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HIGH FREQUENCY OF BATS IN THE DIET OF THE BARN OWL *TYTO ALBA* IN A LOWLAND DRY FOREST IN TOLIMA, COLOMBIA

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Abstract · The cosmopolitan distribution of the Barn Owl *Tyto alba* and its relatively well documented diet through the study of pellets have provided evidence of the broad diversity of prey it relies on. In most studies, both in tropical and temperate regions, rodents are its main prey, with other small mammals and vertebrates, and insects complementing its diet. Although bats have been recorded in the diet of *T. alba* at many localities, they seldom represent an important part of its diet. This study describes the diet of a small colony of *T. alba* from a mosaic of agricultural fields, pastures for cattle ranching and tropical dry forests in Tolima, central Colombia. Overall, we collected 516 pellets between 2016 and 2017 in a non-systematic manner, and recovered 335 skulls of rodents (67%), bats (29%), birds (3%) and shrews (1%), as well as invertebrate prey. The large proportion of bats in the diet of *T. alba* in this study is only matched by a few other studies, and further documents the wide range of prey included in the diet of this nocturnal raptor. This is one of the first studies on the diet of *T. alba* in tropical dry forests in Colombia and complements the existing data on its diet in the American tropics and worldwide.

Resumen · Alta frecuencia de murciélagos en la dieta de la lechuza de campanario *Tyto alba* en un bosque seco tropical de Tolima, Colombia

La distribución cosmopolita de la lechuza de campanario *Tyto alba* y la extensa documentación sobre su dieta a partir del estudio de los contenidos de egagrópilas han evidenciado la amplia variedad de su dieta. En la mayoría de estudios tróficos en zonas tropicales y temperadas de *T. alba*, los roedores son las presas más abundantes. Aunque en algunos estudios se ha reportado que también consumen murciélagos, por lo general estos constituyen una parte poco representativa de su dieta. En este estudio reportamos la dieta de *T. alba* en un mosaico de zonas agrícolas, pastizales para ganadería y remanentes de bosque seco tropical en Tolima, Colombia. A partir de 516 egagrópilas recolectadas de forma no sistemática entre 2016 y 2017, obtuvimos 335 cráneos de roedores (67%), murciélagos (29%), aves (3%) y musarañas (1%), así como invertebrados. La amplia representación de murciélagos en la dieta de *T. alba* en este estudio es comparable con otros pocos estudios en Centro y Suramérica, y apoya la noción que este depredador nocturno tienen una dieta que incluye una gran diversidad de presas. Este estudio de la dieta de *T. alba* es uno de los primeros en los bosques secos en Colombia y complementa la información existente sobre su dieta en los trópicos americanos y en el resto del planeta.

Key words: *Agroecosystems · foraging · pellets · predation · Tytonidae*

INTRODUCTION

The Barn Owl *Tyto alba* is a nocturnal predator distributed all over the world, except for Antarctica. The American populations are often treated as a separate species, *T. furcata* (Uva et al. 2018). *Tyto alba* has been widely researched, and a large number of studies have focused on describing its diet (Roulin & Christe 2013). Many studies, including several in tropical dry forests of South America, have provided a list of prey items and documented the relative frequency of prey in *T. alba*'s diet (Gómez et al. 2012, Cadena-Ortiz et al. 2019), while some others have further contributed to describe seasonal patterns of variation in its diet (González-Fischer et al. 2011, Moysi et al. 2018) and to quantify the effect this nocturnal raptor might play in controlling rodent and other small mammal populations (Kross et al. 2016).

Overall, bats are a relatively infrequent prey in owls' diets. In a recent review about owl depredation on bats in Europe, Sieradzki and Mikkola (2020) estimated average bat representation in the diet of eight owl species to range between 0.01%–0.12%. Nonetheless, a few studies have found that bats are frequent prey in the diet of some Neotropical owl species, including Stygian Owl *Asio stygius*, Spectacled Owl *Pulsatrix perspicillata*, Mottled Owl *Ciccaba virgata* and *T. alba* (Ibañez et al. 1992, Gerhardt et al. 1994, Motta-Junior 2006, Sommer et al. 2009, Restrepo-Cardona et al. 2018, Brown 2020). In a meta-analysis based on more than 800 studies on the diet of *T. alba* and more than 4 million prey, Roulin & Christe (2013) estimated bats represented, on average, 12 out of every 1000 (1.2%) individual prey. In South America, few studies have recorded bats in *T. alba's* diet, and for

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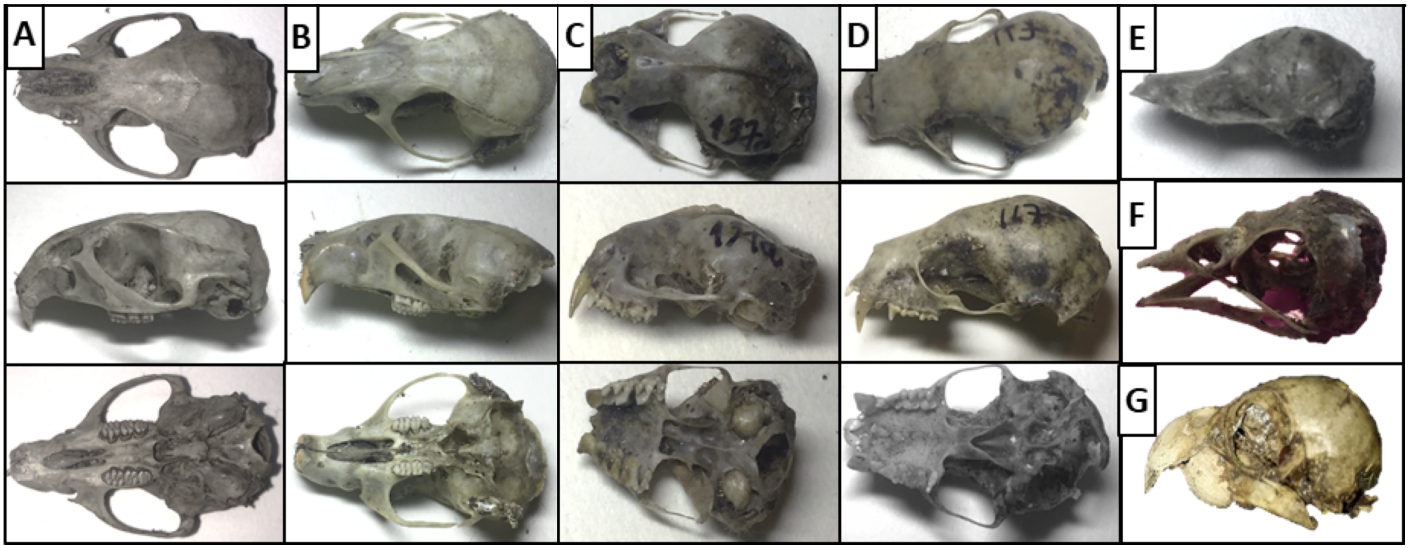

Figure 1. Skulls obtained from the pellets of Barn Owl Tyto alba at Doima: (A) Sigmodon hispidus, (B) Zygodontomis brevicauda, (C) Molossus sp., (D) Phyllostomus bicolor, (F) Molothrus bonariensis, (G) Brotogeris jugularis.

those that include bats, they represent only a small proportion of prey (De Groot 1983, Delgado & Calderón 2007, González-Fischer et al. 2011, Hernández-Muñoz & Mancina 2011).

In Colombia, *T. alba* is often found in open habitats and in urban areas and their surroundings (Hilty & Brown 1986). Its diet is quite ample, and varies depending on the region where it is found, as well as on seasonal patterns of prey availability (Cerpa & Yáñez 1981). In Colombia, studies on *T. alba* diet have found rodents, marsupials, amphibians, and rarely bats and birds as prey (Delgado & Calderón 2007, Delgado & Ramírez 2009, Restrepo-Cardona et al. 2018). Studies conducted in Chile and Argentina reported scarce (if any) evidence of bats in the diet of *T. alba* (Cerpa & Yáñez 1981, Aragón et al. 2002, Gómez et al. 2012). Here, based on owl pellets, we describe for the first time the diet of *T. alba* in a degraded tropical dry forest and surrounding areas in central Colombia.

METHODS

Pellets were collected from several nests and from the floor inside a single old and abandoned tower, where up to four breeding pairs of *T. alba* (and their nestlings) were simultaneously observed at Hacienda El Aceituno in Doima, Tolima (4°21'10.3''N, 74°59'37.92''W, 700 m a.s.l.), between the eastern and central Andean Cordilleras in central Colombia. The landscape is characterized by a matrix of extensive rice fields, pastures for livestock and some remnants of tropical dry forests. Pellet collection took place between 2016 and 2017 with four sampling visits. We attempted to minimize disturbance to the nests by collecting pellets that were not close to the nests and nestlings, minimizing noise and making short pellet collection visits. During each visit, pellets were picked up directly from the floor and below active nests. Collection of pellets was opportunistic, as we collected new and old pellets during each of the four visits, and mixed all pellets prior to their inspection, limiting our ability to evaluate seasonal differences in diet. Every pellet collected throughout the study was individually disintegrated and cleaned with water to separate the bones from the dirt and organic matter (fur and feathers), following methods described in Delgado & Calderón (2007). Skulls and mandibles were separated from the bones in each pellet and kept in small marked Ziplock bags. Only skulls were considered individual samples and used to estimate the relative frequency of prey items. Postcranial elements as well as invertebrate remains were discarded and not used in this study.

Each skull was identified to the lowest taxonomic category possible; in case of skulls covered by dirt that prevented us to conduct dental examination, we submerged the sample in alcohol for at least 10 min and used a toothbrush or tweezers to further clean it. We compared each specimen to taxonomic descriptions found in the South American Bat Identification key and in South American Mammals (Volume I & II) (Díaz et al. 2016, Patton et al. 2015, Gardner 2007), and more specific publications on rodent taxonomy (Anderson 1999, Weksler 2006). Also, direct comparison between field specimens and museum vouchers held at Colección Mastozoológica of Museo de Historia Natural de la Universidad Distrital Francisco José de Caldas in Bogotá was done to confirm the identification of prey remains to corresponding families or genera. Specimens included in this study are held at Universidad de Los Andes' Museum of Natural History JC Marinkelle and can be made available upon request.

RESULTS

Overall, we were able to recover 335 vertebrate skulls out of 516 pellets retrieved from the ground below *T. alba* nests at the Hacienda Aceituno (Figure 1). Rodents were the most frequent prey, accounting for 67% of prey (N = 224 skulls), which belonged to at least nine rodent genera (Table 1, Figure 2). Cane mice *Zygodontomys* sp. were the most frequent prey, accounting for c. 38% of prey, while common mice *Mus musculus* and cotton rats *Sigmodon* sp. were also frequent prey, accounting for 13% and 4.2% respectively (Table 1). Skulls from the spiny pocket mouse *Heteromys anomalus* and from genera such as *Oecomys*, *Necromys*, *Microryzomys,* and *Proechimys* were found less frequently (< 10 individuals/skull-species). Based on the geographical distribution of rodents (Solari et al. 2013), we assigned rodents from the genus *Zygodontomy*s, *Sigmodon,* and *Mycroryzomys* to *Z. brevicauda*, *S. hispidus,* and *M. minutus*, but further morphological ana-

Table 1. Prey items consumed by the Barn Owl Tyto alba in Doima, Tolima, Colombia.

Prey item				Number of Individuals	Percentage of inviduals (%)	Weight (g)	Total Biomass (%) (g)
Class	**Order**	**Family**	**Scientific name**				
MAMMALIA	 **Rodentia**	Cricetidae	*Zygodontomys* sp.	127	39.1	62	7874 (60.1)
			Sigmodon sp.	14	4.3	87	1218 (9.4)
			Necromys sp.	8	2.5	26	208 (1.6)
			Microryzomys minutus	5	1.5	16	80 (0.6)
			Microryzomys sp.	2	0.6	16	32 (0.2)
			Oecomys sp.	1	0.3	38	38 (0.3)
		Echimyidae	*Proechyimys* sp.	1	0.3	60	60 (0.5)
		Muridae	*Mus musculus*	42	12.9	20	840 (6.5)
		Heteromyidae	*Heteromys anomalus*	7	2.2	59	413 (3.2)
			Heteromys sp.	2	0.6	59	118 (0.9)
			Unidentified	15	4.6	N.A.	
		Total rodents		**224**			**10881 (84.2)**
	 **Chiroptera**	Vespertilionidae	*Myotis* sp.	16	4.0	5	80 (0.6)
			Myotis riparius	4	1.2	5	20 (0.2)
		Molossidae	*Molossus* sp.	26	8.0	14	364 (2.8)
		Phyllostomidae	*Artibeus jaimaicensis*	20	6.2	44	880 (6.8)
			Artibeus literatus	1	0.3	65	65 (0.5)
			Dermanura sp.	4	1.2	12	48 (0.4)
			Phyllostomus sp.	2	0.6	84	168 (1.3)
			Phyllostomus hastatus	1	0.3	84	84 (0.7)
		Unidentified		14	4.3	N.A.	
		Total bats		**88**			**1709 (13.2)**
	 **Soricomorpha**	*Soricidae*	*Cryptotis* sp.	3	0.9	6	18 (0.1)
	Total mammalian preys			**315**			**12608 (97.6)**
 **AVES**	**Psittaciformes**	Psittacidae	*Brotogeris jugularis*	2	0.6	59	118 (0.9)
	Columbiformes	Columbidae	*Columbina talpacoti*	1	0.3	43	43 (0.3)
	Passeriformes	Icteridae	*Molothrus bonariensis*	2	0.6	35	70 (0.5)
		Thraupidae	*Tiaris bicolor*	1	0.3	10	10 (0.1)
			Sporophila sp.	1	0.3	15	15 (0.1)
		Tyrannidae	*Megarynchus pitangua*	1	0.3	56	56 (0.4)
		Unidentified		2	0.6	N.A.	
	Total avian preys			**10**			**312 (2.4)**
Total				**325**	**100**		**12920 (100)**

lyzes are needed to confirm these identifications. Fifteen rodent skulls could not be identified due to damage.

Bats were the second more frequent prey, representing 29% (N = 98 skulls) of the vertebrate diet of *T. alba*. Bat prey included at least nine different species and at least five different genera (Table 1). *Molossus* was the most frequent genus, accounting for 7.8% of all prey, followed by Neotropical fruit bats *Artibeus* spp. and Moused-eared bats *Myotis* spp., which accounted each c. 6% of the diet. Spear-nosed bats *Phyllostomus* sp. and other leaf-nosed bats *Dermanura* sp. were occasionally represented, and 14 bat skulls could not be identified due to their fragmentary condition. Finally, birds and shrews represented only 3% and 1% of *T. alba*'s diet, respectively (Table 1). As noted above, invertebrate prey were not included in this study. Regarding biomass intake, rodents and bats represented an estimated of 84.2% and 13.2% of *T. alba's* diet, respectively (Table 1).

DISCUSSION

Contrary to most studies on *T. alba*'s diet in South America and worldwide, bats were an important prey in our study area within the heavily degraded dry tropical forests of Doima. The high frequency of bats we found in *T. alba*'s diet (29% of total prey consumed) may be partially explained by the gregarious habits of several Molossidae and Phyllostomidae bat species that can inhabit intervened forests and abandoned human constructions (Williams & Genoways 2007, Hernández-Muñoz & Mancina 2011, Brito et al. 2018). The nesting site of *T. alba* at Hacienda El Aceituno is an enormous building with several abandoned rooms and a four-story tower where hundreds of bats roost. Also, the >4000 ha of adjacent rice crops may hold a large insect biomass that may support large bat populations (Puig-Monserrat et al. 2015, Bhalla et al. 2023). Additionally, bats from the genus *Myotis* are usually found in forested areas (Brito et al. 2018), as those adjacent to *T. alba* nesting sites in Doima, and could represent locally abundant prey for barn owls. Nonetheless, we point out that factors influencing the high representation of bats in the diet of barn owls in this study remains to be fully understood.

Consumption of bats by *T. alba* is considered relatively infrequent worldwide, especially in latitudes where bat diversity is low (Vargas et al. 2002, Hernández-Muñoz & Mancina 2011, Roulin & Christe 2013). On the contrary, there is a relatively high bat diversity and abundance in tropical forests (Vargas et al. 2002, Gardner 2007), making it plausible that bats could be important prey items for predators like *T. alba* (Gerhardt et al. 1994). Considering that bats are a difficult prey to catch, *T. alba* possibly hunt them when they fly out of their diurnal hides, roosts, or breeding spots (Sommer et al. 2009), especially in gregarious taxa like *Artibeus* species (Hernández-Muñoz & Mancina 2011). Yet, only a handful of studies in Central and South America have found a relatively high proportion of bats in the diet of *T. alba* (25% to 83% in urban areas of Argentina, Romano et al. 2002; 51% in Bolivia, Vargas et al. 2002). There are records of bat consumption in other studies in the American tropics, where they represent only a minor proportion (<5%) of *T. alba*'s diet (Delgado & Cataño 2004, Escarlate-Tavares & Pessôa 2005, Delgado & Calderón 2007, Hernández-Muñoz & Mancina 2011). For northern South America, this study is the first evidence of bats representing an important part of the diet of *T. alba*.

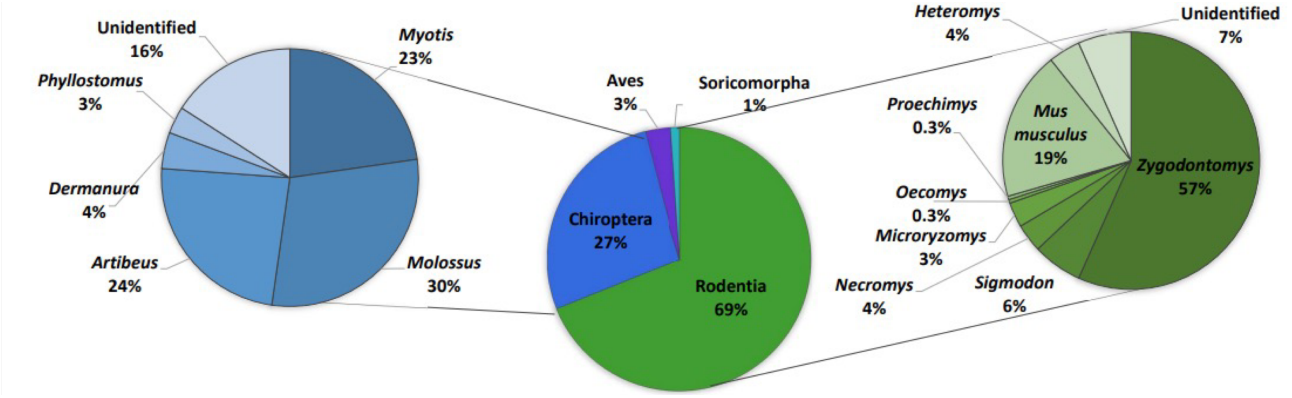

Figure 2. Prey items, grouped by class, genus and species if identified, consumed by Barn Owl *Tyto alba* during approximately one year at a dry tropical forest in Doima, Tolima, Colombia. The study included pellets collected in a building with 1–4 breeding pairs.

As in most studies on *T. alba*'s diet, rodents were their main prey (Roulin & Christe 2013 and references therein). The frequency of cane mouse and house mouse in our study area might be influenced by the proximity of the nesting site to extensive rice fields. These rodents have nocturnal habits, are terrestrial, and are often found in open savannas, bushes and agricultural regions, as well as associated to intervened areas such as human settlements (Voss 1991, 1992, Brito et al. 2018). High consumption of *Oligoryzomys*, *Microryzomys*, and *Sigmodon* sp. by *T. alba* has been previously recorded (Delgado & Cataño 2004, Delgado & Ramírez 2009, Brito et al. 2018).

In studies in the Caribbean islands, birds can represent up to 17% of *T. alba*'s diet (Buden 1974, Johnston 1974, Johnston & Hill 1987), but this may be due to the low density of rodent and bat populations compared to continental areas (Hernández-Muñoz & Mancina 2011). The low frequency of birds in the diet of *T. alba* in this study can be related with the preference of consumption towards other organisms that can be more easily hunted since they also have a nocturnal ecology. Only three shrew skulls were found in this study, which are usually a common item reported by other authors (Restrepo-Cardona et al. 2018, Escarlate-Tavares & Pessôa 2005). The low consumption of shrews could be explained by their potential low availability in our study site, although this needs to be studied further.

This study documents a high diversity of prey items in a small colony of *T. alba* living in a human-modified matrix of rice fields, abandoned human buildings, pastures for cattle ranching, and tropical dry forest patches, and further complements our understanding of its diet in the relatively understudied but heavily degraded landscapes of central Colombia. We note that the diet of *T. alba* in this study does not represent the species' diet throughout its geographical distribution, as it may well respond to the immediate ecological conditions surrounding the nesting site at Doima. Future studies focused on the temporal and spatial variation of *T. alba*'s diet in this geographical region may further contribute to our understanding of the species' feeding ecology, as well as its potential role on controlling rodent and other small mammal populations in landscapes dominated by people.

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