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Natural history

Frugivory of bats in a threatened semiarid region in southeastern Brazil

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Resumen

Los murciélagos frugívoros tienen una alta capacidad de dispersión de semillas contribuyendo al establecimiento de numerosas especies vegetales. Aquí, examinamos la dieta frugívora de los murciélagos filostómidos en el Parque Nacional Cavernas do Peruaçu, al norte de Minas Gerais, Brazil, una región de ecotonos de los biomas de Caatinga y Cerrado. Realizamos cuatro expediciones entre diciembre de 2008 y noviembre de 2009, totalizando 80 noches de muestreo, para recolectar datos y heces de murciélagos capturados. *Artibeus planirostris* y *Carollia perspicillata* proporcionaron el mayor número de muestras fecales. Se registraron cuatro familias de plantas, el mayor número para Cecropiaceae, seguida de Solanaceae; Piperaceae y Moraceae.

Palabras clave: Caatinga, Chiroptera, Dispersión de semillas, frutos.

Abstract

Fruit bats have a high seed dispersal capacity contributing to the establishment of numerous plant species. In this work we examined the frugivorous diet of phyllostomid bats in the Cavernas do Peruaçu National Park, north of Minas Gerais, Brazil, an ecotone region of Caatinga and Cerrado biomes. Four expeditions were carried out between December 2008 and November 2009, totalling 80 nights of sampling, to collect data and feces from captured bats. The highest number of fecal samples were provided by *Artibeus planirostris* and *Carollia perspicillata*. Four plant families were registered, the largest number for Cecropiaceae, followed by Solanaceae; Piperaceae, and Moraceae.

Key words: Caatinga, Chiroptera, fruits, Seed dispersal.

Frugivory and seed dispersal by animals are vital ecological processes for forest dynamics and ecosystem functioning, with significant implications for habitat maintenance and restoration. In tropical regions, approximately 75 to 90% of tree species depend on animals to disperse their seeds, mammals and birds being the main seed dispersers of plants with fleshy fruits (Lobova et al. 2009; Jacomassa & Pizo 2010; Bello et al. 2017). Among mammals, bats have some characteristics that make up a key group in seed dispersal, such as, they can defecate during the flight, cross agricultural matrices and degraded areas, perform long night flights, and feed mainly on pioneer species or on those in initial successional stages, profoundly influencing the forest dynamics (Peña-Domene et al. 2014; Regolin et al. 2021). In Brazil, few studies focusing on the bat-fruit interaction were conducted in the region known as the "Dry diagonal of South America", which contains the biomes Cerrado, Caatinga and Pantanal. This region is characterized by prolonged droughts that have promoted the development of an odd biota, adapted to these climate conditions (Furley & Metcalf 2007). Also, in Brazil, the advance of agricultural frontiers in areas of Cerrado and Caatinga in the last 50 years has resulted in the reduction of 50 to 60% of native areas (Pires 2020). Therefore, the understanding of plant-bat relationships is necessary for a better comprehension of how bats can influence the dynamics of a rapidly changing biota. To address this knowledge gap, we collected data on bat-fruit interactions in the Cavernas do Peruaçu National Park (CPNP), inserted in a semi-arid region of Brazil (Lombardi et al. 2005) and known as a high profile research and conservational area (Biodiversitas 2005).

CPNP is located in the state of Minas Gerais (coordinates 14º54'-15º15'S and 44º03'-44º22'W), inserted in an ecotone between Cerrado and Caatinga (Figure 1). The region presents different physiognomies, such as carrasco (deciduous shrubby vegetation), plants occurring on calcareous outcrops (xerophytic vegetation and karst vegetation exposed to the sun or shaded by the trees of the surrounding deciduous forest), riparian forest, and veredas (riparian vegetation consisting of *buriti* palm trees and *pindaíba* shrubs) (Lombardi et al. 2005). The climate is classified as Aw, according to the Köppen scale, with average temperatures around 24° C and an annual range of 16° C to 34° C. October and November are the warmest months, while June and July are the coldest ones. The average annual rainfall is 832.4 mm, of which January average is 183 mm, and July only 1 mm (Brandão & Magalhães 1991). Four expeditions were carried out between December 2008 and November 2009, totaling 80 nights of sampling. To compare phytophysiognomies, we divided the vegetal formation into two groups according to their general structure: 1 - "Forest" group that includes semi-decidual, tropical dry, and riparian forests, and 2 - "Cerrado" group that consists of the open vegetal formations: cerrado *s.s.*, carrasco, and hyperxerophic formation. Ten nights of sampling were dedicated to each group, Forest and Cerrado, by expedition.

Mist nets were used to collect bats with an effort of 237,571 m²/h. The identifications were carried out with the keys of Gardner (2007) and Reis et al. (2007), and the nomenclature used followed Simmons (2005) and Garbino et al. (2020). We measured with a caliper and weighed with the aid of balance. We packed the bats in cotton bags for defecation, and subsequently, we released them at the same place of capture. The feces were collected in absorbent paper envelopes and later dissolved in distilled water to separate the seeds. At the laboratory, the seeds were identified according to the available bibliography (Lobova et al. 2009), and with the assistance of the Forest Seed Sector of the Department of Forest Sciences at the Federal University of Lavras. Bat captures were permitted by Federal Licence ICMBio process 14875-2.

To verify the differences in the consumption of food items by bats, between the rainy and dry seasons and the phytophysiognomies, a permutational multivariate analysis of variance was used (PERMANOVA, by the Bray-Curtis index with 9999 random permutations)

(Anderson 2001), and to determine which items had the greatest contribution to dissimilarity, the SIMPER test (percentage of similarity) was employed. The analyses were performed using the statistical program PAST version 4.03 (Hammer et al. 2001).

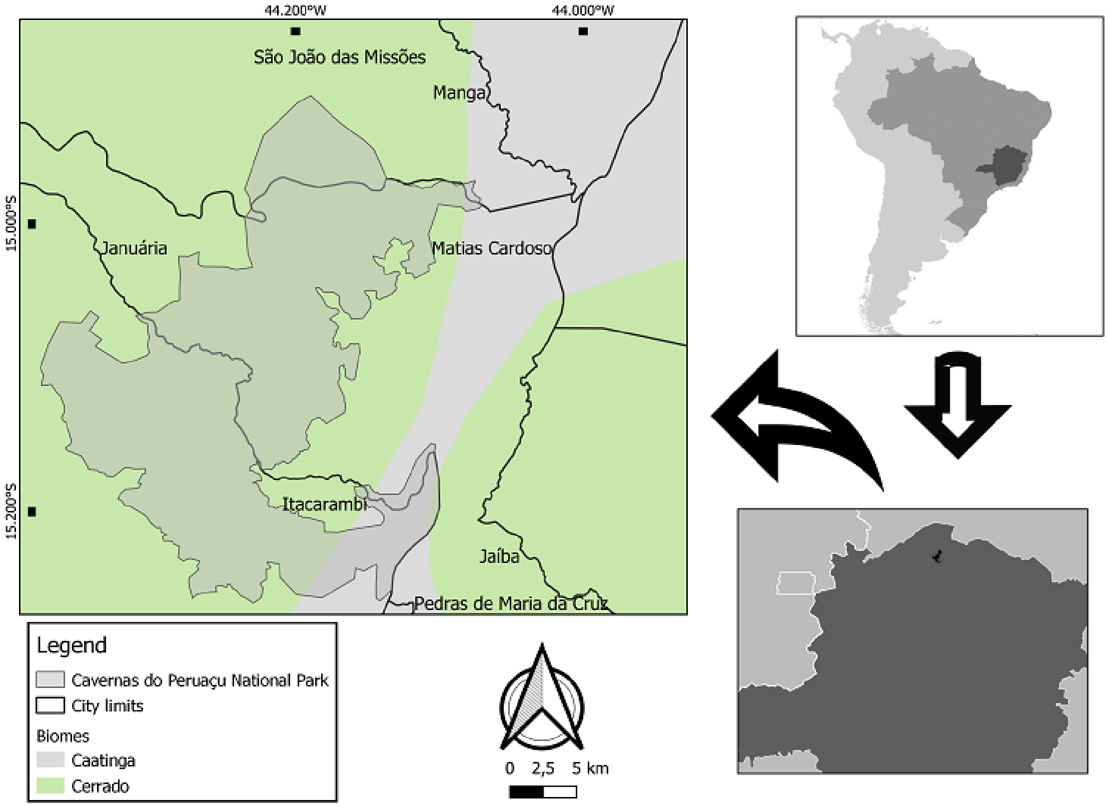

Figure 1. Location of Cavernas do Peruaçu National Park in the northern region of Minas Gerais, Brazil.

We collected 80 fecal samples of 10 species of plants from seven species of bats (Table 1), from a total of 749 individuals. 60 samples contained seeds and 20 had only pulp. We were able to identify, at the species or genus level, 24 bat-fruit interactions. Of the 60 seed-containing samples, 76.6% belonged only to two bat species, *Artibeus planirostris* and *Carollia perspicillata*. Regarding the plants, *Cecropia saxatilis* was the most consumed with seeds found in 21 samples, followed by *Piper amalago* and *Solanum paniculatum*, found in nine and eight samples, respectively. The PERMANOVA analyses showed that there were no differences between the dry and rainy seasons ($F = 2.19$, $p = 0.0713$), and there were also no significant differences between the phytophysiognomies ($F = 1.55$, $p = 0.1501$). The SIMPER analysis showed the pulp had the greatest contribution (33.34%), followed by *Cecropia saxatilis* (23.68%), and Solanum sp. 03 (10.56%) (Table 2). This result is in connection with the find that the pulp and *Cecropia saxatilis* were more frequent in the samples during the rainy season, while Solanum sp. 03 was more consumed during the dry season. *Artibeus planirostris* and *Carollia perspicillata* interacted with a greater diversity of fruits.

Our results are in agreement with data already known about the Neotropical bat diet, which describes a preference of certain bat genera for fruits of specific plants, *Carollia* prefers *Piper*, *Sturnira* prefers *Solanum*, and *Artibeus* prefers *Ficus* and *Cecropia* (Andrade et al. 2013). Despite the preference for Piper fruits, we recorded a high consumption of Solanum fruits by *Carollia perspicillata*. As the same result was found in other studies, it is possible to infer that bats can alternate their diet according to the local availability of fruits. The dispersion of pioneer plants such as *Solanum*, *Cecropia,* and *Ficus*, shows the importance of bats in the succession processes in different environments (Garcia et al. 2000; Muller & Reis 1992). The PERMANOVA results did not indicate differences in the seasonal analyses, but it is important to highlight that other studies revealed higher consumption in rainy periods, when food supply sources greatly increase, especially of Piperaceae species (Passos et al. 2003; Mello et al. 2004)

TABLE 1. Number of samples and frequency of occurrence (%) of food items present in the diet of frugivorous bats in the CPNP.

Items Consumed\Bats	*Artibeus lituratus*	*Artibeus planirostris*	*Carollia perspicilatta*	*Chiroderma villosum*	*Glossophaga soricina*	*Phyllostomus hastatus*	*Platyrrhinus lineatus*	*Sturnira lilium*	*Vampyressa pussilla*
MORACEAE									
Ficus obtusifolia	1 (10%)	1 (3,4%)							
Ficus sp. 01		2 (6,6%)							
Ficus sp. 02	1 (10%)	1 (3,4%)							
Subtotal	2 (20%)	4 (13,4%)							
PIPERACEAE									
Piper amalago		3 (10%)	6 (24%)						
Piper sp. 1		1 (3,4%)	2 (8%)						
Subtotal		4 (13,4%)	8 (32%)						
SOLANACEAE									
Solanum paniculatum		3 (10%)	4 (16%)		1 (25%)				
Solanum sp. 01			2 (8%)						
Solanum sp. 02		3 (10%)	3 (12%)				1 (14,2%)		
Solanum sp. 03	1 (10%)	1 (3,4%)					1 (14,2%)	1 (100%)	
Subtotal	1 (10%)	7 (23,4%)	9 (36%)		1 (25%)		2 (28,4%)	1 (100%)	
URTICACEAE									
Cecropia glaziovii	5 (50%)	10 (33,3%)	4 (16%)				1 (14,2%)		1 (100%)
Subtotal	5 (50%)	10 (33,3%)	4 (16%)				1 (14,2%)		1 (100%)
Unidentified pulp	2 (20%)	5 (16,5%)	4 (16%)	1 (100%)	2 (75%)	2 (100%)	4 (57,4%)		
Total samples	10 (100%)	30 (100%)	25 (100%)	1 (100%)	3 (100%)	2 (100%)	7 (100%)	1 (100%)	1 (100%)

We found that the richness of fruits consumed by bats was greater than that found in anthropized areas of Cerrado (Martins et al. 2014; Torres et al. 2018), but it was lower than that recorded in preserved areas of the Atlantic Forest (Laurindo et al. 2018). Those results were expected because warmer and humid tropical areas usually present a greater diversity of fleshy fruits (Chen et al. 2017). We noted that 25% of the samples contained only fruit pulp because several species of frugivorous bats consume fruits that have large seeds, which are not ingested (Melo et al. 2009; Laurindo & Vizentin-Bugoni 2020). Hence, it is important to emphasize that this type of sampling probably underestimates the resources consumed by bats, since they can consume and disperse fruits with large seeds that will not pass through their digestive tract. This shows that complementary sampling techniques to assess the diversity of fruits consumed by bats should be employed (Laurindo & Vizentin-Bugoni 2020).

TABLE 2: SIMPER analysis (Bray-Curtis) regarding the dissimilarity of consumed items. Av.dissim = dissimilarity value; Contrib.%= item's contribution to dissimilarity.

Item	Av. dissim	Contrib.%	Cumulative%	Mean Dry	Mean Rain
Polpa	27,91	33,34	33,34	0,667	1,56
Cecropia saxatilis	19,83	23,68	57,02	0,556	1,78
Solanum sp. 03	8,843	10,56	67,58	0,111	0,333
Solanum paniculatum	6,342	7,574	75,16	0,333	0,556
Piper amalago	5,614	6,705	81,86	0,556	0,44
Solanum sp. 02	5,29	6,331	88,35	0,111	0,667
Ficus obtusifolia	3,164	3,786	92,14	0,222	0
Piper sp. 01	1,987	2,357	94,5	0,222	0,111
Ficus sp. 02	1,622	1,941	96,44	0	0,222
Ficus sp. 01	1,489	1,781	98,22	0,222	0
Solanum sp. 01	1,489	1,781	100	0,222	0

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