THE INFLUENCE OF ENVIRONMENTAL PARAMETERS ON NESTING SUCCESS OF UPLAND GAME BIRDS[a]

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Abstract: Between January 1976 and June 1978, environmental factors were analyzed to evaluate the fate of 480 dummy nests and 38 Attwater's prairie chicken (*Tympanuchus cupido attwateri*) nests. Fifty-eight percent of both dummy nests and Attwater's prairie chicken nests were destroyed by predators. Analysis of these data indicated that nest success was affected by density of nests, proximity of artificial environmental factors to nesting areas, and time of year. Vegetation type appeared to have no influence on predation rates. Predation on nests of ground-nesting upland game birds does not appear to be haphazard or random.

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This study was undertaken to assess the possible effects of environmental parameters (cover type, density of nests, proximity of artificially maintained environmental features, and time of year) on nest success of ground-nesting game birds. Nest loss from numerous causes has long been known to be heavy for ground nesting game birds (Campbell et al. 1973:40). Predatory animals usually account for a substantial proportion of this loss. Henry (1969) concluded that predation on ground-nesting birds was apparently haphazard and the species responsible for predation depended on the relative population of the various predators and the availability of other foods. There is a need to determine if such losses to predation are truly haphazard or if some environmental parameters may be influencing predation rates.

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METHODS AND MATERIALS

The study was conducted on the 6,100-ha Lake Pasture of the O'Connor Brothers Riverside Ranch approximately 29 km northeast of Refugio in Refugio County, Texas. The area was a slightly rolling coastal grassland intersected with two small drainages of intermittent flow. The pasture has always been in native prairie vegetation and has not been burned or fertilized to our knowledge. The area is continually grazed by one animal unit (primarily cow-calf) per 6.5 ha.

Historically, the study area has supported a viable population of Attwater's priarie chicken. An estimated 250-300 chickens utilized the pasture during the study. (Cogar et al. 1977). Spring populations of bobwhite quail (*Colinus virginianus*) were at least double that of the prairie chicken population.

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Field work began in January 1976 and continued to June 1978. The study area was divided into 5 major vegetation types on the basis of species composition, visual obstruction, and vegetation height (Table 1). Visual obstruction and vegetation height were recorded during spring (February-April), summer (May-June), fall (August-October), and winter (November-January) of 1976. Visual obstruction and vegetation height were determined by establishing 28 permanent 60 m transects, chosen subjectively to obtain representative samples of the study area. Steel posts were permanently set at the ends of each transect. A range pole (Robel et al. 1970) was used in making obstruction measurements along the transects. The pole was placed vertically in the vegetation at the zero point and at each subsequent 2 m interval along each transect, and observed from a height of 1 m and a distance of 4 m. Thirty obstruction measurements per transect were made to the closest decimeter or half-decimeter visible on the pole. The vegetation height measurements from each vegetation type were measured at every range pole placement to obtain a mean maximum height per vegetation type.

Table 1. The visually dominant plants within and the percent composition of the five vegetation types in which dummy nests were established on the Lake Pasture, O'Connor Brothers' Riverside Ranch, Refugio County, Texas (after Cogar et al. 1977).

Vegetation type	*Percentage of study area*	*Visually dominant plants*
Spiny aster	2.5	spiny aster (*Aster spinosus*)[a], baccharis (*Baccaris halimifolia*), sumpweed (*Iva frutescens*), and longtom (*Paspalum lividum*)
Cordgrass	4.3	cordgrass (*Spartina spartinae*) and sumpweed
Balsamscale	11.0	balsamscale (*Elyonurus tripsacoides*)
Hardpan	11.2	whorled dropseed (*Sporobolus pyramidatus*), Texas willkommia (*Willkommia texama*), shortspike windmillgrass (*Chloris subdolichostachya*), tassajillo (*Opuntia leptocaulis*), Texas prickly pear (*Opuntia lindheimeri*), and Devils pincushion (*Echinocactus texensis*)
Midgrass	51.6	tall dropseed (*Sporobolus asper*), little bluestem (*Schizachyrium scoparium*), Texas grama (*Bouteloua rigidiseta*), Texas wintergrass (*Stipa leucotrichia*), sumpweed, ruellia (*Ruellia nudiflora*), ragweed (*Ambrosia psilostachya*), broomweed (*Xanthocephalum texanum*), indiangrass (*Sorghastrum neutrans*), and big bluestem (*Andropogon gerardii*).

[a]Common and scientific names follow Gould (1975).

Four hundred-eighty dummy nests were established monthly from March through June 1976, during August, September, and November 1976, and during January, March, and May 1977. Nests (4 pullet eggs) were established in 5 vegetation types: spiny aster, cordgrass, balsamscale, hardpan, and clumped midgrass. Each vegetation type had 16 group nests and 16 single nests. A group of nests consisted of 5 nests, each within 46 m of one another. Single nests were at least 91 m from other nests. In addition, 273 nests were established within 46 m of a road or mown pipeline rights-of-way and 207 were established over 46 m from these features. Because Henry (1969) found predators were attracted by the deterioration of eggs and human disturbance of the nest sites, our nests were visited and collected after 23 days. Undisturbed nests were considered successful.

The fate of nests of radio-tagged Attwater's prairie chickens located on the study areas were determined for the 1976 through 1978 nesting seasons. Prairie chicken nest data were analyzed as to vegetation type, time of year, and proximity to roads or mown pipeline rights-of-ways.

Statistical tests followed methods in Glass and Stanley (1970); all analyses were conducted at a 0.05 level of significance. Chi-square contingency tests were used to determine whether or not difference in nest success (dependent variable) varied within the measured environmental parameters (independent variables).

RESULTS

The mean obstruction indices, mean maximum vegetation height, and number of transects, established for each of the five vegetation types are presented in Table 2. The cordgrass type had the greatest annual obstruction index (6.91) and the greatest mean maximum height (80.6 cm). Hardpan had the least annual obstruction index (1.37 cm) and the smallest mean maximum height (23.8 cm).

Heavy rains flooded 50 nests, 40 to the extent that they were eliminated from further consideration for this paper. Overall, 58.4% of the dummy nests were successful. There was no significant difference in success of nests within different vegetation types (Table 3).

When fates of individual nests within a group were compared with single nests, the data (Table 3) indicated the success of group nests (62%) was greater than that of single nests (39%). However, when considering group nests as a unit, the unit was less (25%) successful (i.e., at least 1 nest destroyed) than were single-placed nests (39%).

Predators destroyed 30% of the nests that were over 46 m from artificially maintained environmental features, whereas significantly more nests (50%) within 46 m of these features were destroyed (Table 3).

Survivial of dummy nests varied significantly by season of year (Table 3). During the spring season, 52% of the nests were successful. Seventy-five percent of summer established nests were successful. Fall nests had a 50% survival rate and success of nests established during winter was 73%.

Dummy nests established in March were more successful than those established in April and May (Fig. 1). However, following the "normal" nesting season for Attwater's priarie chicken, the success of dummy nests again increased (Fig. 1).

Thirty-eight Attwater's prairie chicken nests were located; 7 during 1976, 12 during 1977, and 19 during 1978. The first chicken nest was initiated on 15 March and the last on 4 May. The fate of 36 of these nests was determined: 3 (8.3%) were abandoned, 12 (33.3%) hatched successfully, and 21 (58.3%) were destroyed by predators.

All of the Attwater's prairie chicken nests were located in the midgrass vegetation type. There was no significant difference in the success of these nests with regard to distance from artificially maintained environmental featurs. Successful nests averaged 93.6 m from these features, whereas unsuccessfulnests averaged 92.9 m. The success of nests as related to time the first egg was laid was nonsignificant. Seven of 21 (33.3%) nests in which the first egg was laid during March were successful, whereas, 3 of 10 (30.0%) nests initiated during April and May were successful. Of 5 hens that had their first nest destroyed during March, 2 were successful in bringing off broods with second attempts during April.

Table 2. Mean obstruction indices, mean maximum vegetation height (cm), and number of transects established for the five vegetation types in which dummy nests were established on the Lake Pasture, O'Connor Brothers' Riverside Ranch, Refugio County, Texas (after Cogar et al. 1978).

Vegetation type		*Number of transects*[a]	*Obstruction index* $\bar{X}$[b]	*Obstruction index* *S.D.*	*Vegetation height* $\bar{X}$	*Vegetation height* *S.D.*
Spiny Aster	Spring	2	2.05	1.06	26.6	
	Summer	2	3.06	1.49	41.9	18.0
	Fall	2	4.08	1.45	60.8	18.5
	Winter	2	3.10	1.25	52.1	20.5
	Year	8	3.07	1.96	50.1	22.2
Cordgrass	Spring	1	7.10	1.80	79.7	22.9
	Summer	1	6.22	1.92	80.0	12.2
	Fall	1	7.90	1.61	84.9	24.0
	Winter	1	6.43	1.73	77.8	21.2
	Year	4	6.91	1.87	80.6	20.4
Balsamscale	Spring	2	3.04	1.38	78.9	34.1
	Summer	2	3.27	4.24	61.9	24.5
	Fall	2	4.41	1.19	74.2	23.8
	Winter	2	3.15	1.32	65.3	28.6
	Year	8	3.47	2.44	70.1	28.6
Hardpan	Spring	3	1.17	0.71	24.2	16.1
	Summer	3	1.38	0.64	22.6	12.9
	Fall	3	1.58	0.89	24.8	12.1
	Winter	3	1.34	0.55	23.5	11.8
	Year	12	1.37	0.72	23.8	13.3
Midgrass	Spring	7	2.22	0.76	49.2	20.8
	Summer	7	2.47	0.77	42.9	14.0
	Fall	7	3.42	0.89	55.5	16.1
	Winter	7	2.65	0.85	50.4	18.2
	Year	28	2.69	0.93	49.5	17.9

[a]N is 30 (number of observations per transect) times the number of transects.
[b]Large index number implies high obstruction of vision.

DISCUSSION

Early in the study we hypothesized that Attwater's prairie chickens may be nesting in a vegetation type that offered the greatest chance of nest success. However, even though all chicken nests were located in the midgrass vegetation type, our dummy nest study indicated that there was no difference in predation rates between the various vegetation types compared. The obstruction of vision and height of the vegetation in these types were not correlated with dummy nest success or location of Attwater's prairie chicken nests.

Contrary to our observations, Chesness et al. (1968) observed that predation was highest among poorly concealed pheasant (*Phasianus colchicus*) nests in Iowa. Klimstra and Roseberry (1975:28) thought that the different rates of predation on bobwhite quail

Table 3. Fate of dummy nests as influenced by vegetation type,density of nests, distance from artificially maintained environmental features, and season of year for the Lake Pasture, O'Connor Brothers' Riverside Ranch, Refugio County, Texas, 1976-1977.

Environmental parameter	*Nest fate* *Successful* *N*(%)	*Unsuccessful* *N* (%)	*Total*
Vegetation type			
spiny aster	47(56)	37(44)	84
cordgrass	57(70)	23(30)	81
balsamscale	48(53)	43(47)	91
hardpan	50(53)	45(47)	95
midgrass	55(62)	34(38)	89
Density			
grouped	228(62)	139(38)	367
single	29(39)	44(61)	73
Distance			
less than 46 m	126(50)	127(50)	253
greater than 46 m	131(70)	56(30)	187
Season			
spring	146(52)	133(48)	279
summer	53(75)	18(25)	71
fall	36(60)	24(40)	60
winter	22(73)	8(27)	30

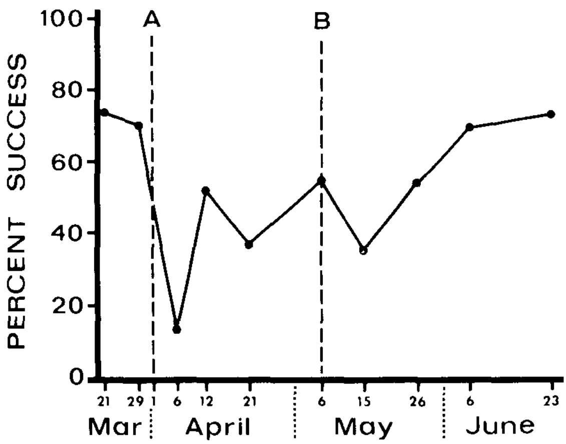

Fig. 1. Percent success of dummy nests during the spring (February-April) and summer (May-June) seasons on the Lake Pasture. O'Connor Brothers' Riverside Ranch, Refugio County, Texas 1976-1977 (Mean initiation date of Attwter's prairie chicken nests, A and mean hatch date, B).

nests in Illinois probably reflected differential utilization of the habitats by predators. Cogar et al. (1977) indicated that the majority of Attwater's prairie chicken activities occurred in the midgrass vegetation type. It may be that nests are established in the midgrass type not because of differential selective pressures due to predation, but because other necessary requirements may be more available in this type.

Individual dummy nests placed in groups of 5 were more successful than those placed as single nests while the group as a unit was less successful than single-placed nests. Predators apparently located grouped nests more readily than single-placed nests; however, after finding a single nest of a group, they apparently failed to search the immediate area for other nests. Small predators may become satiated after feeding on 4 hen eggs or the scent of the destroyed eggs may deaden the predators' abilities to scent other eggs for short periods until the animal has left the general vicinity of the grouped nests.

Tinbergen (1960) noted that when a prey species was low in density, predators lacked a searching image for the prey. He observed that when prey density is low, predatory consumption is lower than would be expected. At moderate densities, predation is unexpectedly high, and at high densities, predation drops again. At high densities, the predators become satiated or stopped using that prey. Boggess et al. (1978) noted that predator losses might be more a function of prey availability than of predator density.

The greater success of dummy nests placed more than 46 m from roads and mown pipeline rights-of-way indicated that predators may be using such features as travel lanes, centers of activity, and/or as areas for greatest hunting activity. Because these features provided convenient travel lanes, areas close to these lanes may have received more predator activity than surrounding areas. It is also conceivable that predators may hunt these areas more often because of the abundance of other food associated with these openings (edge effect) in the prairie vegetation. Small predators such as opossum (*Didelphus virginiana*), raccoons (*Procyon lotor*), skunks (*Mephitis mephitis*), and armadillos (*Dasypus novemcinctus*) were seen using culverts associated with rights-of-way as den sites. Hunting activity may be associated with areas in close proximity to these dens.

Klimstra and Roseberry (1975) suspected that nests along fencerows might be especially vulnerable because fences provided travel lanes for predators, however, their data did not substantiate their conjecture. Chesness et al. (1968) noted that many of their destroyed nests were in road ditches and narrow fencerows used as travel lanes by predators.

It appeared that predators were more successful at locating nests during the spring than during other quarters of the year. However, during the spring, dummy nests established early were more successful than those established later. These data indicated that predators may develop a searching image (Tinbergen 1960). Tinbergen (1960) noted that when a new species (in our case eggs) appears in a given area, its risk of becoming prey is low at first. At this early stage predators had not developed a searching image for that species. Once the predator acquired the image for the prey, intensity of predation increased suddenly.

Robel (1970) working in Kansas noted that greater prairie chicken (*Tympanuchus cupido pinnatus*) nests initiated before 1 May experienced greater success than nests started later. Baker (1953:28) also found that the majority of young greater prairie chicken produced each year in Kansas resulted from early nests. Klimstra and Roseberry (1975) reported that in Illinois, only 21.3% of the early season bobwhite quail nests were destroyed, as compared to 30.8% of the midseason nests and 45.3% of the late season nests. However, Chesness et al.(1968) noted that predation on pheasant nests was most severe early in the nesting season, nests established on 1 May as opposed to mid-May. They also found that the influence of the various species of nest predator changed with season. Avian predators dominated early nest destruction while mammals destroyed the majority of late nests.

There is the possibility that energy requirements for predators may be higher during the spring because of the reproductive requirements of the predators. Klimstra and Roseberry (1975:28) thought that this was true for skunks and foxes in Illinois. Boggess et al. (1978:370) noted that the increased energy demands of coyotes when the pups were growing rapidly might have led to heavier sheep losses in Iowa.

Because of small sample size, nests of Attwater's prairie chicken failed to support much of the data obtained from the dummy nest study. However, we did find that predation rates of dummy nests (58%) and those of the prairie chicken (58%) were equal.

The relative importance of individual predators was difficult to assess because individual predator sign was not always left at the nest site. Originally, we thought that individual predators could be determined by the manner in which the eggs were destroyed. After testing with predators at a local zoo, we concluded that there was too much individual variation within a predator species to differentiate between predators on method of egg entry alone.

SUMMARY AND CONCLUSIONS

During January 1976 through June 1978 a study of the effects of environmental parameters on the nesting success of upland game birds yielded data on 480 dummy nests and 38 Attwater's prairie chicken nests. Analysis of these data as to reasons of predation provided the following conclusions:

1. Although predator density plays an important role on the success of ground nesting game birds, there are other environmental factors that contribute to nest failure.
2. Results from dummy nests indicated vegetation type had no effect on predation rates.
3. Nests grouped in small areas appear to have greater individual survival than did widely spaced single nests.
4. Features such as roads, pipeline rights-of-ways, and fencerows that disturb the natural nesting cover of ground nesting game birds appear to add to nest failure. The mechanism(s) behind this failure is as yet unclear, but these features may provide travel lanes, den sites, and/or edge effect that concentrates prey and therefore predators.
5. Early spring nests have a greater chance of survival than do those laid later in the spring. This may be due to the delayed development of an early spring nest searching image by predators following a fall and winter period without positive reinforcement of finding active nests.
6. Predation on nests of ground nesting upland game birds does not appear to be haphazard or random. Predation is a result of a combination of several environmental factors.

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