

## The Role of Egg Size and Composition in Artificial Nest Predation Experiments

**Brad W. Goodner**<sup>1</sup>, Department of Biology, University of Richmond, Richmond, VA 23173, **Leif E. Jacobson**, The Collegiate School, N. Mooreland Rd., Richmond, VA 23229, and **Asha L. Goodner**, School of Nursing, Virginia Commonwealth University, Richmond, VA 23298

### ABSTRACT

Artificial nests have been used extensively to study the impact of nest predation. The use of Japanese Quail eggs as surrogate eggs in these experiments has been questioned recently since Japanese Quail eggs are much larger than the eggs of most neotropical passerines. A direct comparison between Japanese Quail eggs and passerine-size clay eggs was conducted and found that passerine-size clay eggs incurred significantly more predation. A subsequent experiment found that the difference was mainly due to egg composition and not to size. The results suggest that the use of clay eggs in future artificial nest predation experiments will more completely sample attempted egg predation, especially that by small mammals.

### INTRODUCTION

Several species of neotropical migratory songbirds have experienced significant population declines during the last thirty years (Hagan & Johnston, 1992). There are possible contributing factors on both the breeding grounds in the forests of eastern North America and the wintering grounds in Central and South America (Bohning-Gaese et al., 1993; Haila et al., 1993; Sauer et al., 1996). Nest predation is one such factor. Most studies have found nest predation to increase with increasing forest fragmentation (Paton, 1994 (review); Donovan et al., 1995; Hoover et al., 1995; Robinson et al., 1995). Forest fragmentation increases the amount of edge which is favored by some potential predators (e.g., corvids and raccoons).

While a few nest predation studies have used natural nests, most work has followed the lead of Wilcove (1985) in using artificial nests (Paton, 1994; Haegen & DeGraaf, 1996). Artificial nests allow for greater control over experimental design and a larger sample size. However, there are many potential problems with using artificial nests, such as the lack of parental activity near the nest and the potential for unnatural olfactory cues or nest positioning (Whelan et al., 1994; Major & Kendal, 1996). While some problems cannot be addressed (e.g., lack of parental activity), most researchers attempt to control for others (e.g., olfactory cues, nest position). Recently, Haskell (1995a) has questioned the validity of past artificial nest experiments on the grounds that the surrogate eggs used were too large. The surrogate egg of choice has been the Japanese Quail, which are at least four times larger than the typical neotropical passerine egg. Using Japanese Quail eggs might mask the real impact of small mammals as nest predators.

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1 Correspondence: Brad Goodner, Science Center E-105, University of Richmond, Richmond, VA 23173

Haskell (1995b) went on to use passerine-size clay eggs in one study that found that fragmentation had no effect on artificial nest predation rate.

While there is a dramatic size difference between Japanese Quail and passerine eggs, there is only circumstantial evidence that the size difference actually matters. We designed and carried out field experiments to 1) directly compare predation rates between Japanese Quail eggs and passerine-size clay eggs and 2) to separate the effects of egg size and composition.

#### MATERIALS AND METHODS

Japanese Quail eggs (typically 24 mm x 30 mm) were purchased and screened for scratches and cracks before use. White modelling clay was used to make surrogate eggs ovoid in shape. Small clay eggs had approximate dimensions of 14 mm x 21 mm, similar to the mean egg size for all neotropical migratory songbird species (Haskell, 1995a). Large clay eggs had the same approximate dimensions as the Japanese Quail eggs. Before use, all types of eggs were washed in a commercial odor masking product (Odors Away), rinsed with water, and allowed to air dry. There was no detectable clay odor after this treatment, rather all eggs had a similar aroma. Latex gloves were worn throughout these procedures.

Artificial nests were constructed using small straw hats (17 cm diameter total, 5 cm depression diameter) coated with mud and allowed to dry. The nests were placed along the edge of a suburban woodlot in Richmond, Virginia. In the first experiment, conducted in midsummer of 1997, each nest contained either one small clay egg or one Japanese Quail egg. In the second experiment, conducted in late summer of 1998, each nest contained either one small clay egg, one large clay egg, or one Japanese Quail egg. The order of eggs was determined using a random number table. Nests were spaced 10 m apart. Each nest was placed on the ground 0.5 m into the woodlot and care was taken to hide each nest to the same extent without much disturbance to the surrounding vegetation. Latex gloves, nylon jackets, and long pants were worn to minimize introduction of human odors.

Eight days later, the nests were recovered and the status of each egg determined. Eggs were analyzed using a stereo microscope for scratches and bite marks. Bite mark comparisons were made to animal skulls (striped skunk, white-footed mouse, eastern gray squirrel, and eastern chipmunk), and to a clay egg handled by a captive white-footed mouse.

#### RESULTS

Predation was defined as the removal, breakage, or significant surface alteration (i.e., bite marks) of an egg. If large sight-directed predators, such as crows, jays, and raccoons, are the major egg predators along a woodlot edge, then similar predation rates would be expected for Japanese Quail eggs and the smaller clay eggs. All of the large predators mentioned above are common in the area used for these experiments. However, as pointed out by Haskell (1995a), if small mammals are significant egg predators then we might expect a difference between the eggs based on size. In the first experiment, as shown in Table 1, there was a highly significant difference in egg predation that supports a major role for small mammals in egg predation. Furthermore, of the 28 clay eggs with bite marks, 23 had marks consistent with the incisor width of chipmunks and 3 had bite marks consistent with the incisor width of white-footed mice.

TABLE 1. Chi-square test for difference in proportions of eggs intact and incurring predation between the two egg types. The null hypothesis is that the proportion of eggs incurring predation is the same for the two egg types. Passerine-size clay eggs were much more likely to incur predation ( $df = 1$ ,  $X^2 = 31.3$  (with Yates' correction),  $P < 0.0001$ ).

	Japanese Quail Eggs	Passerine-size Clay Eggs
Intact	23	1
Incurring Predation	6	28

While the results of the first experiment are consistent with a difference in predation based on egg size, there is the real worry that differences in egg composition may also affect the predation rate. Clay eggs show the result of any mouthing by an animal, while natural egg shell either breaks or stays intact. Therefore, another possible explanation for the data is that small mammals mouth the Japanese Quail eggs as much as the smaller clay eggs, but rarely break the real eggs. In order to distinguish between these two possible explanations, a second experiment was carried out to determine if predation rates differ between passerine-size clay eggs, Japanese Quail-size clay eggs, and Japanese Quail eggs. As shown in Table 2, clay eggs were predated more often than Japanese Quail eggs, regardless of the size of the clay eggs. Again, almost all of the predated clay eggs showed bite marks from small mammals.

#### DISCUSSION

The results obtained in these experiments directly address the concerns and speculations raised by Haskell (1995a; 1995b). As predicted, clay eggs are more heavily predated than Japanese Quail eggs, with small mammals probably accounting for the difference. However, the size of the clay egg is not as important as first thought. Small mammals do attempt to mouth Japanese Quail-size eggs. We see that mouthing as bite marks on clay eggs of that size, but we miss it with real eggs whose threshold of deformation is much higher. These findings suggest that past forest fragmentation studies using only Japanese Quail eggs underestimated the role of small mammals as nest predators (Paton, 1994 (see artificial nests in review)). While this underestimation may cause some concern, the connection between forest fragmentation and nest predation still has very strong support. In addition to studies using artificial nests, a few studies using natural nests have been published in the last few years and they also show that nest predation increases with increasing forest fragmentation (Paton, 1994 (see natural nests in review); Donovan et al., 1995; Hoover et al., 1995; Robinson et al., 1995). Further, a recent study using camera surveillance of natural nests in the Great Smoky Mountains have documented several small mammal species as predators of Wood Thrush eggs (G. Farnsworth & T. Simons, personal communication).

Based on our results, we believe that artificial nests can still be useful in future nest predation studies, with some changes. If passerine-size real eggs continue to be hard to obtain, then a combination of Japanese-Quail eggs and clay eggs of various sizes could be an informative substitute. This combination would allow researchers to determine the extent to which egg size matters in their particular field situation and to possibly identify the egg predators themselves.

TABLE 2. Chi-square tests for difference in proportions of eggs intact and incurring predation between different egg types.

A. The null hypothesis is that the proportion of eggs incurring predation is the same for all three egg types. There is a significant difference in predation rates between the three types of eggs ( $df = 2$ ,  $X^2 = 9.26$ ,  $P < 0.01$ ).

	Japanese Quail Eggs	Japanese Quail-size Clay Eggs	Passerine-size Clay Eggs
Intact	11	4	3
Incurring Predation	8	15	16

B. The null hypothesis is that when egg size is held constant, the proportion of eggs incurring predation is the same for real eggs and clay eggs. Clay eggs were more likely to incur predation than real eggs of the same size ( $df = 1$ ,  $X^2 = 3.96$  (with Yates' correction),  $P < 0.05$ ).

	Japanese Quail Eggs	Japanese Quail-size Clay Eggs
Intact	11	4
Incurring Predation	8	15

C. The null hypothesis is that when egg composition is held constant, the proportion of eggs incurring predation is the same for large eggs and small eggs. There was no difference in predation rates between the two sizes of clay eggs ( $df = 1$ ,  $X^2 \sim 0$ ,  $P > 0.99$ ).

	Japanese Quail-size Clay Eggs	Passerine-size Clay Eggs
Intact	4	3
Incurring Predation	15	16

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## LITERATURE CITED

- Bohning-Gaese, K., M.L. Taper, & J.H. Brown, 1993. Are declines in North American insectivorous songbirds due to causes on the breeding range? *Conservation Biology* 7:76-86.
- Donovan, T.M., F.R. Thompson III, J. Faaborg, & J.R. Probst, 1995. Reproductive success of migratory birds in habitat sources and sinks. *Conservation Biology* 9:1380-1395.
- Haegen, W.M.V., & R.M. DeGraaf, 1996. Predation on artificial nests in forested riparian buffer strips. *Journal of Wildlife Management* 60:542-550.
- Hagan III, J.M., & D.W. Johnston (ed.), 1992. *Ecology and conservation of neotropical migrant landbirds*. Smithsonian Institution Press, Washington, D.C. 609 p.
- Haskell, D.G. 1995a. Forest fragmentation and nest predation: Are experiments with Japanese Quail eggs misleading? *The Auk* 112:767-770.
- Haskell, D.G., 1995b. A reevaluation of the effects of forest fragmentation on rates of bird-nest predation. *Conservation Biology* 9:1316-1318.
- Hoover, J.P., M.C. Brittingham, & L.J. Goodrich, 1995. Effects of forest patch size on nesting success of wood thrushes. *The Auk* 112:146-155.
- Major, R.E., & C.E. Kendal, 1996. The contribution of artificial nest experiments to understanding avian reproductive success: A review of methods and conclusions. *Ibis* 138:298-307.
- Paton, P.W. 1994. The effect of edge on avian nest success: How strong is the evidence? *Conservation Biology* 8:17-26.
- Robinson, S.K., F.R. Thompson III, T.M. Donovan, D.R. Whitehead, & J. Faaborg, 1995. Regional forest fragmentation and the nesting success of migratory birds. *Science* 267:1987-1990.
- Sauer, J.R., G.W. Pendleton, & B.G. Peterjohn, 1996. Evaluating causes of population change in North American insectivorous songbirds. *Conservation Biology* 10:465-478.
- Haila, Y., I.K. Hanski, & S. Raivio, 1993. Turnover of breeding birds in small forest fragments: The "sampling" colonization hypothesis corroborated. *Ecology* 74:714-725.
- Whelan, C.J., M.L. Dilger, D. Robson, N. Hallyn, & S. Dilger, 1994. Effects of olfactory cues on artificial-nest experiments. *The Auk* 111:945-952.
- Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. *Ecology* 66:1211-1214.

