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EFFECTIVENESS OF NYLON LINES FOR DETECTING ROCK DOVES FROM LANDING ON LEDGES

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Rock doves (*Columba livia*) frequently cause nuisance and public health problems by defecating while roosting on ledges, ornamental architecture, and roofs of buildings (Courtsal 1983). The feces can deface sides of buildings, kill vegetation, produce objectionable odors, contaminate food destined for humans and livestock, and spread diseases to people (Courtsal 1983). Courtsal (1983) recommended altering ledges to a 45° angle and using porcupine wires or pulsating electric cables to deter rock doves from roosting on ledges. Porcupine wires and materials for altering the angle of ledges can be costly.

Monofilament lines or wires stretched across flight paths have been successful in excluding house sparrows (*Passer domesticus*) (Aguero et al. 1991) and gulls (*Larus argentatus*, *L. delawarensis*) (McAtee and Piper 1936; Ostergaard 1981; Blokpoel and Tessier 1983, 1984), partially successful in excluding cormorants (*Phalacrocorax* spp.) (Barlow and Bock 1984, Moerbeek et al. 1987) and great-tailed grackles (*Quiscalus mexicanus*) (Tipton et al. 1989), and unsuccessful in excluding American robins (*Turdus migratorius*) (Aguero et al. 1989), European starlings (*Sturnus vulgaris*) (Aguero et al. 1989, 1991) and rock doves (Blokpoel and Tessier 1984). The monofilament lines and wires were widely spaced and repelled birds by species-specific avoidance responses rather than physical exclusion. In this study, we evaluated the relative effectiveness of 0, 1, 2, or 3 closely spaced nylon lines stretched across ledges for deterring landings by rock doves.

STUDY AREA

The study was conducted at Colorado State University's Hughes Football Stadium, Fort Collins. The eastern portion of the stadium consists of a 5.4-m-high concrete wall and overhang that is divided into 17 sections (6.7-7.4 m wide) by 0.5-m-wide concrete pillars. A 0.3-m-deep ledge is located 3.4 m above the ground on each section. A concrete overhang is located 0.4 m above the ledges and extends 1.8 m outward from the concrete walls. Rock doves used the ledges for daytime roosts and crawled behind 3 ledges and under the concrete bleachers where they nested, raised young, and roosted.

METHODS

Design

Before we initiated the experiment, we obtained hourly counts of the number of landings by rock doves on each of the 17 ledges twice daily for 4 days from 16 to 19 March 1990. The numbers of landings on the southern 9 ledges were determined concurrently, as were landings on the northern 8 ledges. The 1-hour counts were alternated between these 2 groups of ledges and were conducted during 2 mornings (0700-1220 hr) and 2 afternoons (1300-1820 hr). These data primarily were obtained to assist with designing the study.

We initially examined the use of 1 and 2 strands of 14-kg clear monofilament line for deterring rock doves from landing on ledges. The doves often flew directly into the lines, which suggested that they could not see them. To avoid possible injuries to doves, we replaced the monofilament line with a white 75-kg tensile-strength nylon line that seemed to provide a visual as well as a physical deterrent. We did not observe any injuries to doves that attempted to land on ledges protected with white nylon lines.

We determined the relative effectiveness of 0, 1, 2, and 3 white nylon lines by counting the number of successful and unsuccessful landings by rock doves in relation to number of lines during 4 consecutive weekends (Friday through Monday, 30 Mar-23 Apr). We used 2 separate cross-over latin-square experimental designs to assign 0 (control), 1, 2, or 3 lines to the 4 ledges with highest preliminary rock dove activity and

to the 4 ledges with the next highest activity each weekend. Within each group of 4 ledges, the allocation of treatments to ledges each weekend was randomly chosen subject only to the balance constraints of a latin square.

All line treatments were located 8 cm in front of the ledges. In addition, treatments with 1 line were located 12 cm above the ledges whereas 2 lines were 8 and 18 cm above, and 3 lines were 5, 12, and 18 cm above the ledges. The distances between lines were determined by adjusting prototypes until a similar number of rock doves landed after flying below, between, and above the lines (when landings occurred). The lines were stretched to about 9 kg of tension.

Lines were stretched across each ledge receiving a treatment for about 5 hours each day from Friday through Monday (Friday and Monday afternoons, Saturday and Sunday mornings) and observations were conducted during those periods. After the 5-hour periods, the lines were removed to avoid adverse impacts on dove roosting, incubation, and care of young. One observer sat on a chair next to 2 buildings and about 10 m from the ledges, while recording all data. Because it was impossible for 1 person to observe all the ledges at once, the observer alternated 1-hour counts of successful and unsuccessful landings between 2 groups (southern and northern) of 4 ledges. Each group contained 2 of the most active and 2 of the next most active ledges determined during pretreatment counts. About 15 minutes elapsed after movement of the observer between the northern and southern ledge-groups before counting resumed; this was to allow rock dove activity to return to normal.

Activities on the southern group of ledges always were counted during the second and fourth hours of Friday afternoons, the first and third hours of Monday afternoons, the first and third hours of Saturday mornings, and the second and fourth hours on Sunday mornings. Activities on the northern group of ledges were counted during the alternate hours. Observations during evaluation of lines were recorded verbally on a tape and transcribed by 2 listeners to increase accuracy.

Statistical Analyses

The 8 hours of observations on number of attempted landings (successful plus unsuccessful landings) and proportion of attempted landings that were successful by doves on each ledge each weekend were averaged by pooling counts before analyses were conducted. Observer and tape recorder errors resulted in the loss of 1 hour of observations on the northern group of ledges during the afternoon of the second weekend and 1 hour of observations on the southern group of ledges during the afternoon of the third weekend. Thus, 7 hours of observations were extrapolated to 8 hours for each ledge where data were missing. The number of attempted landings ($n = 0-2,909/\text{ledge}/\text{weekend}$) were transformed to ranks to stabilize variances and otherwise meet the assumptions necessary for analysis of variance

(ANOVA) (Conover 1980:335-338). Then the effects of number of lines, weekends, and ledges on number of attempted landings and proportion of attempted landings that were successful were tested with ANOVA (GLM procedure, SAS Inst. Inc. 1988:549-640). The "protected" least significant difference test (Milliken and Johnson 1984:31-33, Saville 1990:177) was used to separate means when the overall F -test indicated significant ($P < 0.05$) treatment effects.

Trends in the number of attempted landings and the proportion of attempted landings that were successful in relation to the number of lines/ledge and in relation to consecutive weekends were examined with linear and quadratic contrasts. The effect of time (days within weekends) on the proportion of attempted landings that were successful was determined by comparing 32 (8 ledges \times 4 weekends) 4-day slopes and testing if their average was different from 0 with a t -test. To balance the analyses, the missing hourly data noted above were imputed by averaging the 1 hour of observations/ledge obtained on the day of missing data with 2 hours of observations on the same ledge obtained the previous day.

RESULTS

Rock doves landed 1,383 (range = 136-766) times on the 4 most active and 160 (range = 25-57) times on the 4 next most active ledges during 64 ledge-hours of counts before the line experiment began. All attempted landings appeared successful. The average number of landings/ledge/hour on these ledges ranged from 3.1 to 95.8. Doves made 14,497 attempted landings of which 4,802 were successful on the 8 ledges with 0, 1, 2, and 3 lines during 248 ledge-hours of counts during the experiment.

The average number of attempted landings by rock doves did not vary in relation to the number of lines/ledge nor in relation to weekends (Tables 1-3). The average number of attempted landings on ledges without lines was similar to that on ledges with 1, 2, and 3 lines. However, the average number of attempted landings varied among ledges. A line-by-weekend interaction was not significant. The average number of successful landings/hour on ledges with 1 ($\bar{x} = 11.7$, $SE = 5.4$), 2 ($\bar{x} = 7.7$, $SE = 3.3$), or 3 ($\bar{x} = 5.6$, $SE = 2.5$) lines was lower than the average of 24.1 ($SE = 4.8$) landings/ledge before the experiment began.

Table 1. Average hourly^a number (based on untransformed data) of attempted landings and proportion of attempted landings that were successful on ledges by rock doves in relation to the number of nylon lines stretched above ledges in Fort Collins, Colorado, during 1990.

No. lines	No. attempted landings		Proportion successful landings	
	\bar{x}	SE	\bar{x}	SE
0	52.8A ^b	25.7	0.99A ^b	0.008
1	51.5A	21.3	0.23B	0.046
2	52.8A	21.6	0.13C	0.033
3	73.2A	45.3	0.10C	0.032

^a Each ledge was monitored 2 hours/day for 4 days to obtain average hourly values before randomly reassigning the number of lines (0-3)/ledge until each ledge received each treatment.

^b Means in a column sharing the same letter are not different ($P > 0.05$) (no. of attempted landings was based on ranked data) using the "protected" least significant difference test.

The proportions of attempted landings that were successful by rock doves varied and decreased linearly, but not quadratically, with the number of lines stretched across ledges (Tables 1, 3). The proportions of attempted landings that were successful on ledges with 1, 2, and 3 lines combined were lower than on ledges without lines. The proportion of attempted landings did not differ between 2 or 3 lines, but 2 or 3 lines were more effective than 1 line, which was more effective than no lines for excluding doves.

The proportions of attempted landings that were successful increased linearly and quadratically from weekends 1 through 4 (Tables 2, 3). The proportions of attempted landings that were successful also increased linearly ($F = 7.03$; 1,31 df; $P = 0.013$) and quadratically ($F = 5.13$; 1,31 df; $P = 0.031$) from day 1 through day 4 of the 4 weekends. The proportions of attempted landings that were successful did not vary by ledge (Table 3). A significant interaction was found between lines and weekends, with the proportion of landings that were successful increasing faster with time for 2 and 3 than for 1 or 0 lines (Tables 3, 4).

The number of rock doves that were found on the overhang above the ledges and on adjacent buildings during evenings (1800-1840 hr), at the end of the line experiments, was

Table 2. Average hourly^a number (based on untransformed data) of attempted landings and proportion of attempted landings that were successful on ledges in relation to time (consecutive weekends) that rock doves experienced nylon lines stretched above ledges in Fort Collins, Colorado, during 1990.

Week-end	No. attempted landings		Proportion successful landings	
	\bar{x}	SE ^b	\bar{x}	SE ^c
1	103.9A ^d	48.5	0.29A ^d	0.013
2	38.2A	14.1	0.33AB	0.013
3	46.2A	20.8	0.36B	0.013
4	42.0A	16.8	0.46C	0.013

^a Each ledge was monitored 2 hours/day for 4 days to obtain average hourly values before randomly reassigning the number of lines (0-3)/ledge until each ledge received each treatment.

^b Standard errors were computed separately for each weekend from the raw data.

^c Standard error was computed based on the mean square error from the ANOVA in Table 4.

^d Means in a column sharing the same letter are not different ($P > 0.05$) (no. of attempted landings was based on ranked data) using the "protected" least significant difference test.

related to the number of lines stretched across ledge 9, which had the highest activity before the line experiment. We observed 150-170, 104, 45, and 25-30 doves in the area when 3, 2, 1, and 0 lines, respectively, were present on ledge 9.

DISCUSSION

Rock doves were deterred from landing on ledges when nylon lines were placed across their flight paths. Nylon lines reduced the proportion of successful landings to attempted landings as well as the total number of landings. The success of the lines also was indicated by the direct relationship between the number of lines stretched across ledge 9, which had the largest number of pretreatment landings, and the number of doves found on the overhang above the ledges and on adjacent buildings at the end of daily experiments. The doves apparently were deterred from entering the roosting and nesting area behind ledge 9.

Although we expected to find a greater number of attempted landings on ledges with 1, 2, or 3 nylon lines than on ledges without lines (because of additional attempts following a failure to land), we did not find such a rela-

Table 3. Effect of lines, weekends, and ledges on number of attempted landings and proportion of attempted landings that were successful by rock doves on ledges in Fort Collins, Colorado, during 1990.

Source	Sum-of-squares	df	F	P
Attempted landings				
Lines	26.69	3	0.89	0.484
Weekends	49.19	3	1.64	0.249
Ledges	1,982.57	7	28.27	<0.0001
Lines × weekends	41.45	9	0.46	0.869
Linear contrasts ^a				
0 vs. 1, 2, and 3 lines	13.50	1	1.35	0.276
Lines	2.64	1	0.26	0.620
Weekends	26.41	1	2.64	0.139
Quadratic contrasts ^b				
Lines	10.55	1	1.05	0.332
Weekends	10.13	1	1.01	0.341
Error	90.18	9		
Proportion of attempted landings that were successful				
Lines	4.27	3	1,002.61	<0.0001
Weekends	0.12	3	29.18	<0.0001
Ledges	0.03	7	2.87	0.072
Lines × weekends	0.06	9	4.97	0.013
Linear contrasts				
0 vs. 1, 2, and 3 lines	4.19	1	2,954.43	<0.0001
Lines	0.07	1	49.83	<0.0001
Weekends	0.11	1	79.44	<0.0001
Quadratic contrasts				
Lines	0.01	1	3.57	0.092
Weekends	0.01	1	5.76	0.040
Error	0.01	9		

^a Represents the comparison of 0- to 1-, 2-, and 3-line ledges combined or the regression of lines or weekends on the number of attempted landings or proportion of attempted landings that were successful.

^b Represents the comparison of 0- to 1-, 2-, and 3-line ledges combined or the regression of lines or weekends on the number of attempted landings squared or proportion of attempted landings that were successful squared after adjusting for the linear effect.

relationship. This relationship likely was obscured by a large number of doves landing on ledges without lines after failing to land on ledges with lines. However, the number of attempted landings when lines were present (Table 1) was more than twice the number of pretreatment attempted landings ($\bar{x} = 24.1$), indicating that the presence of lines increased attempts to land.

The proportion of attempted landings that were successful on ledges protected with nylon lines increased linearly from weekends 1 through 4 and from days 1 through 4 within weekends, whereas the number of attempted landings did not vary from weekends 1 through 4. This suggests that the increased success rate was related to doves learning how to circumvent the lines rather than a relatively lower

proportion of the unsuccessful doves testing the lines on the latter weekends.

The number of attempted landings varied by ledge. This variation likely was influenced by relatively high activity on 3 ledges that was associated with doves crawling behind the ledges to large roosting and nesting areas. However, the proportion of attempted landings that were successful was unrelated to ledges and the associated variations in activity.

The scope of inference for our data is limited to our study site. Rock doves usually made horizontal or slightly ascending approaches to the ledges that we observed. Their angle of approach may have been limited by a concrete overhang that was above the ledges. Additional lines may be required on ledges without an

Table 4. Proportion of attempted landings that were successful by rock doves on ledges in relation to weekends and the number of lines stretched across the doves' flight paths in Fort Collins, Colorado, during 1990.

Lines	Weekends							
	1		2		3		4	
	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE
0	0.997	0.003	0.990	0.010	0.994	0.006	0.966	0.029
1	0.112	0.045	0.177	0.001	0.218	0.062	0.405	0.083
2	0.025	0.012	0.146	0.059	0.108	0.016	0.244	0.044
3	0.034	0.006	0.012	0.012	0.108	0.028	0.226	0.005

overhang if doves approach the ledge in a descending angle of flight.

MANAGEMENT RECOMMENDATIONS

We determined that 1, 2, or 3 nylon lines stretched across the flight paths of rock doves were moderately to quite successful in deterring landings on ledges in spite of what we believe were persistent attempts by doves. The doves used all the ledges as daytime loafing sites, but we believe that they primarily were attracted to the site by large sheltered roosting and nesting areas behind 3 of the ledges. Most ledges where doves cause problems do not provide the extensive shelter and nesting areas that our study site provided. Thus, we suspect that doves would be relatively less persistent and that nylon lines would be even more effective, especially during short periods of use, in deterring doves from landing on other sites.

In contrast to our study, lines likely would be installed on all ledges and remain in use for extended periods at other sites. It is unknown if continuous use of lines would cause doves to abandon the sites or if they would become more persistent in attempting to land and quickly habituate to the lines. Additional research is needed to determine whether and to what extent doves habituate to lines left in place for extended periods.

Our closely spaced nylon lines inhibited rock doves from landing on ledges, apparently by providing both physical and visual deterrence. Some doves were deterred from landing after

contacting the lines, whereas others approached the lines but did not attempt to land. Closely spaced lines also may exclude species, such as European starlings, that were not deterred by widely spaced lines (Aguero et al. 1989, 1991).

SUMMARY

We tested the effectiveness of 75-kg white nylon lines stretched across ledges for deterring landings by rock doves. The proportion of successful landings to attempted landings was reduced from 0.99 (0 lines) to 0.23 (1 line), 0.13 (2 lines), and 0.10 (3 lines). The number of successful landings/ledge/hour was reduced to 11.7, 7.7, and 5.6 landings with 1, 2, and 3 lines, respectively, compared to 24.1 pretreatment. The proportion of doves that successfully negotiated the lines to land increased from weekends 1 through 4 and from days 1 through 4 within weekends, indicating that some doves learned to circumvent the lines. Large roosting and nesting areas behind 3 of the ledges likely increased the incentive for rock doves to land there during this study. Nylon lines may be even more effective for deterring landings by rock doves at other sites where incentives are lower.

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REPELLENCY OF CINNAMIC ACID DERIVATIVES TO ROOKS AND CHAFFINCHES

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Laboratory trials have shown that cinnamamide (C-amide) and 3,5 dimethoxycinnamic acid (3,5-C) can reduce feeding in rock doves (*Columba livia*) housed in individual cages (Crocker and Perry 1990, Crocker et al. 1993). Cinnamamide also was shown to be repellent when sprayed on wheat grains rather than lab-

oratory food, and to be effective against caged birds living in small groups (D. R. Crocker, unpubl. data). Nevertheless, laboratory results do not necessarily reflect the behavior of birds in the wild and it is important to test repellents under conditions that more closely match their intended application.

As plant breeding techniques become increasingly sophisticated, seeds become more valuable and more effort is spent protecting

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