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BIRD RESPONSE TO MONOFILAMENT LINES

AT BACKYARD FEEDERS

by

Kimberly K. Kessler

A THESIS

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BIRD RESPONSE TO MONOFILAMENT LINES AT BACKYARD FEEDERS

Kimberly K. Kessler, M.S.

University of Nebraska, 1991

Advisor: Ron J. Johnson

The impact of monofilament lines on bird species using backyard feeders was evaluated using tests that included manipulating food availability and no-choice (switchback) trials. Both methods were tested during 2 seasons and at multiple sites. Pole-mounted hopper-type feeders, each with a 80-cm diameter tray below the feeder, were used in all trials. An 80-cm diameter wire hoop was attached to the lid of feeders receiving line treatments. Four 9-kg test monofilament lines were spaced at 60-cm intervals and strung between the hoop and tray. House sparrows and blue jays (Cyanocitta cristata) were repelled by lines in all experiments. House sparrows were the only birds to reduce hopper use when hoops without lines were tested. Common grackle (Quiscalus quiscula) numbers were reduced by lines in most experiments, but grackles used feeders with lines equally in one experiment when tray food was limited at the feeder without lines, and during one of the summer switchback experiments when large numbers of begging juveniles were observed foraging with the adults. Northern Cardinals (Cardinalis cardinalis) were repelled by lines when an alternative food supply (control feeder) was available, but the presence of large grackle flocks or the absence of a control feeder resulted in equal or greater cardinal use of feeders with lines. Twelve other species were not repelled by lines. This includes Harris' sparrows

(Zonotrichia querula) and dark-eyed juncos (Junco hyemalis), that preferred feeders with unlimited food in the trays. As with cardinals, large grackle flocks appeared to cause higher than expected use of feeders with lines.

Lines were also tested as a technique to prevent house sparrow damage to oat crops. Parallel lines were effective when adjacent unprotected crops were available but failed to protect oats when adjacent fields were harvested and oats depleted. However, the failure of the lines may have been related to a number of other factors, making additional research necessary to fully evaluate the potential of the technique.

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INTRODUCTION

House sparrows (Passer domesticus) are often unwelcome at backyard feeding stations because they use food and space intended for other species (Dennis 1988). Moreover, people attempting to exclude house sparrows from storage areas, grain crops, or birdhouses, usually don't want house sparrows at their feeding stations. Agüero (1990) found that almost total exclusion of house sparrows resulted when monofilament lines, spaced 30 or 60 cm apart, were placed over or around feeding stations in studies conducted during fall and winter. However, lines appeared to be less effective in reducing house sparrow numbers during the summer, indicating that there may be seasonal differences in bird response to lines (Agüero et al. 1991). While monofilament lines have been effective in repelling several other species of birds (Pochop et al. 1990), little is known about the response of most backyard bird species.

Studies conducted at the University of Nebraska-Lincoln provide evidence that the presence of house sparrows may deter some bird species from using feeding stations. At pole mounted feeders in a backyard site, Harris' sparrows (Zonotrichia querula), dark-eyed juncos (Junco hyemalis), and American goldfinches (Carduelis tristis), which readily passed through lines, were negatively correlated with house sparrows, which were excluded from feeders with lines (R. J. Johnson and K. W. Eskridge, Univ. of Nebraska-Lincoln, unpub. data). However, limited ground food below the hoppers may be an alternative reason for the response of Harris' sparrows and juncos, two primarily ground-feeding species. The only ground food available was that which spilled from the hoppers, resulting in a potentially limited ground food supply, particularly at control feeders where house sparrows fed. Instead of avoiding house sparrows *per se*, Harris' sparrows and juncos may have selected feeders with fewer birds using a limited resource.

The goal of this study was to identify the response of bird species using backyard feeding stations to monofilament lines and to study associated species interactions. Additionally, understanding patterns among species repelled by lines may help clarify the mechanisms responsible for the effectiveness of lines and wires as a control technique.

Two approaches were used to test bird response to monofilament lines: 1) manipulation of food available on the ground below feeders with and without lines, and 2) presentation of feeders with lines in no-choice (switchback) experiments. Based on studies of other species, birds were expected to be highly, moderately, or not repelled by lines (McAtee and Piper 1936, McLaren et al. 1984, Tipton et al. 1989, Steinegger et al. 1991). Species highly repelled by the lines were expected to prefer feeders without lines in all experiments despite negative interactions with other species at control feeders, increased food availability at feeders with lines, or the absence of a feeder without lines. Species moderately repelled by lines were expected to prefer feeders without lines in most experiments, but certain species interactions, conditions of food availability, or the absence of a feeder without lines were expected to result in increased (usually equal) use of feeders with lines. Species not repelled by lines were expected to show equal use of feeders with and without lines except for those situations where species interactions or food availability resulted in a feeder preference.

LITERATURE REVIEW

House sparrows were first released in the United States in 1851, and by 1889, complaints from bird-enthusiasts, biologists, and farmers prompted the U.S. government to commission the first comprehensive study on the ecological and economic impacts of the house sparrows in the U.S. (Barrows 1889, Summers-Smith 1988). House sparrow numbers continued to rise in the U.S. until the period from 1910-1920 when population numbers declined sharply (Summers-Smith 1963). Reasons suggested for the population decline have included replacement of horses by automobiles and the adaptation of native control agents to the new organism (Summers-Smith 1963). House sparrow numbers have been declining in the eastern portion of the U.S, but house sparrows continue to be a problem in the central, grain-producing portions of the country (Kalinoski 1975, Dennis 1978, Kricher 1983).

Problems with house sparrows in the U.S have continued and include crop damage, consumption and contamination of stored grains and livestock feeds, and problems with sparrow numbers and behavior at backyard feeders (Dennis 1978, Fitzwater 1983, Dennis 1988, Johnson and Timm 1987). Competition for nesting areas with native bird species, damage to buildings, fecal deposits on stored equipment and public areas, and fecal deposits and noise associated with roosting areas are among the problems associated with house sparrow nesting and roosting behavior (Barrows 1889, Kalmbach 1940, Summers-Smith 1963, Gowaty 1984, Johnson and Timm 1987). The risk of disease transmission because of the close association between house sparrows, human habitations, and livestock facilities has also been cited as a concern (Kalmbach 1940, Summers-Smith 1963, Mitchell et al. 1973).

House sparrows do, however, have some positive attributes. House sparrows are frequently startled from feeding sites, a behavior which may keep all birds at the station more alert and reduce the risk of predation (Dennis 1978). House sparrows may also attract some species, like dickcissels (Spiza americana), to feeding stations (Dennis 1978). Lastly, house sparrows inhabit urban areas, unacceptable to most other bird species and may be one of the only species to come to some urban feeders (Summers-Smith 1988).

House Sparrow damage to Agriculture

House sparrow damage to fruit and vegetable crops includes peck damage to fruit, as well as damage to buds, flowers, and sprouting plants (Barrows 1889, Dearborn 1912, Kalmbach 1940, Porter 1977, Fitzwater 1983). Dawson and Bull (1970) ranked house sparrows among the top 6 species reported in New Zealand to damage fruit crops, primarily nectarine buds, cherries, and grapes. Jensen (1974), also in New Zealand, found house sparrows to be one of the 2 major species damaging apple crops. However, he only observed house sparrows eating already damaged fruit and never initiating damage to fruit. House sparrows may also have been eating insects attracted by the damaged fruit. Crase et al. (1976) reported that European starlings (Sturnus vulgaris), sparrows (unspecified) and finches (Carpodacus spp.) do the most damage to grape crops in the United States. Boudreau also (1972) found house sparrows to be one of the principal species foraging on grapes in California. Mann (1986) described house sparrow consumption and damage to the flower buds and ovaries of peach trees in residential areas of Ludhiana, Punjab. He believed that house sparrow damage to peach buds and flowers caused the reduction in peach yields from an expected average of 75 kg per tree to 0-2 kg per tree. Ritchie (1931), in Britain, described house sparrow damage to gardens as including "succulent greens;" lettuce; and the fruit, buds, and flowers of peas. However, Ritchie (1931) believed that most of the damage, except that done to pea blossoms, was caused by juvenile birds.

House sparrows are also a pest species in grain crops, feedlots, and grain storage areas (Barrows 1889, Dearborn 1912, Kalmbach 1940, Hammer 1948, Fitzwater 1983). Johnson and Timm (1987) estimated annual house sparrow damage to grain crops and stored grain in Nebraska to equal $2 million in grain consumption or contamination, including approximately $30,000 lost due to house sparrow consumption of feed at cattle and swine facilities. Dawson (1970) estimated wheat loss caused by house sparrows in Hawke's Bay, New Zealand to amount to 2.6 to 8.4% of the total crop.

House Sparrow Problems at Backyard Feeders

House sparrows are commonly considered pests at backyard feeding sites because they use food and space intended for other birds (Wade 1966, Laycock 1976, Dennis 1978, Harrison 1979). In a survey of 725 households, house sparrows ranked among the 3 least-popular birds at backyard feeders. Only European starlings (Sturnus vulgaris) and common grackles (Quiscalus quiscula) received lower ratings (Dennis 1988).

House sparrows have also been accused of "harassing" and/or driving some bird species from feeding areas, but in most cases scientific evidence of this behavior is lacking. Kalinoski (1975) found house sparrows to be dominant to house finches (Carpodacus mexicanus) at feeding stations, with house sparrows winning 96% of the 696 interspecific interactions. Johnson and Eskridge (1989 Univ. of Nebraska-Lincoln, unpub. data) found higher numbers of dark-eyed juncos, Harris' sparrows, and goldfinches at feeders where monofilament lines were used to exclude house sparrows. All 3 species were also negatively correlated with house sparrows. However, the response of Harris' sparrows and dark-eyed juncos may be attributable to food availability instead of direct interference by house sparrows Barrows (1889) cites reports of house sparrows stealing food from American robins (Turdus migratorius) and blue jays (Cyanocitta cristatta). House sparrows have also been observed to steal insects from winter wrens (Troglodytes troglodytes), Eurasian blackbirds (Turdus merula), mistle thrush (Turdus viscivorus), American robins, and starlings (Brockmann and Barnard 1979).

In laboratory studies, Barnard and Sibly (1981) found that house sparrows used one of two foraging strategies, producer or scrounger, with individuals consistently using one strategy. Scroungers obtained the majority of their food (meal worms) by searching areas adjacent to successful foragers, following successful foragers, or (rarely) taking food directly from successful foragers. If the number of scrounger sparrows was too high in relation to producer sparrows, producer sparrows were observed to leave the site. Similarly, house sparrows might cause other birds to leave a feeding site for the same reasons that producer sparrows leave. Dennis (1978) mentions house sparrows pushing in among other species of feeding birds and taking food, and hypothesized that this behavior might have been the cause of occasional grackle attacks and decapitations of house sparrows.

On the positive side, the presence of house sparrows may help to attract some bird species to feeding stations (Dennis 1978, Katzir 1981). Dennis (1978) observed that dickcissels rarely appeared at feeding stations without house sparrows and often formed flocks with house sparrows. House sparrows are easily startled from feeding stations and their nervous behavior may help to keep all birds using the feeding station more alert (Dennis 1978). Foraging in mixed-species groups can provide the same advantages as foraging with conspecifics in terms of increased foraging efficiency and increased likelihood of predator detection. However, the potential advantages will vary depending upon the species involved (Morse 1970; Rubenstein et al. 1977; Morse 1977; Metcalfe 1984; Sullivan 1984a,b; Beveridge and Deag 1987; Popp 1988).

Mixed-species foraging may be especially beneficial for non-flocking species of birds and for birds that use the same habitat as the flocking species but different foods (Sullivan 1984a,b).

Current Techniques used for House Sparrow Damage

A variety of techniques have been used to control house sparrow damage including: lethal methods such as shooting, trapping, or poisoning; and exclusion or repellant devices such as gustatory repellents and covering high value crops with netting (Fitzwater 1983, Knight 1988). However, most of these techniques have limited applicability and may not provide adequate protection. For example, Fitzwater (1983) mentions the use of acoustical or visual repellents but states that these techniques are effective only for short periods of time and should be alternated frequently for maximum impact.

Hanging feeders, providing an abundance of food at a variety of feeding stations, and providing foods that are not preferred by house sparrows have been suggested as control techniques for house sparrows at backyard feeders, but these techniques also have weaknesses (Dennis 1978). House sparrows will eventually use hanging feeders, and providing an abundance of food at a variety of sites might attract more house sparrows instead of creating space for other species. Providing foods that are less desirable to house sparrows can be effective, but many species that are considered desirable at backyard feeders use the same foods as house sparrows.

Recently, Agüero et al. (1991) found that monofilament lines could be used to exclude house sparrows from feeding stations. The lines are inexpensive, easy to install, and are a socially acceptable means of controlling house sparrow numbers. Additionally, there appears to be little evidence of habituation to the technique (Agüero et al. 1991).

Wires and Monofilament Lines as a Bird Control Technique

Monofilament lines and/or wires have been tested in a variety of situations to exclude gulls and waterfowl. Successful techniques to exclude ring-billed gulls (Larus delawarensis) have included grids over a landfill (Forsythe and Austin 1984), parallel lines over landfills and nesting sites (Blokpoel and Tessier 1983, McLaren et al. 1984), and crossed patterns over public areas (Blokpoel and Tessier 1984). Parallel wires have been used at 41-cm spacings for hatchery raceways (Ostergaard 1981), and 3 and 12-m intervals at landfills to exclude herring gulls (Larus argentatus) (McLaren et al. 1984, Dolbeer et al. 1988). Great black-backed gulls have been repelled from a landfill using parallel lines at 3-m intervals (Dolbeer et al. 1988). However, the technique appears to be species specific since the lines failed to significantly reduce numbers of laughing gulls (Larus atricilla) at a landfill site where herring gulls and great black-backed gulls were successfully repelled (Dolbeer et al. 1988).

Lines have also been tested on various species of waterfowl. Parallel lines spaced 6 m apart, and in 3 and 9-m grids excluded Canada Geese (Branta canadensis) from lakes and ponds (Terry 1984; L. L. Walker, Reno Sparks Canada Goose Task Force, unpub. rep.), and parallel lines at 12-16 m intervals have repelled brant (Branta bernicla bernicla) from crop fields in the Netherlands (Peiffer 1977). Six-meter grids have significantly reduced American widgeon (Anas americana), canvasback (Aythya valisineria), and lesser scaup (Aythya afinis) at an airport drainage pond (Terry 1984). Three-meter grids have caused a slight reduction in mallard (Anas platyrhynchos), black duck (Anas rubripes), green-winged teal (Anas crecca), blue-winged teal (Anas discors), ring-necked ducks (Aythya collaris), hooded mergansers (Lophodytes cucullatus) and ruddy ducks (Oxyura jamaicensis) in the same ponds (Terry 1984). Three and 6-m grids failed to significantly reduce numbers of buffleheads (Bucephala albeola) and wood ducks (Aix sponsa)(Terry 1984).

Less information is available on the impact of lines and wires on terrestrial birds. Many authors have suggested stringing black thread over crops to prevent damage by birds, but most reports lack data as to the exact impact of the technique (Montgomery 1913, Seymour 1979, Larkcom 1986). Bunting et al. (1978) state that the effectiveness of black threads is usually short lived. Cottoning, a similar technique that places the tread directly on the plant to be protected instead of spacing lines over the crop, has been used to reduce bullfinch damage to peach buds (Healey and Davis 1972).

Wires and lines have been subjected to more quantitative analysis than have black threads. Wires, arranged in a zigzag pattern over broccoli, were effective in preventing pigeon (unspecified) damage (Wright 1958). Clear, 3.6-kg test monofilament lines spaced 30 cm apart have repelled birds (unspecified) from strawberries and sprouting plants (Knight 1988). Monofilament lines descending from a center pole in a tepee pattern with 60-cm spacings at the bottom have repelled birds (unspecified) from peach trees (Knight 1988). Monofilament lines, 1.8-, 3.6, and 9-kg test, clear and fluorescent yellow, placed parallel at 30-cm or 60-cm intervals, over or around feeding stations have excluded house sparrows (R. J. Johnson, Univ. of Nebraska-Lincoln, unpub. data, Agüero 1990). Based on a small number of observations, cardinal and blue jay visits may also be reduced by lines at 30 and 60 cm spacings (Agüero 1990). Great-tailed grackle (Quiscalus mexicanus) damage to citrus was reduced by the use of parallel monofilament lines at 3, 7, and 11 m intervals. However, the authors felt that the reduction was too small for the technique to be economically feasible unless damage to the crop was severe (Tipton et al 1989). Forsythe and Austin (1984) used 6x6 m grids to reduce numbers of fish crows (Corvus ossifragus) and American crows (Corvus brachyrhynchos) at a landfill. Unlike Forsythe and Austin (1984), Dolbeer et al. (1988) found that American crows were not repelled by parallel lines spaced 3 m apart over a landfill. Lines and wires, as tested, have failed to significantly exclude European starlings, morning doves (Zeniada macroura), rock doves (Columba livia), American robins, and brown thrashers (Toxstoma rufum) (Dolbeer et al. 1988, Rappole 1989, Steinegger et al. 1989, Agüero 1990).

Height of the lines from the substrate has depended largely upon the intended use of the protected area, but increased height can result in birds entering the treatment area from the sides (Blokpoel and Tessier 1984). Moerbeek et al. (1987) indicated that there may be an optimal height of 30-40 cm from the water surface for control of cormorants. Birds walking into the area from the sides have been cited as the reason for the failure of wires to protect fish ponds in Australia (Barlow and Bock 1984). Forsythe and Austin (1984) and Blokpoel and Tessier (1984) both noted that most gulls passing through the lines in their experiments walked in from the sides. Horizontal and vertical perimeter lines have been used to prevent bird entrances from the sides of treatment areas (McAtee and Piper 1936, Salmon and Conte 1981, McLaren et al. 1984, Dolbeer et al. 1988).

Low visibility of the lines and wires is one possible reason for the effectiveness of the lines, resulting in the lines/wires becoming apparent only when the bird is too close to easily avoid the obstacle (Salmon 1984). Depending upon the angle of the light and the approach pattern of the bird, monofilament lines may seem to appear and disappear (Knight 1988). Blokpoel and Tessier (1984) suggest that flying gulls focus on the ground to look for food and accidentally fly into the wires or lines. Agüero et al. (1991) found no difference between house sparrow response to 1.8, 3.6 or 9 kg test lines or to north/south or east/west orientations. However, in one experiment, fewer house sparrows were observed at feeders with small-diameter clear (low visibility) line than larger-diameter fluorescent yellow (high visibility) line. Reasons for this response are unclear but may be attributable to house sparrow numbers at the site or other factors. There may, however, be upper and lower limits to the visibility of the line for effective use. Terry (1984) observed one instance where Canada geese, which have been reported to be totally excluded by lines, passed through the lines when entering the pond at night when the lines could not be seen. On the other hand, if the lines or wires are too visible (or too wide in diameter) some birds have been seen perching on the wires and fishing from them (Lagler 1939).

Spacing of the lines may be critical to the effectiveness of the technique. Dolbeer et al. (1988) stated that parallel wires spaced at 3-m intervals were successful in repelling birds with wingspans > 132 cm but not with wingspans $\leq$ 104 cm. McAtee and Piper (1936) suggested that for species with wingspans 60 cm or greater, line spacings 2 or 3 times the wingspan should be effective. However, house sparrows have been repelled by spacings of 30 and 60 cm but European starlings and robins, species with larger wingspans, were not repelled (Agüero 1990).

Lines and wires, especially those arranged in grids, may disrupt or block normal landing and escape patterns (Pochop et al. 1990). In some cases, birds passing through lines will make several unsuccessful approaches before entering the lines (Dolbeer et al. 1988). McAtee (1936) speculated that lines might repel birds in flight, but might not affect birds that walked into treated areas. Some ducks and gulls appered to learn to hover and drop through lines into the treatment area (Terry 1984, Dolbeer 1988). Birds under lines may be unable to fly up freely in all directions, a factor that may be especially important in escape from predators (Pfeiffer 1979). Birds passing through lines appear nervous and are easily frightened from the site (Amling 1980, McLaren et al. 1984, Moerbeek et al. 1987). Moerbeek et al. (1987) found that cormorants departing from feeding sites under lines started flight runs as far as possible from the line they faced. Blokpoel and Tessier (1983) found that the few ring-billed gulls that did nest under lines nested within 2 m of the edge of the covered area. Whether this reflects use of an area from which aerial escape is easier or is a safe distance that can be walked is unclear.

The presence of lines may be especially hazardous in the case of escaping flocks of birds where crowding may inhibit an individual's ability to avoid aerial obstacles. This would explain observations made by Moerbeek et al. (1987) that lines excluded flocks of cormorants but not individuals. This would also explain the response of other flocking species of birds including Canada geese, house sparrows, and many species of gulls. However, not all species repelled by lines form flocks. For example, although the number of observations was small, Agüero (1990) found evidence that blue jays and northern cardinals might be repelled by lines. Also, not all species that form feeding flocks are repelled by lines, including rock doves, starlings, cowbirds and laughing gulls (Dolbeer 1988, Rappole 1989, Steinegger et al. 1989). Additionally, flocking behavior may reduce the effectiveness of lines in that birds under the lines may attract others to the area. Gulls have been observed to decoy to ducks and coots, that are not readily repelled by the lines (McAtee and Piper 1936). This may also occur with conspecifics, especially in the summer and early fall when numbers of young birds passing through the lines are the highest (Blokpoel and Tessier 1984, McLaren 1984, Agüero 1990).

Effectiveness of lines may vary with season and age of the bird (Pochop et al. 1990, Agüero et al. 1991). Lines appear to be less effective with young birds, with juveniles being found in higher proportions under the lines than in the population as a whole (Blokpoel and Tessier 1984; McLaren et al. 1984). Agüero (1990) found higher numbers of birds under lines during his summer experiments and attributes this trend, in part, to the presence of young birds and to the high energy demands on the adults. Summers-Smith (1963) recorded an increase in the number of juvenile and adult house sparrows in his traps during the summer and fall due in part to the increased number of young, inexperienced birds in the population. The increase in the number of adults captured may be attributed to two causes: the increased energy demand on the adult, or a change in foraging strategies during the breeding season. In order to meet the increased energetic demands of rearing young, normally wary adult house sparrows may take risks by selecting feeding sites they would otherwise avoid. During the breeding season, adult house sparrows shift from primarily group foraging strategies to individual foraging strategies because of the need for insects for the young, causing them to feed in areas otherwise not used (Summers-Smith 1963).

CHAPTER 1

BIRD RESPONSE TO MONOFILAMENT LINES AND FOOD AVAILABILITY AT BACKYARD FEEDERS

BIRD RESPONSE TO MONOFILAMENT LINES AND FOOD AVAILABILITY AT BACKYARD FEEDERS

House sparrows (Passer domesticus) are common but sometimes unwelcome guests at backyard feeders, using food and space intended for other species (Dennis 1988). Kalinoski (1975) found that house sparrows displaced house finches (Carpodacus mexicanus) at feeding stations. Johnson and Eskridge (Univ. of Nebraska, Lincoln, unpub. data) observed a negative correlation between house sparrows and American goldfinches (Carduelis tristis), Harris sparrows (Zonotrichia tristis), and dark-eyed juncos (Junco hyemalis). However, Harris' sparrows and juncos may have responded to a potentially limited ground food supply by foraging at feeders where house sparrows were excluded by monofilament lines.

There may be positive aspects to house sparrows at backyard feeders. House sparrow "nervous" behavior may keep all birds at the feeder more alert (Dennis 1978). Non-flocking birds using backyard feeders may increase foraging efficiency when feeding near house sparrow flocks, a benefit similar to that observed in downy woodpeckers (Picoides pubescens) foraging near flocks of chickadees and titmice . Sullivan (1984) found that downy woodpeckers foraging near flocks of black-capped chickadees (Parus atricapillus) or tufted titmice (Parus bicolor) had greater foraging efficiency than woodpeckers foraging alone. Lastly, house sparrows may attract other species to the feeders. Dennis (1978) observed that in the eastern United States, dickcissels (Spiza americana) formed foraging flocks with house sparrows and were rarely seen at feeding stations without house sparrows.

Agüero et al. (1991) found that monofilament lines spaced 30 and 60 cm apart over feeding stations effectively excluded house sparrows. Lines have been tested on a variety of species and appear to be species-specific in their effect (Pochop et al. 1990). For example, Steinegger et al. (1991) found that European starlings (Sturnus vulgaris), American robins (Turdus migratorius), and brown thrashers (Toxostoma rufum) were not repelled by lines placed around grape plants. The technique may provide a management option for people wishing to selectively exclude sparrows from their feeders, but the response of many backyard bird species remains unknown.

Combinations of lines and food availability were used to evaluate bird response to lines at backyard feeders and to evaluate interactions among bird species using the feeders. I hypothesized that species that are highly repelled by lines would avoid feeders with lines in all experiments (Table 1.1). Species moderately repelled by lines should avoid feeders with lines, but conditions of food availability and some species interactions might result in equal or greater use of feeders with lines. Species not repelled by lines should use feeders equally unless influenced by food availability or species interactions.

METHODS

Data were collected simultaneously at two sites, the horticulture garden at the University of Nebraska-Lincoln East campus, and the backyard of a home in Lincoln, Nebraska, approximately 5 km northeast of the horticulture garden. Experiments were conducted in two blocks, from 8 December 1989 to 3 February 1990 (winter) and from 1 March to 25 April 1990 (spring), to test for a seasonal effect on bird response to the lines.

Four pole-mounted hopper-type feeders, spaced 3 m apart, were used at each site (2 control feeders, 2 feeders with lines). An 80-cm-diameter plywood tray, with a 3.8 cm outside rim and an opening in the tray center for the pole, was on the ground below each feeder. All treatment feeders had lines supported by a 9 gauge (U.S. standard) wire hoop 80-cm in diameter attached to the feeder top (Fig. 1.1). The diameter of the hoop was selected so that the lines fell approximately 20 cm from the feeder perches, the point where birds would likely set their wings before landing. Four clear, 9-kg test (0.46 mm diameter) monofilament lines (Stren®, E.I. Du Pont De Nemours & Co., Wilmington, Del.) were installed vertically between the hoop and the rim of the tray and spaced at 60-cm intervals. Light-weight springs were attached between the lines and the tray to maintain tension on the lines. Control feeders were without lines and hoops.

Three tests were conducted during each block. The first test 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 treatment with limited tray food (C+L-). Each experiment lasted 12 days and was preceded by a 3-day pretreatment period to evaluate bird use of feeders before the installation of lines. Experiments were separated by 6-day rest periods without treatments, in addition to the 3-day pretreatment period, to allow bird use of all feeders to return to pretreatment levels.

Treatments were rotated among the feeders at each site every 3 days (period). Each of the 2 treatments was assigned to two numbers between 1 and 4 and these numbers were then considered four separate treatments so that treatments could be rotated among feeders using a 4 x 4 Latin square design using period and feeder as blocking criteria.

Feeding stations were supplied with a mixture of 40% black oil-type sunflower seeds, 30% white proso millet and 30% finely-cracked corn. Suet bags were attached to each feeder to better attract woodpeckers (Picoides spp.) and black-capped chickadees. At the beginning of each 3-day period of the experiment, the hoppers were filled with 2 kg of food. During pretreatment periods and treatments with unlimited food in the trays, 1 kg of food was added to the tray at the beginning of each 3-day period and supplemented as needed to maintain an unlimited food supply. Fifty grams of food were added daily to the limited-food trays, an amount selected because it was always less than the average daily tray-food consumption from the pretreatment periods. At the end of each day, limited food trays were cleaned and stocked with 50 g of new food, thereby preventing the buildup of unconsumed bait.

Data were collected daily during 8 15-minute intervals randomly selected from the 3-hour period starting 20 minutes before sunrise. During each 15-minute interval, the bird species and numbers present, and their location (hopper or tray) were recorded each minute for each feeder, starting at time zero (16 observations total). Birds were counted only if they were located on or within the rim of the tray or on the tray of the hopper. Squirrels feeding in the trays would prevent bird use of trays and bias data, so squirrels were immediately chased from the trays. Data collection resumed 2 minutes after the observer returned to the blind and continued until 16 observations were obtained for the interval. Two minutes were sufficient for birds to resume feeder use.

Data were analyzed by combining Latin squares from different sites using analysis of variance (ANOVA) for replicated Latin squares with a split plot treatment arrangement when the numbers (1-4) were whole plot treatments and hopper or tray were split plot treatments (Lentner and Bishop 1986). The treatment differences were then tested using an appropriate contrast among the 4 numbers. For each species, the total number counted per-period was analyzed using analysis of variance on square roots to reduce heterogeneity of error variance (Snedecor and Cochran 1967). Data were not analyzed for a species if there were < 50 observations available for the experiment (48 observations is an average of 4 observations per day). Results from individual sites are reported when bird behavior differed at the two sites.

RESULTS

House sparrows and blue jays (Cyanocitta cristata) were highly repelled by the lines, preferring control feeders in all experiments ($P \leq 0.0055$)(Table 1.2). An average of 2% (SD = 8) of all house sparrows counted were at feeders with lines compared to 12% (SD = 13) of all blue jays counted were at feeders with lines.

Common grackles (Quiscalus quiscula) were one of 2 species moderately repelled by lines (Table 1.3). Grackles were repelled by lines ($P \leq 0.0275$) in all experiments except the winter C-L+ experiment ($P = 0.3620$). Although grackles preferred control feeders, the proportion of observations at treatment feeders, 23% (SD = 23.87), was higher than that for blue jays or house sparrows.

Northern cardinals (Cardinalis cardinalis), another species moderately repelled by lines, preferred the control feeder ($P \leq 0.0274$) in the two winter experiments with $\leq$651 total grackle observations. Data from the spring C+L+ experiment, also with $\leq$651 grackle observations, indicated a similar trend. Cardinals were not repelled by lines during the winter C+L+, spring C-L+, and spring C+L- experiments, each with $\geq$ 3646 grackle observations (Table 1.3). Additionally, in the winter C+L+ experiment, cardinals showed no feeder preference ($P = 0.9045$) at the house site with high grackle counts, but preferred control feeders ($P = 0.0341$) at the garden site with low grackle counts (total grackle counts: house 4654; garden 195)(Table 1.4). Between-site differences in cardinal response to also occurred during the winter C-L+ experiment. Cardinals preferred control feeders at the house site ($P = 0.0123$), but did not have a feeder preference at the garden site ($P = 0.7908$).

Harris' sparrows and dark-eyed juncos were not repelled by lines, and both species preferred feeders with lines and unlimited food in trays in the spring and winter C-L+ experiments ($P \leq 0.0002$)(Table 1.5). In the winter C+L- experiment, both species preferred the control feeders (Harris' sparrow $\underline{P} = 0.0002$; junco $\underline{P} = 0.0546$), but in the spring C+L- experiment with high grackle numbers, neither species exhibited a feeder preference ($\underline{P} \geq 0.2900$). Similarly, in the spring C+L+ experiment without large grackle flocks, neither species exhibited a feeder preference ($\underline{P} \geq 0.6181$), but both species preferred the feeder with lines in the winter C+L+ experiment ($\underline{P} \leq 0.0039$) with large grackle flocks. As with the cardinals in the winter C+L+ experiment, Harris' sparrows and juncos exhibited a feeder preference ($\underline{P} \leq 0.0021$) only at the house site with high grackle counts (Tables 1.6 & 1.7).

Dark-eyed junco feeder preference differed between sites in the spring C+L+ experiment, and both Harris' sparrow and junco feeder preference differed between sites during the winter C+L- experiment (Tables 1.6, 1.7). During the spring C+L+ experiments, house sparrow numbers were higher at the house site (467) where juncos preferred feeders with lines ($\underline{P} = 0.0020$) than the garden site (80) where juncos did not have a feeder preference ($\underline{P} = 0.3635$). During the winter C+L- experiment, Harris' sparrows and juncos, as expected, preferred the C+ feeder ($\underline{P} \leq 0.0351$) at the garden site with relatively low house sparrow (285) and blue jay (51) observations. However, at the house site with high house sparrow (876) and blue jay (511) numbers, neither species had a feeder preference ($\underline{P} \geq 0.7465$).

Brown-headed cowbirds (Molothrus ater) and mourning doves (Zenaida macroura) also were not repelled by the lines. However, cowbirds preferred the feeder with lines in the spring C-L+ experiment ($\underline{P} = 0.0235$) and morning doves preferred the feeder with lines in the winter C-L+ experiment ($\underline{P} = 0.0221$)(Table 1.8).

European starlings did not exhibit a preference in any of the experiments ($\underline{P} \geq 0.2509$). Black-capped chickadees, downy woodpeckers, house finches (Carpodacus mexicanus), American goldfinches, and white-throated sparrows (Zonotrichia albicollis) also were not repelled by lines, but data were not available in all experiments (Table 1.9).

DISCUSSION

As expected, based on the findings of Agüero et al (1991), house sparrows were repelled by lines in all experiments. Blue jays were also highly repelled by lines in all experiments.

Common grackles were classified as a moderately repelled species because of equal feeder use in the winter C-L+ experiment, and because of the high number of grackle observations at feeders with lines. Equal grackle use of control and treatment feeders in the winter C-L+ experiment was as expected for a species influenced by both food availability and the presence of lines. If food was the only determining factor, then a preference for the L+ feeder would have been expected. Contrary to the expected results, grackles preferred the control feeder in the spring C-L+ experiment. Reasons for grackle avoidance of the L+ feeder in the spring C-L+ experiment are unclear but may be related to seasonal differences in the physical condition and energy requirements of the grackles, or an interaction between the lines and the number of grackles in the tray.

Grackles present in the winter C-L+ experiment had survived a period of heavy snow cover, high winds, and below-zero temperatures, which may have increased the grackle's energy requirements. Alternatively, there may be a limit to the number of grackles that can safely forage under the lines without inhibiting the birds' ability to escape. In fact, on several occasions grackles hit the lines with their wings when startled from the feeders. Thus, as the number of grackles at the site increases, and the potential limit at the L+ feeders is met, the number of individuals required to use the C- feeders would increase. If the number of individuals required to use control feeders increased sufficiently, the results could indicate a preference for feeders with lines.

Northern cardinals were also moderately repelled by lines, but showed higher flexibility in feeder use than did common grackles, even to the extent of preferring feeders with lines in the spring C-L+ experiment. The presence of large grackle flocks appeared to influence cardinal feeder preference, with cardinals exhibiting higher than expected use of feeders with lines during all experiments with $\geq$ 3646 total grackle counts.

Harris' sparrows and dark-eyed juncos were not repelled by lines and, as expected for primarily ground foraging species, appeared to be influenced by tray food availability. As with northern cardinals, the presence of 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.

The presence of large numbers of blue jays and house sparrows may also have influenced Harris' sparrow and dark-eyed junco feeder preference. In most instances where Harris' sparrow and junco use of feeders differed between sites, use of feeders with lines at the house site was higher than expected given food availability in the trays, indicating that the birds may be avoiding a species repelled by lines. In the winter C+L+ experiment at the house sites with 512 blue jay counts and 1667 house sparrow counts, Harris' sparrows and juncos preferred feeders with lines, but the response was confounded by the presence of large numbers of grackles. Junco and Harris' sparrow use of control feeders was lower than expected during the C+L- experiment at the house site given tray food availability, but total blue jay (511) and house sparrow (876) counts were high. Blue jay and house sparrow numbers were also high at the garden site during the C+L+ experiment, and while Harris' sparrow numbers indicate a trend towards preferring feeders with lines, juncos did not exhibit a feeder preference. The lack of junco feeder preference may be due to the large number of junco observations (Total counts = 8519). Feeder pressure may have been so high that the space at the preferred feeder was filled and the remaining birds were forced to use the control feeders. Further observations will be needed to quantify the effects of high house sparrow and blue jay numbers on other species using the feeders.

Brown-headed cowbirds and mourning doves were not repelled by lines and, in some instances, appeared to be influenced by food availability. The lack of consistent mourning dove response to food availability was unexpected because mourning doves were never observed foraging in the hoppers and were expected to have been influenced by tray food availability.

Six other species were also not repelled by lines. The response of European starlings, black-capped chickadees, downy woodpeckers, house finches (*Carpodacus mexicanus*), and American goldfinches was as expected for species not repelled by lines and without a preference for ground foraging. The lack of starling feeder preference is also consistent with the findings of Agüero et al. (1991) and Steinegger et al. (1991). White-throated sparrows were also not repelled by lines and were never observed foraging in the hoppers. However, unlike the Harris' sparrows and juncos, they did not exhibit a preference for the L+ feeder in the spring C-L+ experiment. White-throated sparrows might not have exhibited a feeder preference because they were primarily observed during the first morning interval when bird numbers were low and food still available in the food-limited trays.

Monofilament lines appear to be an effective, inexpensive, and environmentally appealing technique for reducing house sparrow numbers at backyard feeders. Blue jay, common grackle, and northern cardinal numbers were also reduced at feeders with lines. However, common grackles and northern cardinals, the two species moderately repelled by lines, may not be repelled by lines if the control, a readily available food source, is not available. Because lines selectively exclude only some species, primarily house sparrows and blue jays, they provide opportunities for studying interactions among species in a relatively natural setting.

SUMMARY AND CONCLUSIONS

Monofilament lines spaced 60 cm apart around pole-mounted hopper-type feeders reduced house sparrow and blue jay numbers in all experiments. Common grackles were moderately repelled by lines, but certain conditions of increased food availability under lines resulted in increased use of feeders with lines. Northern cardinals were also moderately repelled by lines but used feeders with lines more often than did common grackles and even preferred feeders with lines in one experiment (grackle numbers = 6289), indicating that when the option of a control feeder is removed, northern cardinals may not be repelled by lines. Eight other species were not repelled including Harris' sparrows and dark-eyed juncos, which appeared to be influenced by ground food availability.

Northern cardinal, dark-eyed junco, and Harris' sparrow use of feeders with lines was higher than expected during all experiments with high numbers (>3500 total observations) of common grackles. There were also some indications that large numbers of house sparrows and blue jays may have caused Harris' sparrows and dark-eyed juncos to increase use of feeders with lines.

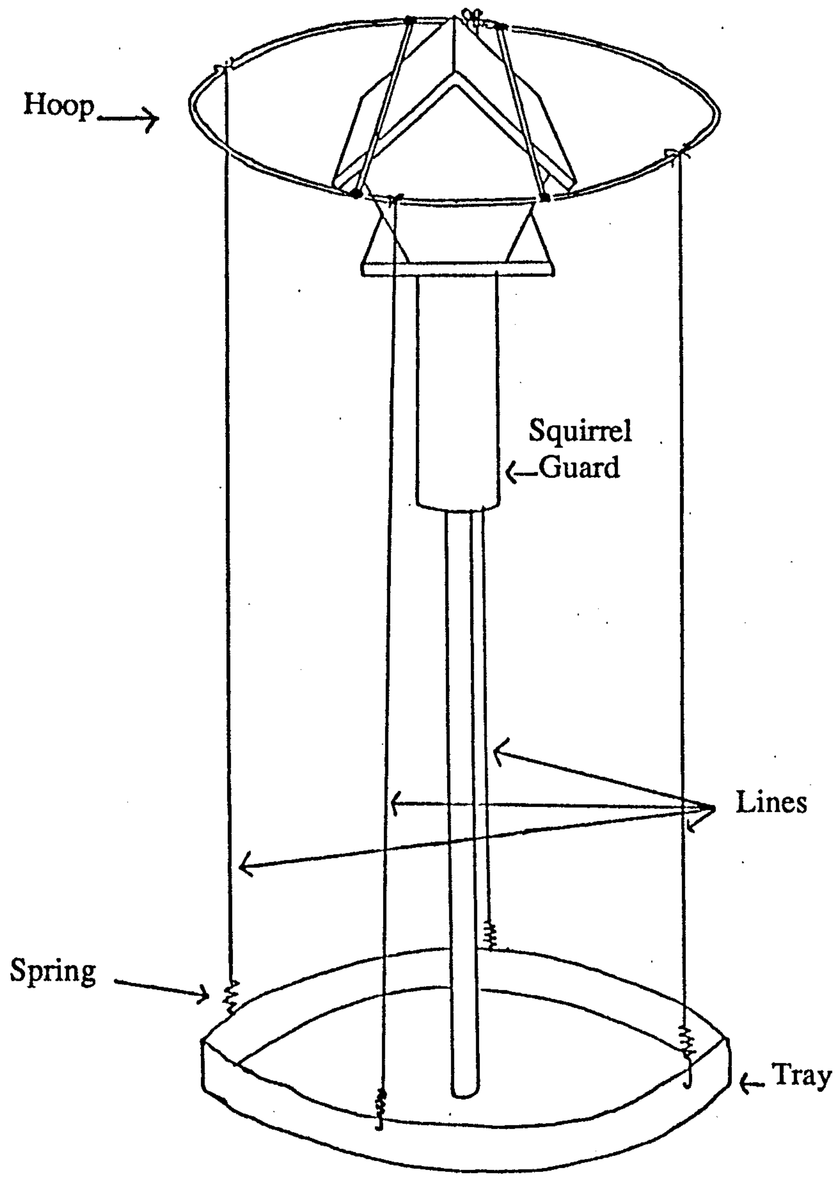

Fig. 1.1. Diagram of pole-mounted hopper-type feeder with hoop and lines.

Table 1.1 Expected feeder preferences for species highly, moderately, or not repelled by lines in test of feeders that were control (C) or monofilament line (L) treated, with either limited (-) or unlimited (+) food in trays, Lincoln, Nebraska 1989-90.

Response to lines	Feeding location[a]	Experiment		
		C+L+	C-L+	C+L-
Highly-repelled	all	C+	C-	C+
Moderately-repelled	hopper	C+	C-	C+
Moderately-repelled	tray	C+	L+ or none	C+
Not-repelled	hopper	none	none	none
Not-repelled	tray	none	L+	C+

[a] Species were expected to prefer feeding in hoppers or trays or use both locations. Species using both locations should respond in the same manner as species preferring hoppers.

Table 1.2. Total numbers for species highly repelled by lines, 2 sites combined, at pole-mounted hopper type feeders that were control (C) or monofilament-line (L) treated, with either unlimited (+) or limited (-) food in the trays below hoppers, Lincoln, Nebraska, 1989-90.

Season	House Sparrow			Blue Jay		
Treatment	C+L+	C-L+	C+L-	C+L+	C-L+	C+L-
Winter						
Control	3620	332	1411	776	132	595
Lines[a]	5	2	5	216	14	11
P-value[b]	0.0001	0.0004	0.0001	0.0001	0.0002	0.0001
Spring						
Control	497	267	695	133	72	92
Lines[a]	50	7	10	12	18	8
P-value[b]	0.0001	0.0001	0.0001	0.0021	0.0055	0.0028

[a] All lines were clear 9-kg test and spaced 60 cm apart around the feeder.

[b] P-values were obtained using ANOVA for repeated Latin squares on square root transformations of per-period treatment totals.

Table 1.3. Total numbers for species moderately repelled by lines, 2 sites combined, at pole-mounted hopper-type feeders either control (C) or monofilament-line (L) treated, with either unlimited (+) or limited (-) food in the trays below the hopper, Lincoln, Nebraska, 1989-90.

Season	Common Grackle			Northern Cardinal		
Treatment	C+L+	C-L+	C+L-	C+L+	C-L+	C+L-
Winter						
Control	3016	316	164	425	234	402
Lines[a]	1833	335	45	365	104	175
P-value[b]	0.0073	0.3620	0.0004	0.0844	0.0274	0.0182
Spring						
Control	510	2505	5054	55	38	27
Lines[a]	36	1141	1235	19	49	54
P-value[b]	0.0275	0.0002	0.0001	0.1095	0.4718	0.0008

[a] All lines were clear, 9-kg test and spaced 60 cm apart around the feeder.

[b] P-values were obtained using ANOVA for repeated Latin squares on square root transformations of
per-period treatment totals.

Table 1.4. Total northern cardinal numbers, by site, at pole-mounted hopper-type feeders that were either control (C) or monofilament-line (L) treated, with either unlimited (+) or limited (-) food in trays below the hoppers, Lincoln, Nebraska, 1989-90.

		Garden			House		
Season	Treatment	C+L+	C-L+	C+L-	C+L+	C-L+	C+L-
Winter	Control	173	39	59	252	195	343
	Lines[a]	89	44	36	276	60	139
	P-value[b]	0.0341	0.7908	0.0763	0.9045	0.0123	0.0120
	Common grackles[c]	195	56	63	4654	596	146
Spring	Control	55	28	22	32	---	---
	Lines[a]	19	47	45	19	---	---
	P-value[b]	0.1315	0.1054	0.0047	0.5899	---	---
	Common grackles[c]	7	1137	3416	539	2509	2873

[a] All lines were clear 9-kg test monfilament and spaced 60 cm apart around the feeder.
[b] P-values were obtained using ANOVA for repeated Latin squares on square root transformations of per-period treatment totals.
[c] Total observations, treatments combined.

Table 1.5. Total numbers for species not repelled by lines but influenced by tray food, 2 sites combined, at pole-mounted hopper-type feeders that were control (C) or monofilament-line (L) treated, with either unlimited (+) or limited (-) food in trays below hoppers, Lincoln, Nebraska 1989-90.

		Harris' Sparrow			Dark-Eyed Junco		
Season	Treatment	C+L+	C-L+	C+L-	C+L+	C-L+	C+L-
Winter	Control	836	340	1867	4962	1093	2719
	Lines[a]	1144	959	1005	5726	1785	2251
	P-value[b]	0.0039[c]	0.0001	0.0002	0.0371[c]	0.0001	0.0546
Spring	Control	108	280	273	925	1021	21
	Lines[a]	111	766	323	864	1776	23
	P-value[b]	0.6181	0.0001[c]	0.2900[c]	0.7405	0.0002[c]	0.7679[c]

[a] All lines were clear 9-kg test monfilament and spaced 60 cm apart around the feeder.

[b] P-values were obtained using ANOVA for repleated Latin squares on square root transformations of per-period treatment totals.

[c] Total grackle observations, treatments combined, >3500.

Table 1.6. Total Harris' sparrow numbers, by site, at pole-mounted hopper-type feeders that were either control (C) or monofilament-line (L) treated, with either unlimited (+) or limited (-) food in trays below the hoppers, Lincoln, Nebraska, 1989-90.

		Garden			House		
Season	Treatment	C+L+	C-L+	C+L-	C+L+	C-L+	C+L-
Winter	Control	761	319	1781	75	21	86
	Lines[a]	911	885	917	233	74	88
	P-value[b]	0.2445	0.0004	0.0002	0.0009	0.0123	0.8836
	Common grackle[c]	195	56	63	4654	596	146
	House sparrow[c]	1958	285	540	1667	50	876
	Blue jay[c]	480	51	95	512	95	511
Spring	Control	72	241	245	36	39	28
	Lines[a]	59	703	285	52	63	38
	P-value[b]	0.2992	0.0002	0.2595	0.6765	0.3748	0.9392
	Common grackle[c]	7	1137	3416	539	2509	2873
	House sparrow[c]	80	254	694	467	10	11
	Blue jay[c]	33	44	69	112	112	31

a All lines were clear, 9-kg monofilament and spaced 60 cm apart around the feeder.
b P-values were obtained using ANOVA for repeated Latin squares on square root transformations of per-period totals.
c Total observations, treatments combined.

Table 1.7. Total dark-eyed junco numbers, by site, at pole-mounted hopper-type feeders either control (C) or monofilament-line (L) treated, with either unlimited (+) or limited (-) food in trays below the hoppers, Lincoln, Nebraska, 1989-90.

		Garden			House		
Season	Treatment	C+L+	C-L+	C+L-	C+L+	C-L+	C+L-
Winter	Control	4255	846	1989	707	247	730
	Lines[a]	4264	1450	1517	1462	335	734
	P-value[b]	0.8822	0.0017	0.0351	0.0021	0.0758	0.7465
	Common grackle[c]	195	56	63	4654	596	146
	House sparrow[c]	1958	285	540	1667	50	876
	Blue jays[c]	480	51	95	512	95	511
Spring	Control	689	810	---	236	211	---
	Lines[a]	499	1358	---	365	418	---
	P-value[b]	0.3635	0.0001	---	0.0020	0.0251	---
	Common grackle[c]	7	1137	3416	539	2509	2873
	House sparrows[c]	80	254	694	467	10	11
	Blue jays[c]	33	44	69	112	46	31

[a] All lines were clear 9-kg test and spaced 60 cm apart around the feeder.
[b] P-values were obtained using ANOVA for repeated Latin squares on square root transformations of per-period totals.
[c] Total numbers, treatments combined.

Table 1.8. Total numbers for species not repelled by lines but possibly influenced by tray food, 2 sites combined, at pole-mounted hopper-type feeders that were control (C) or monofilament-line (L) treated, with either unlimited (+) or limited (-) food in trays below the hopper, Lincoln, Nebraska, 1989-90.

		Brown-Headed Cowbird			Mourning Dove		
Season	Treatment	C+L+	C-L+	C+L-	C+L+	C-L+	C+L-
Winter	Control	1420	239	17	148	8	222
	Lines[a]	1090	167	51	162	62	153
	P-value[b]	0.0882	0.7629	0.0742	0.5736	0.0221	0.2336
Spring	Control	64	555	172	183	110	224
	Lines[a]	213	1029	84	140	186	216
	P-value[b]	0.1140	0.0235	0.2022	0.8181	0.6824	0.9286

[a] All lines were clear, 9-kg test and spaced 60 cm apart around the feeders.

[b] P-values were obtained using ANOVA for repeated Latin squares on square root transformations of per-period data.

Table 1.9. Total numbers for species not repelled by lines at feeders that were control (C) or monofilament line (L) treated, with either unlimited (+) or limited (-) food in trays below the hoppers, Lincoln, Nebraska 1991.

Species		Winter			Spring		
Experiment		Control	Lines[a]	P-value[b]	Control	Lines[a]	P-value[b]
European	C+L+	888	725	0.7578	169	159	0.9587
starling	C-L+	67	40	0.5319	132	82	0.5256
	C+L-	24	67	0.2509	---	---	---
American	C+L+	59	21	0.1501	0	62	0.0452
goldfinch	C-L+	34	23	0.9217	---	---	---
	C+L-	57	78	0.4884	---	---	---
House	C+L+	53	116	0.2052	---	---	---
finch	C-L+	36	28	0.6147	---	---	---
	C+L-	158	149	0.3051	---	---	---
Black-	C+L+	91	116	0.4561	---	---	---
capped	C-L+	72	73	0.5572	---	---	---
chickadee	C+L-	77	91	0.6008	---	---	---
Downy	C+L+	---	---	---	29	33	0.6865
Woodpecker	C-L+	35	53	0.5931	---	---	---
	C+L-	15	36	0.2339	---	---	---
White-	C+L+	53	52	0.5104	---	---	---
throated	C-L+	---	---	---	45	35	0.5637
sparrow	C+L-	---	---	---	---	---	---

[a] All lines were clear, 9-kg test and spaced 60 cm apart around the feeder.

[b] P-values were obtained using ANOVA for repeated Latin squares on square root transformations of per-period totals.

CHAPTER 2

LINES TO EXCLUDE HOUSE SPARROWS FROM OAT FIELDS

LINES TO EXCLUDE HOUSE SPARROWS FROM OAT FIELDS

Worldwide, estimates of house sparrow (Passer domesticus) damage to grain crops range from 2.6 to 30% of the crop (Southern 1945, Dawson 1970). In 1987, Johnson and Timm estimated house sparrow damage to small grains in Nebraska to be $314,000 per year. House sparrow damage is also a problem in various fruit crops, especially grapes, and in private gardens (Bull 1970, Boudreau 1972, Fitzwater 1983, Mann 1986).

Techniques suggested for reducing sparrow damage have included exclusion; visual and acoustical repellents; removal of roosting areas adjacent to the crop; and removal of sparrows through trapping, poisoning, or shooting (Fitzwater 1983). Knight (1988) used monofilament lines as a means of reducing bird (spp. unspecified) damage to row crops, fruit trees, vineyards, and bedded crops. However, the technique appears to be effective only for certain species (Pochop et al. 1990, Steinegger et al. 1991). Agüero et al. (1991) found that parallel monofilament lines spaced at 30 and 60-cm intervals over feeding stations effectively repelled house sparrows. The repellency of lines to house sparrows was somewhat less in summer, the period when oat damage occurs, possibly because of the high number of juvenile birds in the flock and time-energy budget constraints on the adult birds (Agüero et al. 1991).

During June 1990, a flock of approximately 300 house sparrows was observed in oat fields on the University of Nebraska-Lincoln campus, providing an opportunity to evaluate monofilament lines as a method to protect oat crops from house sparrow damage.

METHODS

A 18 x 24 m section of an oat field in the horticulture garden at the University of Nebraska-Lincoln East Campus was selected for use as the study field. The study plot was on the northwest corner of a series of 6 oat fields available in the garden. Preliminary observations indicated that this was one of several oat fields in the horticulture garden used by the sparrow flocks.

Data were collected during 8 15-minute intervals each day, 4 randomly selected from the 3 hours immediately after sunrise, and 4 intervals from the 3 hours immediately before sunset. For each minute of the observation intervals, starting with zero, the number of house sparrows in the study plot was recorded, providing 16 observations per interval.

On 1 July 1990, pretreatment observations were made to quantify sparrow use of the study plot (Table 2.1). On 2 July, 8 support poles were placed around the perimeter of the study plot. A perimeter line of 20-kg test, 0.46 mm diameter, clear monofilament line (Stren, E.I. Du Pont Nemours & Co., Wilmington, Del.), attached 110 cm above the ground, was connected to the poles to support parallel cross lines. Parallel lines were installed with an east-west orientation at 180-cm intervals, with approximately 21 cm between the oats and lines. Data were collected from the morning on 3 July through the evening of 7 July. Observations continued until at least 15 intervals of observations were available from periods when the flock was feeding within 100 m of the treatment field. Sparrows foraging in these areas were considered to have the opportunity to forage in the treatment field, because they flew over the treatment field on their way to perch sites in the trees beside the treatment field. Lines were removed after the evening study period on 7 July, and data collection continued from the morning of 8 July through the evening of 10 July.

The lines were reinstalled on 12 July with the intention that all other fields would be mowed and disked to eliminate alternative food sources. The oats were harvested by 15 July but technical difficulties and weather conditions prevented disking the fields. Data collection was delayed with the intention that the fields would be disked to remove alternative food sources. Fields were checked daily to determine whether the flocks were using the treatment plot.

On 31 July a flock of approximately 300 sparrows was observed feeding under the lines in the study plot and data collection resumed in the morning of Aug. 1. It was apparent that 1.8-m intervals of the parallel lines failed to repel the sparrows, so line spacings were reduced to 60 cm after the morning study period on 2 Aug. Data were collected in the evening of 2 Aug. and in the morning of 3 Aug. with the sparrows still not repelled by lines. Heavy rains had crushed the oats to the point where the lines were > 50 cm above the top of the oat plants. Line distance above the surface of the plants may have been critical to the effectiveness of the technique, so the lines were dropped to 20 cm above the oats, a height found effective in previous trials at feeding stations. Data were collected from the evening of 3 Aug. through the evening of 4 Aug. By the end of this period the number of house sparrows had dropped to groups of no more than 20 birds. As the large flock had not been seen foraging elsewhere in the horticulture garden, data collection was discontinued.

RESULTS

Sparrow flocks were not observed in the study field during the July treatment period indicating that lines repelled house sparrows when the other oats were readily available (Table 2.2). However, the lines were not effective during August when the remaining oats had been depleted, and when the lines were at heights of $\geq$ 50 cm above the oats and at spacings of either 180 or 60 cm. A space of 50 cm or more between the lines and the oats provided sufficient room for the sparrow flocks to fly underneath the lines. Sparrows disturbed by passing vehicles or people flushed from the oats, moved to the opposite end of the treatment plot, and returned to the oats while flying below the lines. When the spacing between the lines and the oats was reduced to 21 cm this behavior was not observed.

There were several difficulties with the monofilament lines, the most notable being that the lines would stretch under the tension required to maintain the desired distance between the oats and lines. Stretching was a particular problem for the perimeter lines that supported the parallel lines covering the field. Additionally, exposure to weather conditions (sunlight and heat) caused the lines to become brittle.

The combination of line stretching and degradation necessitated frequent maintenance to maintain tension and to repair breaks.

DISCUSSION

Data from July indicate that monofilament lines may be an effective technique for reducing house sparrow damage to oat crops when an alternative food source is readily available. However, the potential effectiveness of monofilament lines at protecting oat crops in the absence of an alternative food source remains unclear.

Late in the study, after food appeared to be depleted in the other oat fields, a sharp decrease in the number of birds in the treatment field was observed when lines were spaced 60 cm apart and 21 cm over the oats. However, the decrease in house sparrow use of the study plot may relate to factors other than the presence of lines. Alternative explanations for the observed reduction in bird numbers include: the birds may have depleted the remaining grain in the study plot or one of the ripening sorghum crops elsewhere on campus may have attracted the sparrows.

The failure of lines when installed $\geq$ 50 cm above the oats was surprising, especially when the spacing between lines was reduced to 60 cm, a spacing found to effectively exclude sparrows from feeding stations (Agüero et al. 1991). Agüero et al. (1991) suggest that lines are effective at feeding stations because of a need for rapid escape from predators. The same mechanism was expected to be in effect in the oat fields. With the lines $\geq$ 50 cm above the oats, the perceived risk might have been altered because that the sparrows were able to fly away from disturbances without flying through the lines. Moerbeek et al. (1987) found that lines were most effective in reducing cormorant numbers when the distance between the lines and the surface of the water inhibited pre-flight runs of cormorants. However, in most instances, the role of line/wire height from the substrate is unclear. Distances ranging from 0.6-10 m from the substrate have been effective at repelling ring-billed gulls (Blokpoel and Tessier 1983, Blokpoel and Tessier 1984, Forsythe and Austin 1984) and spacings of 0.2-24 m have been effective in repelling herring gulls (Ostergaard 1981, McLaren et al. 1984, Dolbeer 1988).

High numbers of juveniles may have influenced bird response to lines in this study. Young birds may not have the experience necessary to recognize and avoid unusual situations and may also have reduced foraging efficiency because of inexperience, which could cause them to enter areas avoided by adults (McLaren et al. 1984). Agüero et al (1991) observed that juveniles comprised a large proportion of the house sparrows under the lines in their experiment. In studies with gulls, lines appeared less effective in repelling juveniles than adults (Blokpoel and Tessier 1984, McLaren et al. 1984). Young birds might also serve as decoys, attracting foraging adults to the treatment area.

Summers-Smith (1963) suggests that, for house sparrows, food availability may be a critical factor during the breeding season with nutritional demands of reproduction and rearing young causing adults to take additional risks in foraging. He observed an increase in the number of adults trapped during the period from April to

August and hypothesized that the difference may be due to increased energy requirements during the breeding season. In experiments with starlings and juncos exposed to periods of food deprivation, there is an increase in the frequency of "high-risk" behaviors (Caraco et al. 1980, Cuthill and Guilford 1990).

Habituation is an often cited cause for the failure of damage control techniques but appears unlikely with monofilament lines. Other studies where monofilament lines have been found to be effective have found little evidence of habituation (McLaren et al. 1980, Agüero 1991), including one report by Amling (1980) in which the technique remained effective at excluding gulls from a reservoir for 8 years.

SUMMARY AND CONCLUSIONS

Parallel monofilament lines, spaced 180 cm apart and 21 cm over a ripening oat crop, appeared to be an effective means of protecting a crop from house sparrow damage when an alternative food source was readily available. However, in the absence of an alternative food source, lines spaced 180 or 60 cm apart and $\geq$ 50 cm over the crop were not effective. The failure of the technique was unexpected given the success of lines in preventing house sparrow use of feeding stations in winter and spring experiments. The reason for the failure is unclear but might be due to several factors including the presence of juvenile birds in the flock, the time-energy demands on adult birds, and the height of the lines above the oats. It is uncertain whether reducing the height of the lines above the crop to 21 cm caused the observed reduction in bird use of the field.

Results have highlighted research needs. The presence of house sparrows flying under the lines indicates need for tests evaluating the impact of distance between the lines and the crop, side lines, and line arrangements. Use of grids, zig-zag, or random patterns may also enhance results. Research is also needed to investigate relationships between line effectiveness over small grain crops and the availability of alternative food sources. If perceived risk is the mechanism that makes lines effective, then frightening devices that increase the perceived risk of the area may enhance results. Alternative line materials that are less prone to stretching and breakage than monofilament lines should also be considered in future experiments. With additional research, line techniques might be developed to provide an effective and socially acceptable means of protecting small grain crops from house sparrow damage.

Table 2.1. Schedule of events during a test of monofilament lines to protect oats from house sparrow damage, Lincoln, Nebraska, 1990.

Date	Events
28 June	Sparrows reported in oat fields.
1 July	Pretreatment observations of sparrow use of oats.
3-7 July	Data collection. Lines spaced 180 cm apart and 21 cm over the oats.
7 July	Lines removed, after evening data collection period.
8-10 July	Data collection. Lines removed.
12 July	Parallel lines 180 cm apart and 21 cm above the oats reinstalled.
15 July	Oats harvested but fields not disked.
31 July	Flock of approx. 300 sparrows observed in treatment plot.
1-2 August	Data collection. Oats covered by parallel lines 180 cm apart and, because heavy rains had crushed oat stalks, ≥ 50 cm above the oats.
2-3 August	Data collection. Parallel lines 60 cm apart and ≥ 50 cm above oats.
3-4 August	Data collection. Parallel lines 60 cm apart and 21 cm above oats.

Table 2.2. House sparrow use of oat fields with and without monofilament lines, Lincoln, Nebraska, 1990.

Date	Treatment: Spacing (cm)	Treatment: Distance above oats (cm)	Number of Intervals[a]	House Sparrows Counted ()[b]
1 July	Control		8	165.0
3-7 July	180	21	20	1.2
8-10 July	Control		24	238.0
1-2 Aug.	180	≥ 50	8	546.0
2-3 Aug.	60	≥ 50	8	1739.0
3-4 Aug.	60	21	12	98.0

[a] Only intervals with house sparrows foraging within 100 m of the treatment plot were included.

[b] Values reported are means across all 15-minute intervals during the dates indicated.

CHAPTER 3

BIRD RESPONSE TO LINES AT BACKYARD FEEDERS: SWITCHBACK TRIALS

BIRD RESPONSE TO LINES AT BACKYARD FEEDERS: SWITCHBACK TRIALS

House sparrows (Passer domesticus) are common but sometimes unwelcome visitors at backyard bird feeders, using food and space intended for other species of birds (Dennis 1963, 1988, Chapter 1). Studies have shown that monofilament lines spaced 30 and 60 cm apart, effectively repel house sparrows from feeding areas (Agüero et al. 1991, Chapter 1). However, lines spaced 60 cm apart around pole-mounted feeders also highly repelled blue jays (Cyanocitta cristata) and moderately repelled common grackles (Quiscalus quiscula) and northern cardinals (Cardinalis cardinalis) (Chapter 1). Although Dennis (1988) found that grackles were less popular than house sparrows, options are needed to minimize impacts on blue jays and northern cardinals.

Many people have only one feeder or wish to exclude house sparrows from all feeders. However, monofilament lines might not be as effective in the absence of an alternative food source. In all tests conducted at University of Nebraska-Lincoln, a control feeder without lines was 3-5 m from a treatment feeder (Agüero 1990, 1991; Chapter 1). Because northern cardinals and common grackles were not repelled by lines in some experiments (Chapter 1), they might not be repelled by lines when the alternative food source is removed. Additionally, a study evaluating monofilament lines as a technique to prevent house sparrow damage in oat fields indicated that the absence of a readily available food source may have caused an observed failure of lines to protect oats during some portions of the experiment (Chapter 2). Research evaluating the effectiveness of lines and wires in controlling gull and waterfowl species have also suggested that lines may not be as effective when alternative resources are limited (McLaren et al. 1984, Terry 1984).

Wire hoops without lines may provide a means of reducing house sparrow numbers without repelling other species. In a preliminary study conducted by Johnson and Eskridge (University of Nebraska-Lincoln, unpublished data), wire hoops, 80-cm in diameter, attached to the lids of pole-mounted hopper-type feeders reduced house sparrow use of the hoppers but did not appear to repel other species.

In this study, the purpose was to evaluate bird response to specific treatments when an alternative treatment was absent. Therefore, hoops with or without lines and controls were offered separately using switchback trials. The experiments were conducted in the spring and repeated in the summer to evaluate seasonal differences in response to lines because research conducted by Agüero et al. (1991) indicated that house sparrow use of feeders with lines increased during the summer.

METHODS

Data were collected simultaneously at 4 sites, the horticulture garden at the University of Nebraska-Lincoln East campus; a farmyard 7.6 km southeast of the horticulture garden; the backyard of a home in Lincoln, 3.8 km northeast of the horticulture garden; and the backyard of a home 8 km north and 1.6 km west of Milford, Nebraska. The experiments were conducted in two blocks, from 24 February to 2 April (spring) and from 18 June to 25 July (summer) 1991.

Each block consisted of an 8-day test of hoops without lines (hoop treatment) followed by an 8-day test of hoops with lines (hoop/line treatment), a 6-day rest period, and a repetition of the first 2 trials. The 6-day rest periods without treatments allowed bird use of feeders to return to pretreatment levels. At the beginning of each block, one of 2 treatment series was assigned to each site, either control-treatment-control-treatment or treatment-control-treatment-control, as described by Brandt (1938) for 4 period switchback trials. Treatments were rotated every 2 days (period) resulting in a total of 8 days for a test. Periods were limited to 2 days because a longer period with lines might have caused house sparrows to abandon the site.

Two pole-mounted hopper-type feeders, spaced 3.8 m apart, were used at each site. An 80-cm-diameter plywood tray, with a 3.8 cm outside rim and an opening in the tray center for the pole, was on the ground below each feeder (Figure 3.1). Both feeders at each site received the same treatment. During tests of the effectiveness of the hoop treatment, a hoop 80 cm in diameter, made of rigid 4.06 mm diameter (9 gauge-U.S. standard) wire, was attached to the hopper lid (Fig. 3.2). The diameter of the hoop was selected so that the lines fell about 20 cm from the feeder perches, the point where the birds would likely set their wings before landing.

Feeding stations were supplied with a mixture of 40% black oil-type sunflower seeds, 30% white proso millet, and 30% finely-cracked corn. At the beginning of each 2-day period of the experiment, hoppers were filled with 2 kg of food, and restocked as necessary to maintain an unlimited supply. Because the hoop treatment was not expected to influence bird use of trays (Johnson and Eskridge, Univ. of Nebraska-Lincoln, unpub. data.), tray food was limited during tests of hoop treatments to encourage bird use of hoppers. Fifty grams of food were added daily to the limited-food trays. At the end of each day, limited-food trays were cleaned and stocked with 50 grams of new food, thereby preventing the buildup of unconsumed food.

During tests evaluating effectiveness of the hoop/line treatments, feeders and hoops were identical to those used in tests of hoop treatments. Four 9-kg test (0.46 mm diameter), clear monofilament lines (Stren®, E.I. Du Pont De Nemours & Co., Wilmington, Del.) were installed vertically between the hoop (described above) and the rim of the tray and spaced at 60-cm intervals. Light-weight springs were attached between the lines and the tray to maintain tension on the lines. To make feeders with lines as attractive as possible to foraging birds, 1 kg of food was added to the tray at the beginning of each 2-day period and supplemented as needed to maintain an unlimited food supply. The food supply in the hopper was maintained in the same manner as in tests of hoop treatments.

Data were collected daily during 8 15-minute intervals randomly selected from the 3-hour period starting 20 minutes before sunrise. At the start of each minute of the interval, the bird species present and numbers, and their location (hopper or tray) were recorded for each feeder, starting at time zero (total of 16 observations). Birds were counted if they were located on or within the rim of the tray or on the hopper tray. Sex of cardinals and house sparrows was recorded because preliminary observations indicated that the sexes might respond differently to the lines. During summer experiments, observations of adult female and juvenile house sparrows were combined because they could not be reliably distinguished under field conditions.

Squirrels attempting to feed in the trays affected bird use of trays and biased the data, so they were immediately chased from the trays. Data collection resumed 2 minutes after the observer returned to the blind and continued until 16 observations were obtained for the interval. Two minutes allowed sufficient time for birds to resume normal feeder use.

Data were analyzed using the methods described by Brandt (1938) for 4-period switchback trials. Square roots of period totals were used in the analysis to reduce heterogeneity of the data (Snedecor and Cochran 1967). In tests of the hoop treatment, data from the hoppers and trays were analyzed separately because the effect of the hoop treatment on hopper use was not expected to be the same as the effect of hoop treatment on tray use (Johnson and Eskridge, 1989, Univ. of Nebraska-Lincoln, unpub. data). Data were not analyzed unless >50 observations (48 observations results in an average of 6 observations per day) were available. Resource availability limited the number of observation sites to 4 and resulted in a low powered test (2 degrees of freedom). Therefore, P-values ≤ 0.1 were considered significant during the switchback trials.

RESULTS

House sparrow numbers were reduced by the hoop/line treatment in all experiments (males $P \leq 0.0708$; females $P \leq 0.0808$)(Table 3.1). For males, the proportion of all observations at feeders with the hoop/line treatment, averaged across trials per season, was 4.4% (SD = 0.1) in the spring and 7.7% (SD = 1.6) in the summer. The proportion of all female observations at hoop/line treatment feeders, per trial, was 0.8% (SD = 0.2) in spring and 12.8% (SD = 2.7) in summer for females and juveniles. The increase in the proportion of females under lines during the summer may have been due to juvenile birds that were counted as females.

House sparrows were the only birds to consistently respond to the presence of hoop treatments. Male house sparrow use of hoppers with hoop treatments was reduced in all experiments ($\underline{P} \leq 0.0761$) except the first summer trial ($\underline{P} \leq 0.1027$) (Table 3.2). Numbers of female house sparrows in hoppers were reduced by the hoop treatment in the second spring trial and the first summer trial ($\underline{P} \leq 0.0383$). Male and female house sparrow numbers indicate a similar trend in the remaining trials and the lack of significance in the remaining trials might have been due to the low power of the test. As with tests of hoop/line treatment, the average proportion of all observations, per trial, at the hopper of hoop-treatment feeders, was higher during summer than during spring experiments for female house sparrows (spring 6.0%, SD = 3.2, summer 31.3%, SD = 12.2). However, the difference in the average proportion of males at hoppers with the hoop treatment was less pronounced (spring 11.4, SD = 2.4, summer 15.4, SD = 6.4).

House sparrow response to trays, when hoppers were protected by hoop treatment, differed between sexes. Female house sparrows preferred trays of feeders with hoop treatments ($\underline{P} = 0.0001$) in the first replication of the summer experiment (Table 3.2). Conversely, male house sparrows preferred trays of feeders without the hoop treatment during the second replication of the summer experiments ($\underline{P}$ = 0.0843). Neither sex exhibited a tray preference in any of the remaining experiments.

Blue jay numbers, like house sparrow numbers, were reduced by the hoop/line treatment in the summer trials ($\underline{P} \leq 0.0805$) and showed the same trend as in the spring trials (Table 3.3). As with the house sparrows, the proportion of blue jay counts under lines was higher for the summer experiments (12.6% spring, 26.9% summer). The lack of significance in the spring experiments ($\underline{P} \geq 0.2349$) may have been due to the high variability of the data, especially since the proportion of counts under lines was lower for the spring experiments than for the summer experiments.

Hoop treatments appeared to have little to no effect on blue jay feeder use. Blue jays preferred hoppers without the hoop treatment ($\underline{P}$ = 0.0011) in the second replication of the spring experiment, but the number of observations was low and there was no evidence of a feeder preference in any other test of the hoop treatment (Table 3.4).

Grackle numbers were reduced by the hoop/line treatment in two of the three experiments with sufficient grackle observations for analysis (Table 3.3). Common grackles were the only birds, aside from male house sparrows, to exhibit a preference for trays of feeders without the hoop-treatment. Grackles preferred trays of hoop treatment feeders in the second replication of the summer experiment ($\underline{P}$ = 0.0892), and data from the first replication of the summer experiment indicate the same trend (Table 3.4). There was no evidence of a common grackle preference for hoppers with the hoop treatment.

Brown-headed cowbirds (Molothrus ater) preferred hoop/line treatment feeders in the second replication of the spring experiment ($\underline{P}$ = 0.0433), but did not exhibit a feeder preference in the other 2 trials with adequate cowbird counts for analysis (P $\geq$ 0.4360) (Table 3.5). Brown-headed cowbirds preferred trays of feeders with the hoop treatment in the second replication of the summer experiment (P = 0.0289) and observations at hoppers and trays of the remaining tests of the hoop-treatment indicate a similar trend.

American goldfinches (Carduelis tristis) and dark-eyed juncos (Junco hyemalis) exhibited a feeder preference in tests of the hoop treatment (Table 3.6). American goldfinches preferred trays of feeders with the hoop treatment in the first replication of the spring experiment (P = 0.0295). While this preference may have been mathematically significant, it probably lacks biological relevance. Dark-eyed juncos preferred hoppers without the hoop treatment in the first replication of the spring experiments (P = 0.0346). There was no evidence of a feeder preference for either species in any of the remaining experiments.

When data from the 2 sexes were combined, cardinals did not exhibit a feeder preference in any of the tests of the hoop or hoop/line treatments (P $\geq$ 0.1700). Only a limited number of trials had sufficient cardinal data to analyze results from the 2 sexes separately (hoop/line treatment: 1 trial for males, 2 trials for females; hoop treatment: hoppers, 1 trial for males; trays, 1 trial for males, 1 trial for females). When sufficient data were available for analysis, neither male or female cardinals exhibited a feeder preference in test of the hoop treatment (P $\geq$ 0.2511) or in tests of the hoop/line treatment (P $\geq$ 0.3543).

There was no evidence of feeder preferences for mourning doves (Zenaida macroura), black capped chickadees (Parus atricapillus), red-headed woodpeckers

(Melanerpes erythrocephalus), red-bellied woodpeckers (Melanerpes carolinus), white-crowned sparrows (Zonotrichia leucophrys), Harris' sparrows (Zonotrichia querula), European starlings (Sturnus vulgaris) and American tree sparrows (Spizella arborea), in any test of the hoop or hoop/line treatment, but data were not available for all trials (Tables 3.7-3.9).

DISCUSSION

Monofilament lines spaced 60 cm apart around backyard feeders reduced house sparrow and blue jay numbers, even in the absence of a readily available alternative food source. This result was as expected, given that both species have been highly repelled by lines in previous tests at feeding stations (Agüero et al. 1991, Chapter 1). House sparrows were the only birds to consistently reduce hopper use when the hoop treatment was used, and, as with lines, there appeared to be a seasonal difference in house sparrow response to the hoop treatment. Reasons for house sparrow tray preferences during 1 of 4 tests of the hoop treatment for each sex remain unclear. For the spring switchback experiments, the average proportion of counts at feeders with lines (house sparrow: male 4.4%, female .8%; blue jay 12.6%) was similar to that observed for the winter and spring tests when a control feeder was present (house sparrow 2%, blue jay 12%)(Chapter 1).

The increase in house sparrow and blue jay use of feeders with lines during the summer trials supports earlier findings indicating that there may be seasonal differences in bird response to lines (McLaren et al. 1984, Agüero et al. 1991). Possible reasons for the seasonal difference in response include potentially high time-energy demands on adults during the breeding season and the presence of young birds in the flock. Several studies have shown that increases in food deprivation periods (energy requirements) result in increases in "risky" behaviors (Caraco 1980, Popp 1987, Cuthill and Guilford 1990). Summers-Smith (1963) reported an increase in the number of adult house sparrows trapped during the period from April to August (breeding season) and suggested that the time-energy demands of obtaining food for themselves and their young may cause the adult sparrows to use foraging areas that they would otherwise avoid. Alternatively, young-of-the-year may lack the experience necessary to recognize "risky" situations and enter areas avoided by adults (Summers-Smith 1983, McLaren 1984).

Northern cardinals were not expected to be repelled by lines in the absence of an alternative food source because they used feeders with lines equally or even preferred feeders with lines in some of the earlier experiments (Chapter 1). As expected, northern cardinals were not repelled by hoop or hoop-line treatments during any of the trials. Likewise, the sexes were not observed to respond differently to the lines, but there were never more than 80 observations, per sex, available for analysis.

Common grackle numbers were reduced by lines in 2 of the 3 trials with sufficient grackle observations for analysis. This response is consistent with earlier studies (Chapter 1) in which grackles exhibited less variability in response to lines than had northern cardinals (Chapter 1). However, as with the earlier studies (Chapter 1), the number of grackles passing through lines may be too high for lines to be an effective management tool, especially during the early part of the summer when grackles were not repelled by the lines. The high proportion of grackles using feeders with lines (42.59%) during the first replication of the summer experiments may be due to the large number of grackle family groups, whereby pressure to provide food for the juveniles and/or the high number of juveniles may have caused the observed decrease in response to lines. Because common grackles are single-brooded (Johnsgard 1979), pressure to feed newly fledged birds would have diminished by the second summer trial of the experiment, which would explain the grackle preference for control feeders during the second summer trial of the hoop/line treatment.

Grackle use of feeder hoppers was not influenced by the hoop treatment, but they appeared to prefer the trays of feeders without the hoop treatment during one trial. It seems unusual that the presence of the hoop treatment should directly influence tray use when grackle use of hoppers was not influenced by the hoop treatment.

Brown-headed cowbirds were the only birds to prefer feeders with the hoop/line or hoop treatment during any of the experiments. Cowbirds were often observed at the feeders at the same time as common grackle flocks and the observed feeder preference may relate to interactions between the two species. Common grackles tended to prefer control feeders during tests of hoop/line treatment and control trays during tests of the hoop treatment.

Reasons for the erratic feeder preferences of blue jays and dark-eyed juncos in tests of the hoop treatment remain unclear but may be related, in some instances, to low numbers of observations, interactions among species, or some other factor not measured during the experiment. Although statistically significant, the similarity between the total number of counts for the two treatments makes biological significance of the finding questionable.

Use of the hoop/line or hoop treatment will provide bird feeding enthusiasts with easy, inexpensive and environmentally appealing options for manipulating bird species use of feeding stations. Previously, the only disadvantages of the technique was the impact of lines on northern cardinal and blue jay use of the feeders. However, data from this experiment indicate that in the absence of a readily available alternative, cardinals will use feeders with lines. Hoops without lines may be used to repel house sparrows without repelling northern cardinals or blue jays.

SUMMARY AND CONCLUSIONS

Monofilament lines spaced 60 cm apart around backyard feeders were an effective means of reducing house sparrow and blue jay numbers in the absence of adjacent feeders without lines. Time-energy demands of reproduction and/or the presence of juvenile birds appeared to increase house sparrow, blue jay, and common grackle use of feeders with lines during the summer experiments. The increase in grackle use of feeders with lines during the period when juveniles were begging from adults may make lines an ineffective grackle management tool for the period immediately after fledging. Northern cardinals, a species found to be moderately repelled by lines in earlier studies, were not repelled by lines in the absence of a readily available alternative food source. Nine other species were not repelled by lines.

House sparrows were the only birds that consistently responded to the hoop treatment. Common grackles, brown-headed cowbirds, blue jays, and dark-eyed juncos showed a feeder preference during 1 replication each of tests with the hoop treatment, but reasons for the preferences remain unclear.

Use of lines or hoops will provide feeder owners with options for managing bird populations at their feeding stations. However, further research is needed to understand feeder preferences for those species exhibiting inconsistent feeder preferences.

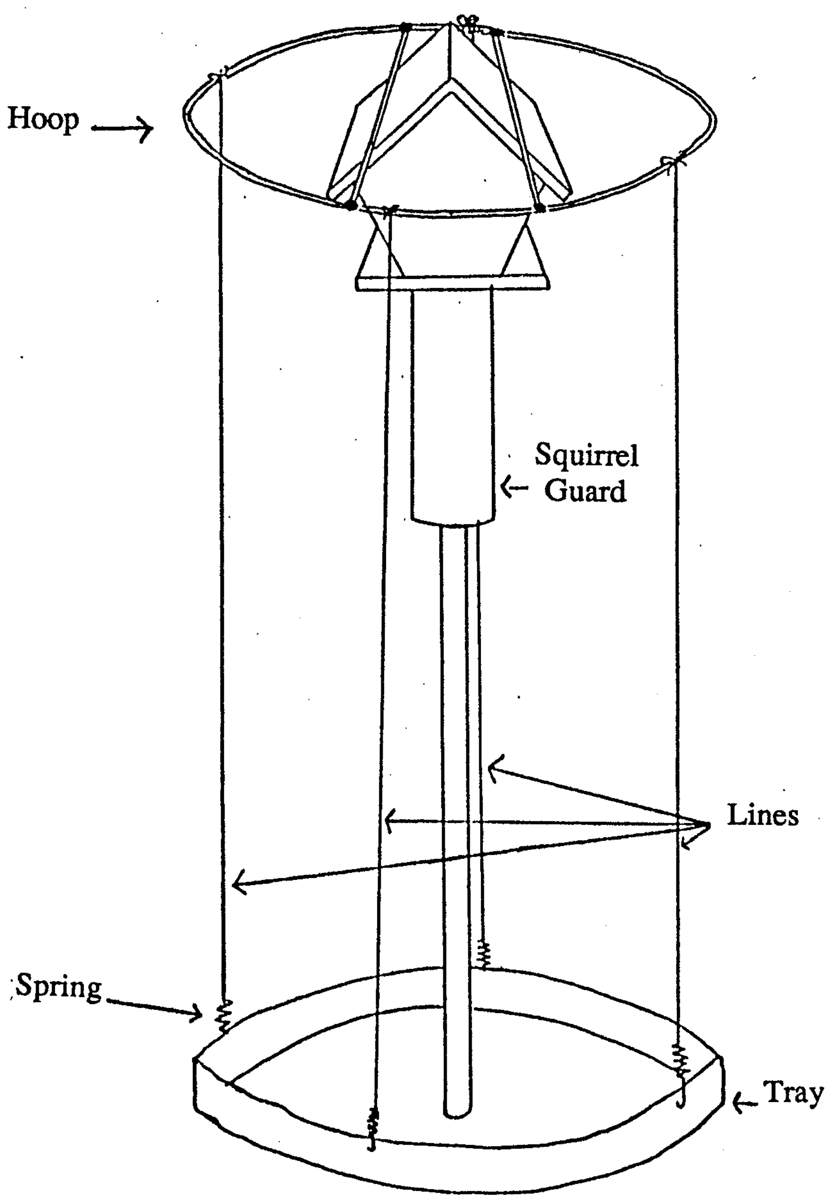

Fig. 3.1. Diagram of pole-mounted hopper-type feeder with hoop/line treatment.

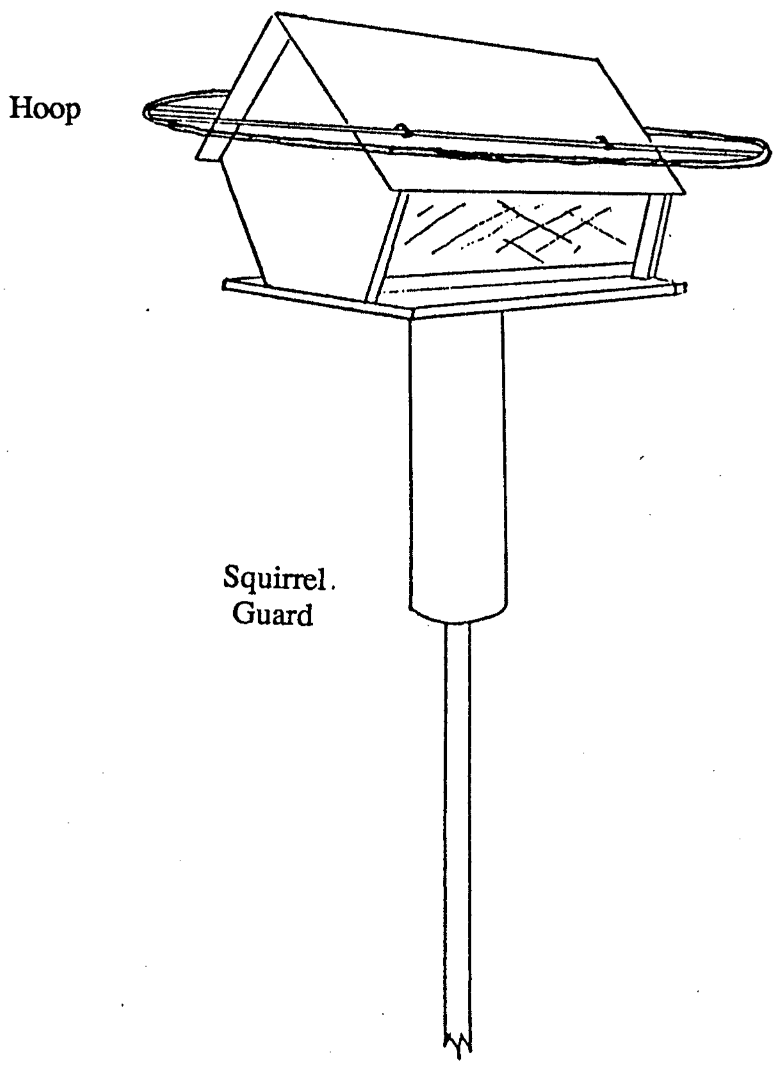

Fig. 3.2 Diagram of hopper with hoop treatment for pole-mounted hopper-type feeder.

Table 3.1. Total house sparrow numbers at pole-mounted feeders in no-choice (switchback) trials, 4 sites combined: tests of hoop/line treatment, Lincoln, Nebraska, 1991.

		Spring[a]		Summer[b]	
Sex	Treatment	Trial 1	Trial 2	Trial 1	Trial 2
Male					
	Control	519	759	886	901
	Hoop/Line	24	34	86	64
	P-value[c]	0.0708	0.0149	0.0655	0.0272
Female	(Count includes juveniles during summer trials.)				
	Control	332	318	2114	3719
	Hoop/Line	2	3	366	456
	P-value[c]	0.0043	0.0132	0.0808	0.0250

[a] Spring, trial 1: 4-11 March; trial 2: 26 March-2 April.

[b] Summer, trial 1: 27 June-3 July; trial 2: 18-25 July.

[c] P-values obtained by using a test for 4-period switchback trials on square root transformations of the totals for each period. (Brandt 1938).

Table 3.2. Total house sparrow numbers, 4 sites combined, at pole-mounted feeders in no-choice (switchback) trials: tests of hoop treatment1, Lincoln, Nebraska, 1991.

		Spring[a]				Summer[b]			
		Trial 1		Trial 2		Trial 1		Trial 2	
Sex	Treatment	Hopper	Tray	Hopper	Tray	Hopper	Tray	Hopper	Tray
Male	Control	584	306	485	407	582	790	746	841
	Hoop	85	372	54	472	71	746	185	631
	P-value[c]	0.0630	0.6028	0.0555	0.8948	0.1027	0.6786	0.0761	0.0843
Female	Control	355	293	356	275	1156	2540	1478	4319
	Hoop	14	271	32	239	339	3198	982	4447
	P-value[c]	0.1796	0.9723	0.0357	0.3916	0.0383	0.0001	0.3206	0.2235

[a] Spring, trial 1: 24 February-3 March; trial 2: 18-26 March.
[b] Summer, trial 1: 19-27 June; trial 2: 10-18 July.
[c] P-values were obtained using a test for 4-period switchback trials on square root transformations of totals from each period (Brandt 1938).

Table 3.3. Total common grackle and blue jay numbers at pole-mounted feeders in no-choice (switchback) trials, 4 sites combined: tests of hoop/line treatment, Lincoln, Nebraska, 1991.

Species	Treatment	Spring[a]		Summer[b]	
		Rep. 1	Rep. 2	Rep. 1	Rep. 2
Blue Jay					
	Control	70	230	294	4720
	Hoop/Line	11	30	76	520
	P-value[c]	0.3329	0.2349	0.0805	0.0181
Common Grackle					
	Control	---	955	5176	4720
	Hoop/Line	---	488	3840	520
	P-value[c]	---	0.0084	0.1659	0.0181

[a] Spring, trial 1: 4-11 March; trial 2: 26 March-2 April.

[b] Summer, trial 1: 27 June-3 July; trial 2: 18-25 July.

--- Data not analyzed because <50 observations were available.

[c] P-values obtained by using a test for 4-period switchback trials on square root transformations of the totals for each period. (Brandt 1938).

Table 3.4. Total common grackle and blue jay numbers, 4 sites combined, at pole-mounted hopper-type feeders in no-choice (switchback) trials: tests of hoops without lines, Lincoln, Nebraska, 1991.

Species	Spring[a]				Summer[b]			
	Trial 1		Trial 2		Trial 1		Trial 2	
Treatment	Hopper	Tray	Hopper	Tray	Hopper	Tray	Hopper	Tray
Common grackle								
Control	---	---	271	96	1828	1592	2309	1240
Hoop	---	---	237	86	1558	767	2379	1353
P-value[c]	---	---	0.2901	0.0892	0.2901	0.2808	0.1705	0.3126
Blue jay								
Control	147	15	34	51	37	64	245	525
Hoop	129	42	18	26	42	130	273	407
P-value[c]	0.4859	0.1376	0.0011	0.7524	0.9659	0.9020	0.3675	0.4084

[a] Spring, trial 1: 24 February-3 March; trial 2: 18-26 March.

[b] Summer, trial 1: 19-27 June; trial 2: 10-18 July.

--- Data not analyzed because <50 observations were available.

[c] P-values were obtained using a test for 4-period switchback trials on square root transformations of period totals (Brandt 1938).

Table 3.5. Total brown-headed cowbird numbers, 4 sites combined, at pole-mounted feeders in no-choice (switchback) trials: tests of hoop and hoop-line treatments, Lincoln, Nebraska, 1991.

Test Treatment	Spring[a] Trial 1	Spring[a] Trial 2	Summer[b] Trial 1	Summer[b] Trial 2
Hoop-lines (Tray and hopper observations combined)				
Control	---	34	688	2352
Hoop/Line	---	99	548	1966
P-value[c]	---	0.0433	0.9358	0.4360
Hoops (Hopper observations)				
Control	---	---	61	83
Hoop	---	---	80	111
P-value[c]	---	---	0.6124	0.8138
Hoops (Tray observations)				
Control	---	---	143	969
Hoop	---	---	258	1237
P-value[c]	---	---	0.8458	0.0289

[a] Spring, trial 1: 24 February-3 March; trial 2: 18-26 March.

[b] Summer, trial 1: 19-27 June; trial 2: 10-18 July.

--- Data not analyzed because <50 observations were available.

[c] P-values obtained by using a test for 4-period switchback trials on square root transformations of totals from each period (Brandt 1938).

Table 3.6. Total American goldfinch and dark-eyed junco numbers, 4 sites combined, at pole-mounted feeders in no-choice (switchback) trials: tests of hoop treatment, Lincoln, Nebraska, 1991.

Species	Spring[a]				Summer[b]			
	Trial 1		Trial 2		Trial 1		Trial 2	
Treatment	Hopper	Tray	Hopper	Tray	Hopper	Tray	Hopper	Tray
American goldfinch								
Control	537	376	176	100	---	---	---	---
Hoop	671	388	349	143	---	---	---	---
P-value[c]	0.6866	0.0295	0.3968	0.4226	---	---	---	---
Dark-eyed junco								
Control	286	878	26	670	---	---	---	---
Hoop	113	629	32	751	---	---	---	---
P-value[c]	0.0346	0.5616	0.4439	0.4021	---	---	---	---

[a] Spring, trial 1: 24 February-3 March; trial 2: 18-26 March.
[b] Summer, trial 1: 19-27 June; trial 2: 10-18 July.
--- Data not analyzed because <50 observations were available.
[c] P-values obtained using a test for 4-period switchback trials on the square root transformations of totals from each period (Brandt 1938).

Table 3.7. Total numbers counted for species without treatment preferences at pole-mounted feeders, 4 sites combined: tests of hoop/line treatment, Lincoln, Nebraska, 1991.

Species	Treatment	Spring[a]		Summer[b]	
		Trial 1	Trial 2	Trial 1	Trial 2
Northern cardinal					
	Control	59	26	40	46
	Hoop/Line	54	25	19	47
	P-value[c]	0.4125	0.2437	0.1700	0.4783
American goldfinch					
	Control	36	633	---	---
	Hoop/Line	42	826	---	---
	P-value[c]	0.9498	0.1757	---	---
Black-capped chickadee					
	Control	143	103	47	---
	Hoop/Line	172	188	93	---
	P-value[c]	0.1577	0.3730	0.2417	---
Red-headed woodpecker					
	Control	---	---	---	70
	Hoop/Line	---	---	---	54
	P-value[c]	---	---	---	0.6663
Red-bellied woodpecker					
	Control	81	59	---	---
	Hoop/Line	68	63	---	---
	P-value[c]	0.4226	0.4226	---	---
Dark-eyed junco					
	Control	1227	710	---	---
	Hoop/Line	923	679	---	---
	P-value[c]	0.3189	0.4960	---	---

Table 3.7. (cont.)

Species	Treatment	Spring[a] Trial 1	Spring[a] Trial 2	Summer[b] Trial 1	Summer[b] Trial 2
Mourning Dove					
	Control	22	58	220	488
	Hoop/Line	91	31	184	449
	P-value[c]	0.3438	0.2929	0.7779	0.2059
Harris' sparrow					
	Control	36	633	---	---
	Hoop/Line	42	826	---	---
	P-value[c]	0.9498	0.1757	---	---
White-crowned sparrow					
	Control	---	43	---	---
	Hoop/Line	---	43	---	---
	P-value[c]	---	0.4226	---	---

[a] Spring, trial 1: 4-11 March; trial 2: 26 March-2 April.

[b] Summer, trial 1, 27 June-3 July; trial 2: 18-25 July.

--- Data not analyzed because <50 observations were available.

[c] P-values obtained by using a test for 4-period switchback trials on square root transformations of the totals from each period (Brandt 1938).

Table 3.8. Total numbers in hoppers, 4 sites combined, for species without treatment preferences at pole-mounted feeders in no-choice (switchback) trials: tests of hoop treatment, Lincoln, Nebraska, 1991.

		Hopper Observations			
		Spring[a]		Summer[b]	
Species	Treatment	Trial 1	Trial 2	Trial 1	Trial 2
Northern cardinal					
	Control	83	---	---	---
	Hoop	41	---	---	---
	P-value[c]	.6239	---	---	---
European starling					
	Control	16	---	---	---
	Hoops	42	---	---	---
	P-value[c]	.5613	---	---	---
Red-bellied woodpecker					
	Control	39	50	---	---
	Hoops	43	38	---	---
	P-value[c]	.6667	.4226	---	---
Red-headed woodpecker					
	Control	---	---	---	29
	Hoops	---	---	---	26
	P-value[c]	---	---	---	.1541
Black-capped chickadee					
	Control	80	101	---	---
	Hoops	134	124	---	---
	P-value[c]	.7144	.2882	---	---

[a] Spring, trial 1: 24 February-3 March; trial 2: 18-26 March.
[b] Summer, trial 1: 19-27 June; trial 2: 10-18 July
[c] P-values obtained by using a test for 4-period switchback trials on square root transformations of the totals from each period (Brandt 1938).

Table 3.9. Total numbers in trays, 4 sites combined, for species without a treatment preference at pole-mounted feeders in no-choice (switchback) trials: tests of hoop treatment, Lincoln, Nebraska, 1991.

		Tray Observations			
		Spring[a]		Summer[b]	
Species	Treatment	Trial 1	Trial 2	Trial 1	Trial 2
Mourning dove					
	Control	31	---	136	331
	Hoops	36	---	105	437
	P-value[c]	.6032	---	.7932	.9110
Harris' sparrow					
	Control	190	319	---	---
	Hoops	120	321	---	---
	P-value[c]	.4655	.6181	---	---
American tree sparrow					
	Control	---	43	---	---
	Hoops	---	28	---	---
	P-value[c]	---	.4226	---	---
Northern cardinal					
	Control	69	26	18	34
	Hoops	45	32	25	41
	P-value[c]	.4466	.5285	.6216	.9379

[a] Spring, trial 1: 24 February-3 March; trial 2: 18-26 March.

[b] Summer, trial 1: 19-27 June; trial 2: 10-18 July.

--- Data not analyzed because <50 observations were available.

[c] P-values obtained by using a test for 4-period switchback trials on square root transformations of the totals from each period (Brandt 1938).

FINAL COMMENTS

Why are widely spaced lines and wires an effective management tool for some species? Although the results from this study fail to provide an answer, they have narrowed the range of possibilities and indicated areas for future research.

Although all trials at feeding stations (Agüero et al 1991, Chapters 1,3) have found house sparrows to be highly repelled by lines, research conducted by Pochop (1991) indicated that lines were not effective in excluding house sparrows from nest boxes. The difference in response in different situations may be attributable to the mechanism that makes lines effective. The two sites differ in that the risk of predation is high at foraging sites, but, for the-cavity nesting house sparrow, relatively low at nests sites. The ability to escape rapidly in any direction may be a critical factor in foraging site selection, and house sparrows may perceive the difficult-to-see lines as a barrier to rapid escape. However, the need for rapid escape may not be as high at nest boxes, thereby reducing the perceived risk of entering a nest surrounded by lines. Data on the response of birds to lines at feeding and nesting sites are available for only one other species. Blokpoel and Tessier (1983,1984) reported that lines and wires excluded ring-billed gulls from feeding areas and traditional nesting areas. This response is as predicted because the gulls feed and nest in open areas where the need for rapid escape is expected to be high.

Laboratory studies have shown that increases in food deprivation periods usually result in increased "risky" behavior (Caraco et al. 1980, Popp 1987, Cuthill and Guilford 1990). The increase in risk-prone behaviors when time-energy budgets are strained may explain the increase in house sparrows, blue jays, and common grackles at feeders with lines during the summer experiments (Agüero 1991, Chapter 3). Summers-Smith (1963) observed a similar seasonal increase both in adult mortality and in the number of adults caught in baited traps. He suggests that the high energy demands of reproduction may cause adults to forage in areas they would otherwise avoid. A similar mechanism may operate for the blue jays and common grackles (Chapter 3).

In several tests of monofilament lines, juvenile birds were found in higher proportions under the lines than in the population as a whole (Blokpoel and Tessier 1984, McLaren 1984, Agüero 1990). Young birds may lack the experience necessary to recognize "risky" environments and therefore enter areas avoided by adults (Agüero 1990, Summers-Smith 1963).

Even if birds are repelled because they perceive lines as a barrier to escape from predation, the question of the species-specific nature of the response remains. Why should some species be more sensitive to the risk associated with the lines than others. House sparrows have been described as being especially wary, and more easily startled than other species of birds (Summers-Smith 1963, Dennis 1978). After centuries of close association with humans, and human things, natural selection may have favored house sparrows that are more alert and wary of unusual situations. It seems reasonable that birds with brighter coloration might also be at greater risk of predation than birds with cryptic coloration, and therefore more sensitive to obstacles that might interfere with escape from predators. This might explain why northern cardinals and blue jays respond to lines, but does not explain why blue jays consistently avoid lines while northern cardinals vary line response. It also fails to explain the common grackle response to lines.

Several other factors may also contribute to the species-specific effectiveness of monofilament lines. These factors include the relationship between wingspan and line spacing or pattern, flocking behavior, preferred habitat, physiology, and diet.

Several authors suggest that the relationship between wingspan and the distance between lines may be the factor that makes lines effective, but the data from the feeding stations provide little evidence to support this theory. Eleven species with wingspans larger than a house sparrow were observed in sufficient numbers for data analysis. Eight of these species were not repelled by lines. Red-headed woodpeckers, red-bellied woodpeckers and mourning doves were not repelled by lines, but all have wingspans greater than common grackles, the largest species to be repelled by lines at backyard feeders. However, there will be spacings that are too narrow for a bird to enter, and there should also be a similar upper limit to the line spacing, beyond which lines lose their repelling effect.

Species that form foraging flocks may be more likely to perceive lines as a risk. When startled from a foraging area with lines, an individual would have to avoid conspecifics in addition to the lines. This would explain the response of house sparrows and common grackles, most gulls, canada geese and brant, but fails to explain the response of blue jays and northern cardinals (Pochop et al. 1990).

Additionally, brown headed cowbirds, Harris' sparrows and dark-eyed juncos were also observed foraging in groups, but these species were not repelled by lines.

Preferred habitat may influence a species perception of the risk presented by lines. A woodland species would be adapted to a physically complex environment, and might be less likely to perceive monofilament lines as a barrier to escape. The list of large birds not repelled by lines does include several woodpecker species (Appendix B). However, blue jays and northern cardinals are also woodland species and should be accustomed to physically complex environments, yet both species are repelled by lines. Preferred habitat also fails to explain why ring-billed gulls, greater black-backed gulls, and herring gulls are repelled by lines but laughing gulls, which use similar habitats, are not repelled by lines (Dolbeer 1988).

Clements (1990) suggests that species-specific differences in response to perceived risk may be related to the range of food types used by a species. A species using a wide variety of food types like a house sparrow, blue jay, or common grackle, would be less inclined to engage in "risky" behaviors to obtain food because of the wide variety of alternatives available. Northern cardinals have a narrower range of foods to chose from and would be expected to use feeders with lines more than the other three species. This would explain the lack of cardinal response to lines during the no-choice (switchback) trial. However, European starlings also use a wide variety of food types but were not repelled by lines around backyard feeders.

While not directly addressed by this study, there may be physiological differences in a bird species' ability to perceive lines. House sparrows apparently have difficulties with the discrimination of colors at the red end of the spectrum, a pattern opposite of that for most other diurnal species of birds (Summers-Smith 1963).

The real basis for the differences among species in response to lines may be a combination of the factors mentioned above. For example, common grackles may perceive lines as a risk because of a combination of large wingspan, the presence of conspecifics, and the fact that they do not spend large amounts of time foraging in physically complex environments.

If reasons for the species-specific effectiveness of lines are understood, then current applications of lines as a management tool can be refined and new applications developed. Research evaluating bird response to lines in a variety of situations, e.g. nesting, roosting and foraging, is needed. Laboratory research may permit evaluation of the impact of each of the factors mentioned above because environmental and treatment variables can be controlled (e.g. food availability, temperature, and interactions among species). However, if birds respond to lines because of perceived risk, then they may respond differently to lines in a predator-free laboratory environment. Many birds avoid lines without any prior negative experience with the lines. Research evaluating the development acquisition of risk perception may also be beneficial.

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APPENDIX A

INTRODUCTION

This preliminary experiment used 2 feeders at 2 sites to evaluate research design and data collection techniques prior to the experiments described in Chapter 1. Findings allowed refinement of the technique to better meet the objective of evaluating the impact of tray food availability and species interactions on bird response to feeders with lines.

METHODS

The experiment was conducted from 1 November to 3 December 1990. Data were collected simultaneously at two sites, the horticulture garden at the University of Nebraska-Lincoln East campus, and the backyard of a home in Lincoln, Nebraska approximately 5 km from the garden site.

Two pole-mounted hopper-type feeders, spaced 1.8 m apart, were used at each site, one control feeder and one feeder with lines. An 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 with lines had a 9 gauge (U.S. standard) wire hoop 80 cm in diameter attached to the feeder top (Fig. 1). The diameter of the hoop was selected so that the lines fell at the point where the birds would likely set their wings before landing. Four 9-kg test 0.46 mm diameter monofilament lines (Stren®, E.I. Du Pont De Nemours & Co., Wilmington, Del.) were installed vertically between the hoop and the rim of the tray and spaced at 60-cm intervals. Light-weight springs were attached between the lines and the tray to maintain tension on the lines.

The experiment consisted of a 3-day pretreatment period, followed by 4 3-day treatment periods. Pretreatment periods were used to evaluate bird use of feeders before line installation. Treatments were randomly assigned to feeders at the beginning of the first treatment period and rotated between feeders at each site at the beginning of each subsequent period.

Data were collected daily during 4 15-minute intervals randomly selected from the 3-hour period starting 20 minutes before sunrise. During each interval, the bird species present, number, feeder, and location (hopper or tray) were recorded each minute, starting at time zero (16 observations total). Squirrels feeding in the trays would reduce bird use of trays and bias data, so squirrels were immediately chased from the trays. Data collection resumed 2 minutes after the observer returned to the blind and continued until 16 observations were obtained for the interval. Two minutes allowed sufficient time for the birds to resume feeder use.

Feeding stations were baited with a mixture of 50% black oil-type sunflower seeds, 30% white proso millet, and 20% finely-cracked corn. At the beginning of each period of the experiment, hoppers were filled with 2 kg of food and the trays with 1 kg of food, and restocked as necessary to maintain an unlimited food supply.

RESULTS AND DISCUSSION

Higher numbers of house sparrows, common grackles, European starlings and blue jays were observed at feeders without lines, while higher numbers of Harris sparrows, dark-eyed juncos and black-capped chickadees were observed at feeders with lines (Table A.1). Brown-headed cowbird and northern cardinal numbers were approximately equal at the two sites.

High feeder usage by grackles appeared to exclude other species from the feeding stations. To increase the feeding space available for other species, 2 more feeders were added to each site for experiments in chapter 1. In addition, the distance between feeders was increased from 1.8 m to 3.8 m for subsequent experiments because the presence of some species, especially blue jays and grackles, at one feeder appeared to affect other species use of the adjacent feeder.

Total house sparrows counted at the house site (38) were low compared to the garden site (760). Therefore, to make the feeders more attractive to house sparrows, the proportion of corn in the feed mixture was increased. The feed mixture used for subsequent experiments contained 30% finely cracked corn, 30% white-proso millet and 40% black oil-type sunflowers.

Table A.1. Total number of birds, 2 sites combined, at pole-mounted hopper-type feeders with (lines) and without (control) monofilament lines spaced 60 cm apart, Lincoln, Nebraska, 1989.

Species	Control	Lines
House Sparrow	796	2
Common Grackle	971	250
European Starling	286	137
Blue Jay	129	39
Harris Sparrow	108	185
Dark-Eyed Junco	236	287
Black-Capped Chickadee	55	81
Northern Cardinal	53	66
Brown-Headed Cowbirds	147	154

APPENDIX B

Table B.1. Wingspans of bird species observed at pole-mounted hopper-type feeders in tests of bird response to hoops with or without monofilament lines, Lincoln, Nebraska, 1989-91.

Species	Wingspan (cm)[a]
Northern Flicker (Colaptes auratus)	50-54
Mourning Dove (Zenaida macroura)	43-48
Common Grackle (Quiscalus quiscula)	43-46
Red-Headed Woodpecker (Melanerpes erythrocephalus)	41-46
Red-Bellied Woodpecker (Melanerpes carolinus)	40-44
Blue Jay (Cyanocitta cristata)	39-44
European Starling (Sturnus vulgaris)	39
Hairy Woodpecker (Picoides villosus)	37-43
American Robin (Turdus migratorius)	37-41
Brown Thrasher (Toxostoma rufum)	31-37
Wood Thrush (Hylocichla mustelina)	33-35
Red-Winged Blackbird (Agelaius phoeniceus)	30-36
Brown-Headed Cowbird (Molothrus ater)	29-34
Downy Woodpecker (Picoides pubescens)	26-32
Northern Cardinal (Cardinalis cardinalis)	26-30
Harris' Sparrow (Zonotrichia querula)	25-29
White-Crowned sparrow (Zonotrichia leucophrys)	24-25
White-Breasted Nuthatch (Sitta carolinensis)	23-29
Purple Finch (Carpodacus purpureus)	23-26
House Sparrow (Passer domesticus)	23-24
Dark-Eyed Junco (Junco hyemalis)	23-25
White-Throated Sparrow (Zonotrichia albicollis)	22-24
American Tree Sparrow (Spizella arborea)	21-24

Table B.1. (cont.)

Species	Wingspan
Pine Siskin (Carduelis pinus)	21-23
American Goldfinch (Carduelis tristis)	20-22
Red-Breasted nuthatch (Sitta canadensis)	20-21
Field Sparrow (Spizella pusilla)	20-21
Grasshopper Sparrow (Ammodramus savannarum)	20-20
Black-Capped Chickadee (Parus atricapillus)	19-21

[a] Data from Roberts (1974).

APPENDIX C

Table C.1. Bird species with < 50 observations per trial at pole-mounted hopper-type feeders that were control (C) or monofilament line (L) treated, with either unlimited (+) or limited (-) food in the trays below the hoppers, 2 sites combined (Chapter 1), Lincoln, Nebraska, 1989-90.

		Experiment					
		C+L+		C-L+		C+L-	
Season	Species	Control	Lines	Control	Lines	Control	Lines
Winter	White-breasted nuthatch	12	12	---	---	---	---
	Red-breasted nuthatch	2	8	---	---	---	---
	Northern flicker	1	8	5	5	5	0
	Red-winged blackbird	0	1	---	---	---	---
	Purple finch	0	1	0	11	2	2
	Hairy woodpecker	---	---	---	---	5	0
Spring	Red-winged blackbird	---	---	---	---	1	0
	Purple finch	0	2	0	32	0	1
	Hairy woodpecker	---	---	---	---	1	2
	American robin	1	2	---	---	0	7
	Red-breasted nuthatch	---	---	---	---	1	6
	Wood thrush	---	---	0	1	0	1

Table C.2. Total numbers, 4 sites and 2 trials per season combined, at pole-mounted hopper-type feeders for species with < 50 observations per trial in no-choice (switchback) experiments: tests of hoops with lines, (Chapter 3), Lincoln, Nebraska, 1991.

	Spring		Summer	
Species	Control	Hoop/Lines	Control	Hoop/Lines
Brown thrasher	---	---	17	8
House finch	18	24	28	43
White-breasted nuthatch	15	33	12	27
Downy Woodpecker	23	10	3	7
Northern flicker	13	8	---	---
American Robin	---	---	0	1
Red-winged blackbird	17	20	20	12
American tree sparrow	3	18	---	---
Field sparrow	20	21	---	---
White-crowned sparrow	56	67	---	---
Pine siskin	6	0	---	---

Table C.3. Total numbers, 4 sites and 2 trials per season combined, at pole-mounted hopper-type feeders for species with < 50 observations per trial in no-choice (switchback) experiments: tests of hoops without lines, (Chapter 3), Lincoln, Nebraska, 1991.

	Spring		Summer	
	Control	Hoop	Control	Hoop
Species	Hopper/tray	Hopper/tray	Hopper/tray	Hopper/tray
Carolina wren	---	---	0/0	0/1
Brown thrasher	2/0	1/0	0/5	0/6
House finch	9/3	5/0	0/0	16/0
Red-headed woodpecker	*/0	*/0	*/26	*/6
Red-bellied woodpecker	*/8	*/7	*/0	*/0
Downy Woodpecker	/0	/1	2/0	6/0
Northern flicker	4/6	0/1	0/0	0/1
European starling	*/2	*/3	*/0	*/0
Red-winged blackbird	12/0	17/0	0/17	0/14
White-breasted nuthatch	30/0	32/1	18/0	17/0
Black-capped chickadee	*/16	*/20	*/0	*/4
Rufous-sided towhee	0/0	1/0	---	---
Harris' sparrow	36/*	20/*	---	---
Field sparrow	0/10	0/0	---	---

* > 50 observations available, therefore data is discussed in Chapter 3.

Table C.3. (cont.) Total numbers, 4 sites and 2 trials per season combined, at pole-mounted hopper-type feeders for species with < 50 observations per trial in no-choice (switchback) experiments: tests of hoops without lines, (Chapter 3), Lincoln, Nebraska, 1991.

	Spring		Summer	
	Control	Hoop	Control	Hoop
Species	Hopper/tray	Hopper/tray	Hopper/tray	Hopper/tray
Grasshopper sparrow	0/3	0/0	---	---
White-crowned sparrow	0/62	0/19	---	---
White-throated sparrow	0/1	0/0	---	---