

THE EFFECT OF SUPPLEMENTAL PREY AND PRESCRIBED FIRE ON SUCCESS OF ARTIFICIAL NESTS

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Abstract: Nest predation hinders recruitment of avian species and may be affected by availability of alternative prey and amount of nesting cover. Therefore, we evaluated effects of food abundance (i.e., supplemental prey) and time since prescribed fire on nest success of artificial ground nests. We monitored the fate of 759 artificial ground nests from June to July 2000. No interaction ($P = 0.74$) occurred between fire and supplemental prey treatments. Nest success in prey-supplemented plots (37.6%) did not differ ($P = 0.70$) from control plots (44.9%), and nest success in burned plots (41.8%) did not differ ($P = 0.86$) from nonburned plots (40.7%). Motion-sensitive cameras placed on feeders revealed that mesomammals accounted for >80% of visits to feeders, indicating that supplemental prey was detected and consumed by mesomammals. Nest predators differed as a function of food abundance, with combined avian and small-mammal predation being greater in prey-supplemented (46.5%) than in control (25.9%) plots. Nest predators also differed as a function of prescribed fire. Avian predation of nests was greater in burned (13.7%) than nonburned (9.9%) plots, whereas small-mammal predation was greater in nonburned (30.9%) than in burned (15.1%) plots. Altering food and cover to manage nest success may result in compensatory predation. Further work to quantify the extent of compensatory predation is needed to fully understand trade-offs of various practices for managing nest predation.

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Nest predation limits avian productivity (Ricklefs 1969, Martin 1992). Predation-management approaches often concentrate on suppressing predator populations to alleviate the impact of predation on specific prey species (Greenwood 1986, Cote and Sutherland 1996). Others have suggested managing predation through habitat manipulation (Clark et al. 1996) or altering food availability to predators (Vander Lee et al. 1999). Managing for dense nesting cover may hinder movement of mesomammals, reduce olfactory detection of nests, and conceal nests from visual predators such as corvids, potentially increasing nest success (Clark et al. 1996). However, compensatory predation may occur because many small mammals prefer dense ground cover (Choromanski-Norris et al. 1989, Landers and Crawford 1995).

Managing vegetation with fire is a common practice in the southeastern United States (WalDROP et al. 1992), and prescribed burning is an important land-management tool. It is used to maintain native ground-cover vegetation and to control hardwood encroachment (Cain et al. 1998). Thus, prescribed fire encourages early-successional habitats and provides nesting cover,

brood-rearing habitat, and escape cover for numerous ground-nesting birds in the Southeast (Dickson 1981, Hurst 1981, Landers 1981). Judicious prescribed burning also creates diverse vegetation structure and dense herbaceous ground cover (Brockway and Lewis 1997) while increasing forage quality and quantity (Crawford 1984), but prescribed fire initially reduces cover and may increase susceptibility of prey to predation (Whelan 1995). Any negative effects that immediately follow prescribed fire are likely offset by benefits within fire-dependent communities. For example, Johnson and Temple (1990) observed greater nesting success in tallgrass prairie that had been burned during the previous 1–3 years. They recommended burning at least every 3 years to increase nesting success in this region. However, our knowledge of the effects of prescribed fire on avian nest success in fire-maintained forests is limited.

Food availability also alters predator–prey relationships (Rusch et al. 1972, Pehrsson 1986), yet this relationship has received little experimental study. Schmidt (1999) used foraging theory to model nest predation as an interaction between predator and prey. He predicted that increasing abundance of alternative foods would decrease nest predation. He also predicted that predation rates would be influenced by nest-site character-

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istics through changes in nest recognition time and encounter rates. We directly tested his prediction regarding nest success and alternative prey abundance and indirectly tested his prediction of nest success relative to nest-site characteristics as impacted by prescribed fire. Our objectives were to determine the effect of food availability and effect of nesting cover on survival of artificial ground nests. We tested the hypothesis that nest survival would increase as a result of providing supplemental prey for predators. In addition, we related nest success to time since prescribed fire to explore the relationship between cover and nest success.

STUDY AREA

Our study took place in Baker County, Georgia, on Ichauway, a former hunting plantation and current research facility of the Joseph W. Jones Ecological Research Center. This 11,700-ha ecological reserve had 1 of the most extensive tracts of privately owned longleaf pine (*Pinus palustris*) in the Southern Coastal Plain. Natural loblolly pine (*P. taeda*) stands, slash pine (*P. elliotti*) flatwoods, and mixed hardwoods (*Quercus* spp.) were patchily distributed throughout the longleaf pine forest. Wiregrass (*Aristida beyrichiana*) and old-field grasses (e.g., *Andropogon* spp.) dominated the understory (Goebel et al. 1997). Plant species richness was high, with >1,000 vascular plant species documented on the property (Drew et al. 1998).

Topography was flat to gently rolling, with elevation ranging from 30 to 100 m (Beck and Arden 1983). Ichawaynochaway Creek bisected the property, while the eastern boundary of Ichauway was the Flint River. The climate was subtropical with mild, short, wet winters and humid, hot summers (Lynch et al. 1986). Average temperatures ranged from 11 °C in winter to 27.5 °C in summer. Annual precipitation averaged 131 cm (Goebel et al. 1997); however, drought conditions existed during 1998–2000.

Prescribed fire and wildlife food plots were prominent management practices on Ichauway. Most of Ichauway was burned by prescription on a 2-year rotation to reduce hardwood encroachment and fuel accumulation while enhancing herbaceous ground cover and wildlife habitat. Widely scattered food plots consisting of grain sorghum (*Sorghum vulgare*), Egyptian wheat (*Sorghum* spp.), brown top millet (*Brachiaria ramosa*), cowpea (*Vigna* spp.), corn (*Zea mays*), and winter wheat (*Triticum aestivum*) made up approximately one-fifth of the property.

METHODS

We used artificial nests to evaluate the effect of supplemental prey and prescribed fire on predation rates. Artificial nests permit controlled experiments (Major and Kendal 1996, King et al. 1999) and do not require the time needed to locate and monitor natural nests (King et al. 1999). However, we approached this experiment with the understanding that artificial nest experiments yield only an index of actual predation rates (Keyser et al. 1998).

Ichauway was divided into 177 burn units surrounded by roads. We randomly selected 28 burn units (i.e., plots) for study with the constraint that all plots must be separated by ≥ 1 km. Plots ranged in size from 7.7 ha to 62.7 ha. The open canopy of the longleaf pine overstory contributed to a dense herbaceous understory, and regular prescribed fire minimized hardwood encroachment within all sampled plots. Basal area of sampled plots ranged between 11 and 19 m²/ha. We planned to assign equal replication to the 2-way factorial arrangement of feeding and burning treatments, but this was not achieved because we were unable to burn 2 plots. Sixteen plots (9 prey-supplemented, 7 control) were not burned the previous year, whereas only 12 (5 prey-supplemented, 7 control) were burned February–April prior to sampling.

We provided commercial dry dog food ad libitum as supplemental feed (Vander Lee et al. 1999). We used weatherproof feeders with an opening to dispense food. We attached an open can of cat food to the feeder to serve as a scent attractant. Because predators travel along edges and roads for foraging and traveling (Small and Hunter 1988), we placed feeders along roads at 200-m intervals around experimental plots. We kept the number of feeders per unit perimeter constant to ensure that the probability of a predator encountering a feeder was equal among prey-supplemented plots. We began feeding on 25 May 2000, 3 weeks prior to artificial nest placement, and continued throughout the sampling period.

We placed artificial nests from 15 June to 8 July, well within the nesting season for the region. Each artificial nest consisted of 2 Japanese quail (*Coturnix coturnix*) eggs and 1 wax-covered wooden egg. Because small-mammal predators are unable to penetrate the quail egg shell (Ettel et al. 1998), the wax-covered wooden egg helped us to identify predators by tooth and beak marks.

We constructed nests by creating a slight depression in the ground and placing eggs in this depres-

sion. Prior to nest placement, we pressed a nail into the ground in the middle of the depression. A metal detector allowed for positive determination of nest fate through relocation of the nail. We made no attempt to conceal the nest beyond cover provided by the immediate surroundings (Mankin and Warner 1992). We washed all quail eggs in pond water to eliminate scent, and we wore rubber boots and gloves to limit human-scent contamination during nest placement.

Because an inverse relationship may exist between nest density and nest success (Bergerud 1988, Picman and Schriml 1994), we placed nests at a density of 1 nest/ha to maintain constant density of artificial nests within each plot. We placed transects parallel to the major axis of the sampled plot. We placed nests at 30-m intervals along transects, and we ensured that all nests were ≥ 100 m from an edge. We placed a flag 15 m away from each nest to facilitate nest relocation. We returned to nests 7 days after placement and considered a nest depredated if any of the quail or wax eggs were damaged, missing, or out of the nest.

We used infrared, motion-sensitive 35mm cameras (TrailMaster® Infrared Trail Monitors; Goodson & Associates, Lenexa, Kansas, USA) to photograph visitation at the feeders. We placed cameras opportunistically on feeders that appeared to have the most predator visitation based on food consumption. We routinely checked cameras to ensure proper functioning. We replaced film as needed and moved cameras weekly to ensure thorough sampling of regularly used feeders.

We used a general linear model (GLM procedure; SAS Institute 1990) to determine whether predation rates differed among treatments. We used a completely randomized design and a 2-way analysis of variance (ANOVA) with supplemental feeding (prey-supplemented or control) and burning (burned or nonburned) serving as main effects. We included both main effects and their interaction in the model. Plots ($n = 28$) were considered the experimental unit of analysis with the proportion of successful nests within a plot being used as the response variable. Nest success was arcsine-transformed to meet assumptions of ANOVA (Zar 1984).

We analyzed wax eggs separately to determine whether nest predators differed among treatments. We partitioned nest predators into 3 categories: mesomammal, avian, and small mammal. We classified missing wax eggs as unknown. We performed 2-way contingency tables and separate chi-square tests for the main effects of feeding and burning.

RESULTS

We placed 791 nests during summer 2000. Thirty-two nests were not relocated and were excluded from analysis. Overall nest success ($\bar{x} \pm SE$) was $41.2 \pm 4.6\%$. No interaction occurred between supplemental prey and fire ($F_{1, 24} = 0.11$, $P = 0.74$). Nest success did not differ ($F_{1, 24} = 0.15$, $P = 0.70$) between prey-supplemented ($37.6 \pm 7.1\%$) and control ($44.9 \pm 6.8\%$) plots. We detected no difference ($F_{1, 24} = 0.03$, $P = 0.86$) in nest success between burned ($41.8 \pm 7.5\%$) and nonburned ($40.7 \pm 6.4\%$) plots.

Of 442 depredated nests, 136 wax eggs were not disturbed. Wax eggs were missing from 135 of the depredated nests, while 24 wax eggs had been moved. Forty-five wax eggs were completely melted and were eliminated from further analysis.

Predator sign was identifiable on wax eggs in 102 depredated nests. Small-mammal predators accounted for 67 (65.7%) of the identifiable marks, while avian predators accounted for 28 (27.4%). Mesomammals accounted for 7 (6.9%) of the identifiable marks; thus, their marks were excluded from further analysis due to small sample size.

Nest predators differed ($\chi^2_2 = 11.4$, $P = 0.003$) between prey-supplemented and control plots, with birds and small mammals depredating a higher proportion of nests in prey-supplemented plots and unknown predators depredating a higher proportion of nests in control plots (Fig. 1). Nest predators also differed ($\chi^2_2 = 6.85$, $P = 0.033$) between burned and nonburned plots, with small mammals depredating a higher proportion of nests in nonburned plots and unknown predators and birds depredating a higher proportion of nests in burned plots (Fig. 2).

We photographed 541 potential nest predators at feeders. Mesomammals accounted for >80% of

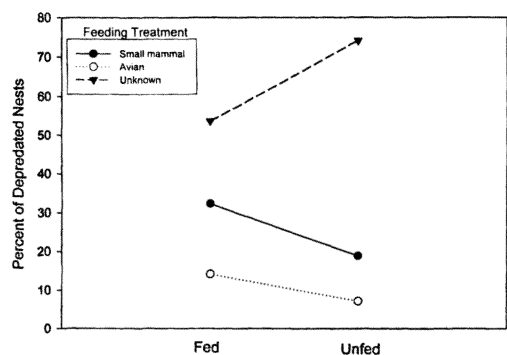


Fig. 1. Percentage of artificial nests depredated by 3 predator assemblages relative to presence or absence of supplemental prey, southwestern Georgia, USA, Jun–Jul 2000.

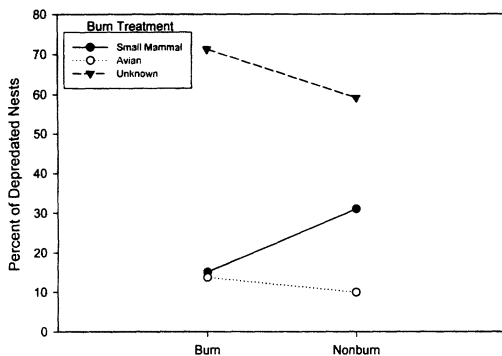


Fig. 2. Percentage of artificial nests depredated by 3 predator assemblages relative to presence or absence of prescribed fire, southwestern Georgia, USA, Jun–Jul 2000.

photographs. Raccoons (*Procyon lotor*) and opossums (*Didelphis virginiana*) were principal users of feeders, with 296 and 155 photographs taken, respectively. Of the remaining 90 photographs, crows (*Corvus* spp.) accounted for 81, blue jays (*Cyanocitta cristata*) accounted for 8, and 1 photograph was taken of a striped skunk (*Mephitis mephitis*). Most photographs were of a single animal at the feeder, although multiple raccoons and crows were occasionally photographed.

DISCUSSION

We found no effect of food abundance on artificial nest success in our study; thus, we found little support for Schmidt's (1999) hypothesis. However, we did not provide prey-supplementation to the entire suite of nest predators (i.e., we did not provide supplemental food to small mammals). If we had provided alternative prey to all predators, our results may have differed.

The spatial arrangement of alternative prey may influence nest success. We focused our feeding efforts on mesomammals and corvids by providing supplemental prey around the perimeter of treated plots that contained artificial nests. Similarly, Crabtree and Wolfe (1988) and Greenwood et al. (1998) concentrated on providing food to striped skunks on the edges of treated areas. As with our study, they found overall nest success remained constant. In contrast, using a similar treatment (e.g., providing prey along the perimeter of the treated areas), Vander Lee et al. (1999) found nest survival doubled in areas that received supplemental prey in northwestern Texas. Cooper and Ginnett (2000) provided supplemental prey in a different spatial arrangement

by placing artificial nests around deer feeders (i.e., they placed nests around the food instead of placing food around the nests) and observed a significant decrease in nest success.

We observed greater avian and small-mammal marks on wax eggs in prey-supplemented plots than in control plots. In addition, our motion-sensitive cameras provided evidence that our prey-supplementation was indeed attracting targeted mesomammals. Therefore, we hypothesize that compensatory predation was at least partially responsible for the similar predation rates between prey-supplemented and control plots. Compensatory predation has been observed in other food-supplementation studies. Duck nest predation by striped skunks was reduced in food-supplemented areas in the Prairie Pothole Region, but compensatory predation caused overall nest success to remain constant (Crabtree and Wolfe 1988, Greenwood et al. 1998).

Johnson and Temple (1986) found that birds in tallgrass prairies had highest nest success 1 growing season after being burned. In contrast, we found no difference in artificial nest success between recently burned and nonburned areas. Artificial nests placed in recently burned areas may have been more visible to predators; however, foraging by predators may have been limited because many plants do not fruit the year of a burn (Stoddard 1963, Johnson and Landers 1978).

Our data suggest that compensatory predation also may have occurred as a result of prescribed fire. Unknown and avian predators depredated more nests in burned than in nonburned plots, whereas small mammals depredated more nests in nonburned than in burned plots. Recently burned areas do not provide sufficient overhead cover to protect small mammals from aerial predators (With 1994), but vegetation recovery permits small mammals to return to these areas after 1 growing season (Arata 1959). Avian predators rely on sight for locating nests (Dion et al. 2000). Artificial nests were more exposed in burned plots and probably were more visible to avian predators than in nonburned plots. We further suggest that increased visual and olfactory detection of nests due to an absence of vegetation may have led to increased mesomammal predation following prescribed fire. We hypothesize that as vegetation cover increases following prescribed fire, there will be decreased visual and olfactory detection of nests by birds and mesomammals, resulting in decreased predation from these predators. However, as vegetation cover increases, small-mammal populations

will increase (Arata 1959), and nest predation by small mammals will subsequently increase to at least partially compensate for reduced mesomammal and avian predation.

MANAGEMENT IMPLICATIONS

The objective of managing predation using alternative prey is to elicit a change in diet without a numerical response in the predator population. However, increasing food availability to predators may cause predator populations to increase (Clark et al. 1996), resulting in decreased nest success. This seems more likely if increased food is available for long periods. Furthermore, diversity of the predator community may determine the likelihood that compensatory predation will occur; a more diverse community may be more likely to produce a compensatory response. Therefore, if providing alternative food is expected to result in decreased nest predation, the alternative food should not result in an increased predator population and the predator community should not be diverse.

Managing nest predation by increasing nesting cover depends on the ability to reduce olfactory and visual detection of nests by predators without increasing predator populations. Efficacy of increasing cover to reduce nest predation also will be related to the predator community and to susceptibility of nests to dominant predators (e.g., small mice cannot destroy large eggs; Ettel et al. 1998). Therefore, if increased cover results in an increase in 1 or more nest predators, nest success may not increase and may decrease, depending on relative susceptibility of nests to the increasing predator populations.

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