Effect of Predator Control on Reproductive Success and Hen Survival of Attwater's Prairie-chicken

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Abstract: From 1980–1981, we tested the hypothesis that removal of potential nest predators would increase the reproductive success of the endangered Attwater's prairie-chicken (*Tympanuchus cupido attwateri*). Striped skunks (*Mephitis mephitis, N* = 74), opossums (*Didelphis virginiana, N* = 83), and raccoons (*Procyon lotor, N* = 9) were removed from a 522-ha predator removal area (PR) during February–June 1980 and 1981. Predator indices were lower ($P < 0.002$) and prairie-chicken nest success was higher (82% vs. 33%, $P < 0.019$) in the PR than a 620-ha control area (CO). Breeding season hen survival was <9% on both areas and survival curves were different between PR and CO ($P < 0.015$). Small sample size caused by declining populations and treatment effects that were compounded with site effects make our results equivocal. Managers may need to consider predator management of a diverse group of species that prey on prairie-chicken adults and nests for a control program to be effective.

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The Attwater's prairie-chicken is an endangered grouse inhabiting areas of the Gulf Coastal Prairie in Texas. Prairie-chickens are a ground-nesting species and many nests fail to hatch because of destruction by predators or other causes (Lehmann 1941, Horkel et al. 1978, Lutz 1979, and Lawrence 1982). Several authors have recommended predator management to increase productivity of ground-nesting birds (Stoddard and Komarek 1941, Anderson 1957, Livezey 1981, Sargeant and Arnold 1984, Greenwood 1986). Other studies have documented positive effects of predator control on nesting success (Balser et al. 1968, Chesness et al. 1968, Trautman et al. 1974).

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Attwater's prairie-chickens declined from an estimated 1,584 in 1980 (Lawrence and Silvy 1980), the first year of this study, to 68 in 1995 (U.S. Fish and Wildl. Serv., unpubl. data). Remaining populations of Attwater's prairie-chickens are "island populations" (Lawrence and Silvy 1980). Excessive nest losses can occur on such units because predators also are attracted to localized areas (Braun et al. 1978, Sargeant and Arnold 1984). While habitat loss and degradation are the major reasons for the endangered status of Attwater's prairie-chicken (Lehmann 1968), strategies for maintaining viable populations on managed areas need to be investigated. Our objective was to determine if nest success and productivity of Attwater's prairie-chickens could be increased by controlling major nest predators.

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Study Areas

Unreplicated treatments were in the 6,400-ha Lake Pasture of the O'Connor Brothers' River Ranch, about 28.8 km northeast of Refugio, Texas. Moderate, continuous grazing of 1 animal unit (=1 cow calf)/6.5 ha was maintained throughout the study. Elevation of the study areas varied from 15.2 to 17.6 m. Lake Pasture was intersected by 2 man-made drainages with intermittent flow (Cogar et al. 1977, Horkel 1979).

Within the Lake Pasture an unfenced, 522-ha predator-reduction area (PR) and a 620-ha control area (CO) were chosen due to similarities in: 1) vegetation consisting of open prairie that was favored nesting habitat (Cogar et al. 1977, Horkel 1979, Lutz 1979); 2) development for petroleum production and all-weather roads (Lutz 1979); 3) prairie-chicken populations (34 and 32 males in 1980 and 38 and 31 males in 1981 using leks in PR and CO, respectively), and 4) prairie-chicken nest success in the 2 years immediately prior to this study (calculated from Lutz 1979: 47–55). Also, during each of the 4 years before this study, no radio-tagged prairie-chickens were known to travel the 2.3 km between the most proximate boundaries of these 2 treatment areas (R. S. Lutz, unpubl. data).

Methods

Striped skunks ($N = 74$), opossums ($N = 83$), and raccoons ($N = 9$) were removed from PR by trapping and spotlight hunting during 1980 and 1981. Steel leg-hold traps (Victor 1.5, double-coil spring) and wire-cage live traps (Havahart) with sardine bait were set during February–June 1980 and 1981 and

checked daily (March–May is the nesting season for Attwater's prairie-chicken). Leg-hold traps were placed in the end of culverts to avoid interaction with non-target wildlife and cattle. During 76 nights in 1980, an average of 14 leg-hold and 9 live traps were employed and during 84 nights in 1981, 12 leg-hold and 9 live-traps were employed. Captured animals were killed immediately. Predators were further removed by spotlight hunting, shooting mammalian predators with a .22 caliber rifle along roads and mowed pipeline rights-of-way within the PC area. Spotlight sampling (Rybarczyk et al. 1980) was conducted to evaluate predator levels in CO. Biweekly predator indices (predators observed/km) from March–May were compared between PR and CO using paired *t*-tests for each year.

Prairie-chicken hens were captured using a helinet (Brown 1981) and radio-tagged with 17-g solar-powered transmitters (Wildl. Materials Inc., Carbondale, Ill.) attached with a backpack harness. Radio-marked hens were located 2–7 times per week. Hens were not flushed until they were thought to be incubating in order to minimize disturbance during laying.

Initiation dates were estimated based upon location data or, if the hatch date was known, were calculated by back-dating, assuming a laying rate of 1 egg/day and a 23-day incubation period (Horkel 1979:54). Nests in the egg-laying stages were rarely located and nests destroyed during laying were not found. We assumed that chronology of nesting should be the same in PR and CO; therefore, any difference in initiation date between the 2 areas may reflect differential nest loss during laying and subsequent renesting. Mean nest initiation was calculated as the sum of the number of days since the first known initiation of the year to the estimated initiation date for each bird divided by sample size.

Nest success was calculated by the Mayfield Method (Mayfield 1975). In using this method, we assumed an average exposure of 35 days (12 days laying plus 23 days of incubation). The Mayfield Method accounts for the higher probability of hatching in nests discovered nearer to the date of hatch. We also calculated apparent nest success to compare with data collected during earlier studies.

Hen survival was estimated using the product-limit method (Kaplin and Meier 1958, PROC LIFETEST, SAS Inst. 1990). We compared homogeneity of survival curves between areas using Log-rank tests (SAS Inst. 1990).

Results

Predator Removal

In 1980, 106 predators, consisting of 49 striped skunks, 52 opossums, and 5 raccoons, were removed from PR 1 month before and during the nesting period (10 Feb–24 Jun) (Table 1). In 1981, 25 striped skunks, 31 opossums, and 4 raccoons were removed during 10 February–27 June. Predator indices from March–May were lower in PR than in CO both in 1980 (PR $\bar{x}$ = 0.12 predator/

Table 1. Numbers of predators removed from the predator-reduction area by method in the Lake Pasture, O'Connor Brothers' River Ranch, Refugio County, Texas, 1980 and 1981.

	1980		1981		
Species	Hunting	Trapping	Hunting	Trapping	Total
Striped skunk	38	11	17	8	74
Opossum	14	38	12	19	83
Raccoon	0	5	0	4	9

km, CO $\bar{x} = 0.71$; paired t-test, $t = 5.99$, $P \leq 0.002$) and 1981 (PR $\bar{x} = 0.05$ predator/km, CO $\bar{x} = 0.42$; paired t-test, $t = 5.99$, $P \leq 0.001$).

Attwater's Prairie-Chicken Production

Nineteen nests were found by telemetry and 4 were located by other methods. Twelve Attwater's prairie-chicken nests were located during 1980. Two of 3 nests (all first nests) in PR and 2 of 9 in CO (1 known renest) were successful. All unsuccessful nests were destroyed by predators except 1 in CO, where the hen was killed 150 m from the nest site, but the eggs were not destroyed.

Seven of 8 nests within PR were successful during 1981. All nests in PR were thought to be first nests except the 1 unsuccessful nest, which was probably a renest. Two of 4 nests in CO were successful; both successful nests were first nests, while 1 renest was lost to a predator and 1 abandoned due to flooding. The flooded nest was excluded from this analysis.

Combined 1980 and 1981 nest success was higher ($\chi^2 = 5.49$, 1 df, $P < 0.019$) in PR (82%) compared to CO (33%) (Table 2). Mayfield's (1975) nest success was 75% in PR and 26% in CO. Mean nest initiation dates were significantly different (Mann-Whitney U; $z = 2.47$, 9 and 10 df, $P < 0.01$) between PR (5.2 days after the first estimated initiation) and CO (13.4 days after the first estimated initiation).

Extensive flooding occurred in Lake Pasture following 33.3 cm of rain on 1–3 May 1981 and 25.6 cm on 11–12 June 1981. Increased adult mortality occurred during the week following the 1–3 May storm. During this period, 6 of 7 radio-tagged hens with broods died while 1 of 5 hens nesting or without broods died. No radio-monitored broods were known to survive the 1–3 May storm nor were any broods observed later in the year. Only 1 of 3 incubating hens abandoned her nest as result of the flooding; the 2 other hens continued to incubate after their nests had been temporarily inundated.

Radio-marked hen survival was low during the breeding season (Fig. 1). We combined years for analysis since there was no difference in survival between years (Log-rank $\chi^2 = 0.13$, 1 df, $P < 0.716$). The survival curves were different between areas (Log-rank $\chi^2 = 5.96$, 1 df, $P < 0.015$); however, calculated survival was low in both PR (survival = 0%) and CO (survival = 9%). Sixty-four

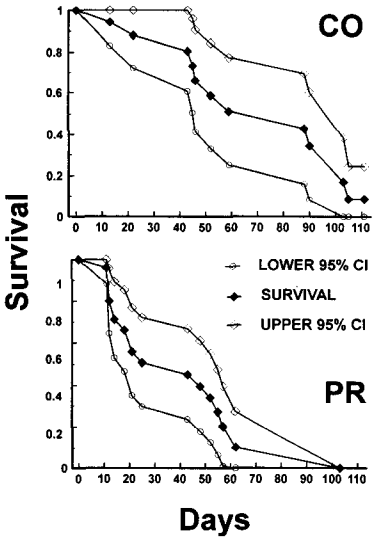

Fig. 1. Product-limit survival estimates for radio-marked Attwater's prairie-chickens in Refugio County, Texas, during 10 March–30 June 1980 and 1981, CO $N = 18$ and PR $N = 25$.

percent ($N = 25$) of mortalities, where the cause was known, were attributed to mammalian predators, 16% were due to avian predators, and 20% were weather-related.

Discussion

Predator indices and number of predators removed from PR suggest that nest predator populations in PR were lower than CO. However, Lutz (1979) noted that predator activity, as indexed by coyote, skunk, and raccoon scat counts along roads, ranked lower in PR than CO in 1978–79. The original study design called for switching the predator reduction and control areas during the second year of the study; however, the small sample of nests in PR during 1980 and concern about residual effect of predator reduction resulted in our continuing with the same areas during the second year. This weakened our inferences about the effect of the reduction program on predator numbers. There were indications that predator numbers in PR were lower in 1981 than 1980, suggesting a residual effect (Lawrence 1982: 49); however, Lutz (1979: 64) noted a significant difference in predator indices in PR between years when predator reduction was not in effect. Duebbert and Kantrud (1974) and Greenwood (1986) noted that the residual effects of predator control were of short duration. Beasom (1974) noted coyotes and bobcats (*Lynx rufus*) increased rapidly to former levels after completion of short-term predator-control program, though indices for smaller predators were erratic throughout his study.

We believe that by removing skunks, opossums, and raccoons, we were focusing on the major nest predators. Although coyotes (*Canis latrans*) were known to prey on Attwater's prairie-chicken nests, no attempts were made to

control coyotes because of the small study areas. A few eggs are taken by snakes (Lutz 1979), but no other nest predator was observed taking Attwater's prairie chicken eggs during the 4 years prior to our study.

Removal of a large number of potential nest predators from PR apparently resulted in increased nest success (82% on PR vs. 33% on CO). Because treatments were not replicated, treatment and site effects may be confounded. However, data collected on these study areas during 1978–79 (calculated from Lutz 1979:47–56), indicated 32% success for nests ($N = 22$) on the area that later became our control site and 35% ($N = 17$) success for nests on the area that became our predator reduction site (Table 2). Lehmann (1941:37) observed 32% ($N = 19$) nest success for Attwater's prairie-chickens in Colorado County, Texas, during 1937–38 and Horkel (1979:55), working on our study area during 1976–77, observed nest success of 42% ($N = 19$). The later mean nest initiation date for hens in CO probably resulted from greater nest destruction during egg-laying. This hypothesis is compatible with the higher nest predation observed in CO.

Breeding season hen survival was lower than the 36% reported by Lutz et al. (1994), data that included the sample of hens from CO during this study. The shape of the survival curves was different between the 2 areas; however, by 30 June survival was low in both areas. Survival estimates may have been biased low (Burger et al. 1991); however, transmitters and attachment techniques were the same as used during other studies on Attwater's prairie-chickens where survival was greater (Lutz et al. 1994). Potential predators (coyotes, white-tailed hawks [*Buteo albicaudatus*], and great horned owls [*Bubo virginianus*]) of adult Attwater's prairie-chickens were observed on both areas, and a great horned owl nested in PR during 1981. Jackrabbit (*Lepus californicus*) and eastern cottontail (*Sylvilagus floridanus*) indices were 3.5 times greater in CO than in PR during 1981 (Lawrence 1982). Coyotes and avian predators may have responded to lower densities of skunks and opossum in PR by increasing predation on jackrabbits, cottontails, and adult prairie-chickens. While most hen mortality was attributed to mammalian predation, the figure for mammalian predation may be biased upwards since some carcasses may have been scavenged.

Table 2. Nest success of Attwater's prairie-chicken in predator-reduction area (PR) and control areas (CO) in the Lake Pasture, O'Connor Brothers' River Ranch, Refugio County, Texas, 1978–1979 (Lutz 1979, no predator reduction) and 1980–1981 (our study).

	1978–1979		1980–1981	
Areas	*N* nests	% successful	*N* nests	% successful
PR	17	35	11	82
CO	22	32	12	33

Predation was not the only variable that influenced prairie-chicken numbers during our study. Flooding dramatically affected productivity during 1981. Following the first major storm, we observed increased mortality of radio-tagged hens. A second major storm apparently eliminated any production that may have resulted from renesting, as no broods were observed after 1 May. Lehmann (1941:32–35) and Horkel (1979:88) also documented loss of nest and broods of Attwater's prairie-chicken to heavy rains.

Management of an endangered species, such as Attwater's prairie-chicken, might require manipulation of predator population levels to favor survival, especially considering the island nature of many habitats that may concentrate both prairie-chickens and predators. We were unable to draw strong inferences about the effect of predator reduction on prairie-chicken nest success; small sample size of nests and unreplicated treatments make our findings equivocal. However, this study will not be replicated due to current low numbers of Attwater's prairie-chickens in the wild. These results may help managers assess the risk of alternative management techniques to increase Attwater's productivity in the wild. There is some indication that adult survival was lower in the predator reduction area, and it may be necessary to control a diverse group of species that prey on both prairie-chicken adults and nests for a control program to be effective.

A predator-reduction program used in conjunction with other management tools such as electric fences around nests to increase nest success (Lokemoen et al. 1982) might prove beneficial for Attwater's prairie-chicken. If techniques, habitats, and captive-reared prairie-chickens become available for reintroduction into the wild, predator reduction may be used at the release site to increase the probability of a successful transplant.

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