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MONOFILAMENT LINES AND A HOOP DEVICE FOR BIRD MANAGEMENT AT BACKYARD FEEDERS

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Bird feeding is a popular and widespread activity in the United States, with participation in 1991 of >63.1 million adults ≥16 years old and expenditures for bird food of >$2 billion (U.S. Fish and Wildlife Service and U.S. Bureau of the Census 1993). However, the mix of bird species that comes to backyard feeding stations often includes birds such as house sparrows (*Passer domesticus*), an exotic in the United States, that are less desirable (Harrison 1979, Dennis 1988). In a recent survey of 725 households that feed birds, only European starlings (*Sturnus vulgaris*) and common grackles (*Quiscalus quiscula*) received a popularity rating lower than house sparrows (Dennis 1988). The house sparrow habit of usurping nest boxes from purple martins (*Progne subis*) and Eastern bluebirds (*Sialia sialis*) and problems they cause around buildings or other structures (Fitzwater 1983) may contribute to their low popularity. Although various types of feeders and foods currently available may help discourage undesirable species (Dennis 1978), no easy, inexpensive, and effective method has been reported.

Agüero et al. (1991) found that monofilament lines spaced 30 and 60 cm apart over feeding stations effectively excluded house sparrows from feeding areas and appeared to be species-specific, failing to repel European starlings from the same sites. Other studies evaluating lines and wires as a management tool provided additional evidence of effectiveness and selectivity (Pochop et al. 1990). For example, parallel wires spaced 3 m apart and 24 m high over a landfill excluded herring gulls (*Larus argentatus*) and great black-backed gulls (*Larus marinus*) but failed to repel laughing gulls (*Larus atricilla*), American crows (*Corvus brachyrhynchos*), rock doves (*Columba livia*), and European starlings (Dolbeer et al. 1988). Although the technique offered a potential management option for people wishing to exclude house sparrows from feeders, the response of many backyard bird species to lines was not documented.

We used 2 series of experiments to assess the potential of lines and a hoop device for bird management at backyard feeders. In the first series (choice trials), we evaluated bird responses to line treatments with or without supplemental ground food. In the second series, we evaluated bird responses to lines and a wire hoop, used to support lines in all experiments, under more rigorous conditions using no-choice tests. We expected that species highly repelled in the choice tests would continue to avoid feeders with lines, but that moderately repelled species, in the absence of a feeder without lines, would increase use of feeders with lines.

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METHODS

General Methods

In all experiments, we used pole-mounted hopper-type feeders (locally constructed), spaced about 3 m apart (Fig. 1). A round, 80-cm diameter plywood tray with a 3.8-cm high outside rim and an opening in the tray center for the pole was on the ground below each feeder. Feeders were mounted approximately 1.5–1.8 m above ground and equipped with a guard to prevent Eastern fox squirrels (*Sciurus niger*) from entering and damaging the feeders. All feeders with lines (hoop–line treatment) had lines supported by a 4.1-mm diameter (9 gauge U.S. standard) wire hoop 80-cm in diameter attached like a halo to the feeder top (patent pending). Four clear, 9-kg test (0.46 mm diameter) monofilament lines (Stren®, E. I. du Pont de Nemours and Co., Wilmington, Del.) were installed vertically between the hoop and the rim of the tray and spaced at 60-cm intervals. Lines were approximately 20 cm from the feeder perches. Light-weight springs connected lines to trays to maintain tension on the lines.

We supplied feeding stations with a mixture of 40% black oil-type sunflower seeds, 30% white proso millet, and 30% finely-cracked corn, and hung a suet bag (about 8 cm diameter) from the side of each feeder. Food in the hoppers was unlimited. During experiments with unlimited (+) food in the trays and in periods between experiments, 1 kg of food was added to the tray every 3 days (choice tests) or 2 days (no-choice) and supplemented as needed to maintain an unlimited food supply. During experiments with limited (−) food in the trays, we cleaned trays at the end of each day to prevent accumulation of hopper spillage and added 50 g of new food, an amount selected because it was always less than the average daily tray-food consumption during pretreatment periods of choice experiments.

In all studies, bird observations were recorded daily during eight 15-minute intervals randomly selected from the 3-hour period starting 20 minutes before sunrise. During each 15-minute interval, bird species and numbers present were recorded each minute for every feeder, starting at time 0 (16 observations total). Birds were counted only if they were located on or within the rim of the tray or on the hopper feeding shelves. Except in no-choice tests of the hoop without lines, the number of birds at the hopper and tray of each feeder was combined for analysis. Temperatures during experiments ranged from about −28 C in winter to about 37 C in summer.

Choice Trials

Data were collected simultaneously at 2 sites: the horticulture garden at the University of Nebraska–Lincoln East Campus and the backyard of a home in Lincoln, Nebraska, about 3 km northeast of the horticulture garden. One observer/site, located 10–14 m from the feeders and inside the house (house site) or in a blind (garden site), collected data using a tape recorder, data sheets, and binoculars. Experiments were conducted in 2 seasons, from 8 December 1989–3 February 1990 (winter) and from 1 March–25 April 1990 (spring).

Three tests were conducted during each season. The first evaluated bird response to control (C) versus line-treatment feeders (L), both with unlimited food in the tray (C+L+). The second evaluated control with limited tray food versus the line treatment with unlimited tray food (C−L+). The third evaluated control with unlimited tray food versus the line treatment with limited tray food (C+L−). Each experiment lasted 12 days and was preceded by a 3-day pretreatment period, used to assess food consumption and bird species and numbers using feeders. Experiments were separated by 9-day (includes 3-day pretreatment) rest periods without treatments, but with unlimited food in all hoppers and trays.

Four feeders (2 control feeders, 2 hoop–line) were installed at each site. Treatments were rotated among feeders at each site every third evening. Each of the 2 treatments was randomly assigned to 2 unique numbers from 1–4. The numbers 1–4 were then considered as 4 separate treatments so that treatments could be rotated among feeders using a randomized 4 × 4 Latin square design with period and feeder as fixed blocking factors.

Data were analyzed by combining Latin squares from the 2 sites using analysis of variance (ANOVA) for replicated Latin squares with site as a fixed blocking factor (Lentner and Bishop 1986). The treatment differences were then tested using an appropriate single degree of freedom contrast. For each species, the total number counted per 3-day period was analyzed using ANOVA on square roots to reduce heterogeneity of error variance (Snedecor and Cochran 1989). Data were not analyzed for a species if <48 observations (an average of 4 observations/day) were available for the experiment. We tested for site by treatment interactions and evaluated whether significant interactions resulted from reversed responses to control versus treatment at the 2 sites. If the response direction was the same at both sites, we based conclusions on across-site means. If response direction differed between sites, we addressed these individually using appropriate contrasts and postulated reasons for the reversed responses.

No-choice Trials

We used no-choice switchback experiments to compare responses to 2 treatments (hoop with lines and hoop without lines) and a control (without hoop or lines) with only 1 of the 3 available on each day. Data were collected simultaneously at 4 sites, including the 2 sites used in the choice trials, a farmyard 7.6 km southeast of the horticulture garden, and the backyard of a home 8 km north and 1.6 km west of Milford, Nebraska. The farmyard site had a horse stable and pastures within

40 m of the feeders, but there appeared to be no other feeders or obvious food sources within the immediate area of our 4 sites. One observer/site collected data as in the choice trials, with observations at the new sites made from inside the house (Milford site) or a blind (farmyard). Experiments were conducted from 24 February–2 April 1991 (spring) and from 18 June–25 July 1991 (summer).

Each time block consisted of an 8-day test of hoops without lines (hoop treatment) followed immediately by an 8-day test of hoops with lines (hoop–line treatment), a 6-day rest period, and a repetition of the 8-day tests. The tests of hoops only and of hoop-lines were not separated by rest periods, thus minimizing length of the study period and reducing variability due to seasonal changes. At the beginning of each block, 1 of 2 treatment series was randomly assigned to each site, either control–treatment–control–treatment or treatment–control–treatment–control, as described by Brandt (1938) for 4-period switchback trials. Sites and test periods were used as 2 separate fixed blocking factors. Treatments were rotated every second evening, resulting in the total of 8 days for a test. Periods were limited to 2 days to reduce the possibility of house sparrow abandonment of study sites.

Two feeders installed at each site received the same treatment. During hoop tests, only the hoop used to support the lines was attached to the feeders. Food in hoppers was unlimited in all experiments but, because the hoop treatment was not expected to influence tray use (R. J. Johnson, unpubl. data), tray food was limited to encourage use of the hoppers. During hoop–line tests, feeders and hoops were identical to those used in hoop tests except that lines were added and trays, as well as hoppers, were stocked with an unlimited food supply.

Sex of house sparrows was recorded because of earlier casual observations (R. J. Johnson, unpubl. data) that males and females may respond differently to lines. During summer experiments, observations of adult female and juvenile house sparrows were combined because they could not be readily distinguished under field conditions.

Data were analyzed for each season using an ANOVA that combined 2 separate 4-period switchback trials, each having a control and a single treatment (Brandt 1938). The ANOVA pooled treatment sums of squares and error sums of squares from the 2 separate switchback trials for each season. Square-root transformations of period totals were used in the analysis to reduce heterogeneity of error variance (Snedecor and Cochran 1989). In tests of the hoop treatment, data from the hoppers and trays were analyzed separately because the effect of the hoop treatment on the hopper was expected to differ from the effect on the tray. For tests of the hoop-line treatment, bird observations from the hoppers and trays were combined for analysis because the birds had to pass through the lines to reach either location. Data were not analyzed unless >48 observations were available (an average of 6 observations/day/8-day test). Data also were excluded if ≥90% of the observations were from 1 site.

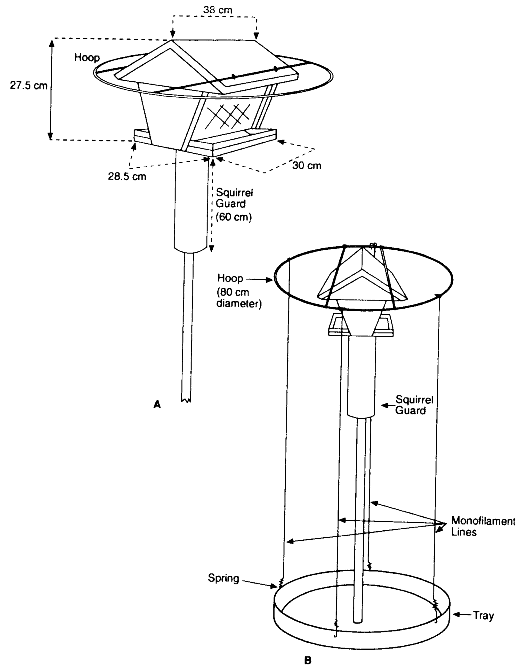

Fig. 1. Pole-mounted hopper-type feeder with ground-feeding tray and with the hoop only (A) or hoop–line (B) treatment installed.

RESULTS AND DISCUSSION

Birds highly responded to treatments, moderately responded, or were not repelled. Highly repelled species avoided feeders with lines in all experiments. Moderately repelled species usually preferred feeders without lines but showed equal or greater use of feeders with lines when food was limited or crowding or interference from other species occurred at feeders without lines.

Hoop–Line Treatment

Highly Repelled Species.—House sparrows were highly repelled by the hoop–line treatment in all experiments as expected from the findings of Agüero et al. (1991), regardless of tray food availability in choice trials and absence of a control feeder in the no-choice trials ($P \leq 0.012$, Table 1). Only 2% of all house sparrow visits in winter and spring hoop–line

Table 1. Total visits (repelled species) and percent of total visits at control (C) feeders when treatment feeders (L) were protected by a hoop-line device during choice (2 sites combined) or no-choice switchback (4 sites, 2 trials combined) tests with either unlimited (+) or limited (−) food in the ground trays, Lincoln, Nebraska, 1989–1991.

		C + L +				C − L + choice		C + L − choice	
		Choice		No-choice					
Species		W[a]	Sp	Sp	Su	W	Sp	W	Sp
House sparrow (total or male)[b]	%	99[c]	91[c]	95[c]	93[c]	99[c]	97[c]	99[c]	99[c]
	n	3,625	547	1,215	1,927	334	265	1,416	705
House sparrow (female and juvenile)[d]	%			99[c]	88[c]				
	n			656	6,655				
Blue jay[e]	%	78[c]	92[c]	88	68[c]	90[c]	80[c]	98[c]	92[c]
	n	992	145	342	2,217	146	90	606	100
Common grackle	%	62[c]	93[c]	66	57[c]	49	69[c]	78[c]	80[c]
	n	4,849	546	1,416	16,490	651	3,636	209	6,289
Northern cardinal[e]	%	54[c,f]	70	59	57	69[c,f]	45	70[c]	31[c]
	n	790	125	176	152	338	85	577	88

[a] Choice trials: winter (W), 8 December 1989–3 February 1990; spring (Sp), 1 March–25 April 1990. No-choice trials: spring, 24 February–2 April 1991; summer (Su), 18 June–25 July 1991.
[b] Choice trials show totals; no-choice trials are male.
[c] C vs. L differed ($P \leq 0.05$).
[d] Includes juveniles during summer experiments.
[e] Blue jay (*Cyanocitta cristata*), Northern cardinal (*Cardinalis cardinalis*).
[f] Site by treatment interaction present ($P \leq 0.05$).

experiments and 11% of all visits in summer (includes juveniles) were at feeders with lines. On mornings following treatment rotations, birds responded rapidly to new feeder-treatment assignments, with house sparrows, for example, using the feeders newly assigned as controls within 5–15 minutes of encountering them.

Blue jays were highly repelled by the hoop-line treatment in all experiments with an adjacent control feeder ($P \leq 0.011$). In no-choice experiments, they were repelled in summer ($P = 0.010$) and, although spring no-choice data showed a similar response, blue jay visits were fewer and results not significant ($P = 0.195$). Only 13% of all blue jay visits in winter and spring hoop-line tests and 32% of all visits in summer were at feeders with lines. Overall, the hoop-line treatment consistently reduced blue jay visits to feeders.

Moderately Repelled Species.—Common grackles were repelled by the hoop-line treatment ($P \leq 0.032$) in all choice experiments except the winter C−L+ ($P = 0.268$). During no-choice tests, they were repelled in summer. In the 5 choice experiments with differences (all winter or spring), 28% of all grackle visits were at feeders with lines, and in the summer no-choice trials, 43% were at feeders with lines. Common grackles were classified as moderately repelled by the hoop-line treatment because of the relatively high numbers of grackle visits at feeders with lines and because of the lack of feeder preference in the winter C−L+ experiment, as expected for a species influenced by both food availability and the presence of lines. This lack of feeder preference in the winter C−L+ but preference for C− in the spring repetition may have resulted from winter conditions of heavy snow cover, high winds, and below-zero temperatures, thus increasing energy requirements during that season. Alternatively, there may be a limit to the number of grackles that can safely forage under the lines without inhibiting their ability to escape, a possible factor in spring with high grackle numbers. Overall, the hoop-line treatment appeared to discourage common grackles, but the number of visits to feeders with lines indicates limited effectiveness of lines to deter grackles.

Northern cardinals also were classified as moderately repelled by lines, but showed greater flexibility in feeder use than did common grackles. Northern cardinals preferred control feeders in the 3 winter choice experiments ($P \leq 0.042$), but site-by- treatment interactions were observed in 2 of these ($P \leq 0.020$). During the winter C+L+, cardinals preferred C+ feeders at the garden site (66% C+, $n = 262$; $P = 0.027$), which had 195 recorded grackle visits, but showed no preference at the house (48% C+, $n = 528$; $P = 0.720$) with 4,654 grackle visits recorded. In the winter C−L+, cardinals preferred C− feeders at the house site (76% C−, $n = 255$; $P = 0.015$) but showed no preference at the garden (47%, C−, $n = 83$; $P = 0.934$). Grackle visits were relatively low at both sites (house: $n = 596$, garden: $n = 55$), and reasons remain unclear for this between-site difference. In two other choice experiments that had ≥3,600 grackle visits recorded, cardinals either increased their use of feeders with lines (spring C−L+, $P = 0.713$), or preferred feeders with lines (spring C+L−, $P = 0.004$). In no-choice experiments, cardinals were not repelled by the hoop–line treatment in spring or summer ($P \geq 0.169$), but cardinal visits to feeders with the hoop–line treatment were always lower than to feeders without. Overall, lines may reduce cardinal visits to feeders, particularly when an unprotected feeder is present, but, in contrast, cardinals may benefit when feeders with lines provide refuge from the crowding or interference of large grackle flocks.

Species Not Repelled.—Harris' sparrows (*Zonotrichia querula*) and dark-eyed juncos (*Junco hyemalis*) were not repelled by the hoop–line treatment and, as expected for a primarily ground-foraging species, appeared to be influenced by tray food availability in the choice trials (C−L+ trials; C+L−, winter; Table 2). As with Northern cardinals, large grackle flocks appeared to cause higher than expected junco and Harris' sparrow use of feeders with lines in the winter C+L+ and spring C+L− experiments. Moreover, although the winter C+L+ experiment had no site-by-treatment interactions for these 2 species ($P \geq 0.064$), there appeared to be a site pattern similar to that of Northern cardinals during the same experiment. At the house site, with high grackle numbers, both species preferred L+ feeders ($P \leq 0.003$) but essentially used feeders equally at the garden ($P \geq 0.281$). A site-by-treatment interaction occurred with juncos during the spring choice C+L+ trial ($P = 0.013$) in which they preferred L+ feeders at the house site ($P = 0.002$) but showed no preference at the garden ($P = 0.242$), and for juncos and Harris' sparrows in the winter C+L− experiment ($P \leq 0.036$) in which neither species exhibited a feeder preference at the house site ($P \geq 0.747$) but preferred C+ feeders at the garden ($P \leq 0.037$). Reasons remain unclear for these between-site differences.

Mourning doves, European starlings, American goldfinches, black-capped chickadees, downy woodpeckers, house finches, white-throated sparrows, and red-headed woodpeckers were not repelled by the hoop–line treatments ($P \geq 0.187$), but data were not available in all experiments for some species (Table 2). A site-by-treatment interaction occurred with European starlings in the winter C+L+ ($P = 0.035$) in which they showed no preference at the house site ($P = 0.425$) but preferred lines at the garden ($P = 0.030$); reasons are unknown. The overall lack of starling feeder preference is consistent with the findings of Agüero et al. (1991) and Steinegger et al. (1991). Additionally, although brown-headed cowbird responses to lines and food availability in the hoop–line trials were inconsistent, cowbirds appeared to be unaffected by the hoop–line treatments.

Hoop Treatment

Hoop Treatment: Hopper.—The hoop treatment consistently repelled male and female house sparrows from feeder hoppers in

Table 2. Total visits and percent of total visits at control (C) feeders for species not repelled when treatment feeders (L) were protected by hoop-line treatment during choice (2 sites combined) or no-choice switchback (4 sites, 2 trials combined) tests with either unlimited (+) or limited (−) food in the ground trays, Lincoln, Nebraska, 1989–1991.

		C + L +				C − L + choice		C + L − choice	
		Choice		No-choice					
Species[a]		W[b]	Sp	Sp	Su	W	Sp	W	Sp
Harris' sparrow	%	42[c]	49	44		26[c]	26[c]	65[c,d]	46
	n	1,980	219	1,854		1,299	1,058	2,872	597
Dark-eyed junco	%	46[c]	52[d]	55		38[c]	37[c]	55[d]	48[e]
	n	10,688	1,789	3,532		2,878	2,798	4,970	44
European starling	%	51[d]	52	63		63	62	25	71[e]
	n	1,485	328	56		107	214	96	41
Brown-headed cowbird[f]	%	57[c]	23	26[e]	55	59	35[c]	25	67
	n	2,510	277	133	5,495	404	1,574	68	256
Mourning dove[f]	%	48	57	36	53	11[c]	37	59	52
	n	310	323	222	1,341	70	296	375	446
American goldfinch[f]	%	74	0[c]	37[e]		60	0[e]	42	9[e]
	n	80	62	7,359		57	8	135	11
Black-capped chickadee[f]	%	44	31[e]	40	39	50	23[e]	46	38[e]
	n	207	35	605	129	145	43	168	24
Downy woodpecker[f]	%	38[e]	47			40	57[e]	27	0[e]
	n	29	62			88	21	51	11
House finch[f]	%	31	37[e]		39	56	59[e]	51	11[e]
	n	169	30		71	64	34	307	9
White-throated sparrow[f]	%	51	50[e]			63[e]	56	31[e]	33[e]
	n	90	12			16	80	16	6

[a] No-choice trials also had summer data for red-headed woodpeckers (*Melanerpes erythrocephalus*; 56%, $n = 124$). For white-crowned sparrows (*Zonotrichia leucophrys*; 46%, $n = 123$), white-breasted nuthatches (*Sitta carolinensis*; 31%, $n = 48$), and red-bellied woodpeckers (*Melanerpes carolinus*; 52%, $n = 271$), ≥90% of visits (all no-choice, spring) were at 1 site; not analyzed.
[b] Choice trials: winter (W), 8 December 1989–3 February 1990; spring (Sp), 1 March–25 April 1990. No-choice trials: spring, 24 February–2 April 1991; summer (Su), 18 June–25 July 1991.
[c] C vs. L differed ($P \leq 0.05$).
[d] Site by treatment interaction present ($P \leq 0.05$).
[e] Total observations <48 or ≥90% at 1 site; not analyzed.
[f] Scientific names in same order as in table: *Molothrus ater, Zenaida macroura, Carduelis tristis, Parus atricapillus, Picoides pubescens, Carpodacus mexicanus, Zonotrichia albicollis.*

spring and summer ($P \leq 0.042$, Table 3). Blue jays were repelled from feeder hoppers by the hoop treatment in spring ($P = 0.032$) but not summer ($P = 0.312$), and in spring nearly half (45%) of their hopper visits were to those with hoops. Blue jays appeared unaffected by the hoop without lines. The hoop treatment did not repel common grackles or Northern cardinals during either season ($P \geq 0.096$).

Black-capped chickadees preferred hoppers with hoops during spring tests ($P = 0.041$) but showed no preference during summer ($P = 0.501$). Other species that visited feeder hoppers in sufficient numbers for analysis but showed no response to the hoop treatment were Harris' sparrows, dark-eyed juncos, European starlings (spring), and brown-headed cowbirds (summer, $P \geq 0.190$).

Hoop Treatment: Trays.—House sparrow use of feeder trays did not differ for males in either season ($P \geq 0.148$) or females in spring ($P = 0.072$), but in summer, females and juveniles preferred trays of hoop feeders ($P = 0.039$), possibly because exclusion from the hoppers caused a shift to the trays in these no-choice trials. Other species that visited the ground trays but showed no tray-use response to the hoop treatment included common grackles, Northern cardinals, blue jays, and mourning doves in spring and summer, Harris' sparrows and dark-eyed juncos in spring, and brown-headed cowbirds in summer ($P \geq 0.062$).

One question about repellency techniques is whether effectiveness remains when an unprotected control is not readily available. In

Table 3. Total visits and percent of total visits at control feeders when treatment feeders were protected by a hoop during no-choice switchback tests with 4 sites and 2 trials combined, Lincoln, Nebraska 1991.

Species[a]		Hopper		Tray	
		Sp[b]	Su	Sp	Su
House sparrow (male)	%	88[c]	84[c]	46	51
	n	1,206	1,584	1,557	2,814
House sparrow	%	94[c]	67[c]	53	47[c]
(female/juvenile)[d]	*n*	757	3,955	1,078	14,304
Blue jay	%	55[c]	48	49	58
	n	328	597	134	1,126
Common grackle	%	54	51	53	57
	n	506	8,074	182	4,952
Northern cardinal	%	60	22	54	42
	n	149	63	176	123
Black-capped chickadee	%	42[c]	53		
	n	434	53		

[a] Three other species recorded in spring (Sp) with ≥90% of the observations at 1 of the 4 sites: American goldfinch (hopper: 41% control, $n = 1{,}733$; tray: 47%, $n = 1{,}007$), red-bellied woodpecker (hopper: 52%, $n = 170$), and white-breasted nuthatch (hopper: 48%, $n = 62$).
[b] Spring dates: 24 February–2 April 1992; summer (Su): 18 June–25 July 1991.
[c] Control vs. hoop treatment differed ($P \leq 0.05$).
[d] Includes juveniles during summer experiments.

our no-choice trials, both the hoop only and hoop–line treatments performed approximately as expected based on earlier tests that used the same treatments but with an adjacent control feeder. For example, comparing spring 1990 tests with control available to the spring 1991 no-choice trials shows that the proportion of all visits to feeders with lines remained low for house sparrows (9% vs. 3% with no-choice) and blue jays (8% vs. 12%) but apparently increased during no-choice trials for common grackles (7% vs. 34%) and Northern cardinals (30% vs. 41%). Thus, the treatments evaluated appeared to provide management options for house sparrows (hoop only, hoop–line) and blue jays (hoop–line) even without a readily available alternative food source present. In contrast, moderately repelled grackles and cardinals, although preferring no lines, may increase use of hoop–line feeders when other food is limited.

The proportion of blue jay, common grackle, and house sparrow visits to feeders with the hoop–line treatment was generally higher during summer experiments than during spring. For house sparrows, the seasonal difference was greater with females–juveniles than with males and was also apparent with the hoop only treatment. The increased use of treatment feeders during summer was similar to the response of juveniles and breeding-season adults to lines in other experiments (McLaren et al. 1984, Agüero et al. 1991), a possible result of reduced wariness in adults during the breeding season (Summers-Smith 1988) or the presence of young birds in the flock.

We evaluated species that were highly or moderately repelled by lines for similarities that might elucidate the underlying mechanism of line effectiveness. As with the conclusions reached by Agüero et al. (1991), wingspan did not appear to be the primary factor driving bird response to lines, because mourning doves, red-headed woodpeckers, European starlings, downy woodpeckers, and Harris' sparrows, which were not repelled by lines, had wingspans larger than those of house sparrows. We also speculated that primarily woodland species might be more tolerant of lines because they are adapted to a spatially complex environment, but blue jays, a woodland species, were highly repelled by lines. Additionally, it seemed unlikely that the response to hoops resulted from birds forming an association between the presence of hoops and the presence of lines. Hoop only treatments were always presented before hoop–line treatments, and although 2 of the sites used in the choice tests also were used in the no-choice trials, 1 of the no-choice sites had never been used and another had not been used for >2 years prior to this experiment.

Bird response might be related to risk aversion. Here, lines are hypothesized to repel because they present an obstruction that interferes with rapid escape (Agüero et al. 1991). Birds should respond to lines depending upon the perceived risk of predation and associated need for rapid escape. This could explain why ring-billed gulls (*Larus delawarensis*) that nest and forage in the open (high risk of predation) respond to lines at foraging and nesting sites (Blokpoel and Tessier 1983, 1984; Forsythe and Austin 1984), but house sparrows that feed in the open but nest in cavities (relatively low risk of predation), respond to lines at foraging sites but not nest sites (Pochop et al. 1993).

Although many studies have shown that risk perception can affect foraging behavior of birds (Caraco et al. 1980, Cuthill and Guilford 1990, Todd and Cowie 1990, Tuttle et al. 1990), there is little to explain why some species would be more sensitive to risk than others. Clements (1990) suggested that foraging generalists should be less likely to engage in "risky" behavior because of the wide variety of foraging alternatives available. However, this does not explain the response of cardinals, a foraging specialist, to lines or the lack of response from starlings, a foraging generalist.

MANAGEMENT IMPLICATIONS

Our results indicate that bird size, wingspan, habitat association (e.g., woodland), and foraging breadth (i.e., specialist or generalist) are not sufficient to define the mechanism of line effectiveness. The most likely mechanism proposed appears to be that lines interfere behaviorally with rapid escape from sites where there is predation risk. Yet it is unclear why some species (e.g., house sparrows) respond and others do not.

A device to repel unwelcome birds from backyard feeders ideally should be highly repelling to the undesirable species but have no negative effects on desirable ones. Although opinions may vary on which species are undesirable, the hoop only or the hoop plus lines offer inexpensive and environmentally appealing options to repel house sparrows from feeder hoppers (hoop only treatment) or to repel house sparrows and blue jays from feeders with some repellency to common grackles and Northern cardinals. The hoop also allows house sparrows to continue to feed on the ground under hoppers, a possible advantage where the wariness of house sparrows might serve as a predator alert for other species or where species such as dickcissels (*Spiza americana*) may come to feeders with house sparrows (Dennis 1978). Although some of the variability in bird response to lines and food availability observed in these experiments can be explained, e.g., the apparent response of Northern cardinals, Harris' sparrows and juncos to large grackle flocks, much remains unknown. Additional research and a better understanding of the underlying mechanisms will be needed before we fully understand this management tool.

SUMMARY

We used choice and no-choice (switchback) experiments in Nebraska to evaluate monofilament lines and a wire hoop to manage birds at backyard feeders. House sparrows were highly repelled by the hoop–line treatment in all experiments and they were the only species repelled consistently from feeder hoppers by the hoop only treatment. Blue jays were highly repelled by the hoop-line treatment in all experiments that had an adjacent control feeder. In switchback experiments, they were repelled by the hoop–line in summer and appeared to be repelled in spring.

Common grackles were moderately repelled by the hoop–line treatment, but the number of visits to feeders with lines indicated limited

effectiveness of lines as a management technique for this species. Northern cardinals also were moderately repelled by the hoop–line treatment, but when large grackle flocks were present (>3,600 total grackle visits), cardinals increased their use of feeders with lines. Cardinals appeared to prefer feeders without lines, especially when offered a choice between feeders with or without lines, but apparently benefit when feeders with lines provided refuge from the crowding or interference of large grackle flocks.

Harris' sparrows and dark-eyed juncos were not repelled by the hoop–line treatment and appeared to be influenced in the choice trials toward unlimited tray food availability and, like Northern cardinals, away from large grackle flocks. Mourning doves, European starlings, American goldfinches, black-capped chickadees, downy woodpeckers, house finches, white-throated sparrows, and red-headed woodpeckers were not repelled by the hoop–line treatments. Brown-headed cowbird responses in the choice trials were inconsistent, but they appeared unaffected by the hoop–line treatment.

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