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Avian predation and parasitism on artificial nests and eggs in two fragmented landscapes.—Forest fragmentation negatively affects abundance and distribution of Neotropical migratory songbirds, in part by increasing incidences of nest predation and parasitism (Whitcomb et al. 1981, Small and Hunter 1988). Recent studies using artificial nests and eggs of domestic chickens or Japanese Quail (*Coturnix coturnix*) (Wilcove 1985, Yahner and Scott 1988) have shown greater rate of nest predation in landscapes with increasing fragmentation. Relatively high rates of nest parasitism by Brown-headed Cowbirds (*Molothrus ater*) on active bird nests also have been documented in fragmented landscapes of the Midwest (Brittingham and Temple 1983). A few experimental studies have attempted to elicit parasitism by cowbirds, but these studies were hindered by small sample size or use of eggs that were considerably larger than those of songbirds, such as eggs of Japanese Quail (Laskey 1950, Thompson and Gottfried 1981). None of these experimental studies addressed nest parasitism in relation to fragmented landscapes.

In a series of experimental studies dealing with depredation of artificial nests in forested stands of central Pennsylvania (Yahner and Cypher 1987, Yahner et al. 1989), corvids were found to have a major impact on fate of artificial avian nests. Conversely, occurrence of parasitism by cowbirds on active bird nests was uncommon in these stands (Yahner 1991). This differential effect of predation and parasitism on nesting success was not unexpected because avian nest predators may be more abundant than mammalian nest predators in forested landscapes (Angelstam 1986), and cowbirds usually are relatively low in abundance in deciduous forests of the eastern United States (Brittingham and Temple 1983).

State Game Lands (SGL) 176 in central Pennsylvania is characterized by two different landscapes, a mosaic of uncut-clearcut forested stands (Barrens Grouse Habitat [BGH] Management Area) and an intermix of forest and farmland (Toftrees Area) (Yahner and Scott 1988, Rollfinke and Yahner 1990). Thus, SGL 176 provided us with the opportunity to contrast nest predation and parasitism in distinct landscapes (see Saunders et al. 1991). We tested the hypothesis that avian predation and parasitism on artificial arboreal nests (natural nests containing artificial eggs of two color patterns) did not differ between uncut-clearcut forest and forest-farmland landscapes. In addition, we tested whether use of ceramic eggs, which simulated natural bird eggs in terms of color and size, could be used as a means of assessing avian predation and parasitism.

Study area and methods.—We conducted the study on two sites at State Game Lands (SGL) 176, Centre County, Pennsylvania. One site, the BGH Management Area, is managed for Ruffed Grouse (*Bonasa umbellus*) habitat, using an even-aged system of forest clearcutting under the supervision of the Pennsylvania Game Commission. The BGH Management Area contains 136 4-ha blocks that are divided into 1-ha (100 × 100 m) plots. Subsequent to the third cutting cycle in winters 1985–1987, 63% of the BGH Management Area was comprised of clearcut stands of three age classes, and 37% was 60- to 65-year-old forest (Yahner 1991).

The second site, the Toftrees Area, is about 10 km from the BGH Management Area and is a 450-ha intermix of approximately 50% forest and 50% farmland. Forested stands at the Toftrees Area were similar in age to those of the BGH Management Area. A portion (200 ha) of the Toftrees Area was irrigated with wastewater (chlorinated effluent) (see details in Rollfinke et al. 1990, Yahner and Morrell 1991). Overstory trees in uncut forest on both sites at SGL 176 were oak (*Quercus* spp.), aspen (*Populus* spp.), and red maple (*Acer rubrum*) (Yahner et al. 1989, Yahner and Morrell 1991).

The most common avian species nesting ≤ 2 m above ground at SGL 176 were Gray

Catbird (*Dumetella carolinensis*), Wood Thrush (*Hylocichla mustelina*), Golden-winged Warbler (*Vermivora chrysoptera*), Chestnut-sided Warbler (*Dendroica pensylvanica*), Common Yellowthroat (*Geothlypis trichas*), Hooded Warbler (*Wilsonia citrina*), Indigo Bunting (*Passerina cyanea*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), Field Sparrow (*Spizella pusilla*), and Black-billed Cuckoo (*Coccyzus erythrophthalmus*) (Rollfinke et al. 1990, Yahner 1991).

Natural songbird nests were collected at the two sites during late summer 1989, and each was reinforced on the outside from the base to below the rim with chicken wire painted with flat brown paint. Artificial eggs were ceramic, oval in shape (15 × 22 mm), and hand-painted either baby blue to represent a generic egg of several species, e.g., Wood Thrush or Black-billed Cuckoo, or beige with brownish specks toward one end to represent a generic egg of other species, e.g., Common Yellowthroat or Field Sparrow (Harrison 1975). We chose to use ceramic eggs in order to focus principally on avian predators which tend to be visually oriented while foraging; ceramic eggs were presumed to be unattractive as a food item to mammalian predators, which primarily use olfaction while foraging. Moreover, we assumed that ceramic eggs with comparable color and size to those of natural songbird eggs would induce parasitism by cowbirds better than larger natural chicken or quail eggs (Laskey 1950).

The study was divided into five trials from late May through June 1990, which corresponded with the timing of nest parasitism by cowbirds (Orians et al. 1989). Each trial was eight days in length. During a trial, 15 random locations were selected at interfaces of uncut and clearcut plots at the BGH Management Area and at interfaces of uncut forest and farmland at the Toftrees Area. Minimum distance between adjacent locations was 100 m, and the same location was not used in the subsequent trial.

A nest with blue eggs and a nest with brown eggs were placed at each location, giving a total of 60 nests/trial equally divided between sites and egg color (N = 300 total nests). Nests were located 5 m into uncut forest along the interface and were 20 m apart (Yahner et al. 1989). Each nest was attached 1 m above ground to the nearest woody stem (1–5 cm dbh) (Yahner and Cypher 1987). A previous study showed that predation rates of nests placed by investigators in this manner and actual nests placed by breeding birds were not different (Yahner and Voytko 1989).

We placed one egg daily (indirect host activity) in each nest for three consecutive days (days 1–3) during each trial, resulting in three eggs/nest (Thompson and Gottfried 1981). Rubber gloves and boots were worn when placing nests and eggs to minimize human scent (Nol and Brooks 1982). We determined the fate (disturbed vs undisturbed) of nests and eggs on day 2, day 3, and 5 days after placement of the third egg (day 8). Appearance of nest and eggs and mode of disturbance were used to categorize predators (Rearden 1951, Nol and Brooks 1982). A disturbed nest had ≥ one missing egg or ≥ one egg with bill marks due to pecking by an avian predator (Yahner et al. 1989). Eggs removed by predators by days 1 or 2 were replaced on the next visit to the nest. Nests and eggs were removed on day 8, and the next trial was initiated immediately.

The dependency of nest fate (disturbed vs undisturbed) on site (BGH Management Area vs Toftrees Area), egg color (blue vs brown), and trial (trials 1–5) was examined by 4-way tests-of-independence (Dixon 1985). Separate analyses were conducted for days 2, 3 and 8 (Yahner and Wright 1985). Likelihood ratios (G^2) were computed to test for interactions of nest fate with each of the three independent variables using log-linear models, which is appropriate for examining attribute variables in multi-way contingency tables (Sokal and Rohlf 1981, Dixon 1985).

Results.—Of the 300 nests, 49 (16.3%) were disturbed by day 2, 67 (22.3%) by day 3, and 172 (57.3%) by day 8 (Table 1). At least 90% of the disturbed nests had ≥ one egg removed

TABLE 1
NUMBER OF ARTIFICIAL AVIAN NESTS THAT WERE DISTURBED BY DAYS 2, 3, AND 8

Trial	Site	Egg color	No. disturbed nests		
			Day 2	Day 3	Day 8
1	BGH Management Area	Blue	4	6	9
		Brown	3	4	10
		Total	7	10	19
	Toftrees Area	Blue	0	4	13
		Brown	2	3	10
		Total	2	7	23
2	BGH Management Area	Blue	2	3	5
		Brown	3	2	11
		Total	5	5	16
	Toftrees Area	Blue	2	3	11
		Brown	5	3	10
		Total	7	6	21
3	BGH Management Area	Blue	3	4	8
		Brown	4	4	7
		Total	7	8	15
	Toftrees Area	Blue	0	4	8
		Brown	3	4	9
		Total	3	8	17
4	BGH Management Area	Blue	3	7	11
		Brown	2	1	9
		Total	5	8	20
	Toftrees Area	Blue	2	4	7
		Brown	1	3	8
		Total	3	7	15
5	BGH Management Area	Blue	4	4	8
		Brown	3	3	12
		Total	7	7	20
	Toftrees Area	Blue	2	1	4
		Brown	1	0	2
		Total	3	1	6
All	BGH Management Area	Blue	16	24	41
		Brown	15	14	49
		Total	31	38	90
	Toftrees Area	Blue	6	16	43
		Brown	12	13	39
		Total	18	29	82

from the vicinity of the nest on days 2, 3, or 8. We attributed virtually all nest disturbances to avian predators, particularly Blue Jays (*Cyanocitta cristata*) and American Crows (*Corvus brachyrhynchos*), based on nest or egg appearance (e.g., peck marks on eggs). Furthermore, several previous experimental studies in the vicinity showed that corvids were the major predator on artificial nests (e.g., Yahner and Cypher 1987, Yahner et al. 1989). Ceramic eggs also would be of no food value to predators that forage mainly via olfaction (e.g., mammals). No nests were parasitized by cowbirds.

Slightly more nests were disturbed at the BGH Management Area than at the Toftrees site by days 2, 3, and 8. However, fate of nests was dependent on site only on day 2, with 31 (20.7%) nests disturbed at the BGH Management Area compared to only 18 (12.0%) at the Toftrees Area ($G = 4.2$, df = 1, $P = 0.04$).

Slightly more nests with brown eggs were disturbed than those with blue eggs by days 2 and 8, but these relationships were not significant ($P \geq 0.43$) (Table 1). Conversely, fate of nests tended to be associated with egg color by day 3 ($G = 3.3$, df = 1, $P = 0.07$), with 40 (26.7%) nests with blue eggs disturbed versus 27 (18.0%) nests with brown eggs disturbed.

Fate of nests was not dependent on trial by days 2 and 3 ($P \geq 0.21$) (Table 1). In contrast, rate of disturbance declined over time by day 8, with 42 (70.0%) of the nests disturbed in trial 1 and only 26 (43.3%) disturbed in trial 5 ($G = 9.7$, df = 4, $P = 0.05$).

Discussion.—The rate of disturbance on artificial nests in our study (57%) was comparable to those reported in studies of nesting success of actual bird nests. For example, Yahner (1991) observed that 52% of the nests of 14 species were unsuccessful over a 3-year period at the BGH Management Area; at least 90% of the unsuccessful nests were due to avian predators (R. H. Yahner, unpubl. data). Moreover, the rate of nest disturbance in our study was similar to those noted in previous studies at the BGH Management Area, which used artificial nests (chicken wire lined with leaf litter) containing fresh brown chicken eggs (e.g., Yahner and Cypher 1987, Yahner and Scott 1988, Yahner et al. 1989). Yahner et al. (1989), in a study examining nest loss in relation to edge contrast, observed that 51% of the artificial nests placed 1.5 m above ground were disturbed. Yahner and Cypher (1987), in a study comparing nest loss among stands of different age since clearcutting, reported that 68% of the artificial nests located 0.5–1.5 m above ground were disturbed. These two studies and other previous studies (e.g., Yahner and Wright 1985, Yahner and Scott 1988, Yahner and Voytko 1989) attributed most depredation of artificial nests to corvids.

In contrast, the 57% rate of nest disturbance in our present study was considerably lower than that reported by Yahner and Morrell (1991) in a study at the Toftrees Area, which dealt with depredation of artificial nests (chicken wire lined with leaf litter) containing fresh brown chicken eggs. In the study by Yahner and Morrell (1991), 78% of the artificial nests placed at 1.5 m above ground were lost to predators. They contended that at least 90% of the disturbed nests at the Toftrees Area were due to mammalian predators, primarily raccoon (*Procyon lotor*); in most cases, these nests were destroyed within two days of placement (R. H. Yahner, pers. obs.; see also Storaas 1988). Best (1978) also reported a 78% predation rate on nests of Field Sparrows in farmlands of Iowa where mammals were major nest predators.

Differential rates of nest disturbance by avian and mammalian predators at the BGH Management Area versus the Toftrees Area were not unexpected because Blue Jays were more common at the former site, whereas raccoons were more prevalent at the latter site (Yahner and Scott 1988, Yahner and Morrell 1991). Avian nest predators often are more abundant in forested landscapes (e.g., BGH Management Area), whereas mammalian nest predators generally predominate in forest-farmland landscapes (e.g., Toftrees Area) (Angelstam 1986, Yahner and Scott 1988, Yahner and Morrell 1991).

We partially attribute the greater rate of nest disturbance at the BGH Management Area than at the Toftrees Area on day 2 to higher densities of Blue Jays in forested stands at the former site than the latter site (Yahner 1986, Rollfinke and Yahner 1990). Furthermore, a significantly greater susceptibility of nests with blue eggs by day 3 compared to nests with brown eggs at both sites combined perhaps occurred because blue eggs were more conspicuous than brown eggs to corvids which rely primarily on vision while foraging (Yahner and Wright 1985).

Previous studies, using artificial nests with brown chicken eggs at SGL 176, showed that rates of nest disturbance either did not vary among trials (Yahner and Scott 1988, Yahner et al. 1989, Yahner and Voytko 1989, Yahner and Morrell 1991) or declined over time (Yahner and Wright 1985, Yahner and Cypher 1987). The decline in rates observed in the latter two studies was attributed to the social behavior of American Crows in mid-summer. In mid-summer, crows probably fledged young and moved away from wooded areas at SGL 176 to more distant communal roosting sites and agricultural feeding areas, thereby reducing their impact on avian nests (Cross 1946, Yahner and Wright 1985, Yahner and Cypher 1987). Perhaps this behavior of crows may have explained partially lower rates of disturbance over time in our study. Another factor that may have contributed to reduced rates of disturbance in our study over time was that corvids eventually learned that artificial (ceramic) eggs were of no food value and, hence, avoided this food source (Krebs 1978). However, rates of disturbance may not have declined over time if eggs were of some food value.

Abundance of Brown-headed Cowbirds was similar at the BGH Management and Toftrees areas, despite marked differences in the landscape of these two sites (Yahner 1986, Rollfinke and Yahner 1990). Abundance of cowbirds on our sites was lower than at sites in the Midwest where 48% of the active bird nests were parasitized by cowbirds (Brittingham and Temple 1983). In contrast, only three (3%) of 95 active avian nests were parasitized over a three-year period at the BGH Management Area (Yahner 1991).

Thompson and Gottfried (1976) did not observe parasitism by cowbirds on 159 experimental nests containing two eggs of Japanese Quail; they suspected that this was due to the large size of quail eggs. In a later study, Thompson and Gottfried (1981) artificially placed three House Sparrow (*Passer domesticus*) eggs in each of 50 abandoned nests. In 25 of these nests, the three eggs were placed on the same day; in the remaining 25 nests, one egg was placed on each of three consecutive days. None and one (4%) of the nests in these first and second groups, respectively, were parasitized. In contrast, Thompson and Gottfried (1981) reported that five (23%) of 22 active bird nests in the vicinity of the abandoned nests were parasitized. They concluded that indirect evidence of host activity via daily placement of eggs by an investigator can elicit parasitism by cowbirds, but that their studies lacked a sufficient sample size to determine if parasitism of nests without direct host activity at nests (Rothstein 1976) frequently occurs. Recently Freeman et al. (1990) found that 28 (22%) of the 30 incidences of cowbird parasitism on nests of Red-winged Blackbirds (*Agelaius phoeniceus*) occurred on inactive nests, which represented a high rate of parasitism despite the lack of host activity.

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Notes on the breeding and reproductive biology of the Helmeted Manakin.—The Helmeted Manakin (*Antilophia galeata*: Pipridae) is a monotypic species with a mating system and distribution that may be atypical for a sexually dichromatic manakin (Marini and Cavalcanti, unpubl. data). The range (tableland of central and southern Brazil, from Maranhão and Piauí, south to Paraná, north of Mato Grosso do Sul, northeast of Paraguay [Meyer de Schauensee 1970] and also in Ceará, Brazil [P. T. Z. Antas, pers. comm.] and in extreme eastern Bolivia [Bates et al., in press]) and habitat (gallery forests in the "cerrado" region of central Brazil) are unique among manakins. In addition, Sick (1967) considered its call sonorous and "rather different from other manakins, but similar to some cotingas." Females are olive green, and adult males are black with a red crown, neck and upper back. Subadult males have green plumage mixed with black and red feathers. Immature males are similar to females. The nest and eggs were described by Ihering (1900, 1902). Since then nothing has been published about the Helmeted Manakin's natural history. The Helmeted Manakin taxonomic status is uncertain because little is known about its biology. The objective of this paper is to provide data on the Helmeted Manakin's breeding biology that may lead to a better understanding of its classification.

Study area.—This study was conducted in the gallery forest of the Córrego Capetinga (a creek) at the Ecological Station of the University of Brasília, Brasília, Distrito Federal, Brazil (15°58′S; 47°56′W). The gallery forests consist of ribbons of evergreen trees along water courses, with the tallest trees between 20 and 30 m, surrounded by natural semi-open grasslands ("cerrado"). The gallery forest studied has at least 120 species of plants, of which 76 are trees or big shrubs (Ratter 1980). Detailed information on the study area and region are in Ratter (1980), Eiten (1984), and Marini (1989).

Methods.—Nests and testes of collected birds were measured with a metal caliper accurate to 0.1 mm. Observations were made mostly in the morning (06:30–13:00) from April 1988 to March 1989. Song intensity (number of male songs/h) and chase frequency (number of chases/h) were quantified on a 2.5-ha plot, marked by a grid of 34 points at 30 m intervals. Only males under sight were sampled. The results are the combined observations of four adult males and three subadult males color banded in the study plot. Searching for birds lasted 5 min at each point with a 2–3 min interval between points. The number of hours of searching is the sum of 5 min searching periods. I visited each point approximately 41 times, totaling 117.1 hours of searching during the 12-month period of study. I made 450 sightings which lasted from a few seconds to 5 min.