UNIVERSIDADE FEDERAL DE SÃO CARLOS
CENTRO DE CIÊNCIAS BIOLÓGICAS E DA SAÚDE
PROGRAMA DE PÓS-GRADUAÇÃO EM CONSERVAÇÃO DA FAUNA

VINÍCIUS CARDOSO CLÁUDIO

Morcegos do Parque Estadual Carlos Botelho, Sudeste da Mata Atlântica: Taxonomia e Saúde Ambiental

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Dissertação apresentada ao Programa de Pós-Graduação em Conservação da Fauna, para obtenção do título de mestre profissional em Conservação da Fauna.

Orientador: Fabrício Braga Rassy

Co-orientador: Ricardo Moratelli

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Assinaturas dos membros da comissão examinadora que avaliou e aprovou a Defesa de Dissertação de Mestrado do candidato Vinícius Cardoso Claudio, realizada em 27/02/2018:

Prof. Dr. Fabrício Braga Rassy
FPZSP

Profa. Dra. Ana Paula Carmignotto
UFSCar

Profa. Dra. Suzan Pantaroto de Vasconcellos
UNIFESP

Prof. Dr. João Batista da Cruz
FPZSP

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RESUMO

A Mata Atlântica representa um dos 25 *hot spots* de biodiversidade mundiais, porém um passado de exploração levou a redução de sua área original em 92%. Este fato, aliado as constantes ameaças à fauna, está forçando muitas espécies ao limiar da extinção. O Parque Estadual Carlos Botelho (PECB) é um grande remanescente de Mata Atlântica no sudeste brasileiro, apresentando mais de 37000 ha e nenhum estudo prévio com morcegos. Nós realizamos o primeiro inventário de quirópteros no PECB, fornecendo informações sobre a dstribuição, história natural a taxonomia das espécies, com foco na morfologia externa, uma vez que muitas espécies são externamente similares e difíceis de identificar em campo. Adicionalmente, nós descrevemos a diversidade da microbiota oral e retal de morcegos frugívoros, nectarívoros, insetívoros, hematófagos e carnívoros do PECB, e seus padrões de resistência a antibióticos. Nós realizamos campanhas mensais, entre outubro de 2016 e setembro de 2017, capturando 412 morcegos de 34 espécies, das famílias Phyllostomidae, Vespertilionidae e Molossidae. As capturas foram feitas com o uso de redes-de-neblinas instaladas no sub-bosque (39600 m².h) e dossel (2017.5 m².h), além de buscas ativas (42h). As bactérias foram identificadas com o uso da técnica de MALDI-TOF e os padrões de resistência bacteriana foram avaliados com a técnica de disco difusão de Kirby-Bauer em oito espécies de bactérias. Espécies raras na Mata Atlântica de São Paulo foram capturadas em redes de dossel. As espécies *Micronycteris schmidtorum* e *Molossus currentium* foram registradas pela primeira vez no estado. O elevado número de espécies capturadas no PECB ultrapassa a maioria dos estudos realizados em áreas similares, e reforça a importância do emprego de diferentes metodologias de captura, como redes de dossel e buscas ativas. 596 isolados foram identificados até o nível de gênero e provável espécie. As espécies de bactéria mais comuns entre os grupos de dieta foram *Escherichia coli*, *Klebsiella oxytoca e Serratia marcescens*. Os frugívoros apresentaram a microbiota mais diversa, seguidos pelos insetívoros. Os resultados gerais apresentaram uma pequena ocorrência de bactérias resistentes a antibióticos, o que pode estar relacionado à efetividade do Parque na conservação da vida selvagem e meio ambiente. Uma vez que a maior causa de aquisição de resistência está relacionada ao contato com atividades antrópicas, o acesso limitado de turistas em determinadas regiões do Parque parece estar sendo efetivo na proteção do ambiente.

Palavras-Chave: Mata Atlântica; Chiroptera; microbiota; distribuição; morfologia.

ABSTRACT

The Atlantic Forest in one of the 25 biodiversity hot spots in the world, but has suffered with a severe exploitation in the past and the biome area was reduced to 8% of its original extent. This fact, associated to the constant threats to the fauna, is pushing many species to the threshold of extinction. Carlos Botelho State Park (CBSP) is a large remnant on the Brazilian southeastern Atlantic Forest, with more than 37000 ha and no previous studies on bats. Therefore we aimed to perform the first bat inventory on CBSP, to provide data on the distribution, natural history and taxonomy of the species, focusing on the external morphology, once many species are externally similar and hard to identify on field. Additionally, we describe the microbiota diversity from oral and rectal cavities of frugivore, nectarivore, insectivore, sanguivore and carnivore bats from CBSP, and their antibiotic-resistance patterns. We conducted monthly fieldworks between October 2016 and September 2017, capturing 412 bats of 34 species of the families Phyllostomidae, Molossidae and Vespertilionidae. Captures were made using ground level mist-nets (39600 m².h), canopy mist-nets (2017.5 m².h) and searches for roosts (42 h). Bacteria were identified using the MALDI-TOF technique and the antibiotic-resistance patterns were evaluated by the Kirby-Bauer's antibiotic disc diffusion technique on eight selected bacteria. Species rarely sampled on the Atlantic Forest of São Paulo were captured on canopy mist-nets. The species *Micronycteris schmidtorum* and *Molossus currentium* were registered for the first time in the state of São Paulo. The elevated number of species captured on CBSP surpasses most of the studies conducted on similar areas, and reinforces the importance of employing mixed capture methodologies, such as elevated mist-nets and searches for roosts. We identified 596 isolates at genus level and tentatively species level. The most common bacteria between groups were *Escherichia coli*, *Klebsiella oxytoca* and *Serratia marcescens*. The frugivore bats presented the most diverse microbiota, followed by the insectivore bats. The general results exhibited a low occurrence of resistant bacteria, which could be related to the effectivity of the Park in conserving the wildlife and environment. Once the major causes of resistance-acquiring are related to antropic activites, the limited access for tourists on certain regions of the Park seems to be effectively protecting the environment.

Keywords: Atlantic Forest; Chiroptera; microbiota; distribution; morphology.

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1.1 INTRODUÇÃO GERAL

A Mata Atlântica cobria, em 1500, cerca de 70% do Estado de São Paulo e sua área total foi reduzida em 92% durante os últimos quatro séculos, sendo considerado um dos biomas mais ameaçados do planeta (CAMPANILI; SCHAFFER, 2010; FUNDAÇÃO SOS MATA ATLÂNTICA, 2013). Essa redução esteve relacionada, até o início do século passado, principalmente ao desmatamento para a implantação de monoculturas, e atualmente as principais ameaças ao bioma são os incêndios, perda e fragmentação de habitats, a caça e o tráfico de espécies nativas, a invasão de espécies exóticas e outras atividades antrópicas (SÃO PAULO, 2008; CAMPANILI; SCHAFFER, 2010). Dentre as áreas de Mata Atlântica remanescentes no Estado, e em bom estado de conservação, se encontra o contínuo ecológico do Paranapiacaba, que abrange mais de 120.000 ha e diversas unidades de conservação (SÃO PAULO, 2008). A região abriga extensas áreas de florestas maduras, que juntamente com o fato de englobar diversas áreas protegidas a torna propícia para ações e investimentos em conservação em longo prazo (SÃO PAULO, 2008; CAMPANILI; SCHAFFER, 2010).

Nesse contexto se encontra o Parque Estadual Carlos Botelho, uma unidade de conservação criada em 1982 que abrange cerca de 37.000 ha de Mata Atlântica, com amplas regiões representadas pela floresta ombrófila (SÃO PAULO, 2008). O Parque, juntamente com os remanescentes vizinhos, apresenta um grande potencial para o desenvolvimento de pesquisas científicas. A região, no entanto, ainda apresenta grandes lacunas de conhecimento. As informações sobre a fauna de quirópteros do parque ainda são precárias, e todos os dados disponíveis para a região são provenientes de estudos em áreas vizinhas, como o Parque Estadual Intervales e o Parque Estadual Turístico do Alto Ribeira (SÃO PAULO, 2008). Além do grande potencial e carencia de conhecimento sobre a quiropterofauna do Parque, o desenvolvimento de pesquisas com quirópteros em unidades de conservação também foi incentivado por Bernard et al. (2011).

Os morcegos (178 espécies) representam cerca de 25% dos mamíferos do país (701 espécies), que apresenta a segunda maior riqueza de espécies de quirópteros do mundo, superado apenas pela Colômbia, com 187 espécies de morcegos (BERNARD et al., 2011; PAGLIA et al., 2012; NOGUEIRA et al., 2014). Os morcegos desempenham importantes papéis ecológicos, como polinização, dispersão de sementes e controle de insetos, além de atuarem como hospedeiros de diversos agentes zoonóticos (CALISHER et al., 2006; PERACCHI et al., 2006; BERNARD et al., 2011;

PERACCHI et al., 2011). Apesar disso, o conhecimento sobre história natural, microbiota, ocorrência e distribuição das espécies de morcegos no Brasil ainda é insuficiente e fragmentado, o que pode inclusive influenciar no desenvolvimento de listas de espécies ameaçadas, resultando em números subestimados (AGUIAR; MACHADO, 2005; REIS et al., 2007; DANIEL et al., 2013; REIS et al., 2017). Adicionalmente, a grande maioria dos estudos realizados atualmente tem como base metodológica o emprego de redes-de-neblina instaladas no sub-bosque florestal, favorecendo a captura de morcegos da família Phyllostomidae (SIMMONS; VOSS, 1998; BERGALLO et al., 2003). O emprego de metodologias complementares, como redes de dossel, buscas ativas e identificação por vocalização seriam de grande importância para a obtenção de dados mais robustos e verossímeis sobre a real distribuição e diversidade dos quirópteros brasileiros.

Desta forma, a conservação dos morcegos depende diretamente da ampliação de esforços amostrais e inventários, do depósito de vouchers em museus, do treinamento de taxonomistas, da publicação de dados precisos sobre a distribuição de espécies, da compreensão das respostas dos quirópteros aos produtos da interferência antrópica, como a fragmentação e o contato com agrotóxicos, entre outros (BERNARD et al., 2011; REIS et al., 2017). As atividades antrópicas possuem também grande influência sobre a microbiota dos morcegos, sendo que o desenvolvimento de resistência a antibióticos por bactérias é um problema crescente à saúde publica e ambiental (THALLER et al., 2010; OLUDURO, 2012). O uso de antibióticos nos meios hospitalar, veterinário, na agricultura ou profilaxias em geral pode acarretar na disseminação dessas substâncias no meio ambiente e na transmissão através do contato direto ou indireto entre animais (RADHOUANI et al., 2014). Apesar dos efeitos nocivos, as resistências bacterianas provenientes desse contato podem também servir para a avaliação dos impactos antrópicos nos ambientes naturais, uma vez que amostras de ambientes com mínima interferência antrópica tendem a apresentar baixas taxas de resistência a antibióticos (ÖSTERBLAD et al., 2005; THALLER et al., 2010; RADHOUANI et al., 2014). A microbiota dos morcegos é regulada por diversos fatores, como o estado de saúde dos indivíduos, estágio de desenvolvimento e hábito alimentar (CARRILLO-ARAUJO et al., 2015). No entanto, estudos sobre a microbiota de morcegos ainda são muito primitivos e sofrem com a falta de esforços e dados sobre história natural dos morcegos, desta maneira, prever a influência destes fatores na

microbiota dos morcegos é, ainda, uma tarefa muito imprecisa (CARRILLO-ARAUJO et al., 2015).

Desta forma, a realização de um inventário de quirópteros no Parque Estadual Carlos Botelho (PECB) é de fundamental importância para preencher uma lacuna de conhecimento na região, bem como fornecer dados sobre a distribuição de morcegos de maneira geral. Adicionalmente, o estudo da microbiota dos morcegos do Parque pode servir como ferramenta para a avaliação da efetividade da unidade na preservação das espécies e meio ambiente, através da comparação dos resultados obtidos com dados provenientes de outras localidades de áreas degradadas.

1.2 OBJETIVOS

Os objetivos principais são: (1) inventariar a quiropterofauna do PECB, utilizando diferentes métodos de amostragem e considerando as diferentes fitofisionomias e altitudes presentes na área; e (2) analisar a diversidade de bactérias aeróbias presentes nas cavidades oral e retal dos quirópteros inventariados.

1.2.1 Objetivos Específicos

- Avaliar a eficácia de diferentes metodologias para a captura de quirópteros;
- Fornecer dados precisos sobre a distribuição de espécies na região;
- Caracterizar a fauna de quirópteros do Parque, incluindo uma descrição qualitativa dos caracteres morfológicos externos, para auxilio na diagnose dos gêneros e espécies amostradas, além de dados quantitativos para todos os indivíduos adultos coletados de cada espécie;
- Analisar a diversidade da microbiota bacteriana considerando os diferentes grupos de dieta dos morcegos capturados e as cavidades de onde as amostras foram coletadas;
- Avaliar a sensibilidade das bactérias isoladas a diferentes tipos de antibióticos.

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THE BAT FAUNA OF CARLOS BOTELHO STATE PARK, ATLANTIC FOREST OF SOUTHEASTERN BRAZIL, INCLUDING NEW DISTRIBUTIONAL RECORDS

THE BAT FAUNA OF CARLOS BOTELHO STATE PARK, ATLANTIC FOREST OF SOUTHEASTERN BRAZIL, INCLUDING NEW DISTRIBUTIONAL RECORDS

Abstract

The Atlantic Forest in one of the 25 biodiversity hot spots in the world, but has suffered with a severe exploitation in the past and the biome area was reduced to 8% of its original extent. This fact, associated to the constant threats to the fauna, is pushing many species to the threshold of extinction. Carlos Botelho State Park is a large remnant on the Brazilian southeastern Atlantic Forest, with more than 37000 ha and no previous studies on bats. Therefore we aimed to perform the first bat inventory on CBSP, to provide data on the distribution, natural history and taxonomy of the species, focusing on the external morphology, once many species are externally similar and hard to identify on field. We conducted monthly fieldworks between October 2016 and September 2017, capturing 412 bats of 34 species of the families Phyllostomidae, Molossidae and Vespertilionidae. Captures were made using ground level mist-nets (39600 m².h), canopy mist-nets (2017.5 m².h) and searches for roosts (42 h). The number of species captured exclusively in one method was: 11 on ground-level mist-nets, 5 on canopy mist-nets and 7 on searches for roosts. The species *Dermanura cinerea*, *Eptesicus taddeii*, *Glyphonycteris sylvestris* and *Lampronycteris brachyotis* are rare on inventories conducted on the Atlantic Forest of São Paulo and were captured on canopy mist-nets. The species *Micronycteris schmidtorum* and *Molossus currentium* were registered for the first time in the state of São Paulo, and captured only on canopy mist-nets and roosts, respectively. The species *Lasiurus ebenus* was captured for the first time since its description, and additional information for the species is provided. The elevated number of species captured on CBSP surpasses most of the studies conducted on similar areas, and reinforces the importance of employing mixed capture methodologies, such as elevated mist-nets and searches for roosts.

Key words: Chiroptera; inventory; taxonomy, distribution.

2.1 INTRODUCTION

The Atlantic Forest includes a large variety of phytophysiognomies, leading to an expressive environmental diversity. This characteristic provided conditions for the

evolution of numerous species, resulting in the establishment of an extremely rich biotic complex, on both animal and vegetal aspects (CAMPANILI AND SCHAFFER, 2010). Due to its large biological diversity, the biome has been recognized as one of the 25 biodiversity hot spots, and one of the richest ecologic regions in the world (MYERS et al., 2000; CAMPANILI AND SCHAFFER, 2010).

Currently, Atlantic Forest remnants totalize 27% of the original area, if considered all the successional stages and phytophysiognomies: forests, natural grasslands, restingas and mangroves (MMA, 2006). However, forest remnants larger than 100 ha correspond to about 8% of the biome original extent, and the combined area of the 232,939 native forest fragments larger than 3 ha totalize 11.4% of the original extent (147,018 km²; FUNDAÇÃO SOS MATA ATLÂNTICA, 2013). This situation is the consequence of an exploitation history in the biome, and the current and constant threats to the Atlantic Forest biodiversity conservation, such as the antropic influence to the environment integrity, deforestation and loss of habitat; illegal activities and overexploitation of species for human use; introduction of exotic species; and disorder. These factors continue to push many species to the threshold of extinction (PINTO et al., 2005; TABARELLI et al., 2005; BRITO, 2006).

These threats led to the reduction of the biome original extent, which is currently composed mainly by fragments surrounded by urban areas and agriculture, nevertheless, more than 8,000 endemic species of mammals, birds, reptiles, amphibians and vascular plants are still found on the Atlantic Forest (MYERS et al., 2000). The larger remnants and endemism areas of the biome are located on Southeast and South regions, representing strategic regions to conservation strategies (COSTA et al., 2000). Among the threatened terrestrial animal species of the Atlantic Forest are 185 vertebrate species (69.8% of the threatened species in Brazil), of which 118 are birds, 16 amphibians, 38 mammals and 13 reptiles. The amount of endemic species is very expressive, for example we can found 90 mammal species endemic to the biome, more than 30% of the mammal species registered for the biome (CAMPANILI AND SCHAFFER, 2010; PAGLIA et al., 2012). A total of 298 mammal species are registered for the Atlantic Forest, of which 113 are bats (PAGLIA et al., 2012). Within these species, four are classified as “vulnerable” in the last Brazilian list of threatened species: *Furipterus horrens* (Cuvier, 1828), *Natalus macrourus* (Gervais, 1856), *Lonchorhina aurita* Tomes, 1863 and*Eptesicus taddeii* Miranda, Bernardi & Passos, 2006 (MMA, 2014).

Bats, rodents and marsupials together represent two thirds of Brazilian mammals (COSTA et al., 2005). Due to its great variety of trophic levels, bats play indispensable ecologic roles on tropical forests (KALKO, 1998), having great importance on ecosystems maintenance, acting on the pollination and seed dispersion of plant species and control of insect population, including agriculture plagues (GOODWIN; GREENHAL, 1961; VOGEL, 1969; PIJL, 1975; PERACCHI et al., 2006; CLEVELAND et al., 2006). Therefore, they are considered indicators of functional integrity of communities (MEDELLÍN et al., 2000). Despite their ecologic roles, the greater threat to bats and other small mammals is still the lack of basic scientific knowledge. The absence of data on these animals' biology, taxonomy, systematics, distribution and natural history lead to its inclusion on lists of threatened species. These lists, many times, include recently described or locally rare species, although widely distributed, once the number of bat inventories in Brazil is still insufficient and there are many data-poor areas (COSTA et al., 2005; REIS et al., 2007; BERNARD et al., 2011).

The field identification of bat species may bring some difficulties to the execution of inventories (COSTA et al., 2005), once the species-level identification of many genera includes skull and teeth characters, which may be visible only in laboratory (DIAS; PERACCHI, 2008). Additionally, most of the identification keys are based on those characters and do not include diagnostic features of external morphology, making the fieldwork harder and generating a high number of erroneous species identifications on lists and inventories. Therefore, the collection of voucher specimens to afford studies of external morphology, development of museum studies and revisions, and intensification of fieldwork and inventories are important to improve the knowledge of bats (BERGALLO et al., 2000; PATTERSON, 2001, 2002; BERNARD et al., 2011). In this way, we provide the first bat species annotated list for the Carlos Botelho State Park, a large remnant of Atlantic Forest in the state of São Paulo, employing distinct and complementary methodologies of capture to better uncover the local diversity of bats; and also provide taxonomic data for all the species captured, focusing on external morphology and diagnostic characters in order to support future studies.

2.2 MATERIAL AND METHODS

2.2.1 Study site

Carlos Botelho State Park (CBSP) is a protected area created in 1982 (24°06'55" – 24º14'41"S; 47º47'18" – 48º07'17"W). It comprises 37644 ha of Atlantic Forest, with ca. 62% of the total area composed by pristine forests, presenting high biodiversity and unique, rare or fragile vegetal phytophysiognomies. The ombrophilous forest is the most representative phytophysiognomy within the CBSP, covering almost all the area of the Park, and shrub grasslands are restricted to a small area. The climate is classified as Cfb (KOTTEK et al. 2006), with medium temperatures ranging from 17 to 22ºC (SÃO PAULO, 2008). December, January and February are the hottest months, with temperature averaging 25ºC; and June, July and August are the coldest months, with temperature averaging 18ºC. Pluviosity ranges from 1700 to 2400 mm without dry months throughout the year, and the altitude ranges from 20 to 940 m (PONÇANO et al. 1981; SÃO PAULO, 2008).

2.2.2 Fieldwork

From October 2016 to September 2017 48 net-nights were conducted on the CBSP. The altitudinal range of sampling sites varied from 80 to 850 m. On each night 10 ground-level mist-nets (0.5 m height) and one canopy mist-net (8–10 m height) were used. Nets remained opened from dusk to 4 h after sunset. Sampling effort was calculated according to Straube and Bianconi (2002). For selecting sampling sites (Figure 1), we priorized areas that are know to attract bats, such as natural openings, streams and rivers, natural roosts, fructifying and flowering plants (MARINHO-FILHO, 1991). All the sampling nights were made according to the lunar cycle, priorizing the new moon (ESBERÁRD, 2007). Additionally, we conducted active searches for roosts, guided by interviews with the park staff and looking for sites that could roost bats, such as hollow trees, fallen trees, rocks, foliage and human buildings (SIMMONS; VOSS, 1998).

Field identifications were based on identification keys provided by Gardner (2008d), Díaz et al. (2016), López-Baucells et al. (2016) and Reis et al. (2017). The following external measurements were taken for all adult individuals captured: weight (W), body length (BL), forearm length (FA), tibia length (TL), ear length (EL), and tragus length (TRL). Additional qualitative diagnostic characters were also observed

when necessary, according to Dias and Peracchi (2008), such as: general pelage color, pelage texture, teeth morphology, and uropatagium, ears and tragus shape. One adult male and one adult female were capture for each species, totalizing 60 specimens collected as vouchers under the permits SISBIO/ICMBIO 54.381-1/2016 and COTEC/SMA-IF 260108-006.479/2016. Additional specimens were marked and released. They were fixed with 10% of buffered formalin and preserved in 70% alcohol with skull removed. Skin and skull were deposited in the Coleção de Vertebrados da Universidade Federal de São Carlos – *campus* Sorocaba (ZSP; Sorocaba, SP, Brazil) and in the Museu Nacional, Universidade Federal do Rio de Janeiro (MN; Rio de Janeiro, RJ, Brazil).

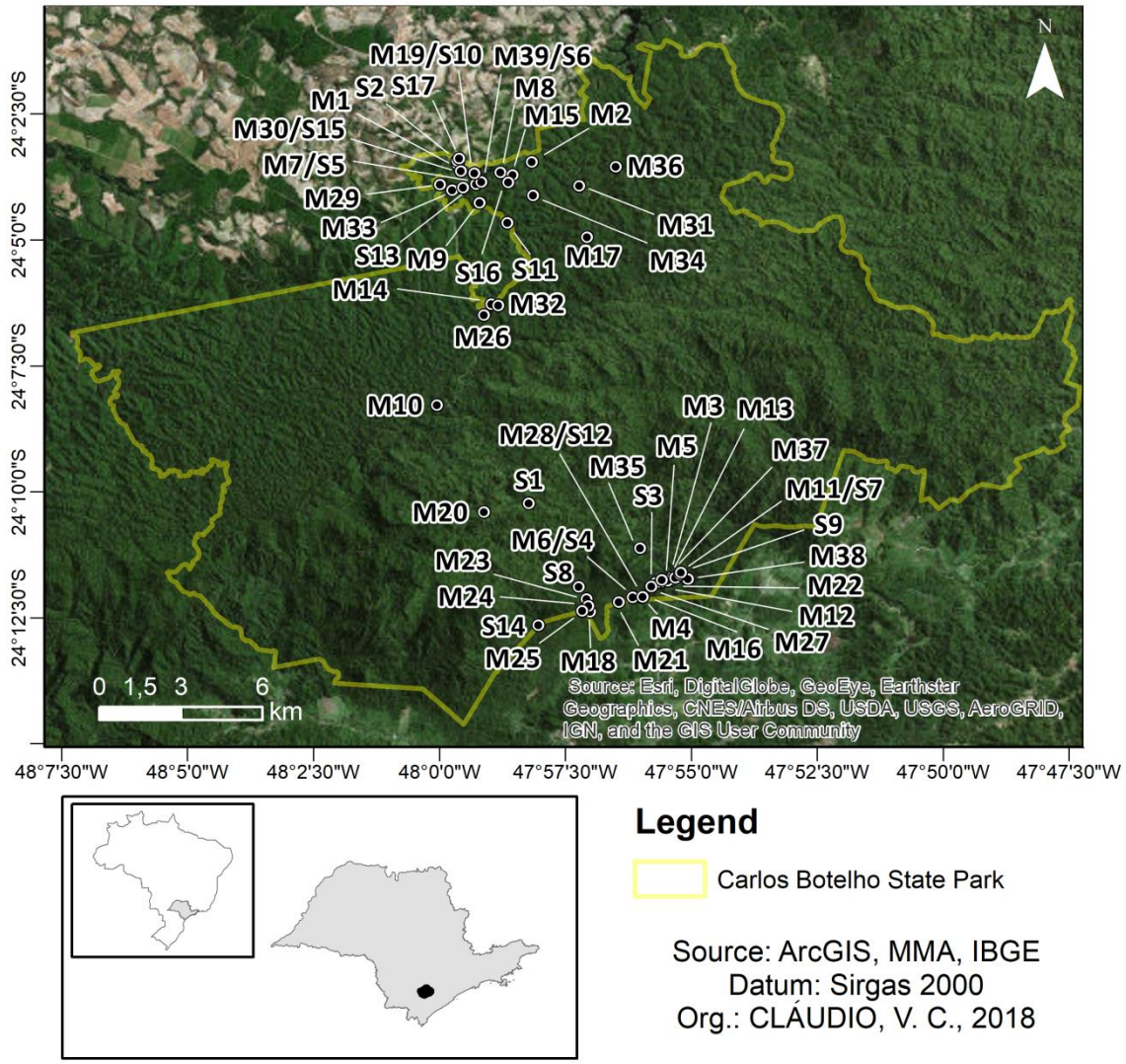

Figure 1. Location of mist-net (M) and search for roosts (S) sampling sites on Carlos Botelho State Park. Additional information is available in Appendix 1.

Thirteen skull measurements were taken from vouchered specimens, according to Simmons and Voss (1998) and Velazco et al. (2010): greatest length of skull, including internal incisors (GLS); condyloincisive length (CI); braincase breadth (BB); zygomatic breadth (ZB); postorbital breadth (PB); palatal width at canines (CC); mastoid breadth (MB); palatal length (PL); maxillary toothrow length (MXTL); molariform toothrow length (MLTL); dentary length (DL); mandibular toothrow length (MNTL) and coronoid height (CH). Additional external and skull measurements were taken when necessary.

2.3 RESULTS AND DISCUSSION

We captured 412 bats, distributed into three families and 34 species (Table 1). Among them, we recorded 22 species on 39600 m².h of ground-level mist-nets (304 captures; Figure 2), 14 species on 2017.5 m².h of canopy mist-nets (41 captures; Figure 2), and 11 species on 42 h of search for roosts (67 captures; Figure 2). A total of 60 specimens were collected as vouchers. The total number of species recorded for the CBSP surpasses most of the surveys conducted in the Atlantic Forest of Southeastern Brazil: Parque Estadual da Cantareira, São Paulo (22 species; ground-level mist-nets; 136080 m².h; 598 captures [AIRES, 2003]), Parque Estadual Intervales, São Paulo (24 spp.; ground-level mist-nets; 371 captures [PASSOS et al., 2003]), Parque Estadual da Ilha do Cardoso, São Paulo (27 spp.; ground-level mist-nets; 61776 m².h; 393 captures [FAZZOLARI-CORRÊA, 1995]), Reserva Biológica do Tinguá, Rio de Janeiro (28 spp.; ground-level mist-nets; 655 captures [DIAS; PERACCHI, 2008]); and Parque Estadual Turístico do Alto Ribeira, São Paulo (35 spp.; ground-level and elevated mist-nets, and roosts; 25320 m².h; 2002 captures [ARNONE, 2008]).

The randomized accumulation curves of ground-level mist-nets efforts appear to level off, indicating that most of the local species pool was captured (Figure 2). However, the effectiveness of this method is directly related to phyllostomid captures, and other families are usually under-sampled on short-term or mist-net based studies (SIMMONS; VOSS, 1998; BERGALLO et al., 2003). Additionally, the curves of canopy mist-nets and roosts captures are still in an accumulation stage (Figures 2 and 3), and more efforts could increase the species list once those methods were responsible for the capture of rare species on CBSP and also in other studies (see VOSS; EMMONS, 1996; SIMMONS; VOSS, 1998; FEIJÓ; ROCHA, 2017; GREGORIN et

al., 2017). Besides the accumulation curves, the number of captures should also be considered when analyzing the completeness of the sampling effort. According to Bergallo et al. (2003), at least 1000 captures are necessary to sample the majority of phyllostomid species on Atlantic Forest areas. Thus, even presenting a high richness, a larger sample period and additional captures could also increase the number of species registered on CBSP. Arnone (2008) considered that even the sampling effort of 2.002 captures and 35 registered species on Parque Estadual Turístico do Alto Ribeira, São Paulo, did not represent the total local richness and more species could be registered on the area.

Table 1. Bat species captured at Carlos Botelho State Park, São Paulo, Brazil. Captures are divided by sampling method. Specimens were deposited in the Coleção de vertebrados da Universidade Federal de São Carlos – *campus* Sorocaba (ZSP) and in the Museu Nacional, Universidade Federal do Rio de Janeiro (MN).

Species	Method			Total	Voucher material
	Ground	Canopy	Roost		
Family Phyllostomidae					
Subfamily Micronycterinae					
Lampronycteris brachyotis	-	1	-	1	ZSP 040
Micronycteris microtis	2	-	-	2	ZSP 011; ZSP 028
Micronycteris schimdtorum	-	1	-	1	ZSP 013
Subfamily Desmodontinae					
Desmodus rotundus	16	2	-	18	ZSP 006; ZSP 031
Diphylla ecaudata	4	-	-	4	ZSP 039; ZSP 049
Subfamily Phyllostominae					
Mimon bennettii	1	-	-	1	ZSP 041
Trachops cirrhosus	3	-	-	3	ZSP 024
Subfamily Glossophaginae					
Anoura caudifer	20	6	15	41	ZSP 001; ZSP 012
Anoura geoffroyi	22	6	-	28	ZSP 014; ZSP 057
Glossophaga soricina	-	-	1	1	ZSP 060
Subfamily Carolliinae					
Carollia perspicillata	95	-	-	95	ZSP 008; ZSP 022; ZSP 023; ZSP 045
Subfamily Glyphonycterinae					
Glyphonycteris sylvestris	-	2	-	2	ZSP 033; ZSP 042
Subfamily Stenodermatinae					
Artibeus fimbriatus	37	8	1	46	ZSP 027; ZSP 037
Artibeus lituratus	7	3	-	10	ZSP 015; ZSP 056
Artibeus obscurus	27	4	-	31	ZSP 009; ZSP 025
Dermanura cinerea	7	1	-	8	ZSP 035; ZSP 036
Platyrrhinus lineatus	-	1	-	1	ZSP 032
Platyrrhinus recifinus	1	-	-	1	ZSP 055

Pygoderma bilabiatum	3	-	-	3	ZSP 043; ZSP 044
Sturnira lilium	27	4	-	31	ZSP 002
Sturnira tildae	5	-	-	5	ZSP 029; ZSP 038
Vampyressa pusilla	1	-	-	1	ZSP 058
Family Molossidae					
Subfamily Molossinae					
Cynomops abrasus	-	-	1	1	ZSP 021
Molossops neglectus	-	1	-	1	ZSP 016
Molossus currentium	-	-	1	1	ZSP 050
Molossus molossus	-	-	28	28	ZSP 003; ZSP 018; ZSP 020; ZSP 053
Molossus rufus	-	-	3	3	ZSP 019, ZSP 026; ZSP 059
Family Vespertilionidae					
Subfamily Vespertilioninae					
Eptesicus taddeii	2	1	-	3	ZSP 017; ZSP 048
Lasiurus ebenus	1	-	-	1	MN 83982
Histiotus velatus	-	-	13	13	ZSP 004; ZSP 046
Subfamily Myotinae					
Myotis albescens	-	-	2	2	ZSP 005
Myotis nigricans	20	-	1	21	ZSP 010; ZSP 051
Myotis riparius	2	-	-	2	ZSP 007; ZSP 052
Myotis ruber	1	-	1	2	ZSP 047; ZSP 054
Total species	22	14	11	34	-
Total captures	304	41	67	412	-

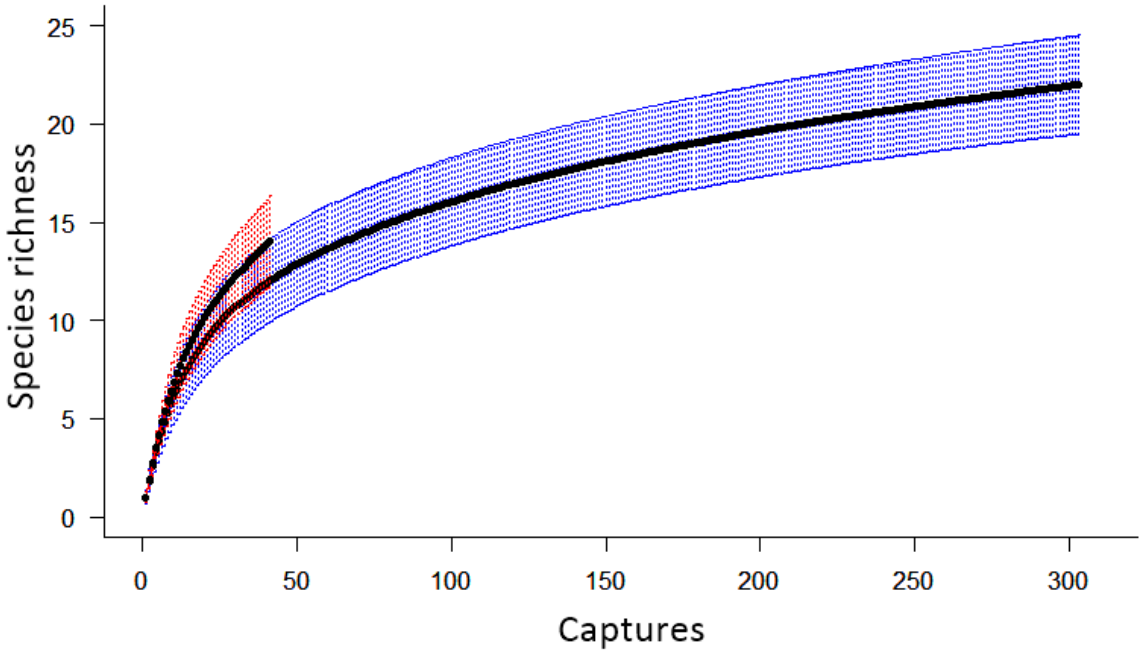

Figure 2. Individual-based species accumulation curve (randomized in PAST 3.18 Software) of bat species captured in Parque Estadual Carlos Botelho with 39600 m².h of ground-level mist-nets (Blue), and with 2017.5 m².h of canopy mist-nets (Red). Error bars show confidence interval (95%). The curve was generated in RStudio Software.

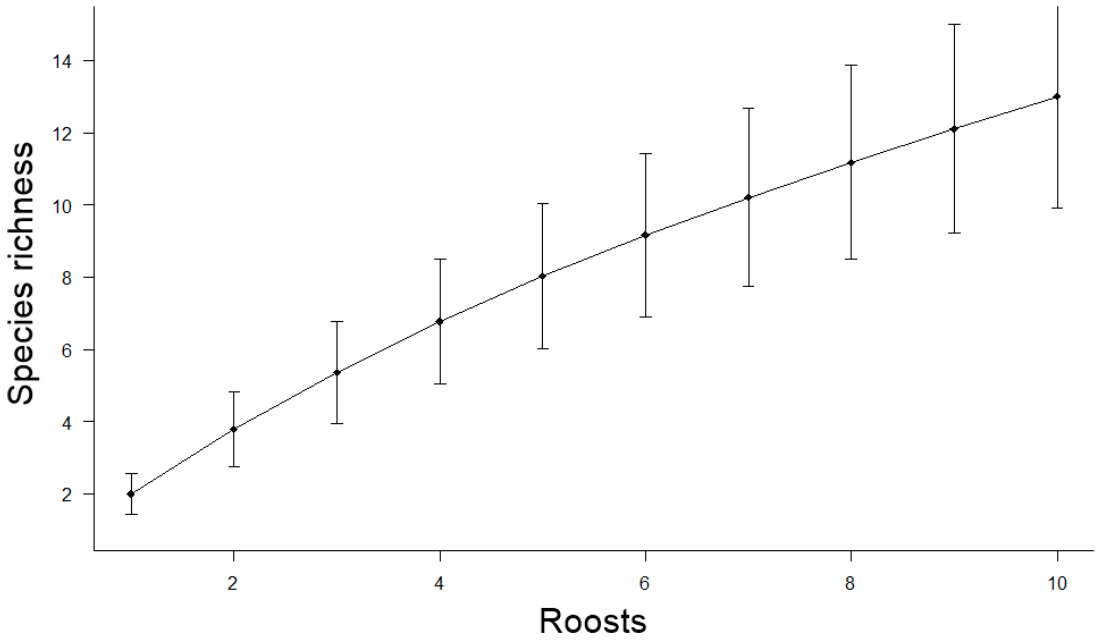

Figure 3. Sample-based species accumulation curve (randomized in PAST 3.18 Software) of bat species captured in Parque Estadual Carlos Botelho with 42 h of search for roosts. Error bars show confidence interval (95%). The curve was generated in RStudio Software.

The high richness found on CBSP may be related to the use of multiple sampling methods, rather than ground-level mist-nets only, as observed in many studies conducted in Brazilian Atlantic Forest (e.g., DIAS et al., 2002; DIAS; PERACCHI, 2008; MARTINS et al., 2015). The efficacy of multiple sampling methods is confirmed by the species uniquely sampled by each method. Among the 34 species reported, 11 were obtained exclusively with ground-level mist nets; 5 exclusively with canopy mist-nets; and 7 exclusively with search for roosts. Additionally, the first register of the species *Micronycteris schmidtorum* and *Molossus currentium* for the state of São Paulo, along with all other molossids captures, were made with canopy nets or search for roosts. Molossids are rarely captured in ground-level mist-nets due to its foraging habits (KALKO et al, 1996). Few species rarely registered in the state of São Paulo, such as *Dermanura cinerea*, *Eptesicus taddeii*, *Glyphonycteris sylvestris* and *Lampronycteris brachyotis* (see GARBINO, 2016), were also captured with those complementary methods.

The employ of mixed methodologies for bat sampling showed positive results in others studies and is encouraged by many authors (SIMMONS; VOSS, 1998; FEIJÓ; ROCHA, 2017; GREGORIN et al., 2017). Beyond the role in complementing the species list, the rate of bats captured in the canopy was higher than that in the ground-

level, with one capture each 130.2 m².h in the ground-level against one capture each 49.2 m².h in the canopy. Those unusual methodologies could not only register rare species, but also provide complementary information on its real abundance. The selectivity of ground-level mist-nets could lead to the misinterpretation of species abundance, once species rarely captured in ground-level mist-nets do not necessarily present low local abundances and could be more efficiently sampled with different methods (FEIJÓ; ROCHA, 2017). Therefore, we encourage the use of mixed methodologies and reinforce that continued capture efforts on the Park could enlarge the species list and provide additional information on the local species.

The list of species, identification process, distribution and natural history notes for all the species captured on CBSP are stated below. The taxonomic arrangement and nomenclature follow Nogueira et al. (2014).

Figure 4. Bat species captured in Carlos Botelho State Park. *Lampronycteris brachyotis* (A); *Micronycteris microtis* (B); *Micronycteris schmidtorum* (C); *Desmodus rotundus* (D); *Diphylla ecaudata* (E); *Mimon bennettii* (F); *Trachops cirrhosus* (G); *Anoura caudifer* (H); *Anoura geoffroyi* (I); *Glossophaga soricina* (J); *Carollia perspicillata* (K); and *Glyphonycteris sylvestris* (L).

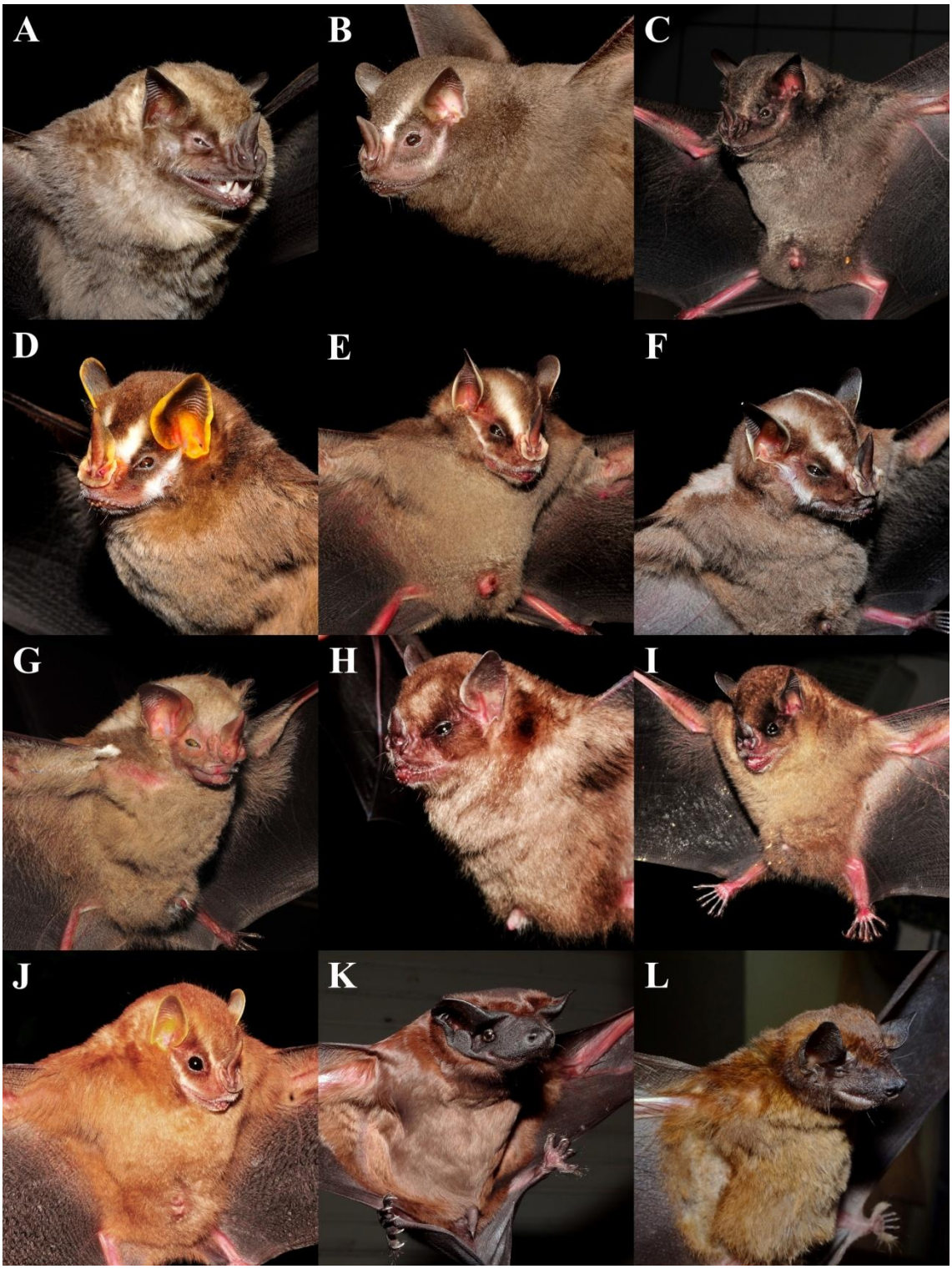

Figure 5. Bat species captured in Carlos Botelho State Park. *Artibeus fimbriatus* (A); *Artibeus lituratus* (B); *Artibeus obscurus* (C); *Dermanura cinerea* (D); *Platyrrhinus lineatus* (E); *Platyrrhinus recifinus* (F); *Pygoderma bilabiatum* (G); *Sturnira lilium* (H); *Sturnira tildae* (I); *Vampyressa pusilla* (J); *Cynomops abrasus* (K); and *Molossops neglectus* (L).

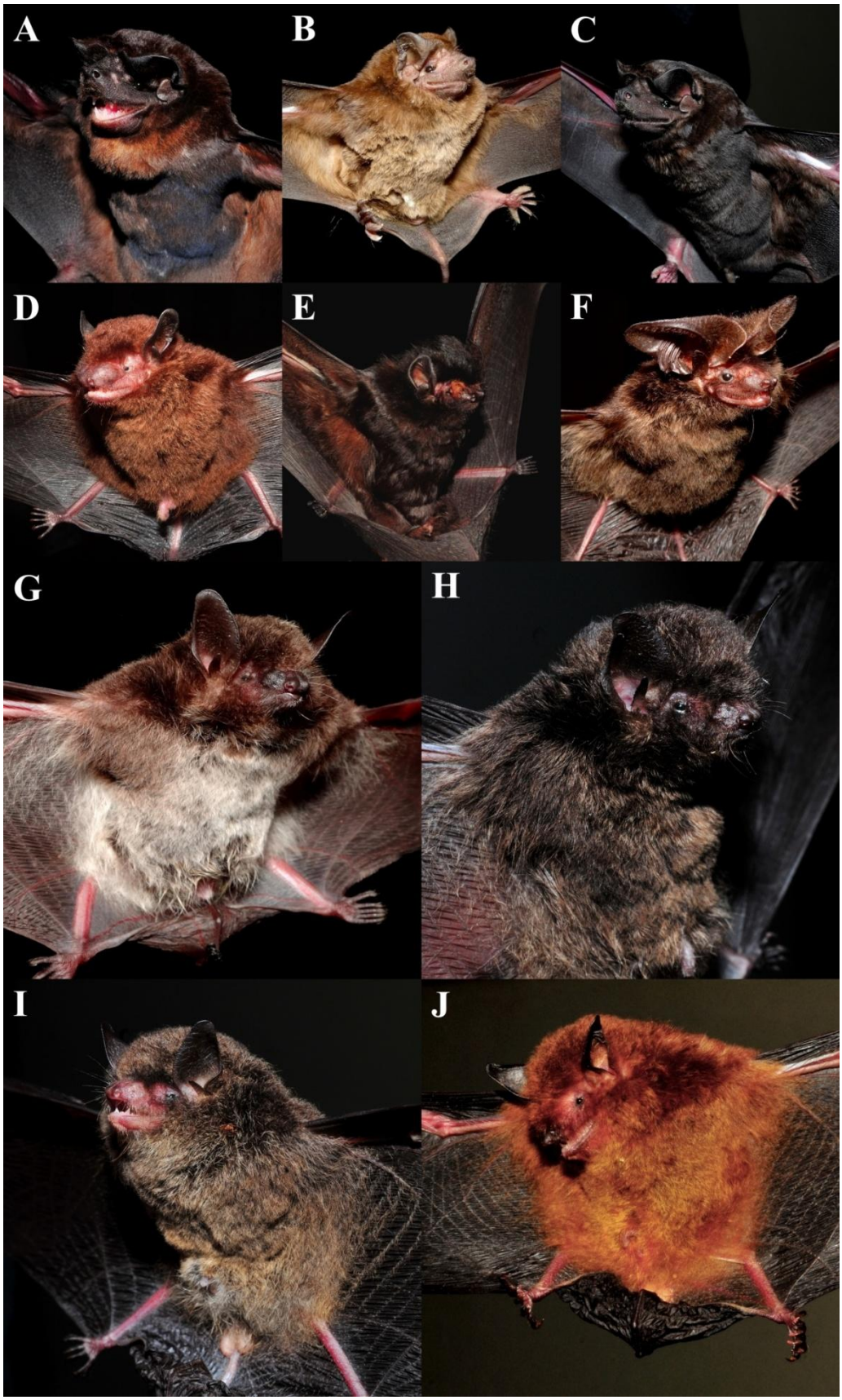

Figure 6. Bat species captured in Carlos Botelho State Park. *Molossus currentium* (A); *Molossus molossus* (B); *Molossus rufus* (C); *Eptesicus taddeii* (D); *Lasiurus ebenus* (E); *Histiotus velatus* (F); *Myotis albescens* (G); *Myotis nigricans* (H); *Myotis riparius* (I); and *Myotis ruber* (J).

Phyllostomidae Gray, 1825

Micronycterinae Van Den Bussche, 1992

***Lampronycteris brachyotis* (Dobson, 1879)**

Figure 4A

Taxonomy: The genus *Lampronycteris* is monotypic and represented only by *Lampronycteris brachyotis*. This genus is morphologically similar to others that occur in Brazil, such as *Glyphonycteris*, *Micronycteris*, *Neonycteris* and *Trinycteris* (WILLIAMS; GENOWAYS, 2008; NOGUEIRA et al., 2014). *Lampronycteris* can be separated from *Micronycteris* by the lack of an interauricular band of skin connecting the ears, that is present in *Micronycteris*; from *Neonycteris* by the size, forearm >35mm in *Lampronycteris*; from *Trinycteris* by the calcar length (equal or larger than foot in *Lampronycteris*) and for the ear length (more than 16mm in *Lampronycteris*); and from *Glyphonycteris* also by the calcar length (shorter than foot in *Glyphonycteris*) and for upper incisors length and shape (similar to canines in *Glyphonycteris*; shorter and narrower in *Lampronycteris*) (WILLIAMS; GENOWAYS, 2008; DÍAZ et al., 2016; LÓPEZ-BAUCELLS et al., 2016). The characters of the specimen from CBSP are similar to those described for *L. brachyotis* (SANBORN, 1949; MEDELLÍN et al., 1985; NOGUEIRA et al., 2007b; WILLIAMS; GENOWAYS 2008): pointed ears with lacking interauricular band of skin; calcar slightly longer than foot; upper incisors shorter and in line with canines; dorsal fur bicolored, with pale orange basis and orange brown tips; head, throat and chest with bright orange color; the ventral fur pale orange with white regions caused by irregular distribution of melanin (leucism); and ears, wings and membranes dark brown (wings and membranes also presented some white spots). External and skull measurements of voucher material in table 2.

Distribution: In Brazil the species is recorded on the states of Acre, Amazonas, Pará, Tocantins, Piauí, Bahia, Espírito Santo, São Paulo, Mato Grosso and Paraná (REIS et al., 2017). In the state of São Paulo the species is recorded only in two localities on the south region of the state (GARBINO, 2016).

Field observations: We captured only one specimen of *L. brachyotis*; on May an adult non-reproductive female was taken in a mist-net suspended 8 m over a small stream on sampling site M5.

Table 2. Selected measurements (mm) and weigth (g) for specimens of *Lampronycteris brachyotis*, *Micronycteris microtis* and *Micronycteris schimdtorum* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Lampronycteris brachyotis*	*Micronycteris microtis*	*Micronycteris microtis*	*Micronycteris schimdtorum*
	ZSP 040 ♀	ZSP 011 ♂	ZSP 028 ♀	ZSP 013 ♂
W	16.0	10.5	8.5	9.0
BL	60.66	50.94	41.28	49.52
FA	41.50	34.11	34.93	35.56
TL	16.96	14.88	15.46	17.67
EL	17.66	21.29	21.64	18.37
TRL	5.90	6.93	6.28	5.73
GLS	21.81	18.79	18.30	20.13
CI	19.68	16.38	16.19	17.62
BB	8.77	7.80	7.50	8.06
ZB	10.76	8.76	8.80	9.18
PB	5.02	3.91	3.91	4.41
CC	3.99	3.07	3.11	3.36
MB	9.03	7.52	7.48	7.96
PL	10.61	9.14	8.57	9.67
MXTL	8.28	6.88	6.66	7.76
MLTL	6.89	5.84	5.66	6.47
DL	14.79	11.86	11.64	12.52
MNTL	9.42	7.57	7.62	8.24
CH	5.15	3.65	3.69	4.61

***Micronycteris microtis* Miller, 1898**

Figure 4B

Taxonomy: Eight species of *Micronycteris* are recorded in Brazil: *M. brosseti* Simmons and Voss 1998, *M. hirsuta* (Peters, 1869), *M. homezorum* Pirlot, 1967, *M. megalotis* Gray, 1842, *M. microtis* Miller, 1898, *M. minuta* (Gervais, 1856), *M. sanborni* Simmons, 1996 and *M. schmidtorum* Sanborn, 1935 (NOGUEIRA et al., 2014). Those species are divided in two groups, the "pale venter" (*M. brosseti*, *M. minuta*, *M. homezorum*, *M. sanborni*, *M. schmidtorum*) and "dark venter" bats (*M. hirsuta*, *M. megalotis*, *M. microtis*), these groups can also be separated by the interauricular band height, that is high in the "pale venter" group and low in the "dark venter" group (SIMMONS et al., 2002). Specimens from CBSP belong to the "dark venter" group, exhibting a light brown dorsal fur, with pale basis; the ventral fur color is also light brown and weakly bicolored, similar to the dorsum in general coloration; and low

interauricular band. The forearm length is shorter than 35 mm, differing from *M. hirsuta* (forearm larger than 41mm) (SIMMONS et al. 2002; WILLIAMS; GENOWAYS, 2008; DÍAZ et al., 2016). *M. microtis* and *M. megalotis* can be differed by the length of the ears (less than 21 mm in *M. microtis* and more than 18.5 mm in *M. megalotis*); the length of the fur on lower third of marginal surface of pinna (less than 3.9 mm in *M. microtis* and more than 4.1 mm in *M. megalotis*); and the length of dorsal fur over the upper back (less than 11.3 mm in *M. microtis* and more than 9.1 mm in *M. megalotis*) (SIMMONS; VOSS, 1998; WILLIAMS; GENOWAYS, 2008; MORAS et al.. 2014). The measurements of specimens from CBSP were all within the range of *M. microtis*: length of ears 21.5 mm; length of the fur on pinna 3 mm; and length of dorsal fur 11 mm. Specimens from CBSP general coloration is brown, the dorsal fur is bicolored, with a light brown basal band and mid brown distal band; ventral fur coloration is similar to the dorsal, weakly bicolored and also mid brown. The interauricular band is low, with a shallow notch. External and skull measurements of voucher material in table 2.

Distribution: In Brazil the species is recorded on the states of Amazonas, Pará, Amapá, Rondônia, Bahia, Rio de Janeiro, Espírito Santo, Minas Gerais, São Paulo and Mato Grosso (REIS et al., 2017). In the state of São Paulo the species know only by four localities (GARBINO, 2016).

Field observations: We recorded one adult male and one adult female of *M. microtis*, both of them were taken in mist-nets set at ground-level on the sampling sites M3 and M16. Captures occurred on October and February.

***Micronycteris schmidtorum* Sanborn, 1935**

Figure 4C

Taxonomy: M. schmidtorum belong to the "pale venter" group, and can be differed from the other species based on the following characters: *M. schmidtorum* and *M. brosseti* present the calcar longer than hindfoot, which is smaller or equal than hindfoot in the other species; and dorsal fur larger than 7 mm, which is smaller than 7 mm in the other species (SIMMONS; VOSS, 1998; WILLIAMS; GENOWAYS, 2008). *M. schmidtorum* and *M. brosseti* can be distinguished based on tibia length (longer than 14.5 mm in *M. schmidtorum* and shorter in *M. brosseti*); and the length of the auricular fur (longer than 5 mm in *M. schmidtorum* and shorter than 4 mm in *M. brosseti*; SIMMONS; VOSS, 1998; WILLIAMS; GENOWAYS, 2008). The specimen from CBSP presented a

bicolored dorsal fur (ca. 7.5 mm), with light brown basis and nut-brown tips; the venter is tricolored, with whitish basis and tips, and a brown mid band. The posterior surface of the forearm is sparsely furred, and the uropatagium is also sparsely furred on the proximal third. The calcar is larger than foot, and the auricular fur length averages 5.5 mm. External and skull measurements of voucher material in table 2.

Distribution: The species is widely distributed in Brazil, and was previously registered on the states of Amapá, Amazonas, Pará, Tocantins, Mato Grosso, Maranhão, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia and Minas Gerais (ROCHA et al., 2017). Our record represents the southernmost register of the species in Brazil, the first register of the state of São Paulo, and enlarges the species distribution in more than 700 km southward (Figure 7).

Field observations: In October we captured an adult male that was taken in a mist-net elevated 8 m over a wide trail on sampling site M4.

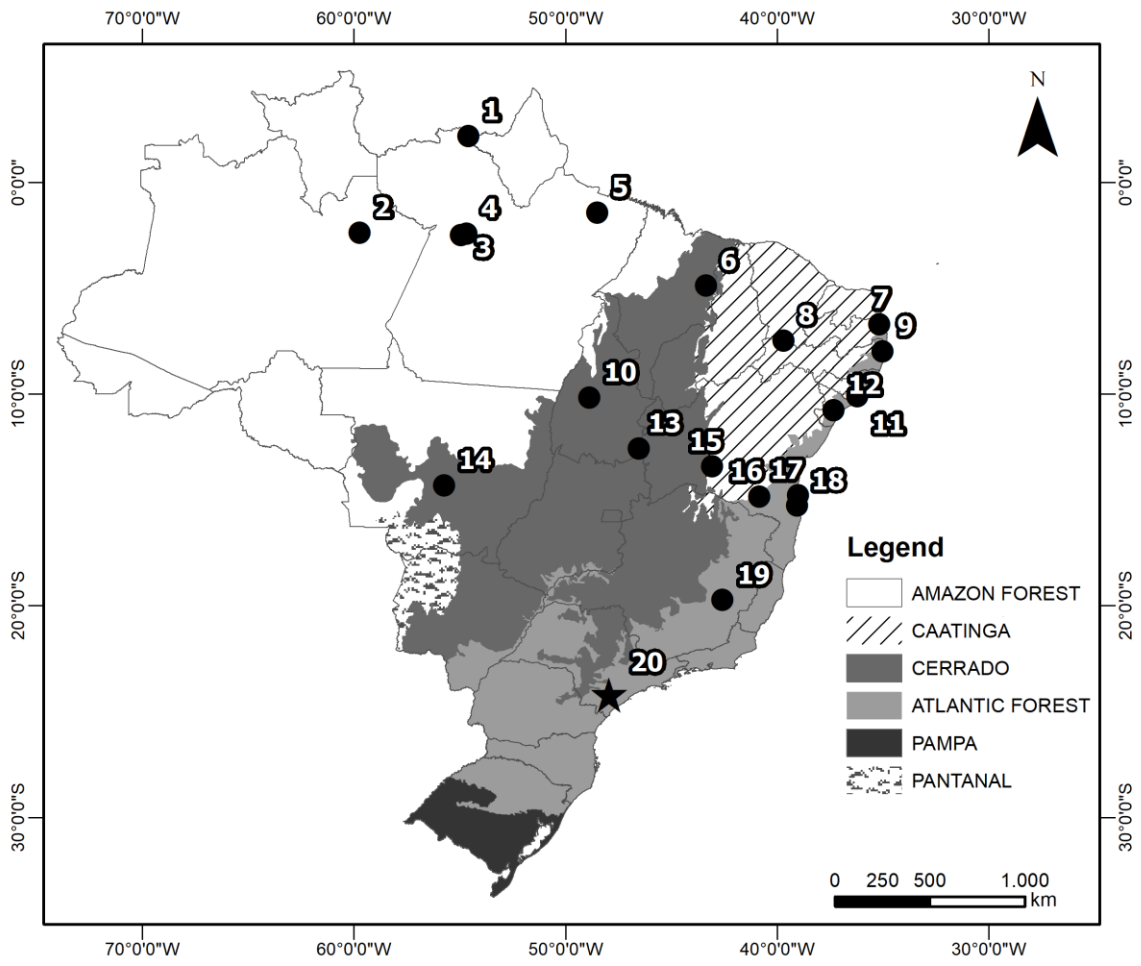

Figure 7. Geographic distribution of *Micronycteris schmidtorum* in Brazil. Black Circles: Previous records for the species; Black Star: new record from the state of São Paulo. Additional information is available in Table 15.

Desmodontinae J. A. Wagner, 1840

Desmodus rotundus (É. Geoffroy, 1810)

Figure 4D

Taxonomy: D. rotundus is the only species in the genus. The subfamily Desmodontinae also includes another two monotypic genus, represented by the species *Diaemus youngii* (Jentink, 1893) and *Diphylla ecaudata* Spix, 1823 (KWON; GARDNER 2008). *D. rotundus* can be separated from the other two species of the subfamily based on the presence of an elongated thumb with two rounded basal pads (*D. youngii* also present an elongated thumb, but only one pad; *D. ecaudata* present a small thumb and no pads); *D. rotundus* can also be differed from *D. youngii* by the presence of a tiny calcar, that is absent in *D. youngii* (KWON; GARDNER 2008; LÓPEZ-BAUCELLS et al., 2016). Specimens from CBSP dorsal fur coloration is dark brown, with whitish basis and dark brown tips; the ventral fur is also bicolored, with a gray basis and whitish/silver tips. The thumb is elongated and two basal pads are present. External and skull measurements of voucher material in table 3.

Distribution: In Brazil the species is recorded on all the states (REIS et al., 2017). In the state of São Paulo the species is also widely distributed (GARBINO, 2016).

Field observations: We captured 18 individuals (5 males and 13 females) of *D. rotundus*, of which 16 were taken in mist-nets set at ground-level on sampling sites M2, M14, M16, M18, M19, M23, M24, M25, M29, M34, M36 and M39, and two at a mist-net elevated 8 m on sampling site M33. Two lactating females were captured on June.

Diphylla ecaudata Spix, 1823

Figure 4E

Taxonomy: This species can be separated from *D. rotundus* as described above. Besides the short thumb, another character that can differ *D. ecaudata* from *D. youngii* is the presence of a short calcar in *D. ecaudata*, that is absent in *D. youngii* as cited above. Also, *D. youngii* is the only species of the subfamily that present white tips on the wings (KWON; GARDNER 2008). Specimens from CBSP presented a bicolored dorsal fur, with light brown basis and brown tips; the venter is also bicolored, with light brown basis and grayish tips. The forearm, legs and uropatagium are furred. The specimens presented a tiny calcar, reduced thumbs and well developed eyes. External and skull measurements of voucher material in table 3.

Distribution: In Brazil the species is recorded on the states of Amazonas, Acre, Rondônia, Pará, Amapá, Tocantins, Ceará, Pernambuco, Sergipe, Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina (REIS et al., 2017). In the state of São Paulo the species is distributed along the coastal Atlantic Forest (GARBINO, 2016).

Field observations: The four captures of *D. ecaudata* (3 males and 1 female) occurred in mist-nets set at ground-level on sampling sites M17, M25, M28 and M34.

Table 3. Selected measurements (mm) and weigth (g) for specimens of *Desmodus rotundus* and *Diphylla ecaudata* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Desmodus rotundus*	*Desmodus rotundus*	*Diphylla ecaudata*	*Diphylla ecaudata*
	ZSP 006 ♀	ZSP 031 ♂	ZSP 039 ♂	ZSP 049 ♂
W	34.0	39.5	30.0	27.0
BL	83.52	80.42	70.91	68.38
FA	64.01	61.55	53.44	52.59
TL	28.44	27.62	21.92	21.97
EL	17.67	19.66	13.45	13.46
TRL	6.74	7.33	6.97	5.52
GLS	25.92	24.96	23.00	23.48
CI	23.11	21.96	20.41	20.77
BB	13.00	12.45	11.50	11.38
ZB	12.20	12.42	12.61	12.37
PB	5.74	5.77	6.70	6.80
CC	6.36	6.46	5.77	5.71
MB	11.57	11.68	11.39	11.34
PL	10.21	9.55	7.48	7.66
MXTL	3.73	3.62	3.54	3.67
MLTL	1.41	1.31	1.47	1.76
DL	15.36	14.82	13.68	13.87
MNTL	8.06	7.06	6.40	6.54
CH	6.37	6.00	4.53	4.56

Phyllostominae Gray, 1825

Mimon bennettii (Gray, 1838)

Figure 4F

Taxonomy: Mimon bennettii (Gray, 1838) is the only species of the genus registered in Brazil (HURTADO; PACHECO, 2014; NOGUEIRA et al., 2014). The species is very similar to *Gardnerycteris crenulatum* (Geoffroy, 1803). The diagnosis of those species is based on the morphology of the noseleaf, which is smooth in *M. bennettii* and

serrated in *G. crenulatum*; and the dorsal color, that is mid brown with lighter reddish venter and no stripes in *M. bennettii*, and dorsal fur dark brown with a single white stripe and yellowish brown ventral fur in *G. crenulatum* (ORTEGA; ARITA, 1997; NOGUEIRA et al., 2007b; HURTADO; PACHECO, 2014). The specimen from CBSP general coloration is reddish, and presented a bicolored dorsal fur, with mid brown basal band and reddish brown distal band; the venter is weakly bicolored, with general reddish light brown coloration. The wings are attached along the tibia, the ears are pointed and well developed, and noseleaf is also well developed and smooth. The tail extends to middle of uropatagium. External and skull measurements of voucher material in table 4.

Table 4. Selected measurements (mm) and weigth (g) for specimens of *Mimon bennetti*, *Trachops cirrhosus* and *Glyphonycteris sylvestris* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Mimon bennetti*	*Trachops cirrhosus*	*Glyphonycteris sylvestris*	*Glyphonycteris sylvestris*
	ZSP 041 ♀	ZSP 024 ♂	ZSP 033 ♂	ZSP 042 ♂
W	22.0	32.0	18.0	12.0
BL	65.83	74.32	52.12	55.39
FA	57.29	57.89	40.96	43.30
TL	24.77	25.55	15.02	15.98
EL	35.30	27.20	17.89	15.87
TRL	13.99	10.27	6.38	7.31
GLS	25.55	28.08	20.96	22.01
CI	22.86	24.69	19.17	19.94
BB	9.77	11.23	9.11	9.36
ZB	13.52	13.31	10.34	10.62
PB	4.71	5.18	5.01	5.01
CC	5.40	5.75	3.52	3.77
MB	10.53	11.69	8.62	8.93
PL	12.75	11.22	9.86	10.39
MXTL	9.56	10.20	8.30	8.77
MLTL	8.01	8.19	6.63	7.27
DL	17.14	18.19	13.60	14.50
MNTL	10.89	11.40	9.18	10.05
CH	5.92	4.97	3.81	4.19

Distribution: In Brazil the species is recorded on the states of Amapá, Piauí, Bahia, Mato Grosso, Mato Grosso do Sul, Goiás, Distrito Federal, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina (REIS et al., 2017). The type locality of the species is in the state of São Paulo, where the species is distributed on the central, eastern and southeastern regions (GARBINO, 2016).

Field observations: A non-reproductive female was netted on May; the capture occurred in a mist-net set at ground-level crossing a wide stream on sampling site M18.

***Trachops cirrhosus* (Spix, 1823)**

Figure 4G

Taxonomy: T. cirrhosus is the only species of its monotypic genus and can be easily distinguished from the other members of the subfamily Phyllostominae, once it is the only species that presents elongated papillae-like projections around the mouth (LIM; ENGSTROM, 2001; WILLIAMS; GENOWAYS, 2008). The dorsal fur coloration of the specimens from CBSP is grayish brown, with light brown basis; the ventral fur is slightly lighter than dorsal fur and also bicolored, with whitish gray basis and gray tips. The ears are rounded and well developed, the tail reaches the middle of the interfemoral membrane and the margins of noseleaf are serrated. External and skull measurements of voucher material in table 4.

Distribution: In Brazil the species is recorded on the states of Amazonas, Acre, Rondônia, Roraima, Pará, Amapá, Tocantins, Mato Grosso, Mato Grosso do Sul, Goiás, Distrito Federal, Paraná, São Paulo, Rio de Janeiro, Minas Gerais, Espírito Santo, Bahia, Sergipe, Alagoas, Pernambuco, Paraíba, Ceará, and Piauí (REIS et al., 2017). In the state of São Paulo the species is distributed along the coastal Atlantic Forest (GARBINO, 2016).

Field observations: We captured three individuals (2 males and 1 female) of *T. cirrhosus*, which were taken in mist-nets set at ground-level on sampling sites M4, M10 and M16. Captures occurred on January and February, one lactating female was captured on January.

Glossophaginae Bonaparte, 1845

***Anoura caudifer* (E. Geoffroy, 1818)**

Figure 4H

Taxonomy: The genus *Anoura* is represented in Brazil by the species *A. caudifer* E. Geoffroy, 1818) and *A. geoffroyi* Gray, 1838 (NOGUEIRA et al., 2014). These two species can be separated based on morphologic characters: *A. caudifer* is smaller, with forearm <39 mm (>39 mm in *A. geoffroyi*); the tail is always absent in *A. geoffroyi* (present in *A. caudifer*, although reduced and sometimes not visible); narrow

uropatagium in *A. caudifer* (very reduced in *A. geoffroyi*); and well furred uropatagium with the fur reaching the feet in *A. geoffroyi* (only a central fringe present in *A. caudifer*) (MANTILLA-MELUK; BAKER, 2006; NOGUEIRA et al., 2007a; DÍAZ et al., 2016). Specimens from CBSP presented bicolored dorsal fur, with pale basis and brown tips; ventral fur lighter than dorsal, mid brown and almost unicolored; face and membranes mid brown. Uropatagium with a central fringe of dense hairs; the tail was visible in all specimens captured. External and skull measurements of voucher material in table 5.

Distribution: In Brazil the species is recorded on the states of Acre, Amazonas, Amapá, Bahia, Espirito Santo, Goiás, Minas Gerais, Mato Grosso do Sul, Mato Grosso, Pará, Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina and São Paulo (REIS et al., 2017). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: We captured 41 specimens of *A. caudifer*, of which 20 (12 males and 8 females) were taken in mist-nets set at ground-level on sampling sites M3, M4, M6, M7, M11, M16, M19, M20, M21, M22, M23, M25, M27, M29 and M38; six (1 male and 5 females) were taken at mist-nets elevated 8 m on sampling sites M5 and M9; and 15 were captured on a roosting site inside a culvert on sampling site S1. Captures occurred on October, November, December, February, April, May, July, August and September. Lactating females were captured on May, October and December, and pregnant females were caught on August, September, October, November and December.

***Anoura geoffroyi* Gray, 1838**

Figure 4I

Taxonomy: The diagnosis of *A. geoffroyi* is described above. Specimens from CBSP presented a dark brown color on dorsum, with pale basis; venter color grayish and unicolored; face and membranes mid brown. The uropatagium well furred with hairs reaching the feet; the tail was absent in all the specimens captured. External and skull measurements of voucher material in table 5.

Distribution: In Brazil the species is recorded on the states of Amapá, Bahia, Ceará, Espirito Santo, Goiás, Minas Gerais, Mato Grosso do Sul, Mato Grosso, Pará, Paraíba, Pernambuco, Piauí, Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, Tocantins e São Paulo (REIS et al., 2017). In the state of São Paulo the species is recorded on the north, central and southeastern regions (GARBINO, 2016).

Field observations: We recorded 28 captures of *A. geoffroyi*, of which 22 (5 males and 17 females) were taken in mist-nets set at ground-level on sampling sites M4, M6, M7, M17, M20, M21, M23, M26 and M32, and six (2 males and 4 females) at mist-nets elevated 8 m on sampling sites M5, M6, M7, M20 and M31. Captures occurred on October, November, March, April, May, August and September; pregnant females were caught on September, October and November.

Table 5. Selected measurements (mm) and weigth (g) for specimens of *Anoura caudifer*, *Anoura geoffroyi* and *Glossophaga soricina* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Anoura caudifer*	*Anoura caudifer*	*Anoura geoffroyi*	*Anoura geoffroyi*	*Glossophaga soricina*
	ZSP 001 ♂	ZSP 012 ♀	ZSP 014 ♀	ZSP 057 ♂	ZSP 060 ♂
W	12.0	12.0	22.0	17.5	10.5
BL	61.22	53.32	69.79	63.05	54.13
FA	38.18	36.17	42.00	42.23	36.92
TL	13.87	14.00	16.20	15.52	15.64
EL	13.86	12.57	14.33	15.87	15.35
TRL	4.70	5.77	4.98	5.57	5.99
GLS	23.00	22.52	26.23	25.52	21.06
CI	22.28	21.81	25.51	24.64	19.93
BB	9.51	8.92	9.95	9.95	8.85
ZB	10.03	9.52	11.20	11.30	9.84
PB	4.78	4.49	5.19	5.26	4.90
CC	4.52	4.20	4.61	4.86	3.90
MB	8.94	8.68	10.10	9.80	8.78
PL	12.81	12.41	15.26	14.20	11.53
MXTL	8.41	8.32	10.23	9.50	7.40
MLTL	7.25	7.03	8.54	7.46	5.51
DL	16.83	16.35	19.20	17.83	14.43
MNTL	9.35	8.77	11.30	10.53	8.32
CH	4.27	3.64	4.57	4.90	4.26

***Glossophaga soricina* (Pallas, 1766)**

Figure 4J

Taxonomy: Three species of the genus are registered in Brazil: *G. commissarisi* Gardner, 1962, *G. longirostris* Miller, 1898 and *G. soricina* (Pallas, 1766) (NOGUEIRA et al., 2014). The diagnosis of these species is based mainly on tooth characters: *G. commissarisi* can be separated from the other two species by the position and shape of incisors, the lower incisors are reduced and present distinct gaps between them, while the other two species present large lower incisors, that are usually in

contact, forming a complete arc between canines; upper incisors not procumbent (greatly procumbent on the other two species). *G. longirostris* and *G. soricina* can be separated by the shape of inner upper incisors, that are larger than the outer in oclusal view in *G. soricina* and about the same size of the outer in *G. longirostris*; and the lower incisors that are large and weakly cusped in *G. longirostris* and spatulated in *G. soricina* (WEBSTER, 1993, NOGUEIRA et al., 2007a, LÓPEZ-BAUCELLS et al., 2016). Specimens from CBSP presented a bicolored dorsal fur, with light brown basis and nut-brown tips; the ventral fur is also bicolored, with light brown basis and nut-brown tips. The rostrum is short and the lower lip is grooved and surrounded by small warts. External and skull measurements of voucher material in table 5.

Distribution: In Brazil the species is recorded on all the states (REIS et al., 2017). In the state of São Paulo the species is also widely distributed (GARBINO, 2016).

Field observations: On September we captured an adult male in a roosting site on a building roof, on sampling site S17; at the same roost we captured one specimen of *M. rufus*.

Carolliinae Miller, 1924

Carollia perspicillata (Linnaeus, 1758)

Figure 4K

Taxonomy: The genus is represented in Brazil by *C. benkeithi* Solari & Baker, 2006, *C. brevicauda* (Schinz, 1821) and *C. perspicillata* (Linnaeus, 1758) (NOGUEIRA et al., 2014). *C. benkeithi* is smaller than the other two species, with a forearm shorter than 39 mm (forearm can reach 45 mm in *C. perspicillata* and 42 mm in *C. brevicauda*); forearm naked (forearm dorsally furred in *C. perspicillata* and *C. brevicauda*); dorsal fur without sharply defined banding (marked banding in *C. perspicillata* and *C. brevicauda*); and short ventral fur, with brown-tipped bicolored hairs (ventral fur unicolored in *C. perspicillata* and slightly bicolored in *C. brevicauda*) (ALLEN, 1890; CLOUTIER; THOMAS, 1992; SIMMONS; VOSS, 1998; SOLARI; BAKER, 2006; LÓPEZ-BAUCELLS et al., 2016). The effectivity of the diagnostic characters between *C. perspicillata* and *C. brevicauda* are still discussed (DIAS; PERACCHI, 2008). Useful characters to separate these species are: outer inferior incisors obscured by cingulum of canine in *C. perspicillata* (easily visible in *C. brevicauda*); mandible generally V shaped in *C. perspicillata* (tending to be U shaped in *C. brevicauda*); upper

toothrow straight in *C. perspicillata* (bowed lingually in *C. brevicauda*); dorsal fur shorter and weakly tricolor in *C. perspicillata* (hairs are longer with well marked banding in *C. brevicauda*); forearm of *C. brevicauda* is usually hairier than in *C. perspicillata*; and tibia length > 14 mm in *C. perspicillata* and < 16 mm in *C. brevicauda* (PINE, 1972; CLOUTIER; THOMAS, 1992; THOMAS, 2017).

Table 6. Selected measurements (mm) and weigth (g) for specimens of *Carollia perspicillata* and *Pygoderma bilabiatum* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Carollia perspicillata*	*Carollia perspicillata*	*Pygoderma bilabiatum*	*Pygoderma bilabiatum*
	ZSP 022 ♂	ZSP 045 ♂	ZSP 043 ♂	ZSP 044 ♂
W	15.0	19.0	18.0	16.0
BL	59.93	55.65	59.60	59.22
FA	39.07	42.25	37.91	37.19
TL	16.99	16.34	19.82	21.16
EL	19.51	17.23	18.83	18.95
TRL	6.77	6.53	6.99	6.80
GLS	22.06	22.32	20.42	20.46
CI	19.97	20.41	17.57	17.40
BB	9.19	9.54	10.66	10.31
ZB	10.80	11.12	13.85	13.72
PB	5.32	5.46	7.94	7.85
CC	4.87	4.93	6.16	6.08
MB	9.35	9.75	11.04	10.75
PL	10.37	10.22	6.59	6.83
MXTL	7.28	7.38	5.49	5.62
MLTL	5.78	5.91	4.49	4.59
DL	13.99	14.45	12.02	12.03
MNTL	8.57	8.56	5.79	6.00
CH	5.38	5.28	4.36	4.53

Specimens from CBSP presented a well marked tetracolored dorsal fur, with a light brown basal band (ca. 10% of fur extent), followed by a large dark brown band, a light brown band and dark brown tips; the venter is lighter and unicolored. The well marked tetracolored pattern of the dorsal fur diverge from the characters observed by other authors for the species (PINE, 1972; CLOUTIER; THOMAS, 1992; DIAS;PERACCHI, 2008), but the tibia length (averaging 16.8 mm), the dorsal fur length (averaging 8 mm), sparsely furred thumb and forearm, and skull features were useful to distinguish specimens from CBSP from *C. brevicauda*. External and skull measurements of voucher material in table 6.

Distribution: In Brazil the species is recorded on all the states (REIS et al., 2017). In the state of São Paulo the species is also widely distributed (GARBINO, 2016).

Field observations: We captured 95 individuals (51 males and 44 females) of *C. perspicillata*, all of them were taken on mist-nets set at ground-level on sampling sites M3, M4, M5, M6, M10, M13, M14, M16, M17, M18, M19, M20, M21, M22, M23, M24, M25, M27, M28, M31, M33 and M34. Captures occurred on all the months except July and December. We recorded lactating females on February, May and November; pregnant females on January, April, September and October; and juveniles on January, February, March, April, May and June.

Glyphonycterinae Baker, Solari, Cirranello, and Simmons 2016

Glyphonycteris sylvestris Thomas, 1896

Figure 4L

Taxonomy: The genus is represented in Brazil by the species *Glyphonycteris behnii* (Peters 1856), *Glyphonycteris daviesi* (Hill, 1965) and *Glyphonycteris sylvestris* Thomas, 1896 (NOGUEIRA et al., 2014). *G. behnii* validity is still discussed, once Simmons and Voss (1998) suggested that *G. behnii* is a senior synonym of *G. sylvestris* based on results obtained by Simmons (1996), which examined two specimens referred as *G. behnii* and concluded that forearm and skull measurements of those specimens overlap the values registered for *G. sylvestris*. Gregorin et al. (2011b), however, suggest that the two specimens analyzed by Simmons (1996) should be considered *G. sylvestris* and the occurrence of *G. behnii* restricted to Brazil. The three species that occur in Brazil can be separated by morphological and dental characters: *G. daviesi* is much bigger than the other two and can be separated by the forearm length (> 52 mm in *G. daviesi*, < 44 mm in *G. sylvestris* and between 44 and 47 mm in *G. behnii*); *G. daviesi* present one pair of upper incisors, and the other species two pairs; and by the dorsal fur coloration, that is unicolored in *G. daviesi* and tricolored on the other two (SIMMONS; VOSS, 1998; NOGUEIRA et al., 2007b; WILLIAMS; GENOWAYS, 2008). Additionally, *G. sylvestris* can be separated from *G. behnii* by skull measurements (GLS < 22 mm in *G. sylvestris* and > 21 mm in *G. behnii*) (WILLIAMS; GENOWAYS, 2008; GREGORIN et al., 2011b). Specimens from CBSP presented a tricolored dorsal fur, with gray basal band, followed by a pale gray mid band and dark gray tips; the ventral fur is bicolored, with a gray basal band and light gray distal band. Ears are medium

sized and pointed; the tail does not reach the edge of interfemoral membrane; and calcar smaller than foot. Incisors resemble canines on size and shape; and premolars of same size. External and skull measurements of voucher material in table 4.

Distribution: In Brazil the species is recorded on the states of Amazonas, Amapá, Minas Gerais, Pará, Paraná, Rio de Janeiro, Roraima, and São Paulo (REIS et al., 2017). In the state of São Paulo the species is recorded in only two locations (GARBINO, 2016).

Field observations: We captured two adult males of *G. sylvestris* in mist-nets elevated 8 m over a wide stream, on sampling sites M18 and M24. Captures occurred on March and May.

Stenodermatinae P. Gervais, 1856

Artibeus fimbriatus Gray, 1838

Figure 5A

Taxonomy: Five species of the genus *Artibeus* can be found in Brazil: *Artibeus concolor* Peters, 1865, *Artibeus fimbriatus* Gray, 1838, *Artibeus lituratus* (Olfers, 1818), *Artibeus obscurus* (Schinz, 1821) and *Artibeus planirostris* (Spix, 1832) (NOGUEIRA et al., 2014). *A. concolor* present a small size, under the range of the other species in the genus, and can be easily distinguished (forearm < 53 mm in *A. concolor* and > 55 mm in the other species); *A. concolor* also present tricolored dorsal fur (bicolored in the other species of the genus) (MARQUES-AGUIAR, 2007; ZÓRTEA, 2007; DÍAZ et al., 2016). The identification of the species captured in the field were based on characters related by Koepcke and Kraft (1984), Marques-Aguiar (1994), Lim and Engstrom (2001), Haynes and Lee Jr. (2004), Holis (2005), Zortéa (2007), Marques-Aguiar (2008), Dias and Peracchi (2008) and Araújo and Langguth (2010): base of noseleaf (attached or separate from upper lip), brightness of facial stripes, presence/absence of fur on the dorsal side of forearm, corporal size, presence/absence of fur on the dorsal side of uropatagium, presence/absence of ventral frosting and length of dorsal fur. *A. fimbriatus* can be distinguished from *A. lituratus* by the presence of sparse hairs on the dorsal side of the uropatagium in *A. fimbriatus* (densely furred on *A. lituratus*); presence of ventral frosting in *A. fimbriatus* (absent in *A. lituratus*); weakly marked facial stripes in *A. fimbriatus* (brilliant in *A. lituratus*); longer dorsal fur (6–8 mm in *A. lituratus* and close to 8 mm in *A. fimbriatus*); and presence of sparse hairs on the dorsal side of the forearm in *A. fimbriatus* (densely furred on *A. lituratus*) (KOEPCKE; KRAFT, 1984;

MARQUES-AGUIAR, 1994; HAYNES; LEE JR., 2004; MARQUES-AGUIAR, 2008; DIAS; PERACCHI, 2008; ARAÚJO; LANGGUTH, 2010).

A. fimbriatus and *A. planirostris* can be distinguished by the presence of sparse hairs on the dorsal side of the uropatagium and forearm in *A. fimbriatus* (almost naked in *A. planiostris*); base of the noseleaf attached to the upper lip in *A. fimbriatus* (separated in *A. planirostris*); and length of dorsal fur (close to 8 mm in *A. fimbriatus* and 6–8 mm in *A. planirostris*) (KOEPCKE; KRAFT, 1984; MARQUES-AGUIAR, 1994; HAYNES; LEE JR., 2004; HOLIS, 2005; MARQUES-AGUIAR, 2008). *A. obscurus* and *A. fimbriatus* can be separated by the length of dorsal fur (close to 8 mm in *A. fimbriatus* and 8–10 mm in *A. obscurus*); base of the noseleaf attached to the upper lip in *A. fimbriatus* (separated in *A. obscurus*); presence of sparse hairs on the dorsal side of the uropatagium in *A. fimbriatus* (almost naked on *A. obscurus*); and presence of sparse hairs on the dorsal side of the forearm in *A. fimbriatus* (densely furred on *A. obscurus*) (MARQUES-AGUIAR, 1994; HAYNES; LEE JR., 2004; MARQUES-AGUIAR, 2008; DIAS; PERACCHI, 2008; ARAÚJO; LANGGUTH, 2010).

Table 7. Selected measurements (mm) and weigth (g) for specimens of *Artibeus fimbriatus*, Artibeus *lituratus* and *Artibeus obscurus* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Artibeus fimbriatus*	*Artibeus fimbriatus*	*Artibeus lituratus*	*Artibeus lituratus*	*Artibeus obscurus*	*Artibeus obscurus*
	ZSP 027 ♀	ZSP 037 ♂	ZSP 015 ♀	ZSP 056 ♂	ZSP 009 ♂	ZSP 025 ♀
W	48.0	49.5	64.5	65.0	39.0	43.0
BL	81.02	81.61	94.72	88,37	77.50	77.82
FA	67.61	64.71	68.04	70,29	57.11	58.01
TL	28.72	27.05	30.06	26,61	22.94	21.16
EL	19.85	23.00	19.13	22,67	21.59	21.88
TRL	4.90	7.18	6.32	7,78	7.32	6.59
GLS	31.28	32.10	32.60	31.82	27.79	28.26
CI	28.06	28.53	28.95	28.22	25.00	25.73
BB	13.40	13.32	13.64	13.70	12.45	12.38
ZB	18.33	19.03	19.75	18.30	16.64	17.06
PB	7.35	7.69	7.86	6,54	6.69	6.38
CC	9.08	8.95	9.35	8.47	7.73	7.44
MB	14.44	14.93	15.62	14.82	13.44	13.33
PL	15.78	16.15	16.04	15.90	14.02	14.40
MXTL	11.27	11.92	11.94	11.06	10.41	10.36
MLTL	9.68	10.08	10.14	9.42	8.89	8.86
DL	21.61	21.41	21.87	21.83	19.55	19.69
MNTL	13.55	13.49	13.67	13.05	11.87	11.19
CH	9.14	8.83	9.89	10.03	8.06	7.91

Specimens from CBSP presented bicolored dorsal fur, with pale brown basis and grayish brown tips; venter fur weakly bicolored, with pale basis and frosted tips. Dorsal fur averaging 8.5 mm (7.9–9.3 mm); forearm and uropatagium sparsely furred; noseleaf attached to the upper lip; ears and tragus brown; and poorly marked facial stripes. External and skull measurements of voucher material in table 7.

Distribution: In Brazil the species is recorded on the states of Ceará, Pernambuco, Sergipe, Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Mato Grosso do Sul, Paraná, Santa Catarina and Rio Grande do Sul (REIS et al., 2013). In the state of São Paulo the species is recorded on the central, south and southeastern regions (GARBINO, 2016).

Field observations: We recorded 46 captures of *A. fimbriatus*, of which 37 (14 males and 23 females) were taken in mist-nets set at ground-level on sampling sites M7, M14, M16, M18 M20, M21, M24, M26, M27, M28, M32, M35, M36 and M38; eight (4 males and 4 females) in mist-nets elevated 8 m on sampling sites M14, M24, M26, M28 and M31; and one adult female on a building roof, on sampling site S2. Captures occurred on November, February, March, April, May, June, July and September. Lactating females were netted on February, March and July; pregnant females on February, March and November; and juveniles on February, March, April, May and July.

***Artibeus lituratus* (Olfers, 1818)**

Figure 5B

Taxonomy: The distinction between *A. lituratus* and *A. fimbriatus* is discussed above. *A. lituratus*can be separated from *A. planirostris* and *A. obscurus* by the base of the noseleaf attached to the upper lip (separated in *A. planirostris* and *A. obscurus*); and densely furred dorsal side of the uropatagium in *A. lituratus* (almost naked in *A. planirostris* and *A. obscurus*). *A. lituratus* can also be separated from *A. planirostris* by the presence of dense fur on the dorsal side of the forearm in *A. lituratus* (almost naked in *A. planirostris*). Additionally, *A. lituratus* present short dorsal fur (6–8 mm), which is longer in *A. obscurus* (8–10 mm) (KOEPCKE; KRAFT, 1984; MARQUES-AGUIAR, 1994; HAYNES; LEE JR., 2004; HOLIS, 2005; ZORTÉA, 2007; MARQUES-AGUIAR, 2008; DIAS; PERACCHI, 2008; ARAÚJO; LANGGUTH, 2010). Specimens from CBSP presented bicolored dorsal fur, with grayish brown basal band

and chocolate brown tips; ventral fur weakly bicolored with pale brown basis and grayish tips, frosting absent. Uropatagium and forearm densely furred; bright and well marked facial stripes; edge of ears and tragus yellowish; dorsal fur ranging from 7.7 to 8.9 mm; and noseleaf attached to the upper lip. External and skull measurements of voucher material in table 7.

Distribution: In Brazil the species is recorded on all the states (REIS et al., 2017). In the state of São Paulo the species is also widely distributed (GARBINO, 2016).

Field observations: We captured 10 specimens of *A. lituratus*, of which seven (4 males and 3 females) were taken in mist-nets set at ground-level on sampling sites M6, M18, M19, M21, M22 and M32; and three (1 male and 2 females) in mist-nets elevated 8 m on sampling sites M15, M20 and M24. Captures occurred on November, January, February, March, May and September. We netted lactating females on January, March and November; and juveniles on September.

***Artibeus obscurus* (Schinz, 1821)**

Figure 5C

Taxonomy: *A. obscurus* and *A. planirostris* can be distinguished using the length of dorsal fur (8–10 mm in *A. obscurus* and 6–8 mm in *A. planirostris*); densely furred dorsal side of the forearm in *A. obscurus* (almost naked in *A. planirostris*); and more evident ventral frosting in *A. obscurus* (KOEPCKE; KRAFT, 1984; MARQUES-AGUIAR, 1994; HAYNES; LEE JR., 2004; HOLIS, 2005; MARQUES-AGUIAR, 2008; DIAS; PERACCHI, 2008; ARAÚJO; LANGGUTH, 2010). Specimens from CBSP presented bicolored dorsal fur, with pale brown basis and grayish dark brown tips; venter fur weakly bicolored, with pale basis and frosted tips. Dorsal fur averaging 11 mm (10.35–11.8 mm); forearm densely furred; uropatagium sparsely furred; base of noseleaf usually free; ears and tragus brown; poorly marked facial stripes; and dark mask on the region of the eyes usually present. External and skull measurements of voucher material in table 7.

Distribution: In Brazil the species is recorded on the states of Amazonas, Acre, Rondônia, Pará, Amapá, Roraima, Ceará, Piauí, Paraíba, Pernambuco, Sergipe, Bahia, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina (REIS et al., 2013). In the state of São Paulo the species is distributed along the coastal Atlantic Forest (GARBINO, 2016).

Field observations: We recorded 31 captures of *A. obscurus*, of which 27 (10 males and 17 females) were taken in mist-nets set at ground-level on sampling sites M3, M4, M5, M16, M18, M21, M22, M23, M24, M25, M27, M28, M37 and M38; and four females in mist-nets elevated 8 m on sampling sites M5, M18, M24 and M28. Captures occurred on October, January, February, March, April, May, July, August and September. We captured lactating females on January, February, April, May and July; pregnant females on May and August; and juveniles on January and April.

Table 8. Selected measurements (mm) and weigth (g) for specimens of *Dermanura cinerea*, *Platyrrhinus lineatus*, *Platyrrhinus recifinus* and *Vampyressa pusilla* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Dermanura cinerea*	*Dermanura cinerea*	*Platyrrhinus lineatus*	*Platyrrhinus recifinus*	*Vampyressa pusilla*
	ZSP 035 ♀	ZSP 036 ♀	ZSP 032 ♀	ZSP 055 ♂	ZSP 058 ♂
W	14.0	13.0	23.0	20.0	9.0
BL	55.57	54.22	58.09	62.26	50.69
FA	40.15	40.69	44.82	42.51	34.48
TL	16.33	15.70	18.03	16.01	12.91
EL	12.89	13.16	16.26	14.75	13.99
TRL	5.21	5.34	5.15	5.42	5.19
GLS	20.46	21.04	24.77	25.10	20.10
CI	18.44	18.42	22.31	23.18	18.46
BB	9.59	9.02	10.43	10.71	8.75
ZB	12.51	11.65	14.33	14.69	11.72
PB	4.68	4.49	5.43	5.92	5.05
CC	5.78	5.33	6.26	6.31	4.89
MB	10.12	9.50	11.33	11.93	9.54
PL	10.00	9.99	12.29	12.50	9.60
MXTL	6.56	6.75	9.33	9.42	6.83
MLTL	5.79	5.89	7.84	7.86	5.38
DL	12.97	13.23	16.93	17.44	12.76
MNTL	7.05	7.35	10.60	10.45	7.33
CH	5.01	5.45	5.96	5.99	4.26

***Dermanura cinerea* Gervais, 1856**

Figure 5D

Taxonomy: Four species of the genus can be found in Brazil: *Dermanura anderseni* (Osgood, 1916), *Dermanura bogotensis* (Andersen, 1906), *Dermanura cinerea* Gervais, 1856and *Dermanura gnoma* (Handley, 1987) (NOGUEIRA et al., 2014). *D. gnoma* can be separated from the other three species by the presence of a third lower molar (two in the other species) (SIMMONS; VOSS, 1998; MARQUES-AGUIAR, 2008; LIM;

ENGSTROM, 2001; DÍAZ et al., 2016). *D. cinerea* present the dorsal side of the interfemoral membrane practically naked, without hairs extending beyond the posterior edge, while in *D. anderseni* and *D. bogotensis* it is conspicuously furred and the hairs may extend beyond the posterior edge of the uropatagium (GONÇALVES; GREGORIN, 2004; MARQUES-AGUIAR, 2008; LIM et al., 2008; CALDERÓN; PACHECO 2012; Díaz et al., 2016; Reis et al., 2017; Rocha et al., 2017). Specimens from CBSP presented bicolored dorsal fur, with mid brown basis and dark brown tips; venter also bicolor, with light brown basis and grayish brown tips. Uropatagium is practically naked with a shallow notch, and noseleaf and ear edges yellowish brown to bright yellow. External and skull measurements of voucher material in table 8.

Distribution: In Brazil the species is recorded on the states of Amazonas, Acre, Rondônia, Pará, Amapá, Roraima, Tocantins, Maranhão, Piauí, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, Mato Grosso, Minas Gerais, Goiás, Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina (REIS et al., 2013), however, according to Reis et al. (2017), those registers should be revised. In the state of São Paulo the species is recorded only in three locations of the coastal Atlantic Forest (GARBINO, 2016).

Field observations: One of the eight (5 males and 3 females) individuals of *D. cinerea* was captured in a mist-net elevated 8 m over a stream on sampling site M27, and the other seven were taken in mist-nets set at ground-level on sampling sites M21, M22, M23, M25, M27 and M28. Captures occurred on April, August and September. One pregnant female was captured on August.

***Platyrrhinus lineatus* (É. Geoffroy, 1810)**

Figure 5E

Taxonomy: In Brazil the genus *Platyrrhinus* is represented by eight species: *Platyrrhinus angustirostris* Velazco, Gardner & Patterson, 2010, *Platyrrhinus aurarius* (Handley & Ferris, 1972), *Platyrrhinus brachycephalus* (Rouk & Carter, 1972), *Platyrrhinus fusciventris* Velazco, Gardner & Patterson, 2010, *Platyrrhinus incarum* (Thomas, 1912), *Platyrrhinus infuscus* (Peters, 1880), *Platyrrhinus lineatus* (É. Geoffroy, 1810) and *Platyrrhinus recifinus* (Thomas, 1901) (NOGUEIRA et al., 2014). According to Gardner (2008a), Velazco et al. (2010) and Díaz et al. (2016), *P. lineatus* and *P. recifinus* present an intermediate size within the genus, and can be separated from the small species by the forearm size (larger than 42 mm in *P. lineatus* and *P.*

recifinus and shorter than 42 mm in *P. angustirostris*, *P. brachycephalus*, *P. fusciventris* and *P. incarum*); *P. infuscus* is larger than *P. lineatus* and *P. recifinus* (forearm >54 mm in *P. infuscus* and <48 mm in *P. lineatus* and *P. recifinus*); and *P. aurarius* is also larger than *P. lineatus* and *P. recifinus* (forearm >49 mm in *P. aurarius*) and presents a darker fur coloration with buff facial stripes that are usually inconspicuous (white and conspicuous in *P. lineatus* and *P. recifinus*).

The distinction between *P. lineatus* and *P. recifinus* is based on several characters: presence of one interramal vibrissa in *P. lineatus*, absent in *P. recifinus*; tricolored dorsal fur in *P. lineatus*, tetracolored in *P. recifinus*; upper inner incisors in contact in *P. lineatus*, in contact or separated in *P. recifinus*; larger size in *P. lineatus* (forearm >45 mm), forearm < 46 mm in *P. recifinus*; lower incisors bilobed in *P. lineatus*, trilobed or flat in *P. recifinus* (VELAZCO, 2005; DIAS; PERACCHI, 2008; VELAZCO et al., 2010). The specimen from CBSP presented a tricolored dorsal fur, with a narrow mid brown basal band, a paler mid band and a mid brown distal band; ventral fur light brown. Facial stripes bright and well marked, dorsal stripe bright, uropatagium with a deep notch and furred edge. The edge of the ears and noseleaf are whitish and one interramal vibrissa is present. Upper inner incisors in contact, and lower incisors well developed and bilobed. External and skull measurements of voucher material in table 8.

Distribution: In Brazil the species is recorded on the states of Tocantins, Piauí, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul (VELAZCO et al., 2005; REIS et al., 2013). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: We capture one adult female of *P. lineatus* on a mist-net elevated 8 m over a wide stream on sampling site M24. The capture occurred on March.

***Platyrrhinus recifinus* (Thomas, 1901)**

Figure 5F

Taxonomy: The diagnosis of *P. recifinus* is discussed above. The specimen from CBSP presented a tetracolored dorsal fur, with a narrow mid light brown band, followed by a brown band, a paler band and a chocolate brown distal band; ventral fur grayish light brown. Facial stripes bright and well marked; dorsal stripe bright; and uropatagium with a deep notch and furred edge. The edge of the ears and noseleaf are paler and the

interramal vibrissa is absent. Upper inner incisors separated; and lower incisors reduced, separated and flat. External and skull measurements of voucher material in table 8.

Distribution: In Brazil the species is recorded on the states of Alagoas, Bahia, Espírito Santo, Minas Gerais, Paraíba, Pernambuco, Rio de Janeiro and São Paulo (VELAZCO et al., 2005; REIS et al., 2017). In the state of São Paulo the species is recorded on all the regions, however, in few localities (GARBINO, 2016).

Field observations: We captured one adult male of *P. recifinus* on a mist-net set at ground-level on a wide trail on sampling site M22. The capture occurred on September.

***Pygoderma bilabiatum* (Wagner, 1843)**

Figure 5G

Taxonomy: The genus *Pygoderma* is monotypic, represented by *Pygoderma bilabiatum* (Wagner, 1843) (GARDNER, 2008b). The species *Ametrida centurio* Gray, 1847, and *Sphaeronycteris toxophyllum* Peters, 1882, are both registered in Brazil and similar to *P. bilabiatum* (NOGUEIRA et al., 2014; REIS et al., 2017). *S. toxophyllum* can be differed from the other two by the presence of an indistinct U-shaped noseleaf attached to the outgrowth that emerges from the face (LIM; ENGSTROM, 2001; ANGULO et al., 2008; REIS et al., 2013; LÓPEZ-BAUCELLS et al., 2016). *A. centurio* and *P. bilabiatum* can be distinguished mainly by size, forearm shorter than 33.2 mm in the first and larger than 36 mm in *P. bilabiatum*; and also by the presence of double lip from the base of noseleaf to the corner of mouth (LIM; ENGSTROM, 2001; VILAR et al., 2015; DÍAZ et al., 2016). Additionally, *P. bilabiatum* differs from the other two species by the presence of "doughnut-shaped" glandular tissue masses surrounding the eyes (TAVARES; TEJEDOR, 2009). Specimens from CBSP presented a tricolored dorsal fur, with a mid brown basal band, light brown mid band and grayish brown distal band; the venter is light brown with patches on the shoulders. The uropatagium is densely furred; the tragus yellowish; the eyes well developed; and the double lip extend from the edge of the noseleaf through all the upper lip. External and skull measurements of voucher material in table 6.

Distribution: In Brazil the species is recorded on the states of Alagoas, Bahia, Distrito Federal, Espírito Santo, Minas Gerais, Mato Grosso do Sul, Paraíba, Pernambuco, Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina and São Paulo (REIS et al., 2017). The type locality of the species is in the state of São Paulo, where the species is widely distributed (GARBINO, 2016).

Field observations: The three individuals (2 males and 1 female) of *P. bilabiatum* were taken on mist-nets set at ground-level on dirt roads, on sampling sites M31 and M34. The captures occurred on May and June, one juvenile was captured on May.

***Sturnira lilium* (É. Geoffroy, 1810)**

Figure 5H

Taxonomy: The genus *Sturnira* is represented in Brazil by the species *Sturnira lilium* (É. Geoffroy, 1810), *Sturnira magna* de la Torre, 1966 and *Sturnira tildae* de la Torre, 1959 (VELAZCO; PATTERSON, 2013; NOGUEIRA et al., 2014). *S. magna* is one of the largest species of the genus and can be easily separated from the other two congeners in Brazil by the forearm size (>55 mm in *S. magna* and <51 mm in *S. lilium* and *S. tildae*) (GIANINNI; BARQUEZ, 2003; GARDNER, 2008c; DÍAZ et al., 2016). *S. lilium* and *S. tildae* differ in some morphological characters: *S. lilium* is smaller than *S. tildae* (forearm 39–45 mm in *S. lilium* and 44–51 mm in *S.tildae*); the dorsal fur is bicolored in *S. lilium* and strongly tricolored in *S. tildae*; *S. lilium* present narrow inner upper incisors that can be pointed, while in *S. tildae* those are flattened and weakly bilobed; and the cusps of m1 and m2 in *S. lilium* are always tall and separated by a deep notch, while in *S. tildae* those are separated by shallow notches and lack vertical edges (GANNON et al., 1989; SIMMONS; VOSS, 1998; LIM; ENGSTROM, 2001; GIANINNI; BARQUEZ, 2003; GARDNER 2008c; LÓPEZ-BAUCELLS et al., 2016). Specimens from CBSP presented a tetracolored dorsal fur, with narrow whitish basis, followed by a light brown band, a paler cream band and a mid brown distal band, sometimes orangish brown; the contrast between the three first bands is poor; the venter is grayish light brown. Yellow patches on the shoulders were observed in some individuals. The fur coloration is divergent from data recorded by other authors, according to Gannon et al. (1989), Lim and Engstrom (2001) and López-Baucells et al. (2016) the dorsal fur is bicolored in *S. lilium*. The upper inner incisors present large basis and separated narrower tips, bilobed or not. External and skull measurements of voucher material in table 9.

Distribution: In Brazil the species is recorded on South, Southeastern, and part of the Northeastern and Center-West regions (VELAZCO; PATTERSON, 2013). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: We recorded 31 captures of *S. lilium*, which 27 (14 males and 13 females) were taken in mist-nets set at ground-level on sampling sites M2, M13, M17,

M20, M22, M23, M26, M29, M31, M32, M34, M35, M37 and M39; and four males in mist-nets elevated 8 m, on sampling sites M1, M31 and M32. Captures occurred on all months except November and December. We captured lactating females on March, May and June; pregnant females on February, September and October; and juveniles on January, April, May, June and August.

Table 9. Selected measurements (mm) and weigth (g) for specimens of *Sturnira lilium* and *Sturnira tildae* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Sturnira lilium*	*Sturnira tildae*	*Sturnira tildae*
	ZSP 002 ♂	ZSP 029 ♀	ZSP 038 ♀
W	21.0	23.0	-
BL	62.70	63.75	66.43
FA	44.20	46.61	45.29
TL	18.56	19.66	18.55
EL	14.40	18.40	18.38
TRL	6.24	5.43	6.36
GLS	23.89	24.41	23.51
CI	21.35	21.97	21.05
BB	10.71	10.60	10.82
ZB	14.36	14.74	14.51
PB	6.11	6.18	5.98
CC	6.29	6.17	5.62
MB	11.29	11.36	11.43
PL	10.27	10.75	10.69
MXTL	6.83	7.00	6.81
MLTL	5.39	5.61	5.57
DL	15.62	15.60	15.23
MNTL	8.51	7.88	7.76
CH	6.12	6.02	5.82

***Sturnira tildae* de la Torre, 1959**

Figure 5I

Taxonomy: The diagnosis of *S. tildae* is discussed above. Specimens from CBSP presented a tetracolored dorsal fur, with narrow whitish basis, followed by a blackish dark brown band, a paler cream band and a mid brown distal band, sometimes orangish brown; the contrast between the three first bands is well marked; the venter is grayish light brown. Yellow patches on the shoulders were observed in some individuals. As observed in *S. lilium*, the fur coloration is also divergent from data recorded by other authors: according to Lim and Engstrom (2001) and López-Baucells et al. (2016), the dorsal fur is strongly tricolored in *S. tildae*. The upper inner incisors present basis and

tips of the same size, in contact and bilobed. External and skull measurements of voucher material in table 9.

Distribution: In Brazil the species is recorded on the states of Amazonas, Acre, Rondônia, Pará, Amapá, Roraima, Tocantins, Sergipe, Mato Grosso, Mato Grosso do Sul, Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Santa Catarina (REIS et al., 2013). In the state of São Paulo the species is distributed along the coastal Atlantic Forest (GARBINO, 2016).

Field observations: The five (2 males and 3 females) captured *S. tildae* were taken in mist-nets set at ground-level on sampling sites M5, M16, M22, M28 and M35. Captures occurred on February, April, May, June and September.

***Vampyressa pusilla* (Wagner, 1843)**

Figure 5J

Taxonomy: In Brazil the genus *Vampyressa* is represented by *Vampyressa pusilla* (Wagner, 1843) and *Vampyressa thyone* Thomas, 1909 (NOGUEIRA et al., 2014). Those two species are externally similar, though *V. pusilla* is slightly larger: *V. pusilla* forearm ranges from 32.3 to 36.0 mm while in *V. thyone* forearm measurements are between 29.3 and 34.0 mm. Furthermore, additional external characters that can distinguish these species are the hairier legs and forearm in *V. pusilla* (relatively less fur on legs and forearm in *V. thyone*); *V. pusilla* dorsal fur is longer than in *V. thyone* and clearly extending beyond the uropatagium edge, forming a fringe (in *V. thyone* the fur is shorter not clearly extending beyond the uropatagium edge); the noseleaf is uniformly brown in *V. pusilla* and present a yellowish outer edge in *V. thyone*; and the margin of ears, that are faintly paler in *V. pusilla* and yellow in *V. thyone* (LIM et al., 2003; ARROYO-CABRALES, 2008; TAVARES et al., 2014; REIS et al., 2017). The specimen from CBSP presented a tetracolored dorsal fur, with narrow whitish basis, followed by a mid brown band, a paler light brown band and mid brown tips; the venter is weakly bicolored, with mid brown basis and grayish brown tips. The uropatagium is short and furred at the edge, forming a fringe; legs and forearm densely furred; edge of the ears is paler; yellowish tragus; and bright facial stripes. External and skull measurements of voucher material in table 8.

Distribution: In Brazil the species is recorded on the states of Goiás, Mato Grosso do Sul, Bahia, Alagoas, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná,

Santa Catarina and Rio Grande do Sul (REIS et al., 2013). In the state of São Paulo the species is recorded on few localities that are widely distributed (GARBINO, 2016).

Field observations: On September we captured an adult male of *V. pusilla* in a mist-net set at ground-level on a wide trail, on sampling site M21.

Molossidae P. Gervais, 1856

Molossinae P. Gervais, 1856

Cynomops abrasus (Temminck, 1826)

Figure 5K

Taxonomy: Five species of the genus are registered in Brazil: *Cynomops abrasus* (Temminck, 1826), *Cynomops greenhalli* Goodwin, 1958, *Cynomops milleri* (Osgood, 1914), *Cynomops paranus* (Thomas, 1901) and *Cynomops planirostris* (Peters, 1866) (NOGUEIRA et al., 2014). *C. abrasus* is the most distinctive species in the genus, and can be distinguished from the other congeners by size (forearm larger than 41 mm in *C. abrasus* and shorter than 39 mm in the other four species) (PETERS et al., 2002; EGER, 2008; LÓPEZ-BAUCELLS et al., 2016). The specimen from CBSP presented general reddish dark brown fur coloration, with cinnamon brown venter. The muzzle is flat; upper incisors separated and resembling canines in shape; ears separated and rounded; and antitragus also rounded, without constriction at the base. External and skull measurements of voucher material in table 10.

Distribution: In Brazil the species is recorded on the states of Goiás, Maranhão, Minas Gerais, Mato Grosso do Sul, Mato Grosso, Pará, Paraíba, Piauí, Rio de Janeiro, Santa Catarina e São Paulo (REIS et al., 2017). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: On December we captured an adult male of *C. abrasus* in a roosting site on a building roof, on sampling site S7. At the same roosting site we captured eleven individuals of *Molossus molossus* and one *Molosssus rufus.*

Molossops neglectus Williams & Genoways, 1980

Figure 5L

Taxonomy: The two species of the genus can be found in Brazil: *Molossops neglectus* Williams & Genoways, 1980 and *Molossops temminckii* (Burmeister, 1854) (EGER, 2008; NOGUEIRA et al., 2014). The principal characters that distinguish these species

are cited by many authors (WILLIAMS; GENOWAYS, 1980; ASCORRA et al., 1991; LIM; ENGSTROM, 2001; GREGORIN; TADDEI, 2002; GREGORIN et al., 2004; EGER, 2008; BARQUEZ et al., 2011): *M. neglectus* is larger than *M. temminckii* (forearm larger than 34.8 mm in *M. neglectus* and shorter than 33 mm in *M. temminckii*); and venter coloration darker and slightly lighter than dorsum in *M. neglectus* and frosted or lighter than dorsum in *M. temminckii*. The specimen from CBSP presented general reddish dark brown fur coloration, with paler base; the venter is lighter, with light brown coloration. The muzzle is flat; ears are small, separated and triangular; antitragus small and rounded; and upper incisors separated and resembling canines in shape. External and skull measurements of voucher material in table 10.

Table 10. Selected measurements (mm) and weigth (g) for specimens of *Cynomops abrasus*, *Molossops neglectus* and *Molossus rufus* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Cynomops abrasus*	*Molossops neglectus*	*Molossus rufus*	*Molossus rufus*	*Molossus rufus*
	ZSP 021 ♂	ZSP 016 ♀	ZSP 019 ♂	ZSP 026 ♂	ZSP 059 ♂
W	30.0	11.5	42.0	21.0	35.5
BL	73.88	54.37	86.08	73.33	75.65
FA	45.50	36.73	51.11	50.32	51.20
TL	14.70	11.77	19.48	21.22	19.79
EL	16.64	11.40	13.49	13.29	15.07
TRL	4.66	1.83	4.40	2.97	3.60
GLS	21.58	15.57	23.97	21.82	22.92
CI	20.85	15.03	21.20	20.11	20.71
BB	10.50	8.14	11.32	11.53	10.93
ZB	15.02	10.04	14.19	13.27	14.15
PB	5.32	4.79	4.69	4.81	4.50
CC	5.62	4.27	6.26	6.04	6.53
MB	11.62	8.33	12.27	12.14	12.05
PL	9.32	7.32	8.48	8.33	8.52
MXTL	7.67	6.06	8.25	8.08	8.34
MLTL	6.21	4.86	6.60	6.44	6.51
DL	16.00	11.13	16.40	15.48	16.57
MNTL	9.15	7.09	9.41	9.33	9.54
CH	4.85	3.76	5.13	4.81	4.96

Distribution: In Brazil the species is recorded on the states of Amazonas, Minas Gerais, Pará, Paraná, Rio de Janeiro, Rio Grande do Sul e São Paulo (REIS et al., 2017). In the state of São Paulo almost all the few records of the species are distributed on the east region of the state (GARBINO, 2016).

Field observations: A pregnant female of *M. neglectus* was captured on November in a mist-net elevated 8 m over a trail, on sampling site M7.

***Molossus currentium* Thomas, 1901**

Figure 6A

Taxonomy: The genus is represented in Brazil by six species: *Molossus aztecus* Saussure, 1860, *Molossus coibensis* J.A. Allen, 1904, *Molossus currentium* Thomas, 1901, *Molossus molossus* (Pallas, 1766), *Molossus pretiosus* Miller, 1902 and *Molossus rufus* É. Geoffroy, 1805 (NOGUEIRA et al., 2014). *M. coibensis*, *M. pretiosus* and *M. rufus* can be separated from the other three species by the length of dorsal fur, which is shorter than 3.5 mm in *M. coibensis*, *M. pretiosus* and *M. rufus* and longer on the other three species (DOLAN, 1989; SIMMONS; VOSS, 1998; EGER, 2008; GREGORIN et al., 2011a); and by the dorsal fur coloration, which is unicolored or weakly bicolored on *M. coibensis*, *M. pretiosus* and *M. rufus* and bicolored on the other three (GARDNER, 1965; DOLAN, 1989; SIMMONS; VOSS, 1998; LÓPEZ-GONZÁLEZ; PRESLEY, 2001; EGER, 2008). *M. currentium* can be separed from *M. aztecus* and *M. molossus* based on size, *M. currentium* present a forearm length larger than 40 mm, which ranges from 35.7 to 39.9 on the other two species (DOLAN, 1989; SIMMONS; VOSS, 1998; LIM; ENGSTROM, 2001; GREGORIN; TADDEI, 2002; GREGORIN et al., 2011a). The specimen from CBSP presented general blackish brown coloration. The dorsal is well bicolored, with whitish basis extending to 1/3 of fur length, and dark brown tips. The dorsal fur at the shoulders average 6.5 mm. The upper incisors are spatulated, with slightly divergent tips. Muzzle with a ridge between nose and eyes; antitragus rounded, with a constriction at the base; and ears rounded and rising from the same point in the forehead. External and skull measurements of voucher material in table 11.

Distribution: The species was previously registered on the states of Amazonas, Pará, Mato Grosso do Sul, Bahia and Minas Gerais (TAVARES et al., 2010; RAMOS et al., 2013; GARCIA et al., 2014). However, Nogueira et al. (2014) considered the register of the species on the state of Minas Gerais as the only valid reference assigning the species to Brazil. Our record represents the southernmost register of the species in Brazil, the first register on the state of São Paulo, and enlarges the species distribution in more than 1000 km southward (Figure 8).

Field observations: On June we captured an adult male of *M. currentium* in a roosting site on a building roof, on sampling site S9.

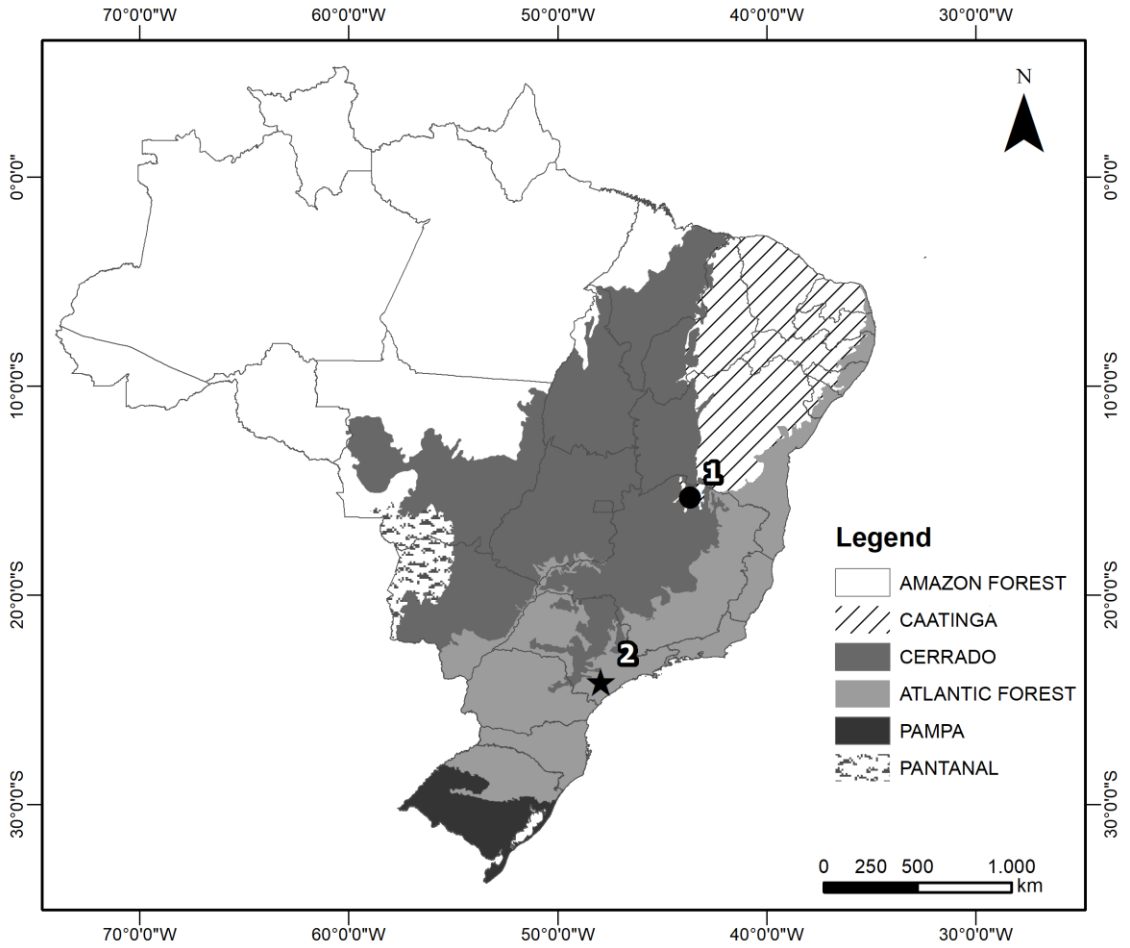

Figure 8. Geographic distribution of *Molossus currentium* in Brazil. Black Circle: Previous record for the species; Black Star: new record from the state of São Paulo. Additional information is available in Table 16.

***Molossus molossus* (Pallas, 1766)**

Figure 6B

Taxonomy: M. aztecus and *M. molossus* are similar in size, overlapping on forearm length, the principal character to distinguish these two species are the coloration of the dorsal fur (the basal band is white in *M. molossus*, reaching 1/2 of hairs length, and reaching less than 1/3 of dorsal fur on *M. aztecus*); and shape of upper incisors, which are spatulated in *M. aztecus* and pincer-like in *M. molossus* (BARQUEZ et al., 1999; GREGORIN et al., 2011a; REIS et al., 2017). Specimens from CBSP presented general mid brown coloration. The dorsal fur varies from weakly to well bicolored, with grayish basis extending from 1/4 to 1/3 of fur length, and mid brown tips. The dorsal fur at the shoulders average 5 mm. The upper incisors are pincer-like. Muzzle with a ridge between nose and eyes; antitragus rounded, with a constriction at the base; and ears

rounded and rising from the same point in the forehead. External and skull measurements of voucher material in table 11.

Distribution: In Brazil the species is recorded on almost all the states, the only exception is Rio Grande do Norte State (REIS et al., 2017). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: We recorded 28 captures (4 males and 24 females) of *M. molossus*, all of those were taken in roosting sites on building roofs, on sampling sites S2 and S7. On S2 we also captured 13 *Histiotus* velatus, 2 *Myotis albescens* and 1 *Myotis ruber*; on S7 we also captured 1 *Cynomops abrasus* and 2 *Molossus rufus*. Captures occurred on October, December and July. We captured lactating females on December and pregnant females on October and December.

Table 11. Selected measurements (mm) and weigth (g) for specimens of *Molossus currentium* and *Molossus molossus* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Molossus currentium*	*Molossus molossus*	*Molossus molossus*	*Molossus molossus*	*Molossus molossus*
	ZSP 050 ♂	ZSP 003 ♀	ZSP 018 ♂	ZSP 020 ♀	ZSP 053 ♀
W	22.5	15.5	19.0	21.0	14.5
BL	64.36	60,36	67,68	60,33	55,05
FA	40.43	39,17	38,94	39.50	38,88
TL	15.20	14,62	13,69	14,63	12,68
EL	9.57	11,76	12,11	12,23	11,13
TRL	4.50	3,66	3,85	4,93	3,79
GLS	18.92	17.46	18.26	17.99	17.34
CI	16.74	16.38	16.59	16.01	15.92
BB	9.82	8.99	9.11	9.53	9.16
ZB	11.85	11.07	10.77	11.22	10.74
PB	4.29	4.03	4.15	3.95	4.10
CC	5.01	4.46	4.70	4.62	4.23
MB	10.55	9.87	9.24	9.95	9.78
PL	6.95	6.70	6.82	6.68	6.63
MXTL	6.32	6.30	6.22	6.30	6.06
MLTL	4.97	4.93	4.82	4.98	4.97
DL	12.85	12.12	12.60	12.36	12.32
MNTL	7.39	7.38	7.05	7.15	6.90
CH	3.92	3.88	3.63	4.00	3.74

***Molossus rufus* É. Geoffroy, 1805**

Figure 6C

Taxonomy: The distinction between *M. rufus*, *M. aztecus* and *M. molossus* is discussed above. *M. rufus* can be distinguished from *M. coibensis* and *M. currentium* by size (forearm shorter than 36 mm in *M. coibensis*, 41–44 mm in *M. currentium* and 46.0–54.0 mm in *M. rufus*) (SIMMONS; VOSS, 1998; LÓPEZ-GONZÁLEZ; PRESLEY, 2001; NOGUEIRA et al., 2008; GREGORIN et al., 2011).The distinction between *M. rufus* and *M. pretiosus* is based on the following characters: *M. rufus* is larger than *M. pretiosus* (forearm 42.6–49.0 mm in *M. pretiosus*); The shape of the upper incisors (long and slightly convergent in *M. pretiosus*, short and spatulated in *M. rufus*); general fur coloration (dark brown in *M. pretiosus* and dark or reddish brown in *M. rufus*); and face and membranes coloration (not black, slightly paler, in *M. pretiosus* and black in *M. rufus*) (GREGORIN; TADDEI, 2000; LIM; ENGSTROM, 2001; GREGORIN; TADDEI, 2002; EGER, 2008; NOGUEIRA et al., 2008; DÍAZ et al., 2016). Specimens from CBSP presented general reddish dark brown coloration, with unicolored dorsal fur. The dorsal fur at the shoulders average 5 mm. The upper incisors are spatulated and in contact. Muzzle with a ridge between nose and eyes; antitragus rounded, with a constriction at the base; and ears rounded and rising from the same point in the forehead. External and skull measurements of voucher material in table 10.

Distribution: In Brazil the species is recorded on the states of Alagoas, Amazonas, Amapá, Bahia, Ceará, Espírito Santo, Maranhão, Minas Gerais, Mato Grosso do Sul, Mato Grosso, Pará, Paraíba, Pernambuco, Piauí, Paraná, Rio de Janeiro, Roraima, Rio Grande do Sul, Santa Catarina and São Paulo (REIS et al., 2017). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: We captured 3 adult males of *M. rufus* in roosting sites on building roofs, on sampling sites S7 and S17. On S7 we also captured 11 *Molossus molossus* and 1 *Cynomops abrasus*; on S17 we also captured 1 *Glossophaga soricina*. Captured occurred on January, September and December.

Vespertilionidae Gray, 1821

Vespertilioninae Gray, 1821

***Eptesicus taddeii* Miranda, Bernardi & Passos, 2006**

Figure 6D

Taxonomy: Six species of the genus occur in Brazil: *Eptesicus andinus* J.A. Allen, 1914, *Eptesicus brasiliensis* (Desmarest, 1819), *Eptesicus chiriquinus* Thomas, 1920, *Eptesicus diminutus* Osgood, 1915, *Eptesicus furinalis* (d'Orbigny & Gervais, 1847) and *Eptesicus taddeii* Miranda, Bernardi & Passos, 2006 (NOGUEIRA et al., 2014). *E. andinus* and *E. chiriquinus* can be distinguished from other congeners by the length of dorsal fur (larger than 8 mm in *E. andinus* and *E. chiriquinus*, less than 8 mm in the other species) (SIMMONS; VOSS, 1998; MIRANDA et al., 2006; DAVIS; GARDNER, 2008). *E. taddeii* can be separated from *E. diminutus* and *E. furinalis* by size (forearm 44.1–48.7 mm in *E. taddeii* and less than 42.5 mm for *E. diminutus* and *E. furinalis*) (MIES et al., 1996; SIMMONS; VOSS, 1998; MIRANDA et al., 2006). The distinction between *E. taddeii* and *E. brasiliensis* is based on the shape of the ears (rounded in *E. taddeii* and more triangular in *E. brasiliensis*); the muzzle is more inflated in *E. taddeii* than in *E. brasiliensis*; and size, *E. taddeii* is larger than *E. brasiliensis* (forearm 44.1–48.7 mm versus 40.5–46.5 mm) (MIRANDA et al., 2006). Specimens from CBSP presented a tricolored dorsal fur, with narrow whitish basis, followed by a large mid brown band and reddish tips. However, according to Miranda et at. (2006), the dorsal fur in *E. taddeii* is bicolored, with the basal two-thirds brown and tips red. The ventral fur of the specimens from CBSP is also bicolored, with a large mid brown basal band and contrasting reddish tips, pattern similar to the described by Miranda et al. (2006). Further external characters are similar to the described for the species: the dorsal fur is short (ca. 6 mm); the ears are triangular with rounded terminal portion; muzzle inflated; and large forearm. External and skull measurements of voucher material in table 12.

Distribution: In Brazil the species is recorded on the states of São Paulo, Paraná, Santa Catarina and Rio Grande do Sul (REIS et al., 2017). In the state of São Paulo the species is registered in only three locations (GARBINO, 2016).

Field observations: Two adult females of *E. taddeii* were taken on mist-nets set at ground-level on sampling sites M20 and M34; and one was taken on a mist-net elevated

8 m over a trail, on sampling site M7. Captures occurred on March, June and November. A pregnant female was captured on March.

***Lasiurus ebenus* Fazzolari-Corrêa, 1994**

Figure 6E

Taxonomy: According to Nogueira et al. (2014) seven species of the genus are recognized in Brazil: *Lasiurus blossevillii* ([Lesson, 1826]), *Lasiurus castaneus* Handley, 1960, *Lasiurus cinereus* (Palisot de Beauvois, 1796), *Lasiurus ebenus* Fazzolari-Corrêa, 1994, *Lasiurus ega* (Gervais, 1856), *Lasiurus egregius* (Peters, 1870) and *Lasiurus salinae* Thomas, 1902. However, Baird et al. (2015) consider *L. salinae* as a subspecies of *L. blossevillii*. *L. ebenus* can be distinguished from all the congeners based on membranes and fur coloration, which are black. The other species present lighter colors, with fur coloration varying from reddish to yellowish, orange or whitish (FAZZOLARI-CORRÊA, 1994; BIANCONI; PEDRO, 2007; REID, 2009). The specimen from CBSP presented a tricolored dorsal fur, with black basis and tips; bicolored ventral fur, with dark-brown basis and black tips; and black membranes and face. The interfemoral membrane is furred until half of its length, the ventral region of the humera and forearms are also furred. External and skull measurements of voucher material in table 12.

Distribution: This record represents the second known register of the species since it's discover on 1994. The species only registered location was on the Ilha do Cardoso State Park, more than 100 km away from CBSP (CLAUDIO et al., *no prelo*).

Field observations: On February we captured an adult male of *L. ebenus* on a mist-net set at ground-level over a small stream, on sampling site M20.

***Histiotus velatus* (I. Geoffroy, 1824)**

Figure 6F

Taxonomy: In Brazil the genus is represented by *Histiotus alienus* Thomas, 1916, *Histiotus diaphanopterus* Feijó, Rocha & Althoff, 2015, *Histiotus laephotis* Thomas, 1916, *Histiotus montanus* (Philippi & Landbeck, 1861) and *Histiotus velatus* (I. Geoffroy, 1824) (REIS et al., 2017). *H. diaphanopterus* can be easily distinguished from the congeners by the presence of a distinctly bicolored dorsal fur, which is unicolored or weakly bicolored in the other species; and a very high skin between ears (4 mm in *H. diaphanopterus* and shorter than 4 mm in the other species) (FEIJÓ et al.,

2015). *H.velatus* distinction from the remaining congeners can be made by the presence of a triangular ear shape in *H. velatus*, which is oval in the other species (VIZOTTO; TADDEI, 1973; FEIJÓ et al., 2015). Specimens from CBSP presented a weakly bicolored dorsal fur, with dark brown basis and yellowish brown tips; venter also bicolored, with dark brown basis and grayish brown tips. The ears are large, triangular and connected by a narrow band of skin (3 mm). External and skull measurements of voucher material in table 12.

Table 12. Selected measurements (mm) and weigth (g) for specimens of *Eptesicus taddeii*, *Lasiurus ebenus* and *Histiotus velatus* from CBSP, São Paulo. See Material and Methods for description of measurements.

Measurement	*Eptesicus taddeii*	*Eptesicus taddeii*	*Lasiurus ebenus*	*Histiotus velatus*	*Histiotus velatus*
	ZSP 017 ♂	ZSP 048 ♀	ZSP 030 ♂	ZSP 004 ♂	ZSP 046 ♀
W	12.0	12.0	12.5	13.0	11.0
BL	61.43	56.47	62.13	62.02	58.92
FA	47.33	47.15	45.67	45.80	47.42
TL	20.48	19.62	21.42	20.24	20.03
EL	16.34	10.35	15.32	26.11	27.31
TRL	6.80	7.87	7.53	12.12	12.92
GLS	17.86	17.90	13.9	18.43	18.12
CI	16.86	16.87	13.93	17.19	16.80
BB	8.29	8.29	8.28	8.20	8.04
ZB	11.79	11.98	9.91	10.18	10.15
PB	4.15	4.20	4.64	4.18	3.97
CC	5.46	5.45	5.52	5.06	4.84
MB	8.72	9.06	8.38	8.37	8.30
PL	9.30	9.11	6.38	9.11	9.21
MXTL	6.80	6.76	4.70	6.08	5.98
MLTL	5.19	5.39	3.70	5.00	4.76
DL	13.34	13.61	9.58	12.71	12.64
MANTL	8.31	8.29	5.53	6.58	7.47
CH	4.64	4.81	3.28	3.94	4.34

Distribution: In Brazil the species is recorded on the states of Piauí, Ceará, Mato Grosso, Maranhão, Goiás, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul (REIS et al., 2017). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: All the 13 (1 male and 12 females) specimens of *H. velatus* captured were taken in a roosting site on building roofs, on sampling site S2. On S2 we

also captured 17 *Molossus molossus*, 2 *Myotis albescens* and 1 *Myotis ruber*. Captures occurred on May, July and October. Pregnant females were caught on October.

Myotinae Tate, 1943

Myotis albescens (E. Geoffroy, 1806)

Figure 6G

Taxonomy: In Brazil the genus is represented by *Myotis albescens* (É. Geoffroy, 1806), *Myotis izecksohni* Moratelli, Peracchi, Dias & Oliveira, 2011, *Myotis lavali* Moratelli, Peracchi, Dias & Oliveira, 2011, *Myotis levis* (I. Geoffroy, 1824), *Myotis nigricans* (Schinz, 1821), *Myotis riparius* Handley, 1960, *Myotis ruber* (É. Geoffroy, 1806) and *Myotis simus* Thomas, 1901 (REIS et al., 2017). *M. simus* differ from the other species on the length of dorsal fur (shorter than 4 mm in *M. simus* and larger on the other species); and by the attachment of the wing membrane along the tibia, which is attached at the feet on the other species (MORATELLI et al., 2011b; MORATELLI et al., 2013). *M. albescens* and *M. levis* can be separated from the other species of the genus by the presence of a fringe of hairs along the edge of the interfemoral membrane and frosted dorsal fur. These two can be distinguished by the ear length (9-14 mm in *M. albescens* and 14-18 mm in *M. levis*) (MORATELLI; OLIVEIRA, 2011). Specimens from CBSP presented a bicolored dorsal fur, with blackish brown basis and mid brown tips, averaging 6 mm on shoulder region; the venter fur is strongly lighter than the dorsal and bicolored, with dark brown basis and white tips. The fringe of hairs on the edge of the uropatagium is present; the wing membrane is attached to the feet; face and ears are dark brown. External and skull measurements of voucher material in table 14.

Distribution: In Brazil the species is recorded on the states of Acre, Amazonas, Amapá, Bahia, Minas Gerais, Mato Grosso do Sul, Pará, Paraná, Rio de Janeiro, Rondônia, Roraima, Rio Grande do Sul e São Paulo (REIS et al., 2017). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: On October we captured two pregnant females of *M. albescens* in a roosting site on a building roof, on sampling site S2; at the same roost we captured 13 *Histiotus velatus*, 17 *Molossus molossus* and 1 *Myotis ruber*.

***Myotis nigricans* (Schinz, 1821)**

Figure 6H

Taxonomy: M. nigricans and *M. riparius* can be distinguished from *M. lavali* by the dorsal fur coloration, which is strongly bicolored in *M. lavali* and unicolored or weakly bicolored in *M. nigricans* and *M. riparius* (LÓPEZ-GONZÁLEZ et al., 2001; MORATELLI et al., 2011a; MORATELLI et al., 2013). *M. ruber*can be separated from *M. nigricans* and *M. riparius* by general fur coloration, which is reddish in *M. ruber* and danker on the other two (THOMAS, 1902; LÓPEZ-GONZÁLEZ et al., 2001). *M. izecksohni* can be separated from *M. riparius* by the dorsal fur length (7.8- 8.5 mm in *M. izecksohni* and ~5 mm in *M. riparius*) (MORATELLI et al., 2011a; MORATELLI et al., 2013); and from *M. nigricans* by the larger size (forearm 33.1–38.3 mm in *M. izecksohni* and 30.5–38.9 mm in *M. nigricans* – averaging 33 mm), and darker general fur coloration (dark to medium-brown dorsal fur, and light brown venter in *M. izecksohni*, and mummy-brown dorsal fur and cinnamon-brown ventral fur in *M. nigricans*) (MORATELLI et al., 2011a; DIAS et al., 2015). *M. nigricans* can be differed from *M. riparius* by dorsal fur texture (silky in *M. nigricans* and woolly in *M. riparius*); the position of the second upper premolar (aligned with other premolar in *M. nigricans* and not aligned in *M. riparius*); and the presence of a few hairs lighter than general dorsal fur coloration in *M. riparius*, absent in *M. nigricans* (LAVAL, 1973; LÓPEZ-GONZÁLEZ et al., 2001; MORATELLI et al., 2013; DÍAZ et al., 2016). Specimens from CBSP presented a slightly bicolored dorsal fur, with blackish brown basis and dark brown tips, averaging 7 mm on shoulder region; the venter fur is lighter than the dorsal and bicolored, with dark brown basis and mid brown tips. The fringe of hairs on the edge of the uropatagium is absent; the wing membrane is attached to the feet; face and ears dark brown; and the second upper premolar is aligned to the toothrow. External and skull measurements of voucher material in table 13.

Distribution: In Brazil the species is recorded on the states of Amazonas, Amapá, Bahia, Ceará, Pará, Piauí, Paraíba, Pernambuco, Rio Grande do Norte, Roraima, Sergipe, Tocantins, Mato Grosso, Mato Grosso do Sul, Goiás, Paraná, Rio Grande do Sul, Santa Catarina, Minas Gerais, São Paulo, Rio de Janeiro and Espírito Santo (REIS et al., 2017). In the state of São Paulo the species is widely distributed (GARBINO, 2016).

Field observations: We recorded 21 captures of *M. nigricans*, of which 20 (13 males and 7 females) were taken on mist-nets set at ground-level, on sampling sites M3, M4,

M11, M17, M20, M21, M27, M29, M37 and M39; and one adult male in a roosting site between abandoned roof tiles, on sampling site S12. Captures occurred on January, March, April, July, August, September, October and December. A lactating female was netted on January, and a pregnant female on September.

Table 13. Selected measurements (mm) and weigth (g) for specimens of *Myotis nigricans* and *Myotis riparius* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Myotis nigricans*	*Myotis nigricans*	*Myotis riparius*	*Myotis riparius*
	ZSP 010 ♂	ZSP 051 ♂	ZSP 007 ♀	ZSP 052 ♂
W	5.0	4.5	5.0	5.0
BL	41.77	42.30	43.42	41.89
FA	34.07	33.74	33.46	34.39
TL	15.42	14.83	14.43	14.67
EL	12.38	11.90	11.17	13.68
TRL	5.37	6.56	6.52	6.58
GLS	13.34	13.67	13.42	13.47
CI	12.56	12.99	12.72	12.67
BB	6.62	6.27	6.67	6.96
ZB	7.80	7.98	8.17	8.50
PB	3.55	3.46	3.42	3.67
CC	3.23	3.29	3.59	3.63
MB	6.54	6.53	6.69	6.90
PL	6.83	7.00	7.07	7.16
MXTL	4.92	4.94	5.06	5.04
MLTL	4.07	4.04	4.42	4.15
DL	9.46	9.49	9.88	9.90
MNTL	6.38	6.31	6.55	6.32
CH	2.78	2.70	2.79	2.90

***Myotis riparius* Handley, 1960**

Figure 6I

Taxonomy: The diagnosis of *M. riparius* is discussed above. Specimens from CBSP presented unicolored to slightly bicolored dorsal fur, with blackish brown basis and sometimes mummy brown tips, averaging 5 mm on shoulder region; the venter fur is lighter than the dorsal and bicolored, with dark brown basis and cinnamon brown tips. The fringe of hairs on the edge of the uropatagium is absent; the wing membrane is attached to the feet; face is reddish and ears light brown; and the second upper premolar is not aligned to the toothrow. External and skull measurements of voucher material in table 13.

Distribution: In Brazil the species is recorded on the states of Acre, Amazonas, Amapá, Bahia, Minas Gerais, Pará, Paraná, Rio Grande do Sul, Santa Catarina, São Paulo and Tocantins (REIS et al., 2017). In the state of São Paulo the species is distributed on the east region of the state, mostly on the coastal Atlantic Forest (GARBINO, 2016).

Field observations: One adult male and one adult female of *M. riparius* were captured in mist-nets set at ground-level on wide trails, on sampling sites M2 and M39. Captures occurred on July and October.

Table 14. Selected measurements (mm) and weigth (g) for specimens of *Myotis albescens* and *Myotis ruber* from CBSP, São Paulo State. See Material and Methods for description of measurements.

Measurement	*Myotis albescens*	*Myotis ruber*	*Myotis ruber*
	ZSP 005 ♀	ZSP 047 ♂	ZSP 054 ♂
W	9.0	7.5	7.0
BL	54.09	49.87	48.26
FA	37.15	41.23	39.32
TL	16.71	17.10	16.70
EL	11.62	14.25	16.34
TRL	6.52	8.26	9.11
GLS	14.50	15.63	15.14
CI	13.61	14.93	14.37
BB	7.05	7.19	6.85
ZB	8.50	9.54	9.44
PB	3.89	3.76	3.84
CC	3.66	4.16	4.35
MB	7.08	7.59	7.35
PL	6.86	8.07	7.98
MXTL	5.07	6.17	5.85
MLTL	4.15	5.25	4.85
DL	8.95	12.19	11.43
MNTL	6.60	7.90	7.47
CH	1.93	3.48	3.58

***Myotis ruber* (E. Geoffroy, 1806)**

Figure 6J

Taxonomy: M. ruber can be distinguished from their congeners by the general fur coloration, which is bright cinnamon-red on the dorsum and yellowish on venter. *M. simus* can present similar coloration, but the wing membrane attachment on feet differ these species, as discussed above (THOMAS, 1902; LÓPEZ-GONZÁLEZ et al., 2001; MORATELLI et al., 2011b). Specimens from CBSP presented a bicolored dorsal fur, with blackish brown basis and reddish tips, averaging 6 mm on shoulder region; the

venter fur is lighter than the dorsal and bicolored, with dark brown basis and reddish tips. The fringe of hairs on the edge of the uropatagium is absent; the wing membrane is attached to the feet; face is reddish and ears dark brown; and the feet nails are reddish. External and skull measurements of voucher material in table 14.

Distribution: In Brazil the species is recorded on the states of Bahia, Pernambuco, Minas Gerais, Paraná, Rio Grande do Sul, Santa Catarina, São Paulo, Rio de Janeiro and Espírito Santo (REIS et al., 2017). In the state of São Paulo the species is distributed on the central and east regions of the state, mostly on the coastal Atlantic Forest (GARBINO, 2016).

Field observations: We captured two adult males of *M. ruber*, of which one was taken in a mist-net set at ground-level along a river on sampling site M29; and one was taken in a roosting site on a building roof, on sampling site S2. On S2 we also captured 17 *Molossus molossus*, 13 *Histiotus velatus* and 2 *Myotis albescens*. Captures occurred on May and August.

Table 15. Locality records of *Micronycteris schmidtorum* in Brazil. The map numbers correspond to the records as indicated in Fig. 7.

Map	Locality	Coordinates	Author
1	Parque Nacional Montanhas do Tumucumaque, Amapá	02°10'N, 54°34'W	Martins et al. 2006
2	Manaus, Amazonas	02°24'S, 59°43'W	Bernard 2001
3	Alter do Chão, Pará	02°30'S, 54°57'W	Bernard and Fenton 2002
4	Santarém, Pará	02°27'S, 54°40'W	Bernard et al. 2001
5	Belém, Pará	01°27'S, 48°30'W	Simmons 1996
6	Inhamum Municipal Environmental Protection Area, Caxias, Maranhão	04°53'S, 43°22'W	Olímpio et al. 2016
7	Reserva Biológica Guaribas, Paraiba	06°42'S, 35°11'W	Rocha et al. 2017
8	Exu, Pernambuco	07°30'S, 39°42'W	Ascorra et al. 1991
9	São Lourenço da Mata, Pernambuco	08°00'S, 35°01'W	Ascorra et al. 1991
10	Paraíso do Tocantins, Tocantins	10°10'S, 48°52'W	Nunes et al. 2005
11	Reserva Particular do Patrimônio Natural (RPPN) Sitio Pau-Brasil, Cururipe, Alagoas	10°06'S, 36°13'W	Rocha et al. 2017
12	Parque Nacional Serra de Itabaiana, Areia Branca, Sergipe	10°46'S, 37°21'W	Rocha et al. 2017
13	Aurora do Tocantins, Tocantins	12°35'S, 46°32'W	Felix et al. 2016
14	APA Cabeceiras do Rio Cuiabá, Rosário Oeste, Mato Grosso	14°19'S, 55°43'W	Louzada et al. 2015
15	Médio Rio São Francisco, Bahia	13°25'S, 43°04'W	Sá-Neto and Marinho-Filho 2013
16	Vitória da Conquista, Bahia	14°51'S, 40°51'W	Falcão et al. 2005
17	Ilhéus, Bahia	14°46'S, 39°01'W	Faria et al. 2006
18	Una, Bahia	15°16'S, 39°04'W	Faria et al. 2006
19	Parque Estadual Rio Doce, Minas Gerais	19°44'S, 42°34'W	Tavares & Taddei 2003
20	Carlos Botelho State Park, São Paulo	24°12'S, 47°56'W	This study

Table 16. Locality records of *Molossus currentium* in Brazil. The map numbers correspond to the records as indicated in Fig. 8.

Map	Locality	Coordinates	Author
1	Jaíba, Minas Gerais	15°20'S, 43°40'W	Tavares et al. 2010
2	Carlos Botelho State Park, São Paulo	24°11'S, 47°55'W	This study

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Appendix 1. Information on bats sampling sites selected on Carlos Botelho State Park, São Paulo State. The map numbers correspond to the sampling sites as indicated in Fig. 1.

Map	Phytophysiognomy	Coordinates	Altitude
M1	Mata Secundária Densa	24°03'29"S, 47°59'37"W	789 m
M2	Mata Secundária Densa	24°03'26"S, 47°58'09"W	819 m
M3	Floresta Ombrófila Densa Submontana	24°11'45"S, 47°55'24"W	89 m
M4	Floresta Ombrófila Densa Submontana	24°12'05"S, 47°55'59"W	50 m
M5	Floresta Ombrófila Densa Submontana	24°11'46"S, 47°55'34"W	75 m
M6	Floresta Ombrófila Densa Submontana	24°12'05"S, 47°56'09"W	46 m
M7	Floresta Ombrófila Densa Montana	24°03'52"S, 47°59'16"W	800 m
M8	Floresta Ombrófila Densa Montana	24°03'38"S, 47°58'47"W	783 m
M9	Mata Secundária Aberta	24°04'15"S, 47°59'12"W	727 m
M10	Floresta Ombrófila Aberta Montana	24°08'16"S, 48°00'02"W	821 m
M11	Floresta Ombrófila Densa Submontana	24°11'38"S, 47°55'13"W	96 m
M12	Floresta Ombrófila Densa Submontana	24°11'47"S, 47°55'42"W	69 m
M13	Floresta Ombrófila Densa Submontana	24°11'43"S, 47°55'25"W	106 m
M14	Floresta Ombrófila Densa Montana	24°06'16"S, 47°58'57"W	761 m
M15	Mata Secundária Densa	24°03'42"S, 47°58'32"W	824 m
M16	Floresta Ombrófila Densa Submontana	24°12'04"S, 47°55'57"W	51 m
M17	Floresta Ombrófila Densa Montana	24°04'56"S, 47°57'04"W	836 m
M18	Floresta Ombrófila Densa Submontana	24°12'22"S, 47°57'00"W	52 m
M19	Mata Secundária Densa	24°03'40"S, 47°59'18"W	775 m
M20	Floresta Ombrófila Aberta Montana	24°10'23"S, 47°59'06"W	648 m
M21	Mata Secundária Aberta	24°12'10"S, 47°56'26"W	45 m
M22	Floresta Ombrófila Densa Submontana	24°11'45"S, 47°55'28"W	82 m
M23	Floresta Ombrófila Densa Submontana	24°12'07"S, 47°57'04"W	74 m
M24	Floresta Ombrófila Densa Submontana	24°12'15"S, 47°57'02"W	60 m
M25	Floresta Ombrófila Densa Submontana	24°12'21"S, 47°57'09"W	55 m
M26	Floresta Ombrófila Densa Montana	24°06'29"S, 47°59'07"W	750 m
M27	Floresta Ombrófila Densa Submontana	24°11'52"S, 47°55'47"W	65 m
M28	Floresta Ombrófila Densa Submontana	24°12'04"S, 47°55'57"W	51 m
M29	Mata Secundária Densa	24°03'53"S, 47°59'59"W	709 m
M30	Mata Secundária Densa	24°03'37"S, 47°59'34"W	813 m
M31	Floresta Ombrófila Densa Montana	24°03'55"S, 47°57'13"W	810 m
M32	Floresta Ombrófila Densa Montana	24°06'17"S, 47°58'49"W	752 m
M33	Mata Secundária Densa	24°04'00"S, 47°59'44"W	739 m
M34	Floresta Ombrófila Densa Montana	24°04'06"S, 47°58'08"W	848 m
M35	Floresta Ombrófila Densa Submontana	24°11'06"S, 47°56'01"W	225 m
M36	Floresta Ombrófila Densa Montana	24°03'32"S, 47°56'29"W	787 m
M37	Floresta Ombrófila Densa Submontana	24°11'41"S, 47°55'18"W	92 m
M38	Floresta Ombrófila Densa Submontana	24°11'43"S, 47°55'03"W	170 m
M39	Floresta Ombrófila Densa Montana	24°03'48"S, 47°59'15"W	806 m
S1	Floresta Ombrófila Densa Montana	24°10'13"S, 47°58'13"W	580 m
S2	Mata Secundária Densa	24°03'25"S, 47°59'38"W	786 m
S3	Floresta Ombrófila Densa Submontana	24°11'44"S, 47°55'34"W	77 m
S4	Floresta Ombrófila Densa Submontana	24°12'05"S, 47°56'10"W	46 m
S5	Floresta Ombrófila Densa Montana	24°03'52"S, 47°59'16"W	800 m
S6	Floresta Ombrófila Densa Montana	24°03'50"S, 47°59'10"W	774 m
S7	Floresta Ombrófila Densa Submontana	24°11'37"S, 47°55'13"W	96 m
S8	Floresta Ombrófila Densa Submontana	24°11'52"S, 47°57'13"W	120 m
S9	Floresta Ombrófila Densa Submontana	24°11'35"S, 47°55'12"W	99 m
S10	Mata Secundária Densa	24°03'40"S, 47°59'18"W	775 m
S11	Mata Secundária Aberta	24°04'39"S, 47°58'38"W	741 m
S12	Floresta Ombrófila Densa Submontana	24°12'04"S, 47°55'57"W	51 m
S13	Mata Secundária Densa	24°03'57"S, 47°59'31"W	781 m
S14	Floresta Ombrófila Densa Submontana	24°12'38"S, 47°58'02"W	110 m
S15	Mata Secundária Densa	24°03'37"S, 47°59'34"W	813 m
S16	Floresta Ombrófila Densa Montana	24°03'51"S, 47°58'37"W	813 m
S17	Mata Secundária Densa	24°03'22"S, 47°59'36"W	788 m

2

BACTERIAL DIVERSITY AND ANTIBIOTIC-RESISTANCE IN BAT FAUNA OF CARLOS BOTELHO STATE PARK, ATLANTIC FOREST OF SOUTHEASTERN BRAZIL

BACTERIA DIVERSITY AND ANTIBIOTIC-RESISTANCE IN BAT FAUNA OF CARLOS BOTELHO STATE PARK, ATLANTIC FOREST OF SOUTHEASTERN BRAZIL

Abstract

Bats are distributed worldwide and represent 20% of the world mammals, playing fundamental ecological roles and also hosting many zoonoses. The basic knowledge of bats is still scarse, and their microbiota is poorly known. Their dietary habits have great influence on the microbiota diversity and antibiotic-resistance patterns, which represent a growing and serious issue to public health and the environment. Here we describe the microbiota diversity from oral and rectal cavities of frugivore, nectarivore, insectivore, sanguivore and carnivore bats from Carlos Botelho State Park, and their antibiotic-resistance patterns. Using the MALDI-TOF technique we identified 596 isolates at genus and probable species level. The most common bacteria between groups were *Escherichia coli*, *Klebsiella oxytoca* and *Serratia marcescens*. The frugivore bats presented the most diverse microbiota, followed by the insectivore bats. The antibiotic-resistance patterns were evaluated by the Kirby-Bauer's antibiotic disc diffusion technique on eight selected bacteria (five pathogenic and three abundant species within dietary groups). The general results exhibited a low occurrence of resistant bacteria, which could be related to the effectivity of the Park in conserving the wildlife and environment. Once the major causes of resistance-acquiring are related to antropic activites, the limited access for tourists on certain regions of the Park seems to be effectively protecting the environment, those results are in agreement to other studies on sites with reduced human impact.

Key words: Microbiota; Chiroptera; antibiogram; conservation.

3.1 INTRODUCTION

More than 1300 species of bats are distributed worldwide, representing ca. 20 % of the world mammals (FENTON; SIMMONS, 2014). Bats are the mammals with the greatest ecological diversity, their diets include frugivory, sanguinarivory, insectivory, nectarivory, carnivory and piscivory, although many species are not restricted to one dietary habit and many nutricional sources are shared between groups (HERRERA et al., 2001; FENTON; SIMMONS, 2014). Due to this diverse diet they play an important

role on several ecological services such as seed dispersal, pollination and pest control, but also carry many zoonoses (CALISHER et al., 2006; PERACCHI et al., 2006). Even presenting fundamental ecologic roles, the basic knowledge of bats is still scarse, and also is the knowledge about bats' microbiota, which is poor and mostly related to the gastrointestinal diversity (SOUZA et al., 1999; COSTA et al., 2005; DANIEL et al., 2013; GALICIA et al., 2014; BANSKAR, 2016). Additionally, studies focused on the interaction, influence and ecologic role of bats oral and rectal microbiota are also scarce, despite their importance on the digestion, vitamin synthesis, protection against harmful microorganisms and also public health (KLITE, 1965; PINUS; MÜLLER, 1980; DI BELLA et al., 2003; WHITAKER et al., 2004; MÜHLDORFER et al., 2010; OLUDURO, 2012).

Previous studies of bat gut microbiome showed that the bacteria diversity is in part related to the host diet and that there is an overlap between dietary groups, once many species can compensate the lack of some requirements with different food sources during resources shortages (CARRILLO-ARAUJO et al., 2015; BANSKAR et al., 2016). Besides the microbiota diversity, the bacteria antibiotic-resistance patterns could be also modulated by dietary habits (REMINGTON; SCHIMPFF, 1981; GRAVES et al., 1988; RADHOUANI et al., 2014). Among the major causes of resistance acquiring is the contact with antropic environments (THALLER et al., 2010; RADHOUANI et al., 2014). Antimicrobial resistant bacteria are a growing and serious problem to public health and the environment, and are reported to be present even on remote habitats (OLUDURO, 2012; SMITH et al., 2014). The presence of antimicrobial resistance in wildlife brings many implications, imposing limits to the quantity and quality of antibiotics used on the control of human and wildlife diseases, serving as potential reservoirs of resistant bacteria, and the zoonotic potential of enteric bacteria (OLUDURO, 2012; RADHOUANI et al., 2014).

Therefore, we aimed to describe the oral and rectal microbiota diversity of five dietary groups of bats from the Carlos Botelho State Park (CBSP), a conservation unit on the Atlantic Forest of Southeastern Brazil; identify the antibiotic-resistance profile of eight selected bacteria of those bats; and evaluate the effectivity of the protected area on the conservation of wildlife, considering the antibiotic-resistance patterns. We also hypothesized that the diet of the bats would influence on the resistance pattern of the bacteria analyzed, once species with animal-based diets should be more exposed to antibiotics and more susceptible to acquiring resistant strains.

3.2 MATERIAL AND METHODS

3.2.1 Samples collection

Fieldwork was conducted monthly from October 2016 to September 2017 on the Carlos Botelho State Park (CBSP; 24°12'–24°4'S, 47°47'–48°7'W), which is a conservation unit in the Brazilian Southeastern Atlantic Forest, created in 1982. The park phytophysiognomy is mostly represented by the ombrophilous forest, and ca. 23300 ha are composed by pristine forests (SÃO PAULO, 2008). The bats were captured with mist-nets and searching for roosts. Monthly, oral and rectal cavities of one bat of each species captured were swabbed with sterile cotton swabs, which were then separately transported in Stuart's transport medium and refrigerated. Samples used in this study were collected from 113 bats of 33 species.

3.2.2 Isolation and identification of the microbiota

Samples collected in fieldwork were plated on 5% sheep blood agar and MacConkey agar, and incubated aerobically at 36ºC for 24h. The colonies were further isolated by morphotype and preserved in Tryptic Soy Broth and 20% glycerol at -80ºC; all the isolates are stocked at the Culture Collection of the Fundação Parque Zoológico de São Paulo. The isolates were later identified by the matrix-assisted laser desorption/ionization (MALDI) technique, using MALDI Byotiper System in collaboration with the Proteomics Laboratory at Universidade Federal de São Paulo (VEEN et al., 2010). The database of this technique is mostly composed by pathogenic species, therefore a great part of the identifications tend to result on pathogenic bacteria species. Isolates were analyzed using a formic acid-based direct, on-plate preparation method. Small amounts of a single colony were smeared directly onto a spot of the MALDI-TOF MS steel anchor plate. Each spot was then overlaid with one microliter of 70% formic acid and allowed to dry. The dried mixture was overlain with 1 μl of matrix solution (α-cyano-4-hydroxycinnamic acid [HCCA]) dissolved in 50% acetonitrile, 47.5% water, and 2.5% trifluoroacetic acid and allowed to dry prior to analysis using the MALDI Biotyper. An *Escherichia coli* isolate was used for instrument calibration. Two positive controls (*Escherichia coli* and *Staphylococcus aureus*) were included with each run (SCHIMITT et al., 2013).

3.2.3 Antibiotic sensitivity

Antibiotic sensitivity tests were performed on Mueller Hinton agar using Kirby-Bauer's antibiotic disc diffusion technique (BAUER et al., 1966). The tests were performed for a subset of the identified isolates: the most pathogenic bacteria species *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, *Stenotrophomonas* sp. and *Salmonella* sp.; and the most abundant and representative bacteria over the bat species and dietary groups (*Escherichia coli*, *Klebsiella oxytoca*, and *Serratia marcescens*). The antibiotics used on the tests were selected according to the bacteria characteristics, and the discs were firmly placed on the seeded plates, that were incubated at 36ºC for 24h. The sensibility of each isolate for different antibiotics was evaluated by the zones of inhibition, which were measured and compared with the susceptibility pattern of each antibiotic defined by the Clinical and Laboratory Standards Institute (NCCLS, 2002).

The antibiotics tested for *Acinetobacter baumannii* were: amikacin (AMI, 30 μg), ceftazidime (CAZ, 30 μg), ceftriaxone (CRO, 30 μg), ciprofloxacin (CIP, 5 μg), chloramphenicol (CLO, 30 μg), gentamicin (GEN, 10 μg), imipenem (IPM, 10 μg) and norfloxacin (NOR, 10 μg). The antibiotics tested for *Pseudomonas aeruginosa* were: ceftazidime (CAZ, 30 μg), ceftriaxone (CRO, 30 μg), ciprofloxacin (CIP, 5 μg), gentamicin (GEN, 10 μg), imipenem (IPM, 10 μg) and norfloxacin (NOR, 10 μg). The antibiotics tested for *Stenotrophomonas maltophilia* and *Stenotrophomonas* sp. were: ceftazidime (CAZ, 30 μg), ceftriaxone (CRO, 30 μg), ciprofloxacin (CIP, 5 μg), gentamicin (GEN, 10 μg), imipenem (IPM, 10 μg), norfloxacin (NOR, 10 μg) and Trimethoprim-sulphamethoxazole (SUT, 1.25/23.75 μg). The antibiotics tested for *Escherichia coli*, *Klebsiella oxytoca*, *Salmonella* sp. and *Serratia marcescens* were: amikacin (AMI, 30 μg), ceftazidime (CAZ, 30 μg), ceftriaxone (CRO, 30 μg), ciprofloxacin (CIP, 5 μg), chloramphenicol (CLO, 30 μg), gentamicin (GEN, 10 μg), imipenem (IPM, 10 μg), doxycycline (DOX, 30 μg), ampicillin (AMP, 10 μg), amoxicillin-clavulanate (AMC, 20/10 μg) and cephalexin (CFL, 30 μg).

3.3 RESULTS

3.3.1 Oral and rectal microbiota

We isolated 830 morphotypes of bacteria from five different dietary groups of bats (carnivores, frugivores, insectivores, nectarivores and sanguivores), of which 596 were identified at genus and probable species level by the Maldi-Tof methodology. The

successfully identified isolates are divided into oral and rectal bats cavities, of which 243 correspond to the oral cavity and 353 to the rectal cavity. The number of successfully identified isolates on the oral cavity is represented by: 14 isolates from two species of carnivore bats; 16 isolates from two species of sanguivore bats; 25 isolates from three species of nectarivore bats; 75 isolates from 14 species of insectivore bats; and 113 isolates from 10 species of frugivore bats (Table 1; Figure 1). The number of successfully identified isolates on the rectal cavity is represented by: 11 isolates from two species of carnivore bats; 27 isolates from two species of sanguivore bats; 60 isolates from two species of nectarivore bats; 90 isolates from 15 species of insectivore bats; and 165 isolates from 11 species of frugivore bats (Table 2; Figure 2).

Table 1. Oral microbiota from bats of Carlos Botelho State Park, São Paulo State.

Species	Diet	Oral Microbiota (Number of isolates)
Family Phyllostomidae		
Subfamily Micronycterinae		
Micronycteris microtis	*Insectivore*	*Hafnia alvei* (2); *Serratia marcescens* (1); *Streptococcus gallinaceus* (1)
Micronycteris schimdtorum	*Insectivore*	-
Subfamily Desmodontinae		
Desmodus rotundus	*Sanguivore*	*Acinetobacter* sp. (1); *Arthrobacter* sp. (1); *Klebsiella* sp. (1); *Kluyvera* sp. (1); *Pantoea* sp. (1); *Pseudomonas stutzeri* (2); *Raoultella* sp. (1); *Serratia marcescens* (2); *Serratia* sp. (1); *Staphylococcus aureus* (1); *Streptococcus gallinaceus* (1)
Diphylla ecaudata	*Sanguivore*	*Staphylococcus* sp. (2)
Subfamily Phyllostominae		
Mimon bennetti	*Carnivore*	*Citrobacter freundii* (1); *Enterobacter* sp. (2); *Klebsiella* sp. (1); *Lactococcus lactis* (1); *Serratia marcescens* (1)
Trachops cirrhosus	*Carnivore*	*Aeromonas hydrophila* (2); *Kluyvera ascorbata* (2); *Lactococcus lactis* (1); *Serratia marcescens* (3)
Subfamily Glossophaginae		
Anoura caudifer	*Nectarivore*	*Arthrobacter* sp.(1); *Cedecea lapagei* (1); *Lactococcus lactis* (1); *Microbacterium* sp. (1); *Pseudomonas fulva* (1); *Pseudomonas koreensis* (1); *Pseudomonas* sp. (1); *Rahnella* sp. (2); *Serratia marcescens* (6); *Staphylococcus aureus* (1); *Streptococcus* sp. (1)
Anoura geoffroyi	*Nectarivore*	*Arthrobacter* sp. (1); *Enterobacter cloacae* (1); *Pantoea agglomerans* (1); *Pantoea* sp. (1); *Pseudomonas* sp. (1); *Staphylococcus aureus* (1); *Staphylococcus* sp. (1)
Glossophaga soricina	*Nectarivore*	*Staphylococcus* sp. (1)
Subfamily Carolliinae		
Carollia perspicillata	*Frugivore*	*Escherichia* sp. (1); *Escherichia vulneris* (1); *Neisseria* sp. (1); *Pseudomonas aeruginosa* (1); *Pseudomonas extremorientalis* (2); *Pseudomonas* sp. (1); *Serratia liquefaciens* (1); *Serratia marcescens* (5); *Staphylococcus* sp. (1); *Stenotrophomonas maltophilia* (1)
Subfamily Glyphonycterinae		
Glyphonycteris sylvestris	*Insectivore*	*Serratia* sp. (4)
Subfamily Stenodermatinae		
Artibeus fimbriatus	*Frugivore*	*Acinetobacter* sp. (1); *Arthrobacter* sp. (1); *Burkholderia* sp. (1); *Enterobacter cloacae* (2); *Enterobacter* sp. (3); *Klebsiella oxytoca* (2); *Pseudomonas* sp. (3); *Raoultella ornithinolytica* (1); *Raoultella terrigena* (4); *Serratia marcescens* (3); *Serratia* sp. (2); *Stenotrophomonas* sp. (1)
Artibeus lituratus	*Frugivore*	*Acinetobacter* sp. (2); *Lactococcus* sp. (1); *Leclercia adecarboxylata* (1); *Leclercia* sp. (1); *Pantoea agglomerans* (1); *Pantoea* sp. (1); *Salmonella* sp. (1); *Serratia marcescens* (2); *Serratia* sp. (1); *Staphylococcus saprophyticus* (1); *Streptococcus* sp. (1)
Artibeus obscurus	*Frugivore*	*Enterobacter* sp. (1); *Leclercia adecarboxylata* (1); *Ochrobactrum intermedium* (1); *Ochrobactrum* sp. (1); *Pantoea agglomerans* (6); *Pseudomonas koreensis* (2); *Pseudomonas* sp. (6); *Serratia marcescens* (5); *Serratia* sp. (1); *Stenotrophomonas* sp. (1)
Dermanura cinerea	*Frugivore*	*Pantoea* sp. (3); *Serratia marcescens* (1); *Serratia* sp. (2)
Platyrrhinus lineatus	*Frugivore*	*Enterobacter asburiae* (1); *Klebsiella oxytoca* (1); *Klebsiella* sp. (1)
Platyrrhinus recifinus	*Frugivore*	*Enterobacter* sp. (2); *Serratia marcescens* (2)

Pygoderma bilabiatum	*Frugivore*	-
Sturnira lilium	*Frugivore*	*Acinetobacter lwoffii* (1); *Escherichia coli* (2); *Hafnia* sp. (2); *Lactococcus lactis* (1); *Pantoea agglomerans* (1); *Pantoea ananatis* (2); *Pseudomonas* sp. (3); *Streptococcus* sp. (1)
Sturnira tildae	*Frugivore*	*Acinetobacter* sp. (1); *Bacillus thuringiensis* (1); *Enterobacter* sp. (1); *Escherichia coli* (2); *Leclercia* sp. (1); *Pseudomonas* sp. (1); *Stenotrophomonas* sp. (1)
Vampyressa pusilla	*Frugivore*	*Enterobacter* sp. (2)
Family Molossidae		
Subfamily Molossinae		
Cynomops abrasus	*Insectivore*	*Acinetobacter pittii* (2); *Enterobacter cloacae* (1)
Molossops neglectus	*Insectivore*	*Enterobacter* sp. (1); *Escherichia coli* (1); *Serratia marcescens* (2); *Staphylococcus* sp. (1)
Molossus currentium	*Insectivore*	*Hafnia* sp. (1); *Serratia marcescens* (4)
Molossus molossus	*Insectivore*	*Cedecea lapagei* (1); *Citrobacter* sp. (1); *Ochrobactrum* sp. (1); *Ochrobactrum tritici* (1); *Serratia marcescens* (2); *Serratia* sp. (1); *Staphylococcus* sp. (1)
Molossus rufus	*Insectivore*	*Acinetobacter baumannii* (1); *Acinetobacter* sp. (1); *Escherichia coli* (1); *Proteus vulgaris* (1); *Salmonella* sp. (1); *Serratia marcescens* (2)
Family Vespertilionidae		
Subfamily Vespertilioninae		
Eptesicus taddeii	*Insectivore*	*Serratia* sp. (2)
Lasiurus ebenus	*Insectivore*	*Enterobacter cloacae* (1); *Pseudomonas aeruginosa* (2); *Serratia marcescens* (3)
Histiotus velatus	*Insectivore*	*Enterobacter* sp. (1); *Erwinia persicina* (1); *Hafnia alvei* (2); *Pseudomonas* sp. (1); *Serratia marcescens* (2); *Staphylococcus* sp. (1)
Subfamily Myotinae		
Myotis albescens	*Insectivore*	*Staphylococcus* sp. (2)
Myotis nigricans	*Insectivore*	*Aeromonas hydrophila* (1); *Enterobacter* sp. (2); *Lactococcus lactis* (1); *Pantoea agglomerans* (1); *Pantoea* sp. (1); *Serratia marcescens* (3); *Serratia* sp. (2); *Yokenella regensburgei* (1)
Myotis riparius	*Insectivore*	*Serratia marcescens* (2)
Myotis ruber	*Insectivore*	*Enterococcus faecalis* (1); *Ewingella americana* (2); *Pseudomonas* sp. (1); *Serratia marcescens* (2); *Serratia* sp. (1)

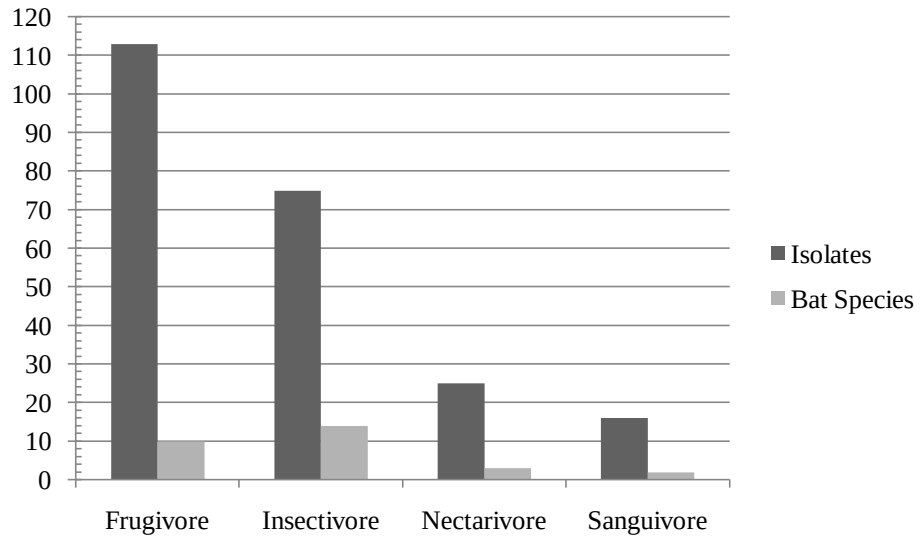

Figure 1. Number of isolates identified on the oral cavity of each dietary group of bats from Carlos Botelho State Park, São Paulo State.

Table 2. Rectal microbiota from bats of Carlos Botelho State Park, São Paulo State.

Species	Diet	Rectal Microbiota (Number of isolates)
Family Phyllostomidae		
Subfamily Micronycterinae		
Micronycteris microtis	*Insectivore*	*Citrobacter koseri* (1); *Citrobacter* sp. (1); *Enterobacter cloacae* (1); *Hafnia alvei* (2)
Micronycteris schimdtorum	*Insectivore*	*Staphylococcus* sp. (2)
Subfamily Desmodontinae		
Desmodus rotundus	*Sanguivore*	*Acinetobacter* sp. (1); *Brevundimonas* sp. (1); *Citrobacter* sp. (2); *Edwardsiella* sp. (1); *Escherichia coli* (3); *Klebsiella oxytoca* (4); *Klebsiella* sp. (2); *Pantoea* sp. (2); *Pseudomonas* sp. (1); *Staphylococcus aureus* (1); *Staphylococcus* sp. (1)
Diphylla ecaudata	*Sanguivore*	*Enterobacter cloacae* (1); *Enterobacter* sp. (1); *Escherichia* sp. (3); *Klebsiella oxytoca* (1); *Serratia marcescens* (2)
Subfamily Phyllostominae		
Mimon bennetti	*Carnivore*	*Citrobacter freundii* (1); *Hafnia alvei* (1); *Klebsiella oxytoca* (1); *Kluyvera ascorbata* (1); *Vagococcus fluvialis* (1)
Trachops cirrhosus	*Carnivore*	*Escherichia coli* (2); *Kluyvera ascorbata* (3); *Serratia marcescens* (1)
Subfamily Glossophaginae		
Anoura caudifer	*Nectarivore*	*Acinetobacter baylyi* (1); *Acinetobacter* sp. (2); *Bacillus* sp. (2); *Cedecea lapagei* (3); *Enterobacter radicincitans* (1); *Enterobacter* sp. (1); *Erwinia* sp. (4); *Ewingella* sp. (1); *Klebsiella oxytoca* (2); *Klebsiella* sp. (1); *Kluyvera* sp. (1); *Pantoea agglomerans* (1); *Pantoea ananatis* (1); *Pantoea* sp. (2); *Pseudomonas* sp. (4); *Pseudomonas taetrolens* (1); *Raoultella terrigena* (1); *Serratia marcescens* (3); *Staphylococcus aureus* (3); *Staphylococcus* sp. (1); *Streptococcus agalactiae* (1); *Streptococcus* sp. (1)
Anoura geoffroyi	*Nectarivore*	*Citrobacter freundii* (1); *Enterobacter* sp. (5); *Hafnia alvei* (1); *Hafnia* sp. (2); *Klebsiella* sp. (1); *Kluyvera ascorbata* (1); *Kluyvera* sp. (1); *Pantoea ananatis* (1); *Pantoea* sp. (1); *Raoultella terrigena* (1); *Serratia* sp. (1); *Staphylococcus capitis* (1); *Staphylococcus epidermidis* (1); *Staphylococcus* sp. (1); *Stenotrophomonas* sp. (1); *Streptococcus agalactiae* (1)
Glossophaga soricina	*Nectarivore*	-
Subfamily Carolliinae		
Carollia perspicillata	*Frugivore*	*Acinetobacter* sp. (1); *Bacillus* sp. (1); *Enterobacter* sp. (4); *Escherichia* sp. (1); *Ewingella* sp. (1); *Leclercia adecarboxylata* (2); *Pantoea* sp. (2); *Pseudomonas putida* (2); *Pseudomonas* sp. (1); *Raoultella terrigena* (1); *Serratia marcescens* (4); *Staphylococcus* sp. (1)
Subfamily Glyphonycterinae		
Glyphonycteris sylvestris	*Insectivore*	*Serratia marcescens* (1); *Staphylococcus* sp. (1)
Subfamily Stenodermatinae		
Artibeus fimbriatus	*Frugivore*	*Acinetobacter* sp. (1); *Enterobacter asburiae* (1); *Enterobacter cloacae* (2); *Enterobacter* sp. (5); *Erwinia* sp. (1); *Escherichia coli* (4); *Klebsiella* sp. (1); *Lactococcus* sp. (2); *Leclercia adecarboxylata* (1); *Raoultella ornithinolytica* (1); *Raoultella* sp. (1); *Raoultella terrigena* (2); *Serratia marcescens* (2)
Artibeus lituratus	*Frugivore*	*Bacillus megaterium* (1); *Citrobacter freundii* (1); *Enterobacter cloacae* (1); *Enterobacter* sp. (2); *Escherichia coli* (2); *Klebsiella oxytoca* (1); *Lactococcus lactis* (2); *Lactococcus* sp. (1); *Pantoea agglomerans* (1); *Pantoea* sp. (2); *Serratia marcescens* (2); *Serratia* sp. (1)
Artibeus obscurus	*Frugivore*	*Enterobacter aerogenes* (1); *Enterobacter ludwigii* (1); *Enterobacter* sp. (6); *Enterococcus* sp. (1); *Erwinia* sp. (1); *Escherichia coli* (6); *Escherichia* sp. (4); *Hafnia* sp. (1); *Klebsiella oxytoca* (2); *Klebsiella* sp. (1); *Raoultella planticola* (1); *Raoultella terrigena* (1); *Serratia marcescens* (4); *Serratia* sp. (1); Sph*ingobacterium* sp. (1)
Dermanura cinerea	*Frugivore*	*Citrobacter* sp. (1); *Enterobacter* sp. (3); *Klebsiella* sp. (1); *Stenotrophomonas maltophilia* (1)
Platyrrhinus lineatus	*Frugivore*	*Enterobacter* sp. (4); *Kluyvera ascorbata* (1)
Platyrrhinus recifinus	*Frugivore*	*Enterobacter* sp. (1); *Raoultella* sp. (1); *Serratia marcescens* (1)
Pygoderma bilabiatum	*Frugivore*	*Enterobacter cloacae* (2); *Leclercia adecarboxylata* (2); *Leclercia* sp. (1); *Pseudomonas* sp. (1); *Serratia marcescens* (2); *Stenotrophomonas* sp. (1)
Sturnira lilium	*Frugivore*	*Citrobacter freundii* (2); *Citrobacter* sp. (2); *Enterobacter* sp. (1); *Escherichia coli* (8); *Escherichia* sp. (5); *Klebsiella* sp. (2); *Kluyvera ascorbata* (1); *Kluyvera* sp. (1); *Pantoea* sp. (1); *Pseudomonas* sp. (2); *Serratia marcescens* (2)
Sturnira tildae	*Frugivore*	*Aeromonas* sp. (1); *Cedecea* sp. (1); *Citrobacter freundii* (1); *Citrobacter* sp. (1); *Enterobacter* sp. (2); *Escherichia coli* (1); *Escherichia* sp. (3); *Kluyvera* sp. (1); *Providencia alcalifaciens* (3); *Pseudomonas* sp. (2); *Streptococcus gallolyticus* (1)
Vampyressa pusilla	*Frugivore*	*Staphylococcus* sp. (1)
Family Molossidae		
Subfamily Molossinae		
Cynomops abrasus	*Insectivore*	*Providencia rettgeri* (2); *Providencia* sp. (1)
Molossops neglectus	*Insectivore*	*Enterococcus* sp. (1); *Providencia rettgeri* (2)
Molossus currentium	*Insectivore*	*Lactococcus* sp. (1); *Proteus* sp. (1); *Proteus vulgaris* (1)

Molossus molossus	*Insectivore*	*Enterococcus faecalis* (2); *Enterococcus* sp. (2); *Escherichia coli* (3); *Hafnia alvei* (2); *Hafnia* sp. (2); *Klebsiella oxytoca* (2); *Lactococcus* sp. (1); *Staphylococcus* sp. (1);
Molossus rufus	*Insectivore*	*Escherichia albertii* (1); *Escherichia coli* (1); *Proteus vulgaris* (3); *Salmonella* sp. (1)
Family Vespertilionidae		
Subfamily Vespertilioninae		
Eptesicus taddeii	*Insectivore*	*Enterococcus* sp. (1); *Escherichia coli* (1); *Escherichia* sp. (1); *Hafnia alvei* (1); *Providencia* sp. (2); *Serratia* sp. (1)
Lasiurus ebenus	*Insectivore*	*Acinetobacter* sp. (1); *Enterobacter asburiae* (1); *Enterobacter cloacae* (1); *Escherichia vulneris* (1); *Klebsiella* sp. (1); *Leclercia* sp. (1); *Pseudomonas aeruginosa* (1); *Staphylococcus* sp. (1)
Histiotus velatus	*Insectivore*	*Ewingella* sp. (1); *Hafnia alvei* (3); *Hafnia* sp. (3); Sp*hingobacterium* sp. (1)
Subfamily Myotinae		
Myotis albescens	*Insectivore*	*Plesiomonas shigelloides* (1); *Plesiomonas* sp. (1)
Myotis nigricans	*Insectivore*	*Hafnia alvei* (2); *Lactococcus garvieae* (2); *Lactococcus lactis* (1); *Serratia marcescens* (1); *Serratia* sp. (2); *Staphylococcus hominis* (1); *Staphylococcus xylosus* (1)
Myotis riparius	*Insectivore*	*Enterococcus faecalis* (1); *Hafnia alvei* (2); *Raoultella* sp. (1); *Raoultella terrigena* (1); *Serratia marcescens* (4)
Myotis ruber	*Insectivore*	*Cedecea* sp. (1); *Enterococcus faecalis* (1); *Ewingella americana* (2); *Hafnia alvei* (1); *Lactococcus lactis* (1); *Pseudomonas* sp. (1); *Serratia marcescens* (1)

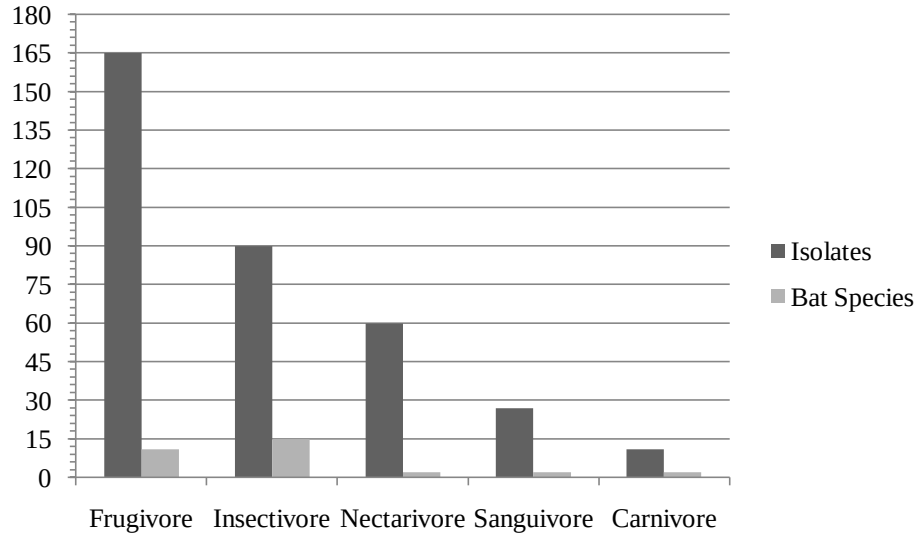

Figure 2. Number of isolates identified on the rectal cavity of each dietary group of bats from Carlos Botelho State Park, São Paulo State.

The total isolates are represented by four bacteria phyla, divided into 15 families. Proteobacteria was the most abundant phylum in all the dietary groups, representing 87% of the total samples, followed by Firmicutes with 12%, and Actinobacteria and Bacteriodetes counting together 1% of the total identified samples. The family Enterobacteriaceae represented 73% of the samples, followed by Pseudomonadaceae, with 7%, and the other 20% are composed by small sums of the families Aeromonadaceae, Bacillaceae, Brucellaceae, Burkholderiaceae, Caulobacteraceae, Enterococcaceae, Lysobacteraceae, Microbacteriaceae, Micrococcaceae, Moraxellaceae, Neisseriaceae, Sphingobacteriaceae,

Staphylococcaceae and Streptococcaceae. The phylum Actinobacteria, represented by *Arthrobacter* sp. and *Microbacterium* sp. was found only in the oral cavity, while the phylum Bacteroidetes is represented only by *Sphingobacterium* sp. in the rectal cavity.

A total of 62 taxa of bacteria were identified in the oral cavity and 72 in rectal cavity of the bats. The Venn diagram analysis indicate (Figures 3 and 4) that the major proportion of the bacteria within the dietary groups are shared between two or more groups. The oral diversity shared between groups varies from 49% to 75%, and even more on the rectal diversity, varying from 59% to 87% of bacteria taxa shared with at least one other group. However, only the species *Serratia marcescens* is shared between all five groups when the oral diversity is analyzed alone, and only the species *Klebsiella oxytoca* and *Serratia marcescens* are shared between all the groups when considered the rectal diversity. Comparing the dietary groups, higher diversity was found on frugivore bats (58 taxa), followed by insectivores (50 taxa), nectarivores (37 taxa), sanguivores (21 taxa) and carnivores (11 taxa).

3.3.2 Antibiotic sensitivity

Strains of one *Acinetobacter baumannii*, two *Pseudomonas aeruginosa*, two *Salmonella* sp., two *Stenotrophomonas maltophilia* and five *Stenotrophomonas* sp. were selected as the most pathogenic isolates and tested for their susceptibility for antibiotics. Additionally, 20 *Escherichia coli*, 13 *Klebsiella oxytoca* and 36 *Serratia marcescens* isolates were also tested to analyze the sensibility responses within different dietary groups. The *Acinetobacter baumannii* isolate developed resistance only to ciprofloxacin, was intermediate to ceftriaxone and sensible to all the other tested antibiotics. The two *Pseudomonas aeruginosa* isolates were sensible to all the antibiotics tested. The two *Salmonella* sp. isolates sensitivity patterns were different, one was sensible to all the antibiotics tested, while the other showed resistance to the antibiotics ampicillin and cephalexin. The two *Stenotrophomonas maltophilia* and five *Stenotrophomonas* sp. isolates sensitivity patterns were also different, all the isolates were resistant to the antibiotics ceftriaxone and imipenem, only one isolate was sensible to the antibiotic gentamicin, and the sensitivity to the antibiotic ceftazidime was variable (Table 3).

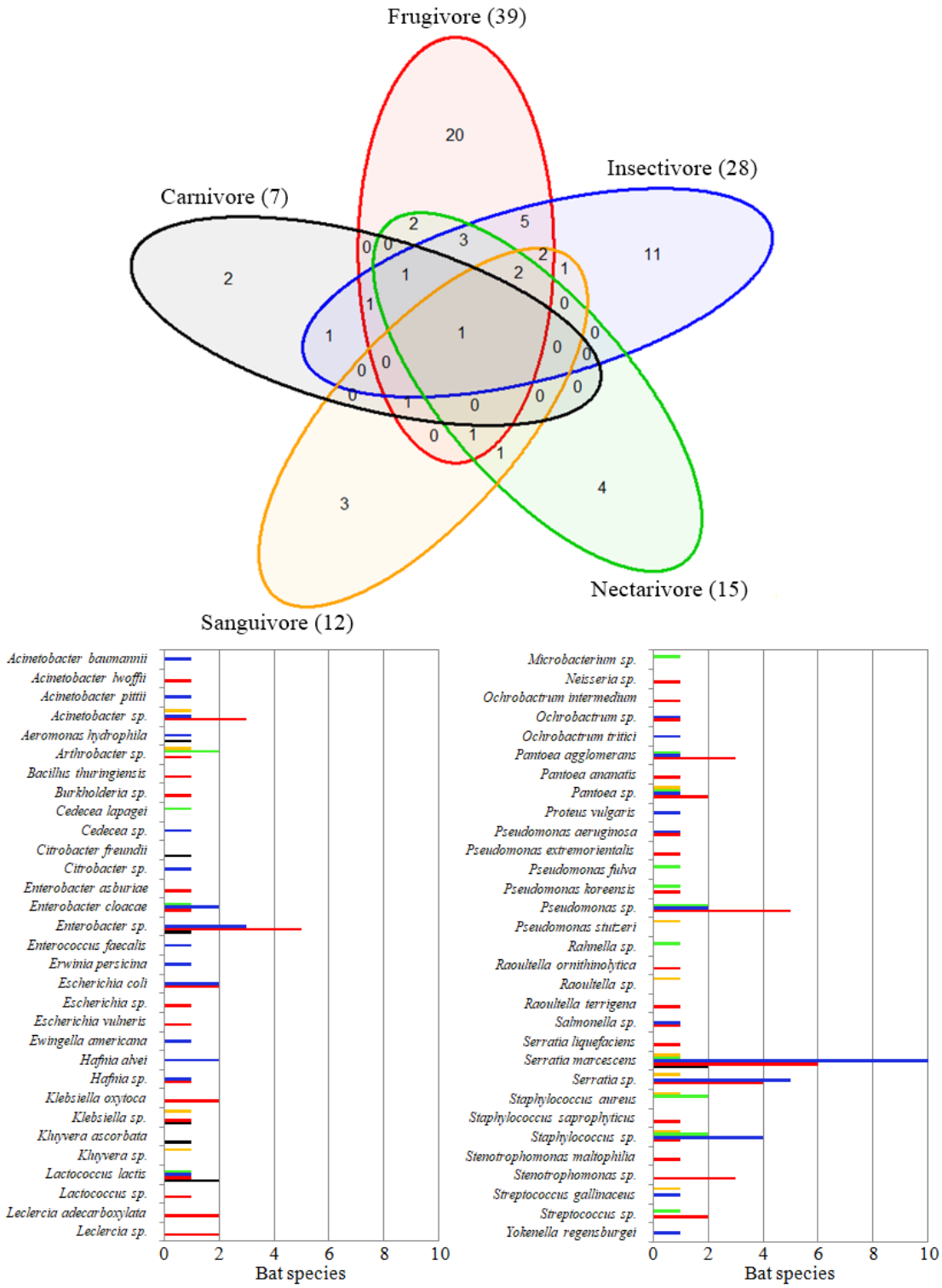

Figure 3. Venn-diagram showing the distribution of bacterial taxa from oral swabs of five dietary groups of bats on Carlos Botelho State Park, São Paulo State. The number of taxa within each group is represented in parenthesis. The abundance of each taxa on bat species is presented in the graph, and separated by dietary groups.

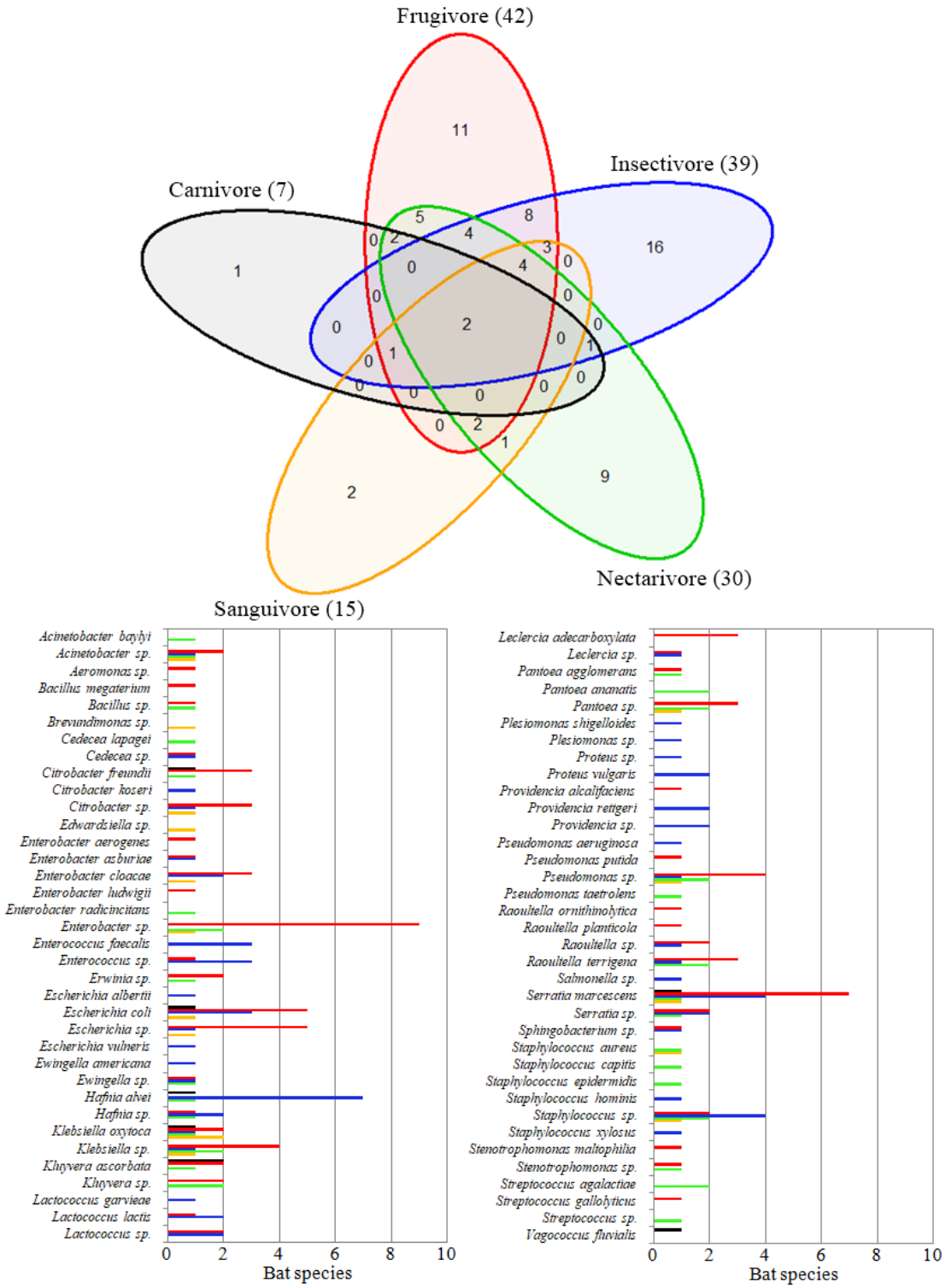

Figure 4. Venn-diagram showing the distribution of bacterial taxa from rectal swabs of five dietary groups of bats on Carlos Botelho State Park, São Paulo State. The number of taxa within each group is represented in parenthesis. The abundance of each taxa on bat species is presented in the graph, and separated by dietary groups.

Table 3. Antibiotic-resistance patterns of *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Salmonella* sp., *Stenotrophomonas maltophilia* and *Stenotrophomonas* sp. from swabs of bats on Carlos Botelho State Park. The resistance patterns are classified as Sensitive (S), Intermediate (I) and Resistant (R). See Materials and Methods section for description of antibiotics.

Bat species	Diet	Bacteria	Cavity	SUT	AMI	CAZ	CRO	CIP	CLO	DOX	GEN	IPM	NOR	AMC	AMP	CFL
Molossus rufus	INS	*Acinetobacter baumannii*	Oral	-	S	S	I	R	S	-	S	S	S	-	-	-
Carollia perspicillata	FRU	*Pseudomonas aeruginosa*	Oral	-	-	S	S	S	-	-	S	S	S	-	-	-
Lasiurus ebenus	INS	*Pseudomonas aeruginosa*	Oral	-	-	S	S	S	-	-	S	S	S	-	-	-
Artibeus lituratus	FRU	*Salmonella* sp.	Oral	-	S	S	S	S	S	S	S	S	-	S	R	R
Molossus rufus	INS	*Salmonella* sp.	Rectal	-	S	S	S	S	S	S	S	S	-	S	S	S
Carollia perspicillata	FRU	*Stenotrophomonas maltophilia*	Oral	S	-	S	R	S	-	-	R	R	S	-	-	-
Dermanura cinerea	FRU	*Stenotrophomonas maltophilia*	Rectal	S	-	S	R	S	-	-	R	R	S	-	-	-
Artibeus fimbriatus	FRU	*Stenotrophomonas* sp.	Oral	S	-	R	R	S	-	-	R	R	S	-	-	-
Artibeus obscurus	FRU	*Stenotrophomonas* sp.	Oral	S	-	R	R	S	-	-	R	R	S	-	-	-
Pygoderma bilabiatum	FRU	*Stenotrophomonas* sp.	Rectal	S	-	R	R	S	-	-	S	R	S	-	-	-
Sturnira tildae	FRU	*Stenotrophomonas* sp.	Oral	S	-	S	R	S	-	-	R	R	S	-	-	-
Anoura geoffroyi	NEC	*Stenotrophomonas* sp.	Rectal	S	-	S	R	S	-	-	R	R	S	-	-	-

The 20 *Escherichia coli* isolates from four dietary groups presented different responses to the antibiotics. None of the isolates from carnivores or frugivores presented resistance to the antibiotics tested (70% of *E. coli* isolates), while the isolates from sanguivores and insectivores presented different responses: one isolate (5% of *E. coli* isolates) from sanguivores was sensible for all the antibiotics and the other one was resistant to ampicillin; and two isolates (10% of *E. coli* isolates) from insectivores were sensible to all the antibiotics, one (5% of *E. coli* isolates) was resistant to ampicillin and cephalexin, and two (10% of *E. coli* isolates) were resistant to amoxicillin-clavulanate, ampicillin and cephalexin (Table 4). The 13 *Klebsiella oxytoca* isolates from five dietary groups presented different responses to the antibiotics, seven isolates (54% of *K. oxytoca* isolates) presented resistance to ampicillin, five isolates (38% of *K. oxytoca* isolates) were intermediate to ampicillin, and one isolate (8% of *K. oxytoca* isolates) was resistant to amoxicillin-clavulanate, ampicillin and cephalexin (Table 5). From the 36 *Serratia marcescens* isolates from five dietary groups, 34 (95% of *S. marcescens* isolates) presented resistance to the antibiotics amoxicillin-clavulanate, ampicillin and cephalexin, and only two isolates (5% of *S. marcescens* isolates) were not resistant to amoxicillin-clavulanate and ampicillin (Table 6).

Table 4. Antibiotic-resistance patterns of *Escherichia coli* from swabs of bats on Carlos Botelho State Park. The resistance patterns are classified as Sensitive (S), Intermediate (I) and Resistant (R). See Materials and Methods section for description of antibiotics.

Bat species	Diet	Bacteria	Cavity	AMI	CAZ	CRO	CIP	CLO	DOX	GEN	IPM	AMC	AMP	CFL
Trachops cirrhosus	CAR	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Artibeus fimbriatus	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Artibeus fimbriatus	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	I
Artibeus lituratus	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Artibeus obscurus	FRU	*Escherichia coli*	Oral	S	S	S	S	S	S	S	S	S	S	S
Artibeus obscurus	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Artibeus obscurus	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Sturnira lilium	FRU	*Escherichia coli*	Oral	S	S	S	S	S	S	S	S	S	S	S
Sturnira lilium	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Sturnira lilium	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Sturnira lilium	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Sturnira lilium	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Sturnira tildae	FRU	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Desmodus rotundus	SAN	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Desmodus rotundus	SAN	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	R	S
Eptesicus taddeii	INS	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Molossops neglectus	INS	*Escherichia coli*	Oral	S	S	S	S	S	S	S	S	R	R	R
Molossus molossus	INS	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S
Molossus rufus	INS	*Escherichia coli*	Oral	S	S	S	S	S	S	S	S	S	R	R
Molossus rufus	INS	*Escherichia coli*	Rectal	S	S	S	S	S	S	S	S	S	S	S

Table 5. Antibiotic-resistance patterns of *Klebsiella oxytoca* from swabs of bats on Carlos Botelho State Park. The resistance patterns are classified as Sensitive (S), Intermediate (I) and Resistant (R). See Materials and Methods section for description of antibiotics.

Bat species	Diet	Bacteria	Cavity	AMI	CAZ	CRO	CIP	CLO	DOX	GEN	IPM	AMC	AMP	CFL
Mimon bennetti	CAR	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	I	S
Artibeus fimbriatus	FRU	*Klebsiella oxytoca*	Oral	S	S	S	S	S	S	S	S	S	R	S
Artibeus fimbriatus	FRU	*Klebsiella oxytoca*	Oral	S	S	S	S	S	S	S	S	S	R	S
Artibeus lituratus	FRU	*Klebsiella oxytoca*	Oral	S	S	S	S	S	S	S	S	S	R	S
Artibeus obscurus	FRU	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Platyrrhinus lineatus	FRU	*Klebsiella oxytoca*	Oral	S	S	S	S	S	S	S	S	S	R	S
Desmodus rotundus	SAN	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	I	S
Desmodus rotundus	SAN	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	I	S
Desmodus rotundus	SAN	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	I	S
Desmodus rotundus	SAN	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	R	S
Diphylla ecaudata	SAN	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	I	S
Molossus molossus	INS	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	R	S
Anoura caudifer	NEC	*Klebsiella oxytoca*	Rectal	S	S	S	S	S	S	S	S	S	R	S

Table 6. Antibiotic-resistance patterns of *Serratia marcescens* from swabs of bats on Carlos Botelho State Park. The resistance patterns are classified as Sensitive (S), Intermediate (I) and Resistant (R). See Materials and Methods section for description of antibiotics.

Bat species	Diet	Bacteria	Cavity	AMI	CAZ	CRO	CIP	CLO	DOX	GEN	IPM	AMC	AMP	CFL
Mimon bennetti	CAR	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Trachops cirrhosus	CAR	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Artibeus fimbriatus	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Artibeus fimbriatus	FRU	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Artibeus lituratus	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Artibeus obscurus	FRU	*Serratia marcescens*	Rectal	S	S	S	S	I	S	S	S	R	R	R
Artibeus obscurus	FRU	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Artibeus obscurus	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Carollia perspicillata	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Carollia perspicillata	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Dermanura cinerea	FRU	*Serratia marcescens*	Oral	S	S	S	S	I	S	S	S	R	R	R
Platyrrhinus recifinus	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Pygoderma bilabiatum	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Pygoderma bilabiatum	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Sturnira lilium	FRU	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Glyphonycteris sylvestris	INS	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Histiotus velatus	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Lasiurus ebenus	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Micronycteris microtis	INS	*Serratia marcescens*	Oral	S	S	S	S	I	S	S	S	R	R	R
Molossops neglectus	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	I	S	R
Molossus cf. *currentium*	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Molossus molossus	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Molossus molossus	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Molossus rufus	INS	*Serratia marcescens*	Oral	S	S	S	S	I	S	S	S	R	R	R
Myotis nigricans	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Myotis nigricans	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Myotis nigricans	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Myotis riparius	INS	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Myotis ruber	INS	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Myotis ruber	INS	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Anoura caudifer	NEC	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Anoura caudifer	NEC	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Anoura caudifer	NEC	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R
Desmodus rotundus	SAN	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	R	R	R
Desmodus rotundus	SAN	*Serratia marcescens*	Oral	S	S	S	S	S	S	S	S	S	S	R
Diphylla ecaudata	SAN	*Serratia marcescens*	Rectal	S	S	S	S	S	S	S	S	R	R	R

3.4 DISCUSSION

3.4.1 Bacteria diversity

The predominance of the phylum Proteobacteria seems to be common on bats microbiota and was also found in other studies, on bats oral and rectal cavities (GALICIA et al., 2014), intestine (CARRILLO-ARAUJO et al., 2015; BANSKAR et

al., 2016) and saliva (DIETRICH, 2017). The phyla Actinobacteria, Bacteriodetes and Firmicutes were also previously reported on bats (see CARRILLO-ARAUJO et al., 2015; DIETRICH, 2017). According to Ley et al. (2008), the mammalian gut microbiota diversity is related to the host diet, and should increase from animal-based diets to omnivorous to herbivore diets. In our results, the frugivores microbiota was the most diverse among the five analyzed dietary groups, and agrees to Ley's theory. The less diverse microbiota found in our study comes from the carnivores group, which is also in agreement to the mammals microbiota theory, but probably is also related to the small number of carnivore samples. However, the insectivore group also presented high microbiota diversity, and diverges from the expected, which could be explained by the inclusion of different alimentary items, rather than insects, on the diet of many species classified as insectivores. Species such as *Glyphonycteris sylvestris*, *Lampronycteris brachyotis*, *Micronycteris microtis* and *Myotis nigricans* analyzed in this study are reported to complement their diet with fruits and/or pollen (GIANNINI; KALKO, 2005; WILLIAMS; GENOWAYS, 2008; NOVAES et al., 2015), which could increase the general microbiota diversity of the insectivore bats group analyzed here.

Some bacteria genera, such as *Arthrobacter*, *Burkholderia*, *Microbacterium*, *Neisseria* and *Rahnella* and were found only in the oral cavity. The genus *Arthrobacter* is composed by soil bacteria, and was also found on bats' wing sacs, chin and axillae by other authors (CONN; DIMMICK, 1947; STUDIER; LAVOIE, 1984; VOIGT et al., 2005); strains of *Arthrobacter* and *Rahnella* were identified as effective inhibitory antagonists of the growth of *Pseudogymnoascus destructans*, the fungus that causes a deadly disease in bats known as white-nose syndrome (MICALIZI et al., 2017). The genera *Burkholderia* and *Microbacterium* were also found on bats' saliva, urine and faeces, and intestine, respectively, by other authors (BANSKAR et al., 2016; DIETRICH et al., 2017). The genus *Neisseria* was found by Dietrich et al. (2017) only on bat saliva samples, and is closely related to mucosal and dental surfaces of animals, being a consistent component of human oral microbiota and also found in many mammal species (BENNET et al., 2014). The rectal cavity exclusive genus *Enterococcus* was also isolated from bats' wings by Voigt (2005). The genus *Brevundimonas*, also found only on the rectal cavity, is not common to bats and was previously reported for marine mammals and originally isolated from water and hospital-related material (SEGERS et al., 1994; WALLACE et al., 2013).

Bacteria genera observed within different dietary groups were also divergent, with some exclusive occurrences. The sanguivore group was the only to present the genus *Edwardsiella*, which was previously isolated from bovine faeces and latter from cattle meat, wild mammals and birds (EWING et al., 1965; VAN DAMME; VANDEPITTE, 1984). Thus, the occurrence of the genus only in this group appears to be related to the feeding habit itself, which is based on blood from domestic and wild mammals, and birds (OLIVEIRA et al., 2017). The insectivore group was the only one where the genera *Plesiomonas*, *Proteus* and *Yokenella* were identified. The genus *Proteus*, however, was also found in sanguivore and frugivore samples in other studies (CHAVERRI, 2006; GALICIA et al., 2014). The genus *Plesiomonas* is reported to be isolated from freshwater and surface water samples (NIEDZIELA et al., 2002), and many species of insectivore bats are associated to these environments (see HANDLEY JR., 1976; LÓPEZ–GONZÁLEZ, 2001; MEYER et al., 2005), where they forage and could be exposed to bacteria. According to Cassel-Beraud and Richard (1988) and Pereira de Oliveira et al. (2001), the genus *Yokenella* was previously isolated from the intestinal tracts of insects and faeces of insect-feeding animals, including bats; therefore it is probably related to this kind of diet. *Vagococcus* was present only in carnivore bats and has been recovered from animals, water, soil and human sources (LAWSON, 2014). Considering the bacteria found on all five dietary groups, we have the species *Serratia marcescens* and *Klebsiella oxytoca*. *Serratia marcescens* was reported in other studies and various dietary groups: in frugivore bats (DANIEL et al., 2013), sanguivore bats (CHAVERRI, 2006; GALICIA et al., 2014), and insectivore bats (VOIGT et al., 2005). The species *Klebsiella oxytoca* was previously reported in frugivore bats (ANAND; SRIPATHI, 2004; DANIEL et al., 2013) and insectivore bats (GORDON; LEE, 1999; DI BELLA et al., 2003), however, Gordon (2001) affirm in his study that *K. oxytoca* is greatly related to Vespertilionid (insectivore) bats rather than to any other Australian mammal.

3.4.2 Antibiotic sensitivity

Generally, the resistance to antibiotics found on our samples was related to the intrinsic resistance of the tested species, according to Leclercq et al. (2011). The species *Pseudomonas aeruginosa* and *Stenotrophomonas maltophilia* did not show any resistance besides their expected intrinsic resistance patterns. The species *Acinetobacter baumannii* and *Stenotrophomonas* sp. presented resistance to the antibiotics

ciprofloxacin and ceftazidime, respectively; those resistances are not intrinsic and could be acquired from different environmental sources. The bat species where the resistant *Acinetobacter baumannii* strain was found is insectivore, and animal-based diet could be a source of resistant strains, through accumulation (RADHOUANI et al., 2014). Yet, the *Stenotrophomonas* sp. resistant strains were found on frugivorous and nectarivorous and could outcome from the contact with water or fruits and even casual ingestion of insects (REMINGTON; SCHIMPFF, 1981; GRAVES et al., 1988; RADHOUANI et al., 2014).

Additionally, we hypothesized that insectivore, carnivore and sanguivore bats would present a higher rate of resistant strains, when compared to frugivores and nectarivores. This was expected once their activities pattern and diet make them more susceptible to exposure to antimicrobials (RADHOUANI et al., 2014; REIS et al., 2017). However, considering the abundant bacteria species *Escherichia coli*, *Klebsiella oxytoca* and *Serratia marcescens* that were used to compare the dietary groups, this pattern was unclear. The only bacteria species that poorly support this hypothesis is *E. coli*, which presented resistant strains only on insectivore and sanguivore bats, and sensible strains on the other dietary types. Once one of the major sources of resistance acquiring includes the contact with antropic and agricultural environments, this fact could be expected to occur mainly on insectivore, carnivore and sanguivore bats rather than herbivores (RADHOUANI et al., 2014; ALONSO et al., 2016). However, the absence of resistant strains of *E. coli* on carnivores, and general absence of resistant strains of *K. oxytoca* and *S. marcescens* do not support our hypothesis. A larger number of samples could help to better evaluate this question.

The tested *K. oxytoca* isolates presented only one resistant strain (5%) and none of the *S. marcescens* isolates presented any resistance besides the intrinsic ones. The small rates of resistant bacteria observed on CBSP in consistently different from the observed on other studies conducted on areas influenced by antropic activities (see GRAVES et al., 1988; COSTA et al., 2008; SHERLEY et al., 2000; OLUDURO, 2012). Graves et al. (1988) found a great number of resistant bacteria on bats and rats from Krakatau Islands, which they correlated, in part, to antropic influence on the local islands. Oluduro (2012) tested the antibiotic-resistance pattern of *E. coli* isolates from Nigerian bats, and also found a great number of resistant isolates; the resistance was attributed to the use of antibiotics on poultry feed or on poultry itself. Analyzing all of our tested isolates, 71 out of 81 (87%) did not present any resistance besides the

expected from the intrinsic pattern, which could be related to the effectiveness of CBSP on the conservation of the wildlife and environment present on the park area and also explain the absence of differences on the resistance patterns between dietary groups. Moreover, Gilliver et al. (1999) inferred that the restriction of the contact to antibiotics would not lead to the decline of acquired resistances; therefore, it is reasonable to expect that resistance patterns on CBSP were always similar to the results presented here and no previous chronic exposures existed. This result is in agreement to Österblad et al (2001) and Thaller et al. (2010), which reported a lack of human-acquired antibiotic resistance on environments with minimal antropic influence and no chronic exposure to antibiotics.

Besides direct exposure to antibiotics, bacterial resistance can be originated through horizontally mobile elements such as conjugative plasmids, integrons and transposons (RADHOUANI et al., 2014). Therefore, the low rate of resistance found on the Enterobacteriaceae of CBSP also suggests a small probability of the diffusion of acquired resistance on the Park. Many authors reported that bacteria from remote areas could work as sentinels and help to evaluate the impact of antropic pressure on wildlife and the role of wild-species and natural environments on the process of resistance acquiring (THALLER et al., 2010; RADHOUANI et al., 2014; SMITH et al., 2014). Our findings reinforce the need of monitoring antimicrobial resistance in wildlife from remote areas, appearing to be an alternative tool to evaluate the environment responses to antropic pressures. On this way, more efforts should be carried out on the Park to better evaluate the local resistance patterns, the impact that the human activites of the surroundings cause inside the Park environment and the hole of wildlife as reservoirs of resistant bacteria.

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