

An important site for conservation of bats in Brazil: Passa Três cave, São Domingos karst area, with an updated checklist for Distrito Federal (DF) and Goiás state

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Abstract

A checklist of bats from Distrito Federal (DF) and Goiás state (GO) and, particularly a single cave (Passa Três cave), located in São Domingos karst area (GO), central Brazil, is presented. Data is based on literature and surveys carried out during 2,000 years. In total, 66 species were recorded, with 30 using caves as shelters. Passa Três cave harbors nine Phyllostomidae species; the most abundant species were *Platyrrhinus lineatus*, *Lonchorhina aurita*, *Desmodus rotundus* and *Carollia perspicillata*; and the less abundants *Trachops cirrhosus*, *Anoura caudifer* and *Glossophaga soricina*. Besides, the cave is shelter of two threatened bats - *Lonchophylla dekeyseri* (Endangered category) and *Lonchorhina aurita* (Vulnerable category), included at Brazilian List of Threatened Fauna, and of a rare species, *Lionycteris spurrelli*. Passa Três cave shows enough attributes to be considered as a SICOM (Sites of Importance for Conservation of Bats), which would ensure its protection.

Keywords

Mammalia, Chiroptera, Caves, Conservation, central Brazil

Introduction

The Order Chiroptera comprises about 22% of all extant mammals, with more than 1,300 described species (BCI 2018) and currently with 182 species known from Brazil (SBEQ 2018). This number is still increasing, with approximately two new bat species described per year in Brazil in the past two decades (Paglia et al. 2012, Nogueira et al. 2014). In the Cerrado, bats surpass rodents in diversity, with 103 species from all nine families that occur in Brazil (Aguiar and Zortéa 2008), representing more than 50% of all mammal species in this phytophysiognomy. The Cerrado is one of the richest tropical savannas, with a high endemism of plants and birds and a high diversity of vertebrates, being considered a “hotspot” for biodiversity conservation (Mittermeier et al. 1999, Myers et al. 2000). According to Reis et al. (2011), 9% of 195 mammals recorded in the Cerrado are endemic to it. Among bats, the nectarivorous *Lonchophylla bokermanni* Sazima, Vizotto & Taddei, 1978, was reported as endemic from this hotspot (Nogueira et al. 2014).

The main threats to Cerrado are land expansion for cattle ranching, soybean plantations and other land uses that had reduced it to only 20% of the original area (Myers et al. 2000, Strassburg et al. 2017). This can directly affect bat assemblages, changing the habitat structure and reducing shelter and food availability.

Bats use many types of roosts, including caves, rocky crevices, foliage roosts, hollow trees and man-made structures such as the buildings, mines and tunnels (Kunz 1982, Pacheco et al. 2010). For several species, caves are the main roosts (Kunz 1982, Arita 1996, Trajano 1995). Bats are the typical troglodytes, or organisms that regularly use subterranean habitats but that must return periodically to the surface (in their case, daily to feed) in order to complete their life cycle, and some are obligatory troglodytes, that depend on caves as obligatory shelters at least during part of their life cycles (Trajano 2012; Trajano and Carvalho 2017). Therefore the conservation of caves and their surrounding are crucial for maintenance of bat populations (Trajano 1995, Arnone 2008, Rocha and Bichuette 2016).

The Red Latinoamericana y del Caribe para la Conservación de los Murciélagos -RELCOM is an international NGO that congregates Latin-American and Caribbean national programs for bat conservation in 22 countries. Among its actions, RELCOM certifies Areas and Sites of Importance for Conservation of Bats (AICOMs and SICOMs), recognized with basis on criteria of diversity, presence of endangered and rare species, maternity colonies, and importance as roosting and migration areas. AICOMs and SICOMs differ only in area size, the latter are smaller. So far, RELCOM certified 80 (64 AICOMs and 16 SICOMs) in 15 countries. However, only recently Brazil have recognized the first and so far the only Brazilian AICOM, the “Alto Ribeira e Alto Parapanema AICOM”, in southeast São Paulo state, SE Brazil (RELCOM 2017). Although many other Brazilian areas are known to fit the RELCOM criteria for Important Areas and Sites for Bat Conservation, no actions have been undertaken to certify them.

We present herein a checklist of bat species from Distrito Federal and Goiás state, with data of a short-term study in Passa Três cave, São Domingos karst area, central

Brazil and part of a State Park (Terra Ronca State Park - PETeR). We discuss the criteria of proposition of SICOMs and the possibility of application to Passa Três cave.

Brazil has ca. of 17,000 recorded caves (CECAV 2018) and a potential to 100,000 according to Auler et al. (2001), and most of this heritage is under threat by mining and other huge economic purposes, such as hydro electrical projects. The São Domingos karst area, Goiás state, central Brazil, is characterized by the presence of huge cave systems crossed by allochthonous streams, with large amounts of organic matter available for cave organisms, supporting rich aquatic and terrestrial communities (e.g., Bichuette and Trajano 2003, Simões et al. 2013, Bichuette et al. 2015). It is the second most intensively surveyed Brazilian karst area after the Alto Ribeira, but so far no comprehensive study on the bat communities from these caves has been undertaken.

Methods

Study Area

Passa Três cave is located in the Parque Estadual Terra Ronca - PETeR, one of the largest protected areas in Goiás state (Figures 1, 2). The Cerrado phytophysionomy, which is the second largest in Brazil, after Amazonian rainforest, comprises about 2 million km² (IBGE 2004). There is still significant economic activity represented by cattle rising and agriculture threatening the original Cerrado. Therefore, although the cave is located inside a Conservation Unit, its protection is not warranted.

The Passa Três cave (GO 14) (Lat -13,60 and Long -46,39), São Domingos County, is a relatively small and confined cave when compared with the cave systems in São Domingos karst area. The cave entrance (sinkhole – Figure 2A), used by the bats for emergence, is about 2.5 m high and 4 m wide; after a flooded low conduit, the cave stream joins the São Vicente I Cave. There are ca. 1.5 km of vadose galleries potential for bat use, mostly the stream conduit, width and height varying from 2 to 8 m, with plenty of concavities and crevices in the ceiling and potential shelters. Stable speleoclimate due to spatial confinement and low noise in comparison with larger caves, make Passa Três cave a particularly good shelter.

According to Köeppen classification (1948), the climate is Aw type, with two well-defined seasons: dry (May-September) and wet (October-April), with annual precipitation between 600 and 2,000 mm (Lima and Silva 2005).

Sampling

Bats were sampled in three occasions at the Passa Três cave entrance; all in the dry season of 2000 (July 25, September 9 and 14), using one mist net (7× 3 m) at the beginning of the night (4 h total collecting efforts). Bats were euthanized through cervical dislodgment (one specimen or a couple per species) and identified using taxonomic

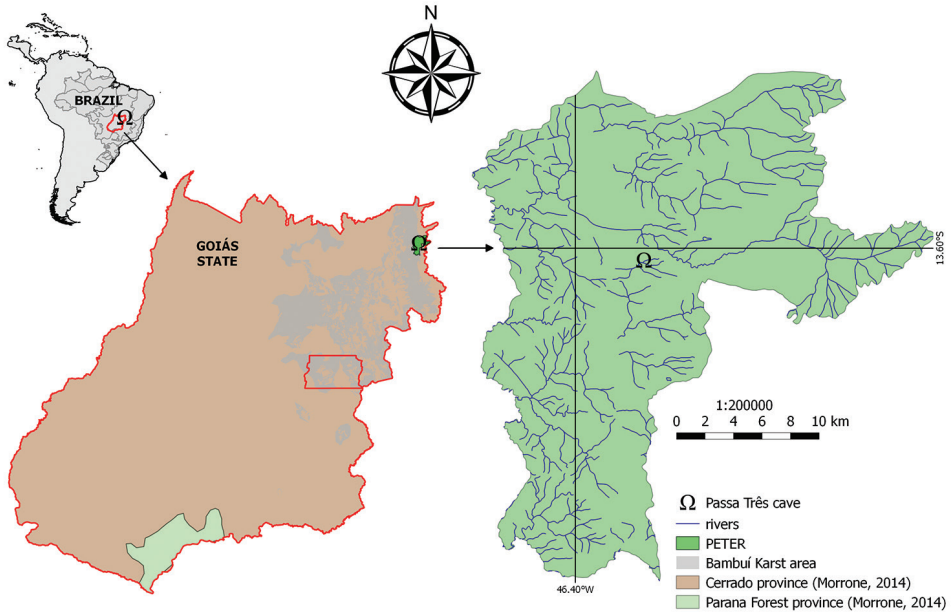


Figure 1. Study area, showing the limits of PETeR (Parque Estadual de Terra Ronca), northeastern state of Goiás, central Brazil. (Map organized in QGIS software, version 2.18, Author: Diego M. von Schimonsky).

keys (Vizotto and Taddei 1973, Gardner 2008). Vouchers of part of studied (collected) material are deposited in the Vertebrates Collection of Laboratório de Estudos Subterrâneos of Universidade Federal de São Carlos (LESV).

Examined material (part): *Anoura caudifer* (LESV 0365 and 0366), *Platyrrhinus lineatus* (LESV 0355 and 0358), *Glossophaga soricina* (LESV 0356 and 0362), *cirrhosus* (LESV 0357, 0367 and 0391), *Lonchorhina aurita* (LESV 0358, 0360), *Lionycteris spurrelli* (LESV 0359 and 0381), *Carollia perspicillata* (LESV 0361), *Lonchophylla dekeyseri* (LESV 0363 and 0364).

Literature review

Secondary data were gathered from literature: Bredt et al. (1999), Esbérard et al. (2001), Esbérard et al. (2005), Zortéa and Tomaz (2006), Reis et al. (2007), Silva et al. (2009), Zortéa and Alho (2008), Silva et al. (2009), Bezerra and Marinho-Filho (2010), Zortéa et al. (2010), Chaves et al. (2012), Reis et al. (2013) and Guimarães (2014).

Following Garbino and Tejedor (2012) and Nogueira et al. (2014), we treat the *Natalus* species recorded in Brazil as *Natalus macrourus* (Gervais, 1856), replacing the

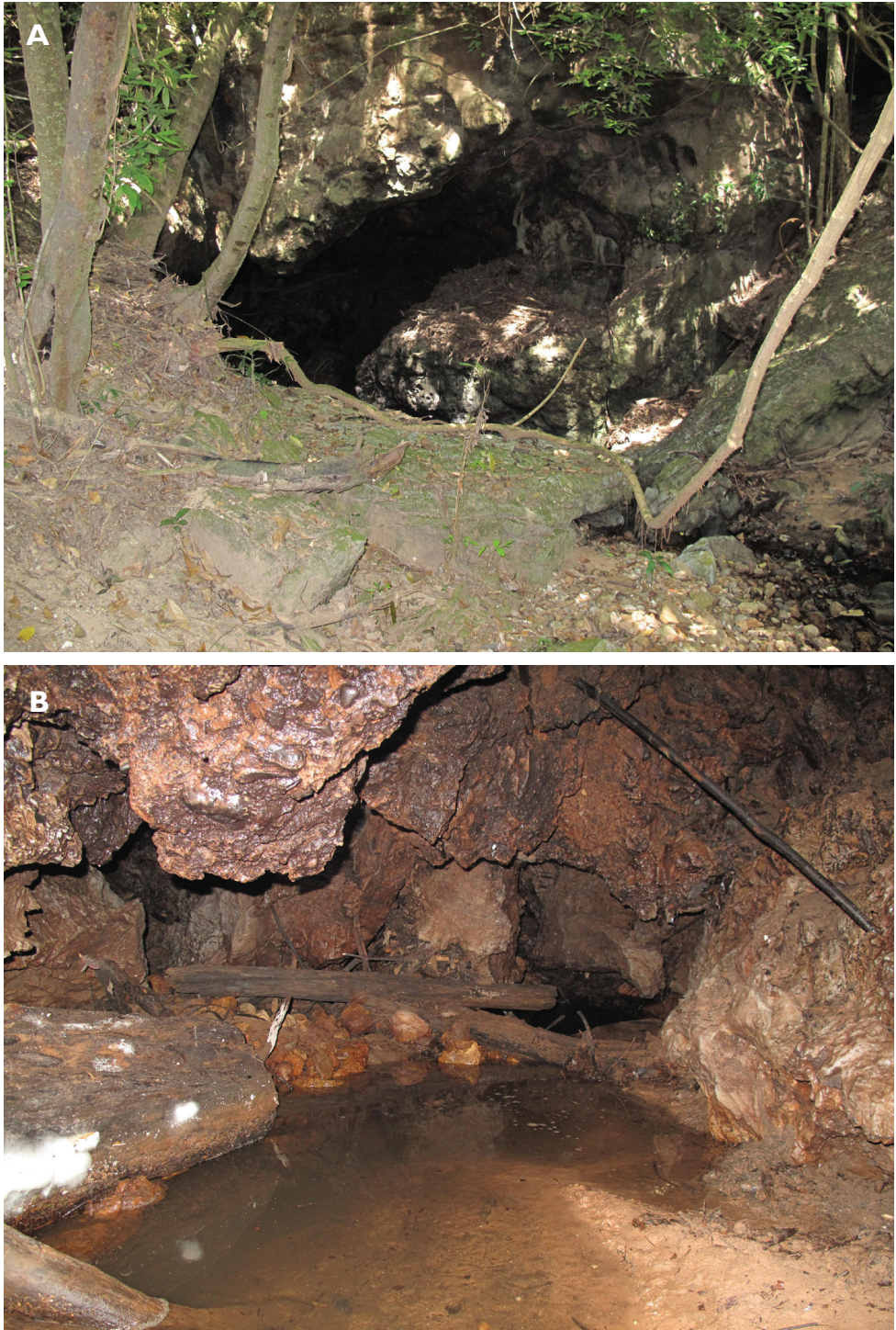


Figure 2. Passa Três cave, São Domingos karst area, Goiás state, central Brazil. **A** cave entrance **B** cave stream conduit close to entrance with short ceiling passages. Photos: M. E. Bichuette.

names *N. stramineus* (Gray, 1838) and *N. espiritosantensis* Ruschi, 1951; *A. planirostris* (Spix, 1823) instead of *Artibeus jamaicensis* (Leach, 1821); *Dermanura cinerea* Gervais, 1856 instead of *Artibeus cinereus* (Gervais, 1856); and *Cynamops planirostris* (Peters, 1866) instead of *Molossops planirostris* (Peters, 1865). The list does not include *Platyrrhinus helleri* (Peters, 1866), which after revision, seems not to occur in Brazil (Velazco et al. 2010, Nogueira et al. 2014).

Results

An updated list of bats for Distrito Federal and Goiás state is shown in Table 1, with 66 species belonging to eight families, including 41 phyllostomids. Among these, 30 species were recorded in caves previously (22 belonging to Phyllostomidae family- see literature cited in Table 1). Two of them are threatened and included in the Brazilian List of Threat-



Figure 3. *Lonchophylla dekeyseri*, Endangered species at Brazilian List of Threatened Fauna. Photo: Roberto Leonam Morim Novaes.



Figure 4. *Lonchorhina aurita*, Vulnerable species at Brazilian List of Threatened Fauna. Photo: Roberto Leonam Morim Novaes.

ened Fauna (MMA 2016): *Lonchophylla dekeyseri* (Figure 3), Endangered (EN), and *Lonchorhina aurita* (Figure 4), Vulnerable (VU) and the rare species, *Lionycteris spurrelli*.

We recorded nine species in Passa Três cave (in parenthesis, the number of specimens captured in July/September, both nights combined): *Anoura caudifer* (0/2), *Carollia perspicillata* (0/2), *Desmodus rotundus* (6/8), *Glossophaga soricina* (2/3), *Lionycteris spurrelli* (1/0), *Lonchophylla dekeyseri* (0/4), *Lonchorhina aurita* (1/1), *Platyrrhinus lineatus* (11/4) and *Trachops cirrhosus* (1/2). Pregnant females of *P. lineatus* and *Lonchorhina aurita* were captured in July; in September we recorded pregnant females of *P. lineatus* and *T. cirrhosus*. Moreover, Passa Três cave is a shelter of two threatened species, *Lonchophylla dekeyseri* (EN) and *Lonchorhina aurita* (VU).

Table 1. Checklist of bats recorded in Distrito Federal and Goiás state. Source: 1 - Bredt et al. (1999), 2 - Esbérard et al. (2001), 3 - Esbérard et al. (2005), 4 - Zortéa and Tomaz (2006), 5 - Reis et al. (2007), 6 - Silva et al. (2009), 7 - Bezerra and Marinho-Filho 2010, 8 - Zortéa et al. (2010), 9 - Chaves et al. (2012), 10 - Reis et al. (2013), 11 - LESV, 12 - Zortéa and Alho (2008), 13 - Guimarães (2014), **14 – Present study.** * Species recorded in caves.

Family/Subfamily/Species	Data Source
Family Emballonuridae	
Subfamily Emballonurinae	
<i>Centronycteris maximiliani</i> (Fisher, 1829)	10
<i>Peropteryx macrotis</i> (Wagner, 1843)*	1, 3, 5, 6, 10
<i>Rhynchonycteris naso</i> (Wied-Neuwied, 1820)	10
<i>Saccopteryx bilineata</i> (Temminck, 1838)	10
<i>Saccopteryx leptura</i> (Schreber, 1774)	10
Family Furipteridae	
<i>Furipterus horrens</i> (Cuvier, 1828)*	1, 2, 3, 10, 13
Family Mormoopidae	
<i>Pteronotus gymnotus</i> Natterer, 1843*	1, 3, 9, 10, 13
<i>Pteronotus parnellii</i> (Gray, 1843)*	1, 2, 3, 9, 10, 12, 13
Family Natalidae	
<i>Natalus macrourus</i> (Gervais, 1856)*	2, 3, 6, 10, 13
Family Noctilionidae	
<i>Noctilio leporinus</i> (Linnaeus, 1758)	7, 10
Family Molossidae	
Subfamily Molossinae	
<i>Cynomops abrasus</i> (Temminck, 1826)	10
<i>Cynomops planirostris</i> (Peters, 1866)	8
<i>Eumops maurus</i> (Thomas, 1901)	10
<i>Molossops temminckii</i> (Burmeister, 1854)	7, 8, 10, 12
<i>Molossus molossus</i> (Pallas, 1766)	10
<i>Neoplatymops mattogrossensis</i> (Vieira, 1942)	10
Family Phyllostomidae	
Subfamily Carolliinae	
<i>Carollia brevicauda</i> (Schinz, 1821)	10
<i>Carollia perspicillata</i> (Linnaeus, 1758)*	1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 14
Subfamily Desmodontinae	
<i>Desmodus rotundus</i> (É. Geoffroy Saint-Hilaire, 1810)*	1, 2, 3, 6, 7, 8, 9, 10, 12, 14
<i>Diaemus youngii</i> (Jentink, 1893)	10
<i>Diphylla ecaudata</i> Spix, 1823*	1, 2, 3, 7, 9
Subfamily Glossophaginae	
<i>Anoura caudifer</i> (É. Geoffroy Saint-Hilaire, 1818)*	1, 2, 3, 7, 8, 11, 12, 13, 14
<i>Anoura geoffroyi</i> Gray, 1838*	1, 2, 3, 8, 10, 12
<i>Choeroniscus minor</i> (Peters, 1868)*	3, 10
<i>Glossophaga soricina</i> (Pallas, 1766)*	1, 2, 3, 6, 7, 8, 10, 11, 12, 14
Subfamily “Glyphonycterinae”	
<i>Glyphonycteris behnii</i> (Peters, 1865)	10, 12
Subfamily Lonchophyllinae	
<i>Lonchophylla mordax</i> Thomas, 1903	5

Family/Subfamily/Species	Data Source
<i>Lonchophylla dekeyseri</i> Taddei, Vizotto & Sazima, 1983*	1, 2, 3, 4, 5, 6, 7, 10, 11, 14
<i>Lionycteris spurrelli</i> Thomas, 1913	2, 5, 10, 11, 14
Subfamily Lonchorhininae	
<i>Lonchorhina aurita</i> Thomas, 1863*	1, 2, 3, 5, 6, 9, 10, 11, 13, 14
Subfamily Micronycteridae	
<i>Micronycteris megalotis</i> (Gray, 1842)*	1, 3, 6, 8, 9, 10
<i>Micronycteris minuta</i> (Gervais, 1856)*	1, 2, 3, 5, 7, 10, 12
Subfamily Phyllostominae	
<i>Chrotopterus auritus</i> (Peters, 1856)*	1, 2, 3, 5, 6, 7, 10, 12
<i>Lophostoma brasiliense</i> Peters, 1866	10, 12
<i>Lophostoma carrikeri</i> (J.A. Allen, 1910)	5, 10
<i>Macrophyllum macrophyllum</i> (Schinz, 1821)	5, 10
<i>Mimon bennettii</i> (Gray, 1838)*	1, 2, 3, 5, 6, 7, 8, 10, 12
<i>Mimon crenulatum</i> (É. Geoffroy Saint-Hilaire, 1803)	8, 12
<i>Tonatia bidens</i> (Spix, 1823)	5, 7
<i>Trachops cirrhosus</i> (Spix, 1823)*	1, 2, 3, 5, 11, 14
Subfamily Stenodermatinae	
<i>Artibeus concolor</i> Peters, 1865	4, 5, 10
<i>Artibeus lituratus</i> (Olfers, 1818)*	3, 5, 10, 12
<i>Artibeus obscurus</i> (Schinz, 1821)	5, 7
<i>Artibeus planirostris</i> Spix, 1823*	2, 3, 8, 9, 10, 12
<i>Chiroderma villosum</i> Peters, 1860	10
<i>Chiroderma vizottoi</i> (Taddei & Lim, 2010)	5
<i>Dermanura cinerea</i> Gervais, 1856	5, 8, 10, 12
<i>Mesophylla macconnelli</i> Thomas, 1901	4, 8, 10, 12
<i>Phylloderma stenops</i> (Peters, 1865)*	1, 2, 3, 5, 10
<i>Phyllostomus discolor</i> (Wagner, 1843)	5, 8, 10, 12
<i>Phyllostomus hastatus</i> (Pallas, 1767)*	1, 3, 5, 8, 9, 10, 12
<i>Platyrrhinus incarium</i> (Thomas, 1912)	5, 10
<i>Platyrrhinus lineatus</i> (É. Geoffroy Saint-Hilaire, 1810)*	1, 3, 5, 7, 10, 11, 12, 14
<i>Sturnira lilium</i> (É. Geoffroy Saint-Hilaire, 1810)*	3, 5, 7, 8, 10, 12
<i>Uroderma bilobatum</i> Peters, 1866	5, 10
<i>Uroderma magnirostrum</i> Davis, 1968	5, 7
<i>Vampyressa pusilla</i> (Wagner, 1843)*	3, 5, 10
Family Vespertilionidae	
Subfamily Vespertilioninae	
<i>Eptesicus diminutus</i> (Osgood 1915)	12
<i>Eptesicus furinalis</i> (d'Orbigny & Gervais, 1847)	7, 8
<i>Eptesicus andinus</i> J.A. Allen, 1914	5, 10
<i>Eptesicus brasiliensis</i> (Demarest, 1819)*	1, 5, 10
<i>Histiotus laephotis</i> Thomas, 1916	5
<i>Histiotus velatus</i> (I. Geoffroy, 1824)	5
<i>Lasiurus blossevillii</i> ([Lesson, 1826])	5, 10
<i>Lasiurus ega</i> (Gervais, 1856)	10, 12
<i>Myotis nigricans</i> (Schinz, 1821)*	1, 2, 3, 5, 8, 10

Discussion

Majority of records for Distrito Federal (DF) and Goiás state (GO) are Phyllostomids, as observed by other authors (e.g. Bredt et al. 1999, Bezerra and Marinho-Filho 2010, Carrijo et al. 2011). In a regional scale, more than 40% of the species recorded in DF and GO use caves, which represents about 16% of Brazilian bats (30 of 179), a high percentage compared to other temperate regions.

Considering the Passa Três cave, all species are Phyllostomidae; the most abundant (e.g., *Platyrrhinus lineatus*, *Lonchorhina aurita*, *Desmodus rotundus* and *Carollia perspicillata*) follow partially the pattern observed in some limestone and sandstone caves in Brazil, when *Desmodus rotundus* and *Carollia perspicillata* are the most abundant. In some cases, *Phyllostomus hastatus*, has shown a high abundance (e.g., Tocantins, in central Brazil, and Bahia, in northeastern Brazil; M.E. Bichuette, pers. obs.). However, *P. hastatus* has not been registered in Passa Três cave. The less abundant species (e.g., *Trachops cirrhosus*, *Anoura caudifer* and *Glossophaga soricina*) follow the pattern observed in some karst areas in Brazil (Trajano and Gimenez 1998, Arnone 2008).

Protection of roosting sites is an essential component of any strategy for the conservation of bats, with caves being the main roots for several bat species (Arita 1996, Kunz 1982). On the other hand, bat guano is an important food source for many subterranean organisms, especially for species restricted to subterranean habitats (troglobites), totally dependent on the resources present in these habitats and prone to rapid extinction following any ecological disequilibrium (e.g. alterations in the energy input), even very localized (Trajano 1995). Therefore, protecting bats is a fundamental part of any program or action for conservation of subterranean systems.

Passa Três cave follows the criteria of Site of Importance for Conservation of Bats (SICOM) according to the RELCOM. However, the proposition must be sent to RELCOM coordination for appreciation and validation. The following attributes were observed: presence of two threatened species – *Lonchophylla dekeyseri* and *Lonchorhina aurita*; presence of a rare species – *Lionycteris spurrelli*; a high diversity of bats compared to other caves in Brazil; reproducing colonies of at least three among these species, including the vulnerable *L. aurita*. Its protection is a priority since the Parque Estadual de Terra Ronca – PETeR has no Management Plan and is impacted by pastures, agriculture and poorly controlled visitation. In addition, the cave is the type-locality of two troglobitic (restricted to subterranean habitats) fishes, both included in the Brazilian Red List of Threatened species, the catfishes *Ancistrus cryptophthalmus* Reis, 1987 and *Ituglanis passensis* Fernández and Bichuette 2002 (Teleostei: Siluriformes) (Bichuette and Trajano 2003). Considering its peculiarity and attributes, it is urgent the inclusion of Passa Três in conservation programs, and implementation of monitoring programs.

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References

- Aguiar LMS, Zortéa M (2008) A diversidade de morcegos conhecida para o Cerrado. II Simpósio Internacional Savanas Tropicais; IX Simpósio Nacional Cerrado, Brasília, Distrito Federal.
- Arita HT (1996) The conservation of cave-roosting bats in Yucatan, Mexico. *Biological Conservation* 76: 177–185. [https://doi.org/10.1016/0006-3207\(95\)00105-0](https://doi.org/10.1016/0006-3207(95)00105-0)
- Arnone IS (2008) Estudo da comunidade de morcegos na área cárstica do Alto Ribeira- SP: Uma comparação com Trajano 1980. MSc. dissertation. Universidade de São Paulo, São Paulo, 114 pp. <http://www.teses.usp.br/teses/disponiveis/41/41133/tde-10072008-183234/pt-br.php>
- Auler A, Rubbioli E, Brandi R (2001) *As grandes cavernas do Brasil*. Belo Horizonte: Grupo Bambuí de Pesquisas Espeleológicas, 228 pp.
- BCI (2018) Bat Conservation International. <http://www.batcon.org> [Accessed at December 2018]
- Bezerra AMR, Marinho-Filho J (2010) Bats of Paraná River Valley, Tocantins and Goiás states, Central Brazil. *Zootaxa* 2725: 41–56. <http://www.mapress.com/zootaxa/2010/2/zt02725p056.pdf>
- Bichuette ME, Trajano E (2003) Epigeal and subterranean ichthyofauna from the São Domingos karst area, upper Tocantins river basin, Central Brazil. *Journal of Fish Biology* 63(5): 1100–1121. <https://doi.org/10.1046/j.1095-8649.2003.00227.x>
- Bichuette ME, Simões LB, Von Schimonsky DM, Gallão JE (2015) Effectiveness of quadrat sampling on terrestrial cave fauna survey – a case study in a Neotropical cave. *Acta Scientiarum Biological Sciences* 37(3): 345–351. <https://doi.org/10.4025/actascibiolsoci.v37i3.28374>
- Bredt A, Uieda W, Magalhães ED (1999) Morcegos cavernícolas da região do Distrito Federal, centro-oeste do Brasil (Mammalia, Chiroptera). *Revista Brasileira de Zoologia* 16(3): 731–770. <https://doi.org/10.1590/S0101-81751999000300012>
- Carrijo VA, Zortéa M, Melo FR, Carvalho HG (2011) Diversidade de morcegos das áreas de influência de uma usina sucroalcooleira da região sudoeste do estado de Goiás. São Lourenço: 10º Congresso de Ecologia do Brasil, 1–2.
- CECAV (2018) Centro Nacional de Pesquisa e Conservação de Cavernas. <http://www.icmbio.gov.br/cecav/canie.html> [22 January 2018]

- Chaves PMR, Franco PAD, Pereira VCR (2012) Diversidade de morcegos (Mammalia, Chiroptera) em gruta de formação calcária localizada na fazenda Cantinho, Município de Formosa- Goiás. *Revista Meio Ambiente e Sustentabilidade* 1(1): 8–28.
- Esbérard CEL, Motta JAO, Calvo EM, Ferreira VM, Carvalho JC, Carvalho CC, Souza CRP, Pires EA, Rosa GMV, Reis JS, Araújo JN, Quege KE (2001) Morcegos cavernícolas de Mambá e arredores, Goiás, Brasil. Brasília: 13th International Congress of Speleology (Speleo Brazil 2001), 361–364.
- Esbérard CEL, Motta JA, Perigo C (2005) Morcegos cavernícolas da Área de Proteção Ambiental (APA) Nascentes do Rio Vermelho, Goiás. *Revista brasileira de Zootecias* 7(2): 285–296.
- Gardner AL (2008) *Mammals of South America: Volume I. Marsupials, xenarthrans, shrews, and bats*. The University of Chicago Press, Chicago and London, 669 pp.
- Guimarães MM (2014) Morcegos cavernícolas do Brasil: composição, distribuição e serviços ambientais. MSc. dissertation. Universidade Federal de Lavras, Lavras, 130 pp.
- IBGE (2004) Instituto Brasileiro de Geografia e Estatística. Mapa de Vegetação do Brasil, 3rd ed. Escala 1:5.000.000. IBGE, Rio de Janeiro. <http://www.mma.gov.br/component/k2/item/7626-mapas-de-cobertura-vegetal> [5 January 2015]
- Köppen W (1948) *Climatologia: con un estudio de los climas de la tierra*. Mexico: Fondo de Cultura Económica, 479 pp.
- Kunz TH (1982) Roosting Ecology of bats. In: Kunz TH (Ed.) *Ecology of Bats*. Plenum Press, New York, 1–55.
- Lima JEFW, Silva EM (2005) Estimativa da produção hídrica superficial do Cerrado brasileiro. In: Scariot A, Silva JCS, Felfili JM (Eds) *Cerrado: Ecologia, Biodiversidade e Conservação*. Ministério do Meio Ambiente, Brasília, 63–72.
- Mittermeier RA, Myers N, Gil PR, Mittermeier CG (1999) *Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*. Monterrey: Cemex, Conservation International and Agrupacion Sierra Madre.
- MMA (2016) Sumário Executivo: Livro Vermelho da Fauna Brasileira Ameaçada de Extinção. ICMBio, Brasília, 76 pp.
- Myers N, Mittermeier RA, Mittermeier CG, Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858. <https://doi.org/10.1038/35002501>
- Nogueira MR, Lima IP, Moratelli R, Tavares VC, Gregorin R, Peracchi AL (2014) Checklist of Brazilian bats, with comments on original records. *Check List* 10(4): 808–821. <https://doi.org/10.15560/10.4.808>
- Pacheco SM, Sodr  M, Gama AR, Brecht A, Cavallini EM, Sanches RVM, Guimarães MM, Bianconi G (2010) Morcegos urbanos: status do conhecimento e plano de ação para conservação no Brasil. *Chiroptera Neotropical* 16: 630–647.
- Paglia AP, Fonseca GD, Rylands AB, Hermann G, Aguiar LMS, Chiarello AG, Patton JL (2012) Lista anotada dos mamíferos do Brasil. *Occasional Papers in Conservation Biology* 6: 1–76.
- Reis NR, Peracchi AL, Pedro WA, Lima IP (2011) *Mamíferos do Brasil* (2nd edn). Universidade de Londrina, Londrina, 439 pp.

- RELCOM (2014) Red Latinamericana y del Caribe para la Conservación de los Murciélagos. <http://www.recomlatinoamerica.net/index.php/que-hacemos/conservacion/18-recom/88-areaspais> [Accessed at August 2017]
- Rocha A, Bichuette ME (2016) Influence of abiotic variables on the bat fauna of a granitic cave and its surroundings in the state of São Paulo, Brazil. *Biota Neotropica* 16(3): e20150032. <https://doi.org/10.1590/1676-0611-BN-2015-0032>
- SBEQ (2018) Sociedade Brasileira para o Estudo de Quirópteros. <http://www.sbeq.net> [Accessed at December 2018]
- Silva JPA, Carvalho AR, Motta JAO (2009) Fauna de morcegos (Mammalia, Chiroptera) em cavernas do bioma Cerrado na região de Indiará (Goiás). *Revista Brasileira de Zoociências*, 11(3): 209–217.
- Simões LB, Ferreira TCS, Bichuette ME (2013) Aquatic biota of different karst habitats in epigeal and subterranean system of Central Brazil – visibility versus relevance of taxa. *Subterranean Biology* 11: 55–74. <https://doi.org/10.3897/subtbiol.11.5981>
- Strassburg BBN, Brooks T, Feltran-Barbieri R, Iribarrem A, Crouzeilles R, Loyola R, Latawiec AE, Oliveira Filho FJB, Scaramuzza CAM, Scarano FR, Soares-Filho B, Balmford A (2017) Moment of truth for the Cerrado hotspot. *Nature Ecology and Evolution*, 1, 0099. <https://doi.org/10.1038/s41559-017-0099>
- Trajano E (1995) Protecting caves for the bats or bats for the caves? *Chiroptera Neotropical*, 1(2): 19–21.
- Trajano E (2012) Ecological classification of subterranean organisms. In: White WB, Culver DC (Eds) *Encyclopedia of Caves*, 2 ed. Academic Press, Chennai, 275–277.
- Trajano E, Gimenez EA (1998) Bat community in a cave from Eastern Brazil, including a new record of *Lionycteris* (Phyllostomidae, Glossophaginae) *Studies on Neotropical Fauna and Environment* 33(2): 69–75. <https://doi.org/10.1076/snfe.33.2.69.2156>
- Velazco PM, Gardner AL, Patterson BD (2010) Systematics of the *Platyrrhinus helleri* species complex (Chiroptera: Phyllostomidae), with descriptions of two new species. *Zoological Journal of Linnean Society* 159(3): 785–812. <https://doi.org/10.1111/j.1096-3642.2009.00610.x>
- Vizotto LD, Taddei VA (1973) Chave para determinação de quirópteros brasileiros. Gráfica Francal, São José do Rio Preto, 72 pp.
- Wilson DE, Reeder DM (2005) *Mammal Species of the World: a taxonomic and geographic reference*. 3.ed. v.1. Baltimore: Johns Hopkins University Press, 2142 pp. <http://www.departments.bucknell.edu/biology/resources/msw3/> [22 January 2018]
- Zortéa M, Alho C (2008) Bat diversity of a Cerrado habitat in central Brazil. *Biodiversity and Conservation* 17: 791–805. <https://doi.org/10.1007/s10531-008-9318-3>
- Zortéa M, Tomaz LAG (2006) Dois novos registros de morcegos (Mammalia, Chiroptera) para o Cerrado do Brasil central. *Chiroptera Neotropical* 12(2): 280–285.
- Zortéa M, Melo FR, Carvalho JC, Rocha ZF (2010) Morcegos da Bacia do rio Corumbá, Goiás. *Chiroptera Neotropical* 16(1): 610–616.