

# VALIDATING THE USE OF ARTIFICIAL NESTS IN PREDATION EXPERIMENTS

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**Abstract:** Artificial nests with Japanese quail (*Coturnix coturnix*) eggs have often been used in experiments to compare patterns of predation with different ecological and nest-site attributes. Many investigators assume that predators respond to artificial nests as they would to natural nests; however, this assumption has rarely been tested. In 1996, in La Plata County, Colorado, we investigated differences in predator response to quail eggs in natural American robin (*Turdus migratorius*) nests in their original location, and artificial wicker-basket nests placed both in a 6 × 8 grid pattern at 30-m intervals and in a natural pattern 30 m in a random direction from each natural nest. Over the 15-day trial, predators responded differently to quail eggs in natural and artificial nests. By the first (5-day) check, predators had depredated 44.4% ( $n = 27$ ) of natural nests, 11.1% ( $n = 27$ ) of artificial nests 30 m from natural nests, and 14.6% of artificial nests in the grid ( $n = 48$ ;  $P < 0.01$ ). By the second (10-day) check, they had depredated similar proportions in all trial types ( $P > 0.10$ ). However, by the final (15-day) check, more artificial nests in the grid had been depredated (91.7%) than either artificial nests located 30 m from natural nests (66.7%) or natural nests (70.4%;  $P < 0.02$ ). We found no difference in predation patterns among nests placed  $\leq 2$  m and those  $> 2$  m aboveground. We suggest that because predators respond differently to natural and artificial nests, caution should be exercised in making management decisions based upon results of artificial nest experiments.

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**Key words:** American robin, artificial nests, *Coturnix coturnix*, grid, Japanese quail eggs, nest density, nest height, predation, *Turdus migratorius*, validation.

Predation is the major cause of nesting mortality among open-cup nesting birds (Ricklefs 1969, Martin 1988a, Martin and Li 1992, Martin 1993a,b) and, along with avian brood parasitism, is often cited among the primary agents of declining populations of North American migratory songbirds (Wilcove 1985, Faaborg et al. 1993, Haskell 1995). Increases in some predator populations, due to human-induced changes in landscape patterns, have been presumed both in North America (Wilcove 1985, Sugden and Beyersbergen 1986, Small and Hunter 1988, Vander Haegen and DeGraaf 1996) and elsewhere (Andr n 1992, Teller a and Santos 1992, Laurance et al. 1993, Huhta et al. 1996). These anthropogenic changes have prompted a surge in predation experiments during the last decade in an attempt to identify predation patterns and provide management recommendations. Most experimental predation studies have been conducted with Japanese quail (hereafter, quail) eggs (but several have used domestic chicken or artificial eggs) to compare patterns of pre-

dation associated with different ecological and nest-site attributes such as habitat fragmentation (Andr n and Angelstam 1988, Yahner and Scott 1988, Yahner et al. 1989, Andr n 1992, Picman and Schriml 1994), size of forest patches (Wilcove 1985, Teller a and Santos 1992), habitat type (Seitz and Zegers 1993, Sloan et al. 1998), predator density (Sugden and Beyersbergen 1986, O'Reilly and Hannon 1989, Reitsma 1992, Teller a and Santos 1992, and references in Martin 1988b), placement of nests (Martin 1987, Seitz and Zegers 1993), and introduced predators (Henry 1969).

Results of studies designed to determine predation among natural nests of different densities (Krebs 1971, Dunn 1977, Page et al. 1983, Zimmerman 1984) and heights (Martin 1993a, Wada 1994, Sloan et al. 1998) have varied widely, most likely due to variations in predator assemblage; therefore, nest density and placement height should be justified for every experimental predation study. In most predation experiments, artificial nests are placed at equal or near equal intervals along transects or in a grid pattern on the ground or in woody vege-

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tation. Nests are often placed at 10-m (Martin 1988b, Laurance et al. 1993), 15-m (Small and Hunter 1988, Rudnicki and Hunter 1993), 25-m (Wilcove 1985, Gibbs 1991, Nour et al. 1993), or 50-m (Gibbs 1991) intervals. While transects or grids control for placement of nests between 2 or more variables (i.e., forest patch size), they are atypical of natural patterns and often create unnatural density. To our knowledge, nests have not been placed above 3 m in most previous studies, and most have been placed in trees or shrubs at heights of <2 m (Wilcove 1985, Martin 1987, Yahner and Cypher 1987, Reitsma et al. 1990, Reitsma 1992, Rudnicki and Hunter 1993, Seitz and Zegers 1993, Tellería and Díaz 1995; but see Gibbs [1991] for nests placed 1–3 m aboveground and Sloan et al. [1998] for nests placed 2–6 m aboveground).

Artificial nests and, occasionally, natural nests relocated to other sites (Martin 1987) were used in most previous experimental studies (but see Møller 1988, Roper 1992). Use of artificial nests has the advantage of enabling investigators to test various ecological variables and can help ensure sufficient sample size. Researchers using artificial nests often assume that predators find and respond to artificial and natural nests similarly (Martin 1988b, Gibbs 1991, Laurance et al. 1993). However, use of artificial nests may not accurately reflect predation patterns of natural nests, and as O'Reilly and Hannon (1989), Rudnicki and Hunter (1993), and others have noted, conclusions should be viewed cautiously because there has been little effort to compare natural nests to artificial nests (but see Willebrand and Marcström 1988). It is therefore critical to validate use of artificial nests by comparing them to natural nests at the same site, rather than embracing this assumption.

In this study, we investigated differences in predator response between natural nests and artificial nests placed both in a grid pattern and in a pattern based upon natural nests. We also compared predation of nests placed at a height <2 m and between 2 and 3.7 m (the height we could reach with a 1.8-m ladder). American robins (hereafter, robin) were selected for this study because they are abundant and have relatively large eggs for passerines. From previous years of study at the same site, we also knew that predation rates on robin nests were 41.5–58.8%, which is typical of many open-cup nesting North American passerines that nest in

shrub and subcanopy layers (Martin 1993a, and references therein). Robin nests are conspicuous and relatively easy to find; most (85.4%,  $n = 287$ ) nests in this and previous years were found prior to or in the incubation stage, thereby improving predation estimates (see Mayfield 1961, 1975). Additionally, the majority of robins at our study site (77.7%;  $n = 287$ ) nested at heights  $\leq 3.7$  m.

## STUDY AREA

From May through July 1996, we searched for robin nests along the La Plata River at the Colorado State University San Juan Basin Research Center, 8 km south of Hesperus, in La Plata County, Colorado (37°14'N, 108°3'W). The site was dominated by narrow-leaf cottonwoods (*Populus angustifolia*) and to a lesser degree by riverbirch (*Betula fontinalis*) and Gambel oak (*Quercus gambelii*). The Research Center was grazed by cattle at a moderate intensity (0.4 head/ha) and was mostly open at ground level (shrubs and other heavy understory were scarce).

## METHODS

We visited robin nests every 1–3 days and recorded contents of the nest until all birds had fledged or until the nest failed from predation or abandonment. On 25–27 June, when many nests were no longer being used but while numerous robins were still breeding within the site (see Fig. 1), we secured, with wire, wicker-basket canary nests (Art. no. B-1990; Rolf C. Hagen, Mansfield, Massachusetts, USA) in the nearest tree located 30 m in a random cardinal direction from all vacated robin nests that were still in good condition and <3.7 m in height. The mean inner-cup diameter was  $94.7 \pm 1.8$  mm ( $\pm$  SD;  $n = 7$ ), and the mean outer-nest diameter was  $103.9 \pm 2.7$  mm ( $n = 7$ ). These dimensions compare to a mean inner-cup diameter of  $95.5 \pm 5.2$  mm ( $n = 48$ ) and a mean outer-nest diameter of  $121.7 \pm 7.2$  mm ( $n = 48$ ) among real robin nests.

We placed nests at the same height as natural nests; therefore, we obtained pairs of nests (1 natural, 1 artificial) at the same height but approximately 30 m apart. We also placed 48 of the same artificial nests in a  $6 \times 8$  grid approximately 30 m apart at various heights from 0.5 to 3.7 m. Heights for the grid nests were selected randomly from the heights of natural nests used in the experiment. As with natural

Table 1. Cumulative numbers of nests with depredated Japanese quail eggs in 3 treatments: natural American robin nests, artificial wicker-basket nests 30 m from natural robin nests, and artificial wicker-basket nests in a 6 × 8 grid 30 m apart, 5, 10, and 15 days after being baited, La Plata County, Colorado, 1996.

Nest type	n	5-day check		10-day check		15-day check	
		n	% depredated	n	% depredated	n	% depredated
Natural robin	27	12	44.4	17	63.0	19	70.4
30 m from robin	27	3	11.1	12	44.4	18	66.7
Grid	48	7	14.6	32	66.7	44	91.7

nests, we marked the site of each artificial nest with uniquely coded flagging tape. The mean nest height was  $2.1 \pm 0.8$  m for natural nests,  $2.1 \pm 0.8$  m for artificial nests 30 m from natural nests, and  $2.1 \pm 0.9$  m for artificial nests in the grid. For each nest, we also noted the tree species.

On 30 June, we added 3 fresh quail eggs to each natural and artificial nest described above. Mean ( $\pm$  SD) measurements of quail eggs were as follows: mass =  $10.6 \pm 0.9$  g, width =  $25.2 \pm 0.7$  mm, and length =  $31.7 \pm 1.6$  mm ( $n = 10$ ). Mean measurements of robin eggs were as follows: mass =  $6.3 \pm 0.3$  g, width =  $21.0 \pm 1.4$  mm, and length =  $29.6 \pm 1.8$  mm ( $n = 10$ ). We previously determined that handling eggs and chicks without gloves did not reduce nesting success of robins on our study area (Ortega et al. 1997); however, we wore rubber gloves while attaching artificial nests and while handling all quail eggs to reduce our scent on eggs (Whelan et al. 1994). We checked all nests 5, 10, and 15 days after addition of quail eggs. Nests were checked with the aid of a mirror on an extension pole and were not touched. A nest was considered depredated if  $\geq 1$  egg(s) disappeared or were damaged.

### Statistical Analyses

We subjected data from  $2 \times 2$  contingency tables to log-likelihood ratio tests with Williams' correction ( $G$ ; Sokal and Rohlf 1981) to determine whether predation was independent of nest type and placement and to determine if predation was similar between natural nests with robin eggs, nestlings, or both, and the same (vacated) nests with quail eggs. We also used log-likelihood ratio tests with Williams' correction to determine whether predation of robins (prior to experiments) was similar among nest-tree species and to test for differences in proportions of depredated nests  $\leq 2$  m and  $> 2$  m aboveground. To test for differences of nest-tree species among ( $3 \times 3$ ) and between ( $2 \times$

3) trial types, we used log-likelihood ratio tests with Williams' correction. We hypothesized there would be no difference in predation at any nest visit (5, 10, 15 days), between or among trial types (natural robin nests, artificial nests 30 m from natural robin nests, artificial nests in the grid), and with other variables (nest substrate, nest height). To determine if there was an association between predation and number of available nests in 1-week periods, we used a Spearman rank correlation coefficient test (Zar 1984). We considered a  $P$ -value  $\leq 0.05$  to be significant for all tests.

## RESULTS

### Nest Predation

Five days after quail eggs were added, a higher proportion of quail eggs in natural nests had been preyed upon than in either artificial nests 30 m from natural nests ( $G_1 = 7.60$ ,  $P < 0.01$ ) or artificial nests in the grid ( $G_1 = 7.68$ ,  $P < 0.01$ ; Table 1). There was no difference in predation between artificial nests 30 m from natural nests and artificial nests in the grid ( $G_1 = 0.18$ ,  $P > 0.50$ ). By the 10-day check, there were no statistically significant differences among trial types ( $G_2 = 3.58$ ,  $P > 0.10$ ); however, by the 15-day check, a higher proportion of quail eggs in artificial nests in the grid were depredated than in both natural nests ( $G_1 = 5.34$ ,  $P < 0.02$ ) and artificial nests 30 m from natural nests ( $G_1 = 6.95$ ,  $P < 0.01$ ). There was no difference in predation between natural nests and artificial nests 30 m from natural nests ( $G_1 = 0.08$ ,  $P > 0.75$ ).

We knew whether or not robin eggs and nestlings had been depredated for 24 of 27 robin nests used in the predation experiments. Robin eggs or nestlings in 14 (58.3%) nests were depredated prior to the experiments. Of these 14 previously depredated nests, quail eggs were depredated in 10 (71.4%), and of 10 robin nests previously untouched by predators, only 2

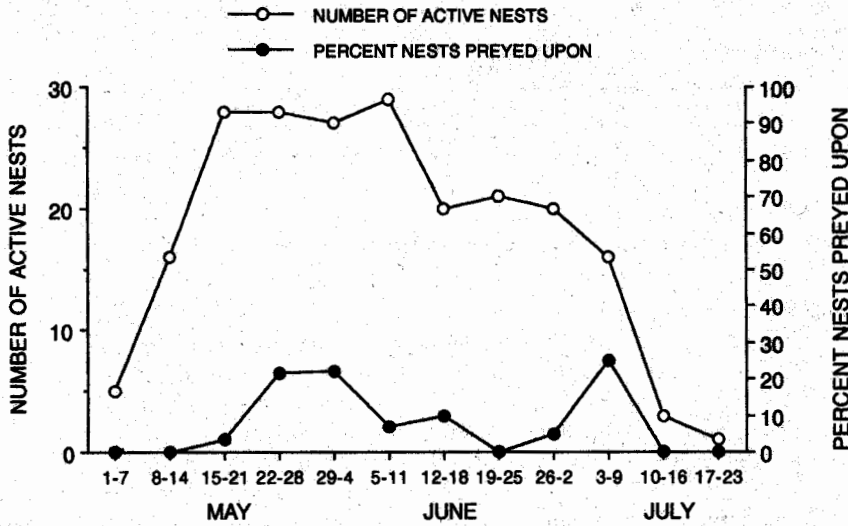


Fig. 1. Number of active nests (with American robin eggs, nestlings, or both) and percentage of nests preyed upon in weekly periods across the breeding season, La Plata County, Colorado, 1996.

(20%) were not depredated when they had quail eggs in them ( $G_1 = 0.44, P > 0.90$ ). In other words, predation was not predictable among individual nests; most nests that escaped predation when they contained robin eggs or young were depredated when they contained quail eggs.

Predation of robin eggs and nestlings varied across the season, showing a bimodal peak (Fig. 1). The first peak occurred when the greatest number of active nests were available; the second peak occurred the week after quail eggs were added. There was an association ( $r_5 = 0.63, P = 0.04$ ) between predation rates and the

number of available nests in 1-week periods (Spearman rank correlation coefficient test, corrected for ties; Fig. 1).

**Nest Height and Nest Substrate**

Predation was generally more prevalent among nests >2 m aboveground, but there were no statistically significant differences between the proportion preyed upon ≤2 m and >2 m aboveground in any trial type (Table 2). We observed the same trend among natural nests used in the experiment when they contained robins: 5 (50%,  $n = 10$ ) nests ≤2 m aboveground were preyed upon, and 9 (64.3%,

Table 2. Cumulative numbers (and percent) of depredated American robin nests and artificial wicker-basket nests in 2 trial types (30 m from natural robin nests and in a 6 × 8 grid 30 m apart) placed ≤2 m and >2 m aboveground, 5, 10, and 15 days after being baited with Japanese quail eggs, La Plata County, Colorado, 1996.

Nest type	n	5-day check	10-day check	15-day check
<b>Natural robin nests</b>				
Nest ≤2 m aboveground	11	3 (27.3%)	7 (63.6%)	7 (63.6%)
Nest >2 m aboveground	16	9 (56.3%)	10 (62.5%)	12 (75.0%)
P		>0.10	>0.90	>0.50
G <sub>1</sub>		2.15	<0.01	0.37
<b>30 m from natural robin nests</b>				
Nest ≤2 m aboveground	11	0 (0%)	5 (45.5%)	7 (63.6%)
Nest >2 m aboveground	16	3 (18.8%)	7 (43.8%)	11 (68.8%)
P			>0.90	>0.75
G <sub>1</sub>			<0.01	0.07
<b>Grid nests</b>				
Nest ≤2 m aboveground	22	1 (4.5%)	12 (54.5%)	19 (86.4%)
Nest >2 m aboveground	26	6 (23.1%)	20 (76.9%)	25 (96.2%)
P		>0.05	>0.10	>0.10
G <sub>1</sub>		3.40	2.60	1.36

Table 3. Numbers and percentage of nests depredated within nest-tree species selected by American robins and used for artificial wicker-basket nests in 2 treatments (30 m from natural robin nests and in a 6 × 8 grid 30 m apart), La Plata County, Colorado, 1996.

Tree species	Natural robin nests		Artificial nests 30 m from natural nests		Artificial nests in grid	
	n	% depredated	n	% depredated	n	% depredated
Narrow-leaf cottonwood	12	44.4	11	40.7	41	85.4
Riverbirch	11	40.7	9	33.3	5	10.4
Other <sup>a</sup>	4	14.8	7	25.9	2	4.2

<sup>a</sup> Other trees include thin-leaf alder (*Alnus tenuifolia*), Gambel oak (*Quercus gambelii*), Rocky Mountain juniper (*Juniperus scopulorum*), and willows (*Salix* spp.).

$n = 14$ ) nests >2 m aboveground were preyed upon ( $G_1 = 0.47$ ,  $P > 0.25$ ). The proportion of nest-tree species varied among trial types ( $G_4 = 21.40$ ,  $P < 0.001$ ; Table 3). The difference occurred between artificial nests in the grid and artificial nests 30 m from natural nests ( $G_2 = 15.74$ ,  $P < 0.001$ ), and between artificial nests in the grid and natural nests ( $G_2 = 12.95$ ,  $P < 0.005$ ); there was no difference between natural nests and artificial nests 30 m from natural nests ( $G_2 = 1.03$ ,  $P > 0.50$ ). In general, the nest-tree species did not appear to significantly affect predation rates (Table 4); however, in most cases, predation was lower among nests in riverbirches. Predation among robin eggs, nestlings, or both prior to the experiments was similar among type of nest substrate (60.0% in cottonwoods,  $n = 10$ ; 54.4% in riverbirches,  $n = 11$ ; 66.7% in other,  $n = 3$  ( $G_2 = 0.15$ ,  $P > 0.90$ ).

## DISCUSSION

Over the 15-day trial, predators responded differently to natural and artificial nests in which quail eggs were added. By the first (5-

day) check, predators had discovered and destroyed significantly more natural nests, but by the second (10-day) check, they had depredated similar proportions in all trial types. By the third and final check, significantly more artificial nests in the grid had been depredated than artificial nests located 30 m from natural nests, whereas predation was similar between natural nests and artificial nests located 30 m from natural nests.

Difference in timing of predation between natural and artificial nests suggests nest appearance and previously developed search images by visually oriented predators may have been important. Wilcove (1985) suggested artificial nests are more conspicuous than natural nests. Operating on a similar assumption, Martin (1987) compared predation of quail eggs in natural nests of hermit thrush (*Catharus guttatus*) and MacGillivray's warbler (*Oporornis tolmiei*) nests (that had been stored over winter) with artificial wicker-basket nests and found that, contrary to his prediction, the predation rate for artificial nests without modification was signifi-

Table 4. Cumulative number and percentage of any depredated (full or partial) Japanese quail eggs in American robin nests and artificial wicker-basket nests in narrow-leaf cottonwoods, riverbirches, and other trees 5, 10, and 15 days after being baited with Japanese quail eggs, La Plata County, Colorado, 1996.

Nest type	n	5-day check		10-day check		15-day check	
		n	% depredated	n	% depredated	n	% depredated
Natural robin							
Narrow-leaf cottonwood	12	4	33.3	8	66.7	10	83.3
Riverbirch	11	7	63.6	8	72.7	8	72.7
Other <sup>a</sup>	4	1	25.0	1	25.0	1	25.0
30 m from natural robin nests							
Narrow-leaf cottonwood	11	1	9.1	6	54.5	7	63.6
Riverbirch	9	1	11.1	2	22.2	5	55.6
Other	7	1	14.3	4	57.1	6	85.7
Grid nests							
Narrow-leaf cottonwood	41	6	14.6	30	73.2	38	92.7
Riverbirch	5	0	0.0	0	0.0	4	80.0
Other	2	1	50.0	2	100	2	100.0

<sup>a</sup> Other trees include thin-leaf alder, Gambel oak, Rocky Mountain juniper, and willows.

cantly lower than for both natural (but relocated) nests and artificial nests with mosses on the outside. He also conducted 15-day trials with 5 days between visits. Martin attributed the difference in predation rates, which were repeatable through time, to differences in appearance of nests. While our data initially supported this view, the major predators appeared to learn the appearance of the artificial basket nests during the 15-day trial.

The potential predators at our site included black-billed magpies (*Pica pica*), scrub jays (*Aphelocoma coerulescens*), Steller's jays (*Cyanocitta stelleri*), rock squirrels (*Spermophilus variegatus*), chipmunks (*Tamias* spp.), deer mice (*Peromyscus maniculatus*), long-tailed weasels (*Mustela frenata*), striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), and garter snakes (*Thamnophis* spp.). We have observed rock squirrels, raccoons, and black-billed magpies prey upon birds' nests at our study site, and we believe these 3 species were among the most important predators.

Willebrand and Marcström (1988) found predation of artificial nests was lower than among natural nests and concluded artificial nests are a poor index of predation of natural nests, especially because they may attract different predators. Through radiotelemetry, they found birds were the main predators of artificial nests, whereas mammals were the main predator of natural nests; they attributed this finding to lack of hen scent on artificial nests. Rudnicki and Hunter (1993) also suggested artificial nests may be less detectable because lack of parental activity and lack of scent may attract fewer predators. Skutch (1985) suggested more feeding visits may be more likely to reveal nest location to potential predators. In contrast, Yahner et al. (1989) suggested artificial nests may be preyed upon at a higher rate because they are unprotected and uncovered by incubating parents. Similarly, in an unfragmented New Hampshire forest, Sloan et al. (1998) found depredation of artificial nests in subcanopy strata was 2–3 times higher than depredation of natural nests within the same strata during the same year. In Norway, Storaas (1988) also found that natural nests of capercaillie (*Tetrao urogallus*) suffered fewer losses than artificial nests with less cover and concluded that predation of artificial nests is a poor index of natural nest predation.

Yahner and Voytko (1989) found little differ-

ence between predation of arboreal artificial nests placed in actual sites selected by several species in the previous year (65%) and artificial nests 30 m from the actual sites but placed at the same height (73%). As in our study, Yahner and Voytko (1989) found no difference between the proportion of nests placed at actual sites in the most commonly used tree species and the proportion of random nests placed in the same tree species, but they did detect a difference between the proportion of actual and random nest sites of more rarely used tree species.

The amount of time experimental nests are exposed varies widely among investigators, from 48 hr (Tellería and Santos 1992) to 15 days (Martin 1987, Reitsma et al. 1990, Reitsma 1992) for simulation of predation on passerines. The length of exposure appeared critical in our study because we obtained opposite results at the 5- and 15-day visit. In our study, predation of artificial nests most closely approximated predation of natural nests at the 10-day visit.

In most experimental predation studies of arboreal nests, nests are placed <2 m aboveground, probably because this height is the maximum that can be easily reached without an investigator climbing the nesting substrate or using a ladder (Martin 1987, Yahner and Cypher 1987, Reitsma 1992, Rudnicki and Hunter 1993, Seitz and Zegers 1993, Tellería and Díaz 1995). Reports of predation among vegetation layers vary widely (see Martin 1993a); therefore, it is important to justify the height at which nests are placed for each study. In our study, the height at which nests were placed did not appear to significantly affect predation rates, but nests placed >2 m aboveground were depredated at a slightly higher rate. In previous studies on robins at the same site, we found variation among years: in 1993, nest height was the same among depredated and nondepredated nests, and in 1994, 1995, and this study, depredated nests were higher (Ortega et al. 1997).

Whether higher predation rates among artificial nests in the grid were due to higher density is unclear, but density of artificial nests in the grid (16.9 nests/ha, including 3 paired nests in natural locations within the grid) was much higher than density of nests outside the grid (1.4 nests/ha of the 54 used in the study). Other studies have yielded conflicting results. Martin (1988b) found predation rates increased with more eggs, and data from several studies of artificial nests show or suggest a pattern of den-

sity-dependent predation (Page et al. 1983, Sugden and Beyersbergen 1986, Reitsma 1992, Marini et al. 1995). Other studies of simulated nests have shown no density-dependent patterns of predation (O'Reilly and Hannon 1989), and Zimmerman (1984) found no relation between predation and nest density of dickcissels (*Spiza americana*). However, predators may not cue in on a particular species, but rather develop a generalized search image for nests with a set of ecological cues; therefore, other species with similar nests may need to be included in the sample to adequately evaluate the effect of nest density.

### MANAGEMENT IMPLICATIONS

Results from this study did not fully support the use of artificial basket nests to provide reliable estimates of nest-predation rates for arboreal nests. Preliminary studies should be conducted at a particular site to determine differences in predator response to artificial and natural nests. Variables that should be explored in preliminary studies include length of exposure, patterns of nest placement, and nest height. In areas where small predators are of major importance, it is also important to validate use of quail eggs when investigating potential patterns of predation for songbirds with smaller eggs (see Roper 1992, Haskell 1995, and references therein). Of particular importance may be the comparison of predator responses to artificial nests and natural nests at each site in studies designed to compare landscape patterns because predator assemblages are known to vary by patch size and in ecotones and may also vary with regard to search images, learning abilities, and abilities to open quail eggs. Further, annual variation in predator communities requires that studies be based on several years of results.

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