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DO CLAY EGGS ATTRACT PREDATORS TO ARTIFICIAL NESTS?

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Abstract.—Quail eggs and artificial nests have become a common way of assessing predation risk for nesting passerine birds. However, the technique is biased against small predators that are unable to destroy large, thick-shelled quail eggs but that are capable of breaking small passerine eggs. To avoid this bias, many researchers use eggs made of modeling clay that can be readily marked by small predators. Unfortunately, modeling clay has an odor that may influence predator behavior. To determine if clay eggs suffered higher rates of predation than quail eggs and whether clay had an odor that influenced predators, we placed 135 artificial ground nests containing either clay, quail, or quail eggs scented with a clay odor. Nests filled with quail eggs had higher cumulative survival (63%: $n = 45$) than those with clay eggs (27%: $n = 45$). However, clay odor did not attract predators, as nests with quail eggs suffered similar frequency of predation (63%: $n = 45$) to those containing "clay-scented" quail eggs (63%: $n = 45$). Based on photographs taken at artificial nests containing both quail and clay eggs, we found that most predators destroyed both eggs. The exception was deer mice (*Peromyscus maniculatus*), which commonly destroyed clay eggs but were incapable of destroying quail eggs.

¿ATRAEN LOS HUEVOS DE ARCILLA A LOS DEPREDADORES HACIA LOS NIDOS ARTIFICIALES?

Sinopsis.—Huevos de especies de *Coturnix* y huevos artificiales se han convertido en una forma común de confirmar nesgos de depredación para aves paserinas anidando. Sin embargo, la técnica está viciada en contra de depredadores prequeños que son incapaces de destruír huevos grandes y de cascarón espeso (como los de *Coturnix*) pero son capaces de destruír prequeños huevos de paserinos. Para evitar este vicio, muchos investigadores utilizan huevos de plastilina que pueden ser rápidamente detectados por depredadores prequeños. Desafortunadamente, la plastilina tiene un aroma que puede influenciar la conducta de depredadores. Para determinar si los huevos de plastilina sufrieron mayores tasas de depredación que los huevos de *Coturnix* y determinar si la plastilina tiene un olor que influencie los depredadores colocamos 135 nidos artificiales en el suelo, conteniendo huevos de plastilina, huevos de *Coturnix*, o huevos de *Coturnix* impregnados con aroma de plastilina. Los nidos con huevos de *Coturnix* tuvieron una supervivencia acumulada superior (63%, n = 45) que los nidos con huevos de plastilina (25%, n = 45). Sin embargo, el aroma de plastilina no atrajo depredadores, ya que los nidos con huevos de *Coturnix* sufrieron tasas de depredación similares (63%, n = 45) que los nidos con huevos impregnados con aroma a plastilina (63%, n = 45). Basandonos en fotograñas tomadas en nidos artificiales que contenían tanto huevos de *Coturnix* como huevos de plastilina, hallamos que la mayoría de los depredadores destruyeron ambos huevos. La excepción fué *Peromyscus maniculatus*, que de común destruyó huevos de plastilina pero fué incapaz de destruír huevos de *Coturnix*.

Artificial nests are a useful tool for testing various ecological and behavioral mechanisms that influence predation risk in nesting birds (Paton 1994, Major and Kendal 1996). However, this approach has a number of underlying assumptions, few of which have been tested (Major and Kendal 1996). For example, studies using artificial nests that attempt to simulate predation on passerine nests commonly use quail (*Coturnix* spp.) eggs. Quail eggs are thicker shelled and 30–100% wider than the eggs of most passerine species (Haskell 1995a, DeGraaf and Maier 1996). The disparity in size between quail and passerine eggs has recently been emphasized (Roper 1992, Haskell 1995a,b, Bayne et al. 1997), because potential predators such as mice (*Peromyscus* spp.) have a mouth wide enough to open small passerine eggs, but insufficient to break quail eggs effectively (DeGraaf and Maier 1996).

To avoid potential biases associated with quail eggs, many studies use eggs made out of modeling clay (Møller 1989, Nour et al. 1993, Major et al. 1994, Haskell 1995b, Bayne et al. 1997). Unlike quail eggs, clay eggs are soft and can be easily marked by small-mouthed predators such as mice. Thus, clay eggs may provide a more accurate assessment of predation risk by sampling a larger suite of potential predators. However, clay eggs may also have biases because of an unnatural odor that could influence predator behavior (Major and Kendal 1996). Our objective was to determine whether nests containing clay eggs suffered different rates of predation and were destroyed by different predators than nests containing Japanese Quail (*Coturnix japonica*) eggs. We also tested whether clay attracted or repelled predators, by comparing rates of predation on quail eggs with clay scent versus quail eggs without any clay odor.

METHODS

Our study was conducted in mid-July 1995 at three forested sites in Prince Albert National Park, Saskatchewan (53°50′N, 105°50′W). Sites were located in 110-yr-old forest composed of approximately 60% trembling aspen (*Populus tremuloides*) and 40% white spruce (*Picea glauca*). The understory at these sites consisted of balsam fir (*Abies balsamifera*) and white spruce seedlings, along with a variety of shrubs including green alder (*Alnus crispa*), beaked hazelnut (*Corylus cornuta*), and rose (*Rosa* spp.). Sites were approximately 5 km apart.

At each site, a total of 45 artificial nests was placed along three separate transects (15 nests per transect). Nests were placed on the ground within 5 m of each transect line at the point of greatest ground cover. Each nest was 20 m apart, whereas transects within sites were approximately 50 m apart. All nests were at least 100 m from any man-made edge.

Wicker nest baskets (10-cm diameter and 6-cm deep), aired outside for at least 5 d prior to use, were lined with dried grass found on site and used as artificial nests (see Rudnicky and Hunter 1993). Along each transect, consecutive nests received one of three egg combinations. In the first nest, we placed a single clay egg painted to resemble a Japanese Quail egg. In the second nest, a single Japanese Quail egg was added to a nest that was lined with a layer of clay embedded in the nest bowl (hereafter, scented quail egg). The volume of clay used to line the nest was approximately the same as the volume of a clay egg. In the third nest, a single Japanese Quail egg was placed (hereafter, unscented quail egg). Nests were checked at 3-d intervals for 12 d. A nest was considered destroyed if eggs were missing, broken, cracked, or if marks were left on clay eggs. When nests were destroyed they were removed from the experiment. Egg remains were collected, and an attempt was made to determine the type of predator based on tooth marks (Bayne and Hobson 1997).

To minimize human odor, quail eggs were rinsed in well water before use. After rinsing, all eggs were handled while wearing latex gloves and rubber boots. Latex gloves were also worn when making the clay eggs. Different latex gloves were used when handling clay and quail eggs.

Data were analyzed using Kaplan-Meier survival analysis. Survival was estimated as the proportion of nests surviving each 3-d observation period, with Mayfield's midpoint assumption used to calculate exposure days (Johnson 1979). Survival curves for clay, unscented quail, and scented quail eggs were compared using a log rank test with pairwise comparisons for each egg type. A Bonferroni correction was applied to the pairwise comparisons to reduce the chance of committing a Type I error (Norūsis 1993).

As part of a larger project examining the effects of forest structure and landscape fragmentation on predation of artificial nests, we identified nest predators using remote cameras (Bayne and Hobson 1997, Bayne et al. 1997). In 1994 and 1995, 36 camera units were located at 21 different sites for a total of 1475 camera days. At each site, two to four camera nests were placed at least 50 m apart. When eggs in camera nests were destroyed, camera units were moved to a different location as these camera units were capable of only taking a single picture of the initial predation event. Camera nests were the same as those used in the clay versus quail experiment discussed above, except that in each camera nest we placed a single quail and a single clay egg. Thus, in any camera nest, predators could choose either the quail or clay egg. A Yates corrected chi-square test was used to determine if different predator species selectively destroyed quail or clay eggs that were placed in the same nest.

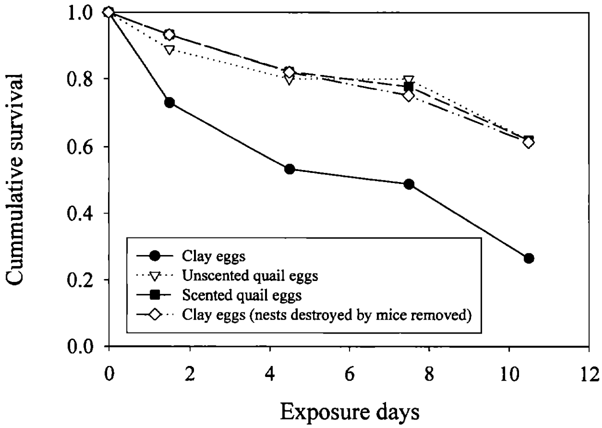

FIGURE 1. Survival curves of nests containing clay, scented quail, or unscented quail eggs over a 12-d observation period. Also plotted is the survival of clay eggs when those nests that were destroyed by mice (based on tooth marks) were removed from the Kaplan-Meier survival analysis.

RESULTS

After 12 d of exposure, the cumulative survival of nests containing clay eggs (27% survived) was significantly lower than nests containing unscented quail eggs (63%) (log rank = 12.83, $P = 0.0006$) or scented quail eggs (63%) (log rank = 12.57, $P < 0.0008$). No difference in survival of nests with scented or unscented quail eggs (log rank = 0.01, $P = 0.98$) was observed (Fig. 1). Of 33 nests with clay eggs that were destroyed by predators, tooth marks indicated that 20 were destroyed by mouse-sized mammals, 3 were destroyed by squirrel-sized mammals, while 10 had eggs that were removed from the nest. To determine if mice caused the difference in survival of different egg types, we repeated our analysis excluding nests with clay eggs that were destroyed by mice. Thus, a nest destroyed by a mouse on day three was considered as successfully surviving predation by other predators for an exposure period of 3 d. No significant difference in the cumulative survival of clay versus unscented quail (log rank = 0.01, $P = 0.96$) or clay versus scented quail (log rank = 0.01, $P = 0.86$) was observed when nests destroyed by mice were excluded (Fig. 1).

Although a variety of predators were identified using camera nests (Table 1), sufficient data to compare whether quail and clay eggs within the same nest were being differentially destroyed by predators were only available for red squirrels (*Tamiasciurus hudsonicus*: $n = 41$) and deer mice (*Peromyscus maniculatus*: $n = 15$). In nests destroyed by deer mice, the clay egg in each nest was more likely to be destroyed than its quail egg counterpart, 93% vs. 40% respectively ($\chi^2 = 4.3$, $P = 0.04$; Table 1). In contrast, when a nest was destroyed by a red squirrel, the clay and quail egg in each nest were destroyed at an equal rate, 98% vs. 90% respectively

TABLE 1. Comparative frequency of predation by different predators on clay and quail eggs placed in the same camera nest. Only nests where a predator was photographed were included.

Predator	n	Clay eggs: Preyed upon	Clay eggs: Survived	Quail eggs: Preyed upon	Quail eggs: Survived
Deer mouse *Peromyscus maniculatus*	15	14 (43%)[b]	1	6 (100%)	9
Red squirrel *Tamiasciurus hudsonicus*	41	40 (73%)	1	37 (84%)	4
Corvids[a]	10	10 (70%)	0	6 (100%)	4
Fisher *Martes pennanti*	7	3 (67%)	4	7 (100%)	0
Striped skunk *Mephitis mephitis*	2	2 (50%)	0	2	0
Porcupine *Erethizon dorsatum*	1	1 (100%)	0	1	0
Black bear *Ursus americanus*	1	1 (100%)	0	0 (0%)	1
Northern flying squirrel *Glaucomys sabrinus*	1	1 (0%)	0	1 (100%)	0
Snowshoe hare *Lepus americanus*	1	1 (0%)	0	0 (0%)	1

[a] Category includes Gray Jays (*Perisoreus canadensis*), American Crows (*Corvus brachyrhynchos*), and Black-billed Magpies (*Pica pica*).

[b] Number in parentheses is the percentage of eggs that were removed from the nest and not found by the observers.

($\chi^2 = 0.85$, $P = 0.4$; Table 1). The only predator that seemed to select different egg types were fishers (*Martes pennanti*) who destroyed 43% ($n = 7$) of the clay eggs and 100% of the quail eggs in camera nests.

DISCUSSION

Nests with clay eggs suffered higher rates of predation than nests with quail eggs. Based on the types of eggs destroyed at camera nests, we believe this difference was because deer mice could mark clay eggs but were incapable of destroying quail eggs. As with other studies (Reitsma et al. 1990, Vander Haegen and DeGraaf 1996), nests where deer mice were photographed often had unbroken quail eggs that were scratched at the apex. This suggests that deer mice attempted to open quail eggs but were unsuccessful because of the large size and thick shell of these eggs. However, in 40% of nests where deer mice were photographed, the quail egg was gone. Although it is possible that deer mice carried these eggs away from the nest, we find this unlikely. Instead, it is more probable that a different type of predator removed the quail egg after the deer mouse had triggered the camera (our camera units only produced one photograph of the initial predation event). Indeed, a number of studies using remote cameras that take multiple pictures (Leimgruber et al. 1994, Vander Haegen and DeGraaf 1996) have found that artificial nests are often visited by more than one species of predator.

The documentation of mice at artificial and natural nests (Maxson and Oring 1978, Reitsma et al. 1990, Bayne and Hobson 1997), their demonstrated ability to consume small passerine and clay eggs (Nour et al. 1993, DeGraaf and Maier 1996), and their widespread distribution across habitats, suggest mice may be significant predators of the eggs of nesting songbirds. Thus, the utility of artificial nest studies that use only quail eggs to simulate predation on passerine nests is questionable, as this methodology seems to exclude mice as predators (DeGraaf and Maier 1996). If quail eggs cannot be destroyed by a full suite of predators, then estimates of total predation rate or even comparisons among different treatments cannot be made. For example, Bayne et al. (1997) found that predation on ground and shrub nests was similar using quail eggs, whereas clay eggs in ground nests suffered 25–40% higher rates of predation than clay eggs in shrub nests. By excluding small mammals as predators, artificial nest studies using quail eggs may create misleading results (Roper 1992, Haskell 1995b).

When camera nests were destroyed by red squirrels, both the quail and clay egg were usually destroyed. This suggests that red squirrels do not preferentially select quail over clay eggs. If clay eggs attracted larger predators such as squirrels, nests with scented quail eggs should have suffered higher rates of predation than those with unscented quail eggs, which was not the case. Further, when nests with clay eggs destroyed by mice were excluded from our analysis, we found no difference in the rate of predation on quail, scented quail, or clay eggs. Together, these data indicate that predators are not attracted to clay eggs because of olfactory cues. In addition, clay eggs suffer higher rates of predation than quail eggs because mice can mark clay eggs but can not destroy quail eggs. Thus, clay eggs seem to be a reasonable alternative to quail eggs, and may provide a more accurate assessment of predation risk for nesting passerine birds. For example, Major et al. (1994) found that artificial nests containing clay eggs suffered very similar rates of predation as natural nests of the New Holland honeyeater (*Phylidonyris novaehollandiae*).

Although clay eggs seem to provide an effective alternative to quail eggs, clay eggs do not provide a reward as real eggs do. As such, predators may learn to avoid nests containing only clay eggs (cf. Nour et al. 1993). Indeed, our data from camera nests suggest that fishers could distinguish between clay and quail eggs. To avoid this potential bias, we recommend the use of both real and clay eggs in the same nest (e.g., Bayne et al. 1997). However, because scented quail eggs were too large to be destroyed by mice, we cannot say whether mice detected nests with scented quail eggs more frequently than those with unscented quail eggs. Thus, studies using clay eggs must be viewed with caution until it is shown that nests with clay eggs suffer rates of predation that are similar to those of nesting passerines.

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