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## Bats (Chiroptera, Phyllostomidae) in the urbanized area in South of Brazil

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**ABSTRACT.** The present study aimed to inventory of bats species present in an urban area, located within the main campus of the State University of Maringá, northwestern Paraná State, and to present data on the diet, reproduction, and activity times of the captured species. Collections were performed monthly, between September 2007 and August 2008, and 377 individuals were captured, belonging to four species from the Phyllostomidae family: *Artibeus lituratus* (90%), *Platyrrhinus lineatus* (6.4%), *Sturnira lilium* (2.4%), and *Carollia perspicillata* (1.3%). The types of fruit ingested consisted especially of Cecropiaceae, Moraceae, Myrtaceae, Piperaceae and Solanaceae. Among the captured exemplars, 51% were female and 49% male. No pregnant females of *A. lituratus* or males with descended testicles were captured in autumn, and the largest recorded numbers of these groups were verified in winter. With regard to lactating females, *A. lituratus* was sampled year-round, with predominance during the warmer season. In spite of the low species diversity, the campus area is used by frugivore species that are generalists and are able to feed and reproduce in urbanized areas. In order to increase that diversity, management programs should be implemented so that urbanization and Chiroptera diversity can coexist with lower risks and losses to ecosystems.

**Keywords:** diversity, capture time, diet, reproduction.

## Morcegos (Chiroptera, Phyllostomidae) em áreas urbanizadas no sul do Brasil

**RESUMO.** O presente estudo inventariou espécies de morcegos ocorrentes numa área urbana, localizada no interior do campus-sede da Universidade Estadual de Maringá, Noroeste do Paraná, apresentando informações sobre a dieta, reprodução e o horário de atividades das espécies capturadas. As coletas foram realizadas mensalmente, entre setembro de 2007 e agosto de 2008, sendo capturados 377 indivíduos, pertencentes a quatro espécies, integrantes da família Phyllostomidae: *Artibeus lituratus* (90%); *Platyrrhinus lineatus* (6,4%); *Sturnira lilium* (2,4%); e *Carollia perspicillata* (1,3%). Entre os frutos consumidos pelos morcegos destacam-se os de Cecropiaceae, Moraceae, Myrtaceae, Piperaceae e Solanaceae. Foram capturados 51% de indivíduos fêmeas e 49% machos. Fêmeas prenhes de *A. lituratus* e machos escrotados não foram amostrados no outono, enquanto que o maior número de registros destes foi verificado para o inverno. Quanto às fêmeas lactantes, *A. lituratus* foi amostrado durante todo o ano, com predomínio na estação mais quente. Apesar da baixa diversidade de espécies, a área do campus é utilizada por espécies frugívoras, generalistas e que são capazes de alimentar-se e reproduzir-se em áreas urbanizadas. Para um incremento desta diversidade, programas de manejo devem ser implementados com o intuito de que a urbanização e quirópteros possam coexistir com menores riscos e prejuízos aos ecossistemas.

**Palavras-chave:** diversidade, horário de captura, dieta, reprodução.

### Introduction

Brazil is regarded as one the countries with the world's greatest biological diversity (MITTERMEIER et al., 2005). Nonetheless, anthropogenic action in natural environments, which has led to habitat fragmentation and destruction, is among the main causes that threaten this mega-biodiversity (TERBORGH, 1992).

The growth in agricultural activity, particularly between 1870 and 1950, stimulated by the high

fertility of the land in northern Paraná, led to the destruction of more than 90% of the seasonal semideciduous forest ecosystem, leaving only forest fragments (REIS et al., 1993). Among the effects of vegetation fragmentation is the reduction in the living area of biotic components, which compromises species diversity and abundance (COSSON et al., 1999). On the other hand, changes in natural habitats make it so that a few species with higher adaptive potential predominate over the remaining species (REIS et al., 2002),

consequently reducing diversity through an increase in specific dominance.

Bats are indicators of the levels of habitat degradation, due to the wide variety and abundance of species in neotropical regions (FENTON et al., 1992). Anthropogenic areas between forest fragments are used by some bat species and are sometimes an important linking habitat between these habitats (BERNARD; FENTON, 2002; ESTRADA et al., 1993). So, one of the first steps to address the conservation priorities of bats in the northwest region of Paraná should therefore be to know the species and to assess the ecologic abundance requirements of species.

It is known that bats, due to a great variety in feeding habits, are responsible for energy transfer in various ecosystems, functioning as dispersing agents, pollinators and biologic controllers of insects (ENCARNAÇÃO; DIETZ, 2006; GARDNER, 1977).

With regard to the reproductive patterns established for tropical bats, four categories are described: i) non-seasonal polyestrous: year-round reproduction with no restricted breeding season; ii) seasonal polyestrous: reproduction during most of the year, with a short period of sexual inactivity; iii) bimodal polyestrous: restricted breeding season, with two birth peaks; iv) seasonal monoestrous: with one restricted breeding season (FLEMING et al., 1972; MARINHO-FILHO, 2003).

However, there is still no single characterization for all neotropical chiropterofauna, and indications of the reproductive state of different species will aid in better identifying such a pattern for all species, as well as possible variations.

Fleming et al. (1972) report that neotropical bats show higher activity during the first few hours of the night, and this activity may be related to predator flight (UIEDA, 1992) or the presence of prey (SCOTT et al., 2009). Therefore, indications of the activity period may aid in the ecological understanding of the species.

In this context, regional assessments in urban areas, as well as contributions with data on the occurrence of species in altered habitats, with native or introduced vegetation, provide ecological elements that allow a better characterization of the local biodiversity. Thus, the present study aimed to make an inventory of bat species present in an urban area, located within the main campus of the State University of Maringá (UEM), in northwestern Paraná state, and present data on the diet, reproduction, and activity times of the captured species.

## Material and methods

### Description of the Study Area

The city of Maringá, in northern Paraná state, is located between 23° 25' S and 51° 57' W and features rolling terrain with altitudes between 500 and 600 m. The vegetation in the region is classified as seasonal semideciduous forest (TOREZAN, 2002).

The main UEM campus is located near the city center, with a total area of 1,336,459.90 m<sup>2</sup>, as shown in Figure 1. In order to characterize the different environments present inside the main UEM campus with regard to the presence of vegetation and direct human activity, samplings were performed at three sites:

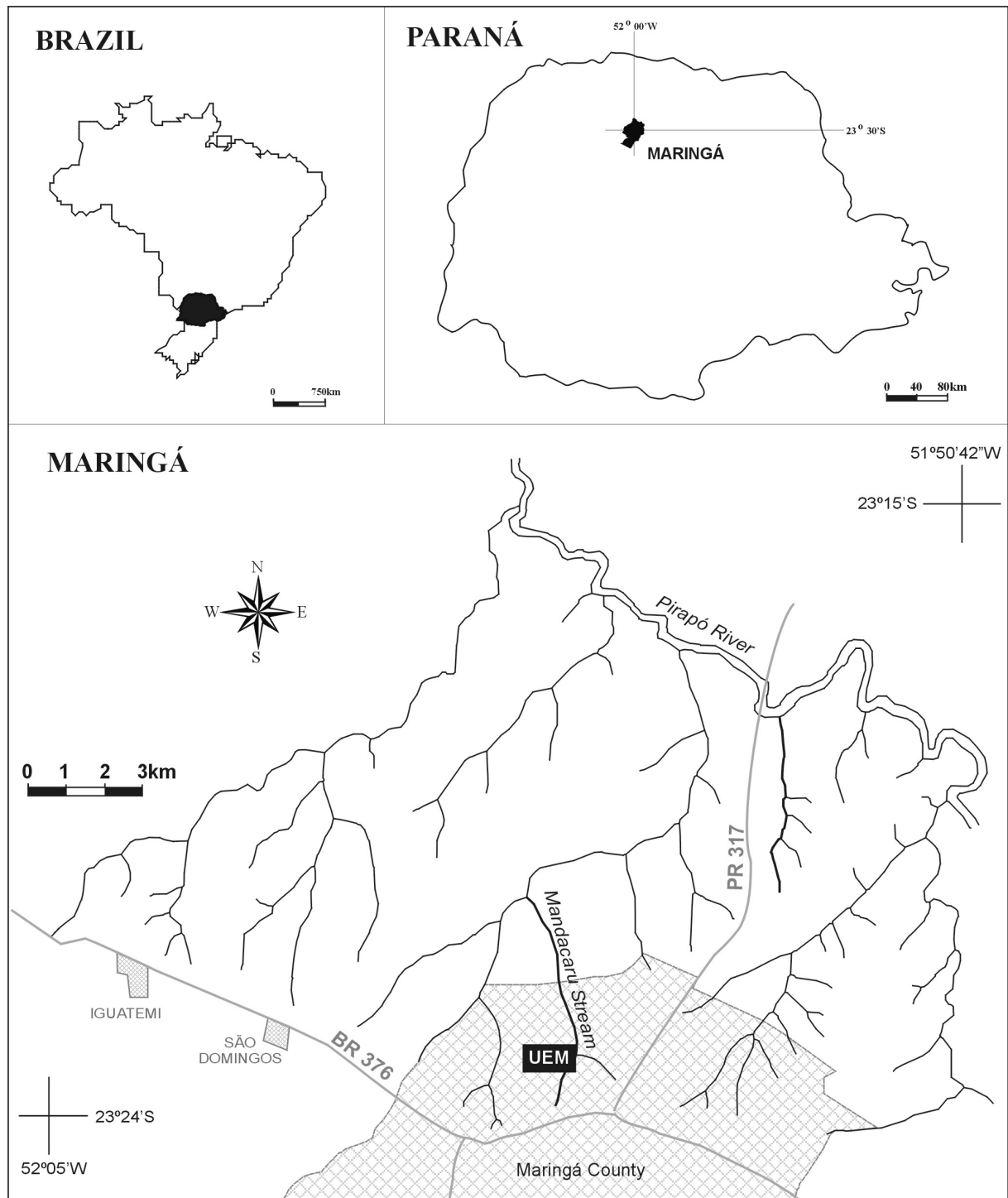
**1. Riparian vegetation:** Area located in the western end of campus. Features native forest remains located on the margins of the Mandacaru Stream and, despite the presence of residences, is a site with little anthropogenic action when compared to the other sampled sites;

**2. Didactic and medicinal plant nursery:** Represents two sampling sites, 100 m apart. They were grouped due to the great variety of arboreal species, most of which were introduced by staff at the State University of Maringá with didactic purposes. In addition to native species such as *Schizolobium parahiba* (guapuruvu), there are a great number of frugivore species, such as guava (*Psidium guajava*), mango (*Mangifera indica*) and guaraná (*Paullinia cupana*);

**3. Warehouse / University Restaurant:** These two sites were grouped into a single sampling point, not only because of their proximity, but also because they feature intense foot and vehicle traffic. In the vicinity of the warehouse there is higher arboreal concentration, forming a small wooded area, with heterogeneous vegetation, marked by introduced species such as gramineae, as well as ornamental, native and fruit species. Near the university restaurant, there are medium and large-sized trees, as well as predominant gramineae (*Paspalum notatum*).

### Samplings

Collections were performed monthly, between September 2007 and August 2008, during three nights, totaling 36 nights of capture. In the samplings, six 6 x 2.5 m mist nets were set between trees, totaling 90 m<sup>2</sup>, at a height between 0.5 and 3 m from the ground, in the first six hours after dusk (18h00-00h00), which covers the longest period of bat activity (ESBÉRARD; BERGALLO, 2005), resulting in a total of 216 hours of exposure and a capture effort of 19,440 m<sup>2</sup> h<sup>-1</sup> (STRAUBE; BIANCONI, 2002).



**Figure 1.** Location of the UEM campus, in the urban area of Maringá, northern Paraná State, Southern Brazil.

Source: Phillipsen et al. (2010).

To identify the sampled exemplars, the study adopted the criteria set by Vieira (1942), Vizotto and Taddei (1973), Jones and Carter (1976), Reis et al. (1993) and Gregorin and Taddei (2002).

Bat diet was verified by field collection of fecal samples at the moment of capture or through defecation by specimens, which were conditioned for

approximately 40 minutes in cotton bags. Considering that only seeds were identified as composing bat diets, comparisons were made of the obtained samples with material deposited at the herbarium of the State University of Maringá, and also with the existing bibliography such as: Gardner (1977), Fleming (1986), Muller and Reis (1992) and Mello et al. (2004).

For each collected exemplar, the secondary sexual characteristics were observed, as proposed by Fleming et al. (1972). Females had their abdomen palpated, observing for swollen teats, presence of hairs and/or milk secretion, thus categorizing specimens as inactive, active, pregnant or lactating. Males could not be classified as inactive or active, as they were not sacrificed and histological analyses of their scrota were not performed. Nevertheless, all male individuals with evident scrota were recorded.

For each captured exemplar, the time and place of capture was recorded, and the size of the right forearm (FA) was obtained with the aid of a manual pachymeter. According to Fleming et al. (1972), this measurement is helpful to identify the species and allows an indication of individual body size (Figure 2). In order to determine the time of greater activity of the species, the nets were checked every fifteen minutes, thereby identifying the time of capture of each collected individual (REIS, 1984), with the objective of reducing capture stress, as well as any damages to the sampling equipment.

### Data analysis

The fecal content exam consisted of drying in room temperature and manual selection of the food items found. Identification was performed with the aid of a stereoscope.

To analyze the reproductive state in relation to the seasons of the year (spring: September, October, November; summer: December, January and February; autumn: March, April and May; winter: June, July and August), the sex ratio of the sampled exemplars was considered, as well as the occurrence of adult individuals fit for reproduction (pregnant or lactating females and males with visible scrotum).

### Results and discussion

During the study period, 377 individuals were captured, belonging to four species from the Phyllostomidae family (Table 1).

**Table 1.** Number (n) and frequency of individual (%) sampling in each sites at the main campus of the State University of Maringá, between September 2007 and August 2008.

Species	Site 1		Site 2		Site 3		Total	
	n	%	n	%	n	%	n	%
<i>Artibeus lituratus</i> (Olfers, 1818)	103	88.8	108	95.6	128	86.5	339	89.9
<i>Platyrrhinus lineatus</i> (E. Geoffroy, 1810)			5	4.4	19	12.8	24	6.4
<i>Sturnira lilium</i> (E. Geoffroy, 1810)	8	6.9			1	0.7	9	2.4
<i>Carollia perspicillata</i> (Linnaeus, 1758)	5	4.3					5	1.3
Total	116	100	113	100	148	100	377	100

The most frequent species, according to the employed method of capture, at each collection site

of the main UEM campus, was *Artibeus lituratus* with 339 individuals, representing 90% of the total sample, followed by *Platyrrhinus lineatus*, with 6.4%.

*Sturnira lilium* had nine exemplars captured (2.4%) and *Carollia perspicillata* five (1.3%). These species were observed only in site 1 despite the record of a single individual in site 3.

The diet of *A. lituratus* was the most diverse, with all identified fruit families being identified; however, a greater intake was observed of Moraceae fruits (78.2%), represented by *Ficus* sp., in addition to Solanaceae (13%) and, in smaller quantities, seeds of Cecropiaceae, Myrtaceae and other undetermined species (Table 3). *Platyrrhinus lineatus* concentrated its feeding on only two families, with findings only of seeds of Moraceae (80%) and Solanaceae (20%) (Table 3). The fecal samples of *S. lilium* evidenced seeds belonging to families Moraceae, Piperaceae and Solanaceae, whereas for *C. perspicillata*, samples of these families were recorded in only two samples (Table 2).

During the day, colonies of *A. lituratus* and *P. lineatus* were found on trees that serve as natural perches at the didactic plant nursery, near the warehouse, and also on the palm trees in the central garden, near the university restaurant.

**Table 2.** Occurrence of food items for each species of frugivore bats (AL=*A. lituratus*; CP=*Carollia perspicillata*; PL=*Platyrrhinus lineatus*; SL=*Sturnira lilium*).

Plants Family/Species	Species of Bats				Total
	AL	CP	PL	SL	
Cecropiaceae					
<i>Cecropia pachystachya</i> Trec.	1				1
Combretaceae					
<i>Terminalia catappa</i> L.	X				X
Moraceae					
<i>Ficus</i> sp.1 L.	6			1	7
<i>Ficus</i> sp.2 L.	12		4	1	17
<i>Ficus</i> sp.3 L.	1	1			2
Myrtaceae					
<i>Myrciaria cauliflora</i> (Mart.) O. Berg	X				X
<i>Psidium guajava</i> L.	1				1
Piperaceae					
<i>Piper gaudichaudianum</i> Kunth		2		2	4
Rosaceae					
<i>Eriobotrya japonica</i> (Thunb.) Lindl.	X				X
Solanaceae					
<i>Solanum</i> sp.1 L.	1				1
<i>Solanum</i> sp.2 L.	1	1	1	2	5
<i>Solanum</i> sp.3 L.	1				1
Indetermined	1			1	2
Total of item for each species	12	3	2	5	

(X) – Visual identification or capture in nets.

With regard to sex, 51% of total captured individuals were female and 49% male. Pregnant *A. lituratus* females and active males were not captured in autumn, while the largest number of records for these categories was verified in winter. As for lactating females, *A. lituratus* was sampled year-round, with predominance during the warmer

season. *Platyrrhinus lineatus*, with three specimens, was not recorded only during spring. *C. perspicillata* did not show individuals with evident scrota during the study period (Table 3).

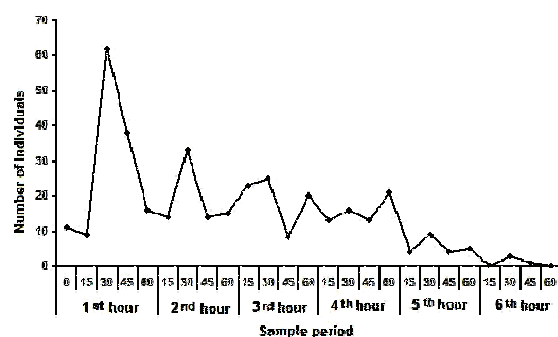
*Platyrrhinus lineatus* totaled three lactating females, each captured during different seasons of the year: summer, autumn and winter. Among the 15 sampled *P. lineatus* males, only one showed visible scrotum during autumn. *S. lilium* had two active males sampled only during summer (Table 3).

**Table 3.** Seasonal distribution of the reproductive condition of sampled bats at the main campus of the State University of Maringá, between September 2007 and August 2008.

Species	Periods							
	Spring 2007		Summer 2008		Autumn 2008		Winter 2008	
	F	M	F	M	F	M	F	M
<i>A. lituratus</i>	1/39	1/38	2/56	6/58	0/40	0/38	4/41	7/29
	15L		18L		14L		9L	
<i>P. lineatus</i>	0/2	0/1	0/4	0/8	0/2	1/3	0/1	0/3
			1L		1L		1L	
<i>S. lilium</i>	0/1	0/1	0/3	2/4				
<i>C. perspicillata</i>			0/1	0/3	0/1			

(/):pregnant females or males with visible scrotum /sampling individuals; (L): lactating females.

In general, for the sampled species, the peak time for capture occurred during the first hour of collection (Figure 2), with a gradual decrease over the nocturnal study period.



**Figure 2.** Number of individuals captured during the first six hours after dusk in samplings performed at the main campus of the State University of Maringá, between September 2007 and August 2008.

Works conducted in urban areas of Brazil, focusing on chiropterofauna, have demonstrated the predominance of the Phyllostomidae family over the others (BARROS et al., 2006; DE KNEGT et al., 2005; REIS et al., 1993). This is justifiable by that fact that the neotropical region features one of the greatest diversities in species belonging to that family (FENTON et al., 1992). In the present study, the exclusivity of Phyllostomidae in the sample is related to the type of sampling employed, which consisted of setting mist nets in the understory.

The low species richness (4) is related mainly to the fact that the research area is located in an urban environment, which has been completely modified from its natural setting. The few trees, the excess lighting on campus, constant changes in the environments (buildings), human movement and automobile noise in the vicinity of the sampled sites, certainly were factors that had an influence on the samplings.

*Artibeus lituratus*, a large-sized bat, with a forearm that can exceed 75 mm (VIZOTTO; TADDEI, 1973), in addition to being the most abundant species (90% of the sampled total), was the only species recorded at all three collection sites, which corroborates the works of Zanon and Reis (2007) and Barros et al. (2006). According to Zanon and Reis (2007), this is due to the great adaptive potential of that species, which inhabits areas with intense anthropogenic action, such as the urban environment. The feeding plasticity of this species, which characterizes it as opportunistic, also favors the occupation and adaptation of its needs to the environment, thereby enabling its presence in disturbed environments. The other three species collected in smaller numbers – *P. lineatus*, *S. lilium* and *C. perspicillata* – are indicators of disturbed areas as well (REIS et al., 2003).

The presence of the mid-sized species (forearm varying between 43 and 50 mm) *P. lineatus* (VIZOTTO; TADDEI, 1973), as well as *A. lituratus*, may be related to the abundance of food and shelter in cities, as recorded by Bredt and Uieda (1996).

*Sturnira lilium*, also a mid-sized species (forearm around 42 mm long) (ZORTÉA, 2007), according to Zanon and Reis (2007), can easily adapt to new environments, including urban ones, competing with more sensitive species for the same habitat.

The presence of *C. perspicillata* (forearm between 38 and 42 mm) only at the riparian forest sampling site, in the vicinity of Mandacaru Stream, may be related to food availability, as it shows a preference for plants from the Piperaceae family, especially the genus *Piper* (LIMA; REIS, 2004; MELLO et al., 2004). Among the sampled areas, that site shows the most restricted human occupation, low light intensity and reduced noise, making it a proper environment for bat foraging. At that same collection site, species belonging to the Vespertilionidae family, although not sampled in the mist nets, were observed foraging at dusk, more specifically in the ten minutes prior to sunset.

The ceilings of some campus buildings, considered to be places for possible shelter, especially for species belonging to the Molossidae family, were investigated, noting that most of them

consisted of recent constructions or had their roofs replaced and protected with screens in order to prevent inhabitation by bats or birds.

With regard to diet, the study observed for all sampled bats species the intake of fruits from the Moraceae family, with three species of *Ficus*. This may be related to different maturation periods of the fruits over the course of the year, thereby providing constant food availability to the frugivores (MULLER; REIS, 1992).

Considered as large-sized among fruit-eating bats, *A. lituratus* showed greater feeding breadth, corroborating the data obtained by Pinto and Ortêncio-Filho (2006). In the present study, it was verified that the diet of this species also consisted of fruits with large seeds, which remained undigested, such as *E. japonica* and *T. catappa*, which were caught in the mist nets. These records demonstrate that this species can feature a generalist diet, despite the preference for Moraceae cited by Fleming (1986), Galetti and Morellato (1994) and Passos et al. (2003).

*Platyrrhinus lineatus* showed lesser diversity in its diet and a feeding preference for *Ficus* sp. 2 (80%), one of the three sampled species belonging to the Moraceae family. Additionally, its feeding was supplemented by one Solanaceae (20%).

Intake of species belonging to Moraceae, Piperaceae and Solanaceae was identified in the fecal samples of *C. perspicillata* and *S. lilium*. Despite the few fecal samples obtained for both species, it can be inferred that there is a feeding preference by *C. perspicillata* and *S. lilium* for *Piper* and *Solanum* fruits, respectively. These data corroborate other works performed in urban areas in the state of Paraná and also elsewhere in Brazil (MULLER; REIS, 1992; LIMA; REIS, 2004; ZORTÉA, 2007).

With regard to reproduction, among the four captured species, *A. lituratus*, *P. lineatus* and *S. lilium* showed evident reproductive characteristics. *Artibeus lituratus* was the only species to feature pregnant females. In all, seven females in gestation period were collected, four of them (57%) during winter, which agrees with the results obtained by Ortêncio-Filho et al. (2007). Lactating females of the same species were sampled during all seasons, with higher representation in summer. This predominance may be related to food availability during the warmer season. On the other hand, males with evident scrota were observed during winter, spring and summer. For *P. lineatus* and *S. lilium*, active males were also recorded when no pregnant females were sampled. It is common among vertebrates for situations such as this to occur, in which males can be reproductively active, regardless of whether the

female cycle is continuous or seasonal (BRONSON, 1985; VITT, 1992).

The predominance of male individuals with evident scrota was verified in summer can be justified by the fact that this season is the period of greater availability of feeding resources, as high energy expenditure is especially required during the lactation phase (GITLEMAN; THOMPSON, 1988; HEIDEMAN, 1995; ZORTÉA, 2003). Pregnancy and lactation are synchronized with high food availability in late spring and early summer (ENCARNAÇÃO; DIETZ, 2006).

Taddei (1976) verified that *A. lituratus*, *C. perspicillata* and *P. lineatus* reproduce year-round, following a non-seasonal polyestrous pattern for these species. *Carollia perspicillata* did not feature reproductive females, which made it impossible to confirm such a pattern for the study area. The same was verified for *Sturmira lilium*, which despite featuring two males with evident scrota, the low number of reproductive exemplars does not allow a confirmation of the seasonal polyestrous pattern reported by Fleming et al. (1972).

With regard to the activity period of the bats, a larger number of captures was observed during the first hour after dusk, with a peak around the first 30 minutes. An explanation for this intense activity during the first hour may be related with the need to break fast, as these animals remain approximately 10 hours per day at rest, without eating (GREENHALL; PARADISO, 1968).

It is worth mentioning that the reduced number of sampled bat species indicates that environments undergoing anthropogenic action and degradation are unfavorable to species diversity, thereby favoring more opportunistic species. The greater representation of specimens with reproductive indicators during summer may be justified by food resource availability and by the mild climate, which promote a greater investment in reproduction. With regard to the timing of activities, it represents the individuals' disposition for foraging in search of food, after a long daytime period at rest.

## Conclusion

The obtained results correspond to previously unknown data on the biology and ecology of bats at the main campus of the State University of Maringá, and corroborate other existing studies on frugivore species. New studies should be conducted in order to implement management and monitoring programs so that urbanization and Chiroptera diversity can coexist with lower risks and losses to ecosystems, and aiming for environment sustainability.

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