

## EFFECT OF EGG SIZE ON PREDATION BY WHITE-FOOTED MICE

R. M. DEGRAAF AND T. J. MAIER

**ABSTRACT.**—We compared predation by wild-trapped, caged white-footed mice (*Peromyscus leucopus*) on eggs of Japanese Quail (*Coturnix coturnix*) and Zebra Finches (*Poephila guttata*) to test the effect of egg size. Nine male and nine female mice were weighed, acclimated to cages for 24 h, and presented with two wicker nests, one containing a Japanese Quail egg ( $33 \times 23$  mm) and the other a Zebra Finch egg ( $16 \times 12$  mm). Nests were checked at 2, 4, 6, 8, 12, 16, and 24 h; after 24 h, no quail eggs were depredated, but 16 of 18 finch eggs were destroyed. Given their ability to consume small eggs and their ubiquity and abundance, white-footed mice are potentially significant nest predators. Received 21 Nov. 1995, accepted 15 Feb. 1996.

While evaluating the effect of forest understory density on predation of artificial nests, we found that white-footed mice (*Peromyscus leucopus*) frequently were recorded by remotely-triggered cameras at ground and shrub nests containing eggs of Japanese Quail (*Coturnix coturnix*). Many of these same nests appeared to be undisturbed at the end of the exposure period (DeGraaf et al., unpubl. data). Eggs of *Coturnix* commonly are used to simulate those of passerines in studies of nest predation because they are the smallest eggs commercially available in large quantity. Many studies have recently been conducted using *Coturnix* eggs to assess effects of habitat fragmentation or structure on forest birds, especially Neotropical migrants (e.g., Small and Hunter 1988, Wilcove 1985, Martin 1987), but none of these studies tested whether mice can open songbird eggs but not the larger quail eggs. Maxson and Oring (1978) reported that predation on Spotted Sandpiper (*Actitis macularia*) eggs essentially was eliminated after *Peromyscus* were trapped out of the study area, indirectly implicating mice as nest predators. White-footed mice have been documented as predators on nests of Prothonotary Warblers (*Protonotaria citrea*) (Guillory 1987). Do *Coturnix* eggs allow assessment of the role of mice as predators on artificial nests?

We compared predation by caged white-footed mice on eggs of Japanese Quail and Zebra Finches (*Poephila guttata*) to test the effect of egg size. *Coturnix* eggs averaged approximately  $33 \times 23$  mm, and finch eggs were approximately  $16 \times 12$  mm. For comparison, egg sizes of several forest passerines are: Gray Catbird (*Dumetella carolinensis*),  $26 \times 19$

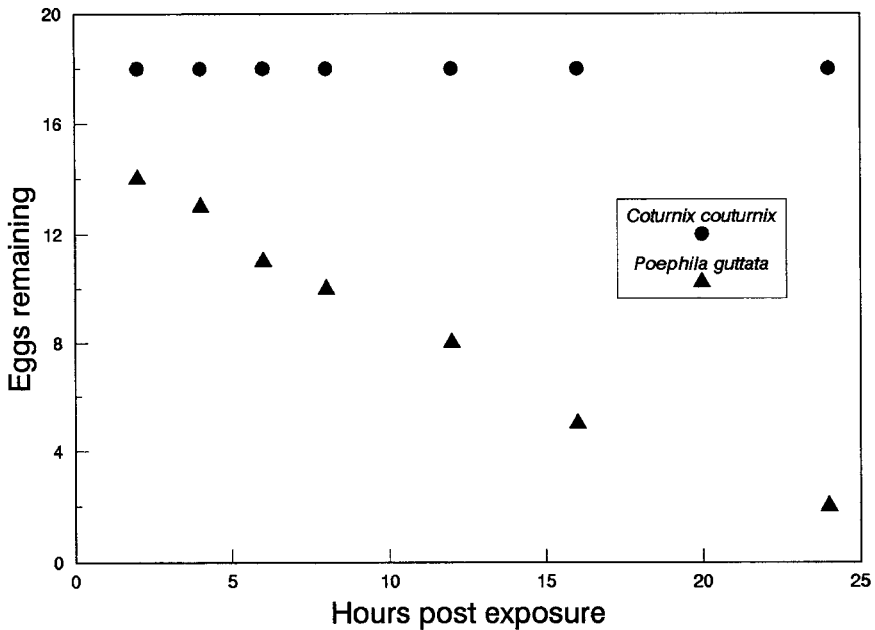


FIG. 1. Numbers of large Japanese Quail (*Coturnix coturnix*) and small Zebra Finch (*Poephila guttata*) eggs remaining after one egg of each type was simultaneously exposed to 18 wild-trapped white-footed mice (*Peromyscus leucopus*) for 24 h.

mm; Wood Thrush (*Hylocichla mustelina*):  $25 \times 19$  mm, and Black-and-White Warbler (*Mniotilta varia*):  $17 \times 13$  mm (Harrison 1975).

#### METHODS

Eighteen white-footed mice, nine males and nine non-lactating females, were selected randomly from 25 individually caged mice wild-trapped over a two-day period in western Massachusetts. Mice were weighed, sexed, and acclimated for at least 24 h to cages in a large, unheated vacant barn. Cages were provided with wood-chip litter, water, and food ad lib. Weights of mice ranged from 11.7 to 27.4 g, representing juvenile, subadult, and adult stages. Mean weight for both males and females was 20.3 g. Each mouse was then provided with two aviculturists' wicker nests, one containing a Zebra Finch egg and the other a Japanese Quail egg, at 09:00 on 13 October 1995. Nests were checked at 2, 4, 6, 8, 12, 16, and 24 h post-exposure and predation on eggs was recorded.

#### RESULTS

After 24 h exposure, no *Coturnix* eggs were depredated, but 16 of 18 finch eggs were destroyed (Fig. 1). White-footed mice are primarily nocturnal (Baumgardner et al. 1980), but predation on finch eggs commenced shortly after exposure, i.e., in mid- to late morning. Mean times until depredation differed ( $0.05 > |t| > 0.02$ ) for female ( $\bar{x} = 6.5$  h) and male ( $\bar{x} = 15.5$  h) mice. We detected no relationship between mouse weight and time to egg depredation. The two finch eggs not eaten within 24 h were given to two other randomly

chosen mice to determine whether these eggs were unpalatable; both eggs were eaten within 24 h. All but one finch egg were opened from the side and the contents eaten through the resulting hole; one egg was opened at both ends. No *Coturnix* eggs were broken after exposure for 13 days.

#### DISCUSSION

White-footed mice probably are significant predators of passerine eggs, but based on the results of our experiments, their effect cannot be experimentally measured using *Coturnix* eggs. The inability of mice to consume quail eggs may be due to several factors. First, the jaw-gape of mice may be too small. We measured the jaw-gape of 22 previously-frozen, locally wild-trapped adult white-footed mice. The jaws were opened, using loops of fine wire until resistance was felt, and the distance between upper and lower incisor tips measured. Jaw-gape ranged from 7.0 to 10.5 mm, with a mean of  $8.9 \pm 1.1$  mm. Such a gape seems too small to open *Coturnix* eggs, which were 23 mm in smaller diameter. Also, eastern chipmunks (*Tamias striatus*) did not open *Coturnix* eggs even though they had previously consumed the contents when presented with broken eggs (Haskell, 1995a).

Second, eggs from commercial quail farms may have thick shells due to diet supplements; this was the case with our quail eggs. Shell thickness may partly explain why *Coturnix* eggs were not opened by mice in the present study, but Spotted Sandpiper eggs, which are about the same size— $32 \times 23$  mm (Harrison 1975:69)—apparently were depredated by mice in Maxson and Oring's (1978) study. We measured shell thickness of five fragments of each of two Spotted Sandpiper eggs, one from the Carnegie Museum and another from the University of Massachusetts Museum of Zoology; both measured 102 microns thick. Two Japanese Quail eggs similarly measured were 229 and 216 microns thick. Japanese Quail egg shells were more than twice as thick as Spotted Sandpiper eggs.

Third, egg shape may be a factor. Spotted Sandpiper eggs are oval to pyriform (Harrison 1975:69); *Coturnix* eggs are short-oval. Mice may be able to open the small end of pyriform eggs that are the same size as short-oval eggs. The eggs of most forest songbirds in the Northeast are oval or short-oval, rarely long-oval (Harrison 1975).

*Coturnix* eggs and those of domestic chickens may be useful to assess predation on eggs of waterfowl and upland game birds, but such eggs are too large or too thick-shelled to adequately assess predation on those of smaller passerines. For example, Ovenbird (*Seiurus aurocapillus*) eggs average  $20.2 \times 15.5$  mm; those of Chestnut-sided Warbler (*Dendroica pensylvanica*) average  $16.7 \times 12.4$  mm (Bent 1953). Haskell (1995a) has shown that the jaw-gape of chipmunks was large enough to break the

eggs of most Neotropical migrant passerines that nest in forest or scrub, but was too small to break Japanese Quail eggs.

The appearance and positioning of artificial nests can be made to approximate those of breeding birds (e.g., Martin 1987, Yahner and Voytko 1989) and precautions taken to avoid leaving human scent at artificial nests (e.g., Whelan et al. 1994). But, if the eggs used cannot be broken by the full suite of potential predators in the habitats being studied, total predation rates or effects of habitat differences cannot be estimated. For example, if the relative abundance of predator species varies across habitat fragment sizes, the bias inherent in using too-large eggs can lead to spurious correlations between fragment size and predation rate. In an investigation of whether the rate of nest predation by small-mouthed mammalian predators varied by fragment size, Haskell (1995b) found that the number of eggs preyed upon by such predators increased with fragment size; in large fragments the predominant nest predators were those which quail egg experiments failed to sample. In both North America (Yahner and Scott 1988) and Europe (Andrén 1992), nest predators in small fragments tend to be large mammals, e.g., raccoon, (*Procyon lotor*) or corvids. Small mammals, e.g., white-footed mice, in contrast, are ubiquitous and abundant, inhabiting many habitat types (Lackey et al. 1985) and a wide range of forest successional stages within extensive forests (Healy and Brooks 1988). Reitsma et al. (1990) suggest that *Peromyscus* may be more important as nest predators than previously thought.

The presence of mice at artificial nests, their demonstrated ability to consume small eggs, and their ubiquity and abundance render them potentially significant nest predators. Eggs susceptible to mouse depredation must be used to estimate their impact. We suggest that such eggs be used in future field studies that use artificial nests to validate mouse predation on nests of small forest passerines.

#### ACKNOWLEDGMENTS

We thank W. R. Danielson for providing Zebra Finch eggs, W. M. Healy for help trapping mice, R. Panza and K. Doyle for providing samples of Spotted Sandpiper eggs, and R. A. Askins, D. G. Haskell, R. T. Holmes, and W. M. VanderHaegen for their critical reviews. M. A. Sheremeta typed the manuscript, and R. T. Brooks prepared the figure.

#### LITERATURE CITED

- ANDRÉN, H. 1992. Corvid density and nest predation in relation to forest fragmentation. *Ecology* 73:794–804.
- BAUMGARDNER, D. J., S. E. WARD, AND D. A. DEWSBURY. 1980. Diurnal patterning of eight activities in 14 species of muroid rodents. *Anim. Learn. Behav.* 8:322–330.
- BENT, A. C. 1953. Life histories of North American wood warblers. U.S. National Mus. Bull. 203.

- GUILLORY, H. D. 1987. Cavity competition and suspected predation on Prothonotary Warblers by *Peromyscus* spp. *J. Field Ornith.* 58:425–427.
- HARRISON, H. H. 1975. A field guide to birds' nests. Houghton Mifflin Co., Boston, Massachusetts.
- HASKELL, D. G. 1996a. Forest fragmentation and nest predation: are experiments with Japanese Quail eggs misleading? *Auk* 112:767–770.
- . 1996b. Nest predation in forest track and the decline of migratory songbirds: a reevaluation of the "fragmentation effect." *Cons. Biol.* 9:1316–1318.
- HEALY, W. M. AND R. T. BROOKS. 1988. Small mammal abundance in northern hardwood stands in West Virginia. *J. Wildl. Manage.* 52:491–496.
- LACKEY, J. A., D. G. HUCKABY, AND B. G. ORMISTON. 1985. *Peromyscus leucopus*. Mammalian Species No. 247. Am. Soc. Mammal.
- MARTIN, T. E., 1987. Artificial nest experiments: effects of nest appearance and type of predator. *Condor* 89:925–928.
- MAXSON, S. J. AND L. W. ORING. 1978. Mice as a source of egg loss among ground-nesting birds. *Auk* 6:582–584.
- REITSMA, L. R., R. T. HOLMES, AND T. W. SHERRY. 1990. Effects of removal of red squirrels, *Tamiasciurus hudsonicus*, and eastern chipmunks, *Tamias striatus*, on nest predation in a northern hardwood forest: an artificial nest experiment. *Oikos* 57:375–380.
- SMALL, M. F. AND HUNTER, M. L. 1988. Forest fragmentation and avian nest predation in forested landscapes. *Oecologia* 76:62–64.
- WHELAN, C. J., M. L. DILGER, D. ROBSON, N. HALLYN, AND S. DILGER. 1994. Effects of olfactory cues on artificial-nest experiments. *Auk* 111:945–952.
- WILCOVE, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. *Ecology* 66:1211–1214.
- YAHNER, R. H. AND D. P. SCOTT. 1988. Effects of forest fragmentation on depredation of artificial nests. *J. Wildl. Manage.* 52:158–161.
- AND R. A. VOYTKO. 1989. Effects of nest-site selection on depredation of artificial nests. *J. Wildl. Manage.* 53:21–25.