Spring 2010

European Starling Preferences for Bait Substrates Used In DRC-1339 Applications

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Human–Wildlife Interactions 4(1):25–31, Spring 2010

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Abstract: Additional bait substrates for the avicide, DRC-1339 Concentrate (3-chloro-4-methylaniline hydrochloride), could provide USDA/Wildlife Services with more flexibility when managing nuisance populations of European starlings (*Sturnus vulgaris*) at livestock facilities. From January 11 to 21, 2008, we conducted 11 2-choice preference tests with 6 bait types at a feedlot in central Kansas. The baits included cracked corn mixed with lard (2 concentrations), 2 forms of distiller's grain (wet powder and pellets), 2 types of livestock feed (calf-starter pellet and sweet-feed mix), and a custom-produced poultry pellet (carrier pellet) made by USDA specifically for baiting starlings. We evaluated bait preference using 95% confidence intervals of mean differences in feeding rates among 4 cages of starlings with 6 starlings per cage. Starlings preferred the carrier pellets. Contemporaneous with the cage tests, we offered the same baits to free-ranging starlings at open-feeding platforms positioned within the feedlot. Free-ranging starlings also favored carrier pellets over other baits. Use of carrier pellets at livestock facilities where starlings have numerous food sources may be more cost-efficient than less-expensive baits (e.g., cracked corn or distiller's grain) because of its higher acceptance by free-ranging starlings.

Key words: 3-chloro-p-toluidine hydrochloride, 3-chloro-4-methylaniline, 3-chloro-4-methylbenzenamine hydrochloride, bait choice, DRC-1339, European starlings, feedlots, human–wildlife conflicts, *Sturnus vulgaris*

European starlings (*Sturnus vulgaris*) forage heavily at livestock facilities from fall through winter. Livestock feed is their primary source of nutrition. Besser et al. (1968) estimated that a flock of 1,000 birds using a feedlot between October and March can eat 3 metric tons of cattle feed. At larger facilities, several hundred thousand starlings may visit daily throughout fall and winter; thus, economic losses can be substantial, especially at facilities using open-trough or open-feeder systems (Glahn et al. 1983). In addition to direct losses of feed, indirect losses may occur. Starlings preferentially select high-energy food items from feed rations, altering the ration's nutrient content, which in turn can hinder weight gain in livestock (Besser et al. 1968). Lastly, starling excrement may be a reservoir for transmissible diseases, and because of its acidic nature it corrodes and degrades facility superstructures (Feare 1975, Clark and McLean 2003).

USDA/Wildlife Services (WS) uses the avicide DRC-1339 Concentrate (3-chloro-4-methylaniline hydrochloride, also 3-chloro-4-methylbenzenamine hydrochloride, 3-chloro-p-toluidine hydrochloride), to kill starlings at sites with excessive numbers of the birds. The standard procedure is to pre-bait with untreated baits placed in heavily used areas of the facility, such as bases of feed troughs and feed-storage bunks, medians of alleyways, and secluded loafing sites inaccessible to livestock. Pre-baiting causes the starlings to focus on the bait site prior to deployment of DRC-1339 baits and induces the starlings to eat the toxic bait quickly, lowering the risk to nontarget species. Quick consumption of the bait is essential because when DRC-1339 is exposed to light, its toxicity declines rapidly.

After starlings take the untreated baits regularly, which may take up to 10 days, DRC-1339 treated baits are broadcast. When applied at feedlots and dairies, typically a 5:1 dilution (untreated:treated) is used. The pellets are spread evenly over the bait site usually by hand-scoops or spreader. A successful application can kill >75% of the targeted population, with additional baitings seldom required (Besser et al. 1967, West 1968).

Competition from foods available at feeding stations and storage areas makes attracting starlings to bait sites difficult. For this reason, WS often uses a high-energy pellet as a carrier for DRC-1339. The carrier pellets used by WS are similar in size and shape to poultry pellets and have a crude protein content of 18% and crude fat content of 28%. The fat content of the carrier pellets is extraordinarily high compared to the 3 to 5% fat content of most commercially produced poultry pellets. Carrier pellets are custom-produced for WS and are expensive ($25/23 kg). Additionally, buyers must purchase a large quantity to initiate an order, which can make availability of carrier pellets an issue. The label for Compound DRC-1339 Concentrate–Feedlots (EPA Reg. No. 56228-10) suggests that poultry pellets and rolled or cracked corn are generally accepted by starlings. Unadulterated cracked corn usually works well with granivorous birds; however, lard is often mixed with cracked corn to make it more palatable to starlings, an omnivorous species that tends not to feed on hard grains. Other baits may be substituted if the birds do not accept the baits listed on the label. Interest has grown in distiller's grain as bait because of its low cost and widespread availability. Distiller's grain, a byproduct of ethanol production, often is used as a feed supplement in cattle rations, and starlings have been observed feeding on it at feedlots and ethanol distilleries.

We tested different bait types against carrier pellets to determine if other baits that are less expensive and more easily available can provide a viable alternative to carrier pellets. In the case of distiller's grain, the addition of a new bait substrate for DRC-1339 would provide WS with more flexibility for managing starlings at livestock facilities. Here, we document the results of 2-choice experiments conducted on both caged and free-ranging starlings at a feedlot during the winter of 2007 to January 2008.

Methods

Study site

The site was a mid-sized (20,000 head) cattle feeder operation located in central Kansas. It was an open-trough system with feed trucks delivering cattle rations by alleyways separating the holding pens. From 2006 to 2008, this site hosted 250,000 starlings per day. Only small numbers of other bird species, including rock pigeons (*Columba livia*), house sparrows (*Passer domesticus*), brown-headed cowbirds (*Molothrus ater*), Brewer's blackbirds (*Euphagus cyanocephalus*), and great-tailed grackles (*Quiscalus mexicanus*) were in the feedlot. Brown-headed cowbirds and great-tailed grackles were the most numerous non-starling feeders.

Starlings began arriving at the feedlot 0.5 hour after sunrise and would leave about 1 hour before sunset. Most of their foraging occurred in feed troughs. Small groups (<200) of foraging starlings used a large storage bunk containing compartments for corn silage and wet distiller's grain. All of the test cages were located on the edges of alleyways across from feed troughs.

The average minimum and maximum temperatures during the experiment were -8° C and 3° C, with the highest temperature being 14° C on January 15 and the lowest -16° C on January 17. The 30-year average minimum and maximum temperatures were -8° and 5° C. No snow accumulation occurred during the study.

Baits

In addition to carrier pellets (CP), we used 5 other baits: (1) wet distiller's grain (DG), a fine-particle bait that is inexpensive, widely-available, and often used as a feed additive for livestock; (2) distiller's grain pellet (DP), which is a dried and pelleted form of distiller's grain; (3) calf-starter pellet (CS), which is used to provide supplemental nutrition for weaning calves; (4) sweet-feed mix (SF), a high-carbohydrate feeding supplement consisting of a mix of pellets and grains; and (5) cracked corn (CC) mixed with lard, a common additive when baiting starlings (*see* Table 2 footnotes for nutrition information on baits). We obtained CS, SF, and CC at a local feed-supply store near the study area. To our knowledge, CS and SF have never been used as a bait for starlings. We included these baits in the tests because of their unique nutritional composition, their pelleted form, and their dimension, with the latter 2 qualities comparable to CP.

We took the DG we used from the feedlot's storage bunk. Its moisture content was about 60%. We estimated evaporative loss by placing trays of DG (protected from free-ranging birds) near the test cages and reweighing them after the 4-hour test periods. We conducted only a single test with DP because we had limited supplies of this bait. We tested DP against CP in the cage tests. In the concurrent feeding-platform test (test 9), we substituted CC with no lard for DP. All baits except CS were tested against CP. The CS did very poorly in the 2-choice tests with CC and SF, which starlings strongly selected against when paired with CP. We thus decided not to make the comparison between CS and CP. This lowered the total number of possible bait-pair tests from 15 to 10. However, we conducted an extra test with CC and CP. Initially, we had mixed 28 g of lard per 1,020 g of CC, but we observed a poor feeding response at the 28-g level (CC-28) during its first test (test 2), both in the cage tests and at the feeding platforms. We considered CC an important bait to test. Managers will sometimes use CC when baiting starlings at livestock facilities because of its lower cost or due to sparseness of CP. Therefore, we increased the concentration of lard to 56 g per 1,020 g (CC-56) for the remaining tests in an effort to enhance CC's attractiveness in the trials. In the final cage test (test 11), we compared CC-28 to CP to assess attractiveness of the 2 lard concentrations against CP.

Captive-bird test

We used starlings caught in modified Australian crow traps at the feedlot. On the afternoon of January 10, 2008, we removed 24 birds from the traps and allocated 6 apiece into our 4 test cages (1.2 × 1.2 × 2.4 m). All cages had perches and covered shelter. On the day of the transfer, we provided freshwater but no maintenance food (viz., Science Diet® Adult Original Cat Food). The following morning we initiated the 2-choice tests 0.5 hour after sunrise. We ran the tests daily from January 11 to 21. We placed 2 clear plastic trays (dimensions 23 × 23 × 6 cm), each containing 114 g of bait side-by-side on the floor of the cage, with the order of presentation (left-to-right) determined by coin flip on test 1 and alternating each test thereafter. After 4 hours, we bagged and labeled the remaining baits and any spillage with the test number, date, cage number, bait type, and starting weight. We provided a tray containing 142 g of maintenance food for the remainder of the day. At 0.5 hour before sunset, we removed the maintenance food and weighed the bagged test baits on a tared top-loading balance. We recorded the final weight to the nearest 0.1 g. The protocol for DG differed from other baits because of its powdery consistency. For this bait, we used 142-g portions instead of 114-g portions. Additionally, we placed DG in smaller and deeper trays to provide enough tray depth for the starlings' longish mandibles to effectively grasp and acquire the bait. The consistency of DG made spillage hard to detect, so we placed the smaller feeding trays within larger trays to catch spillage. We placed a tray (protected from free-ranging birds) with 142 g of DG to estimate evaporative loss during the 4-hr test period. We added back the loss from evaporation to the final weight.

Free-ranging bird test

We used 3 feeding platforms that were open and available to free-ranging starlings in the feedlot. Starlings were the only bird species observed using the open-feeding platforms during the experiment. One of the platforms was abutted by 2 test cages. The other 2 platforms were each abutted by 1 test cage. Tarp shelters visually isolated birds in the test cages from those on the feeding platforms. We used 227-g portions of bait for each feeding platform. We placed the baits at the same time the cage tests were started and collected them at sunset. Except for test 9, the bait pairs were the same as those used during the cage tests. The feeding platforms were double-decked, but we baited only the lower deck. The platform decks were 1.2 × 2.4 m with 2.5 × 2.5-cm retaining strips on the edges and a 2.5-cm furring strip in the center to separate bait pairs. The lower deck was 1.2 m above ground level. The upper deck was 3.2 m above ground level. We placed the baits directly on the decks and used a brush and pan to collect the baits after removing debris. We checked platforms at midday and added another 227-g portion of bait if baits were low or gone. This occurred for CP only. We tried to

Table 1. Feeding rates (g/bird/hr) of caged European starlings in preference tests of paired baits conducted at a cattle feedlot in central Kansas in mid January 2008.

Test	Baits[a] A	Baits[a] B	n[b]	$\bar{x}$ rate (g/bird/hr) $\bar{x}_{A\ (SD)}$	$\bar{x}$ rate (g/bird/hr) $\bar{x}_{B\ (SD)}$	95% CI L	95% CI U	SE	Bait choice[c]	ES[d]
1	CS	SF	4	0.5 $_{(0.36)}$	0.8 $_{(0.46)}$	-0.5	-0.1	0.10	SF	0.8
2	CC-28	CS	4	1.5 $_{(0.49)}$	0.7 $_{(0.25)}$	+0.3	+1.2	0.24	CC	2.2
3	CC-56	SF	4	1.7 $_{(0.26)}$	1.8 $_{(0.71)}$	-0.7	+0.5	0.32	None	0.2
4	CC-56	DG	4	2.1 $_{(0.30)}$	3.0 $_{(1.42)}$	-2.3	+0.6	0.75	None	1.0
5	CP	DG	4	1.9 $_{(0.34)}$	0.7 $_{(1.10)}$	-0.1	+2.6	0.70	None	1.8
6	CS	DG	3	1.3 $_{(1.06)}$	2.5 $_{(1.66)}$	-3.5	+1.1	1.19	None	1.0
7	DG	SF	4	2.1 $_{(0.76)}$	1.6 $_{(0.82)}$	-0.3	+1.3	0.42	None	0.8
8	CC-56	CP	3	0.8 $_{(0.01)}$	2.6 $_{(0.24)}$	-1.6	-2.1	0.14	CP	13.4
9	CP	DP	4	2.5 $_{(0.23)}$	0.0 $_{(0.08)}$	+2.3	+2.8	0.12	CP	17.0
10	CP	SF	4	2.6 $_{(0.40)}$	1.0 $_{(0.53)}$	+0.8	+2.5	0.44	CP	4.0
11	CC-28	CP	4	0.8 $_{(0.10)}$	2.4 $_{(0.44)}$	-1.3	-2.0	0.20	CP	6.0

[a]CP = carrier pellet; CS = calf starter pellet; DG = distiller's grain; DP = distiller's grain pellet; SF = sweet-feed mix; CC-28 = 28 g lard/1,020 g cracked corn; CC-56 = 56 g/1,020 g cracked corn for tests 3, 4, and 8.
[b] Sample unit was cages.
[c] Choice occurred if the 95% CI (confidence interval) did not include zero.
[d] Effect size (ES) = mean difference of the 2 feeding rates divided by the pooled SDs from each bait sample.

keep bait on the platforms for weighing, and we adjusted CP portions to 454 g and then to 908 g, but the starlings also consumed these.

Statistical analysis

Cages were the sampling unit. The measurement was feeding rate in grams per bird per hour. To assess choice between bait pairs, we used 95% confidence intervals (CI) of the mean of differences between feeding rates among cages (Moran 2003). We assumed that no choice was made if zero was included in the 95% CI. Sometimes bait trays were overturned during the cage tests, either by the birds or from wind gusts. However, sample size was always ≥3 cages for all tests. We used Cohen's d statistic to estimate effect size of the treatment (i.e., bait type). Cohen's d in paired (i.e., dependent) tests is the mean difference divided by the pooled Standard Deviations from each sample used in the paired test (Dunlop et al. 1996). Any d statistic >0.8 was considered a strong treatment effect (Cohen 1992). For the feeding-platform tests, we report only the percentage of baits removed.

Results

Captive-bird test

Of the 5 2-choice tests with CP, four had 95% CIs that did not include zero (Table 1). Test 5 with DG showed no choice, although DG was eaten at a much lower rate (0.7 g/bird/hr) than CP (1.9 g/bird/hour) and the effect size was 1.8, inticating a strong treatment effect. The feeding rates in one of the 4 cages during test 5 created a large variance for the mean difference; indeed, for that cage the feeding rate for DG exceeded CP. This was the sole instance for all cages in all tests involving CP (n = 19) where the alternate bait was eaten at a greater rate. All of the 2-choice

Table 2. Percentage of baits eaten by free-ranging European starlings at 3 open-feeding platforms located at a cattle feedlot in central Kansas in mid-January 2008.

		Baits[a]		% Eaten[b]	
Test	Date	A	B	A	B
1	1/11/2008	CS	SF	13	16
2	1/12/2008	CC	CS	18	18
3	1/13/2008	CC	SF	26	21
4	1/14/2008	CC	DG	29	51
5	1/15/2008	CP	DG	100	64
6[c]	1/16/2008	CS	DG		68
7	1/17/2008	DG	SF	53	52
8	1/18/2008	CC	CP	57	100
9	1/19/2008	CC	CP	65	100
10	1/20/2008	CP	SF	100	57
11	1/21/2008	CC	CP	68	100

[a] Bait acronyms with nutrition information in subscript (% protein, fat, and fiber): CP (18, 28, 5) = carrier pellet; CC (7, 3, 4) = cracked corn; CS (25, 3, 6) = calf starter pellet; DG (26, 12, 6) = distiller's grain; and SF (14, 2, 9) = sweet-feed mix.
[b] Portions were 226 g/platform, total 680 g on all 3 platforms combined. Carrier pellet portions were increased to 454 g in test 9 and then to 908 g in tests 10 and 11.
[c] CS not measured because wind gusts caused unknown losses.

tests involving DG had zero within their 95% CIs. Differences in concentrations of lard mixed with CC had no apparent effect when these were paired with CP, with feeding rates equal for the 2 levels (Table 1). Distiller's grain was avoided in the single test conducted against CP. In summary, mean feeding rates of CC, DG, and SF were low when these baits were paired with CP, due to a strong preference for CP.

Free-ranging bird test

The results from the platform tests mirrored the cage tests. Unlike the cage tests, CP appeared to have a synergistic effect on the consumption of baits paired with it, especially CC (Table 2). The amount of DG eaten was probably overestimated because this powdery bait drifted off the platforms during wind gusts, and we could not estimate the amount lost. Also evaporation of DG on the platforms may have been greater than estimated. We estimated the evaporation rate at 7 g per hour, using the formula, evaporated amount/227 g/1 hr, which was the value extrapolated from the average evaporative loss during the cage tests. In summary, we could not quantify the amount of CP taken from the platforms by free-ranging starlings because all quantities of this bait were taken. In contrast, the other baits always had some quantity remaining at the end of the test, with CC being the second most consumed bait.

Discussion

Irrespective of pairings, feeding rates in the cage tests were CP >DG >CC >SF >CS >DP. We believe that the high moisture content of DG contributed to the bait's ranking because the amount eaten was probably based on daily energy demand and not volume consumed. Nevertheless, DG was eaten at greater rates than all other baits paired with it, except when it was paired with CP. Birds probably avoided DP because it was too large (10 x 6 mm) for them to handle and swallow efficiently; or perhaps the birds were using a predefined search image when foraging, and DP failed to match it because of its much larger size compared to the other foods being used at the site. It was apparently not a neophobic response by the caged birds that caused the avoidance, because when we later placed the DP on the top decks of the feeding platforms, it remained uneaten.

Previous studies have shown that starling food preference was directly related to protein levels (Besser et al. 1968, Thompson and Grant 1968, Twedt 1985). In these past studies, however, the fat content was generally low for the foods tested. In our study, both CS and DG had much higher levels of protein compared to the other baits, yet, CS did poorly in its pairings, and DG did poorly paired against CP. The DG and CS had a protein content of ~25% compared to CP's 18%. We noted that CS pellets (Calf-Manna®) expelled in the feces of the caged birds looked practically the same as before being ingested, implying that starlings may have had inordinate trouble digesting this pellet. Thompson and Grant (1968) and Twedt (1985) documented starlings' low digestion coefficients (~37%) for vegetable-based protein in livestock and poultry pellets. We speculate that the strong preference shown for CP, despite its lower protein content, may have been the result of starlings being able to more efficiently metabolize this bait. Starlings are very efficient at metabolizing vegetable-based fats (75% digestion coefficient). The fat content for CS and DG was low (3%) compared to CP (28%), and avid feeding by starlings on CP, both in the cage tests and on the feeding platforms, suggested that fat content was probably a major factor dictating their bait choice.

In winter, fat content of foods has been linked with survival in birds. For example, house finches (*Carpodacus mexicanus*) fed low-fat diets ultimately died at low temperatures; whereas, those fed high-fat diets survived (Sprenkle and Blem 1984). There is also evidence that some bird species are capable of detecting small differences in fat content among foods. Red-winged blackbirds (*Agelaius phoeniceus*) were able to detect a 5% difference in fat content between 2 varieties of sunflower, consistently choosing the variety with the greater amount (Mason et al. 1991). If wintering starlings are optimizing foraging effort by maximizing energy gain per unit time (an assumption of the Marginal Value Theorem in Optimal Foraging Theory), then it would follow that foods with higher quantities of metabolizable energy should be sought (Charnov 1976, Krebs et al. 1977).

When baiting at livestock facilities, it may be tempting to try other baits than CP because of CP's high cost. However, using a less-expensive bait increases the probability that an additional bait may be required if the first attempt is unsuccessful. The additional travel and bait costs, as well as the lost effort in labor in a failed baiting attempt, could well add up to be less than the additional cost of using CP baits. The increase in baiting efficacy could compensate for the extra cost of using this comparatively expensive bait. To help determine the true costs of a DRC-1339 baiting, we suggest that an economic model be developed to estimate direct and indirect costs as related to bait efficacy.

Acknowledgments

We thank C. Salter, S. Gaukler, L. Penry, and J. Thiele for their help and advice on the project and manuscript. The research was done under Study Protocol QA-1337 approved by the National Wildlife Research Center, Fort Collins, Colorado.

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