The present study analyzed the ecological and biological aspects of Artibeus lituratus and Artibeus planirostris captured in the municipality of Nova Xavantina, Mato Grosso, Brazil. The samplings occurred from January/2010 to December/2010 and from August/2012 to July/2013, in three areas of Cerradão and three of Cerrado stricto sensu. A total of 286 specimens of Artibeus lituratus (183 females and 103 males) and 103 of Artibeus planirostris (59 females and 44 males) were captured. Among the environments, greater abundance was recorded in the Cerrado stricto sensu. For both species, there was a significant relationship when analyzing the abundance between seasons, and in the rainy season, there was greater abundance. There was also a correlation between the activity schedule of the individuals and the abundance that was verified by the Rayleigh test. The correlation test between temperature and abundance variations showed significant values. The forearm and weight measurements showed positive results with the performance of the correlation test. This work contributed to expanding the knowledge of bats in the eastern region of Mato Grosso itself, there is little information regarding the ecological and biological aspects of Artibeus lituratus and A. planirostris in the region.

Keywords: Seasons; Reproductive Stages; Activity hours; Bats; Temperature.

1 INTRODUCTION

The Subfamily Stenodermatinae is the most diverse subfamily of phyllostomids, being represented in this account by 14 genera and at least 60 species in South America (Gardner 2008). The genus Artibeus Leach, 1821 is composed of 22 species, occurring throughout the tropical and subtropical range of the New World, from Mexico to the southern coast of Argentina (Simmons, 2005). Plink minus 14 species are in South America and Brazil, five species are recorded (Nogueira et al. 2014, Pereira et al. 2017). Artibeus species have outstanding ecological importance due to the provision of ecosystem services due to seed dispersal. In addition, Artibeus is among the most abundant in the surveys of the fauna of quirópteros (Passos & Passamani 2003; Reis et al. 2013). Artibeus lituratus is the largest species and the largest of its kind and presents several divergent aspects in its characteristics (Miranda et al. 2009), such as body size, which ranges from 93.0 to 113.0 mm, forearm from 65.0 to 78.0 mm and weight from 65.0 to 82.0 g. The species has white and well-visible facial stripes, the ventral hairs do not have a clear end, and their coat is uniform (Reis et al. 2013; Pereira et al. 2017).

The Brazilian regions and biomes have records of lituratus, having already been cited by the states (Reis et al. 2013; Barros et al. 2017). The reproductive pattern of this species varies geographically, with
seasonal polystria being the most frequently observed, with two pregnancies per year. Usually, a puppy is born per pregnancy (Peracchi et al. 2010; Pereira et al. 2017).

*Artibeus planirostris* has a body size ranging from 75.0 to 110.0 mm, a forearm from 56.0 to 66.7 mm, and a weight from 40.0 to 69.0 g (Peracchi et al. 2010; Pereira et al. 2017). It features narrow and unpronounced facial stripes. The forearms are bare or covers with short and rough hair (Reis et al. 2009). This species is also distributed by the different Brazilian biomes (Reis et al. 2013). The available reproductive data indicate seasonal polystria, with two pregnancies per year (Peracchi et al. 2010).

The taxonomic classification and Chiroptera, in specific of the genus *Artibeus,* widely analyzed morphological and metric characteristics, primarily measured of skull and body size, body size and weight, which hinder the identification of phylogenetic relationships (Reis et al. 2007; Bordignon et al. 2017). *Artibeus lituratus* and *A. planirostris* have wide overlaps in their distribution, being symbolic, phylogenetically close, and with great morphological similarity (Lim & Engström 2001; Redondo et al. 2008). However, these species present dissimilarity in the functional morphology of the skull and diet, which may mean evidence of competitive exclusion (Amaral et al. 2016).

Considering the ecological importance of both species. We analyzed the bionomic aspects of *Artibeus lituratus* and *Artibeus planirostris* in two cerrado phytosociomnies. Our goals include understanding (1) the variation in abundance between environments and seasons; (2) hourly activity patterns; (3) how temperature variation affects foraging; (4) comparing morphological aspects for forearm and weight measurements, (5) the reproductive stage according to the capture months.

### 2 MATERIAL AND METHODS

#### 2.1 AREA AND ALL

The survey of the present study was conducted in Nova Xavantina, Mato Grosso. The municipality is located 635 km away from the capital Cuiabá and has a territorial extension of 903,357 km² (Ferreira 2001). The climate of the region is Aw type, according to the Köppen classification, with two well-defined seasons: drought (From April to September) and rain (From October to March). The annual precipitation ranges from 1,300 mm to 1,500 mm with maximum intensity from December to February, with an average monthly temperature of 25°C (Marimon et al. 2003). The captures were carried out in three areas of Cerradão 1: 14°38'14"S and 52°21'49"O, 2: 14°40'23"S and 52°19'31"O, e 3: 14°42'6"S and 052°21'5"O and in three areas of Cerrado *stricto sensu* 4: 14°40'12"S and 52°21'52"O, 5: 14°40'48"S and 52°19'31"O and 6: 14°42'5"S and 052°21'0"O (Fig. 1).

The Mischieline C is a type of forest phytosociomnony proper to the Brazilian Central Plateau, in which the treetops are close and the plant community denotes a closed appearance but has a spacing between the trees that allows the penetration of the sun. The average height of the trees ranges from 10 to 15 m (Rizzini 1997).
The wrong *C. stricto sensu* is a sanamal phytophysiognomy and consists of more spaced, smaller, more twisted trees, which provide the appearance of grasses and rural subshrubs, prevailing the low vegetation (Rizzini 1997). These trees are usually 3 to 6 m high and can reach up to 10 m (Ribeiro & Walter 2008).

2.2 BAT SAMPLING

Data were obtained from samplings carried out between January and December 2010 and between August 2012 and July 2013. Four nights of captures per month were performed, totaling 96 nights, and 48 phytophysiognomy (Cerradão and Cerrado *stricto sensu*). The bats were captured with mist nets (9 × 3 m, 16 mm mesh) armed just before sunset (≅ 18:00h) and closed at dawn (≅ 06:00 h) in places with possible routes of bat flights, being inspected every 30 minutes. Five mist nets were set up per night, maintaining an average distance of twenty meters from each other. A total sampling effort of 118,832 m².h was performed, following the calculation proposed by Straube & Bianconi (2002).

The animals were recorded and identified in specific (Vizotto & Taddei 1973, Gardner 2008; Reis et al. 2013; Nogueira et al. 2014) still in the field and released at the same capture site after the closing of the nets. The information regarding the captured individuals (e.g., sex, body mass, reproductive stage, body measurements, capture time, temperature, and capture environment) was noted in field records. The animals not identified in the field as well as testimony specimens were deposited in the Scientific Collection of the Laboratory of Genetics of the University of the State of Mato Grosso, Nova Xavantina campus, with the following bat records (RM) and tipping numbers: *Artibeus lituratus* (RM: 30, 125, 259, 292, 293, 294, 299, 388, 390, 391, 473) and *Artibeus planirostris* (RM: 126, 199, 200, 258, 298, 301, 331). All field activities were authorized by IBAMA/SISBIO/MT (licença nº 18276-1).

2.3 DATA ANALYSIS

The Chi-Square statistical test ($\chi^2$) was used to test the significance of the variation of abundance between the sexes of the specimens concerning the sampled environments. Posteriormente, the same test was performed to test the significance of the abundance variation among the studied phytophysiognomies. Student's Teste *t* was used to compare the abundance between the seasons and the Rayleigh circular correlation test was used to verify if there was a trend in bat activity time analyzing the relationship between time and abundance of individuals. In addition, the linear correlation test was applied to verify the relationships (i) between abundance and temperature and (ii) between body mass and forearm length.

3 FINDINGS

During the fieldwork, 286 individuals of *Artibeus lituratus* (183 females and 103 males) and 103 of *A. planirostris* (59 females and 44 males). There was a difference in the capture rate of
males and females for *A. lituratus* ($\chi^2 = 3574.443; \text{gl} = 285; p < 0.001$) and for *A. planirostris* ($\chi^2 = 2073.779; \text{gl} = 102; p < 0.001$).

Hears significant variation in the abundances of *A. lituratus* ($\chi^2 = 3429.722; \text{gl} = 285; p < 0.005$) and *A. planirostris* ($\chi^2 = 2105.623; \text{gl} = 102; p < 0.005$) among cerrado phytophysiognomies, being Cerrado s. s. which had the highest catch rate. In addition, a higher abundance of females of both species was observed in both phytophysiognomies (Fig. 2).

*A. lituratus* was captured in all months during the collection periods and *A. planirostris* was not captured only in August (Fig. 3). In the rainy months, there was greater abundance in the catches of *A. lituratus* and *A. planirostris* (N = 216 and N = 92 respectively) when compared with the dry months (N = 70 for *A. lituratus* and N = 11 for *A. planirostris*) (Table 1). When analyzing the rate of captures between the stations, the *t*-test revealed a significant difference for both species (t = 3936.173; gl = 285; *p* < 0.001) and (t = 3273.409; gl = 102; *p* < 0.05).

For *A. lituratus*, the activity schedule was good at 18:00 hours, although it is the time with the fewest records. Between 21:00 and 23:00 the highest abundances were recorded for the species. For *A. planirostris* the recorded activity time was from 19:00 hours. The highest abundances occurred between the hours of 20:00 and 23:00 hours. During the entire night time, individuals were captured, except for 4:00 a.m., where there was no capture of *A. planirostris*. Rayleygh's circular test showed significant results between the time and abundance of *A. lituratus* (*r* = 0.9827; gl = 23; *p* < 0.01) as well as for *A. planirostris* (*r* = 0.6116; gl = 23; *p* < 0.01) (Fig. 4).

During the capture nights, the temperature was between 14 and 29°C. The Mayr activity occurs between the temperatures of 20 to 26°C for *A. lituratus* and between 21 and 25°C for *A. lanirostris* p. The correlations were positive between abundance and temperature for the two species (*A. lituratus*: $r^2 = 0.63380 \text{gl} = 16; p < 0.05$, *A. planirostris*: $r^2 = 0.4451; \text{gl} = 15; p < 0.05$) (Fig. 5).

About the breeding rate of *A. lituratus*, 21 pregnant females were captured, 13 in the Cerrado stricto sensu and eight in Cerradão. Among the captured females, 42 were lactating, 24 in the Cerrado stricto sensu, and 18 in Cerradão. Among the males, 13 scummed specimens were captured, seven collected in the wrong C stricto sensu and six in Cerradão. Of the 10 cubs captured, seven occurred in Cerradão and three in the Cerrado stricto sensu. The reproductive stages of the captured specimens varied according to the months of the year (Table 2).

For *A. planirostris*, two pregnant females were collected, one in each phytophysiognomy; nine lactating females were recorded, three in Cerradão and six in cerrado stricto sensu. The cub was captured in November in the Cerrado stricto sensu. Six sced males were recorded, four in the Cerrado stricto sensu and two in Cerradão (Table 2).

Measurements of forearm length and body mass varied for the two species, tanto for *A. lituratus* as for *A. planirostris*. F-emes presented mean forearm length and body mass higher than males (Table 3). The correlation applied to verify the magnitude and meaning of the association that exists between the weight
value and the variation obtained in forearm measurements showed a high correlation in *A. lituratus* ($r^2 = 0.5107; gl = 284; p < 0.001$), and in *A. planirostris* ($r^2 = 0.4602; gl = 102; p < 0.001$) (Fig 6).

4 DISCUSSION

In a survey conducted in the municipality of Nova Xavantina, Silva & Anacleto (2011) observed that *A. planirostris* and *A. lituratus* were the most abundant. Similar results were found in Cerrado environments in Mato Grosso do Sul, by Ferreira et al. (2010) and Martins et al. (2014).

In studies conducted in different localities in Brazil *A. lituratus* is the most abundant (Trajan 1984; Passos & Passamani 2003; Passos & Gracioli 2004; Bianconi et al. 2006; Brusco & Tozato 2009; Araújo & Langguth 2010; Luz et al. 2011; Bernardi & Steps 2012; Sato et al. 2015). *A. planirostris* is considered a common species and maybe the dominant species in some localities (Gregorin et al. 2011; Alho et al. 2011; Martins et al. 2011; Castro & Michalski 2015; Barros et al. 2017).

In Cerrado environments, some authors mention that a greater abundance of females is found (Ferreira et al. 2010; Cunha et al. 2011). The data of the present study follows these studies. In general, the variation in sex ratio can be expected, with a predominance of females in long-term systematized surveys. This finding can be explained by the fact that there is a tendency for males to form harems and, with this, the colonies have higher numbers of females (Mello & FernanDez 2000; Costa et al. 2010).

The high abundance of *A. lituratus* and *A. planirostris* is also expected, as they are frugivorous species. Passos & Passamani (2003) states that the abundance of frugivorous species in bat survey is higher due to the large number of plant species that produce fruit at different times of the year. Thus, the high abundance of bats occurs due to the great availability of food found in the areas of forests or natural vegetation. Meanwhile, Ferreira et al. (2010), in a study conducted in urban areas, point out that the difference in the high abundance of both studied species can be explained by urban expansion and environmental degradation since both species are generalists and occur in environments with different levels of preservation.

The Cerrado Biome has been suffering from urban sprawl and one of its main characteristics is the spacing between its trees. This attribute can influence occupation and *A. Lituratus* and *A. planirostris*, due to the ease of flight and the adaptability of the species regarding the use of habitat (Silveira et al. 2012). Araújo & Langguth (2010), describe that *A. lituratus* was the only species that occurred in all 12 sampling points surveyed by them, 10 in the Cerrado stricto sensu and two in Mata de Galeria. The data of the present study show the influence of the vegetation characteristics of Cerradão and Cerrado stricto sensu on the abundance of the two studied species.

The time of activity can also influence the abundance of the species, and the results of the present study corroborate with studies previously conducted by Marques (1985), Reis & Peracchi (1987), Sipinski & Reis (1995), Zanon & Reis (2007) and Silva & Anacleto (2011), who observed peak activity in the first hours of capture followed by a decrease in activity in the following hours. Oliveira et al. (2010) observed
similar results reporting that *A. lituratus* and *A. planirostris* were the most active species in the first three hours after sunset, a period in which both species are most active.

Abundance is directly related to temperature, as it is one of the environmental factors that can influence bat activity. At temperatures below 21°C bats tend to reduce their activities (O'Donnel 2002; Filho et al. 2007) and, according to Fleming et al. (1972), bats have a preference for intermediate temperatures. In the present study, the highest abundances of *A. lituratus* and *A. planirostris* occurred between 21°C and 25°C, with a positive correlation between abundance and temperature. Navarro & Leon-Paniagua (1995), Patterson et al. (1996), Diaz et al. (2002), and McCain (2007) obtained similar results, reporting that at low temperatures bat activity tends to decrease.

Studies conducted by Passos & Passamani (2003), Ortêncio-Filho et al. (2007), and Martins et al. (2006) believe that seasonality influences the number of catches. This is due to the availability of resources during the rainy season (Passos & Graciolli 2004; Brusco & Tozato 2009).

Zortéa et al. (2010) and Sato et al. (2015) observed a high abundance of *the species of A. lituratus* and *A. planirostris* at the end of the dry season and the beginning of the rainy season, being observed for this period of females' in lactation and pregnancy. Bordignon (2006), Ortêncio-Filho et al. (2007), and Castillo-Navarro et al. (2017) recorded the occurrence of *females of A. lituratus* lactating only in the rainy season. Ortêncio-Filho et al. (2007), Sato et al. (2015), and Castillo-Navarro et al. (2017) state that the reproductive period suffers a decline at the end of the rainy season, demonstrating that the wet season favors the reproduction of the species.

In the studies conducted by Passos & Passamani (2003), Menezes et al. (2008), Miranda et al. (2009), and Reis et al. (2009), the forearm means and weight of *A. lituratus* and *A. planirostris* recorded were concordant with the data of the present study in which there was a positive correlation between weight and forearm for both species.

When analyzed together, it is noted that there is a separation of the species in two groups of individuals, revealing a low occurrence of overlap between weight and forearm for both. Rui et al. (1999) highlight that even if there is variation between species, there are no significant differences in external morphometry between males and females to characterize sexual dimorphism for *A. lituratus* and *A. planirostris*.

5 CONCLUSIONS

The data presented expands the knowledge about bats in the eastern region of Mato Grosso, as well as the knowledge about the biology of the genus *Artibeus*. Also possible is better knowledge about the abundance of the species that vary in the face of seasonality with higher frequency in the rainy months. As for the time of activity, peaks were recorded in the first hours after sunset. In addition, the rainy season is the preferred period for the reproductive activity of the species.
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M. do Sul. Ch. do Sul. Ch. 185. and distribution of Amazonian bats (Chiroptera): The case of Amapá, eastern most Brazil.
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M. 23:1175 M. do Sul. Ch. 185. and distribution of Amazonian bats (Chiroptera): The case of Amapá, eastern most Brazil.
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Table 1: Number of bats caught in the rainy and dry periods, in the environments of Cerradão and Cerrado stricto sensu.

<table>
<thead>
<tr>
<th>Species</th>
<th>Cerradão</th>
<th></th>
<th>Cerrado stricto</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rain</td>
<td>Drought</td>
<td>Rain</td>
<td>Drought</td>
</tr>
<tr>
<td>Artibeus Lituratus</td>
<td>94</td>
<td>44</td>
<td>122</td>
<td>26</td>
</tr>
<tr>
<td>Gnares</td>
<td>34</td>
<td>6</td>
<td>58</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>128</td>
<td>50</td>
<td>180</td>
<td>31</td>
</tr>
</tbody>
</table>

Table 2: Months of capture and abundance of *Artibeus lituratus* and *Artibeus planirostris* according to the reproductive stage of the captured individuals.

<table>
<thead>
<tr>
<th>Species</th>
<th>Months</th>
<th>A. Lituratus</th>
<th>A. Lituratus</th>
<th>A. planirostris</th>
<th>A. planirostris</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jan</td>
<td>Feb</td>
<td>Sea</td>
<td>Apr</td>
<td>Mai</td>
</tr>
<tr>
<td>Artibeus Lituratus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>♀ Pregnant</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>♀ Lactating</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>♂ Scummed up</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Puppies</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gnares</td>
<td>♂ Scummed up</td>
<td>-</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>♀ Pregnant</td>
<td>-</td>
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<tr>
<td>♀ Lactating</td>
<td>-</td>
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<td>1</td>
<td>-</td>
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</tr>
<tr>
<td>♂ Scummed up</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cub</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3: Mean (minimum and maximum) of forearm length, expressed in millimeters (mm) and body mass expressed in grams (g), for the species *Artibeus lituratus* and *Artibeus planirostris*, distinguishing females and males.

<table>
<thead>
<tr>
<th>Measures</th>
<th>A. Lituratus</th>
<th>A. Lituratus</th>
<th>A. planirostris</th>
<th>A. planirostris</th>
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</thead>
<tbody>
<tr>
<td>Length of the arm</td>
<td>Seventy-one. 5th</td>
<td>Seventy of them. 9th</td>
<td>Six-one. 0</td>
<td>Six of them. 9th</td>
</tr>
<tr>
<td></td>
<td>(47. 5 - 77. 8)</td>
<td>(48. 0 - 81. 0)</td>
<td>(46. 4 - 74. 5)</td>
<td>(52. 6 - 72. 0)</td>
</tr>
<tr>
<td>Body mass</td>
<td>Seventy of them. 9th</td>
<td>Seventy of them. 8th</td>
<td>Forty-four. 0</td>
<td>Forty-two. 5th</td>
</tr>
<tr>
<td></td>
<td>(20. 8 - 94. 8)</td>
<td>(27. 0 - 81. 4)</td>
<td>(27. 1 - 77. 8)</td>
<td>(31. 0 - 66. 0)</td>
</tr>
</tbody>
</table>
Figure 1: Município of Nova Xavantina, State of Mato Grosso. Points 1, 2 and 3 indicate the areas of Cerradão and points 4, 5 and 6 indicate areas of Cerrado stricto sensu.

Figure 2: Abundance of ■ Females and ■ Males of Artibeus lituratus and Artibeus planirostris captured during field work (January/2010 and December/2010 and between August/2012 and July/2013) in cerrado stricto sensu and Cerradão environments.
Figure 3: Number of bat catches of the species ■ *A. lituratus* and ■ *A. planirostris* to the período from January/2010 to December/2010 and between August/2012 and July/2013.

Figure 4: Abundance of *A. lituratus* and *A. planirostris* (respectively) for each capture time, the arc indicates the preferred trend by the times between 21:00 and 23:00 hours for *A. lituratus* and the preferred trend by the times between 20:00 and 23:00 hours for *A. planirostris*.
Figure 5: Plenty of ■ *A. lituratus* and □ *A. planirostris* for each of the temperatures recorded in the capture period (janeiro/2010 and December/2010 and between August/2012 and July/2013).

Figure 6: Correlation between forearm length and mass corporal of *A. lituratus* ○ and *A. planirostris* ■ in the Municipality of Nova Xavantina, Mato Grosso, Brazil.