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DIFFERENCES IN DEPREDATION BY SMALL PREDATORS LIMIT THE USE OF PLASTICINE AND ZEBRA FINCH EGGS IN ARTIFICIAL-NEST STUDIES[1]

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Abstract. Small mammals, such as mice and voles, have been implicated as major egg predators of Neotropical migrant passerines by field studies using soft plasticine eggs or the very small eggs of Zebra Finch (*Taeniopygia guttata*). Nevertheless, the effort required to depredate these commonly used egg surrogates may be less than that required to depredate the larger, thicker-shelled eggs of most passerine species. To compare the depredation of these surrogates to that of the eggs of a mid-sized passerine by a ubiquitous small predator, we exposed dissimilar pairs of plasticine, Zebra Finch, and House Sparrow (*Passer domesticus*) eggs to captive white-footed mice (*Peromyscus leucopus*). Plasticine eggs were marked by mice more than either kind of real egg, and Zebra Finch eggs were breached more often than House Sparrow eggs. We conclude that the use of either plasticine or Zebra Finch eggs may lead to overestimation of the ability or proclivity of small mammals to actually depredate the eggs of most passerines.

Key words: clay eggs, House Sparrow eggs, nest predation, Peromyscus leucopus, *plasticine eggs, predator communities, Zebra Finch eggs.*

Many nest predation studies have approximated naturally occurring eggs by using plasticine egg simulacra or the very small eggs of Zebra Finch (*Taeniopygia guttata*) to identify the effects of small nest predators (Major 1991, Bayne et al. 1997, King et al. 1998). Consequently, ubiquitous small mammals such as mice and voles have often been included as significant components of predator communities, thereby shaping perceptions regarding predation pressures within various habitats (Nour et al. 1993, Darveau et al. 1997, Hannon and Cotterill 1998). Nevertheless, even seemingly small differences between naturally occurring passerine eggs and these commonly used surrogates may prove significant to potential small predators, as the effort necessary to either score soft plasticine or breach small, thin-shelled Zebra Finch eggs may be insufficient to depredate the larger, thicker-shelled eggs of most other passerines (Craig 1998).

Seldom has the ability or proclivity of small mammals that either breach Zebra Finch eggs or score plasticine egg simulacra (often referred to as clay eggs) to also depredate eggs of potential prey species been objectively addressed (Rogers et al. 1997, Ettel et al. 1998). Although members of the Dasyuridae, Muridae, and Soricidae have been implicated as nest predators by use of these egg surrogates (Major et al. 1994, Haskell 1995a, Rogers et al. 1997), some small mammals, such as various voles, have been shown to either lack the physical ability to readily depredate real eggs (Gromov and Polyakov 1992) or the inclination to do so (Maier et al., unpubl. data).

Peromyscus mice, ubiquitous and frequently detected by the use of plasticine and Zebra Finch eggs, have been identified as at least occasional predators of naturally occurring eggs (Blight et al. 1999). After observing that white-footed mice (*P. leucopus*) were capable of depredating Zebra Finch eggs (DeGraaf and Maier 1996), we were curious about the predatory capabilities of these mice on plasticine eggs in comparison to both Zebra Finch and House Sparrow (*Passer domesticus*) eggs, the latter approximating the size of the eggs of many ground-nesting forest passerines, such as larger warblers, sparrows, and smaller thrushes (Harrison 1975). Accordingly, we exposed captive, wild-captured white-footed mice to dissimilar pairs of these eggs. Our objectives were to determine whether real eggs were breached as frequently as plasticine eggs were "depredated" (i.e., consumed, bitten, or otherwise scored), and to compare predation between the two real egg types. If predation by mice differed among the three egg types, then results of studies based on the use of plasticine and Zebra Finch eggs may be biased, in that mice and similar small mammals may be overestimated components of predator communities.

METHODS

Zebra Finch and feral House Sparrow eggs were collected during February–May 1998 and kept refrigerated at 8–10°C in "water glass" preservative (a 10:1 solution of potable water and sodium silicate solution [approx. 27% SiO_2 in 14% NaOH]; DeGraaf and Maier, in press). Immediately prior to use, eggs were thoroughly rinsed with well water and air-dried. Plasticine eggs were fabricated from a white, nontoxic modeling compound with negligible odor (Van Aken Plastalina™, Rancho Cucamonga, California), previously used in field studies (Haskell 1995b). We made all plasticine eggs the approximate size of House Sparrow eggs (23 mm × 15 mm, Harrison 1975) because

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TABLE 1. Comparison of exposure trial outcomes using three egg types as paired samples depredated by 137 captive white-footed mice (*Peromyscus leucopus*), June–October 1998.

Egg Pairs (A vs. B)	Depredation frequencies				Total
	Both A and B	Only A[a]	Only B[a]	Neither A or B	
Clay vs. Zebra Finch	40	10	0	5	55[b]
Clay vs. House Sparrow	13	35	0	0	48
Zebra Finch vs. House Sparrow	10	20	0	4	34

[a] Frequencies used for two-tailed binomial tests.
[b] Pooled results from two separate trials.

smaller plasticine eggs, such as those modeling Zebra Finch eggs (15 mm × 10 mm, Zann 1996), may not provide sufficient area for predators to leave identifiable marks (Pasitschniak-Arts and Messier 1995). All egg-handling operations were done while wearing latex surgical gloves.

Four groups of white-footed mice, totaling 137 animals, were live-trapped from four different mixed-hardwood forest sites in western Massachusetts during June–October 1998. Each group's members were collected within a 2-day period, and consisted mostly of adults, with smaller, similar proportions of subadults and juveniles for all groups. Mice were kept in individual cages (21 × 27 × 14-cm tubs) with pine shavings and non-sterile cotton in a climate-controlled building (15–20°C) and supplied with water and food *ad libitum* throughout their captivity. We followed the guidelines for the capture and handling of mammals approved by the American Society of Mammalogists (1998). Mice were released where captured after each exposure trial.

Exposure trials were performed on each group of mice after allowing them to acclimate to captivity for 12–14 days (Kavanau 1963). The first group (n = 29) and fourth group (n = 26) were exposed to finch and plasticine eggs, the second group (n = 48) to sparrow and plasticine eggs, and the third group (n = 34) to finch and sparrow eggs. At 18:00 EST, individual mice were provided pairs of dissimilar eggs, with each egg contained in an 80-ml paper cup. Egg fate was recorded at 06:00 the next morning, because most activity by caged murids has concluded by then (DeGraaf and Maier 1996, Ettel et al. 1998). Plasticine eggs destroyed, bitten, or marked in any other identifiable manner were considered depredated, as were real eggs if breached.

We used a heterogeneity chi-square analysis to determine if the results from the two separate trials on mice exposed to finch and plasticine eggs could be pooled. We analyzed all paired data using separate two-tailed binomial tests (Zar 1996). To provide an additional measure of differences in the amount of predation between finch and sparrow eggs, we compared the predation proportions of each real egg type from its real-egg vs. plasticine-egg trial (the first and fourth groups were combined) using a 2 × 2 contingency table setup for a binomial comparative trial. Our significance level for all tests was $P < 0.05$.

RESULTS

The separate exposure trials of paired finch and plasticine eggs were homogenous ($\chi^2_3 = 0.8$, $P > 0.8$). Plasticine eggs were "depredated" more frequently than either finch eggs (two-tailed binomial, $P < 0.01$) or sparrow eggs (two-tailed binomial, $P < 0.001$). Finch eggs were depredated more frequently than sparrow eggs in the paired real-egg trial (two-tailed binomial, $P < 0.001$). Finch eggs were also depredated significantly more often than sparrow eggs in the comparison of real-egg predation proportions from the real-egg vs. plasticine-egg trials ($\chi^2_1 = 19.6$, $P < 0.001$), in which 73% of the finch eggs (n = 55) and 27% of the sparrow eggs (n = 48) were breached (Table 1).

DISCUSSION

Our results suggest that depredation of plasticine egg simulacra by small predators may far exceed natural predation of even the smallest passerine eggs. White-footed mice scored plasticine eggs much more frequently than they breached either House Sparrow or Zebra Finch eggs, representing, respectively, mid-range and very small egg sizes from eastern forest and scrub-nesting Neotropical migrant passerines in the U.S. (Haskell 1995a). Similarly, Ettel et al. (1998) observed larger, captive cotton rats (*Sigmodon hispidus*) to depredate plasticine eggs more frequently than Zebra Finch eggs, and Rangen et al. (2000) observed that captive and wild deer mice (*Peromyscus maniculatus*) also depredate plasticine eggs more than an assortment of small finch eggs.

Rangen et al. (2000) speculated that the odor of their plasticine eggs was responsible for the preferential depredation of these simulacra by mice; conversely, Bayne and Hobson (1999) did not find predators to be attracted to their plasticine eggs, but rather occasionally repelled, as in the case of fisher (*Martes pennanti*). We believe that behavioral observations of murids explain why plasticine eggs were depredated more than real eggs. Mice usually open large, hard food objects by gnawing at rough spots or protuberances, eventually shaving a hole (Eisenberg 1968), but passerine eggshells, usually covered by a smooth, hard cuticle and relatively resistant to puncture (Burley and Vadehra 1989), seldom provide such surface discontinuities. Additionally, *Peromyscus* mice will often nibble objects as they gather olfactory cues (King 1968), and Norway rats (*Rattus norvegicus*) invariably attempt to

grasp potential food items directly with their teeth (Calhoun 1963). In such manner, soft plasticine eggs may be easily scored, whereas real eggs take more effort to breach (Blight et al. 1999, Rangen et al. 2000, Maier and DeGraaf 2000b). Thus, plasticine eggs may indicate the presence of certain species, but not their ability or proclivity (especially if either attracted to or repelled from plasticine) to depredate avian eggs.

Unfortunately, when used to record a species' presence, the marks on plasticine eggs may be misidentified without knowledge of a species' behavior. For example, Rogers et al. (1997) assigned mice and shrews major roles in the potential predation of Song Sparrow (*Melospiza melodia*) eggs, based largely on diagnostic marks found on plasticine eggs (reporting that mice made prominent paired grooves, whereas shrews made "many fine tooth marks"). Nevertheless, we observed captive white-footed mice make both types of marks on plasticine eggs; as such, marks may be misidentified (and shrews may play little role in the predation of passerine eggs). Moreover, this type of fine marking by mice has been associated with specific types of plasticine (Maier and Field, unpubl. data); thus, different types of plasticine may influence the depredation of egg simulacra, a possible cause of the contrasting results from some plasticine egg studies. Based on the assumption that predators are inclined to bite plasticine eggs (leaving deep impressions, rather than the light stippling we have observed made by mice), the measurement of incisor width has been touted as a means of specific identification. In practice, however, most studies have found sufficient ambiguity in these measurements to necessitate the use of much broader predator categories (Nour et al. 1993, Hannon and Cotterill 1998, Bayne and Hobson 1999). For these reasons, the identification of specific predators solely through the use of plasticine eggs remains questionable without behavioral knowledge, including responses to various plasticine types, of all of an area's potential nest predators.

What are perceived as small differences between naturally occurring passerine eggs and their real-egg surrogates may be significant to potential small predators. Given the highly significant differences in the frequency of predation of Zebra Finch eggs compared to House Sparrow eggs, our data suggest that Zebra Finch eggs may also be depredated more often than eggs of most other passerine species. Ettel et al. (1998), having observed that cotton rats ate 80% of the Zebra Finch eggs presented to them and none of the Northern Bobwhite (*Colinus virginianus*) eggs, concluded that cotton rats would readily consume any passerine eggs smaller than these quail eggs. Cotton rats have larger gapes (13.7 ± 2.4 mm, Ettel et al. 1998) than white-footed mice (8.9 ± 1.1 mm, DeGraaf and Maier 1996); however, based on the results of our study, assertions regarding a small mammal's predatory capabilities with most passerine eggs may be unsupportable if based solely on their ability to consume Zebra Finch eggs.

Our intent was to compare the depredation of plasticine and Zebra Finch eggs to that of the eggs of a mid-sized passerine by a ubiquitous small predator. House Sparrow eggs, however, may be too large to aptly represent eggs of smaller passerine species, such as those of smaller warblers; nevertheless, even some juvenile white-footed mice (a small species of *Peromyscus*) breached and consumed the contents of these eggs. Further, all of our real eggs (preserved in water glass solution and rinsed) may have been bereft of natural odor, thus influencing their probability of predation; however, other studies have similarly observed more predation on plasticine eggs than on real eggs. Finally, we assumed that the plasticine we used was neither more nor less attractive to mice than other compounds used for egg simulacra, given the absence of published comparisons between types of plasticine.

In conclusion, the depredation of either plasticine or Zebra Finch eggs by small mammals, such as mice, may lead to overestimation of the ability or proclivity of these animals to actually depredate the eggs of most passerines. This inference may be generalized to include small birds, such as parids, engaging in egg-holing (Maier and DeGraaf 2000a, 2000b), if such birds also prove less capable of depredating the eggs of forest passerines than their egg surrogates. Given these potential biases, as well as the ambiguities associated with the use of plasticine eggs in the identification of actual predator species, we suggest that researchers using plasticine or Zebra Finch eggs exercise caution in their quantification of the effects of potential small predators.

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