EFFECTS OF HABITAT ON AVIAN PRODUCTIVITY IN ABANDONED PECAN ORCHARDS IN SOUTHERN GEORGIA

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Abstract.—Daily survival rates (DSRs) of nests, eggs and nestlings were determined for Mourning Doves (*Zenaida macroura*), Northern Cardinals (*Cardinalis cardinalis*), Brown Thrashers (*Toxostoma rufum*) and Northern Mockingbirds (*Mimus polyglottos*) occupying abandoned pecan orchards in a highly fragmented and intensively farmed area of southern Georgia. The effects of nest placement parameters, seasonal factors and habitat disruptions on DSRs for all species combined were statistically analyzed. Egg and nestling DSRs varied significantly by month of nesting, percent cover, vegetative form and position of nest in substrate. Causes of nest failure (no feldglings produced) in order of decreasing importance were predation by small mammals/snakes, avian predation, predation by large mammals and abandonment. Results provide further evidence that the importance of nest placement and habitat disruptions in nesting success is influenced by foraging strategies of the predator community. Site-specific predator/habitat complexes may be a more appropriate criterion than habitat conditions alone for evaluating avian nesting habitat.

EFECTO DEL HABITAT EN LA PRODUCTIVIDAD DE AVES EN UN HUERTO DE PACANA EN EL SUR DE GEORGIA

Sinopsis.—Se determinó la tasa de sobrevivencia diaria (TSD) en nidos, huevos y pichones de individuos de *Zenaida macroura, Cardinalis cardinalis, Toxostoma rufum* y *Mimus polyglottos* que ocuparon un huerto de pacanas abandonado, en una localidad altamente fragmentada e intensivamente cultivada del sur de Georgia. Se analizó estadísticamente, la combinación del efecto de disturbios en el habitat, factores estacionales, y parámetros en la localizacion de los nidos, en la TSD. La TSD para huevos y pichones varió significativmanete de acuerdo con el mes de anidamiento, porcentaje de cobertura, forma de la vegetación y posición del nido en el sustrato. Las causas de fracaso en el anidamiento (no se produjeron volantones) en orden descendente de importancia lo fueron, depredación por pequeños mamíferos y culebras, depredación por otras aves, depredación por mamíferos de considerable tamaño y abandono del nido. Los resultados proveen evidencia adicional, de que las estrategias de forrajeo de los depredadores influyen en la relevancia que puedan tener la localización del nido y disturbios en el habitat, en el éxito de anidamiento. El complejo habitat/depredador de una localidad específica, puede ser un criterio más apropiado, en la evaluación del habitat de anidamiento de aves, que la condición del habitat solamente.

In southern Georgia, abandoned pecan orchards between cultivated groves and agricultural fields are heavily used as nesting habitat by arboreal, open-nesting bird species (White and Seginak 1990). Modern farming trends toward enlarging plots and eliminating transition zones

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between different agricultural types, however, have reduced and severely altered suitable avian habitat (Mahan 1984). As a result of habitat loss and fragmentation, understanding the factors affecting nesting efficacy has become even more critical to maintaining stable populations (Yahner et al. 1989).

The effects of various nest placement parameters, seasonal factors, depredation and habitat discontinuity on avian productivity have been observed to vary widely (Chasko and Gates 1982, Westmoreland and Best 1985, Yahner et al. 1989). Inconsistencies have been attributed to lack of uniformity in experimental designs and differences in the primary cause of nest losses. With regard to the latter explanation, Ratti and Reese (1988) hypothesized that predator species and habitat type form site-specific complexes that determine the factors affecting nest efficacy. The ecological significance and management implications of this hypothesis demand further research on avian productivity in a variety of habitat types (Yahner et al. 1989).

The objectives of this study were to evaluate the effect of nest placement parameters, seasonal factors and habitat disruptions (and their respective levels of human activity) on nest outcome (number of fledglings) in an avian community in the transition zones surrounding pecan agriculture in southern Georgia and to use the results to determine the applicability of the site-specific complex hypothesis of Ratti and Reese (1988). We selected Mourning Doves (*Zenaida macroura*), Northern Cardinals (*Cardinalis cardinalis*), Brown Thrashers (*Toxostoma rufum*) and Northern Mockingbirds (*Mimus polyglottos*) because their abundance in the study area (White and Seginak 1990) provided sufficient sample sizes, and because their relatively low nesting site specificity (Stauffer and Best 1980) produced enough variability for statistical evaluation.

STUDY AREA AND METHODS

Our study area, Wildmeade Plantation (2023 ha), is near Leary in Calhoun County, Georgia (31°32'N, 84°31'W). Pecan production (200 ha) and cultivation of annually rotated row crops (285 ha) predominate agriculture. The plantation staff maintains transition zones between forest edges and fields, establishes pine (*Pinus* spp.) strips, burns pines every other winter and plants food plots to maximize Northern Bobwhite (*Colinus virginianus*) productivity. Abandoned pecan groves (240 ha) are at various stages in succession toward a xeric phase southern mixed hardwood forest. The predominant native species is a shrub variety of live oak (*Quercus virginiana maritima*).

Potential predators of eggs and nestlings are common. Avian predators include Blue Jays (*Cyanocitta cristata*) and American Crows (*Corvus brachyrhynchos*). Gray Rat Snakes (*Elaphe obsoleta spiloides*), Corn Snakes (*Elaphe guttata guttata*), Eastern Coachwhips (*Masticophis flagellum flagellum*) and Southern Black Racers (*Coluber constrictor priapus*) are thought to have sufficient climbing abilities (Conant 1975) to reach arboreal nests. Eastern Fox Squirrels (*Sciurus niger*) are the most common of the small

mammalian nest predators on the study area (J. Seginak, pers. comm.), although Eastern Gray Squirrels (*Sciurus carolinensis*) and Southern Flying Squirrels (*Glaucomys volans*) are also present. Larger mammalian predators include Raccoons (*Procyon lotor*), Opossums (*Didelphis marsupialis*), Spotted Skunks (*Spilogale putorius*), Striped Skunks (*Mephitis mephitis*), Coyotes (*Canis latrans*), Gray Foxes (*Urocyon cinereoargenteus*) and Red Foxes (*Vulpes vulpes*).

The study was conducted from the onset of songbird nesting in early April through final fledging in late July during 1988 and 1989. Every 2 wk, we searched for nests in all uncultivated pecan orchards to discover newly initiated nests. Nests were located by walking along 3-m-wide paths, which divided each orchard into 20 × 20 m blocks. Mourning Dove nests were found by flushing adults, whereas nests of other species were located by observing adult activity and searching potential sites. For relocation, flagging was attached to vegetation at least 5 m from nests. Date of nest initiation was recorded as observation of the first egg or estimated by back-dating from known stages in the nesting cycle.

We visited active nests every 3 d, unless inclement weather posed a threat to exposed nestlings. A mirrored pole was used to view high nests; however, our data were restricted to nests <7 m above the ground. During each visit, we recorded the number and status of eggs and/or the number and age of nestlings. We monitored each nest as described until fledging, predation or abandonment occurred. If the nest was undisturbed and chicks were mature enough to fledge, based on established nestling periods (Harrison 1984), then the nest was considered successful (at least one nestling feldged) and the number of young at last visit recorded as fledged. We attempted to identify predators of disrupted nests by nest appearance, following modifications of the procedures of Best and Stauffer (1980). As a result of the lack of distinguishing features between depredation by small mammals and snakes, we combined them under "other." Nests with punctured eggs, however, were characterized as avian depredations.

Following completion of each nesting season, we recorded nest height, width, depth and position (limb or crotch); substrate species and height; and diameter of supporting branch or trunk at nest position. Percent cover was estimated by determining how many sides (four cardinal points, top and bottom) of the nest were concealed by vegetation from 1 m away. We determined distances to closest cultivated pecan orchard, road, crop and food plot (0.1 ha-food plantings); distances ≤50 m were measured with a tape and distances >50 m were estimated by pacing.

Nest, hatching (number hatched/number laid) and fledging (number fledged/number hatched) success percentages for each year were determined for each species individually and all four species combined to facilitate comparison with previously reported rates. We generated contingency tables to test for differences between nesting seasons.

To identify significant habitat factors, we pooled nests across species based on observations that open-nesting birds in a locality have similar fledging success rates irrespective of their own species density (Gates and

TABLE 1.   Characteristics of nests by class.

Variables	Classes			
	1	2	3	4
Month	April	May	June	July
Nest height (m)	≤1	1–2	>2	
Percent cover	≤33	33–66	>66	
Branch diameter (cm)	≤2	2–4	>4	
Position	limb	crotch		
Vegetative form	tree[a]	shrub[b]		
Distance to[c]				
Pecan orchard (m)	≤100	100–200	>200	
Crop (m)	≤100	100–200	>200	
Road (m)	≤50	50–100	>100	
Food plot (m)	≤50	50–100	>100	

[a] Tree = woody vegetation > 3 m high.
[b] Shrub = woody vegetation ≤ 3 m high.
[c] Categories based on observations of adult behavior and physical factors during peak levels of characteristic human activity.

Gysel 1978), and we grouped nests into classes for each variable (Table 1). We combined substrate species data and substrate height measurements into a single variable called vegetative form. We then used the program SURVIV after White (1983) to calculate daily survival rates (DSRs) by class. To account for potential differences in survival rates between nesting stages and to eliminate effects from asynchronous hatching, DSRs were determined separately for nests, eggs and chicks. Using likelihood ratio tests, we evaluated month of majority of nest cycle, four nest placement parameters and five habitat variables for differences in DSRs among classes. We used DSRs rather than survival estimates for entire periods because of species differences in the duration of egg and nestling phases.

RESULTS AND DISCUSSION

We monitored 256 nests in 1988 and 227 in 1989: clutch size, incubation periods and nestlings phases were similar to established values (Harrison 1984). Nests were located in 34 species of trees, shrubs and vines, in/on two types of human-made structures, on the ground and in dead woody vegetation. DSRs did not differ between years. In both years, predation by snakes/small mammals accounted for more than half of the nest losses, and avian and large mammalian predation were responsible for one-third (Table 2).

Although averages for nest placement variables and distances from habitat disruptions varied with species, relatively large standard deviations and broad ranges substantiated the low nesting site specificity for all four species (Tables 3 and 4). Regardless of the habitat disturbance (and its respective level of human activity), DSRs did not differ significantly with

TABLE 2.   Causes of nest failures (no fledglings produced).

Species	Year	Losses		Abandonment		Proposed cause Large mammal predation		Avian predation		Other predation[a]	
		%	n	%	n	%	n	%	n	%	n
Northern Cardinal	1988	0.71	(55)	1.82	(1)	20.00	(11)	18.18	(10)	60.00	(33)
	1989	0.58	(45)	6.67	(3)	17.78	(8)	13.33	(6)	62.22	(28)
Northern Mockingbird	1988	0.50	(27)	7.41	(2)	18.52	(5)	18.52	(5)	55.56	(15)
	1989	0.44	(28)	10.71	(3)	17.86	(5)	14.29	(4)	57.14	(16)
Brown Thrasher	1988	0.76	(48)	6.25	(3)	12.50	(6)	16.67	(8)	64.58	(31)
	1989	0.53	(19)	5.26	(1)	15.79	(3)	15.79	(3)	63.15	(12)
Mourning Dove	1988	0.80	(49)	14.29	(7)	16.33	(8)	14.29	(7)	55.10	(27)
	1989	0.70	(35)	0.00	(0)	8.57	(3)	17.14	(6)	74.29	(26)
Overall	1988	0.70	(179)	7.26	(13)	16.76	(30)	16.76	(30)	59.22	(106)
	1989	0.56	(127)	5.51	(7)	14.96	(19)	14.96	(19)	64.57	(82)

[a] Includes snake and small mammal.

TABLE 3.   Characteristics of nest placement by species, 1988 and 1989 combined.

Species	Nest height (m)	Branch diameter (cm)	Percent cover	Substrate height (m)
Northern Cardinal	0.94 ± 0.38[a]	0.18 ± 0.01	42.0 ± 21.7	2.35 ± 1.38
	0.5–2.77[b]	0.03–1.40	0–100	0.53–15.76
Northern Mockingbird	1.33 ± 0.55	0.04 ± 0.06	50.8 ± 22.3	3.14 ± 1.27
	0.4–4.07	0.05–5.00	0–100	1.41–10.40
Mourning Dove	2.49 ± 1.51	0.09 ± 0.18	39.1 ± 21.8	9.01 ± 6.40
	0–6.41	0.03–9.10	10–90	0–24.38
Brown Thrasher	1.52 ± 1.27	0.03 ± 0.02	49.6 ± 22.1	4.18 ± 3.86
	0.42–11.10	0.03–1.49	0–90	0.53–22.86

[a] Mean ± SD.
[b] Range.

respect to distance from edge. In both years, DSRs varied significantly ($P < 0.05$) across classes for month of nesting, cover, position and vegetative form (Table 5). The effect of month of nesting on DSRs was observed across all three nest entities in both 1988 and 1989.

In contrast, the effects of cover, position and vegetative form varied with both year and nest entity. We suspect this variation is due, in part, to dramatic precipitation differences between years. Rainfall from April through July of 1988 was 58.5% below that in 1989 (normal). As a result, herbaceous vegetation and deciduous leaf growth were reduced, making cover in non-evergreen nesting substrate a limiting factor.

Inter-site variability.—The observed nesting success percentages were comparable to those reported for similar habitat types in other regions of the United States (Joern and Jackson 1983, Westmoreland and Best 1985). Comparison of the causes of nest failure revealed site-specific

TABLE 4.   Distances to habitat disruptions by species, 1988 and 1989 combined.

Species	Distance (m)				
	Pecans				
	Mature	Sapling	Crop	Road	Food plot
Northern Cardinal	53.3 ± 42.4[a]	56.1 ± 35.5	63.6 ± 49.1	42.6 ± 41.4	40.0 ± 32.0
	0.3–182.0[b]	8.7–181.2	0–182.0	0.6–182.0	1.8–173.7
Northern Mockingbird	58.7 ± 51.3	60.9 ± 48.9	47.1 ± 47.8	45.7 ± 43.5	30.1 ± 30.8
	0.9–182.0	8.2–197.0	0.9–181.1	0.9–169.3	0.9–163.7
Mourning Dove	58.0 ± 47.7	57.7 ± 45.7	51.7 ± 42.6	46.2 ± 46.0	36.9 ± 30.2
	0–182.0	6.4–169.3	0.4–182.0	0.9–173.7	0.6–143.7
Brown Thrasher	45.5 ± 45.4	45.7 ± 36.6	48.9 ± 50.1	39.0 ± 41.6	40.4 ± 35.7
	0.7–182.0	4.3–155.5	0.5–182.0	0.9–150.9	0.9–130.1

[a] Mean ± SD.
[b] Range.

TABLE 5.   Results of likelihood ratio tests for significant variables.

Variable	Year	Entity	Classes			
			1	2	3	4
Month	1988	nest	0.895[a]	0.930[b]	0.930[b]	0.956[b]
		egg	0.905[a]	0.912[a]	0.920[ab]	0.944[b]
		chick	0.842[a]	0.947[b]	0.943[b]	0.957[b]
	1989	nest	0.915[a]	0.956[b]	0.934[ab]	0.957[b]
		egg	0.902[a]	0.931[b]	0.906[a]	0.966[c]
		chick	0.932[a]	0.963[b]	0.946[ab]	0.982[c]
Percent cover	1988	nest	0.902[a]	0.926[a]	0.965[b]	
		egg	0.903[a]	0.910[a]	0.941[b]	
		chick	0.888[a]	0.926[b]	0.980[c]	
	1989	nest	0.931[a]	0.946[ab]	0.965[b]	
		egg	0.910	0.926	0.939	
		chick	0.948	0.953	0.966	
Position	1988	nest	0.903	0.928		
		egg	0.892[a]	0.916[a]		
		chick	0.922	0.931		
	1989	nest	0.923[a]	0.953[b]		
		egg	0.904[a]	0.936[b]		
		chick	0.945	0.958		
Vegetative form	1988	nest	0.909[a]	0.935[b]		
		egg	0.896[a]	0.921[b]		
		chick	0.922	0.938		
	1989	nest	0.949	0.945		
		egg	0.924	0.929		
		chick	0.965[a]	0.946[b]		

[abc] Dissimilar superscripts for row values denote differences ($P < 0.05$).

differences, however. We propose that these disparities result from site-specific differences in predator communities. As in Nolan's (1963) investigation, greater predation by snakes and small mammals was indicated in our study because a higher proportion of failed nests remained intact. High snake and sciurid populations are known for the area (L. DeBary, pers. comm.); on five occasions, we observed Gray Rat Snakes consuming eggs and chicks.

We suspect, however, that some losses attributed to other predation may have been committed by birds. As the Blue Jay population associated with the abundance of acorns and nuts was large, we expected a high rate of avian depredation. Frequently, we observed these birds flying away from recently depredated nests. Similarly, Morrow and Silvy (1982) found Blue Jay populations correlated with nesting failure of Mourning Doves. Yahner and Scott (1988) also attributed the majority of artificial nest depredations in a highly fragmented habitat to the large numbers of corvids in their study area.

As Blue Jays use visual cues to obtain food for their own nestlings, we think that factors affecting concealment (percent cover, position in sub-

strate) have significant effects on nest success. Other investigators (Angelstam 1986, Westmoreland and Best 1985) found concealment significantly affecting nest outcome on sites where corvids were suspected of being a major predator.

In addition to effects of reduced concealment, we propose that significantly lower DSRs in April may be related to the predator breeding cycles. In southern portions of its range, maturation and dispersal of the Eastern Fox Squirrel's first litter (Burt and Grossenheider 1976) coincides with the onset of avian nesting. Thus, eggs from early nests are easy prey for nursing females and juvenile sciurids when food sources are limited. On three occasions, we observed Northern Mockingbirds chasing Eastern Fox Squirrels away from their nests. Early nests were also observed to have reduced survival rates in other regions of the country where other sciurids were common nest predators (Nolan 1963, Yahner 1983).

Experimental design differences.—We think that inconsistencies in results among nesting studies may, in part, be an artifact of different statistical methods. When distance from a habitat edge was measured, as in this study and others (Ratti and Reese 1988, Yahner and Wright 1985), no difference in nest success was observed. In contrast, nest distribution index, which accounts for numbers of nests per distance category (Chasko and Gates 1982), as well as degree of isolation (Joern and Jackson 1983) and percent fragmentation of habitat (Yahner and Scott 1988), which consider overall habitat distribution, were significantly correlated with nesting success. These parameters, thus, may be more effective measures of the influences of habitat disruption. Therefore, we recommend assessing the effects of habitat alterations and their respective levels of human activity on nesting success with these or site-specific indices.

Inconsistencies in our results across nest entities support Ratti and Reese's (1988) explanation for disparities between artificial and natural nesting studies and substantiate the need to examine egg and chick stages separately. In addition, Bart and Robson (1982) showed that maximum-likelihood estimates (MLEs) are the best way to eliminate nest visitation and discovery biases associated with the use of percentages. As few researchers have analyzed nesting stages separately with MLEs, we advise caution in comparing results among nesting studies.

Finally, profound differences in weather conditions in southern Georgia between 1988 and 1989 illustrate the potential for factors contributing to nest success to vary over time and substantiate the need for long-term studies. As all populations are subject to environmental variability, we suggest that the importance of habitat parameters are not only site-specific, but also vary with environmental conditions.

In conclusion, we think long-term research is necessary to determine effects of habitat disruption and role of microhabitat selection on avian reproduction. These studies should be conducted in a variety of ecosystems in light of mounting evidence that factors affecting nesting outcome are both predator- and habitat-type specific.

LITERATURE CITED

ANGELSTAM, P. 1986. Predation on ground-nesting birds' nests in relation to predator densities and habitat edge. Oikos 47:365–373.

BART, J., AND D. S. ROBSON. 1982. Estimating survivorship when the subjects are visited periodically. Ecology 63:1078–1090.

BEST, L. B., AND D. F. STAUFFER. 1980. Factors affecting nesting success in riparian bird communities. Condor 82:149–158.

BURT, W. H., AND R. P. GROSSENHEIDER. 1976. A field guide to the mammals (3rd ed.). Houghton Mifflin Co., Boston, Massachusetts. 289 pp.

CHASKO, G. C., AND J. E. GATES. 1982. Avian habitat suitability along a transmission-line corridor in an oak-hickory forest region. Wildl. Monogr. No. 82. 41 pp.

CONANT, R. 1975. A field guide to reptiles and amphibians of eastern and central North America (2nd ed.). Houghton Mifflin Co., Boston, Massachusetts. 429 pp.

GATES, J. E., AND L. W. GYSEL. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871–883.

HARRISON, C. J. O. 1984. A field guide to the nests, eggs and nestlings of North American birds. Stephen Greene Press, Brattleboro, Vermont. 416 pp.

JOERN, W. T., AND J. F. JACKSON. 1983. Homogeneity of vegetational cover around the nest and avoidance of nest predation in mockingbirds. Auk 100:497–499.

MAHAN, W. E. 1984. Bobwhite quail. International Quail Foundation, Edgefield, South Carolina. 22 pp.

MORROW, M. E., AND N. J. SILVY. 1982. Nesting mortality of Mourning Doves in central Texas. Proc. Annu. Conf. Southeastern Assoc. Fish and Wildl. Agencies 36:537–542.

NOLAN, V., JR., 1963. Reproductive success of birds in a deciduous shrub habitat. Ecology 44:305–314.

RATTI, J. T., AND K. P. REESE. 1988. Preliminary test of the ecological trap hypothesis. J. Wildl. Manage. 52:484–491.

STAUFFER, D. F., AND L. B. BEST. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 44:1–15.

WESTMORELAND, D., AND L. B. BEST. 1985. The effect of disturbance on Mourning Dove nesting success. Auk 102:774–780.

WHITE, D. H., AND J. T. SEGINAK. 1990. Brain cholinesterase inhibition in songbirds from pecan groves sprayed with phosalone and disulfoton. J. Wildl. Dis. 26:103–106.

WHITE, G. C. 1983. Numerical estimation of survival rates from band-recovery and biotelemetry data. J. Wildl. Manage. 47:716–728.

YAHNER, R. H. 1983. Site-related nesting success of Mourning Doves and American Robins in shelterbelts. Wilson Bull. 95:573–580.

———, T. E. MORRELL, AND J. S. RACHAEL. 1989. Effects of edge contrast on depredation of artificial avian nests. J. Wildl. Manage. 53:135–138.

———, AND D. P. SCOTT. 1988. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Manage. 52:158–161.

———, AND A. L. WRIGHT. 1985. Depredation on artificial ground nests: effects of edge and plot age. J. Wildl. Manage. 49:508–513.