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First record of *Macrophyllum macrophyllum* (Schinz, 1821) in Brazilian mangroves, with comments on bat diversity in this ecosystem

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ABSTRACT

We present the first record of *Macrophyllum macrophyllum* for a mangrove ecosystem, a review of the records of this bat in Rio de Janeiro state, and a checklist of bats from Brazilian mangroves. Captured at APA Guapimirim, this specimen represents the fifth record for Rio de Janeiro state, raising the number of species known from Brazilian mangroves to 39, most of them being insectivores. The new record may reflect both the difficulty of sampling this species using traditional methods, and the lack of mammalian research in mangroves. Such studies, however, would be important for the conservation of an ecosystem that is constantly under human disturbance.

Key words: Chiroptera, coastal habitat, Phyllostomidae

RESUMO – Primeiro registro de *Macrophyllum macrophyllum* (Schinz, 1821) em manguezais brasileiros, com comentários sobre a diversidade de morcegos nesse ecossistema

Apresentamos o primeiro registro de *Macrophyllum macrophyllum* para o ecossistema manguezal, uma revisão dos registros desse morcego no estado do Rio de Janeiro e a lista de espécies atualizada de morcegos dos manguezais brasileiros. Capturado na APA Guapimirim, esse espécime representa o quinto registro para o estado, aumentando para 39 o número de espécies conhecidas para os manguezais brasileiros, a maioria delas insetívoras. O novo registro pode refletir tanto a dificuldade de amostragem dessa espécie por métodos tradicionais, quanto a falta de pesquisas com mamíferos em manguezais. Tais estudos, no entanto, seriam importantes para a conservação de um ecossistema constantemente sujeito a perturbações antrópicas.

Palavras-chave: Chiroptera, habitats costeiros, Phyllostomidae

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Mangrove forests span marine, freshwater and terrestrial realms distributed along coastal tropical, subtropical and temperate regions of the world (Giri et al. 2011; Rog et al. 2016). Constantly under a tidal regime, this ecosystem provides several resources (e.g., food, shelter) for biodiversity (Macintosh & Ashton 2002; Nagelkerken et al. 2008; ICMBio 2018), besides their fundamental role on coastal protection (Luther & Greenberg 2009) and carbon sequestration (Sanderman et al. 2018). Despite their relevance, mangrove forests are declining fast, being highly threatened by urban expansion and land use (Giri et al. 2011; Richards & Friess 2016). The knowledge on the ecological relationships between this ecosystem and its associated biodiversity, is fundamental to plan actions for their effective conservation (Rog et al. 2016).

Bats play important roles in mangrove communities, providing several ecosystem services such as pollination, insect population control, and nutrient transfer (Ashraf & Habjoka 2013; Reef et al. 2014; Hogarth 2015; Rog et al. 2016; Nor Zalipah et al. 2020). By covering long distances during flight, they can help connect mangroves with terrestrial habitats (Hogarth 2015). Bats, however, are clearly undersampled in Brazilian mangroves (Peracchi & Nogueira 2010; Soares et al. 2016; Vargas-Mena et al. 2018): of the 16 coastal states with mangroves (ICMBio 2018), only four (Pará, Maranhão, Pernambuco, and Rio de Janeiro) have published bat inventories in this ecosystem (Cruz et al. 2007; Andrade et al. 2008; Lourenço et al. 2010; Soares et al. 2016). This gap is also seen in other Neotropical countries, with few studies being specifically conducted in mangroves (Moreno-Bejarano & Álvarez-León 2003; Salas 2010; Araúz et al. 2020).

During a bat survey at Guapimirim Environmental Protection Area (APA Guapimirim), located in Rio de Janeiro, southeastern Brazil, we sampled the long-legged bat *Macrophyllum macrophyllum* (Schinz, 1821) (Phyllostomidae, Phyllostominae). Previously unknown in Brazilian mangroves (Lourenço et al. 2010; Soares et al. 2016), this species forages over water and has a distribution associated to the presence of perennial rivers (Feijó et al. 2015). It is widely distributed in the Neotropical region, occurring from southern Mexico to northern Argentina, except in Chile and Uruguay (Williams & Genoways 2008). In Rio de Janeiro, one of the best sampled Brazilian states regarding bats (Peracchi & Nogueira 2010), there are only three geographically widespread records of *M. macrophyllum* in southern (Ilha da Gipóia, Angra dos Reis; Carvalho et al. 2011), metropolitan (Universidade Federal Rural do Rio de Janeiro – UFRRJ, Seropédica; Peracchi & Albuquerque 1971), and central (Pedra de Santa Rita, Sumidouro; Novaes et al. 2015) regions. Of particular relevance here, the first record from the metropolitan region, where APA Guapimirim is also located, dates from more than 50 years ago (Peracchi & Albuquerque 1971), and no morphological data related to this or the other two records has been reported. Here we provide details of our record of *M. macrophyllum* from APA Guapimirim, review the material of this species available from previous records in Rio de Janeiro, and present a checklist of bats in Brazilian mangroves.

The specimen, an adult male, was captured in an area known as *Vala da Banana* (latitude -22.686824; longitude -42.996014; DATUM WGS84) in November 2019

(Fig. 1). The site was sampled with seven mist nets (9.0 m x 3.0 m each) set at ground level, parallel to the margin of the Macacu river (nearly two meters from its border), for a period of five hours after sunset. The individual was handled in accordance with the recommendations of Sikes et al. (2016), prepared as skin and skeleton, and is deposited as a voucher specimen (MN 87731) in the mammal collection of Museu Nacional, Universidade Federal do Rio de Janeiro (MN/UFRJ). Additional specimens from Rio de Janeiro analyzed here, whose localities are plotted at Fig. 1A, were MN 77735 (MN/UFRJ) and ALP 0003, 0024, 0620, 0621, 1215, 1216, 3171, 4625 (Adriano Lúcio Peracchi Collection, UFRRJ).

Specimens were measured following Vizotto & Taddei (1973) for external variables, and Nogueira et al. (2012) for skull variables using a digital caliper to the nearest 0.01 mm. Body mass was obtained with a Pesola spring scale for MN 87731, and from the original labels for other specimens. These measurements were compared to morphological data available for specimens from São Paulo, Minas Gerais and Bahia (Dobson 1878; Vieira 1942; Taddei 1975; Feijó et al. 2015), and are summarized in Table 1.

Our specimen conforms in most respects to previous descriptions of *M. macrophyllum* (Harrison 1975; Williams & Genoways 2008; Diaz et al. 2016), presenting a brownish pelage in both ventral and dorsal surfaces, large and rounded ears, well-developed lance-shaped noseleaf with a well-marked central column, large feet with well-developed claws, large calcaneum, large uropatagium with rows of dermal denticles on its ventral surface, long tail inserted in the uropatagium, skull with a short rostrum, three lower premolars and molars, second lower premolar tiny and crowded inward, first upper incisor procumbent, and dental formula 2/2, 1/1, 2/3, 3/3 x 2 = 34 (Fig. 2). When the relative size of tibia and calcaneum is considered, however, specimens analyzed here (calcaneum longer than tibia; Table 1) are different from the condition described by Diaz et al. (2016) – calcaneum the same size of tibia. Comparisons among specimens from eastern Brazil revealed, additionally, that the specimen from APA Guapimirim has slightly larger external dimensions than those from other localities in Rio de Janeiro, and also from Minas Gerais (Vieira 1942) and Bahia (Feijó et al. 2015) (Table 1), except for body mass, foot, and ear lengths. The specimens from São Paulo (Taddei 1975) seem to be larger in most external dimensions, but the topotype from Bahia (Dobson 1878) presents the largest measurements of forearm, body, and tibia length. The specimens from Rio de Janeiro have most of the cranial measurements greater than those from São Paulo and Minas Gerais, and the smallest one is the specimen from Bahia. Additional measurements taken from our specimen were, in millimeters, noseleaf length (12.27), noseleaf width (5.95), and wingspan (228.8).

Essentially insectivorous, *M. macrophyllum* appears to forage exclusively over water, using its developed feet and uropatagium to sweep surface-dwelling insects towards its mouth, but it also hunts flying insects (Weinbeer et al. 2013). Our capture in a mist net set parallel to a river are in agreement with previous data, and may indicate the use of rivers within mangroves as foraging areas. Captured at 19:30h, right after a light rain, the behavior of our individual also matches with previous descriptions for

this species from Panamá, where Weinbeer et al. (2006) recorded a peak of activity just after dusk, and foraging occurring after or even during light rain. *Macrophyllum macrophyllum* has also been captured in mangroves of Colombia (Moreno-Bejarano & Álvarez-León 2003) and Mexico (Hernández-Mijangos et al. 2008), but its behavior was not described.

Macrophyllum macrophyllum is known to occur in 14 Brazilian states, with most records concentrated in Amazon and Atlantic Forest biomes (Feijó et al. 2015). In this study we added two new localities for this species in the state of Rio de Janeiro: the second record for the metropolitan region, in APA Guapimirim, 75 km distant from the first record at UFRRJ (the last capture in this region dates from 36 years ago), and the first record for the northwestern region of the state, based on a specimen (ALP 0003) collected in 1971 in Itaperuna, 125 km from the nearest record in Sumidouro (Novaes et al. 2015). These records show the importance of sampling in watercourses (and associated lagoons), in areas of plain landform (Peracchi & Nogueira 2010), and in roosts close to potential foraging areas (e.g., culverts; Taddei 1975; Marques 1985). This directed effort will also help determine the extent to which the local rarity of this species, usually represented in surveys by just one specimen (e.g., Hernández-Mijangos et al. 2008; Camargo et al. 2009; Rocha et al. 2010; Feijó et al. 2015), is a matter of sampling artifact. Roost samplings usually result in more individuals being reported than net sampling. In Paracou, French Guiana, three individuals sampled in a culvert were the only representatives of *M. macrophyllum* in a study involving more than 3,000 captures, most of them in mist nets (Simmons & Voss 1998). In southeastern Brazil, the two largest samples of this species available in the literature were obtained exclusively in culverts (Peracchi & Albuquerque 1971; Taddei 1975; seven and nine specimens, respectively). Association with this type of roost is common for this bat (e.g., Peracchi et al. 1984; Stutz et al. 2004) and can be long-standing, as we found for the culvert sampled at UFRRJ (from 1966 to 1984). Roost fidelity in this case is probably related not only to the stability of this type of roost (Lewis 1995), but also to its low availability at the sampling site.

The updated list of bats occurring in Brazilian mangroves includes 39 species, 27 genera, and five families (Table 2). The taxonomic list was updated according to the last modifications described in Garbino et al. (2020), and considered only species captured in areas of mangrove *sensu stricto*. It includes representatives of all main diet categories, with insectivores representing the largest group – 18 species (46.2%), which represent 16% of all insectivorous bats recorded in Brazil. Insectivorous species are also greatly represented in mangroves around the world (e.g., Moreno-Bejarano & Álvarez-León 2003; Luther & Greenberg 2009; Salas 2010; Hogarth 2015; Rog et al. 2016; Araúz et al. 2020), possibly attracted by the abundance of insects and other arthropods in this habitat (McKenzie & Start 1989; Hogarth 2015). This would be the case of *M. macrophyllum*, which might be foraging above mangrove rivers to feed on surface-dwelling insects.

None of the listed bat species from Brazilian mangroves are restricted to this habitat, and this lack of endemicity has also been reported for restingas (Nogueira et al. 2010).

In the latter ecosystem, also spread along the Brazilian coast and frequently occurring in association with mangroves (Souza et al. 2008), the diversity of insectivorous bats (17 spp.; Nogueira et al. 2010; Rocha et al. 2017; Soares et al. 2018) is similar to that reported here. However, the knowledge on the functional role played by the several trophic groups while using both these ecosystems is very limited (Nogueira et al. 2010; Hogarth 2015). Whereas in Brazil we can only speculate that bats are using mangroves as feeding areas, in a global survey Luther & Greenberg (2009) cited two insectivorous species (*Hypsugo vordermanni* and *Pipistrellus westralis*) as restricted to this ecosystem in Southeast Asia and northern Australia, respectively, revealing that interactions go beyond feeding. Therefore, we here reinforce the need of further bat inventories in mangroves, and also the need of ecological studies focused on species interactions, in an attempt to better understand the role of bats in this ecosystem.

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Figure 1. (A) Satellite images showing the new records of *Macrophyllum macrophyllum* from Rio de Janeiro, southeastern Brazil (★), and the records from previous studies (●) including, from left (West) to right (East), records of Ilha da Gipóia, Seropédica, APA Guapimirim, Sumidouro, and Itaperuna; MG, Minas Gerais; ES, Espírito Santo; SP, São Paulo; RJ, Rio de Janeiro. (B) Sampled area within mangrove, where *M. macrophyllum* was captured.

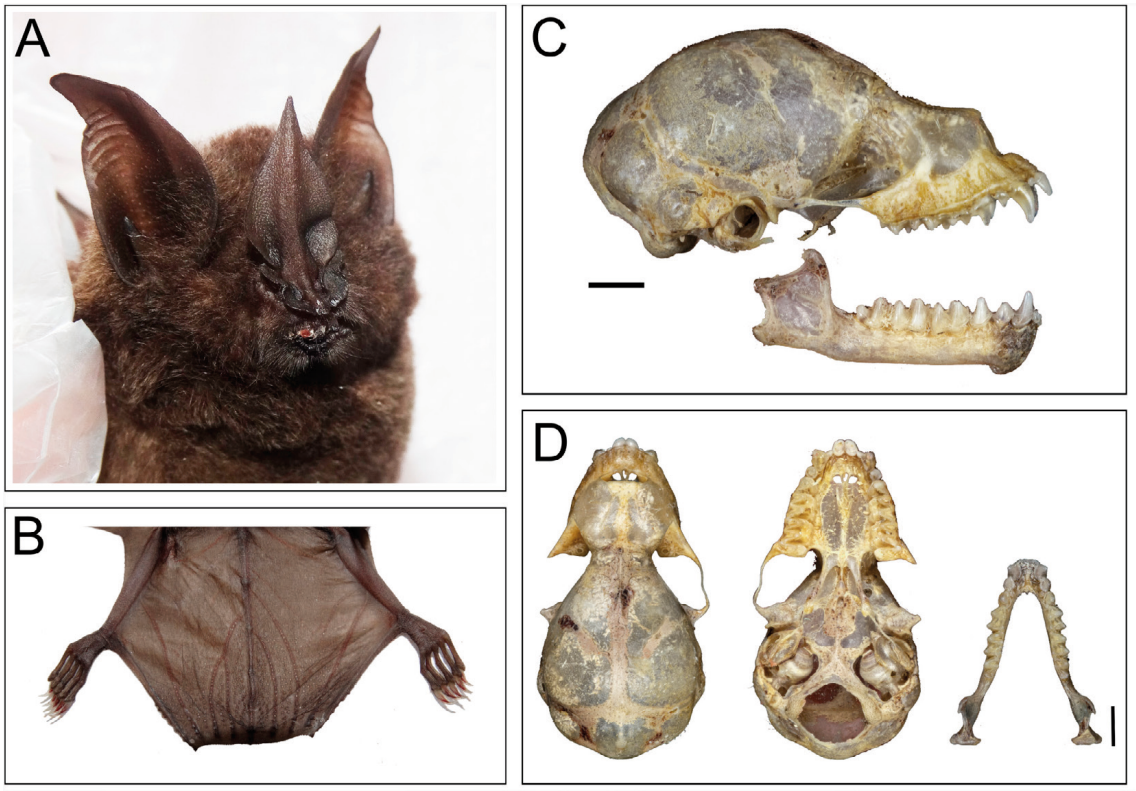

Figure 2. External (A-B) and cranial (C-D) morphology of the adult male *Macrophyllum macrophyllum* (MN 87731) captured in APA Guapimirim, Rio de Janeiro, Brazil. Note the well-developed lance-shaped noseleaf, with a well-marked central column (A) and the rows of dermal denticles on the ventral face of uropatagium (B). Scale bar: 2mm.

Table 1. External and cranial measurements of *Macrophyllum macrophyllum* for southeastern (Rio de Janeiro, São Paulo, and Minas Gerais) and northeastern (Bahia) Brazil. The new records described in this work are marked with an asterisk (*). Weight (body mass) is reported in grams (g); other measurements in millimeters (mm). Measurements of multiple individuals are presented as mean (minimum–maximum).

	Rio de Janeiro				**São Paulo**	**Minas Gerais**	**Bahia**	
Characters	APA Guapimirim* (n=1)	Seropédica (n=7)	Itaperuna* (n=1)	Sumidouro (n=1)	Taddei (1975) (n=8)	Vieira (1942) (n=2)	Feijó et al. (2015) (n=1)	Dobson (1878) (n=1)
Weight	7	9.80 (8-11)[a]	-9---	9	-	-	-	-
Forearm length	35.95	35.42 (35-35.8)	34.49	35	36.75 (35.5-37.5)	34.75	35.0	38.1[d]
Body length	45.70	-	-	43	46.19 (44-48)	40.5	37.4	63.5[d]
Total length	88.42	78.86 (77-82.2)[a]	-	81	-	68	75.6	-
Tail length	42.72	36.46 (34-40)[a]	-	38	-	27.5	38.2	38.4[d]
Ear length	16.38	16.97 (13.6-18)	17	15	18.44 (17.5-19)	10	18.7	16.51[d]
Tragus length	7.14	-	-	-	7.88 (7.5-9)	-	6.7	7.62[d]
Tibia length	14.33	-	13.34	-	16.31 (16-17)	15	-	17.78[d]
Foot length	12.4	12.34 (10.5-13.5)	13.43	12	9.69 (9-10)	11	12.5	12.7[d]
Calcaneus length	19.76	18.81 (16.4-19.8)	18.68	16	19.31 (18-19.5)	-	16.9	19.05[d]
Skull length	17.03	17.14[b]	-	-	17 (16.6-17.4)	17[c]	15.9	-
Condylobasal length	15.18	-	-	-	14.98 (14.7-15.3)	-	13.6	-
Mastoid breadth	8.89	8.96[b]	-	-	9.09 (8.8-9.3)	-	8.4	-
Zygomatic breadth	9.27	-	-	-	9.72 (9.5-9.9)	10[c]	8.4	-
Braincase breadth	8.38	8.08[b]	-	-	8.12 (7.8-8.4)	-	7.8	-
Postorbital breadth	3.37	3.35[b]	-	-	3.19 (3-3.3)	-	3.3	-
Breadth across canines	3.61	3.47[b]	-	-	3.65 (3.6-3.8)	2.5[c]	3.1	-
Breadth across molars	6.75	6.68[b]	-	-	6.69 (6.4-7)	-	6.0	-
Maxillary toothrow	5.88	5.95[b]	-	-	5.66 (5.6-5.8)	6.5[c]	5.3	-
Mandible length	10.72	10.95[b]	-	-	10.64 (10.5-10.8)	11[c]	9.5	-
Mandibular toothrow	6.41	6.56[b]	-	-	6.36 (6.3-6.5)	-	6.2	-

[a]Data taken from labels. [b]Cranial measurements from ALP 4625. [c]Cranial measurements from 5832. [d]Measurements converted from inches to millimeters.

Table 2. Bats recorded in Brazilian mangroves. Species were classified according to their dietary preference, following Kalko et al. (1996). The source of records from Rio de Janeiro (RJ), Pernambuco (PE), Maranhão (MA) and Pará (PA) followed Lourenço et al. (2010), Soares et al. (2016), Cruz et al. (2007) and Andrade et al. (2008), respectively. Captures in areas surrounding mangroves were not considered. The new record described in this work is marked with an asterisk (*).

Taxa	Diet	State			
		RJ	PE	MA	PA
Emballonuridae					
Rhynchonycteris naso	Insectivory		X	X	
Phyllostomidae					
Micronycterinae					
Micronycteris megalotis	Insectivory	X			X
Micronycteris schmidtorum	Insectivory				X
Desmodontinae					
Desmodus rotundus	Hematophagy	X	X		X
Phyllostominae					
Lophostoma brasiliense	Insectivory		X		
Macrophyllum macrophyllum	Insectivory	X*			
Gardnerycteris crenulatum	Insectivory				X
Phylloderma stenops	Omnivory				X
Phyllostomus discolor	Omnivory		X	X	
Phyllostomus hastatus	Omnivory			X	
Tonatia bidens	Insectivory	X			
Tonatia maresi	Insectivory				X
Trachops cirrhosus	Carnivory	X			X
Glossophaginae					
Anoura caudifer	Nectarivory	X			
Glossophaga soricina	Nectarivory	X		X	X
Carolliinae					
Carollia brevicauda	Frugivory			X	
Carollia perspicillata	Frugivory	X	X	X	X
Stenodermatinae					
Artibeus fimbriatus	Frugivory	X			
Artibeus lituratus	Frugivory	X	X	X	
Artibeus obscurus	Frugivory	X			X
Artibeus planirostris	Frugivory	X	X	X	X
Artibeus cinereus	Frugivory			X	X
Chiroderma villosum	Frugivory				X
Platyrrhinus lineatus	Frugivory	X	X		

Taxa	Diet	State			
		RJ	PE	MA	PA
Sturnira lilium	Frugivory	X		X	
Uroderma bilobatum	Frugivory				X
Uroderma magnirostrum	Frugivory				X
Vampyrodes caraccioli	Frugivory	X			
Vespertilionidae					
Eptesicus brasiliensis	Insectivory			X	
Lasiurus blossevillii	Insectivory	X	X		
Lasiurus ega	Insectivory	X			
Myotis albescens	Insectivory				X
Myotis nigricans	Insectivory	X			
Molossidae					
Cynomops abrasus	Insectivory	X			
Molossus molossus	Insectivory	X			X
Molossus rufus	Insectivory	X			
Nyctinomops laticaudatus	Insectivory	X			
Nyctinomops macrotis	Insectivory	X			
Noctilionidae					
Noctilio leporinus	Piscivory	X	X	X	X
Total species (39)		**23**	**10**	**12**	**18**

LITERATURE CITED

Andrade, F. A., M. E. Fernandes, S. A. Marques Aguiar, & G. B. Lima. 2008. Comparison between the chiropteran fauna from terra firme and mangrove forests on the Bragança peninsula in Pará, Brazil. Studies on Neotropical Fauna and Environment 43:169–176.

Araúz, G. J., M. Castillo, & A. Chavarria. 2020. Murciélagos asociados a los manglares en el Golfo de Chiriquí, Panamá. Tecnociencia 22:69–85.

Ashraf, M., & N. Habjoka. 2013. Tropical mangroves; biologically most diverse ecosystem: Megachiroptera as key ecological and conservation tool. Mangrove Action Newsletter 315.

Camargo, G., E. Fischer, F. Gonçalves, G. Fernandes, & S. Ferreira. 2009. Morcegos do Parque Nacional da Serra da Bodoquena, Mato Grosso do Sul, Brasil. Chiroptera Neotropical 15:417–424.

Carvalho, W. D., L. N. Freitas, G. P. Freitas, J. L. Luz, L. M. Costa, & C. E. L. Esbérard. 2011. Efeito da chuva na captura de morcegos em uma ilha da costa sul do Rio de Janeiro, Brasil. Chiroptera Neotropical 17:808–816.

Cruz, L. D., C. Martínez, & F. R. Fernandes. 2007. Comunidades de morcegos em hábitats de uma Mata Amazônica remanescente na Ilha de São Luís, Maranhão. Acta Amazonica 37:613–619.

Díaz, M. M., S. Solari, L. F. Aguirre, L. M. S. Aguiar, & R. M. Barquez. 2016. Clave de identificación de los murciélagos de Sudamérica. Publicación Especial N°2, Programa de Conservación de los Murciélagos de Argentina.

Dobson, G. E. 1878. Catalogue of the Chiroptera in the collection of the British Museum. British Museum, London.

Feijó, A., P. A. Rocha, J. Mikalauskas, & S. F. Ferrari. 2015. *Macrophyllum macrophyllum* (Chiroptera, Phyllostomidae) in the Brazilian caatinga scrublands: river basins as potential routes of dispersal in xeric ecosystems. Mastozoología Neotropical 22:163–169.

Garbino, G. S. T. et al. 2020. Updated checklist of Brazilian bats: versão 2020. Comitê da Lista de Morcegos do Brasil—CLMB. Sociedade Brasileira para o Estudo de Quirópteros (Sbeq). <https://www.sbeq.net/lista-de-especies> acessado em: 10/01/2021.

Giri, C. et al. 2011. Status and distribution of mangrove forests of the world using earth observation satellite data. Global Ecology and Biogeography 20:154–159.

Harrison, D. L. 1975. *Macrophyllum macrophyllum*. Mammalian Species 62:1–3.

Hernández-Mijangos, L. A., R. G. Mejía, M. D. Negrete, & C. M. C. Durante. 2008. Nuevas localidades en la distribución de murciélagos filostóminos (Chiroptera: Phyllostomidae) en Chiapas, México. Revista Mexicana de Mastozoología (Nueva Época) 12:163–169.

Hogarth, P. J. 2015. The biology of mangroves and seagrasses. Oxford University Press, Oxford.

ICMBio. 2018. Atlas dos Manguezais do Brasil. Instituto Chico Mendes de Conservação da Biodiversidade, Brasília.

Kalko, E. K. V., C. O. Handley Jr., & D. Handley. 1996. Organization, diversity, and long-term dynamics of a Neotropical bat community. Long term studies of vertebrate communities (M. L. Cody & J. A. Smallwood, eds.). Academic Press, Boston.

Lewis, S. E. 1995. Roost fidelity of bats: a review. Journal of Mammalogy 76:481–496.

Lourenço, E. C., L. M. Costa, J. L. Luz, R. M. Dias, & C. E. L. Esbérard. 2010. Morcegos em manguezal–análise de uma assembléia e compilação de dados disponíveis no Brasil. Mamíferos de restingas e manguezais do Brasil (L. M. Pessôa, W. C. Tavares & S. Siciliano, eds.). Sociedade Brasileira de Mastozoologia, Museu Nacional, Rio de Janeiro.

Luther, D. A., & R. Greenberg. 2009. Mangroves: a global perspective on the evolution and conservation of their terrestrial vertebrates. BioScience 59:602–612.

Macintosh, D. J., & E. C. Ashton. 2002. A review of mangrove biodiversity conservation and management. Centre for tropical ecosystems research, University of Aarhus, Aarhus.

Marques, S. A. 1985. Espécies associadas e algumas características físicas influindo na presença de *Carollia perspicillata* em bueiros na região de Manaus, AM (Mammalia, Chiroptera: Phyllostomidae). Acta Amazonica 15:243–248.

McKenzie, N. L., & A. N. Start. 1989. Structure of bat guilds in mangroves: disturbance and determinism. Patterns in the Structure of Mammalian Communities (D. W. Morris, Z. Abramsky & B. J. Fox, eds.). Texas Tech University, Lubbock.

Moreno-Bejarano, L. M., & R. Álvarez-León. 2003. Fauna asociada a los manglares y otros humedales en el delta-estuario del río Magdalena, Colombia. Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 27:517–534.

Nagelkerken, I. et al. 2008. The habitat function of mangroves for terrestrial and marine fauna: a review. Aquatic botany 89:155–185.

Nogueira, M. R., A. P. Mazurec, & A. L. Peracchi. 2010. Morcegos em restingas: lista anotada e dados adicionais para o norte fluminense, sudeste do Brasil (Mammalia, Chiroptera). Mamíferos de restingas e manguezais do Brasil (L. M. Pessôa, W. C. Tavares & S. Siciliano, eds.). Sociedade Brasileira de Mastozoologia, Museu Nacional, Rio de Janeiro.

Nogueira, M. R., I. P. Lima, A. L. Peracchi, & N. B. Simmons. 2012. New genus and species of nectar-feeding bat from the Atlantic Forest of southeastern Brazil (Chiroptera: Phyllostomidae: Glossophaginae). American Museum Novitates 3747:1–30.

Nor Zalipah, M., S.A. Mohd Sah, & G. Jones. 2020. Flowering Biology of Mangroves (Genus *Sonneratia*) and the Role of Bats in Their Pollination in Peninsular Malaysia. Handbook of Halophytes: From Molecules to Ecosystems towards Biosaline Agriculture (M. N. Grigore, ed.). Springer Nature Switzerland.

Novaes, R. L. M., D. T. C. Rosa, D. Vrcibradic, & L. S. Avilla. 2015. Bat assemblages from three Atlantic Forest fragments in Rio de Janeiro state, Southeastern Brazil. Biodiversity Data Journal 3:1–12.

Peracchi, A. L., & S. T. Albuquerque. 1971. Lista provisória dos quirópteros dos estados do Rio de Janeiro e Guanabara, Brasil (Mammalia, Chiroptera). Revista Brasileira de Biologia 31:405–413.

Peracchi, A. L., S. D. L. Raimundo, & A. M. Tannure. 1984. Quirópteros do Território Federal do Amapá, Brasil (Mammalia, Chiroptera). Arquivos da Universidade Federal Rural do Rio de Janeiro, Seropédica 7:89–100.

Peracchi, A. L., & M. R. Nogueira. 2010. Lista anotada dos morcegos do Estado do Rio de Janeiro, sudeste do Brasil. Chiroptera Neotropical 16:508–519.

Richards, D. R., & D. A. Friess. 2016. Rates and drivers of mangrove deforestation in Southeast Asia, 2000–2012. Proceedings of the National Academy of Sciences 113: 201510272.

Reef, R., I. Feller, & C. E. Lovelock 2014. Mammalian herbivores in Australia transport nutrients from terrestrial to marine ecosystems via mangroves. Journal of Tropical Ecology 30:179–188.

Rocha, P. A. D., J. S. Mikalauskas, S. F. Gouveia, V. V. B. Silveira, & A. L. Peracchi. 2010. Morcegos (Mammalia, Chiroptera) capturados no Campus da Universidade Federal de Sergipe, com oito novos registros para o estado. Biota Neotropica 10:183–188.

Rocha, P. A. et al. 2017. Rapid surveys as a key tool for the inventory of the bat fauna of Brazil: new records for the coastal restinga. Neotropical Biology and Conservation 12:91–99.

Rog, S. M., R. H. Clarke, & C. N. Cook. 2016. More than marine: revealing the critical importance of mangrove ecosystems for terrestrial vertebrates. Diversity and Distributions 23:221–230.

Salas, J. 2010. Diversidad y Ecología de los quirópteros (Chiroptera), como Indicadores del Estado de Conservación de la Reserva de Producción de Fauna "Manglares El Salado". Tesis Mag. Sc. Facultad de Ciencias Naturales, Universidad de Guayaquil.

Sanderman, J. et al. 2018. A global map of mangrove forest soil carbon at 30 m spatial resolution. Environmental Research Letters 13:055002.

Sikes, R. S., & The Animal Care and Use Committee of the American society of Mammalogists .2016. Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. Journal of Mammalogy 97:663–688.

Simmons, N. B., & R. S. Voss. 1998. The mammals of Paracou, French Guiana, a Neotropical lowland rainforest fauna. Part 1, Bats. Bulletin of the American Museum of National History 237:1–219.

Soares, F. A., G. Graciolli, C. E. Ribeiro, R. S. Bandeira, J. A. Moreno, & S. F. Ferrari. 2016. Bat (Mammalia: Chiroptera) diversity in an area of mangrove forest in southern Pernambuco, Brazil, with a new species record and notes on ectoparasites (Diptera: Streblidae). Papéis Avulsos de Zoologia 56:63–68.

Soares, F., M. Daher, R. Perrelli, J. A. T. Moreno, & S. F. Ferrari. 2018. Note on bats (Mammalia, Chiroptera) in a Restinga area of Rio Grande do Norte, Brazil. Pesquisa e Ensino em Ciências Exatas e da Natureza 2:17–22.

Souza, C. D. G., S. T. Hiruma, A. E. M. Sallun, R. R. Ribeiro, & J. M. A. Sobrinho. 2008. Restinga: Conceitos e Empregos do Termo no Brasil e Implicações na Legislação Ambiental. Instituto Geológico, Secretaria de Meio Ambiente do Estado de São Paulo, São Paulo.

Stutz, W. H., M. C. Albuquerque, W. Ueda, E. M. Macedo, & C. B. França. 2004. Updated list of Uberlândia bats (Minas Gerais state, southeastern Brazil). Chiroptera Neotropical 10:188–190.

Taddei, V. A. 1975. Phyllostomidae (Chiroptera) do norte-ocidental do Estado de São Paulo. I – Phyllostominae. Ciência & Cultura 27:621–632.

Vargas-Mena, J. C. et al. 2018. The bats of Rio Grande do Norte state, northeastern Brazil. Biota Neotropica 18:e20170417.

Vieira, C. O. C. 1942. Ensaio monográfico sobre os quirópteros do Brasil. Arquivos de Zoologia do Estado de São Paulo 3:1–471.

Vizotto, L. D., & V. A. Taddei. 1973. Chave para determinação de quirópteros brasileiros. Universidade Estadual Paulista, São José do Rio Preto.

Weinbeer, M., C. F. Meyer, & E. K. Kalko. 2006. Activity Pattern of the Trawling Phyllostomid Bat, *Macrophyllum macrophyllum*, in Panamá. Biotropica: The Journal of Biology and Conservation 38:69–76.

Weinbeer, M., E. K. Kalko, & K. Jung. 2013. Behavioral flexibility of the trawling long-legged bat, *Macrophyllum macrophyllum* (Phyllostomidae). Frontiers in physiology 4:342.

Williams, S. L., & H. H. Genoways. 2008. Subfamily Phyllostominae Gray, 1825. Mammals of South America, volume 1: marsupials, xenarthrans, shrews, and bats (A. L. Gardner, ed.). University of Chicago Press, Chicago.