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# Evaluation of mirrors to deter nesting starlings

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# Evaluation of mirrors to deter nesting starlings

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**Abstract** European starlings (*Sturnus vulgaris*) nesting in buildings and other structures can cause health, nuisance, and safety problems. We evaluated effectiveness of flashing lights combined with mirrors, and mirrors alone, as deterrents for starlings nesting in starling nest boxes in northern Ohio, 1998–2000. Each year, 100 nest boxes attached to utility poles were randomly assigned equally among 4 treatments (including untreated boxes): 1998—mirrored (internally placed on the back and 2 side walls of nest boxes), mirrored with red-flashing lights, and mirrored with green-flashing lights; 1999—convex mirror above entrance hole, convex mirror at back of nest box, and flat mirror at back of nest box; 2000—mirrors on 3 sides with exposed surface areas of 263 $cm^2$, 527 $cm^2$, or 790 $cm^2$. Starlings nested in 67% (1998) and 78% (1999 and 2000) of the nest boxes. In 1998, boxes within the 3 treatments with mirrors, regardless of lights, had fewer nests and fewer nests with eggs, nestlings, or fledglings than did control boxes ($P \leq 0.002$). Boxes with mirrors and lights had fewer ($P<0.05$) nestlings than mirrored boxes. No difference was noted in number of fledglings produced/nest with nestlings for each treatment. In 1999 and 2000 there was no difference ($P>0.25$) among the 4 treatments in proportion of nest boxes with starling nests, eggs, nestlings, and young fledged. However, in 2000, boxes with complete mirror coverage did show the lowest occupancy rate of the 4 treatments. Mean dates of first egg, clutch size, number of nestlings, and number of fledglings/nest also were similar ($P>$ 0.06) among treatments. We conclude that mirrors, although slightly repellent under some configurations, are not a practical method to repel starlings from nesting in structures.

**Key words** deterrent, European starling, mirror, nest box, *Sturnus vulgaris*

European starlings (*Sturnus vulgaris*) that nest and roost in urban areas can cause health, nuisance, and safety problems (Weber 1979, Feare 1984, Godin 1994, Johnson and Glahn 1994). Killing nuisance birds is often undesirable, infeasible, or biologically unsound (Dolbeer 1998); therefore, a demand exists for effective, nonlethal means to deter birds from problem sites. For starlings, these nonlethal means often involve excluding adults from undesirable nest sites such as the interior of electric signs, exposed corners of buildings, or airplane hangars. Many visual, auditory, and chemical devices are marketed as bird deterrents; however, few have been evaluated quantitatively. Often, quantitative evaluations show such devices to be ineffective (Dolbeer et al. 1988; Bomford and O'Brian 1990; Belant et al. 1997, 1998).

Various types of lights (strobe, flashing, revolving, and search) have been used in attempts to deter birds at feeding, loafing, and roosting sites (Krzysik 1987, Koski et al. 1993). For example, strobes and searchlights have been used to deter birds from airfields, with mixed levels of success (Larkin et al. 1975, Lawrence et al. 1975). However,

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Belant et al. (1997) tested flashing lights in starling nest boxes and found them ineffective at deterring starlings from nesting in the boxes. Various light-emitting devices are recommended as short-term deterrents for night-feeding bird predators at aquaculture facilities (Parkhurst et al. 1987, Salmon et al. 1986).

Currently, products using mirrors (e.g., "Peaceful Pyramid" distributed by Bacton Wood Mill Farm, Edingthorpe, North Walsham, Norfolk, United Kingdom) and strobe lights (e.g., "Bird-Lite" distributed by BIRD-X, Incorporated, Chicago, Ill.) are sold to deter birds in agricultural fields and dimly lit buildings, respectively. Mirrors did depress feeding by black-capped chickadees (*Parus atricapillus*) at feeding stations (Censky and Ficken 1982), but we were unaware of published studies that evaluated the effectiveness of mirrors alone or mirrors combined with flashing lights to deter starlings and other birds from buildings or at nest sites. We evaluated efficacy of flashing lights combined with mirrors, and mirrors alone, in various configurations to deter starlings from nesting in starling nest boxes. If mirrors and lighting in nest boxes were effective to discourage nesting by starlings, we could then explore methods to deploy these devices in hangers and other sites where starling nesting is a problem.

## Methods

We conducted 3 experiments, one each in 1998, 1999, and 2000. We used 100 starling nest boxes (28 × 13 × 17 cm) with removable roofs (Dolbeer et al. 1988) attached to utility poles at the 2,200-ha National Aeronautic and Space Administration (NASA) Plum Brook Station, Erie County, Ohio. Nest boxes were ≥240 m apart and their entrances were covered until the day of treatment in each year (23 April 1998, 26 April 1999, 3 May 2000). For each experiment, we randomly assigned 25 boxes to each of 4 treatments.

We evaluated 4 treatments in 1998: non-mirrored (control), mirrored (internally placed on the back and 2 side walls of nest boxes), mirrored with red-flashing lights, and mirrored with green-flashing lights. Clear mirrors (0.7 cm thick) were cut by a local manufacturer to completely cover the inside walls of nest boxes (25.4 × 12.7 cm and 11.4 × 12.7 cm, for sides and back, respectively; total mirrored surface area = 790 cm$^2$). Red- and green-flashing lights (8.5-cm length, 3.0-cm height, 5.5-cm width; Bell Sports Inc., Rantoul, Ill.) contained 5 5-mm-diameter LEDs (bulbs) with a luminosity of 2 candelas, with each LED spaced 0.5 cm apart in a row. The LEDs flashed in unison at 6-8 Hz. Red-flashing lights contained LEDs that flashed red and had a translucent red plastic lens; green-flashing lights contained LEDs that flashed green and had a translucent clear plastic lens. Control boxes contained inoperable lights with clear lenses that were placed in the same position as flashing lights in treated boxes. Belant et al. (1997) found that operating and inoperable lights did not affect use of boxes by starlings. Therefore, we concluded that presence of an inoperable light would not affect birds while maintaining the same interior shape and dimensions in all boxes.

Mirrors covered the entire wall on the back and 2 side walls inside each box for mirrored treatments and were secured with double-sided tape. One light (red- or green-flashing) was positioned immediately above the entrance hole on the inside of each box for treatments receiving lights. Lights were secured with a 7.5-cm × 2-cm strip of Velcro™. Light flashes, which reflected off each mirror, appeared intense to human eyes in the confines of the nest boxes.

In 1999, the same 100 nest boxes were randomly assigned as nonmirrored (control), convex mirror above entrance hole at a 45° angle to the hole, convex mirror at back of nest box, and flat mirror at back of nest box. The convex mirrors had a diameter of 7.6 cm (45-cm$^2$ surface area) and the flat mirror was 11.4 × 12.7 cm (145-cm$^2$ surface area). The convex mirror above the entrance was held with wire, whereas the interior convex and flat mirrors were put on the back wall with double-sided tape.

In 2000, the same 100 nest boxes were randomly assigned as nonmirrored (control), or mirrors on 3 sides with exposed surface areas of 790 cm$^2$ (same coverage as in 1998 experiment), 527 cm$^2$ (2/3 coverage), or 263 cm$^2$ (1/3 coverage). Mirrors of the appropriate surface area for each treatment covered the back wall of the nest box and the sides extending from the back wall. Mirrors were held in place with double-sided tape.

All nest boxes were inspected on the same day, 7 days apart, from the date of opening (23 April–3 May) to early July each year. During each inspection we replaced batteries in the flashing lights (1998), checked mirror attachment, and recorded the presence of nest, species using box, number of eggs, nestlings, and whether the nestlings died or fledged. A nest-box check was generally completed in 1–2 minutes. Date that the first egg was laid was estimated by back-dating from the observed number of eggs at the time of inspection and assuming a laying interval of one egg/day (Feare 1984).

For each experiment, we used chi-square statistics (Zar 1996) to test whether number of nest boxes with nests, eggs, nestlings, and fledglings was related to treatment. We used one-way analysis of variance (ANOVA) to compare estimated mean date of first egg laying, clutch size, number of nestlings/nest, with nestlings and number of fledglings/nest with nestlings among treatments. Tukey's Studentized Range (HSD) test was used to determine where differences ($P<0.05$) occurred (Statistix 1994).

Prior to the start of the study, procedures involving the monitoring of starling nest boxes were approved by the National Wildlife Research Center Animal Care and Use Committee (QA-849).

## Results

In 1998, starlings built nests in 67 of the 100 boxes and laid eggs in 61. Proportion of nest boxes with starling nests, eggs, nestlings, and young fledged differed ($P \leq 0.002$) among the 4 treatments (Table 1). Boxes within the 3 treatments with mirrors, regardless of lights, had fewer nests and fewer nests with eggs, nestlings, or fledglings than did control boxes ($\chi^2_1 \geq 14.57$). Overall, starling nestlings were produced in 92% of control boxes compared to only 32–48% of boxes with mirrors, regardless of lights. Nest boxes with mirrors and green lights differed in nest initiation ($P=0.01$) and clutch size ($P=0.04$) from control boxes (Table 1). Boxes with mirrors and lights had a lower ($P<0.05$) mean number of nestlings than mirrored boxes. No difference was noted in mean number of fledglings produced/box with nestlings for each treatment. We observed no apparent evidence that starlings built nests differently in boxes with mirrors and active lights compared to control boxes or that they tried to cover mirrors or lights with nest material (e.g., vegetation).

In 1999 and 2000, starlings built nests each year in 78 of the 100 boxes and laid eggs in 67 and 73 boxes, respectively. In each year there was no difference ($P>0.25$) among the 4 treatments in proportion of nest boxes with starling nests, eggs, nestlings, and young fledged (Tables 2, 3). Mean dates of first egg, clutch size, number of nestlings, and number of fledglings did not differ ($P>0.06$) among treatments.

Four other species nested in boxes during the experiments: eastern bluebirds (*Sialia sialis*) with 9 nests in treated boxes and 6 nests in control boxes; house wrens (*Troglodytes aedon*) with 6 nests, 3 each in treated and control boxes; one tree swallow (*Tachycineta bicolor*) nest in a treated box; and one house sparrow (*Passer domesticus*) nest in a treated box.

## Discussion

Three experiments were conducted over 3 consecutive years to evaluate a series of treatments

Table 1. Nesting activity by European starlings in 100 nest boxes assigned to one of 4 treatments (untreated, mirrors completely covering 3 sides without lights, mirrors completely covering 3 sides with green-flashing lights, or mirrors completely covering 3 sides with red-flashing lights), Erie County, Ohio, April–July 1998.

| | Treatment | | | |
|---|---|---|---|---|
| Nesting parameter | Control | Mirrors only | Mirrors w/ green light | Mirrors w/ red light |
| No. of boxes with: | | | | |
| Nests[a] | 25 | 10 | 14 | 18 |
| Eggs[a] | 24 | 9 | 12 | 16 |
| Nestlings[a] | 23 | 9 | 8 | 12 |
| Fledged young[a] | 20 | 9 | 7 | 11 |
| Mean (SD): | | | | |
| Julian date of 1st egg[b] | 122 (6) | 121 (4) | 127 (4) | 128 (9) |
| Clutch size/nests with eggs[c] | 4.8 (0.8)$^{A}$ | 4.7 (0.9)$^{AB}$ | 4.7 (0.5)$^{AB}$ | 3.9 (1.3)$^{B}$ |
| No. nestlings/nests with nestlings[d] | 3.8 (1.3)$^{AB}$ | 4.4 (0.7)$^{A}$ | 2.6 (2.0)$^{B}$ | 2.6 (1.8)$^{B}$ |
| No. fledglings/nest with nestlings[e] | 3.0 (1.6) | 3.7 (0.7) | 2.0 (1.8) | 2.4 (1.9) |

[a] Mean numbers differ among treatments ($\chi^2_3 \geq 14.54$, $P \leq 0.002$).

[b] Means differ among treatments ($F_{3,57} = 4.14$, $P = 0.01$) with untreated boxes differing from boxes with the mirror–green light combination.

[c] Means differ among treatments ($F_{3,57} = 2.93$, $P = 0.04$); means with common letters do not differ ($P < 0.05$).

[d] Means differ among treatments ($F_{3,57} = 4.28$, $P = 0.01$); means with common letters do not differ ($P < 0.05$).

[e] Means do not differ among treatments ($F_{3,57} = 2.29$, $P = 0.09$).

Table 2. Nesting activity by European starlings in 100 nest boxes assigned to one of 4 treatments (untreated, convex mirror above entrance, convex mirror at back of box, or flat mirror at back of box), Erie County, Ohio, May–July 1999.

| | Treatment | | | |
|---|---|---|---|---|
| Nesting parameter | Control | Convex mirror at entrance | Convex mirror at back | Flat mirror at back |
| No. of boxes with: | | | | |
| Nests[a] | 18 | 22 | 18 | 20 |
| Eggs[a] | 15 | 20 | 14 | 18 |
| Nestlings[a] | 13 | 19 | 13 | 17 |
| Fledged young[a] | 8 | 17 | 11 | 14 |
| Mean (SD): | | | | |
| Julian date of 1st egg[b] | 129 (8) | 129 (10) | 126 (6) | 132 (10) |
| Clutch size/nests with eggs[c] | 4.1 (0.8) | 4.6 (0.9) | 4.2 (0.8) | 4.2 (0.7) |
| No. of nestlings/nests with nestlings[d] | 2.7 (1.7) | 3.9 (0.9) | 2.9 (1.3) | 2.9 (1.3) |
| No. of fledglings/nest with nestlings[e] | 1.8 (1.9) | 3.1 (1.2) | 2.1 (1.6) | 2.2 (1.6) |

[a] Mean numbers do not differ among treatments ($\chi^2_3 \leq 3.6$, $P > 0.25$).
[b] Means do not differ among treatments ($F_{3,\ 63} = 1.21$, $P = 0.31$).
[c] Means do not differ among treatments ($F_{3,\ 63} = 1.21$, $P = 0.31$).
[d] Means do not differ among treatments ($F_{3,\ 58} = 2.05$, $P = 0.12$).
[e] Means do not differ among treatments ($F_{3,\ 61} = 1.79$, $P = 0.16$).

involving mirrors and lights, with each year's results guiding the selection of treatments tested in the following year. Thus, we have evaluated the results separately for each year and assumed that they were not confounded by a year effect independent of treatments. We do not believe a year effect was important because habitat management at the 2,200-ha Plum Brook Station remained stable during the 1990s (i.e., there was no agricultural activity or other development at the facility and the mowing regime was the same among years). Furthermore, the breeding-season population of starlings in Ohio has shown long-term stability, 1980–2000 (Saur et al. 2001).

In 1998, it appeared that mirrors with and without flashing lights had some repellent effect on starlings attempting to use nest boxes, although 36% of the boxes with mirrors still produced fledglings (as contrasted with 80% of untreated boxes). However, in 1999 and 2000, no repellent effects were noted in any measurement category, although in 2000 the boxes with complete mirror coverage (same treatment as in 1998) did show the least occupancy rate of the 4 treatments.

Belant et al. (1997) found flashing lights ineffective in deterring starlings from nest boxes. The only reference found indicating that flashing lights were effective against starlings was a report (Anonymous 1970, cited in Lefebvre and Mott 1987) stating that flashing amber lights used in combination with owl decoys dispersed a roosting population. Although a general premise in bird deterrence is that integration of multiple control techniques is likely to be more effective than using individual techniques (Inglis et al. 1983, Mason 1989, Dolbeer 1990), we found

Table 3. Nesting activity by European starlings in 100 nest boxes assigned to one of 4 treatments (untreated, mirrors completely covering 3 sides [790 cm$^2$], mirrors covering 2/3 of each of 3 sides [527 cm$^2$], or mirrors covering 1/3 of each of 3 sides [263 cm$^2$]), Erie County, Ohio, May–July 2000.

| | Treatment | | | |
|---|---|---|---|---|
| Nesting parameter | Control | Mirrors complete | Mirrors 2/3 cover | Mirrors 1/3 cover |
| No. of boxes with: | | | | |
| Nests[a] | 21 | 17 | 19 | 21 |
| Eggs[a] | 21 | 15 | 19 | 18 |
| Nestlings[a] | 20 | 14 | 19 | 17 |
| Fledged young[a] | 18 | 11 | 19 | 14 |
| Mean (SD): | | | | |
| Julian date of 1st egg[b] | 135 (7) | 140 (9) | 140 (9) | 140 (10) |
| Clutch size/nests with eggs[c] | 4.6 (0.7) | 3.9 (1.8) | 4.7 (0.8) | 3.7 (1.9) |
| No. of nestlings/nests with nestlings[d] | 3.4 (1.4) | 3.7 (1.4) | 4.1 (1.1) | 3.4 (1.3) |
| No. of fledglings/nest with nestlings[e] | 2.9 (1.6) | 2.7 (1.9) | 3.7 (1.3) | 2.6 (1.7) |

a Mean numbers do not differ among treatments ($\chi^2_3 \leq 2.6$, $P > 0.25$).
b Means do not differ among treatments ($F_{3,\ 69} = 1.75$, $P = 0.16$).
c Means do not differ among treatments ($F_{3,\ 74} = 2.50$, $P = 0.06$).
d Means do not differ among treatments ($F_{3,\ 69} = 1.09$, $P = 0.36$).
e Means do not differ among treatments ($F_{3,\ 69} = 1.92$, $P = 0.13$).

no evidence that flashing lights enhanced efficacy of mirrors. However, flashing lights may be more effective in repelling birds from roosting sites than from critical habitat components such as nesting sites that are in limited supply. As suggested with avian feeding repellents, effectiveness of a deterrent may be inversely related to the relative attractiveness of the material (or area) being protected (Belant et al. 1996).

In 1999 and 2000, lack of a significant difference in date of the first egg laid indicates that there was no initial repellency provided by mirrors. Presence of mirrors during the breeding season has elicited aggressive behavior in glaucous-winged gulls (*Larus glaucescens*) and female blue grouse (*Dendragapus obscurus*, Stout et al. 1969, Stirling 1968). Censky and Ficken (1982) found that dominant black-capped chickadees were more likely to threaten their mirror image than were mid-rank chickadees. Male starlings are aggressive when claiming and defending nest sites (Stokes 1979, Feare 1984). Therefore, the more aggressive, dominant starlings may have been the birds using the mirrored nest boxes. In Ohio, the starling population has remained stable since 1980 (Saur et al. 2001). However, nest-site competition may still be intense enough in northern Ohio to overcome the slight repellent properties of mirrors indicated by the 1998 data. Because the average life span of starlings is 12–18 months (Feare 1984), some of these starlings may have used mirrored nest boxes as adults or juveniles in the previous year and adapted to having mirrors in the nest boxes.

Only the full-coverage mirrors (i.e., 2 sides and back of box completely covered with mirrors) showed any evidence of repelling starlings, but the repellency exhibited was rather weak and inconsistent between years. Therefore, we conclude that further investigation of the use of mirrors alone to reduce starling presence in buildings, signs, hangers, aircraft, or any other nesting area is not warranted. Mirrors alone will probably not suffice as a repellent technique. However, an integrated approach using mirrors and other repellent techniques should be investigated.

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