———, N. J. BEAN, P. S. SHAH, AND L. CLARK. 1991a. Taxon-specific differences in responsiveness to capsaicin and several analogues: correlates between chemical structure and behavioral aversiveness. J. Chem. Ecol. 17:2539–2551.

——— AND L. CLARK. 1994. Mammalian irritants as chemical stimuli for birds: the importance of training. Auk (in press).

———, ———, AND P. S. SHAH. 1991b. Taxonomic differences between birds and mammals in their responses to chemical irritants. Pp. 311–318 *in* Chemical signals in vertebrates (R. Doty and D. Muller-Schwarze, eds.). Plenum Press, New York, New York.

——— AND J. A. MARUNIAK. 1983. Behavioral and physiological effects of capsaicin in red-winged blackbirds. Pharmacol. Biochem. Behav. 19:857–862.

——— AND D. L. OTIS. 1990. Aversiveness of six potential irritants on consumption by red-winged blackbirds (*Agelaius phoeniceus*) and European starlings (*Sturnus vulgaris*). Pp. 309–323 *in* Chemical senses vol. II: irritation (B. G. Green, J. R. Mason, and M. R. Kare, eds.). Marcel Dekker, New York, New York.

——— AND R. F. REIDINGER. 1983a. Exploitable characteristics of neophobia and food aversions for improvements in rodents and bird control. Pp. 20–42 *in* Vertebrate pest control and management materials (D. E. Kaukienen, ed.). American Society for Testing and Materials, Philadelphia, Pennsylvania.

——— AND ———. 1983b. Importance of color for methiocarb-induced food aversions in red-winged blackbirds. J. Wildl. Manage. 47:383–393.

——— AND W. L. SILVER. 1983. Trigeminally mediated odor aversion in starlings. Brain Res. 269:196–199.

NORMAN, D. M., J. R. MASON, AND L. CLARK. 1992. Capsaicin effects on consumption of food by Cedar Waxwings and House Finches. Wilson Bull. 104:549–551.

SILVER, W. L., J. R. MASON, D. A. MARSHALL, AND J. A. MARUNIAK. 1985. Rat trigeminal, olfactory, and taste responses after capsaicin desensitization. Brain Res. 333:45–54.

SOUDEK, J. 1929. The sense of smell in birds. Proc. Int. Cong. Zool. 1929:755.

SZOLCSANYI, J., H. SANN, AND F.-K. PIERAU. 1986. Nociception is not impaired by capsaicin. Pain 27:247–260.

WALKER, J. C., D. TUCKER, AND J. C. SMITH. 1979. Odor sensitivity mediated by the trigeminal nerve in the pigeon. Chem. Senses Flav. 4:107–116.

WINER, B. J. 1971. Statistical principles in experimental design. McGraw-Hill, New York, New York.

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Depredation of artificial Ovenbird nests in a forest patch.—One of the most likely causes of the decline of Neotropical migrants is the loss of suitable breeding habitat. Forest fragmentation reduces the quantity of habitat and the quality of the remaining habitat for avian reproductive success. Lower reproductive success sometimes can be caused by increased rates of nest predation, and nest predation on artificial nests may be more intense in habitat fragments than in larger, more continuous tracts of similar habitat (Wilcove 1985, Yahner and Scott 1988, Langen et al. 1991).

The Ovenbird (*Seiurus aurocapillus*) is one of several Neotropical migrant landbirds that are associated with the forest interior (Whitcomb et al. 1981, Freemark and Merriam 1986). The species appears to be declining rapidly (Ambuel and Temple 1982, Robbins et al. 1989), but we know of only one study (Hann 1937) that reported predation rates for a large number of Ovenbird nests. Consequently, our objectives were to (1) compare survival rates between artificial domed nests (mimicking that used by the Ovenbird) and artificial open-cup ground nests (typical of many Neotropical migrant species), (2) determine if artificial nests located closer to the forest/field edge exhibit lower survival rates than those located in the forest interior, and (3) compare survival rates, during a five-day cycle, throughout the breeding season.

Study area and methods.—This study was conducted in a 70-ha forest patch adjacent to the east shore of Lake Shelbyville in Shelby County, Illinois (39°N, 88°W) during spring and summer of 1991. This is the largest forest patch bordering the lake and often is referred to as the "Boot" (Robinson 1992). The Boot was selectively logged as recently as 30 years ago, and the remaining stand consists of predominantly young (<30 cm DBH) *Quercus, Aceraceae, Juglandaceae* trees. Numerous steep ravines transect the forest and become more abrupt near the lake. The Boot is surrounded by agricultural fields (soybean and corn) and Lake Shelbyville. Land acquisition for the construction of Lake Shelbyville began in 1960 by the U.S. Army Corps of Engineers, and the lake was completed in 1970. The surrounding floodplain has been left undisturbed and allowed to undergo succession since 1960. The vegetational habitat in this area is extremely heterogeneous and currently is being managed to maintain this heterogeneity (see Robinson 1992 for more details).

Possible nest predators that were identified in the Boot include the American Crow (*Corvus brachyrhynchos*), Blue Jay (*Cyanocitta cristata*), eastern chipmunk (*Tamias striatus*), raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginianus*), and various snakes (Linder, pers. observ.). Additional nest predators that were probably present and have been identified in habitat similar to the Boot include red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), striped skunk (*Mephitis mephitis*), domestic cat (*Felis silvestris*), and the domestic dog (*Canis familiaris*). Population densities of potential predators were not known.

We constructed artificial open-cup nests using plastic cups (90 mm in diameter and 45 mm in depth) painted with flat black paint. Nesting material consisted of dry grasses placed in each cup. Infertile Northern Bobwhite (*Colinus virginianus*) eggs, acquired from a local game farm, were used. Artificial open-cup nests were placed in depressions in the leaf litter so that virtually no plastic was visible. We also constructed artificial domed nests, which were similar to the open-cup nests, but with a leaf litter dome to mimic the nest of the Ovenbird. Domes were built by placing leaf litter on arched twigs/branches that spanned the breadth of the nest. Open-cup nests were located near shrubs, logs, or trees, whereas domed nests were located in open areas. Seven nests of each type were placed 20, 200, and 400 m, respectively, from the forest/agricultural field edge; nests of similar type were >50 m apart, and all nests were >25 m from one another. Nests 400 m from this edge were 100–200 m from the shore of Lake Shelbyville. Small and Hunter (1988) did not find large bodies of water to act as an edge for predators associated with ground nesting birds, therefore, we refer to the area 400 m from the forest/agricultural edge as interior rather than another edge.

A single egg was added daily to each artificial nest to create the appearance of an active nest in an attempt to elicit brood parasitism (Lowther 1979, Thompson and Gottfried 1981). Four trials were conducted between 16 June and 20 July 1991. A single trial consisted of depositing an egg (between 10:00 and 12:00 CST each morning) in each nest for four consecutive days. Nest fate was recorded at each visit; a nest was considered depredated if eggs were broken or missing (Yahner and Scott 1988). Egg fragments, if present, were

TABLE 1

RESULTS OF AN ANOVA ON PREDATION OF ARTIFICIAL GROUND NESTS[a]

	df	F	P
Survival egg-days			
Nest type (N)	1	12.17	0.0374
Distance (D)	2	5.89	0.0282
Time (T)	3	7.78	0.0001
N × D	2	0.77	0.5043
N × T	3	0.95	0.4170
D × T	6	0.86	0.5268
N × D × T	6	0.53	0.7867
Predator-free days			
Nest type (N)	1	10.13	0.0372
Distance (D)	2	12.84	0.0297
Time (T)	3	6.68	0.0002
N × D	2	0.47	0.6260
N × T	3	0.79	0.5020
D × T	6	0.71	0.5273
N × D × T	6	0.66	0.6831

[a] Three effects were examined; nest type (N), distance from field (D), and time of trial (T). Nest type was either open-cup or domed. Nests were placed at distances of 20 m, 200 m, and 400 m from the agricultural edge of east-central Illinois in 1991.

removed daily. Nest locations were changed (>20 m) for each trial. Rubber boots were worn to minimize scent trails.

Survival rates were estimated by calculating egg-days of survival (referred to as egg survival) and the number of predator-free days (referred to as nest survival) each nest experienced. For each nest, we determined egg survival by summing the number of days each egg remained in the nest undisturbed. Each nest could achieve a maximum egg survival of ten (four days for the first egg deposited, three days for the second egg, two days for the third egg, and one day for the fourth) if left undisturbed for the duration of the trial. Nest survival is defined as the total number of days in which the nest was undisturbed. Thus, each nest received a score between 0 and 4.

Data for both nest survival and egg survival were analyzed using an ANOVA. Tests were performed on untransformed data using general linear models (SAS 1990; PROC GLM). Main effects were nest type (two levels: domed and open-cup), distance from the forest/field edge (three levels: 20 m, 200 m, and 400 m), and date of trial (four levels: trials 1, 2, 3, and 4).

Results.—During this study, 172 of the 189 (91%) nests were disturbed at least one time. Whether using nest survival or egg survival, significant differences were found for all three main effects: distance from the edge, date of trial, and nest type. However, no interactions were significant (Table 1). All results for survival measures are based upon pooled data from the four trials and nest type when appropriate. Nests located 20 m from the forest/field edge exhibited significantly lower egg survival ($\bar{x}$ = 1.61 egg-days/nest) than nests located 200 m or 400 m from the edge ($\bar{x}$ = 2.63 and $\bar{x}$ = 2.89 egg-days/nest, respectively). Nests 200 m and 400 m were not statistically different from one another. Nest fate was also associated with nest type. Egg survival was significantly lower for open-cup nests ($\bar{x}$ = 1.81 egg-days) than for domed nests ($\bar{x}$ = 2.94 egg-days), and this relationship was consistent at all three distances from the edge. Nests from trial 1 had a significantly higher egg survival than those of subsequent trials which were statistically indistinguishable from one another. Analyses performed using predation-free days exhibited identical significant relationships amongst the effects (Table 1) as those reported for egg survival.

No brood parasitism was recorded during the study. The lack of parasitism most likely reflects the tendency of Brown-headed Cowbirds (*Molothrus ater*) to locate their host's nest visually by following either parent back to the nest (Thompson and Gottfried 1981). The predators responsible for the extremely high predation rates recorded during this study were not identified.

Discussion.—Our results indicate a difference in predation rates for the two nest types used in this study. Domed nests, mimicking those built by Ovenbirds, had a significantly higher egg survival rate than did open-cup ground nests, typical of most other Neotropical migrants. This effect was seen regardless of the distance from the edge or for the trial period. Our results do not appear to be consistent with the literature (Martin 1992, Robinson 1992), which indicates Ovenbird egg survivorship to be very similar to that of other Neotropical migrants. Robinson (1992) did find that Ovenbirds had lower rates of brood parasitism, suggesting that domed nests may offer some defense against nest disturbance. Despite apparently higher nest survivorship and lower brood parasitism rates, other factors, including low pairing success (Linder 1992, Villard et al. 1994), may contribute to the apparent decline in Ovenbirds (Robbins et al. 1989).

We found egg survival to be significantly lower in nests located near the edge (20 m) than those located in the forest interior (200 m and 400 m). These results are consistent with those of Gates and Gysel (1978), Wilcove (1985), Wilcove et al. (1986), and Andrén and Angelstam (1988). Yahner and Wright (1985), however, recorded no difference between predation rates of artificial nests near the forest/field edge and those in the forest interior. This might be explained by the relatively short distance (50 m) they chose to define the interior.

The significantly higher egg survival rate we recorded during the first trial period has also been reported in several studies of natural nests (Zimmerman 1971, Dolbeer 1976, Best and Stauffer 1980). Subsequent decreased egg survival may result from an increase in the density of nest predators and the development of a search image that increases foraging efficiency (Bowman and Harris 1980).

The forest consisted of an open understory, few shrubs (DBH < 7.5 cm), and almost no grasses. Several studies have shown that greater vegetational diversity and density reduce predator foraging efficiency (Bowman and Harris 1980, Sudgen and Beyersbergen 1986, Yahner and Cypher 1987). The lack of heterogeneity within the Boot may result in high predation rates throughout the forest.

Although our results suggest a higher nest survivorship near forest edge, predation rates upon all artificial nests were high throughout the study area. The results could be interpreted in several ways, depending on what scale and/or criteria are used to define edge (Paton 1994). Despite our own lack of resolution in this study, we support Paton's (1994) suggestion of increasing sampling effort within 200 m of the ecotone.

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LITERATURE CITED

AMBUEL, B. AND S. A. TEMPLE. 1982. Songbird populations in southern Wisconsin forests: 1954 and 1979. J. Field Ornithol. 53:149–158.

ANDRÉN, H. AND P. ANGELSTAM. 1988. Elevated predation rates as an edge effect in habitat islands: experimental evidence. Ecology 69:544–547.

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

BOWMAN, G. B. AND L. D. HARRIS. 1980. Effect of spatial heterogeneity on ground-nest depredation. J. Wildl. Manage. 44:806–813.

DOLBEER, R. A. 1976. Reproductive rate and temporal spacing of nesting of Red-winged Blackbirds in upland habitat. Auk 93:343–355.

FREEMARK, K. E. AND H. G. MERRIAM. 1986. Importance of area and habitat heterogeneity to bird assemblages in temperate forest fragments. Biological Conservation 36:155–141.

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

HANN, H. W. 1937. Life history of the Ovenbird in southern Michigan. Wilson Bull. 49: 145–237.

LANGEN, T. A., D. T. BOLGER, AND T. J. CASE. 1991. Predation on artificial bird nests in chaparral fragments. Oecologia 85:395–401.

LINDER, E. T. 1992. Effects of forest fragmentation on neotropical migrant landbirds in east-central Illinois. M.Sc. thesis, Eastern Ill. Univ., Charleston, Illinois.

LOWTHER, P. E. 1979. Nest selection by Brown-headed Cowbirds. Wilson Bull. 91:118–122.

MARTIN, T. E. 1992. Breeding productivity consideration: what are the appropriate habitat features for management? Pp. 455–473 *in* Ecology and conservation of neotropical migrant landbirds (J. M. Hagan and D. W. Johnson, eds.). Smithsonian Inst. Press, Washington, D.C.

PATON, P. W. 1994. The effect of edge on avian nest success: how strong is the evidence? Conserv. Biol. 8:17–26.

ROBBINS, C. S., D. K. DAWSON, AND B. A. DOWELL. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildl. Monogr. 103:1–34.

ROBINSON, S. K. 1992. Population dynamics of breeding neotropical migrants in a fragmented Illinois landscape. Pp. 408–418 *in* Ecology and conservation of neotropical migrant landbirds (J. M. Hagan and D. W. Johnson, eds.). Smithsonian Inst. Press, Washington, D.C.

SAS INSTITUTE. 1990. SAS/STAT user's guide, version 6, 4th ed. SAS Institute, Inc., Cary, North Carolina.

SMALL, M. F. AND M. L. HUNTER. 1988. Forest fragmentation and avian nest predation in forested landscapes. Oecologia 76:62–64.

SUDGEN, L. G. AND G. W. BEYERSBERGEN. 1986. Effect of density and concealment on American Crow predation of simulated duck nests. J. Wildl. Manage. 50:9–14.

THOMPSON, C. F. AND B. M. GOTTFRIED. 1981. Nest discovery and selection by Brown-headed Cowbirds. Condor 83:268–269.

VILLARD, M. A., P. R. MARTIN, AND C. G. DRUMMOND. 1994. Habitat fragmentation and pairing success in the Ovenbird (*Seirus aurocapillus*). Auk 110:759–768.

WHITCOMB, R. F., C. S. ROBBINS, J. F. LYNCH, B. L. WHITCOMB, M. K. KLIMKIEWICZ, AND D. BYSTRAK. 1981. Effects of forest fragmentation on avifauna of the eastern deciduous forest. Pp. 125–205 *in* Forest island dynamics in man-dominated landscapes (R. L. Burgess and D. M. Sharpe, eds.). Springer-Verlag, New York, New York.

WILCOVE, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211–1214.

———, C. H. MCLELLAN, AND A. P. DOBSON. 1986. Habitat fragmentation in the temperate zone. Pp. 237–256 *in* Conservation biology, the science of scarcity and diversity (M. E. Soulé, ed.). Sinauer, Sunderland, Massachusetts.

YAHNER, R. H. AND B. L. CYPHER. 1987. Effects of nest location on depradation of artificial arboreal nests. J. Wildl. Manage. 51:178–181.

——— 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.

ZIMMERMAN, J. L. 1971. The territory and its density dependent effect in *Spiza americana.* Auk 88:591–612.

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Diet of nesting Killdeer in North Dakota.—The Killdeer (*Charadrius vociferous*) is one of the most widespread of all North American shorebirds and, unlike other shorebirds, tolerates a wide variety of open inland habitats in addition to the shores of coastal and inland water. Given its common status, there is surprisingly little information on the Killdeer diet. The only study is an unpublished report by Baldwin (1971) on their diet during the breeding season (June 16 to July 28) on the shortgrass prairie of eastern Colorado. Henderson (1927), Bent (1929), and Martin et al. (1951) also provide qualitative summaries of the Killdeer diet. Rundle (1982) compared esophageal and gizzard analysis in four species of shorebirds including Killdeer and found the three main taxonomic groups eaten by Killdeer were Coleoptera adults (40% occurrence), Diptera larvae (40%), and Coleoptera larvae (20%). No diet preference studies have been done on the Killdeer.

Because of concern for the impacts of pesticides on upland shorebirds, we conducted a study investigating the direct and indirect effects of carbaryl grasshopper control on Killdeer nesting on the U.S.D.A., Animal Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), Grasshopper Integrated Pest Management (GHIPM) demonstration site in western North Dakota. Killdeer gizzard analyses were performed to investigate a possible functional response in the Killdeer as a result of a reduction in arthropod availability caused by range grasshopper control. Killdeer were collected from areas sprayed with carbaryl Sevin-4 oil formulation and from similar unsprayed habitat. Each Killdeer was analyzed for brain acetylcholinesterase activity, pesticide residues (including organochlorines), whole body % lipids, and gizzard contents. Relative arthropod abundance was also estimated on the sprayed areas. Here, we report the gizzard contents of the Killdeer collected for this research and compare these data with the Killdeer diet reported by Baldwin (1971) which was also based on an analysis of gizzard contents. We also contrast the diet data with the arthropod abundance data to see if Killdeer exhibit any dietary preferences.

This study was conducted on two locations treated for grasshopper control by USDA, APHIS, during the summer of 1992. The first area (Towner area) was primarily on privately owned rangeland, located northwest of Towner in McHenry County, North Dakota. The mixed prairie vegetation of this area is dominated by needle-and-thread grass (*Stipa comata*) and western wheatgrass (*Agropyron smithii*). Small woodlands on the area included green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), quaking aspen (*Populus