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Nest defense behavior of Greater Roadrunners (*Geococcyx californianus*) in south Texas

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ABSTRACT—The Greater Roadrunner (*Geococcyx californianus*) is a medium-sized predatory bird that occurs widely across the southwestern United States. Despite its prevalence in this region, studies examining the nesting and behavioral ecology of this species are limited. In 2015 and 2016, we examined relatively unknown aspects of roadrunner natural history by using infrared video cameras to observe antipredator behaviors associated with Greater Roadrunner nest defense. Nest predation accounted for all nesting failures in our study. The Great Plains rat snake (*Pantherophis emoryi*) accounted for 70.0% of nest predation. We observed rat snakes entering the nest and consuming eggs or nestlings for >6 min before roadrunners flushed from nest sites. We also observed 53.3% of roadrunners actively defending nest sites from snake predators and zero defending nests from coyotes (*Canis latrans*), likely because of the predator size. Active defense sessions in our study lasted 1 min 20 s (95% CI 1 min 17 s) and consisted of 12.0 (95% CI 3.4) bill strikes per min of active defense. We observed no successful nest defenses because partial nest contents were lost during each event; however, >50% of predation events with an active defense session resulted in preservation of at least one viable egg or chick, indicating nest defense was a valuable behavior. Examining nest defense behaviors in larger, predatory birds may elucidate risks and rewards associated with nest defense that may not be observed in studies focusing primarily on passerines. *Received 18 April 2017. Accepted 1 March 2018.*

Key words: Greater Roadrunner, nest defense, nest predation, rat snake, south Texas.

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Comportamiento de defensa nido de Correcaminos Mayores (*Geococcyx californianus*) en el sur de Texas

RESUMEN (Spanish)—El Correcaminos Mayor (*Geococcyx californianus*) es una ave depredadora de tamaño mediano que ocurre ampliamente en el suroeste de los Estados Unidos. A pesar de su prevalencia en esta región, las investigaciones de la ecología de anidación o comportamiento de esta especie son limitadas. En 2015 y 2016, examinamos aspectos de la historia natural del correcaminos que son relativamente desconocidos y usamos cámaras de video infrarrojas para investigar los comportamientos antidepredadores asociados con la defensa del nido del Correcaminos Mayor. La depredación del nido representa todas las fallas de anidación en nuestro estudio. La serpiente de rata de los Great Plains (*Pantherophis emoryi*) representó 70.0% de la depredación de nidos. Observamos que las serpientes de rata ingresaban al nido y consumían huevos o pichones durante > 6 min antes de que los correcaminos huyeron de los nidos. También observamos que el 53.3% de los correcaminos defendían activamente los sitios de nidificación de los depredadores de serpientes y cero defensa de los coyotes (*Canis latrans*), probablemente debido al tamaño de los depredadores. Las sesiones de defensa activa en nuestro estudio duraron 1 min 20 s ± 1 min 17 s y consistieron en 12.0 ± 3.4 ataques de pico por minuto de defensa activa. No observamos ninguna defensa de nidos exitosa porque se perdieron parcialmente los contenidos de nidos durante cada evento, sin embargo, > 50% de los eventos de depredación con una sesión de defensa activa resultaron en la preservación de al menos un huevo o pollito viable, indicando que la defensa de nidos fue un comportamiento valioso. Examinando las conductas de defensa de los nidos en aves rapaces más grandes puede aclarar los riesgos y las recompensas asociadas con la defensa de los nidos que no pueden observar en los estudios centrados principalmente en las paseriformes.

Palabras clave: Correcaminos Mayor, defensa de nidos, depredación de nidos, serpiente de rata, sur de Texas.

In response to predation pressure and to increase reproductive success, bird species have developed antipredator behaviors such as mobbing (Krams and Krama 2002), alarm calling (Knight and Temple 1988, Hatch 1997), and acute attacks on a predator (Olendorf and Robinson 2000). These behaviors are heavily influenced by the tradeoff between survival of offspring and risk of injury or death by adults (Montgomerie and Weatherhead 1988). Researchers also hypothesize that birds may adjust behaviors in response to perceived risk (Lima 2009, Mutzel et al. 2013). Thus, birds may defend their nests more aggressively against relatively small predators that only pose a threat to their young than relatively large predators that could cause injury or death of the adult (Palleroni et al. 2005, Nemec and Fuchs 2013).

Antipredator behaviors are well studied in passerines and domestic birds; however, few studies examine these behaviors in larger, predatory birds. One such species is the Greater Roadrunner (*Geococcyx californianus*), a medium-sized predatory bird that occurs widely across the southwestern United States (Hughes 1996, Maxon 2005). Roadrunners are generally associated with brushy vegetation such as mesquite (Kelley et al. 2011) that has <50% crown cover and includes shrubs 2–3 m in height (Folse 1974). Roadrunners are omnivorous, consuming small mammals, lizards, birds, snakes, seeds, and fruit (Hughes 1996). Nests are ~30 cm in diameter with a shallow bowl consisting of small twigs, grasses, and leaves (Baicich and Harrison 2005). Nesting substrate generally consists of woody shrubs and trees, and clutch sizes can range from 2 to 6 eggs laid at irregular intervals from March until August (Folse and Arnold 1978, Hughes 1996, Baicich and Harrison 2005, Maxon 2005). Previous studies have indicated that predation is the primary cause of roadrunner nesting failure, and in a south Texas study conducted in the 1970s, 71.0% of all roadrunner nest contents were lost through predation (Folse and Arnold 1978).

Despite roadrunner prevalence in most semiarid systems of the southern United States, research that describes this species' nesting behavior is limited (Kelley et al. 2011, Montalvo et al. 2014). Herein, we detail relatively unknown aspects of roadrunner natural history by investigating antipredator behaviors associated with nest defense and offer potential explanations for these traits. Understanding roadrunner nest defense behavior could elucidate risks and rewards associated with defense and offer insight into why other bird species may display similar behaviors.

Methods

We conducted our study in 8 study sites at the San Antonio Viejo Ranch (SAVR) in south Texas, a 61,000 ha property owned and operated by the East Foundation. SAVR is located 25 km south of Hebbronville, Texas, in Jim Hogg and Starr counties. Mean annual temperature in this region was 22 °C with annual ranges between 7 °C and 36 °C, and mean annual rainfall was 21.5 cm (PRISM 2017). During the breeding season (Mar–Aug), mean temperature was 25.7 °C in 2015 and 27.2 °C in 2016 (PRISM 2017), and mean rainfall was 14.1 cm in 2015 and 13.0 cm in 2016 (PRISM 2017).

We searched for roadrunner nests in eight 600 m^2 study sites that we randomly established within each of 4 vegetation types represented at the SAVR (2 study sites per vegetation type). We determined grid size based on nesting density of birds in this region (Flanders et al. 2006), size and shape of vegetation types, and logistics necessary for a concurrent avian nest predation study (Davis 2017). As defined by McLendon et al. (unpubl. report), our vegetation types included early seral, native grassland, shrubland (dominated by woody plants <3 m), and woodland (dominated by woody plants >3 m). Early seral vegetation occurred on $<10\%$ of our study area and was characterized by doveweed (*Croton* spp.), sandbur (*Cenchrus* spp.), and horsemint (*Monarda punctate*). Native grassland occurred on $<10\%$ of our study area and included species such as arrow-feather threeawn (*Aristida purpurascens*), balsamscale grass (*Elyonurus tripsacoides*), Lehmann lovegrass (*Eragrostis lehmanniana*), and seacoast bluestem (*Andropogon littoralis*). Shrubland occurred on $<10\%$ of our study area and included catclaw (*Acacia greggii*), blackbrush (*Acacia rigidula*), and brasil (*Condalia hookeri*). Finally, woodland occurred on ~70% of our study area and consisted primarily of honey mesquite (*Prosopis glandulosa*), amargosa (*Castela texana*), and whitebrush (*Aloysia lycioides*).

We used visual and behavioral cues to systematically search for roadrunner nests in each study site every 3–5 d between March and August 2015 and 2016. We also found nests opportunistically during routine checks of other species' nests and while traveling between study sites. Once we located a nest, we recorded the number of roadrunner eggs or nestlings, if present, and placed a small flag marker 10 m from the nest in a random cardinal direction to aid in relocation of the nest site during subsequent visits.

We placed infrared video cameras ~30 cm from the nest or close enough to view contents and activity around the nest without causing unnecessary disturbance to the birds (Pietz et al. 2012). Our video camera systems consisted of an infrared camera (Rainbow, Costa Mesa, CA), a digital video recorder (DVR; Detection Dynamics, Austin, TX), a 12-volt battery, and a supplemental 20-watt solar panel (Suntech, San Francisco, CA). We used weatherproof 3.6 mm black and white bullet cameras with 940 nm infrared light-emitting diodes. We connected the DVRs to our cameras using a 15 m component cable and used 32 GB memory cards to increase data storage and decrease the need for nest visits to change cards. We checked camera systems every 2–4 d to change memory cards and repair equipment, if necessary. We only placed cameras at nests with contents (eggs or nestlings) to avoid nest abandonment by adult birds. After installation, we covered cables with ground litter to make cameras less conspicuous to predators. We reviewed video footage using a portable viewfinder at the next check to confirm nest status.

After nest success or failure, we first reviewed our camera footage to identify nest predators, date of predation event, time of event, and to confirm the nest stage. For all predation events, we recorded the time elapsed between the predator entering the nest (initiation) until the predator exiting the nest and not returning, hereafter referred to as duration. We also recorded the elapsed time between the initiation of the event and when the attending adult completely flushed from the nest. Within each predation event, we recorded the number and duration of active defense sessions and the number of bill strikes per minute. We then calculated mean values and 95% confidence intervals for predation event duration, flushing time, active defense sessions, and bill strikes per minute.

Results

We monitored 8 roadrunner nests in 2015 and 7 roadrunner nests in 2016. Five roadrunner nests fledged at least 1 young, and 10 roadrunner nests failed. All nest failures were a result of predation, and 40.0% of roadrunner nests experienced multiple predation events before eventual nest failure. We deployed infrared video cameras at all 15 nests. The dominant nest predator in our study was the Great Plains rat snake (*Patheropis emoryi*), accounting for 70.0% ($n = 7$ rat snakes) of nest failures and 68.4% ($n = 13$ rat snakes) and of all predation events. Other nest predators included coyotes (*Canis latrans*), coachwhips (*Masticophis flagellum*), and Green Jays (*Cyanocorax yncas*). We observed snakes depredating or attempting to depredate similar numbers of nests in the incubation stage ($n = 7$) and in the nestling stage (n = 7), and predation events occurred exclusively at night, with the exception of one coachwhip which occurred at 1530 h CDT.

Considering all predator types, roadrunners flushed from their nests (time [95% confidence interval]) 6 min 46 s (10 min 20 s) after being approached by a predator. Roadrunners approached by coyotes (0 min 0 s [0 min 0 s]) flushed 8 min 42 s sooner than roadrunners approached by snakes (8 min 42 s [11 min 5 s]). We observed 53.3% (n = 8) of roadrunners actively defending nest contents against snakes, and 71.4% (n = 10) of predation events by snakes resulted in an active defense by an adult roadrunner. The mean number (95% CI) of active defense sessions we observed per predation event was 1.7 (0.4) with a mean time of 1 min 20 s (1 min 17 s). On average, roadrunners attempted 12.0 (3.4) defense strikes per minute during active defense sessions with the maximum number of mean strikes occurring during the first minute of a session 14.1 (5.1). All defense sessions were in response to snake predators. We observed no successful nest defenses because partial nest contents were lost during each event; however, >50% of predation events with an active defense session resulted in preservation of at least one viable egg or nestling, indicating nest defense was a valuable behavior.

Discussion

As expected, the most common predator we observed at roadrunner nests was the Great Plains rat snake, likely because nests were placed in areas of moderate woody cover (Klug et al. 2010). Roadrunners also waited the longest period of time to flush from the nest when rat snakes were the nest predator compared to the other nest predators we observed on our videos. Previous studies have indicated that birds exhibit nest defense behaviors based on predator species and predator size (Palleroni et al. 2005, Nemec and Fuchs 2013), and thus the size of rat snakes in our study relative to other predators may explain this behavior. We did find it unusual that roadrunners remained at the nest for >6 min after the initiation of a predation event by a snake. Such behavior may seem like a defense measure, but after further review of camera footage, snake predators would often go undetected and consume eggs or nestlings for several minutes before the adult began to actively defend the nest.

All active defense sessions by roadrunners occurred in response to snake nest predators. Again, this may reflect predator size because the size of roadrunners in relation to rat snakes may offset the risk associated with nest defense. Previous studies examining nest defense against snake predators have indicated passerines may exhibit greater defense effort against relatively smaller-bodied snakes (Ellison and Ribic 2012) than larger-bodied snakes (Reidy et al. 2009), potentially explaining the behavior we observed in our study. We also suspect that rat snakes were large enough to defend against roadrunner attacks and small enough for roadrunners to display defense behaviors against them, which resulted in defense session lengths of more than a minute. Predator size may also dictate the number of strikes in our study because roadrunners may put forth a greater effort into defending nests against predators they can discourage without causing physical injury to themselves.

Our study indicates that roadrunners exhibit innate differences in nest defense strategy in response to predator size and species. Additionally, nest defense is a valuable behavior when defending against rat snakes, likely because the risk of defending eggs or nestlings is worth the reward of preserving all or partial nest contents. We hope our findings will encourage future research regarding the underlying mechanisms driving defense behavior in predatory birds as it relates to predator size and predator species. Nest defense studies on longer-lived, predatory birds remain limited, and further study could help test current theories regarding nest defense focusing primarily on passerines.

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Novel observation of a raptor, Collared Forest-falcon (*Micrastur semitorquatus*), depredating a fleeing snake at an army ant (*Eciton burchellii parvispinum*) raid front

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ABSTRACT—*Eciton burchellii* is a Neotropical army ant that influences the ecology of many associated animal species, including their prey and species that attend the ant's foraging raids. At least 29 bird species are obligate specialists on foraging at army ant raid fronts, and additional species across diverse avian orders follow army ant raids in a facultative manner. These facultative ant-following birds include species of raptors in Accipitriformes,