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Egg Size and Cotton Rat Predation

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ABSTRACT.—Although cotton rat (*Sigmodon hispidus*) presence at predated Northern Bobwhite (*Colinus virginianus*) nests has been widely reported, it is unclear how often cotton rats are the actual predators. We presented two sizes of eggs to 35 wild-trapped cotton rats to better understand how avian egg size affects nest predation in the wild. Zebra Finch (*Poephila guttata*) eggs (16.0 × 11.4 mm) and Northern Bobwhite eggs (30.0 × 24.7 mm) were presented to captive cotton rats in 30 × 30 cm enclosures. Eggs were checked every 6 h for 24 h. Food was withheld from 18 of the rats in an attempt to induce egg consumption. No cotton rats consumed bobwhite eggs (0/35 cotton rats), but Zebra Finch eggs were frequently consumed (29/35 cotton rats). The gapes of cotton rats used in this study were smaller than the bobwhite egg widths and may have prevented cotton rats from successfully cracking the eggshells. It is apparent that cotton rats will readily consume eggs smaller than those of the Northern Bobwhite and pose a predation threat to passerines. Based on our data and known abundances of cotton rats throughout their range, we conclude that cotton rats pose a significant threat to smaller birds nesting on or near the ground. However, we offer no evidence to implicate cotton rats as important predators of bobwhite nests. *Received 28 Aug. 1997, accepted 30 July 1998.*

Cotton rats (*Sigmodon hispidus*) are one of the most abundant small mammals of open habitats of the southeastern United States with densities of 24–30 per ha in some areas (Schwartz and Schwartz 1981). These same habitats provide nesting grounds for Northern Bobwhite (*Colinus virginianus*) and several songbird species for whom population declines have been reported (Sauer et al. 1996). Cotton rats have been reported as important predators of Northern Bobwhite nests (e.g., Stoddard 1931, Simpson 1976, Hawthorne 1983). However, supporting evidence is mostly circumstantial. Stoddard (1931) mentioned the use of captive cotton rats in egg presentation experiments but failed to report his results.

Artificial nests have been widely employed to compare predation rates among different habitats and habitat patch sizes (e.g., Wilcove 1985; Burger et al. 1994; Leimgruber et al. 1994). Most artificial nest studies have used Japanese Quail (*Coturnix japonica*) or Northern Bobwhite eggs, which are much larger than the eggs of most passerines. Small-mouthed predators may be unable to consume the larger eggs while being entirely capable of eating smaller eggs (Reitsma et al. 1990; Roper 1992; Haskell 1996a, b). An artificial nest study using bobwhite eggs conducted in western Tennessee in summers 1996 and 1997 documented that cotton rats were frequently responsible for nest and egg disturbance. However, these disturbances rarely resulted in actual damage to the bobwhite eggs (Ettel, unpubl. data).

The objective of this study was to determine the effect of egg size on egg comsumption and to test the hypothesis that cotton rats are often prevented from predating bobwhite eggs because they are unable to bite into them.

METHODS

Thirty-five wild cotton rats (21 females, 12 males, and 2 animals of unknown sex) were collected on the Ames Plantation in Fayette County, Tennessee, in December 1996 and January 1997 using Sherman live traps baited with a mixture of rolled oats and peanut butter. Rats were weighed, sexed and placed into wire cages (30 × 30 cm) in a vacant, unheated building and acclimated for at least 12 hours. Cages were lined with straw for bedding. Because of a lack of available space, 4 cotton rats were placed in larger holding cages. Daily temperatures ranged from −2.2 to 2.7° C and nightly temperatures ranged between −16.1 and −0.6° C between 19 December 1996 and 12 January 1997, when the experiment was conducted.

To induce consumption of the eggs, food was withheld from one group of cotton rats to create an emaciated state. Eighteen of the 35 cotton rats were initially given food consisting of peanut butter and water.

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Food was withheld from the other 17 immediately before and during egg presentation, a duration of 36–48 hours. Unfed rats were weighed both before and after the experiment to check for weight loss. χ^2 analysis was used to test for differences in egg consumption between fed and unfed groups.

Cotton rats were presented with two 11-cm diameter grass nests, one containing a Zebra Finch (*Poephila guttata*) egg and clay mimic and the other a Northern Bobwhite egg and clay mimic. Clay eggs were made of Plastalina®, a soft, malleable modeling clay. Clay eggs were used to simulate conditions of the artificial nest study we conducted in 1996 and 1997 in which both artificial eggs and real eggs were used (Ettel, unpubl. data). Nests were left in the cages for 24 h and egg fate was recorded every 6 h. At the conclusion of the experiment, all cotton rats were euthanized and gape measurements were taken. We used *t*-tests to determine differences in gape or weight according to sex.

Shell thickness of 20 bobwhite eggs from the same commercial game farm as those used in the experiment and 20 bobwhite egg shells from hatched nests of wild birds collected from Fayette and Houston counties, Tennessee was measured using digital calipers. A *t*-test was used to test for differences in shell thickness between the two groups.

We used a logistic regression model to test the effects of the measured variables on both the fate (consumed or not consumed) of each individual egg and the time interval (6 h, 12 h, 18 h, 24 h) in which an egg was consumed (Agresti 1990). Explanatory variables used in the model were: weight, gape, sex (male or female), egg type (clay or real), and egg size (bobwhite or finch) as well as all possible interaction terms. Gape and weight were both treated as continuous variables whereas all other variables represented discrete, binary variables. The stepwise selection procedure was employed to fit a model from the available explanatory variables. A likelihood ratio test and its associated χ^2 statistic was utilized to test model suitability, with significance level set at $P < 0.05$. Individual variables within the final model were tested for significance using the Wald statistic and its associated χ^2, with a significance level set at $P < 0.05$ (Agresti 1990). Analyses were conducted using PROC LOGISTIC from SAS statistical software, version 6.12, on a personal computer (SAS Inst., Inc. 1997).

The four cotton rats held in larger holding cages were not used in these analyses to eliminate potential bias associated with cage size.

RESULTS

Twenty-eight of 35 cotton rats (80%) ate finch eggs but none ate bobwhite eggs. Clay eggs were commonly bitten and partially consumed (31/35 of finch-sized and 23/35 of bobwhite-sized eggs). Some contact with bobwhite eggs by cotton rats was apparent as eggs were often found removed from the nests to other parts of the cages, sometimes buried underneath the straw bedding or the nest itself.

There was no difference in finch egg consumption between fed and unfed cotton rats ($\chi^2 = 0.019$, df = 1, $P > 0.05$), therefore we pooled data from the two groups for the analysis. Mean weight for 33 rats (we were unable to attain weights for 2 rats) was 75.8 ± 30.5 g with no differences between sexes ($t = -0.623$, df = 31, $P > 0.05$). Mean gape size for 31 rats (we were unable to measure gape on 4 rats) was 13.7 ± 2.4 mm with a range of 9.8–18.9 mm and no difference between sexes [$t = -0.030$, df = 25.9 (unequal variances), $P > 0.05$].

Bobwhite eggs averaged 30 × 24.7 mm, whereas finch eggs averaged 16 × 11.4 mm. Thus, bobwhite eggs were 5.8–14.9 mm wider than cotton rat gapes reported in this study, whereas finch egg widths fell within the range of cotton rat gapes. No difference in thickness was found between the wild and domestic bobwhite eggshells ($t = 1.38$, df = 25.9 (unequal variances), $P > 0.05$).

The stepwise selection procedure eliminated all interaction terms and the variables sex and gape in creating a model for egg fate. A final model for egg fate with the variables weight, type, and size was fit (log likelihood, df = 3, $P < 0.001$). The variables weight ($\beta = -0.0321$, Wald $\chi^2 = 6.2949$, $P = 0.012$), type ($\beta = -2.9696$, Wald $\chi^2 = 17.2113$, $P < 0.001$), and size ($\beta = 3.5079$, Wald $\chi^2 = 22.8898$, $P < 0.001$) were individually significant within the model. Negative parameter estimates for both type and weight indicate that clay eggs were more likely to be consumed than real eggs, partially resulting from clay bobwhite eggs frequently being eaten whereas real bobwhite eggs never were. Heavier rats were also more likely to consume eggs than lighter individuals. Parameter estimates for egg size indicate that finch eggs were more likely to be consumed than bobwhite eggs.

For the elapsed time of egg consumption, stepwise selection did not identify any of the explanatory variables as important ($P > 0.05$). This result was apparently caused by egg consumption occurring within the initial 12 hours.

The 17 unfed animals experienced an average weight loss of 7.4 ± 6.0g (9.8 % average decrease in weight). This may represent a significant weight loss. A change in weight was not documented for the 18 rats that were provided food.

After our observation that no cotton rats consumed or even damaged the bobwhite eggs, we presented the 4 remaining cotton rats with broken bobwhite eggs. All four rats ate the damaged eggs including all egg contents and large portions or all of the shell. When subsequently presented a second unbroken bobwhite egg, none of these four rats consumed the egg. The range of gape sizes for these four rats was 11.5–17.5 mm, and thus was similar to the gape sizes of our entire sample.

DISCUSSION

Although cotton rats are widely reported as bobwhite nest predators, our results document the ability of cotton rats to consume small passerine-sized eggs but not bobwhite eggs. Stoddard (1931) and Simpson (1976) present two of the only studies that attribute bobwhite nest predation to cotton rats based upon actual field sign (hair and feces around the nest and egg shell fragments in cotton rat runways). However, Leimgruber and coworkers (1994) noted that several predators often visit a single nest. With the use of motion-sensitive cameras, Fenske-Crawford and Niemi (1997) recorded several small rodents visiting nests without damaging eggs. We suspect that cotton rat presence at predated nests can be accounted for in two ways. Upon finding a nest that has been predated previously by another animal, cotton rats may consume damaged eggs or egg shells at the nest or carry some away. Additionally, as noted in our artificial nest study (Ettel, unpubl. data), cotton rats often destroy the nest itself, scatter eggs, and sometimes carry eggs a short distance away from the nest, all without damaging eggs. These actions could make nests more visible to other predators, thereby making cotton rats accessories to predation, but not actually egg predators themselves.

In this study, although rats moved bobwhite eggs to different parts of the cages, they failed to consume any undamaged bobwhite eggs. However, the smaller finch eggs were frequently eaten. Cotton rats consumed cracked and broken bobwhite eggs presented to them, indicating that the eggs were both palatable to them and that the season of the year and cold temperatures had no effect upon their consumption of eggs.

We believe that the substantial weight loss documented in cotton rats over the short period of the feeding trial demonstrated emaciation. Haskell (1996a) suggested that inexperienced animals may not know how to eat quail eggs, but our cotton rats were taken from an environment in which bobwhite are common. After consuming a broken bobwhite egg, four cotton rats in our study failed to damage an unbroken bobwhite egg when presented with one. Because the commercial bobwhite egg shells used were similar in thickness to egg shells of wild birds, if these cotton rats were capable of eating bobwhite eggs in the wild, then they should have been capable of eating the eggs in this experiment.

After measuring gapes of some small rodents, DeGraaf and Maier (1996) and Haskell (1996a) concluded that some small rodents are unable to bite into quail eggs. Our gape measurements suggested that cotton rats used in this experiment had gapes that were too small to bite into a bobwhite egg. Bobwhite egg widths were larger than the measured gapes. In the wild, predation of bobwhite eggs may require extraordinary effort and may occur only under unique conditions, such as when alternative foods are scarce. Both Stoddard (1931) and Simpson (1976) reported an increase in cotton rat predation of bobwhite nests when cotton rat densities were abnormally high. Additionally, cotton rats do reach weights greater than the largest rat used in this study (165 g; Schwartz and Schwartz 1981). The failure of the rats in this study to eat undamaged bobwhite eggs may indicate that most cotton rats have gape sizes too small to penetrate the eggshell and that only the largest cotton rats may be able to efficiently handle bobwhite eggs.

Our results suggest that cotton rat predation on songbird nests placed on the ground or in vegetation near ground level could be significant. Additionally, by disturbing active nests, cotton rats may possibly be accessories to predation or may induce abandonment of nests by bobwhite hens. However, because of the inability of cotton rats to damage bobwhite eggs in this study, we can offer no evidence to implicate cotton rats as important predators of bobwhite eggs. We suggest that further study be conducted to determine the effect cotton rats have on breeding songbirds in agricultural areas throughout their range, focusing upon evidence beyond the circumstantial. Additional work is needed to quantify claims of significant bobwhite nest predation by cotton rats.

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LITERATURE CITED

AGRESTI, A. 1990. Categorical data analysis. John Wiley and Sons, Inc., New York.

BURGER, L. D., L. W. BURGER, AND J. FAABORG. 1994. Effects of prairie fragmentation on predation of artificial nests. J. Wildl. Manage. 58:249–254.

DEGRAAF, R. M. AND T. J. MAIER. 1996. Effect of egg size on predation by white-footed mice. Wilson Bull. 108:535–539.

FENSKE-CRAWFORD, T. J. AND G. J. NIEMI. 1997. Predation of ground nests at two types of edges in a forest-dominated landscape. Condor 99:14–24.

HASKELL, D. G. 1996a. Forest fragmentation and nest predation: are experiments with Japanese Quail eggs misleading? Auk 112:767–770.

HASKELL, D. G. 1996b. Nest predation in forest tracts and the decline of migratory songbirds: a reevaluation of the "fragmentation effect." Conserv. Biol. 9:1316–1318.

HAWTHORNE, D. W. 1983. Cotton rats. Pp. B 85–87 *in* Prevention and control of wildlife damage. (R. A. Timm, Ed.). Institute of Agriculture and Natural Resources, Univ. Nebraska, Lincoln.

LEIMGRUBER, P., W. J. MCSHEA, AND J. H. RAPPOLE. 1994. Predation on artificial nests in large forest blocks. J. Wildl. Manage. 58:254–260.

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.

ROPER, J. J. 1992. Nest predation experiments with quail eggs: too much to swallow? Oikos 65:528–530.

SAS. 1997. SAS/STAT software: changes and enhancements through release 6.12. SAS Inst. Inc., Cary, North Carolina.

SAUER, J. R., B. G. PETERJOHN, S. SWARTZ, AND J. E. HINES. 1996. The North American breeding bird survey home page. Version 95.1. Patuxent Wildlife Research Center, Laurel, Maryland. URL: www.mbr–pwrc.usgs.gov/bbs/bbs.html.

SCHWARTZ, C. W. AND E. R. SCHWARTZ. 1981. The wild mammals of Missouri, revised edition. Univ. of Missouri Press, Columbia.

SIMPSON, R. C. 1976. Certain aspects of the bobwhite quail's life history and population dynamics in southwest Georgia. Georgia Dept. Natural Resources, Game and Fish Division. Tech. Bull. WL1. Social Circle, Georgia.

STODDARD, H. L. 1931. The bobwhite quail: its habits, preservation and increase. C. Scribner's Sons, New York.

WILCOVE, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology. 66:1211–1214.