or other waterfowl. For instance, managers, by spraying crops inside the refuge, may be able to quickly force geese to forage elsewhere.

LITERATURE CITED


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FIELD EVALUATION OF DIMETHYL ANTHRANILATE AS A BIRD REPELLENT LIVESTOCK FEED ADDITIVE

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Abstract: An alternative to current approaches for controlling birds at feedlots might be the use of feeds containing compounds that are unpalatable to birds but readily accepted by mammals. One such compound is dimethyl anthranilate (DMA), an inexpensive human food flavoring. DMA was incorporated into feed exposed to birds at four swine and cattle feedlots. During treatment 1 (6–13 Feb 1984), DMA was incorporated into high protein cattle pellets and exposed 8 hours/day for 2 days at two sites. Control pellets were similarly exposed at the two other sites. Treatment conditions were then reversed for 2 days. During the final 2 days of the treatment period, DMA-coated poultry crumbles were exposed at two sites and control crumbles were exposed at the other sites. A second treatment period (27 Feb–4 Mar 1984) was similar to the first, except that poultry crumbles were used in all tests. DMA substantially reduced consumption (P < 0.05) during both treatment periods. We suggest that it might be used as a feed additive to reduce bird depredation without primary or secondary hazards to non-target animals.

EUROPEAN STARLING (Sturnus vulgaris) and blackbird (i.e., common grackle [Quiscalus quiscula], red-winged blackbird [Agelaius phoeniceus], and brown-headed cowbird [Molothrus ater]) depredations at swine and cattle feedlots are considered a serious economic problem (Bailey 1966; Besser et al. 1967, 1968; Feare 1975, 1980; Stickley 1979; Twedt and
Losses may result from feed contamination, disease consumption, or feed consumption (Pilchard 1965, Russell 1975, Gough and Beyer 1982, Twedt and Glahn 1982). Problems are exacerbated when complete diets (Rickaby 1978) are presented in open troughs to which birds have access. Birds take up to 9% of the high protein fraction of the diet, thus depriving livestock and altering the composition of the entire ration (Feare and Wadsworth 1981).

Efforts to control problem birds at feedlots mainly have involved trapping and/or the use of lethal chemical agents (Besser et al. 1967, Livingston 1967, West et al. 1967, Bogadich 1968, Feare et al. 1981). These approaches fail to create a suboptimal environment for avian feeding activity, however, and birds may reinfect feedlots when control measures are relaxed (Twedt and Glahn 1982). Additional problems arise when lethal chemicals such as starlicide (1% C-chloro-p-toluidine hydrochloride on poultry pellets) are used, including primary and secondary hazards to nontarget animals, development of bait aversion by target birds, and increased expense and labor in prebaiting, baiting, and monitoring (Cunningham et al. 1979, Glahn 1981).

Twedt and Glahn (1982) outlined management practices that could be implemented at feedlots to substantially reduce bird predation. Among the suggested practices was the use of feeds that are unpalatable or that cannot be metabolized by birds. In the latter case, relatively high levels of non-protein nitrogen (e.g., urea) and/or alfalfa (Medicago sativa) might be added. In the former case, certain tasters might be used. Although passerines apparently lack a well-developed sense of taste (e.g., Welty 1975:72, Kare and Rogers 1976), compounds exist that are unpalatable to birds but readily accepted by mammals. One such compound is dimethyl anthranilate (DMA), an inexpensive and non-toxic food flavoring approved for human consumption but offensive to birds even when presented at low concentrations (Mason et al. 1983). This report includes the results of a field evaluation of DMA, in which the taster was incorporated into high-protein feed exposed to birds at cattle and swine feedlots.

This research was supported by the U.S. Fish and Wildl. Serv. The authors thank Natl. Starch and Chemical Corp., Bridgewater, N.J., for preparing the technical material, and Ralston Purina Corp., St. Louis, Mo., for preparing cattle pellets. We thank M. R. Kare and D. L. Otis for helpful comments on earlier drafts of the manuscript.

**MATERIALS AND METHODS**

**Study Areas**

Four livestock farms in south-central Kentucky were selected as test sites. To achieve independence with regard to bird populations, we spaced these sites a minimum of 9.5 km apart with two sites in Warren and two sites in Barren counties. Starling barn roosts occurred at three of the four test sites (sites 1, 3, 4), and all sites were within the foraging range (approximately 15–20 km) of roosts with 1 + million blackbirds/starlings in Franklin and Munfordville, Kentucky.

Site #1 was a hog lot within the Western Kentucky University Farm located in Warren County. At this site, six pens of feeder pigs (6–10 pigs/pen) were fed a corn/soybean meal hog developer via flip-top self-feeders. Spillage, as well as malfunctioning lids on some feeders, provided birds with a constant food source.

Site #2 was the Bill Balance Farm located in Warren County. This was a Holstein heifer feeding operation where 50–60 head of dairy cattle were fed corn silage supplemented with a ground corn mixture. Silage was normally offered to cattle twice a day with some silage available to the cattle and birds throughout the day.

Site #3 was the G. W. Bellamy Hog and Cattle Farm, located in Barren County. At this site, 20–30 hogs and 15–20 beef cattle were fed a ground corn/soybean ration from self-feeders within a single fenced lot. Feed was available to livestock and birds throughout the day.

Site #4 was the Jimmy Gardner Hog Farm, located in Barren County. This site was the outdoor facility of a major swine feeding operation where most hogs were fed in confinement. It consisted of a 0.75-ha fenced lot containing two barns with a number of flip-top self-feeders that provided a ground corn/soybean hog developer ration to approximately 200 hogs.

**Test and Control Feeds**

Cattle pellets were prepared by Ralston Purina Co. (St. Louis, Mo.) and contained 40% alfalfa, soybean, corn, and meat meal protein, 19% non-protein nitrogen (urea), 5.5% calcium, and 1% phosphorus. Test pellets also contained DMA spray-dried on lipophilic starch.
et al. 1983). The DMA concentration in pellets, as determined by gas chromatography (Kostelc et al. 1981), was 0.28 ± 0.02% (w/w). Control pellets contained lipophilic starch alone.

Pilot work determined that the cattle pellets as supplied were too large (2.0 ± 0.01 cm long × 0.6 ± 0.01 diam) to compete favorably (for bird depredation) with feed exposed for livestock. For that reason, the pellets were crushed (crushed particle size: 0.45 ± 0.04 cm long × 0.36 ± 0.02 cm diam).

Poultry crumbles, rather than cattle pellets, were used during the last 2 days of the first treatment and during the entire second treatment. The crumbles contained 20% protein, 2.5% fat, 7.0% fiber, 2.8% calcium, 0.8% phosphorus, 0.00008% iodine, and 0.7% sodium chloride. Test samples were prepared by mixing crumbles with DMA-treated starch. The DMA concentration on the crumbles was determined to be approximately 0.20% (w/w). Control samples were prepared by mixing crumbles with starch alone. Our aim in substituting poultry crumbles for cattle pellets was to assess whether DMA would protect highly palatable food (poultry crumbles) as well as it protected relatively less preferred food (cattle pellets).

Procedure

Pre-baiting.—On 22 January 1984, one V-shaped roofed wooden trough (2.5 m long × 0.6 m wide × 0.4 m deep) was placed at each site. Over the next 10 days, 10 kg of poultry crumbles were exposed in each trough every 48 hours. Crumbles, a highly preferred food, were exposed to draw starlings to the troughs. Samples were retrieved, and consumption (to the nearest gram) was recorded for each 2-day period, except when rain dissolved the crumbles.

Pre-treatment.—Between 2 February and 5 February (4 days), 5 kg of crushed control cattle pellets were exposed at each site daily between 0650 and 0830, and sequentially retrieved between 1450 and 1630, to provide an approximate 8-hour exposure period. Consumption was measured to the nearest gram. This pre-treatment period established a baseline for consumption of the cattle ration.

Ambient temperatures were measured daily when feed was exposed and when it was retrieved. Weather conditions (i.e., cloud and snow cover, precipitation) and number and species of birds present on or near the experimental troughs at each site were visually estimated when temperatures were recorded.

Treatment 1.—Sites #1 and #3 were selected randomly, and on 6 and 7 February, 5 kg of crushed test cattle pellets were exposed at each site for 8 hours. Crushed control pellets were exposed at sites #2 and #4. On 8 February, 10 kg of poultry crumbles were exposed at each site for 8 hours as a rest period. On 9 and 10 February, treatment conditions were reversed and crushed test pellets were exposed at sites #2 and #4. This second period was followed by a 2nd rest day, on which poultry pellets (not crumbles) were exposed. On 12 February, 2 kg of poultry crumbles treated with DMA starch were exposed for 8 hours at sites #1 and #3, whereas untreated poultry crumbles were exposed at sites #2 and #4. Treatment conditions were reversed on 13 February, and DMA-treated crumbles were exposed at sites #2 and #4. Poultry crumbles were exposed on these days, instead of cattle pellets, to assess the effects of relative palatability on DMA repellency. Pilot work had suggested that birds preferred crumbles to crushed cattle pellets. On all treatment and rest days, temperature, weather conditions, estimates of bird numbers and species, and consumption were recorded.

Treatment 2.—To gain additional data on consumption of DMA-treated poultry crumbles, we carried out another 7-day treatment period between 27 February and 4 March. During the first 3 days of the trial, sites #1 and #3 were randomly selected, and 4 kg of DMA-treated crumbles were exposed daily for 8 hours. Control crumbles (treated with lipophilic starch alone) were exposed at sites #2 and #4. On 1 March, 4 kg of untreated poultry pellets were exposed at each site. During the final 3 days of the trial, treatment conditions were reversed (i.e., DMA-treated crumbles were exposed at sites #2 and #4). Consumption (to the nearest g) was measured daily.

Analysis

Temperature.—Two-way analyses of variance (ANOVA's) with repeated measures on the second factors were used to empirically assess changes in temperature during pre-treatment and treatment 1. Days (12 levels) was the independent factor in one analysis, whereas sites (4 levels) was the independent factor in the other. Time (a.m. vs. p.m.) was the repeated factor in both analyses. Similar analyses were used to
Table 1. Mean numbers (±SEM) and percentages of species present at feedlots during pre-treatment and treatment periods. Mean total number of birds (±SEM) present at each feedlot (regardless of species) is also given, south-central Kentucky, 6–13 February 1984.

<table>
<thead>
<tr>
<th>Species</th>
<th>1</th>
<th>SEM</th>
<th>2</th>
<th>SEM</th>
<th>3</th>
<th>SEM</th>
<th>4</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Starlings</td>
<td>210.0</td>
<td>43.2</td>
<td>69.4</td>
<td>15.0</td>
<td>105.4</td>
<td>17.0</td>
<td>118.5</td>
<td>27.5</td>
</tr>
<tr>
<td>%</td>
<td>77</td>
<td></td>
<td>88</td>
<td></td>
<td>82</td>
<td></td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Grackles</td>
<td>16.7</td>
<td>12.9</td>
<td>0.0</td>
<td>0.0</td>
<td>2.1</td>
<td>2.2</td>
<td>9.6</td>
<td>5.3</td>
</tr>
<tr>
<td>%</td>
<td>6</td>
<td></td>
<td>0</td>
<td></td>
<td>2</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Cowbirds</td>
<td>22.9</td>
<td>11.9</td>
<td>2.1</td>
<td>2.2</td>
<td>1.0</td>
<td>1.1</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>%</td>
<td>8</td>
<td></td>
<td>3</td>
<td></td>
<td>1</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Redwings</td>
<td>2.1</td>
<td>2.1</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>%</td>
<td>1</td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sparrows</td>
<td>18.3</td>
<td>6.5</td>
<td>7.0</td>
<td>3.5</td>
<td>19.4</td>
<td>5.6</td>
<td>11.7</td>
<td>4.6</td>
</tr>
<tr>
<td>%</td>
<td>7</td>
<td></td>
<td>9</td>
<td></td>
<td>15</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.1</td>
<td>1.7</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>%</td>
<td>1</td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>217.5</td>
<td>24.2</td>
<td>63.3</td>
<td>15.3</td>
<td>100.0</td>
<td>3.5</td>
<td>122.7</td>
<td>26.6</td>
</tr>
</tbody>
</table>

Assess data from treatment 2. The factors in these analyses were identical to those above and differed only in the number of days.

Bird Numbers and Species.—Two-way ANOVA's with repeated measures on the second factors were also used to assess the estimated number of birds present when feed was exposed and when it was picked up during treatment 1. The independent and repeated factors were identical to those used for analyses of temperature (i.e., days, sites, and times). Species abundance (i.e., the estimated number of starlings, common grackles, redwings, cowbirds, house sparrows [Passer domesticus], and "other" birds) present when feed was exposed and picked up was assessed by a two-way ANOVA with repeated measures on the second factor. The independent factor was species (six levels), and the repeated factor was feedlots (four levels). Similar analyses were used to assess bird pressure and species abundance during treatment 2.

Pre-treatment.—Pre-baiting and pre-treatment consumption was assessed in a one-way repeated-measures ANOVA. This analysis was used as an assessment of the relative palatability of crushed cattle pellets in comparison with poultry crumbles. The factor was days (six levels). To obtain estimates of daily consumption during the pre-baiting period, we halved the amount consumed during each 48-hour measurement period.

Treatment.—Consumption during treatment periods 1 and 2 was assessed separately in...
two two-way ANOVA's with repeated measures on both factors. The variables in these analyses were (1) order of exposure (three levels; i.e., first presentation of DMA and control cattle pellets at each site, second presentation of each feed at each site, third presentation of each feed at each site), and (2) DMA vs. control cattle pellets (two levels). Consumption of poultry crumbles was included in analysis of treatment 1 data to permit inferences about the relative effectiveness of DMA on two kinds of feed (i.e., cattle pellets and poultry crumbles) that differed in palatability to depredating birds. Tukey b tests (Winer 1962) were used to isolate differences among means ($P < 0.05$) following analyses of variance.

**RESULTS**

**Weather Conditions**

Temperature fluctuated during pre-treatment and treatment 1 ($F[11,36] = 36.1$, $P < 0.01$) and during treatment 2 ($F[5,18] = 47.3$, $P < 0.001$). However, there were no differences in temperature among lots ($P's > 0.25$). During treatment 1, temperatures ranged from $-17$ to $+22$ C with a mean daily temperature of $+7.4 \pm 1.8$ C. During treatment 2, temperatures ranged from $-3.7$ to $+15.2$ C, with a mean daily temperature of $+3.9 \pm 0.9$ C. For both treatment periods, cloud and snow cover varied from 0 to 100%, and precipitation varied from 0% to heavy rain or snow.

**Estimated Bird Numbers and Species**

Because data on bird numbers at feedlots and in the vicinity of experimental troughs were identical, only the former results are presented. There were differences among lots (treatment 1: $F[3,28] = 4.2$, $P < 0.01$; treatment 2: $F[3,20] =$ 4.8, $P < 0.01$) and between morning and afternoon ($F[1,28] = 7.3$, $P < 0.01$; $F[1,20] = 2.2$, $P < 0.02$; respectively) in the number of birds present. Also, for treatment 1 only, there were differences across days in the number of birds present ($F[7,24] = 3.2$, $P < 0.02$).

Tukey tests revealed that more birds were present during pre-treatment than treatment 1 ($P < 0.01$). During both treatment periods, more birds were present during the morning than during the afternoon ($P < 0.01$). Also in both periods, Feedlot #1 had greater numbers of birds (treatment 1: $217.5 \pm 24.2$; treatment 2: $218.7 \pm 42.7$) than the other sites ($P's < 0.01$). Feedlot #2 had the fewest birds ($63.3 \pm 13.3$) during treatment 1 ($P's < 0.01$), but an intermediate number during treatment 2 ($150.4 \pm 49.8$). Feedlots #3 and #4 had the fewest birds ($76.6 \pm 18.8$; $87.5 \pm 11.8$, respectively) during treatment 2, but an intermediate number of birds ($100.0 \pm 3.5$; $122.7 \pm 26.6$, respectively) during treatment 1.

There were overall differences (treatment 1: $F[5,138] = 40.6$, $P < 0.001$; treatment 2: $F[5,120] = 293.1$, $P < 0.001$) in the frequency with which various species were observed. There were also interactions between lots and species abundance (treatment 1: $F[15,138] = 4.1$, $P < 0.01$; treatment 2: $F[15,120] = 3.9$, $P < 0.001$). Starlings were always more numerous than other birds ($P's < 0.001$) (Table 1).

**Consumption**

There were changes in consumption during pre-baiting and pre-treatment ($F[5,15] = 15.2$, $P < 0.001$). Specifically, there was higher consumption of poultry crumbles during pre-baiting than crushed control cattle pellets during pre-treatment ($P < 0.01$) (Table 2). During treatment 1, there were differences in consumption of test and control feed ($F[1,3] = 33.6$, $P < 0.001$) (Table 3). Tukey tests showed that there was less consumption of test (0.005 ± 0.005 kg) than control (2.025 ± 0.65 kg) cattle pellets on all days ($P's < 0.001$). Similarly, there was less consumption of test (0.9 ± 0.3 kg) than control (2.6 ± 0.8 kg) poultry crumbles ($P < 0.001$). Although consumption of poultry crumbles appeared higher than consumption of cattle pellets, the difference was not significant ($P > 0.20$).

Analysis of data collected during treatment 2 produced results similar to those of the earlier treatment period. Less of the DMA-treated

### Table 2. Mean consumption (kg) (+SEM) of poultry crumbles during pre-baiting and of control cattle pellets at feedlots during pre-treatment. Means represent consumption over 48-hour periods, south-central Kentucky, 23 January-5 February 1984.

<table>
<thead>
<tr>
<th>Sites</th>
<th>$\bar{x}$</th>
<th>SEM</th>
<th>$\bar{x}$</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.98</td>
<td>0.02</td>
<td>0.54</td>
<td>0.30</td>
</tr>
<tr>
<td>2</td>
<td>6.60</td>
<td>2.09</td>
<td>0.55</td>
<td>0.37</td>
</tr>
<tr>
<td>3</td>
<td>4.90</td>
<td>2.42</td>
<td>0.60</td>
<td>0.34</td>
</tr>
<tr>
<td>4</td>
<td>5.80</td>
<td>1.05</td>
<td>0.50</td>
<td>0.32</td>
</tr>
</tbody>
</table>
crumbles were consumed (0.15 ± 0.06 kg) than of the control crumbles (2.68 ± 0.32 kg) on all days (F(1,3) = 185.1, P < 0.001) (Table 4).

**DISCUSSION**

Starlings were the most frequently observed avian species at all sites during both treatment periods. This finding is consistent with previous work, suggesting that starlings are the most serious avian pest in feedlots (e.g., Palmer 1976).

Regardless of weather conditions, or the numbers of birds or species present, DMA treatment markedly reduced consumption of cattle pellets and poultry crumbles. Even changing the relative palatability of feed (from less preferred cattle pellets to highly preferred poultry crumbles) did not compromise the repellency of DMA (although it may have influenced overall consumption, see below). Consumption of treated feed did not increase over successive exposures, suggesting that perhaps depredating birds would not habituate to its offensive properties.

Consumption of treated poultry crumbles was slightly higher than consumption of treated livestock feed. No clear interpretation can be given to this observation, because where statistical comparison of DMA cattle pellet and poultry crumble consumption was appropriate (within treatment 1), no significant effects were observed. Regardless, if consumption differences are real, the change in effectiveness of DMA could reflect several factors. Because the DMA did not bind well with the crumbles, it may have blown off or settled to the bottoms of the troughs. Consistent with this possibility, observable amounts of DMA powder were present in the bottoms of troughs when feed was removed. Alternatively, the aversiveness of the compound may decrease when it is merely present on the surface of feed, and not present throughout the feed matrix. Finally, and most likely, the relative palatability of the feed may have interacted with the repellency of DMA. As suggested by Rogers (1978), differences in materials to be protected from damage often influence the efficacy of control compounds. Preferred feed, such as poultry crumbles, may be relatively more difficult to protect.

The results strongly suggest that DMA might be used as a feed additive to reduce bird depredation at livestock feedyards. Use of the compound appears to result in a less optimal food source without primary or secondary hazards to non-target animals. Because birds in the present study (and in previous laboratory evaluations, Mason et al. 1983) did not become accustomed to the compound, we speculate that

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**Table 3.** Consumption (kg) of test (DMA-treated) and control feeds by birds at feedlots during treatment 1. The concentration of DMA in test feed was 0.28 ± 0.02% (w/w), south-central Kentucky, 6–13 February 1984.

<table>
<thead>
<tr>
<th>Feedlots</th>
<th>Cattle pellets</th>
<th>Best</th>
<th>Cattle pellets</th>
<th>Best</th>
<th>Poultry crumbles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 Feb</td>
<td>7 Feb</td>
<td>8 Feb</td>
<td>9 Feb</td>
<td>10 Feb</td>
</tr>
<tr>
<td>1</td>
<td>0.04</td>
<td>0.0</td>
<td>5.0</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>2</td>
<td>1.3</td>
<td>1.3</td>
<td>4.7</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>0.0</td>
<td>0.0</td>
<td>2.3</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>4</td>
<td>2.1</td>
<td>2.7</td>
<td>4.3</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

* DMA-treated feed

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**Table 4.** Consumption (kg) of test (DMA-treated) and control poultry crumbles by birds at feedlots during treatment 2. The concentration of DMA in crumbles was approximately 0.20% (w/w), south-central Kentucky, 27 February–4 March 1984.

<table>
<thead>
<tr>
<th>Feedlots</th>
<th>Poultry crumbles</th>
<th>Best</th>
<th>Poultry crumbles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27 Feb</td>
<td>28 Feb</td>
<td>29 Feb</td>
</tr>
<tr>
<td>1</td>
<td>0.0</td>
<td>0.08</td>
<td>0.68</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>3.75</td>
<td>2.18</td>
</tr>
<tr>
<td>3</td>
<td>0.23</td>
<td>0.25</td>
<td>0.31</td>
</tr>
<tr>
<td>4</td>
<td>1.01</td>
<td>3.98</td>
<td>1.34</td>
</tr>
</tbody>
</table>

* DMA-treated poultry crumbles
reductions in damage would be long-lasting. Moreover, because the chemical is applied directly to the feed, learned aversions by target birds would enhance the efficacy of DMA and not serve as a drawback as it does for toxicants that are applied to bait materials separate from feed. Finally, DMA produced in large quantities would be relatively inexpensive (D. DeRovira, Natl. Starch Corp., pers. commun.), and costs for pre-baiting and monitoring would be eliminated.

A field evaluation in which DMA-treated feed is presented to livestock for an extended period remains to be performed. That assessment is critical for answers to questions such as whether birds would desert a feedlot if only unpalatable feed were available.

LITERATURE CITED


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