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Arthropods and Predation of Artificial Nests in the Bahamas: Implications for Subtropical Avifauna

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ABSTRACT.—Little is known of nest predation patterns in the dry subtropics. We used artificial nests to examine patterns of nest predation and to identify possible nest predators in the Bahamas. Unlike predation patterns in temperate areas, we found no relationship between predation rates and nest cover or distance to the road. Instead, the rate of nest predation depended on distance to ocean. This result and a photograph taken at a disturbed nest implicated the giant white land crab (*Cardisoma guanhumii*) as a possible nest predator. Because land crabs are prevalent throughout the subtropics and could potentially influence nesting behavior, we advise researchers to consider variables associated with land crabs when examining nest predation in the subtropics. Received 14 July 1998, accepted 15 April 1999.

Nest predation studies are abundant in the literature; most have been conducted in northern, temperate areas (reviewed by Paton 1994, Major and Kendal 1996, Hartley and Hunter 1998). Although a few similar studies have taken place in the tropics (e.g., Gibbs 1991, Laurance et al. 1993) and wet subtropics (Latta et al. 1995), no such study has been conducted in dry, subtropical habitat where predator species assemblages may be quite different. Patterns of nest predation might differ in the dry subtropics as a result of differences in numbers and species of egg predators.

Long Island, an outer island in the southern Bahamas archipelago, is characterized by dry,

scrubby vegetation and a relatively depauperate fauna. There has been no prior study to examine avian nest predation on any of the Bahama islands or to determine which egg predators are present. We used artificial nests to determine factors influencing nest survival of ground-nesting birds and to identify important nest predators on Long Island and Hog Cay, Bahamas. Artificial nests are frequently used in predation experiments where it is assumed that they provide a reasonable assessment of the impact of predators on real nests (Burger et al. 1994, but see Major and Kendal 1996). In temperate zone studies, nest predation rates often varied with nest visibility (Major and Kendal 1996) and distance from edge (Paton 1994). We conducted an experiment to determine whether patterns of nest predation in the Bahamas were similar to those observed elsewhere and to identify possible nest predators.

STUDY AREA AND METHODS

We conducted our study on the northern 20 km of Long Island and on Hog Cay, Bahamas. Long Island, one of the outer islands of the Bahamas archipelago, is 128 km long and 6.4 km wide at its widest point. Hog Cay is a small (100 ha), privately owned island located off the northern tip of Long Island. Both islands are covered with dry, scrubby vegetation. Mangroves (*Rhizophora mangle* and *Avicennia germinans*) grow along the coasts of both islands.

We observed 7 ground nesting bird species on Long Island and Hog Cay, Bahamas. The largest included the West Indian Whistling-duck (*Dendrocygna arborea*) and White-cheeked Pintail (*Anas bahamensis bahamensis*). Smaller species included Antillean Night-hawks (*Chordeiles minor*), Common Ground-Doves (*Calumbigallina passerina*), Snowy and Wilson's plovers (*Charadrius alexandrinus* and *C. wilsonia*), and Willets (*Catoptrophorus semipalmatus*).

Potential terrestrial nest predators included introduced rats (*Rattus* spp.), domestic dogs (*Canis familiaris*), and native giant white land crabs (*Cardisoma guanhumii*). Possible avian egg predators included Laughing Gulls (*Larus atricilla*), Yellow-crowned

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Night-Herons (*Nyctanassa violacea*), and Smooth-billed Ani (*Crotophaga ani*).

We utilized artificial ground nests in two experimental trials lasting from mid-May through July 1995. Each trial was 30 days, the approximate incubation time for several ground nesting species in the Bahamas (Paterson 1972). For each trial, two plots were selected on Long Island and one plot was selected in similar habitat on Hog Cay. Trial 1 took place May 17–June 19 and consisted of 25 and 16 nests on Long Island, and 30 nests on Hog Cay. Trial 2 took place June 20–July 21 and consisted of 24 and 16 nests on Long Island, and 30 nests on Hog Cay. Artificial nests were placed in a grid pattern within each of the six sites such that one edge of the grid was located parallel to and 50 m from a road. All nests within the grid were placed 25 m apart and were randomly assigned as “hidden” or “open.” Hidden nests were completely covered by vegetation, whereas open nests could be seen from within 1 m.

Nests consisted of a shallow scrape containing five domestic chicken eggs located under thatch palm (*Thrinax microcarpa*) or a dense bush. Although some studies have detected effects of egg size because small predators (e.g., mice) were unable to break larger eggs (Picman 1988, Haskell 1995), we believe that all potential predators in our study sites were large enough to handle chicken eggs. Nests were examined for survivorship at days 6, 12, 18, and 24, and were considered depredated if one or more eggs was missing or damaged.

To identify specific nest predators, we placed three automatic cameras with flash capability at one nest on each study site during each trial. Cameras were triggered by a motion-sensitive mercury switch glued to the bottom of the eggs. Because cameras were conspicuous, they were placed at previously depredated nests, which were then rebaited with chicken eggs. Cameras were rotated among nests within study sites on a weekly basis.

We also noted the remnants of eggs at the first predation event for each nest. Predators can sometimes be identified by the type of egg remains they leave behind (Reardon 1951; but see Trevor et al. 1991). Depredated eggs were classified as missing or broken (portion of an egg remaining in nest), and appearance of broken eggs was also noted (e.g., many small fragments, half shell remaining).

We developed a logistic regression model to examine the dependency of nest fate on nest type (i.e., hidden or open), distance to road (to examine edge effects), and distance to the ocean (a variable associated with land crab presence). Logistic regression models have been used to analyze factors affecting the success of both natural (Thomas et al. 1996) and artificial nests (Burger et al. 1994, Vander Haegen and DeGraaf 1996) and are appropriate when response variables are binary (e.g., nest success or failure) and factors are continuous (e.g., distance to road/ocean; Hosmer and Lemeshow 1989). We determined the suitability of the model by using the Hosmer and Lemeshow Goodness-

of-Fit Test and associated statistic with a significance level of $P < 0.05$. Individual variables within the model were tested with the Wald χ^2 statistic. Analyses were conducted with SAS (Windows version 6.12; SAS Institute Inc., Cary, North Carolina).

RESULTS

Of 141 artificial nests, 99 (70%) were depredated during the two trials combined. Our overall regression model fit our data (Hosmer and Lemeshow Goodness-of-Fit statistic = 8.57, $df = 8$, $P = 0.38$) and was significant (score statistic = 21.73, $df = 3$, $P < 0.001$). Nest fate depended primarily on distance to the ocean (score statistic = 16.4, $df = 1$, $P < 0.001$). Nests ranged from 100–1500 m from the ocean; the probability of nest success increased with distance from the ocean. Nests located farthest from the ocean (1500 m) had the greatest success (71%), whereas those located 100–325 m from the ocean and had an average success rate of 23% (range 7–37%).

Nest fate was independent of nest type (hidden or open; $\chi^2 = 2.56$, $df = 1$, $P > 0.05$); 44 (63%) and 54 (76%) of the nests were disturbed at hidden and open nests, respectively. In addition, nest fate was not associated with distance to roads ($\chi^2 = 0.18$, $df = 1$, $P > 0.05$).

One camera successfully captured activity near a nest. A photograph was taken of a giant white land crab near two damaged eggs in a nest on Hog Cay. It was not clear whether the crab broke the eggs, or found them after they had been broken.

Of the 190 eggs from 92 nests on which data were collected, 73 (38%) were missing and 117 (62%) were broken at the first nest check after predation. Thirteen (12.5%) of the broken eggs were attributed to rat predation (Flack and Lloyd 1976, pers. obs.).

DISCUSSION

Although the results of artificial nest experiments conducted in the temperate zone are often inconsistent, a few common patterns have emerged. In general, predation rates are higher in nests that are more visible and in habitats with little understory cover (Major and Kendal 1996, Hartley and Hunter 1998). In addition, Paton (1994) found a negative relationship between nest predation rates and distance from habitat edge in most of the 14

artificial nest studies he re-analyzed. We found no such patterns in the Bahamas.

In our study, the only environmental variable that successfully predicted nest fate was distance to the ocean, suggesting that nests were depredated by a species residing in or near the water. Our photograph of a giant white land crab at a nest suggests that land crabs were depredating artificial nests.

Although land crabs are terrestrial and do not rely on the ocean directly on a daily basis, they do need some source of water nearby to survive and the females migrate to the ocean for reproduction to release larvae (Wolcott 1988). Given their reliance on water for reproduction and oxygen exchange, land crabs are generally limited to low-lying areas near mangroves, swamps, and streams, and are rarely more than a few kilometers from the sea (Wolcott 1988).

Giant white land crabs were abundant on both Hog Cay and Long Island but did not appear to be associated with edge habitats. Their mostly vegetarian diets and ground foraging habits could bring them into contact with ground nests regardless of whether the nests were hidden or open. Experiments involving captive land crabs revealed that crabs were able to crack and consume eggs of various sizes corresponding to the egg sizes of ground nesting birds in the Bahamas (Staus and Barnwell 1996). This study also indicated that crabs could be responsible for both broken and missing eggs.

Although some studies document chick predation by giant white land crabs (Gnam 1991), ours is the first study to implicate *Cardisoma* crabs as egg predators. Egg eating behavior has been documented in several *Gecarcinus* spp., land crabs in the same family as *C. guanumi* (Rockwell 1932, Atkinson 1985, Burger and Gochfeld 1988, Burger et al. 1989). Other egg eating species include hermit crabs (*Coenobita rugosa*; Atkinson 1985, Burger et al. 1989), coconut crabs (*Birgus latro*; Atkinson 1985), and ghost crabs (*Ocypode quadrata*; Watts and Bradshaw 1995).

It has been suggested that land crabs play an ecological role similar to that of rats, and that crabs may have exerted considerable influence on tropical island avifaunas (Atkinson 1985). For example, after examining the fossil record, Olson (1981) hypothesized that *Ge-*

carcinus land crabs in the South Atlantic may have prevented the colonization of some islands by burrowing and ground-nesting petrels. Burger and Gochfeld (1988) provided evidence that Roseate Terns (*Sterna dougallii*) in Puerto Rico chose nest sites far from suitable land crab (*G. ruricola*) habitat. The widely distributed giant white land crab might have a similar effect on bird populations within its range.

Our results suggest that egg predation patterns and predator species assemblages in the dry subtropics may be different than those in northern temperate areas. Specifically, land crabs may play a significant role as egg predators. In the future, we urge researchers to consider environmental variables associated with the presence of land crabs (e.g., density of crab burrows, altitude, distance from ocean) when examining nest predation in the subtropics.

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Notes About the Distribution of *Pauxi pauxi* and *Aburria aburri* in Venezuela

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ABSTRACT.—In this paper I review the current distribution of the Northern Helmeted Curassow (*Pauxi pauxi*) and the Wattled Guan (*Aburria aburri*) in Venezuela. The historical range of *P. pauxi* was reduced as a result of human population growth and habitat perturbations. The current distribution corresponds

principally with 18 national parks located from the northern coastal mountains of central Venezuela to the Andes Cordillera and Sierra de Perijá. *Pauxi pauxi* was recorded only in three localities outside national parks and may have expanded from its historical distribution in the eastern part of the country. *Aburria aburri* was recorded in Sierra de Perijá and western Mérida to southern Táchira, including four new localities; three in national parks. Both species are endangered in Venezuela and their survival will depend on environmental education programs and enforcement of the law. Received 9 Feb. 1998, accepted 20 July 1999.

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