMINGS, J. L., J. R. MASON, D. L. OTIS, AND J. F.

HEISTERBERG. 1991. Evaluation of dimethyl and methyl anthranilate as a Canada goose repellent on grass. Wildlife Society Bulletin 19:184-190.
———, P. A. POCHOP, J. E. DAVIS, JR., AND H. W. KRUPA. 1995. Evaluation of ReJeX-iT AG-36 as a Canada goose grazing repellent. Journal of Wildlife Management 59:47-50.
DOLBEER, R. A. 1986. Current status and potential of lethal means of reducing bird damage in agriculture. Proceedings of the International Ornithological Congress 19:474-483.
———. 1990. Ornithology and integrated pest management: red-winged blackbirds *Agelaius phoeniceus* and corn. Ibis 132:309-322.
———, J. L. BELANT, AND L. CLARK. 1993. Methyl anthranilate formulations to repel birds from water at airports and food at landfills. Proceedings of the Great Plains Wildlife Damage Control Workshop 11:42-53.
———, N. R. HOLLER, AND D. W. HAWTHORNE. 1995. Identification and control of wildlife damage. Pages 474-506 *in* T. A. Bookhout, editor. Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesda, Maryland, USA.
———, D. F. MOTT, AND J. L. BELANT. 1997. Blackbirds and starlings killed at winter roosts from PA-14 applications, 1974–1992: implications for regional population management. Proceedings of the Eastern Wildlife Damage Management Conference 7:77-86.
HEISTERBERG, J. F. 1983. Bird damage to sprouting corn in Kentucky and Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 37:41-48.
HOTHEM, R. L., R. W. DEHAVEN, AND S. D. FAIRAIZL. 1988. Bird damage to sunflower in North Dakota, 1979-1981. U.S. Fish and Wildlife Service Technical Report 15.
HUNT, R. A. 1984. Crop depredation by Canada geese in east-central Wisconsin. Proceedings of the Eastern Wildlife Damage Control Conference 1: 245-254.
KAHL, R. B., AND F. B. SAMSON. 1984. Factors affecting yield of winter wheat grazed by geese. Wildlife Society Bulletin 12:256-262.
ROGERS, J. G., JR. 1974. Responses of caged red-winged blackbirds to two types of repellents. Journal of Wildlife Management 38:418-423.
ROYALL, W. C., JR., AND J. A. NEFF. 1961. Bird repellents for pine seeds in the mid-southern states. Transactions of the North American Wildlife and Natural Resources Conference 26:234-238.
SAS INSTITUTE. 1988. SAS/STAT user's guide. Release 6.03. SAS Institute, Cary, North Carolina, USA.
SCHAFER, E. W., JR., W. A. BOWLES, JR., AND J. HURLBUT. 1983. The acute oral toxicity, repellency, and hazard potential of 998 chemicals to one or more species of wild and domestic birds. Archives of Environmental Contamination and Toxicology 12:355-382.
STATISTIX. 1994. User's manual. Version 4.1. Analytical Software, Tallahassee, Florida, USA.
WILSON, E. A., E. A. LEBOEUF, K. M. WEAVER, AND D. J. LEBLANC. 1989. Delayed seeding for reducing blackbird damage to sprouting rice in southwestern Louisiana. Wildlife Society Bulletin 17:165-171.
WORONECKI, P. P., R. A. DOLBEER, AND D. L. OTIS. 1986. Evaluating corn varieties for resistance to damage by blackbirds and starlings. Pages 27-38 *in* R. W. Bullard and S. A. Shumake, editors. Vertebrate Pest Control and Management Materials. American Society for Testing and Materials, STP 974, Philadelphia, Pennsylvania, USA.

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