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Prey Delivery Inside an Artificial Nest Box and Burrows Used by Nesting Burrowing Owls in El Paso, Texas

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Abstract.—Determining the diet of species that nest underground, such as the Burrowing Owl (*Athene cunicularia*), is challenging. Prey information for Burrowing Owls is often limited to prey remains at nest sites and in owl pellets, images collected from above-ground trail cameras, or direct observations of prey acquisition and delivery. To document prey use and nesting behaviors, we equipped an artificial nest box and burrows at Rio Bosque Wetlands Park in El Paso, Texas, with a digital video recorder and three underground infrared cameras. Herein we document the types and frequencies of prey items delivered inside the nest box during the 2019 nesting season, as reflected in videos and images collected continuously from 1 April to 5 July. We reviewed 23,039 video files and documented 580 prey deliveries. We identified 463 (80%) of the delivered prey items to class and 237 items (41%) to family. Invertebrates made up 75% and vertebrates 25% of the identifiable prey items by frequency. Most (55%) of the invertebrates were insects, especially in the orders Orthoptera and Blattodea; scorpions (Scorpiones) were the second most common group (2% of all items). Vertebrate prey were delivered less often and mostly consisted of rodents (14% of all prey items), especially heteromyids, followed by squamate reptiles (6%). Results from this project will aid in conservation and management of this species.

Key Words: *Burrowing Owl*; Athene cunicularia; *artificial nest box*; *infrared cameras*; *prey delivery.*

ENTREGA DE PRESAS DENTRO DE UNA CAJA NIDO ARTIFICIAL Y MADRIGUERAS UTILIZADAS POR *ATHENE CUNICULARIA* ANIDANDO EN EL PASO, TEXAS, EEUU

Resumen.—Determinar la dieta de las especies como *Athene cunicularia*, que anidan bajo tierra, es un desafío. La información sobre las presas de esta especie a menudo se limita a los restos de presas hallados en los sitios de nidificación y sus egagrópilas, a las imágenes recolectadas por cámaras colocadas al ras del suelo en senderos o a observaciones directas de la obtención y entrega de presas. Para documentar el uso de presas y los comportamientos de anidación, equipamos una caja nido artificial y madrigueras de esta especie en el Parque de Humedales Río Bosque, El Paso, Texas, con una grabadora de video digital y tres cámaras infrarrojas subterráneas. En este trabajo documentamos los tipos y frecuencias de presas entregadas dentro de la caja nido durante la temporada de anidación de 2019, según se refleja en los videos y en las imágenes recolectadas continuamente desde el 1 de abril hasta el 5 de julio. Revisamos 23,039 archivos de video y documentamos 580 entregas de presas. Identificamos 463 (80%) presas entregadas hasta el nivel de clase y 237 presas entregadas (41%) hasta el nivel de familia. Los invertebrados constituyeron el 75% y los vertebrados el 25% de las presas identificables en términos de frecuencia. La

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mayoría (55%) de los invertebrados fueron insectos, principalmente de los órdenes Orthoptera y Blattodea; los escorpiones (Scorpiones) fueron el segundo grupo más común (2% de todos los ítems). Las presas consistentes en vertebrados fueron entregadas con menos frecuencia y en su mayoría consistieron en roedores (14% de todas las presas), especialmente heterómidos, seguidos de reptiles escamosos (6%). Los resultados de este proyecto ayudarán a la conservación y manejo de esta especie.

[Traducción del equipo editorial]

INTRODUCTION

The Burrowing Owl (*Athene cunicularia*) is primarily a crepuscular/nocturnal raptor that nests and roosts in burrows typically excavated by fossorial mammals, such as prairie dogs (*Cynomys* spp.), ground squirrels (*Otospermophilus* and *Urocitellus* spp.), American badgers (*Taxidea taxa*), foxes (*Vulpes* spp.), coyotes (*Canis latrans*), and tortoises (*Gopherus* spp.) (Dziadzio and Smith 2016, Conway 2018). Burrowing Owl populations have declined in the United States from factors such as the expansion of urban development and agriculture (Mrykalo et al. 2009, Wilkerson and Siegel 2011), bird-airport strike hazards (Merriman et al. 2007), and reductions of prairie dog populations (Desmond et al. 2000). In Texas, Burrowing Owls are now recognized as a Species of Greatest Conservation Need (Texas Parks and Wildlife Department [TPWD] 2012).

Assessing the diet of nocturnal species that shelter and nest underground is challenging because of limited opportunities for direct observation. Previous diet information for Burrowing Owls comes primarily from collecting and analyzing pellets and prey remains found around burrow entrances (Schlatter et al. 1980, Plumpton and Lutz 1993, Littles et al. 2007, Hall et al. 2009, Myrkalo et al. 2009, Trulio and Higgins 2012), but also from monitoring prey deliveries with above-ground infrared (IR) trail cameras (Poulin and Todd 2006) and using downhole cameras (Garcia and Conway 2009). However, analyses of predatory bird diets based on pellets or prey remains may be biased, because some prey, such as larger mammals, may be more conspicuous or persistent than others (Simmons et al. 1991). Similarly, pellets may overestimate mammalian prey and underestimate avian prey in some circumstances (Redpath et al. 2001). In comparison, an ability to identify all prey items brought to a nest burrow would provide an unbiased assessment of a focal species' use of prey for provisioning the incubating female and owlets.

In this study, we used an underground video system installed to monitor an artificial nest box and burrows used by nesting Burrowing Owls in El Paso, Texas (Balin et al. 2021), to document prey items brought to one nest that produced young during the 2019 breeding season. This is the first documented case of using continuous, underground video monitoring to assess prey delivery at a nest box/burrows occupied by nesting Burrowing Owls. Our objectives were to use the video footage to identify all prey items to the lowest taxon possible, and to determine the timing and composition of prey deliveries during a nesting season.

METHODS

Study Area. Rio Bosque Wetlands City Park (hereafter Park) is a 151-ha natural area surrounded by urbanization and managed to restore native Rio Grande ecosystems. Plant communities include riparian assemblages, tornillo (*Prosopis pubescens*), remnant salt cedar (*Tamarix ramosissima*) stands, and desert scrub. Daytime temperatures typically range from 1–36° C, but exceed 38° C on 12–13 d each summer. Diverse wildlife inhabit the Park, including 242 species of birds and numerous species of arthropods, mammals, reptiles, and amphibians (City of El Paso 2002). Common mammals include black-tailed jack rabbits (*Lepus californicus*), desert cottontails (*Sylvilagus audubonii*), heteromyid rodents, and coyotes (*Canis latrans*). Coyotes and gopher snakes (*Pituophis catenifer*) are among the primary predators of Burrowing Owls in the area.

Monitoring Artificial Nest Box and Burrows. Texas Parks and Wildlife Department installed 26 artificial nests for Burrowing Owls at the Park between 2006 and 2018. We equipped one artificial nest box and burrows with underground IR cameras and a digital video recorder (DVR) monitoring system in 2014 (Fig.1; Balin et al. 2021). This system produced continuous video footage from 1 April–5 July 2019, which formed the basis for the prey analysis. Footage collected from inside the burrow elbows and nest box (Fig. 2A, 2B) was sent to the Borderlands Research Institute at Sul Ross State University in Alpine, Texas, to be reviewed for prey items brought into the nest site. Prey items were identified to the lowest taxon possible, and the date and time (MST) of each delivery was noted.

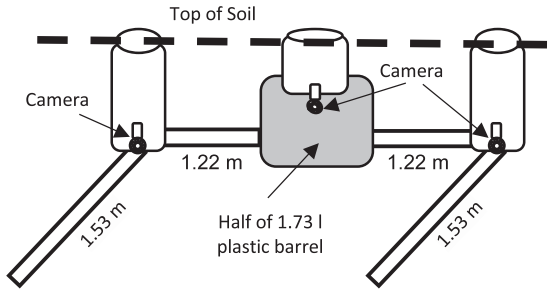

Figure 1. Design schematics showing front view of camera placements as part of an off-grid, underground video surveillance system used to monitor nesting Burrowing Owls in an artificial nest box and burrows at Rio Bosque Wetlands Park, El Paso, Texas, USA.

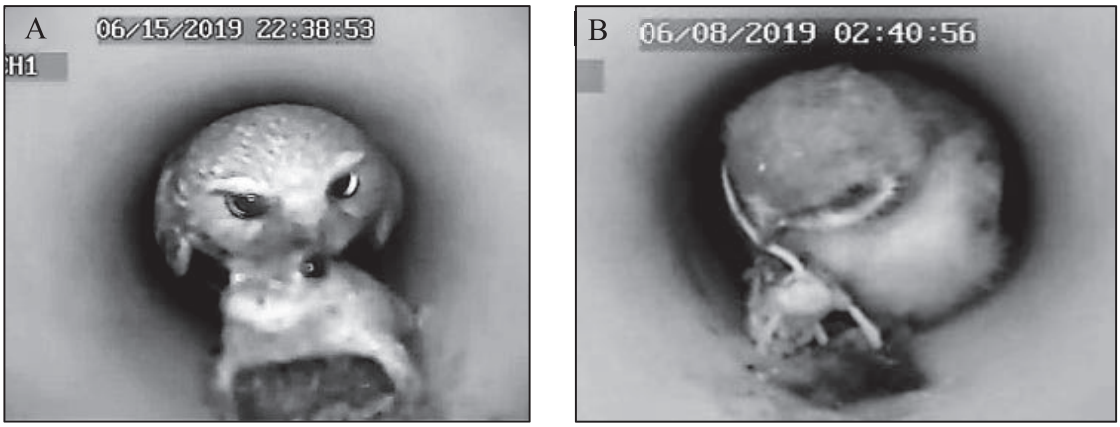

Figure 2. Prey deliveries recorded in June 2019 by an underground video surveillance system used to monitor nesting Burrowing Owls in an artificial nest box and burrows in El Paso, Texas, USA: (A) American bullfrog, *Lithobates catesbeianus*; (B) unidentified heteromyid rodent.

Initially, video of the elbow channels was watched to determine what prey items Burrowing Owls brought to the nest site, and footage from the nest-box camera was used as needed to refine prey identifications.

Analyses. We identified prey items using field guides, reference literature, voucher specimens, and professional experts from Sul Ross State University and TPWD. We counted frequency of occurrence for all prey types and the frequency of prey delivery per week by taxa. We calculated the relative frequencies of different prey taxa, total numbers of prey items/deliveries, and number of eggs and owlets present during deliveries by hour of day, date, and week. We tested for independence of prey types, deliveries per week, and hour of day using Fisher's exact test. We calculated Pearson's correlations to examine relationships between the number of prey deliveries per day and the number of eggs and owlets present. We used SAS EG 8.3 software to conduct statistical analyses.

RESULTS AND DISCUSSION

We terminated video monitoring on 5 July 2019 when prey delivery and owlet activity occurred mainly outside of the nest and burrows. We reviewed 23,039 video files recorded from 1 April to 5 July and documented 580 prey items brought inside the artificial nest box and burrows. Of these items, 117 (20%) remained unidentified and 463 (80%) were identified to class, order, or family (Table 1). Some prey items could not be identified because of their small size, representation as only partial carcasses, or poor image quality. The identified prey items included 346 (75%) invertebrates and 117 (25%) vertebrates (Fig. S1). A majority (55%) of the invertebrates were insects, most commonly identified to the orders Orthoptera (grasshoppers and crickets), Blattodea (cockroaches and termites), and Lepidoptera (butterflies and moths). Other common invertebrate orders included Araneae (spiders), Scorpiones (scorpions), and Scolopendromorpha (centipedes). Mammals, mainly small heteromyid rodents, composed 14.7% of all prey items. Other vertebrate groups included squamate reptiles (6.3%), amphibians (3.5%), and birds (0.9%). Evidence of invertebrates as the dominant prey type by frequency is similar to the pattern found in other studies (Littles et al. 2007, Trulio and Chromezak 2007, Hall et al. 2009, Ruiz Ayma et al. 2019), and the representation of key taxa may be attributed to the abundance of crickets, cockroaches, scorpions, and heteromyid rodents found locally in the northern Chihuahuan Desert.

Egg laying began on 13 April and a clutch of nine eggs was completed on 1 May (Fig. 3). During incubation the male delivered 84 prey items inside the nest box comprising 19% invertebrates, 11% reptiles, 6% mammals, 4% amphibians, 2% birds, and 49% unidentified items. One egg hatched on 19 May, five on 20 May, two on 21 May and one on 22 May. We detected an initial increase in prey deliveries once hatching began, which increased as the entire clutch hatched. The frequency of prey deliveries increased during hatching (259% for invertebrates and 82% for mammals) but decreased for reptile, bird, and unidentified prey species. Post-hatching, the adult owls brought 481 prey items inside the nest box comprising 68% invertebrates, 11% mammals, 4% reptiles, <1% birds, and 14% unidentified items.

We detected uneven prey delivery by taxa across weeks (Table 2) and time of day (Supplemental Material Table S1; $P < 0.001$ in both cases). The number of prey deliveries declined slightly after six owlets perished in late May from various causes and peaked when the remaining three owlets were approximately 2 wk old. Deliveries then decreased

Table 1. Numbers and percentages of identified prey items ($n = 463$) by taxa brought by nesting Burrowing Owls to an artificial nest box and burrows during the 2019 nesting season (1 April–5 July) in El Paso, Texas, USA.

CLASS	ORDER	FAMILY	NUMBER OF INDIVIDUALS	PERCENT OF PREY ITEMS	SUBTOTAL BY ORDER	PERCENT OF PREY ITEMS BY ORDER
Insecta	Orthoptera	Gryllidae	3	0.7	**60**	**12.9**
		Acrididae	2	0.4		
		Tettigoniidae	2	0.4		
		Unknown	53	11.5		
	Coleoptera	Cerambycidae	13	2.8	**17**	**3.7**
		Unknown	4	0.9		
	Blattodea	Blattidae	47	10.1	**47**	**10.1**
	Lepidoptera	Sphingidae	11	2.4	**23**	**5.0**
		Unknown	12	2.6		
	Hemiptera	Cicadidae	2	0.4	**7**	**1.5**
		Coridae	1	0.2		
		Unknown	4	0.9		
	Odonata	Unknown	1	0.2	**1**	**0.2**
	Unknown Insect	Unknown	100	21.6	**100**	**21.6**
Arachnida	Scorpiones	Buthidae	45	9.7	**46**	**9.9**
		Unknown	1	0.2		
	Araneae	Unknown	16	3.4	**16**	**3.4**
	Thelyphonida	Thelyphonidae	1	0.2	**1**	**0.2**
Chilopoda	Scolopendromorpha	Scolopendridae	28	6.1	**28**	**6.1**
Mammalia	Rodentia	Heteromyidae	36	7.8	**65**	**14.0**
		Cricetidae	8	1.7		
		Muridae	2	0.4		
		Unknown	19	4.1		
	Lagomorpha	Leporidae	3	0.7	**3**	**0.7**
Reptilia	Squamata	Gekkonidae	6	1.3	**29**	**6.3**
		Phrynosomatidae	4	0.9		
		Crotaphytidae	1	0.2		
		Scincidae	1	0.2		
		Unknown	8	1.7		
		Colubridae	9	1.9		
Amphibia	Anura	Ranidae	8	1.9	**16**	**3.5**
		Scaphiopodidae	2	0.4		
		Unknown	6	1.3		
Aves	Passeriformes	Tyrannidae	1	0.2	**4**	**0.9**
		Hirundinidae	1	0.2		
		Unknown	2	0.4		
			Identified Prey Items Total		**463**	**100.0**
Unknown	Unknown	Unknown	117			
			Total of Prey Items		**580**	

again and varied until the owlets fledged in early July (Table 2, Fig. 3).

Invertebrate prey were delivered infrequently during daytime hours, but deliveries commenced in earnest during the 2000 H, peaked in frequency between 2000 H and midnight (range = 31–82 total deliveries per hourly block), and then gradually diminished through the nighttime early morning hours (Table S1). Mammal prey deliveries also occurred throughout the night, particularly between 2200 and 0200 H (range = 6–11 total prey deliveries per hourly block), whereas reptile deliveries varied from midnight to 2300 H (range = 0–3 total deliveries per hourly block). The lowest total prey delivery periods, including the unidentified prey items, were from 1000 to 1800 H (range = 0–6 total deliveries per hourly block).

Although the male fed the female during egg laying and incubation, the number of prey deliveries was not

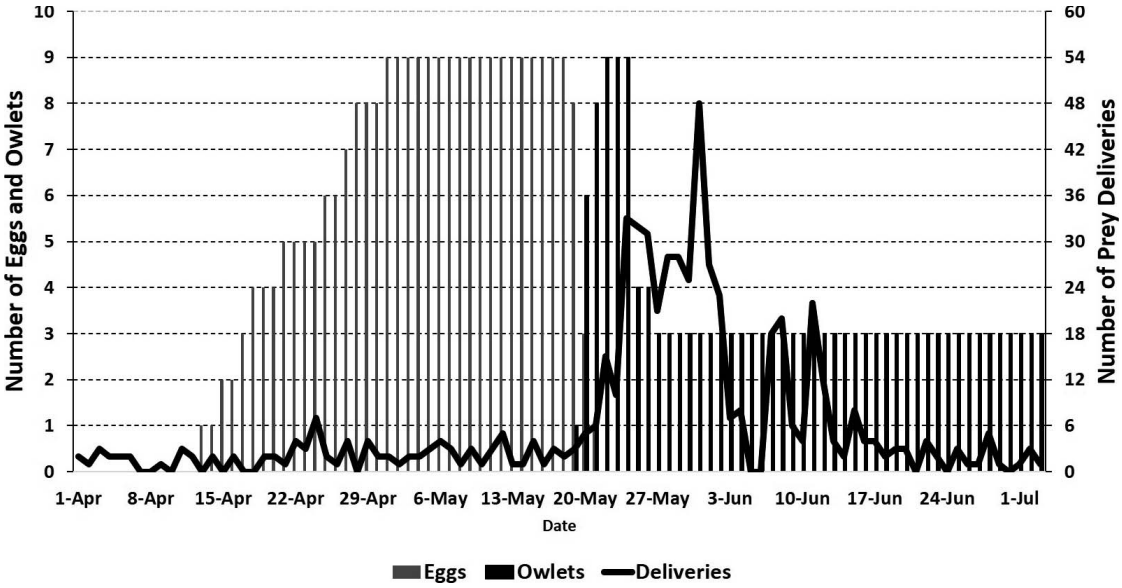

Figure 3. Eggs, owlets, and prey deliveries by date inside an artificial nest box and burrows used by Burrowing Owls during the 2019 nesting season in El Paso, Texas, USA.

correlated with the number of eggs being incubated ($r = 0.030$, $P = 0.86$). Similarly, the number of deliveries post-hatching was not correlated with the number of owlets present ($r = 0.193$, $P = 0.20$). This result suggests the influence of factors other than egg or owlet numbers. For example, the combined biomass of prey deliveries might have been more strongly correlated with the numbers and ages of owlets than the frequency of prey deliveries. Other factors also might have restricted the potential for prey deliveries documented inside the nest box to increase through the nesting cycle, including weather affecting prey availability, unaccounted items brought to the nest and consumed by the adult female, and owlets increasingly being fed outside of the nest box as they aged beyond 2–3 wk.

Given that we monitored only one nesting attempt, drawing broad inferences about diet and prey delivery patterns is not warranted, which also limits the value of comparisons to other studies. More data are needed to provide a complete and general view of the nesting-season

Table 2. Frequency of prey deliveries by Burrowing Owls to an artificial nest box and burrows by week and taxon during the 2019 nesting season (1 April–5 July) in El Paso, Texas, USA.

START OF WEEK	AMPHIBIAN	BIRD	INVERTEBRATE	MAMMAL	REPTILE	UNKNOWN
1 April	0	2	6	1	1	2
8 April	1	0	2	3	2	0
15 April	0	0	2	2	1	2
22 April	1	0	5	3	1	11
29 April	1	0	0	2	1	12
6 May	0	0	1	2	3	14
13 May	0	0	1	3	1	10
20 May	1	0	97	10	4	20
27 May	0	1	149	21	5	24
3 June	0	0	46	5	2	6
10 June	7	0	28	5	4	12
17 June	3	1	3	7	1	3
24 June	2	0	3	3	3	0
1 July	0	0	3	1	0	1

diet of Burrowing Owls in this region of Texas. Further study is needed to determine how the diet in this region compares to other areas, and to evaluate how underground video surveillance compares to other methods of studying Burrowing Owl diets. A more comprehensive methodology would also include installing trail cameras outside of the burrow entrances to document delivered prey items that are never brought underground, analyzing pellet composition and prey remains, and using color video recordings to facilitate improved prey identification.

The merits of our system lie in the value of studying diet based on continuous, constant video recordings that provide precise dates and times of prey deliveries, a permanent record for review, and an enhanced ability to identify invertebrate and other prey items before they are consumed, dismembered, or regurgitated as pellets left around the burrow entrance. In addition, our DVR system captured videos of prey items delivered in low light during nights and early mornings when Burrowing Owls typically forage. Our system provided important information on prey species and relative frequencies of prey delivery to a Burrowing Owl nest site in the northern Chihuahuan Desert and augmented knowledge of Burrowing Owl feeding behavior near an urban area. Such information will aid understanding of the prey ecology of Burrowing Owls in the region and facilitate improved resource management and conservation on behalf of this sensitive species.

SUPPLEMENTAL MATERIAL (available online). Table S1: Frequency by hour of the day (MST) and taxonomic group of prey deliveries to an artificial nest box and burrows used by Burrowing Owls during the 2019 nesting season (1 April–5 July) in El Paso, Texas, USA. Figure S1: Percentages by taxa of identified prey items ($n = 463$) brought by Burrowing Owls to an artificial nest box and burrows during the 2019 nesting season (1 April–5 July) in El Paso, Texas, USA.

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