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Bat assemblage in a karstic area from northern Brazil: seven new occurrences for Tocantins state, including the first record of *Glyphonycteris sylvestris* Thomas, 1896 for the Cerrado

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Abstract: The Cerrado, the second largest morphoclimatic area of South America, has many limestone outcrops with caves. However, studies of the bat fauna in karstic environments in the Cerrado are scarce. We present an inventory of bats in a karstic Cerrado area in the Tocantins state. We used mist-nets to sample caves, savannas, deciduous forests, and periurban environments. We captured 516 bats of 30 species, revealing that the study area is one of richest for bat species in the Brazilian Cerrado. Seven new occurrences of bat species were recorded for the Tocantins state, and we report the first record of *G. sylvestris* from the Cerrado biome. We recorded 21 species simultaneously at one cave, Gruta dos Moura, which is the highest species richness of bats for a single cave in the Neotropics.

Keywords: Chiroptera; conservation; community; Mammalia; Neotropical; range extension; savanna

INTRODUCTION

The Cerrado is the second largest morphoclimatic domain of South America, located in the central portion of the continent (Klink and Machado 2005). It has open vegetation (savanna) and semi-deciduous forest, with dry and mesic habitats (Oliveira-Filho and Ratter 2002). Human activities have drastically transformed part of the Cerrado, and 55% of its original territory was converted in pastures and agricultural fields (Klink and Machado 2005). Its high biological diversity and increasing rates of destruction make it a globally important biodiversity hotspot (Myers et al. 2000).

This morphoclimatic domain is one of the Neotropical ecoregions with lesser knowledge of its wildlife (Cavalcanti and Joly 2002) and biodiversity studies are imminently needed. In this aspect, species surveys are essential to understand regional patterns of biological diversity (Soulé and Wilcox 1980) and can generate important data required for biodiversity conservation plans (Bernard et al. 2011).

An important geological aspect of the Cerrado is the abundance of limestone outcrops and the existence of large caves complexes (Jansen et al. 2012) that are essential roosts for many bat species (Kunz 1982). However, studies of the bat fauna in the karstic environments of the Cerrado are scarce (Trajano and Gimenez 1998; Bredt et al. 1999; Esbérard et al. 2005). Bernard et al. (2011) considered the Cerrado to be the second least studied of the Brazilian biomes for bats, and only 6% of its territory was minimally sampled. Given the knowledge gaps in karstic areas, we inventoried bat species in a karstic Cerrado area in Tocantins state. Here, we present a list of bat species for two caves, new records of bats for Tocantins, and conservation considerations.

MATERIALS AND METHODS

Study sites

The study area is within the priority area for the conservation of Cerrado biodiversity (Cavalcanti and Joly 2002). Our sampling points are in the municipality of Aurora do Tocantins (12°42′ S, 046°24′ W, 470 m above sea level), located in the southeastern Tocantins state, northern Brazil. Aurora do Tocantins is within the Paranã watershed, a subbasin of Tocantins River, and situated in the Paranã Valley. The watershed is bounded by the Serra Geral de Goiás to the east and the Serra Geral do Paranã to the west. The study area has remnants of Cerrado vegetation, including deciduous forest and savanna (Oliveira-Filho and Ratter 2002).

The study area has several massive limestone outcrops. Among the 533 municipalities listed by the

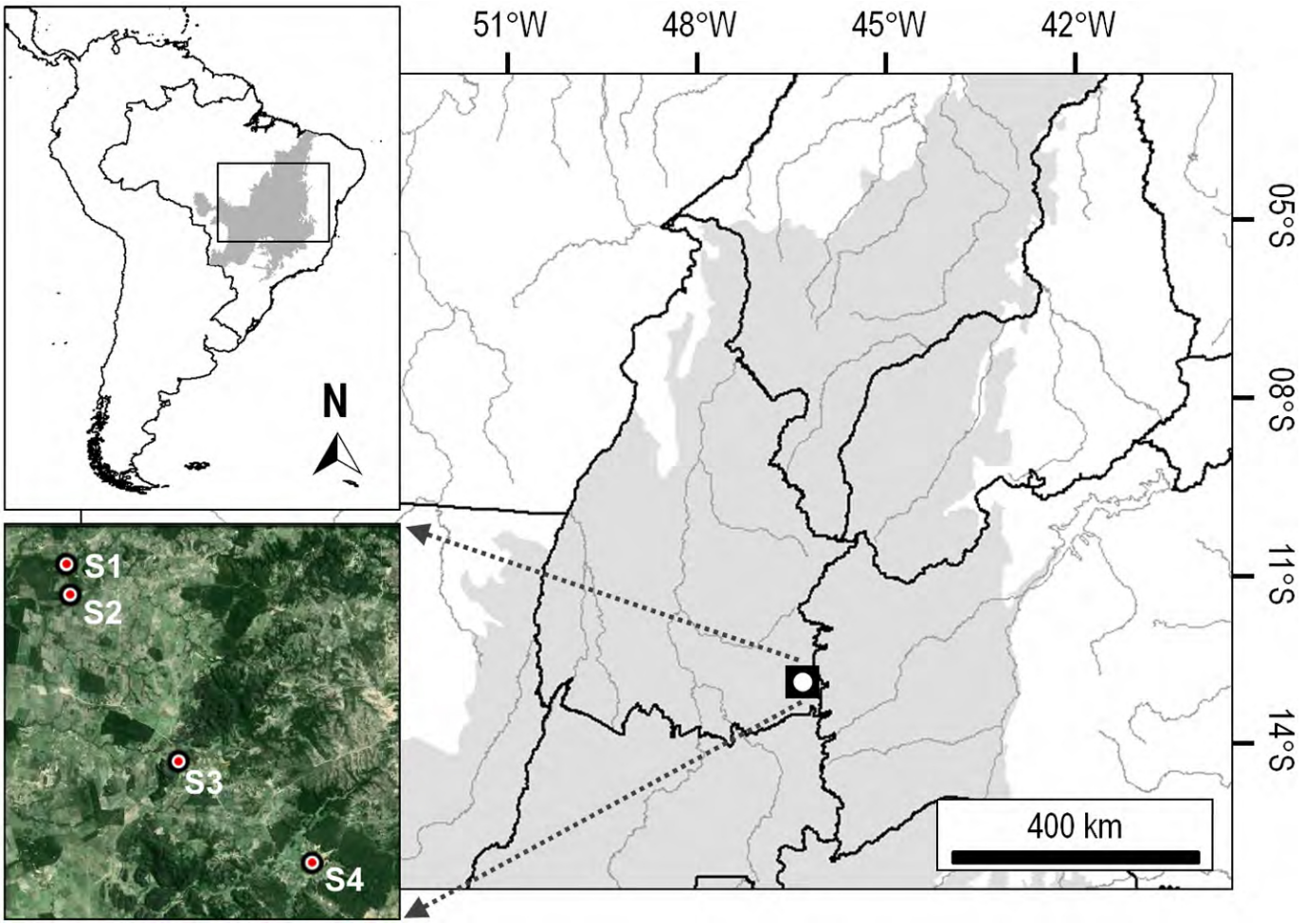

Figure 1. Study area in Aurora do Tocantins, northern Brazil, in the context of the Cerrado (in gray).

Sociedade Brasileira de Espeleologia (2014), Aurora do Tocantins has the eighth highest number of caves (99 records), although many caves in the area are not mapped and officially registered. This makes Aurora do Tocantins one of the most important karstic areas of the Brazilian Cerrado.

Data collection and analysis

We sampled four sites (Site 1: 12°34′54″S, 046°30′59″W; Site 2: 12°35′31″S, 046°30′56″W; Site 3: 12°40′04″S, 046°28′04″W; Site 4: 12°42′46″S, 046°24′19″W) composed of remnants of semi-deciduous forest and savanna in a matrix of open areas (pastures) and agricultural fields (Figure 1; Table 1). In January 2012, we performed eight sampling nights using eight to ten mist-nets (average of 8.8 nets/night, SD ± 0.8) (Zootech®, 9×3 m, 20 mm mesh). The mist-nets remained open all night (from sunset to sunrise), inspected at 30-minute intervals, and placed along trails within forest and savanna remnants. Bats were marked using small holes in wing membranes, a temporary marking technique (Bonaccorso and Symthe 1972).

Table 1. Sampling sites of community structure of bats from karstic Cerrado of Tocantins state, northern Brazil.

Localities	Coordinates	Remnant size (ha)	Sampling effort (m^2·h)
Site 1	12°34′54″ S, 046°30′59″ W	350	14,256
Site 2	12°35′31″ S, 046°30′56″ W	700	2,856
Site 3	12°40′04″ S, 046°28′04″ W	400	2,856
Site 4	12°42′46″ S, 046°24′19″ W	4	2,856

The bats were identified from external characters (e.g., length of forearm, pelage coloration patterns, morphology of ears and tragus, etc.) and craniodental characters, following the literature descriptions (e.g., Simmons and Voss 1998; Lim and Engstrom 2001; Gardner 2008; Reis et al. 2007, 2013). We collected at least one individual of each species, and others that generated identification doubts. Vouchers were deposited in the mammalian collection of Museu Nacional, Universidade Federal do Rio de Janeiro (Appendix, Table A1). All procedures with animals followed the recommendations by Sikes et al. (2011). The captures and specimen collections were authorized by SISBIO/IBAMA (authorization number 4028-1/28717). The nomenclature of bats followed Nogueira et al. (2014).

The sampling effort was calculated following Straube and Bianconi (2002). We calculated the capture efficiency dividing the number of captures by the sampling effort in each locality sampled. The species richness estimation was made using Chao-1 method (Magurran

2004) and the rarefaction curve with 95% confidence interval were performed using the software PAST 3.0 (Hammer et al. 2001).

To determine the composition of bat species occurring simultaneously in caves of Aurora of Tocantins, we chose two caves to sample: Gruta dos Moura (12°34′54″S, 046°30′59″W) and Gruta do Urso (12°34′56″S, 046°30′59″W). These caves were chosen for their ease of access and because of knowledge by one of us (LSA) of their interiors from previous studies (e.g., Castro et al. 2013; Rodrigues et al. 2014; Soibelzon et al. 2015; see these studies for a basic description of caves). These caves are separated by approximately 500 m and have no connection with each other. We set mist-nets in the entrance of the caves before nightfall (16:30 h). The mist-nets remained open for three hours after sunset. To determine which species use the cave as a roost, only individuals captured exiting the caves were considered. Captures made in caves were not considered in the quantitative analysis of community structure.

Table 2. Bats from karstic Cerrado of Tocantins state, northern Brazil, including number of captures per sampling site, total number of capture (N) and relative abundance (%).

Taxa	Site 1	Site 2	Site 3	Site 4	N	%
Emballonuridae						
Peropteryx macrotis (Wagner, 1843)	5	0	0	0	5	1.0
Phyllostomidae						
Micronycterinae						
Micronycteris sanborni Simmons, 1996	4	1	0	0	5	1.0
Micronycteris schmidtorum Sanborn, 1935	1	0	0	0	1	0.2
Desmodontinae						
Desmodus rotundus (É. Geoffroy, 1810)	189	2	6	0	197	38.1
Diphylla ecaudata Spix, 1823	3	0	0	0	3	0.6
Phyllostominae						
Chrotopterus auritus (Peters, 1856)	6	0	0	0	6	1.2
Mimon bennettii (Gray, 1838)	1	0	1	0	2	0.4
Phylloderma stenops Peters, 1865	3	0	0	0	3	0.6
Phyllostomus discolor Wagner, 1843	1	0	0	0	1	0.2
Phyllostomus elongatus (É. Geoffroy, 1810)	5	0	0	0	5	1.0
Phyllostomus hastatus (Pallas, 1767)	15	0	1	4	20	3.8
Trachops cirrhosus (Spix, 1823)	9	0	0	0	9	1.7
Glossophaginae						
Anoura caudifer (É. Geoffroy, 1818)	2	0	0	2	4	0.8
Glossophaga soricina (Pallas, 1766)	29	2	0	1	32	6.2
Lonchophyllinae						
Lionycteris spurrelli Thomas, 1913	4	0	0	0	4	0.8
Lonchophylla dekeyseri Taddei, Vizotto & Sazima, 1983	8	0	0	0	8	1.5
Carolliinae						
Carollia perspicillata (Linnaeus, 1758)	36	2	0	21	59	11.4
Glyphonycterinae						
Glyphonycteris sylvestris Thomas, 1896	1	0	0	0	1	0.2
Stenodermatinae						
Artibeus planirostris Spix, 1823	34	21	32	20	107	20.7
Chiroderma villosum Peters, 1860	0	0	1	0	1	0.2
Platyrrhinus lineatus (É. Geoffroy, 1810)	12	0	0	0	12	2.3
Sturnira lilium (É. Geoffroy, 1810)	4	0	6	0	10	1.9
Mormoopidae						
Pteronotus parnellii (Gray, 1843)	1	0	0	0	1	0.2
Noctilionidae						
Noctilio leporinus (Linnaeus, 1758)	1	0	0	0	1	0.2
Furipteridae						
Furipterus horrens (F. Cuvier, 1828)	5	0	0	0	5	1.0
Molossidae						
Molossops temminckii (Burmeister, 1854)	5	0	1	0	6	1.2
Molossus molossus (Pallas, 1766)	0	0	0	2	2	0.4
Vespertilionidae						
Eptesicus diminutus Osgood, 1915	0	1	1	0	2	0.4
Eptesicus furinalis (d'Orbigny & Gervais, 1847)	1	0	0	0	1	0.2
Total	**385**	**29**	**52**	**50**	**516**	**100**

RESULTS

Assemblage structure

We captured 516 specimens of 30 species: one species of Emballonuridae, 22 species of Phyllostomidae, one species of Mormoopidae, one species of Noctilionidae, one species of Furipteridae, two species of Molossidae, and two species of Vespertilionidae (Table 2).

The total sampling effort was 22.824 $m^2 \cdot h$ and the total capture efficiency was 0.022 bats/$m^2 \cdot h$. The Chao-1 index estimated 45 species as the maximum richness (SD ± 1.0), which is an indication that with increased capture effort more species will be recorded for the region. The rarefaction curve also indicates that more species will be recorded by increasing the capture effort (Figure 2). The family with the most number of captures was Phyllostomidae, with 95% of the captures.

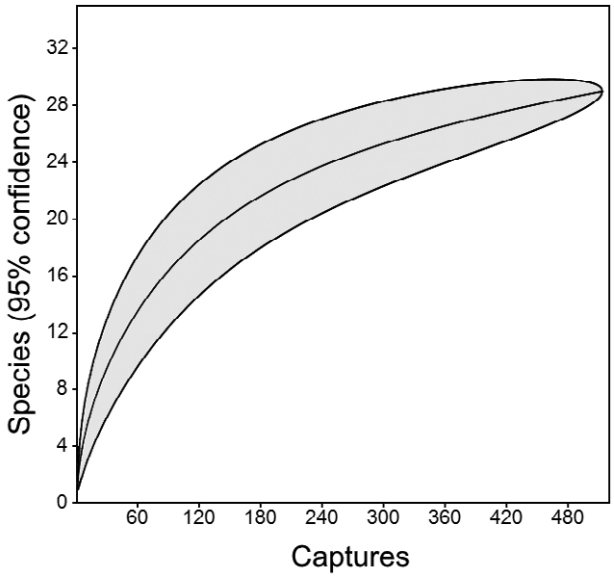

Figure 2. Rarefaction curve for the bat community in Aurora do Tocantins, northern Brazil.

Desmodus rotundus (É. Geoffroy, 1810) was the most abundant species with 197 captures (38%), followed by *Artibeus planirostris* Spix, 1823 and *Carollia perspicillata* (Linnaeus, 1758), with 107 (21%) and 60 captures (12%), respectively. No recapture was made.

New records

We provide seven new occurrence records to Tocantins state: *Peropteryx macrotis* (Wagner, 1843), *Anoura caudifer* (É. Geoffroy, 1818), *Chrotopterus auritus* (Peters, 1856), *Diphylla ecaudata* Spix, 1823, *Glyphonycteris sylvestris* Thomas, 1896, *Mimon bennettii* (Gray, 1838) and *Chiroderma villosum* Peters, 1860 (Figure 3). Previously in the same locality, *Furipterus horrens* (F. Cuvier, 1828) and *Phyllostomus elongatus* (E. Geoffroy, 1810) were already reported as first occurrences for Tocatins state (Novaes et al. 2012, 2014).

The capture of *G. sylvestris* is the first record of this species for the Cerrado domain and expands the species' distribution by approximately 1,500 km south of the Amazonian populations and more than 850 km north of the Atlantic Forest populations (Figure 4). Occurrence data of this species in South America are shown in Table 3.

Caves survey

Through direct observations, mist-netting at caves exits, and manual captures, we recorded 22 species occupying two caves, with a great difference in species richness between them: Gruta dos Moura has 21 species (including 11 exclusive species) and Gruta do Urso has 11 species (with one species recorded only in this cave; Table 4). We compiled the bat richness in 139 caves from seven countries in the Neotropics (Brazil, Bolivia, Colombia, Cuba, Honduras, Mexico, and Venezuela). The species richness in caves ranged from zero in Buena

Figure 3. New records of bats for Tocantins state, northeastern Brazil. **A.** *Peropteryx macrotis*. **B.** *Anoura caudifer*. **C.** *Chrotopterus auritus*. **D.** *Diphylla ecaudata*. **E.** *Mimon bennettii*. **F.** *Chiroderma villosum*. **G.** *Glyphonycteris sylvestris,* including a new record for the Cerrado. Photos by Roberto Leonan Morim Novaes.

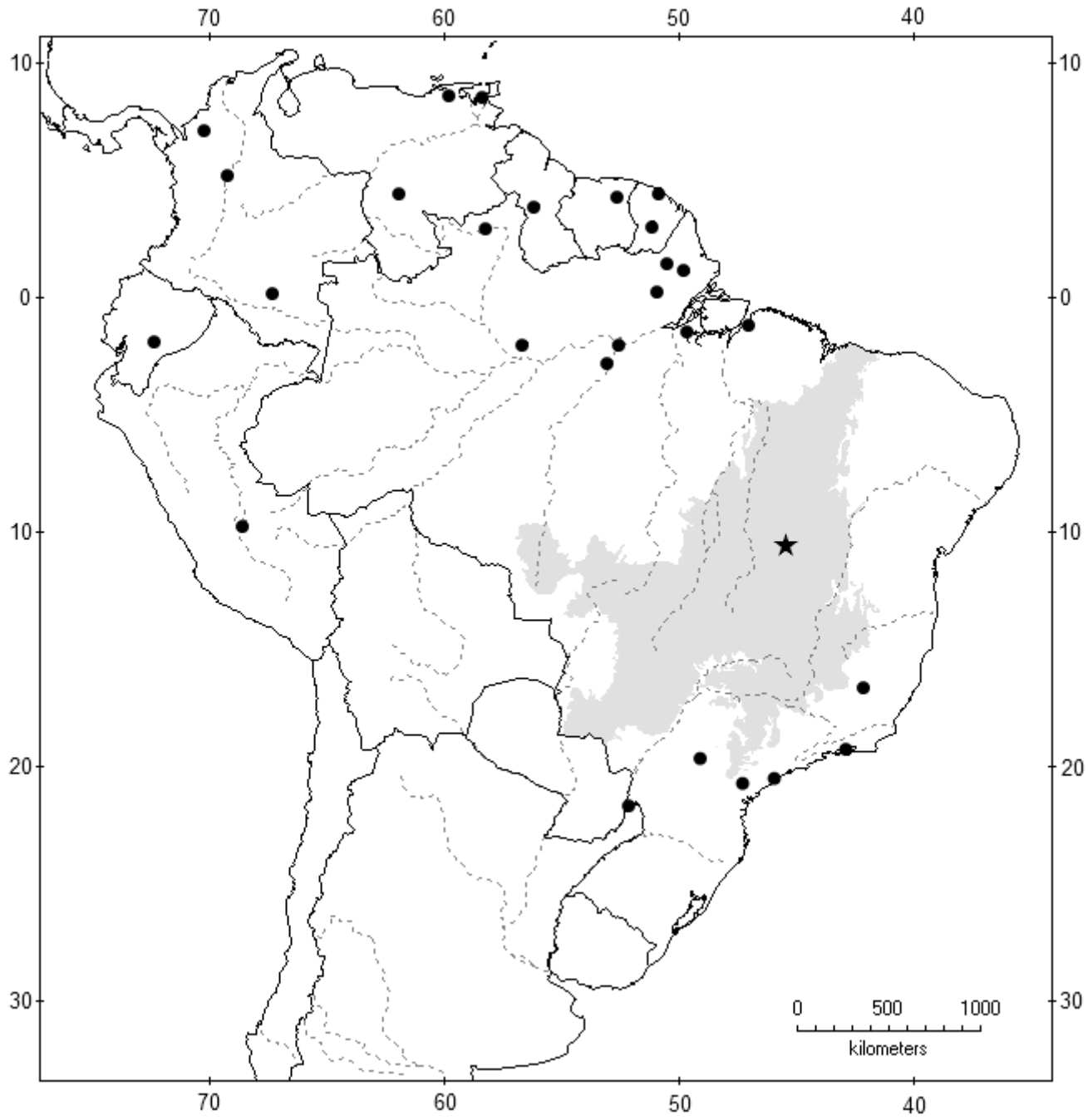

Figure 4. Records of *Glyphonycteris sylvestris* (dots) in South America, including a new record from Cerrado (gray) from Tocantins, Northern Brazil (star).

Vista Cave, Mexico, to 17 at Gruta da Judite, Brazil (Appendix, Table A2). Our literature review indicates Gruta dos Moura as the richest cave for bat species in the Neotropics.

DISCUSSION

Assemblage structure and new records

Bat inventories in the Cerrado presented a richness raging from three to 39 species (e.g., Gonçalves and Gregorin 2004; Bordignon 2006; Zortéa and Alho 2008; Cunha et al. 2009; Bezerra and Marinho-Filho 2010; Ferreira et al. 2010; Zortéa et al. 2010; Cunha et al. 2011; Gregorin et al. 2011; Sousa et al. 2013; Muylaert et al. 2014; Shapiro and Bordignon 2014). However, this richness can be considerably higher in areas with caves (Bredt et al. 1999; Esbérard et al. 2005; Gregorin et al. 2011). Brunet and Medellín (2001) indicate that species richness tends to be higher in karstic areas compared with environments without caves. Probably, the high species richness of bats in Aurora do Tocantins is due to limestone caves, which increase the availability of roosts, making possible the coexistence of a large number of species (Trajano 1995).

Bat species richness in Aurora do Tocantins is higher than the average found in other Cerrado localities, only behind Estação Ecológica Serra Geral de Tocantins, with 39 species (Gregorin et al. 2011). However, the difference between those areas can be explained by the

difference in sampling effort employed, with the effort being greater in Serra Geral do Tocantins (Gregorin et al. 2011). The capture efficiency obtained by us was 0.022 bats/m²·h, also considered high for Cerrado areas, with minimum values of 0.002 bats/m²·h in the Serra Geral do Tocantins (Gregorin et al. 2011) and maximum around 0.032 bats/m²·h in the Aporé-Sucuriú Complex of Mato Grosso do Sul (Bordignon 2006).

Table 4. Bats captured in two caves in Aurora do Tocantins, northern Brazil: presence (X) and absence (–).

Species	Moura Cave	Urso Cave
Peropteryx macrotis	X	X
Glossophaga soricina	X	X
Lionycteris spurrelli	X	–
Lonchophylla dekeyseri	X	–
Desmodus rotundus	X	X
Diphylla ecaudata	X	X
Carollia perspicillata	X	X
Chrotopterus auritus	X	X
Glyphonycteris sylvestris	X	–
Micronycteris sanborni	X	–
Micronycteris schmidtorum	X	–
Mimon bennettii	X	X
Phylloderma stenops	X	–
Phyllostomus discolor	X	–
Phyllostomus elongatus	X	–
Phyllostomus hastatus	X	X
Trachops cirrhosus	X	–
Artibeus planirostris	–	X
Platyrrhinus lineatus	X	X
Furipterus horrens	X	X
Noctilio leporinus	X	–
Pteronotus parnellii	X	–
Total	21	11

This study recorded seven new occurrences of species for Tocantins state, increasing the state's species diversity to 60 (Novaes et al. 2012; Reis et al. 2013; Novaes et al. 2014; Lapenta and Bueno 2015). Other than *G. sylvestris*, occurrences of six widely distributed species in the Brazilian Cerrado were expected in Tocantins and required only formalization with voucher deposits. Our report of *G. sylvestris* is the first from the Cerrado. This species is rare throughout its range and has two disjunct populations: one from Costa Rica to the Amazon basin, occupying areas east of the Andes, Venezuela, Colombia, French Guiana, Suriname, Peru, and Trinidad and Tobago, and another population occurring in the Atlantic Forest in southeastern Brazil (Williams and Genoways 2008). However, our record of this species from Aurora do Tocantins, in a deciduous forest area inserted into the Cerrado, is midway between the two populations. More studies are needed to determine if the population of *G. sylvestris* found in Aurora do Tocantins is relictual and has no functional connection with other populations. However, the incipient distributional information about *G. sylvestris* may result from misidentifications. According

Table 3. Occurrences of *Glyphonycteris sylvestris* in South America.

Locations	Coordinates	Authors
Salazar Trace, Trinidad and Tobago	10°07'N, 61°47'W	Goodwin and Greenhall (1961)
Brokopondo, Brownsweg, Suriname	05°00'N, 54°59'W	Williams and Genoways (1980)
Paracou, Sinnamary, French Guiana	05°16'N, 52°55'W	Simmons and Voss (1998)
Saül, French Guiana	03°38'N, 53°13'W	Brosset and Dubost (1968)
Iwokrama Forest, Potaro-Siparuni, Guyana	04°32'N, 59°05'W	Lim and Engstrom (2001)
Cueva del Guácharo, Monagas, Venezuela	10°07'N, 63°29'W	Linares (1969)
San Juan de Manapiare, Amazonas, Venezuela	05°15'N, 66°05'W	Lim and Engstrom (2001)
Socorré, Alto Rio Sinú, Bolivar, Colombia	Not mentioned	Simmons (1996)
Vereda Las Confusas, Antioquia, Colombia	05°59'N, 74°48'W	Morales-Martínez and Suárez-Castro (2014)
Estación Puerto Abeja, Caquetá, Colombia	00°04'N, 72°26'W	Montenegro and Romero-Ruiz (2000)
Sangay National Park, Morona Santiago, Ecuador	02°05'S, 78°09'W	Tirira et al. (2016)
Cordillera Vilcabamba, Cuzco, Peru	11°35'S, 73°54'W	Koopman (1978)
Ilha de Maracá, Roraima, Brazil	03°25'N, 61°39'W	Robinson (1998)
Montanhas do Tumucumaque, Amapá, Brazil	01°36'N, 52°29'W	Martins et al. (2011)
FLONA do Amapá, Amapá, Brazil	01°17'N, 51°35'W	Martins et al. (2011)
Rio Iratapuru, Amapá, Brazil	00°16'N, 53°06'W	Martins et al. (2011)
Guamá, Pará, Brazil	01°26'S, 48°25'W	Handley (1967)
Estação Científica Ferreira Penna, Pará, Brazil	01°44'S, 51°27'W	Marques-Aguiar et al. (2009)
80 km N of Manaus, Amazonas, Brazil	02°24'S, 59°43'W	Bernard (2001)
Alter do Chão, Pará, Brazil	02°30'S, 54°57'W	Bernard and Fenton (2002)
FLONA Tapajós, Pará, Brazil	03°21'S, 45°57'W	Castro-Arellano et al. (2007)
Aurora do Tocantins, Tocantins, Brazil	12°34'S, 46°31'W	Present study
Antônio Dias, Minas Gerais, Brazil	19°44'S, 42°37'W	Tavares et al. (2010)
ESEC dos Caetetus, São Paulo, Brazil	22°22'S, 49°40'W	Pedro et al. (2001)
Pedra Branca, Rio de Janeiro, Brazil	22°56'S, 43°26'W	Dias et al. (2003)
Juréia-Itatins, São Paulo, Brazil	24°24'S, 47°01'W	Gimenez and Ferrarezzi (2004)
PETAR, Alto Ribeira, São Paulo, Brazil	24°34'S, 48°41'W	Trajano (1982)
Parque Nacional do Iguaçu, Paraná, Brazil	25°43'S, 54°25'W	Sekiama et al. (2001)

to Nogueira et al. (2007), this species can be misidentified as bats of the genera *Carollia* and *Trinycteris*. Therefore, it is possible that taxonomic review of museum collections of *Glyphonycteris*, *Carollia,* and *Trinycteris* specimens may yield new occurrence data for *G. sylvestris*.

We recorded other rare species, including *Micronycteris schmidtorum* Sanborn, 1935*, Phylloderma stenops* Peters, 1865*,* and *Lonchophylla dekeyseri* Taddei, Vizotto & Sazima, 1983. The last species is endemic to the Cerrado and Caatinga ecoregions of South America and is classified as Near Threatened (Sampaio et al. 2008). This shows the importance of conservation of the caves and the surrounding savanna and forest habitats of the Aurora do Tocantins region for the maintenance of bat diversity.

Caves surveys

Studies on bats in caves are rare throughout the Neotropics, precluding a robust data comparison. However, according to our results, Gruta dos Moura, with 21 species, has the highest richness of bat species of any cave in the Neotropical region. Surveys in Brazil revealed species richness ranged from one to 17 species of bats per cave (e.g., Esbérard et al. 1998; Trajano and Gimenez 1998; Bredt et al. 1999; Esbérard et al. 2005). Studies in other Neotropical countries indicate a maximum 12 species per cave (Appendix, Table A2). Arita (1996) found from one to 12 species per cave in a survey conducted in 36 caves in Mexico. Also in Mexico, Brunet and Medellin (2001) studied bat diversity of 20 caves recorded from zero to 11 species per cave. Molinari et al. (2012) found from four to five species in four Venezuelan caves. Siles et al. (2007) reported six to seven species in three caves in Bolivia. In Colombia, one to 10 species were reported in 13 different caves (Muñoz-Saba et al. 1999; Pérez-Torres et al. 2015). Two caves in Honduras had their richnesses estimated from three to five species (Divoll and Buck 2013), and from a cave in Cuba six species were recorded (Mora et al. 2002).

Despite the little knowledge on bat fauna in caves, some studies suggest a trend of positive correlation between the size of the cave and the number of species (Arita 1996; Brunet and Medellín 2001). Probably, this species–area relationship, where larger caves tend to have greater species richness of bats, is explained by greater humidity values and the presence of speleothems and cavities (Brunet and Medellín 2001).

Conservation considerations

Decree 6,640 of 7 November 2008 relaxed the laws to protect Brazilian caves. It represents a retreat in the legislation that protects the natural heritage and allows for the complete destruction of caves that have economic interest. The most plausible result of this loss of protection is an increase in the rate of biodiversity loss (Novaes 2012; Trajano 2013). Moreover, the Gruta dos Moura cave and the surrounding savanna vegetation are within in an area of intensive agricultural activity and not protected by conservation units. Therefore, although it has the highest richness of bat species found in a single cave in Neotropics, this cave is susceptible on anthropogenic exploration, which may cause its complete destruction. Some caves of this karstic complex already have signs of anthropogenic disturbance, such as damaged speleothems and dumped garbage in the cave entrances. We also found signs of hunting (ammunition for firearms) at the entrance to Gruta do Urso.

Considering the expansiveness of the karstic complex of Aurora do Tocantins, we believe that the richness and abundance of bats may be greater than that reported here. Bats contribute in a crucial way to the maintenance of essential ecological services, such as seed dispersal and insect population control (Wilson 1973; Kalka et al. 2008; Kunz et al. 2011; Puig-Montserrat et al. 2015).

In Aurora do Tocantins, the destruction of caves and their surrounding vegetation may do damage to local agriculture by the loss of pest-control bat species (see Boyles et al. 2011). The loss of these caves and their bats would be a serious setback for the conservation of the remaining Cerrado and its biodiversity. Paleontological studies have shown the importance of these caves for the fossil record (Oliveira et al. 2011; Castro et al. 2013; Rodrigues et al. 2014; Soibelzon et al. 2015).

With the exception of this first study of bats from Aurora do Tocantins, there is no other information about the extant wildlife found in the municipality, making it difficult to build a case for classifying the area as a priority for conservation, which would allow its legal protection as a conservation unit.

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APPENDIX

Table A1. Vouchers of bats from Aurora Tocantins deposited in the Museu Nacional, Universidade Federal do Rio de Janeiro, Brazil (MN).

Family	Species	Voucher number
Emballonuridae	*Peropteryx macrotis*	MN81194, MN81196, MN81220, MN81221
Phyllostomidae	*Anoura caudifer*	MN81187, MN81188
	Glossophaga soricina	MN81183, MN81193, MN81199, MN81200, MN81202, MN81203, MN81209, MN81211, MN81212, MN81214, MN81215, MN81216, MN81218
	Lionycteris spurrelli	MN81195, MN81205, MN81217
	Lonchophylla dekeyseri	MN81184, MN81190, MN81213
	Desmodus rotundus	MN78108, MN78109, MN78110, MN78111
	Diphylla ecaudata	MN78112, MN78113
	Carollia brevicauda	MN81197, MN81208, MN81219
	Carollia perspicillata	MN81191, MN81198, MN81210
	Chrotopterus auritus	MN78107
	Glyphonycteris sylvestris	MN78118
	Micronycteris sanborni	MN81185, MN81201
	Micronycteris schmidtorum	MN81206
	Mimmon bennettii	MN78119, MN78120
	Phylloderma stenops	MN81186, MN81189, MN81192
	Phyllostomus discolor	MN78387
	Phyllostomus elongatus	MN78388, MN78389, MN78390
	Phyllostomus hastatus	MN78383, MN78384, MN78385, MN78386
	Trachops cirrhosus	MN78122, MN78123
	Artibeus planirostris	MN78396, MN78397, MN78398
	Chiroderma villosum	MN78393
	Platyrrhinus lineatus	MN78394, MN78397
	Sturnira lilium	MN78391, MN78392
Furipteridae	*Furipterus horrens*	MN78114, MN78115, MN78116, MN78117
Noctilionidae	*Noctilio leporinus*	MN78124
Mormoopidae	*Pteronotus parnellii*	MN78121
Molossidae	*Molossops temminckii*	MN78399, MN78400, MN78401, MN78402
	Molossus molossus	MN81222
Vespertilionidae	*Eptesicus diminutus*	MN81182, MN81204
	Eptesicus furinalis	MN81207

Table A2. Caves compiled by literature review, including species richness of bats and author of the record.

Country	State/district/ department	Municipality	Cave	No. of species	Source
Brazil	Tocantins	Aurora do Tocantins	Gruta dos Moura	21	Present study
	Tocantins	Aurora do Tocantins	Gruta do Urso	11	Present study
	Goiás	Posse	Caverna dos Revolucionários	6	Esbérard et al. 2005
	Goiás	Posse	Caverna Asa Branca	8	Esbérard et al. 2005
	Goiás	Buritinópolis	Gruta da Fazenda Bananal	8	Esbérard et al. 2005
	Goiás	Buritinópolis	Gruna Meândrica	3	Esbérard et al. 2005
	Goiás	Buritinópolis	Gruta da Judite	17	Esbérard et al. 2005
	Goiás	Buritinópolis	Lapa da Fazenda Extrema	9	Esbérard et al. 2005
	Goiás	Buritinópolis	Lapa da Lapa	11	Esbérard et al. 2005
	Goiás	Mambaí	Caverna Nova Esperança	6	Esbérard et al. 2005
	Goiás	Mambaí	Gruta da Fazenda Arroz	5	Esbérard et al. 2005
	Goiás	Mambaí	Caverna Ventura	8	Esbérard et al. 2005
	Goiás	Mambaí	Gruta Borá	4	Esbérard et al. 2005
	Goiás	Mambaí	Gruta do Landim	4	Esbérard et al. 2005
	Goiás	Damianópolis	Lapa da Fazenda Buritizinho	7	Esbérard et al. 2005
	Goiás	Padre Bernardo	Gruta Morro	13	Bredt et al. 1999
	Goiás	Padre Bernardo	Toca da Gameleira	8	Bredt et al. 1999
	Goiás	Padre Bernardo	Gruta das Orquídeas	4	Bredt et al. 1999
	Distrito Federal	Brazlândia	Gruta do Sal	8	Bredt et al. 1999
	Distrito Federal	Brazlândia	Gruta Fenda II	8	Bredt et al. 1999
	Distrito Federal	Brazlândia	Gruta da Barriguda	8	Bredt et al. 1999
	Distrito Federal	Brazlândia	Gruta Labirinto da Lama	5	Bredt et al. 1999
	Distrito Federal	Brazlândia	Gruta Dois Irmãos	9	Bredt et al. 1999

Continued

Table A2. *Continued.*

Country	State/district/ department	Municipality	Cave	No. of species	Source
	Distrito Federal	Brazlândia	Gruta Muralha	2	Bredt et al. 1999
	Distrito Federal	Sobradinho	Gruta da Saúva	7	Bredt et al. 1999
	Distrito Federal	Sobradinho	Gruta dos Morcegos	3	Bredt et al. 1999
	Distrito Federal	Sobradinho	Gruta Kipreste	3	Bredt et al. 1999
	Distrito Federal	Sobradinho	Gruta Mogi	7	Bredt et al. 1999
	Distrito Federal	Sobradinho	Gruta Boca de Lobo	1	Bredt et al. 1999
	Distrito Federal	Planaltina	Gruta Dança dos Vampiros	9	Bredt et al. 1999
	Distrito Federal	Planaltina	Gruta Água Rasa	8	Bredt et al. 1999
	Distrito Federal	Paranoá	Gruta Volks Club	8	Bredt et al. 1999
	Distrito Federal	Paranoá	Toca Mata da Anta	3	Bredt et al. 1999
	Distrito Federal	Ceilândia	Toca do Falcão	6	Bredt et al. 1999
	Distrito Federal	Ceilândia	Fenda do Barreiro	5	Bredt et al. 1999
	Minas Gerais	Itacarambi	Caverna Olhos d'Água	13	Trajano and Gimenez 1998
	Rio de Janeiro	Cantagalo	Caverna Santana	7	Esbérard et al. 1998
	São Paulo	Iporanga	Gruta Águas Quentes	4	Trajano 1985
	São Paulo	Iporanga	Caverna Água Suja	8	Trajano 1985
	São Paulo	Iporanga	Caverna Alambari de Baixo	5	Trajano 1985
	São Paulo	Iporanga	Gruta Alambari de Cima	1	Trajano 1985
	São Paulo	Iporanga	Complexo das Areias	4	Trajano 1985
	São Paulo	Iporanga	Toca Berta Funda	4	Trajano 1985
	São Paulo	Iporanga	Gruta do Betari	5	Trajano 1985
	São Paulo	Iporanga	Gruta do Chapéu	2	Trajano 1985
	São Paulo	Iporanga	Gruta do Córrego Seco	4	Trajano 1985
	São Paulo	Iporanga	Gruta do Grilo	3	Trajano 1985
	São Paulo	Iporanga	Abismo da Gurutuvai	3	Trajano 1985
	São Paulo	Iporanga	Abismo da Hipotenusai	3	Trajano 1985
	São Paulo	Iporanga	Gruta do Jeremias	2	Trajano 1985
	São Paulo	Iporanga	Gruta da Laje Branca	2	Trajano 1985
	São Paulo	Iporanga	Gruta do Macaco	2	Trajano 1985
	São Paulo	Iporanga	Gruta do Morro Preto	4	Trajano 1985
	São Paulo	Iporanga	Gruta do Couto	2	Trajano 1985
	São Paulo	Iporanga	Gruta Ouro Grosso	3	Trajano 1985
	São Paulo	Iporanga	Abismo da Passoca	2	Trajano 1985
	São Paulo	Iporanga	Caverna Santana	3	Trajano 1985
	São Paulo	Iporanga	Santana IV	4	Trajano 1985
	São Paulo	Iporanga	Gruta do Sítio Novo	2	Trajano 1985
	São Paulo	Iporanga	Sumidouro do David	2	Trajano 1985
	São Paulo	Iporanga	Gruta do Zezo	2	Trajano 1985
	São Paulo	Ribeira	Caverna Tiraprosa	5	Trajano 1985
	São Paulo	Ribeira	Toca do Porco	4	Trajano 1985
	São Paulo	Apiaí	Gruta Calcáreo Branco	3	Trajano 1985
	São Paulo	Apiaí	Gruta dos Vieira	4	Trajano 1985
	Paraná	Adrianópolis	Gruta São João	4	Trajano 1985
Mexico	Yucatán	-	Ruins of Kabah	1	Arita 1996
	Yucatán	-	Zorro Cave	1	Arita 1996
	Yucatán	-	Cave "A"	1	Arita 1996
	Yucatán	-	Actun Chac-Xix	1	Arita 1996
	Yucatán	-	Aguacate Cave	1	Arita 1996
	Yucatán	-	Actun Kan-Lol	1	Arita 1996
	Yucatán	-	Actun Dzonot	1	Arita 1996
	Yucatán	-	Actun Kab	1	Arita 1996
	Yucatán	-	Actun X-Maasit	1	Arita 1996
	Yucatán	-	Actun On	2	Arita 1996
	Yucatán	-	Porcupine Cave	2	Arita 1996
	Yucatán	-	La Doña Blanca Cave	2	Arita 1996
	Yucatán	-	Actun Tolok	2	Arita 1996
	Yucatán	-	Guayaba y Aguacate	2	Arita 1996
	Yucatán	-	Acanceh Cave	2	Arita 1996
	Yucatán	-	Iguana Cave	2	Arita 1996
	Yucatán	-	Actun Chunkunab	2	Arita 1996

Continued

Table A2. *Continued.*

Country	State/district/ department	Municipality	Cave	No. of species	Source
	Yucatán	-	Actun Maas	2	Arita 1996
	Yucatán	-	Kabahchen Cave	2	Arita 1996
	Yucatán	-	Actun Sitz	2	Arita 1996
	Yucatán	-	Chocantes Cave	2	Arita 1996
	Yucatán	-	Cave "B"	2	Arita 1996
	Yucatán	-	Bejucos Cave	3	Arita 1996
	Yucatán	-	Actun Oxpehol	3	Arita 1996
	Yucatán	-	Ramonal y Naranja	3	Arita 1996
	Yucatán	-	Roble Cave	4	Arita 1996
	Yucatán	-	Flor de Mayo Cave	4	Arita 1996
	Yucatán	-	Ramonal Cave	4	Arita 1996
	Yucatán	-	Ruins of Mayapan	4	Arita 1996
	Yucatán	-	Cinco de Mayo Cave	5	Arita 1996
	Yucatán	-	Bat Cave	7	Arita 1996
	Yucatán	-	Hoctun Cave	8	Arita 1996
	Yucatán	-	Actun Sabak-ha	8	Arita 1996
	Yucatán	-	Tzab-Nah Cave	9	Arita 1996
	Yucatán	-	Actun Spukil	9	Arita 1996
	Yucatán	-	Actun Lol-Tun	12	Arita 1996
	Puebla	-	La Escondida	1	Brunet and Medellin 2001
	Puebla	-	El Escorpion	1	Brunet and Medellin 2001
	Puebla	-	La Herradura	1	Brunet and Medellin 2001
	Puebla	-	Buenavista	no	Brunet and Medellin 2001
	Puebla	-	El Manantial	1	Brunet and Medellin 2001
	Puebla	-	El Tigre	1	Brunet and Medellin 2001
	Puebla	-	Mision Imposible	2	Brunet and Medellin 2001
	Puebla	-	La Salamandra	6	Brunet and Medellin 2001
	Puebla	-	San Martin	5	Brunet and Medellin 2001
	Puebla	-	El Arenal	4	Brunet and Medellin 2001
	Puebla	-	El Sapo	4	Brunet and Medellin 2001
	Puebla	-	Waterfall	1	Brunet and Medellin 2001
	Puebla	-	Nacho Sosa	2	Brunet and Medellin 2001
	Puebla	-	Los Copales	3	Brunet and Medellin 2001
	Puebla	-	La Ciudad	6	Brunet and Medellin 2001
	Puebla	-	El Coyote	3	Brunet and Medellin 2001
	Puebla	-	La Piramide	3	Brunet and Medellin 2001
	Puebla	-	Virgen	7	Brunet and Medellin 2001
	Puebla	-	El Tigre Grande	1	Brunet and Medellin 2001
	Puebla	-	Cuevade Las Vegas	11	Brunet and Medellin 2001
Honduras	Tegucigalpa	Masca	Piedra Cocha	3	Divoll and Buck 2013
	Tegucigalpa	San Juancito	Cueva1	5	Divoll and Buck 2013
Bolivia	Cochabamba	-	Repechón cave A	7	Siles et al. 2007
	Cochabamba	-	Repechón cave B	7	Siles et al. 2007
	Cochabamba	-	Repechón cave C	6	Siles et al. 2007
Venezuela	Paranaguá	Falcón	Cueva del Guano	5	Molinari et al. 2012
	Paranaguá	Falcón	Cuevade Piedra Honda	5	Molinari et al. 2012
	Paranaguá	Falcón	Cuevade Jacuque	4	Molinari et al. 2012
	Paranaguá	Los Taques	Cueva N° 2 del Pico	4	Molinari et al. 2012
Cuba	La Habana	San José de Las Lajas	Cuevadel Indio	6	Mora et al. 2002.
Colombia	Santander	Curití	Macaragua cave	10	Pérez-Torres et al. 2015
	Antioquia	Río Claro	Caverna de Ilusiones IIIb	1	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	Caverna Corinto	4	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	Caverna Ilusiones IIIa	3	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	Caverna Ilusiones IV	5	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	Caverna Tambores	5	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	Caverna Chontaduro	1	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	Caverna Mauro I	4	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	Caverna Mauro II	2	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	El Condor	3	Muñoz-Saba et al. 1999
	Antioquia	Río Claro	La Danta	2	Muñoz-Saba et al. 1999