PREDATION OF ARTIFICIAL GROUND NESTS AT LAGUNA CARTAGENA NATIONAL WILDLIFE REFUGE, LAJAS, PUERTO RICO

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Predation can have a profound impact on the population dynamics of a species. This impact is even greater in disturbed systems that contain exotic predators or where populations of natural predators are abnormally high. During our studies of waterfowl in Puerto Rico, we became concerned as to the possible impact of introduced rats and mongoose on nesting waterfowl. While previous publications have cited both the black rats (*Rattus rattus*) and the Javan (small Indian) mongoose (*Herpestes auropunctautus*) as West Indian whistling-duck (*Dendrocygna arborea*) egg predators (Birdlife International 2016), we found no published documentation to substantiate this activity. To explore this possible predation, and due to the difficulty of directly observing nests, we used motion detector cameras to monitor artificial nests baited with domesticated chicken (*Gallus domesticus*) eggs. Recent applications of game cameras include documentation of occurrence of rare species as well as new species records, nest predation studies, behavioral studies and activity budgets (Ellis-Felege & Carroll 2012). The use of artificial eggs in manufactured nests in conjunction with the use of game cameras is also a widely used method (Major & Kendal 1996). This paper reports on the use of this technique at Laguna Cartagena National Wildlife Refuge to determine possible egg predators of nesting West Indian whistling-ducks. West Indian whistling-ducks are endemic to the West Indies and considered "vulnerable" by Birdlife International (2016). While a systematic census has yet to be taken, it is estimated that there are at least 150 individuals on the island of Puerto Rico (Goodman et al. 2018).

Study Sites & Methods.–Data were collected at the Laguna Cartagena National Wildlife Refuge part of the Caribbean Islands National Wildlife Refuge System. The refuge is 528.6 ha in size and

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located in the Municipality of Lajas (LCNWR,18.0145° N, 67.0979° W). For additional information on the refuge, see Eitniear & Morel (2012). Vegetation in the lagoon is principally cattails (*Typha domingensis*) and macrophytes, including water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*) (Sánchez-Colón 2015). Bordering the lagoon is a secondary dry forest dominated by mesquite (*Prosopis juliflora*) and mixtures of guamá (*Pithecellobium dulce*) and lead tree (*Leucaena leucocephala*) with occasional sweet acacia (*Vachellia farnesiana*).

We constructed four artificial nests of the same dimension as those of West Indian whistling-ducks and in localities where they have been documented to nest. Nests were constructed from grasses obtained onsite and located them in each of the cardinal directions along the perimeter of the lagoon. We baited the nests with six to ten brown and/or white uncovered eggs from domestic chickens (Fig. 1). Nests showing activity were rebuilt with fresh eggs replacing those in the disrupted nest. Activities at each location were recorded using Moultrie and Wildgame Innovations brand game cameras from 25 June to 9 July 2014 and 1 to 13 October 2014. After the monitoring period, camera SD cards were removed and downloaded for examination.

Results & Discussion.–Over 800 images during the study period contained evidence of interactions of animals with the artificial nests. The vast majority (>400) were rodents. Dogs, horses, mongoose and green iguanas (*Iguana iguana*) also set off the cameras although only mongoose were photographed depredating 11 eggs. In one case a horse and a dog broke eggs after which rats did consume the contents.

The mongoose has been blamed for the loss of many bird and reptile species by predation of adults, young or eggs. The evidence for this, however, is mostly circumstantial and is frequently based on the arrival of the mongoose being followed closely by extinction or severe population decline of another species (Roy 2001). The Indian mongoose was first introduced into Jamaica in 1872 for biological control of rats in sugarcane (Pimentel et al. 1999). It was subsequently

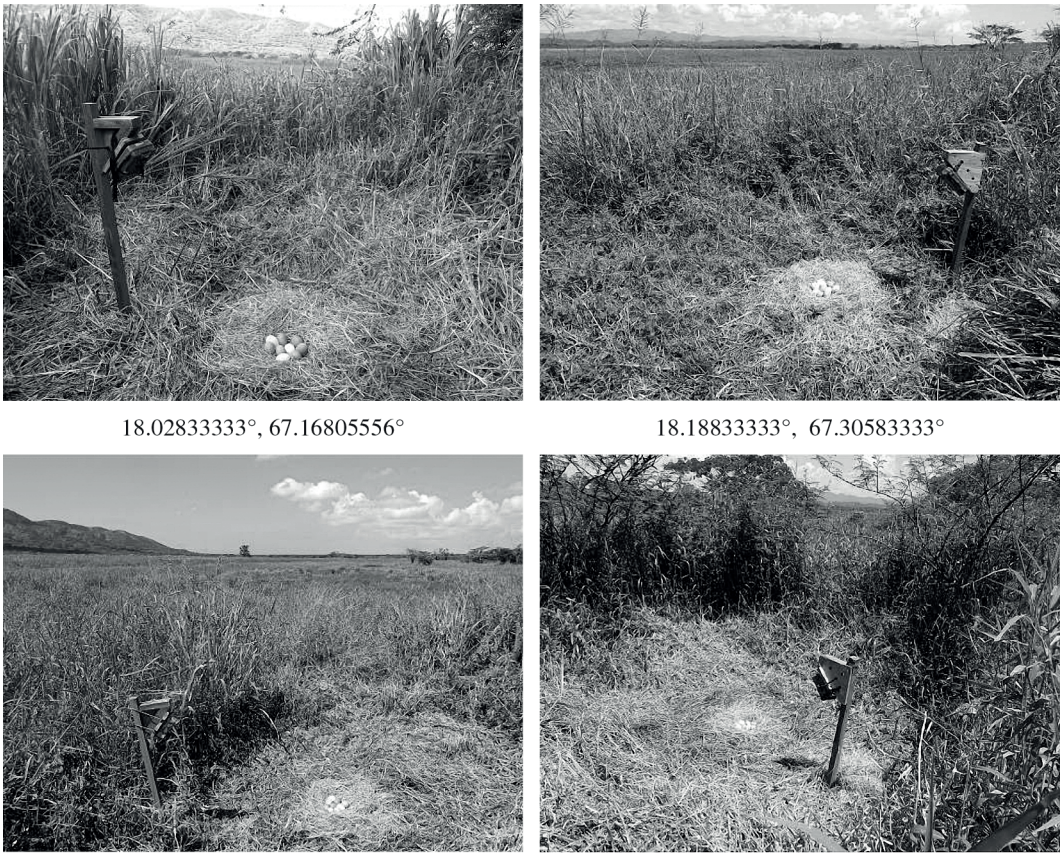

Figure 1. GPS location of game cams placed at Laguna Cartagena National Wildlife Refuge.

introduced to Puerto Rico, other West Indian Islands, and Hawaii for the same purpose. The mongoose controlled the diurnal Norway rat (*R. norvegicus)* but not the nocturnal black rat, and it preyed heavily on native ground nesting birds (Pimentel et al. 1999). Mongoose also preyed on native amphibians and reptiles, causing at least seven amphibian and reptile extinctions in Puerto Rico and other islands of the West Indies (Henderson 1992). Viella (1998) examined stomach contents of mongoose captured in Puerto Rico. Of the 14 food items identified, four (29%) were plant material and 10 (71%) animal. Of the animal matter, 33% was from vertebrates and the remaining 67% from invertebrates. The animals encountered most frequently in the diet were lizards (Anolis spp.), centipedes (Scolopendra spp.), and

cockroaches (Blattelidae). Fruits and seeds (e.g., *Miconia* spp.*)* made up the majority of the plant material. Although only recorded at one nest, we clearly documented that the mongoose is a predator of large eggs (Fig. 2). It is not known if the same individual was being observed; therefore we could not quantify the possible impact of the mongoose.

The black rat is a commonly encountered rodent throughout the island (Shiels & Ramirez de Arellano 2018). Rats have been recorded as being significant bird egg predators. In Puerto Rico, they are an important predator of the endangered Yellow-shouldered Blackbird (*Agelaius xanthomus*) (Medina-Miranda et al. 2013), being the major cause of egg and chick loss in certain breeding areas. Rats climb artificial nest structures and either prevent Yellow-shouldered Blackbirds from using the nest structures, remove or eat the eggs and chicks, or cause adult nest abandonment. While rats are very abundant and were seen in the majority of images, we found no evidence that they could break eggs or attempted to remove them from the nests (Fig. 3). Rats have been documented as a significant predators of seabird eggs. However, an adult Laysan albatross (*Phoebastria immutabilis*) died after rats gnawed on it, but their eggs

Figure 2. The Indian mongoose was the only predator documented to consume large eggs.

Figure 3. Black rat and green iguana photographed at artificial nest.

($\bar{x}$ = 107.6 mm x 68.6 mm ± 0.3, n=105) (Awkerman et al. 2009) were not predated by the rats. On the other hand, Sooty tern (*Onychoprion fuscatus*) eggs ($\bar{x}$ = 49.8 mm x 35.9 ± 1.9 mm, n=30) were depredated by rats that broke the pointed end and dragged them from the burrows (Schreiber et al. 2002). There appears to be a size and shape threshold after which rats are unable to depredate eggs.

Without pointed ends, graded large eggs from domesticated chickens ($\bar{x}$ = 58.8 mm x 44.6 mm, ± 0.3, n=12) and the eggs of West Indian whistling-ducks ($\bar{x}$ = 57.5 mm x 44.4 mm, n=9) (Schonwetter 1967) are above the size/shape threshold above which rats are unable to depredate eggs. While no eggs from West Indian whistling-ducks were used, egg shell thickness of domestic chickens (0.295 mm, Ar et al. 1979) is less that of the whistling-duck (0.036 mm, Mallory & Weatherhead 1990). Rounder eggs are stronger than more elongated ones, which would add additional strength to the rounder whistling-duck eggs (Mallory & Weatherhead 1990). This is especially true given that egg strength as measured by yield point force is correlated with thickness squared (Ar et al. 1979).

In summary, while rats were observed in the majority of images, we found no evidence that they were able to break the eggs and consume them. Mongoose were the only predators of eggs of which we have direct evidence. On four occasions, dogs and horses also broke eggs (Fig. 4), however, under natural conditions the disturbance

Figure 4. Both domesticated dogs and horses broke eggs that were subsequently consumed by rats.

resulting in broken eggs would have likely resulted in the nest being abandoned. Despite the observation of a boa constrictor (*Boa constrictor*) near the refuge observation tower and of a shed skin at one of our sites none of our cameras recorded snakes near our artificial nests. Despite this the species is becoming more abundant on the island and is therefore of concern as large eggs are certainly within its potential diet (Reynolds et al. 2013).

While this study documents that the mongoose eats larger eggs and that rats do not, further study involving more nests and/or mongoose capture recapture over a greater time period is needed to determine actual density of the mongoose population.

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