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EFFECTS OF PREDATOR EXCLOSURES ON NESTING SUCCESS OF KILLDEER

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Nests of shorebirds are often destroyed by predators and in some instances predation may cause severe local declines in breeding success and in size of a breeding population (Hussell and Montgomerie 1966, Cartar 1976). Protecting nests with exclosures may be one means of reducing predator impact on small, threatened, breeding populations of shorebirds. The objectives of this study were: (1) to determine the extent of predation by gulls (*Larus* spp.) on nests of Killdeer (*Charadrius vociferus*), (2) to determine if exclosures protect Killdeer nests from predation, and (3) to develop recommendations regarding use of exclosures to protect nests of shorebirds.

METHODS

The study was conducted on the western third of Long Point, Ontario (42°34′N, 80°16′W), a 33-km peninsula projecting eastward from the north shore of Lake Erie. Killdeer nested on wide sandy beaches and on pebbled islands formed by water cutting through the peninsula from Lake Erie to Long Point Bay.

The exclosure used in the experiments was developed from trials that tested several designs. The selected design (Fig. 1) was the one that Killdeer entered most readily and that seemed most immune to predators. This exclosure was constructed of gray, 1.4-cm mesh hardware cloth and had eight 7 × 12-cm openings. The size of the openings prohibited gulls and other relatively large predators from entering, but allowed Killdeer to enter and exit rapidly. When an exclosure was placed on a nest, all entrances were more than 30 cm from the nest. The indentations between the halves of the exclosure (Fig. 1) allowed the Killdeer to see their nest from outside the structure. The wire metal plates above the 2 entrances in these indentations made it more difficult for some mammalian predators to reach the nest through these entrances.

We placed exclosures on 12 nests that were selected at random from 29 nests discovered. Each exclosure was held in place by 12 wire stakes. After placement, each exclosure was observed from a distance of 50 m, and we recorded how long it took the returning Killdeer to enter the exclosure and sit on the nest. The time was recorded from when the returning bird first approached to within 10 m of its nest.

All nests were checked every 2 days. During these checks, the observer remained more than 3 m from the nest to reduce the possibility of attracting predators to the nest. When nests were lost to predators, remains of egg shells, general condition of the nest, and tracks were recorded to identify the predator (Rearden 1951).

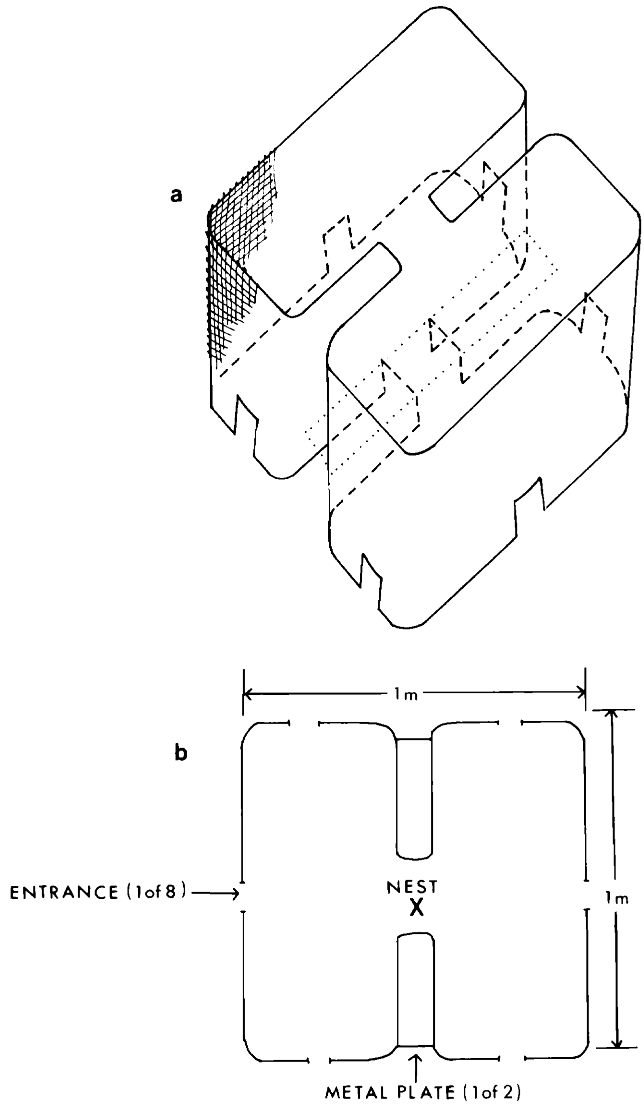

FIGURE 1. Two views of exclosure used in the experiments. (a) Lateral view—dotted line indicates upper surface of metal wire plates above the 2 entrances closest to the nest. (b) Dorsal view—showing location of nest when exclosure was in place.

The calculated numbers of destroyed nests (Mayfield 1975), based on loss rates for each treatment, were compared by a Chi-square test. The calculated number of destroyed nests subtracted from the total number of nests present equalled the calculated number of successful nests. This

TABLE 1. Comparison of number of nests lost in exclosed and unexclosed treatments.

	Exclosed nests	Unexclosed nests
Total nest days	216	245
Total number of nests observed	12	17
Actual number of nests lost	8	12
Calculated number of nests lost*[a]	7.6	12.6
Expected number of nests lost[a]	8.4	11.8

* Calculated number of exclosed and unexclosed nests lost was not significantly different than expected, $\chi^2 = .13$, $P > .05$.
[a] After Mayfield (1975).

latter value, expressed as a percent, was used as a measure of nest success.

Twelve additional nests located on the mainland near Long Point, but outside the study area, were monitored until hatching. These nests were visited every 2 days, but at each visit the eggs were handled.

Gull censuses were conducted from 20 May to 21 July 1978 at 5-day intervals. Numbers and species composition of flocks were recorded when birds were resting on beaches or near shore. All gull censuses took place between 1100 and 1500.

A series of 1-m^2 sand plots was constructed at 10-m intervals along the beach to estimate the level of activity of mammalian predators (Bider 1968). Eighteen plots extended 180 m east-west and 10 plots extended 100 m north-south. Plots were cleared daily between 2000 and 2200 with a wooden board and were checked the following morning between 0700 and 0900. Consequently, only nocturnal and crepuscular activity were monitored. Only tracks of mammals were identified.

RESULTS

After an exclosure was placed on a nest, Killdeer approached the nest cautiously and usually circled the exclosure before entering it. The mean interval between approach and initial entry was 13.8 ± 0.12 min (95% C.I.). At each of the 12 protected nests, both parents entered the exclosure and appeared to incubate normally.

All observed nest losses were caused by predators. There was no significant difference in overall losses to predators between nests with and without exclosures (Table 1). On Long Point nests without exclosures had a 25.9% calculated nest success. On the mainland, nests without exclosures had a 64.0% success, and all losses appeared to be caused by dogs (*Canis familiaris*).

Of 17 unprotected nests on Long Point, 5 (29.4%) were destroyed by gulls, 4 (23.5%) by raccoons, and one each (5.8%) by a mustelid, a snake, and a Common Crow (*Corvus brachyrhynchos*). The calculated number of Long Point nests lost to gulls was significantly less for exclosed than for unexclosed nests (Table 2). Mammals destroyed more exclosed than

TABLE 2. Comparison of number of nests destroyed by gulls and mammals in exclosed and unexclosed treatments. Total nest-days and nests as in Table 1. N is sample size.

	Exclosed nests	Unexclosed nests
	N = 12	N = 17
Gulls		
Actual number of nests lost	0	5
Calculated number of nests lost*	0	7.25
Expected number of nests lost	3.06	4.34
All mammals		
Actual number of nests lost	8	5
Calculated number of nests lost^{NS}	7.66	7.25
Expected number of nests lost	6.45	9.14
Raccoons		
Actual number of nests lost	6	4
Calculated number of nests lost^{NS}	6.39	6.10
Expected number of nests lost	5.36	7.59

*Differences between treatments were significant ($\chi^2 = 5.01$; $P < .025$).
^{NS} Differences between treatments were not significant ($P > .05$).

unexclosed nests, but this difference was not significant (Table 2). The number of nests destroyed by raccoons did not differ between treatment groups (Table 2). Raccoons (*Procyon lotor*) destroyed nests by extending their forelimbs into the exclosure openings, whereas mink (*Mustela vison*) and long-tailed weasels (*M. frenata*) were small enough to go right into the exclosure and at 2 exclosed nests, mink killed one of the incubating adults.

The proportion of nests lost to gulls appeared correlated with the number of gulls in the study area from 9 May to 12 July (Fig. 2). Although the species of gull responsible for any particular nest loss was unknown, Ring-billed Gulls (*Larus delawarensis*) and Bonaparte's Gulls (*Larus philadelphia*), accounted for 99% of gulls censused.

In the study area, tracks of raccoon, mink, long-tailed weasel, and striped skunk (*Mephitis mephitis*) occurred on the sand plots every day from 1 to 21 July 1978. On average, 21% of the 28 sand plots (range 7.0–53.0%) had raccoon or mustelid tracks each day during this period.

DISCUSSION

Killdeer adjusted readily to exclosures placed over their nests, but the efficacy of exclosures in deterring predation depended on the species of predators present. Exclosures reduced nest destruction by gulls, and probably would be effective against other potential avian predators (e.g., crows, *Corvus* spp; jaegers, *Stercorarius* spp.). However, mammals destroyed 64% of exclosed and 43% of unexclosed nests. This difference was not significant, but these high rates suggest that, despite our pre-

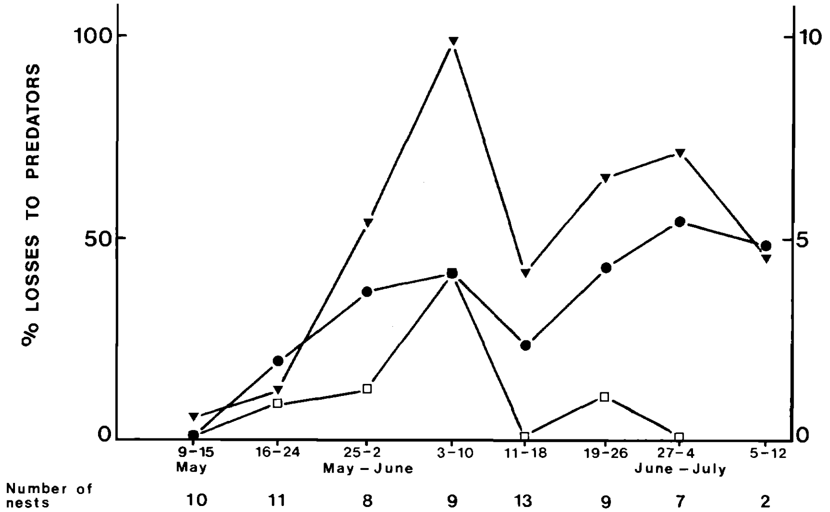

FIGURE 2. Losses of Killdeer nests in relation to numbers of gulls on the study area. Number of nests beneath date. Samples from each date are not independent because the same nests may be in samples from different dates. Open squares = percent of nests lost to gulls. Closed circles = percent of nests lost to predation. Closed triangles = numbers of gulls.

cautions in monitoring the nests, mammalian predators may have found nests by following the observer's scent or perhaps by being attracted by the exclosures themselves.

Predation by raccoons might be reduced if the entrances of the exclosures were smaller. However, the size of entrance used in this study required the birds to lower their heads to enter, and smaller openings might discourage birds from entering at all. Tracks around predator-destroyed nests and on our sand plots indicated that most raccoon predators were small juveniles. Smaller entrances on the exclosure probably would not deter these raccoons from reaching into the nest (Bellrose et al. 1964). Alternatively, if larger exclosures were used, the entrances would be far enough from the eggs that raccoons could not reach the nest. We recommend exclosures to protect nests of shorebirds from avian predators, but if raccoons are present, we suggest that the exclosures should be larger than those described here.

The rate of predation on Killdeer eggs in this study was high compared to rates reported for other temperate zone nesting shorebirds. Rates of predation on Killdeer nests ranged from 6% (n = 39 nests; Bunni 1959:92) to 38% (n = 18 nests; Mace 1971:53). In these studies, domestic dogs or unspecified predators were responsible for egg losses. For Piping Plovers (*C. melodus*) percent predation on the eggs ranged from 0% (n = 174; Wilcox 1959:142) to 9% (n = 51; Cairns 1977:66).

On Long Point, high water levels in spring and early summer may result in a temporary decline in the amount of available habitat for animals using the beaches (e.g., resting gulls, foraging raccoons, and nesting Killdeer). This reduction of habitat may result in concentration of both nesting Killdeer and their potential predators.

SUMMARY

Wire exclosures were placed over nests of Killdeer to test whether these structures would reduce predation on the nests. Gulls were a major predator of Killdeer nests on the Long Point study area, and the proportion of Killdeer nests lost to gulls appeared related to the number of gulls in the area. Nests provided with exclosures lost significantly fewer eggs to gulls than did nests without exclosures, but exclosures did not reduce the rate of predation by mammals or the overall nest loss rate. Such exclosures should be modified (enlarged) if they are used to protect nests of shorebirds when raccoons are present.

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