



Scientific note

Reptiles preyed by the Burrowing owl (*Athene cunicularia*): new records and current knowledge in South America

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Reptiles are largely preyed by other reptiles, mammals, and birds, including birds of prey (Alencar *et al.* 2012, Spencer *et al.* 2014, Cortes-Gomez *et al.* 2015). Consequently, reptiles developed a set of defense mechanisms to avoid predation, such as cryptic or aposematic coloration (Caro 2014). However, these strategies may not always be efficient, especially against specialized birds of prey. There are records on birds of prey finding, capturing, and ingesting different cryptic or aposematic reptiles (Fowler *et al.* 2009), including serpentiform and venomous preys (DuVal *et al.* 2006, Bastian *et al.* 2008, Carevic 2011, Medrano-Vizcaíno 2019). Some examples are a Laughing falcon *Herpetotheres cachinnans* preying on a venomous Amazonian Pit viper *Bothrops atrox* (Medrano-Vizcaíno 2019) and a Burrowing owl *Athene cunicularia* (Molina 1782) preying on a cryptic lizard *Liolaemus occipitalis* (Zilio 2006), an aposematic snake *Phalotris mertensi* (Cruz *et al.* 2014), and a venomous Crossed Pit viper *Bothrops alternatus* (Martins *et al.* 2003). However, the successful predation on venomous snakes

involves strategies that enable the predator to survive, when faced with this type of prey, highlighting the relevance of efficient prey recognition and handling (Wall & Shine 2007, Parker *et al.* 2012).

The Burrowing owl is a small-sized and diurnal bird of prey associated with open habitats. It is found in human-modified areas, such as pastures and semi-urban areas, and is widely distributed in the Americas, occurring from southern Canada to southern Argentina and Chile (Sick 1997). It is a generalist and opportunistic predator that feeds mainly on invertebrates such as insects and small vertebrates, such as rodents (Motta-Junior 2006, Cadena-Ortiz *et al.* 2016, Holt *et al.* 2018). Amphibians and reptiles (Squamata) were also recorded in their diet, yet less frequently (Silva-Porto & Cerqueira 1990, Vieira & Teixeira 2008, Andrade *et al.* 2010). The differences on the ingestion of these prey may be influenced by the seasonal variation in the resource availability throughout the year. In Chile, insect consumption is higher during winter

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(May through September), while small reptiles and mammals are more frequently found in the diet during summer (October through April) (Carevic *et al.* 2013).

Despite the great variety in the Burrowing owls' diet (Motta-Junior 2006, Andrade *et al.* 2010, Cadena-Ortíz *et al.* 2016, Holt *et al.* 2018), few studies have been able to assign preyed items to species level. The lack of fine-scale taxonomic resolution for some prey species is because most studies are based on pellets analysis (Motta-Junior *et al.* 2015), and some prey types, such as soft-bodied or small animals, are quickly digested and are rarely identified in these pellets. This matter limits further conclusions on foraging strategies and prey selection, especially of potentially dangerous or concealed prey, such as some reptiles. We provide three new records of reptile predation by the Burrowing owls in the Brazilian 'Cerrado', a savanna-like biome, and a compilation of Squamata reptiles preyed by this bird in South America.

Field observations were performed in two sites (Parque Nacional de Brasília and Universidade de Brasília), in Distrito Federal, central Brazil. The records for the reptile species preyed by *A. cunicularia* were obtained from electronic scientific publications searched on Web of Science and Google Scholar. The combination of the terms "*Athene cunicularia*" or "Burrowing owl" plus "diet" or "predation" or "feeding" were used. We also searched for new records considering the reference list of the survey papers.

In the morning of February 16th, 2019, at Parque Nacional de Brasília, a tail of *Ophiodes* aff. *striatus* was found at the entrance of a Burrowing owl's hole (15°40'23.6"S, 47°56'56.5"W, WGS84), in an area surrounded by "cerrado" *sensu stricto* (Fig. 1A). On February 18th, 2019, in the same area, a specimen of *Oxyrhopus* cf. *trigeminus* was found with

its head missing at another Burrowing owl's hole, (Fig. 1B-C). On the morning of December 17th, 2020, at Universidade de Brasília (UnB), a juvenile Burrowing owl was observed preying a specimen of *Oxyrhopus rhombifer*, also with its head missing, near the parking lot of the Computer Science Department building (15°45'29.9"S, 47°52'08.5"W, datum WGS84). The owl was pecking lightly at the snake's body and eventually, when a piece of tissue was taken from the snake's body, it was immediately swallowed (Fig. 2B-D). These occasional records were made during a morning track trail in locations where owl holes are common. In all three cases, we noticed a movement in the owl's holes and when observing them more closely, we recorded the predations.

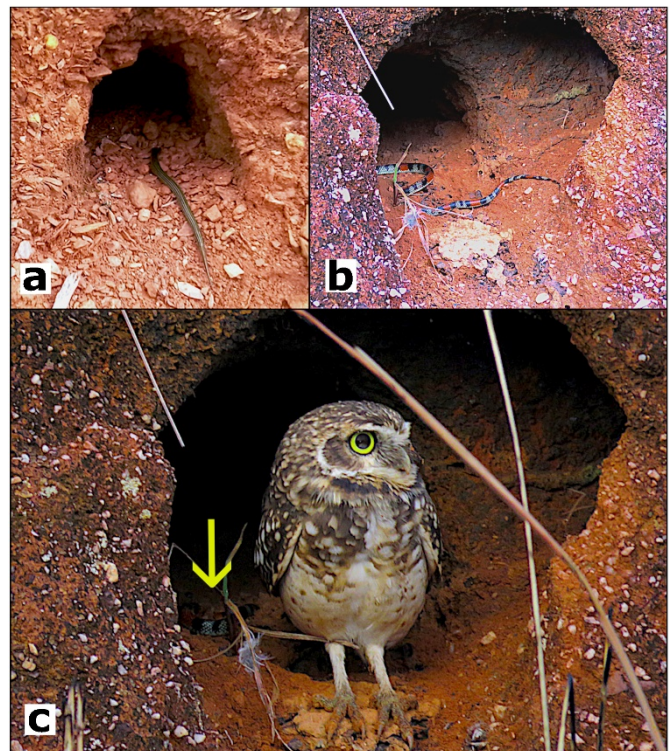


Figure 1. *Ophiodes* aff. *striatus* (A) and *Oxyrhopus* cf. *trigeminus* (B) preyed by *Athene cunicularia* (C) at Brasília National Park, Distrito Federal, Brazil. In detail, the Burrowing owl located at the front of the burrow, exhibiting the *Oxyrhopus* cf. *trigeminus* carcass behind it (C; below of yellow arrow). Photos: Mariana de-Carvalho (A-C).

In our literature review, we found publications from 1928 to 2020, covering almost 90 years of research. However, only 22 articles reported reptiles as part of the Burrowing owls' diet. We found

15 predation records in Brazil, being the country with the highest number of records, followed by Chile (eight), Argentina (four), Peru (three) and Ecuador (two). In total, 32 species (Squamata) were registered as prey, including our records. Lizards represented the most diverse species of prey (n = 21 species; 65,62%) distributed in nine families, followed by snakes (n = 10 species; 31,25%) in three families, and just one species (3,12%) of amphisbaenid (see Table 1). Considering only snakes (n = 10), 70% of the consumed species were aposematic Colubridae, whilst only 20% corresponded to venomous Viperidae species, in which all were from genus *Bothrops*.

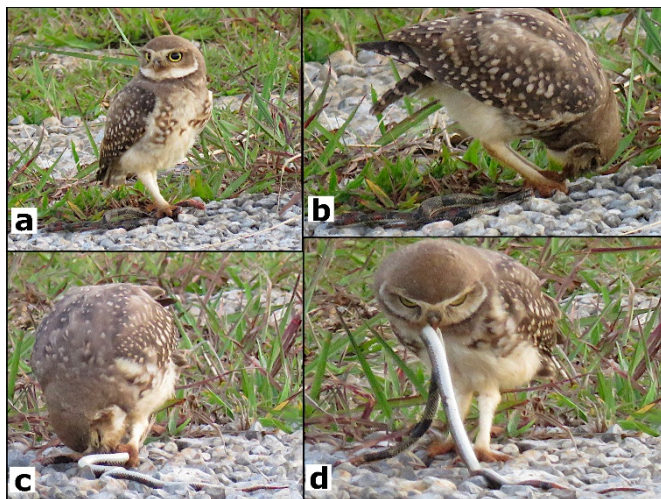


Figure 2. *Oxyrhopus rhombifer* being carried (A) preyed and pecked by juvenile of *Athene cunicularia* (B-D). Photos: Mariana de-Carvalho (A-D).

Lizards are the most abundant reptiles in most of the South American biomes (e.g., Almeida-Gomes *et al.* 2008, Waldez *et al.* 2013, Cavalcanti *et al.* 2014), which may explain the highest consumption of this type of prey. The main strategy employed by lizards to avoid aerial predators is camouflage by cryptic coloration (Pianka & Vitt 2003), (e.g., *Liolaemus occipitalis*, *Phyllodactylus gerrhopygus*, *Hemidactylus mabouia*, and *Enyalius* spp). Nevertheless, some visually oriented predators, such as birds, can still locate and prey on cryptic species, e.g., the Great tit *Parus major* that prey on cryptic larvae and pupae of Swallowtail butterfly (*Iphiclides*

podalirius) (Stefanescu 2000). The survival of cryptic prey is related with background and the ability to remain immobile in the presence of the predator (Loannou & Krause 2009). Also, small movements can be enough for visually oriented predators to detect their prey (Stefanescu 2000).

In order to deceive predators, some non-venomous snakes have evolved aposematic color patterns (Alcock 2011, Caro 2014), such as *Oxyrhopus* and *Phalotris* snakes, that resemble the venomous *Micrurus* spp., i.e., true coral snake (Bosque *et al.* 2018). For this reason, some birds that prey on snakes avoid any variation of the coral pattern, being an innate behavior that does not involve learning (Brodie & Janzen 1995). Yet, this aposematic coral-like pattern does not seem to mislead all predators, and differences in individual personality may also influence the consumption of these prey (Exnerová *et al.* 2010). For example, Burrowing owls have been registered preying on *Oxyrhopus rhombifer* (Sawaya *et al.* 2003), *Phalotris mertensi* (Cruz *et al.* 2014), and *Oxyrhopus* cf. *trigeminus* (present study), all species exhibiting coral-like patterns.

Despite the absence of a warning color, viperids are dangerous prey for birds due to their highly venomous toxin (Martins *et al.* 2002). Dangerous preys can cause injury to predators such as loss or broken talons, damage of the eyes and flight feathers (Mukherjee & Heithaus 2013), affecting its future predations. In all serpentiform predation records, considering our observations and the literature review, the Burrowing owls attack on reptiles' cephalic regions first, indicating that decapitation may be a common strategy for this kind of prey. Attacks on serpentiform prey to the head is a widespread hunting strategy within birds of prey (Niskanen & Mappes 2005) and seems to be effective against dangerous snakes (Parker *et al.* 2012). This behavior was seen in generalist predators like the

Burrowing owls (e.g., Martins *et al.* 2003) and in specialized predators such as the Laughing falcon *Herpetotheres cachinnans* (Medrano-Vizcaíno 2019). However, studies describing how predators seize and avoid being attacked by venomous preys are scarce, and records on these behaviors are important to understand predatory strategies and support further studies.

Our predation records are inedited (except for *O. rhombifer*; Sawaya *et al.* 2003) and add new information about the prey consumed by the Burrowing owl. Our findings reinforce that direct

observations on predation of Squamata reptiles by the Burrowing owl can provide additional data on its foraging behavior. We also encourage further studies with aposematic and camouflaged models to test differences in hunting strategies used for potentially dangerous and harmful prey. Finally, detecting the presence of reptiles in specific taxonomic categories (species or genus levels) in the diet of owls and other bird of prey will contribute to the understanding of its ecological importance and predator-prey relationships.

Table 1. Reptiles preyed by *Athene cunicularia* in South America.

Group	Family	Species	Pattern	Source
Lizards				
	Anguidae			
		<i>Ophiodes</i> sp.	Cryptic	Bastian <i>et al.</i> (2008),Vieira & Teixeira (2008)
		<i>Ophiodes</i> aff. <i>striatus</i>	Cryptic	present study
	Gekkonidae			
		<i>Hemidactylus mabouia</i>	Cryptic	Silva-Porto & Cerqueira (1990)
	Iguanidae		Undetermined	Soares <i>et al.</i> (1992), Santos <i>et al.</i> (2017)
	Liolaemidae			
		<i>Liolaemini</i>	Undetermined	Andrade <i>et al.</i> (2004)
		<i>Liolaemus fuscus</i>	Cryptic	Schlatter <i>et al.</i> (1980)
		<i>Liolaemus nitidus</i>	Cryptic	Torres-Contreras <i>et al.</i> (1994)
		<i>Liolaemus occipitalis</i>	Cryptic	Zilio (2006)
		<i>Liolaemus</i> spp.	Undetermined	Torres-Contreras <i>et al.</i> (1994), Cruz-Jofré & Vilina (2014)
	Leiosauridae		Undetermined	Andrade <i>et al.</i> (2004)
	Phyllodactylidae			
		<i>Phyllodactylus gerrhopygus</i>	Cryptic	Carevic (2011)
		<i>Phyllodactylus</i> sp.	Undetermined	Medina <i>et al.</i> (2014)
	Mabuyidae			
		" <i>Mabuya</i> " sp.	Cryptic	Vieira & Teixeira (2008), Silva-Porto & Cerqueira (1990)
	Teiidae			
		<i>Ameiva ameiva</i>	Cryptic	Otero (2019)
		<i>Callopistes maculatus</i>	Cryptic	Torres-Contreras <i>et al.</i> (1994)
		<i>Callopistes palluma</i>	Cryptic	Faúndez <i>et al.</i> (2018)
		<i>Teius oculatus</i>	Cryptic	Solaro <i>et al.</i> (2012)
	Tropiduridae			
		<i>Microlophus koepckeorum</i>	Cryptic	Medina <i>et al.</i> (2014)
		<i>Microlophus occipitalis</i>	Cryptic	Medina <i>et al.</i> (2014)
		<i>Stenocercus guentheri</i>	Cryptic	Cadena-Ortíz <i>et al.</i> (2016)
		<i>Stenocercus rhodomelas</i>	Cryptic	Cadena-Ortíz <i>et al.</i> (2016)
Snakes				
	Colubridae			
		<i>Chironius</i> sp.	Undetermined	Vieira & Teixeira (2008)

Group	Family	Species	Pattern	Source
		<i>Erythrolamprus poecilogyrus</i>	Undetermined	Aravena (1928)
		<i>Oxyrhopus rhombifer</i>	Aposematic	Sawaya <i>et al.</i> (2003) and present study
		<i>Oxyrhopus cf. trigeminus</i>	Aposematic	present study
		<i>Phalotris mertensi</i>	Aposematic	Cruz <i>et al.</i> (2014)
		<i>Philodryas chamissonis</i>	Cryptic	Torres-Contreras <i>et al.</i> (1994)
		<i>Philodryas patagoniensis</i>	Cryptic	Vieira & Teixeira (2008)
	Leptotyphlopidae			
		<i>Trilepida</i> sp.	Cryptic	Cláudio <i>et al.</i> (2017)
	Viperidae			
		<i>Bothrops alternatus</i>	Cryptic	Martins <i>et al.</i> (2003)
		<i>Bothrops pauloensis</i>	Cryptic	Valdujo & Nogueira (2000)
Amphisbaena				
	Amphisbaenidae			
		<i>Amphisbaena vermicularis</i>	Undetermined	Nolasco <i>et al.</i> (2020)

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