

Influence of nest concealment and distance to habitat edge on depredation rates of simulated grassland bird nests in southeast Kansas

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Many features appear to influence avian nest success, and nest concealment and distance to habitat edge are among the most influential. We placed simulated bird nests baited with House Sparrow (*Passer domesticus*) eggs in two riparian grasslands to document the influence of these two habitat characteristics on nest depredation rates. Over three trials, 49% of nests ($n = 105$) were depredated with a mean daily survival rate of 0.908 (± 0.012 SE). Side and overhead concealment of depredated and undisturbed nests did not differ in any consistent manner, and logistic regression models indicated that nest fate was not influenced by the amount of vegetative concealment surrounding a nest. Depredated simulated nests were closer to habitat edges than undisturbed nests during only one of three trials, suggesting nest depredation was not strongly influenced by habitat edges. Our results indicate that in simulated grassland bird nests baited with sparrow eggs, concealment may be more influential on nest fate than distance to habitat edges. We recommend that future studies of simulated songbird nests use songbird-sized eggs to insure that the potential suite of nest predators is sampled by simulated nests.

Keywords: distance to edge, grassland, nest concealment, nest success, simulated bird nest.

INTRODUCTION

Avian nest success is influenced by many factors. The influence of habitat characteristics on nesting success is of particular interest because these factors can be manipulated by managers to provide suitable breeding habitat (Martin 1992). Of the habitat characteristics believed to influence nest success of songbirds, nest concealment and distance from habitat edges are among the most influential (Sugden and Beyersbergen 1987; Martin and Roper 1988; Paton 1994). Simulated bird nests baited

with quail-sized (*Coturnix* spp.) eggs have been used in most studies investigating these factors in grasslands (Mankin and Warner 1992; Burger, Burger and Faaborg 1994; Clawson and Rotella 1998; Ardizzone and Norment 1999) because they allow researchers to control nest density, nest placement, and other factors that may vary among natural nests. The use of quail-sized eggs, however, appears to exclude gape-limited nest predators such as rodents (Haskell 1995; DeGraaf and Maier 1996; Maier and DeGraaf 2000). Given that small mammals are believed to be important

predators of songbird nests in grasslands (Pietz and Granfors 2000) and that most species of grassland-nesting songbirds produce eggs that are smaller than quail-sized eggs (Baicich and Harrison 1997), it is important to understand the influence of nest concealment and distance from habitat edge on depredation rates of simulated bird nests baited with appropriate, songbird-sized eggs.

In this study, we used simulated bird nests baited with House Sparrow eggs (*Passer domesticus*, hereafter sparrow) to document the influence of two habitat characteristics on depredation rates. Specifically, we examined whether the fates of simulated nests were influenced by the amount of vegetative concealment surrounding nests and whether depredated nests were located closer to habitat edges than undisturbed nests. We predicted *a priori* that simulated nests with greater concealment would experience lower depredation rates and that depredated nests would be located closer to habitat edges than undisturbed nests.

Methods

Experimental trials were conducted during the 1998 breeding season on the Flint Hills National Wildlife Refuge (NWR) located along the Neosho River in Coffey County, Kansas (N38°19', W95°56'). Two riparian grasslands 0.7 km apart and adjacent to the Neosho River were selected for nest trials because they were similar in size (site A = 15.25 ha, site B = 16.50 ha) and were large enough to accommodate an adequate number of simulated bird nests at natural densities. Both sites were dominated by reed canary grass (*Phalaris arundinacea*), while switchgrass (*Panicum virgatum*), Johnsongrass (*Sorghum halpense*), and several forbs occurred in limited numbers. Potential nest predators on the Flint Hills NWR include the Blue Jay (*Cyanocitta cristata*), American Crow (*Corvus brachyrhynchos*), Virginia opossum

(*Didelphis virginiana*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), hispid cotton rat (*Sigmodon hispidus*), and several other murids (U.S. Fish and Wildlife Service 2000). In addition, several species of snakes believed to prey upon bird nests occur in Coffey County (Collins 1993). Logistical constraints prevented quantification of potential nest predators on study sites.

Three nest trials were conducted in 1998: 25 May - 4 June, 20 June-30 June, and 13 July-23 July, representing the early, middle, and late nesting periods of grassland birds in the Flint Hills region of Kansas (Zimmerman 1983). During each trial, 20 simulated bird nests were placed on each site to mimic nest densities of the Dickcissel (*Spiza americana*), an abundant, locally breeding grassland species (Zimmerman 1983). Before nest trials began, each study site was demarcated with pin flags into a grid of 50 x 50 m cells by establishing parallel transects 50 m apart along north-south (y-dimension) and east-west (x-dimension) bearings. In total, 66 cells on Site A and 61 cells on Site B were established. To place nests, a two-stage random design was used. First, 20 cells (*i.e.* 50 x 50 m) were selected randomly from the pool of available cells on each site during each trial. Random x- and y-dimension coordinates were then chosen within each selected cell to serve as the location of each nest.

Each 10-day nest trial contained an initial 3-day pre-treatment period followed by 7-day exposure period. For each trial, 40 new simulated bird nests (20 nests/site) were constructed from 6 x 10 cm sections of weathered chicken wire molded into open cups and lined with grass litter. In the afternoon of the first day of each trial, simulated bird nests without eggs were placed ~5 cm off the ground at the base of bunchgrasses and left for 3 days to mimic the

nest-building phase of the Dickcissel. A pin flag, identical to those used to grid fields, was positioned 10 m from each nest in either a north or south direction to facilitate nest relocation. Three days after the initial placement, two fresh sparrow eggs were added to each simulated bird nest and exposed for 7 days. After 7 days of exposure, nests were checked and their fates recorded. Nests were considered depredated if one or both eggs were disturbed, broken, or missing. The 7-day exposure period was chosen because it is unclear whether eggs exposed for longer periods may become putrid and bias results (Leimgruber, McShea and Rappole 1994). Because we wanted to compare depredation rates from simulated bird nests to natural nests we also searched for natural Dickcissel nests on study sites. Nest searching took place throughout the breeding season, but we did not search for nests during simulated nest trials to avoid undue disturbance to study sites. Unfortunately, few Dickcissels bred on study sites in 1998, making the results of comparisons between simulated and natural nests limited.

To examine the influence of local factors on depredation rates, we quantified the vegetative concealment surrounding each nest and measured the distance between each nest and the nearest habitat edge. Immediately after determining the fate of each simulated bird nest vegetative concealment was measured with a cover box. The cover box was a cube, 10 cm on a side, that fit over simulated bird nests *in situ* and provided a relative measure of concealment from each cardinal direction and from directly overhead. Each face of the cover box (*i.e.* N, E, S, W, and overhead) was divided into four quadrants and each quadrant was given a score of 1 (0-25% concealed by vegetation), 2 (26-50%), 3 (51-75%), or 4 (76-100%) by a single observer (JWR). Thus, the score of each face could range from 4 to 16. All cardinal-direction measurements were made 1 m from the simulated bird nest at a height of 1 m. Overhead concealment was

measured facing north at a height 1 m directly above the cover box. For analysis, cardinal-direction measurements were averaged to provide a mean measure of side concealment. Distances to nearest habitat edges were measured after all nest trials were completed to avoid undue disturbance to study sites. Habitat edges were defined as a change in habitat from either natural (*i.e.* wetland, forest) or anthropogenic factors (*i.e.* cropland, secondary road).

Several precautions were taken to reduce the impact of human scent on eggs and simulated bird nests (Whelan *et al.* 1994). All eggs were washed in local wetlands prior to placement to reduce unnatural scents that may have accumulated on eggs; after washing, only latex gloves were used to handle eggs. Simulated bird nests were handled with latex gloves at all times and rubber boots were worn when placing eggs and nests. After each trial, all eggs, shell fragments, and simulated bird nests were removed from each study site. In addition, care was taken to walk in irregular patterns and to avoid making dead-end trails when placing nests to avoid providing clues to potential nest predators as to the location of simulated bird nests.

Proportions, standard errors, and 95% confidence intervals (CI) were calculated for depredation rates using standard formulas for simple random samples (Tryfos 1996). Because the grid squares of each study site comprised a finite population, the program SUDAAN (Shah, Barnwell and Bieler 1997) was used to calculate variance estimates. To calculate estimates of daily survival, the Mayfield method was used (Mayfield 1975; Johnson 1979). Logistic regression analysis was used to examine the influence of vegetative concealment on nest fates. For each trial on each site, the influence of habitat edge on nest loss was analyzed using a permutation test with the null hypothesis that there was no difference between the mean distance to habitat edge for depredated and

undisturbed nests. Thus, distance measurements from the nearest habitat edge to each nest were permuted for all nests, regardless of fate, for each of 1000 permutations. We then tested the results of permutations against the observed data using Resampling Stats (1995).

Results

Of 120 simulated bird nests, 6 were destroyed by flooding and 9 could not be relocated; those 15 nests were excluded from all analyses. In the remaining nests, a pronounced difference existed in the proportion of nests preyed upon between the first and subsequent trials (Table 1). In the first trial, depredation took place on only 22.9% (± 6.1 SE, $n = 35$) of nests but this increased to 59.4% (± 7.6 SE, $n = 32$) for the second trial and to 63.2% (± 6.6 SE, $n = 38$) for the last trial. Overall, 49% (± 4.2 SE, $n = 105$) of nests were depredated, and daily survival rates of simulated bird nests averaged 0.908 (± 0.012 SE, total exposure days = 556.5). Six of seven natural Dickcissel found on the study site fledged at least one young (total exposure days = 76); the seventh nest was abandoned for unknown reasons.

Logistic regression revealed that depredation rates were influenced inconsistently by the amount of vegetative concealment surrounding nests among sites and trials. Of the 6 models for side cover (*i.e.* 2 sites over 3 trials), only Trial 2 on Site B suggested side cover influenced depredation rates ($B_1 = -0.071$, $P = 0.081$). Of the 6 models for overhead cover, four models indicated depredation rates were influenced by this metric: Trial 1, Site A ($B_1 = -1.93$, $P = 0.061$); Trial 2, Site A ($B_1 = 2.38$, $P = 0.031$); Trial 1, Site B ($B_1 = -0.35$, $P = 0.022$); and Trial 3, Site B ($B_1 = -0.35$, $P = 0.073$). In addition to logistic regression models, mean side and overhead concealment measures were also inconsistent among depredated and undisturbed nests (Fig. 1). Permutation tests

Table 1. Depredation rate (nests depredated/total nests), standard error (SE), and 95% confidence intervals (CI) of simulated bird nests placed in two riparian grasslands during the 1998 breeding season.

Site A			
Nest Trial	% depredated (SE)	95% CI	n
1. 25 May-4 June	18.8 (8.8)	0.1, 37.4	16
2. 20-30 June	58.8 (10.6)	35.3, 81.3	17
3. 13-23 July	57.9 (9.8)	37.3, 78.5	19

Site B			
Nest Trial	% depredated (SE)	95% CI	n
1. 25 May-4 June	26.3 (8.6)	8.2, 44.4	19
2. 20-30 June	60.0 (11.4)	35.6, 84.4	15
3. 13-23 July	68.4 (9.1)	49.3, 87.5	19

revealed that the mean distance to the nearest habitat edge did not consistently influence the fate of simulated nests. During the Trial 2, depredated nests were closer to habitat edges than undisturbed nests for Site A (mean distance to edge for depredated nests = 49.4 m, mean distance to edge for undisturbed nests = 91.7 m, $P = 0.018$) and Site B (mean distance to edge for depredated nests = 64.9 m, mean distance to edge for undisturbed nests = 87.7 m, $P = 0.084$). However, no differences were found during Trial 1 or Trial 3 on either site ($P > 0.20$ for all tests).

Discussion

Results from this experiment indicate that habitat characteristics had no consistent influence on the fates of simulated bird nests baited with sparrow eggs. Logistic regression models were inconsistent in predicting the influence of vegetative concealment on

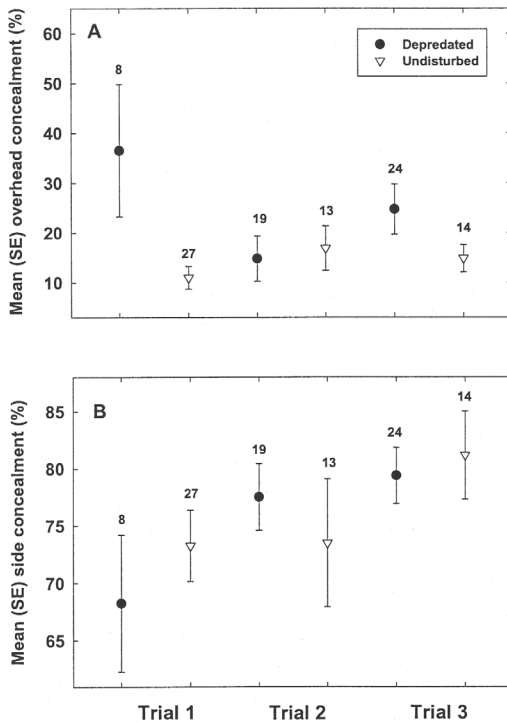


Fig. 1. (A) Mean (\pm SE) overhead concealment scores for depredated (closed circles) and undisturbed (open triangles) nests combined from sites A and B. (B) Mean (\pm SE) side concealment scores for depredated (closed circles) and undisturbed (open triangles) nests combined from sites A and B. Numbers of nests measured are indicated above error bars.

depredation rates, and no clear differences were found in mean nest concealment for depredated and undisturbed nests. However, nest depredation rates increased temporally, suggesting that nest predators on study sites may have learned to associate human disturbance on study sites with the locations of simulated bird nests. Although possible, this seems unlikely for several reasons. First, many precautions were taken during nest and egg placement to limit human disturbance to study sites (see Methods). Moreover, neither study site was visited during simulated nest trials to minimize the role of human disturbance as a factor influencing depredation rates. In addition, if learning was the most important factor influencing

depredation rates, we would expect that depredation rates would increase with each new trial. Depredation rates increased markedly from the first trial, yet they were similar during the last two trials (Table 1). This finding, coupled with an examination of the egg predators on Flint Hills NWR that were most likely to depredate nest suggests that learning probably played a minor role in influencing the temporal pattern of nest depredation. Egg predators found on the Flint Hills NWR depredate nests randomly (snakes; Fitch 1963), or incidentally (skunks; Vickery, Hunter and Wells 1992); avoid tall, dense, vegetation when foraging (corvids; Sugden and Beyersbergen 1987); or occupy small home ranges (small mammals; Cameron and Spencer 1981) relative to simulated bird nest densities. Collectively, these factors suggest that learning by predators probably played a minor role influencing depredation rates on our study sites.

Alternative explanations for the inconsistent influence of concealment suggests that nest predators were not affected by nest concealment, nest concealment was measured at an inappropriate scale, or both. For example, predators that depredate nests incidentally (skunks; Vickery, Hunter and Wells 1992) or which are likely to perceive their habitat on a fine scale (small mammals; Zollner and Lima 1997) may not have been influenced by our quantification of nest concealment. In particular, our quantification of nest concealment was probably not appropriate for small mammals, an important group of eggs predators in grasslands (Pietz and Granfors 2000). Indeed, our observations of grass clippings found in several depredated nests provide circumstantial evidence that cotton rats, known nest predators (Ettel, Buehler and Houston 1998), were responsible for depredating nests (but see Larivière 1999). Nevertheless, because nest predators could not be indexed we can only speculate on the role of small mammals in influencing depredation rates.

On both study sites, depredated nests were closer to habitat edges than undisturbed nests for the second nest trial, but not for the first or last trial. These results are concordant with several studies of simulated nests that have found inconsistent evidence for edge effects in grasslands (Mankin and Warner 1992; Clawson and Rotella 1998; Ardizzone and Norment 1999). In contrast, Burger, Burger and Faaborg (1994) found that simulated bird nests within prairie fragments near wooded edges (<60 m) had consistently higher depredation rates than those located away from edge habitats; however, their results may be biased because the density of simulated bird nests was not controlled for the area sampled. Collectively, these data suggest that edge effects in grasslands may be influenced by an interaction of local characteristics and broader scale factors such as landscape context, regional predator communities, or the scale of analysis (Donovan *et al.* 1997; Winter, Johnson and Faaborg 2000).

The lack of consistent effect of nest concealment or distance to edge in this and other studies suggest that the influence of these habitat characteristics vary in part due to the ecology of nest predators. For example, the foraging efficiency of a medium-sized predator may be decreased by well-concealed nests that could lead to reduce rates of nest depredation. In contrast, small mammals may be more likely to depredate well-concealed nests if the concealment offers protective cover from secondary predators, such as raptors. Thus, the influence of habitat edge will also differ based on the variation in nest predator ecology (Chalfoun, Ratnaswamy and Thompson 2002). Based on these results, we recommend that researchers examining the influence of habitat characteristics on songbird nests focus additional efforts to quantify the predator or group of predators perceived to be most influential on nest success.

As one of the first attempts to use sparrow-sized eggs in simulated bird nests in grasslands, it is not yet clear whether our findings can be generalized to similar habitats. Nevertheless, we suspect that using simulated bird nests baited with sparrow-sized eggs will provide better estimates of the influence of habitat characteristics on nest success in grasslands because larger, quail-sized eggs appear to preclude depredation by some species in other habitats (DeGraaf and Maier 1996; Maier and DeGraaf 2000). Use of appropriate-sized eggs and a focus on the predators that are believed to be most influential on nest depredation rates in future studies should lead to a better resolution of the influence of habitat characteristics on nest success.

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