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RESEARCH ARTICLE

Character variation and taxonomy of short-tailed fruit bats from *Carollia* in Brazil

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ABSTRACT. *Carollia* has a complex taxonomic history and is widely distributed in the Neotropics. Species of *Carollia* appear to have differentiated recently in the late Cenozoic, and present overlapping morphological characters that may not be useful to distinguish among species. *Carollia* has recently been revised, but only a few specimens representing the Brazilian distribution of *Carollia* within Brazil were studied. We reviewed specimens of *Carollia* distributed in several localities of Brazil revisiting previously described morphological characters for species identification, and taxonomic problems within the genus. We found a large degree of overlap between characters previously used to distinguish among species of *Carollia*, and some of them constitute variation within a same species. We also report new records extending the known distribution of *C. benkeithi* to farther east of its previously known distribution (Parauapebas, southeastern Pará, and Vitória do Xingu, Pará, eastern Amazonian Brazil) and one record extending the distribution of *C. brevicauda* south to Corumbá, Mato Grosso do Sul, Brazil.

KEY WORDS. *Carollia*; morphology, Phyllostomidae.

INTRODUCTION

The short-tailed bats from *Carollia* Gray, 1838 are gleaning frugivores that forage in highly cluttered spaces, and may complement their diet with insects (Kalko et al. 1996, McLellan and Koopman 2008). They are frequently captured in mist-nets at ground level, and often are the most abundant genus regionally in Central and South America (Bonaccorso 1979, Fleming 1988, Bernard and Fenton 2002).

Carollia currently includes eight species distributed from central Mexico southward to southern Brazil and northern Argentina (Muñoz et al. 2004, McLellan and Koopman 2008, Velazco 2013). The genus has a complex taxonomic history (Pine 1972, McLellan and Koopman 2008, Zurc and Velazco 2010). In a comprehensive revision Pine (1972) recognized four species, *Carollia brevicauda* (Schinz, 1821), *Carollia castanea* H. Allen, 1890, *Carollia perspicillata* (Linnaeus, 1758) and *Carollia subrufa* (Hahn, 1905) and suggested that there was a possible unrecognized species at that time (Pine 1972). More recently, four new species have been described: *Carollia sowelli* Baker, Solari & Hoffmann, 2002; *Carollia manu* Pacheco, Solari & Velazco, 2004; *Carollia monohernandezi* Muñoz, Cuartas & González, 2004; and *Carollia benkeithi* Solari & Baker, 2006 (McLellan and Koopman 2008).

The sister species *Carollia brevicauda* and *C. perspicillata*, and the closely related small-sized species *C. castanea*, *C. benkeithi* and an undescribed taxa from Eastern Ecuador and Peru are overall difficult to identify based on morphological characters only along most of their distribution (Baker et al. 2002, Solari and Baker 2006, Zurc and Velazco 2010). After the revision of Solari and Baker (2006) only three of species of *Carollia* have been considered as occuring in Brazil: *C. benkeithi*, *C. brevicauda* and *C. perspicillata* (McLellan and Koopman 2008, Nogueira et al. 2014) although Bernard et al. (2011) listed *C. castanea* for the Brazilian Amazon. The incomplete knowledge on the distribution of the small *Carollia* in Brazil are partially related to the lack of revisions of the material previously attributed to *C. castanea* prior to the description of *C. benkeithi* (Solari and Baker 2006). *Carollia brevicauda* and *C. perspicillata*, are widespread in Brazil occurring in sympatry along most of their distribution. The distribution of *C. benkeithi* overlaps with the distribution of the two other species in the Amazon (McLellan and Koopman 2008, Barquez et al. 2015, Sampaio et al. 2016).

Herein we studied specimens of *Carollia* from several regions of Brazil previously identified as *C. benkeithi*, *C. brevicauda* or *C. perspicillata* checking the consistency of the characters available in the literature traditionally used for their differentiation (e.g., Pine 1972, Lim and Engstrom 2001, Solari and Baker 2006, McLellan and Koopman 2008, Zurc and Velazco 2010, Ruelas 2017) and investigating the distribution of the *Carollia* species in Brazil.

MATERIAL AND METHODS

Specimens analyzed for this study are housed in the mammals collection of the Universidade Federal de Minas Gerais (UFMG) and Museu Paraense Emílio Goeldi (MPEG), Brazil (see Appendix 1). To identify them we used a set of characters described in the literature (Lim and Engstrom 2001, Solari and Baker 2006, and McLellan and Koopman 2008). Taxonomy follows McLellan and Koopman (2008), and Nogueira et al. (2014).

We analyzed morphometric variation of the skull using selected measurements and included additional characters to describe and analyze the skull/mandible articulation, which have been considered useful to distinguish among species of *Carollia* (McLellan 1984, Zurc and Velazco 2010). In total, we used fourteen cranial and three external measurements taken in millimeters (mm) using digital calipers accurate to 0.01 mm, as follows: Forearm length (FA), distance from the tip of the olecranon process to the wrist including carpals, taken with the wing partially folded; Ear length (E), perpendicular height from the ear notch to tip of the pinna; Tibia length (Ti), total length including tarsals; Mandible length (ML), from the mandibular symphysis to the condyloid process; Coronoid process height (COH), perpendicular height from the ventral surface of the mandible to the tip of coronoid process; Mandibular toothrow length (MANDL), from the anterior face of the lower canine to the posterior margin of the third lower molar; Greatest length of the skull (GLS), distance from the posteriormost point of the occipital bone to the anteriormost point of premaxilla; Condyloincisive length (CIL), distance from the posteriormost margins of occipital condyles to the anterior face of upper incisors; Palatal length (PL), distance between the posterior palatal notch and the anterior border of the incisive alveolus; Braincase height (BH), from the ventral basioccipital to the uppermost braincase, largest height not including the sagittal crest; Braincase breadth (BB), greatest breadth of braincase; Postorbital breadth (POB), least breadth measured in the postorbital region posterior to the postorbital process; Breadth of foramen magnum (MFB), greatest breadth between the condyloid processes. Width across upper canines (C-C), least width across the upper canines taken from the labial surface of the tooth. Maxillary toothrow length (MTRL), distance from the anterior face of the upper canine to the most posterior edge of the last upper molar; Breadth across upper premolars (BPM), least breadth across the last upper premolars; and Breadth across upper molars (BM), least breadth across the last upper molars.

We performed the Student´s t-test ($p < 0.01$) to test for sexual dimorphism within individuals of the same species. We run a principal component analysis (PCA) to display the variation across the three species (*C. perspicillata*, *C. brevicauda*, and *C. benkeithi*) using 16 $\log_{10}$-transformed measurements. To test for the variation of measurements between *C. perspicillata* and *C. brevicauda* we applied Student´s t-test ($p < 0.01$) and the nonparametric Mann-Whitney U-test. The statistical analysis ware performed using PAST V 3.11 (Hammer et al. 2001).

We also studied the distribution and the scoring of discrete morphological characters available in the literature for species of *Carollia* (e.g., Pine 1972, Solari and Baker 2006, Zurc and Velazco 2010, Ruelas 2017).

RESULTS

We examined 123 specimens of *Carollia*, and identified northern, midwestern and southeastern populations of *Carollia brevicauda* (34) and *C. perspicillata* (86), and northern populations of *C. benkeithi* (3) within Brazil (Appendix 1, Fig. 1).

The hair covering of the forearm, the forearm length, the dorsal fur length and the banding pattern of the individual hairs were the most useful external characters to separate the three species of *Carollia* present in our sampling. We identified individuals having naked forearms with lengths measuring less than 37.0 mm, short dorsal fur, and no evident banding of individual hairs as *C. benkeithi* (Tables 1, 2), and those with forearm length ranging from 35.5 mm to 42.5 mm, longer dorsal fur, and evident banding patterns in individual hairs, consisting in marked dark bases occupying half of their total length as *C. brevicauda* (Tables 1, 2). We identified as *C. perspicillata* individuals with forearms ranging from 37.5 mm to 44.5 mm, short dorsal fur and banding patterns of individual hair less evident, with a dark proximal band occupying less than ¼ of the total length of each hair (Tables 1, 2). The discrete characters for skull and dentition available in the literature were not useful to consistently distinguish among the three species in our sampling of Brazilian specimens, and they were particularly useless to recognize *C. brevicauda* and *C. perspicillata*. We also failed to detect characters from the skull and dentition that could be helpful to sharp separations of the three species.

According to our sampling the three species of *Carollia*: *C. benkeithi*, *C. brevicauda* and *C. perspicillata*, occur sympatrically in Parauapebas, in the FLONA Carajás, southern Pará, and in Vitória do Xingu, Pará, eastern Amazonian Brazil. Sympatric populations of *C. perspicillata* and *C. brevicauda* also occur in the states of Espírito Santo (Guaçuí, Linhares and Mimoso do Sul), Minas Gerais (Jequitaí and Mariana), Bahia (Caetité), Mato Grosso do Sul (Corumbá) and in several localities in Pará, including the East, Center and Southeast in the Amazon basin and the Northwest, in the Guiana shield (Altamira, Xinguara, Canaã dos Carajás, Paragominas and Porto Trombetas) (Appendix 1, Fig. 1).

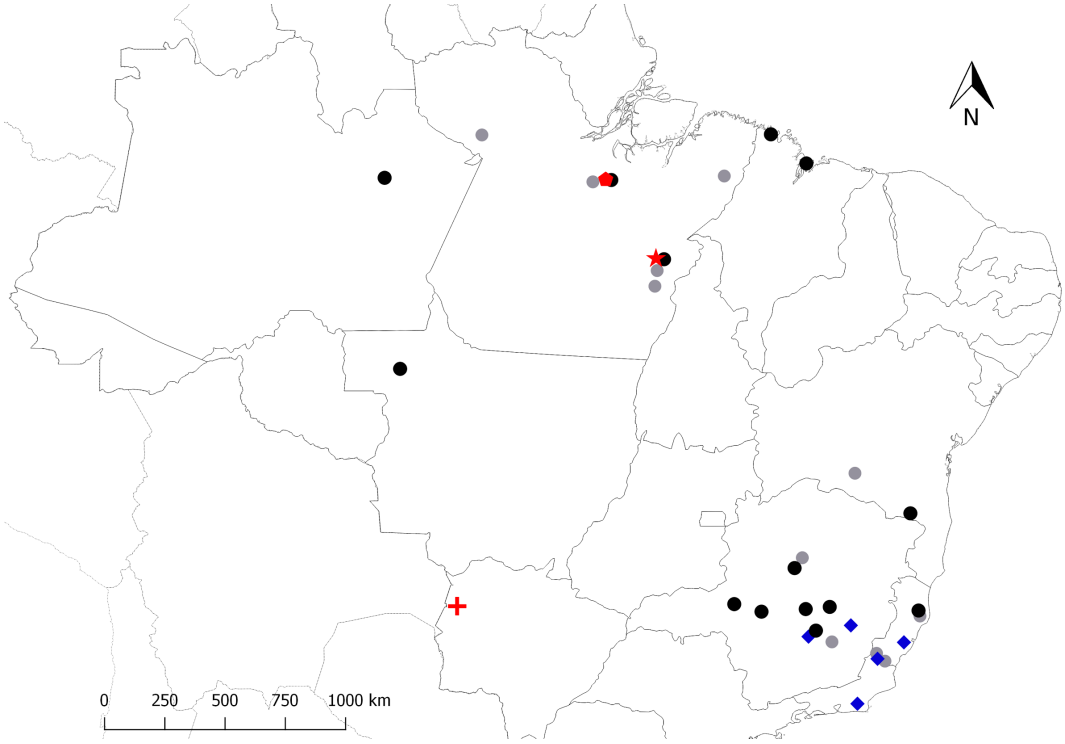


Figure 1. Distribution map of *C. perspicillata* (black dots), *C. brevicauda* (blue diamonds), *C. brevicauda* and *C. perspicillata* in sympatry (gray dots and red cross). *C. benkeithi* and *C. perspicillata* in sympatry (red pentagon), and *C. benkeithi, C. brevicauda* and *C. perspicillata* in sympatry (red star). Both localities of *C. benkeithi* represent new records for the species, and the red cross is a new record for *C. brevicauda*.

Table 1. Measurements (mm) of adults of *Carollia benkeithi, C. brevicauda*, and *C. perspicillata*. See Material and Methods for explanation of measurements and abbreviations. Statistics include the mean, range (in parentheses) and sample size, respectively. Useful measurements to distinguish between *C. perspicillata* and *C. brevicauda* are indicated in boldfaced (Mann-Whitney U-test, $p < 0.01$).

Characters	*C. benkeithi*		*C. brevicauda*		*C. perspicillata*	
	Males	Females	Males	Females	Males	Females
ML	12.87	12.26	14.55 (13.41-15.44) 23	14.16 (13.08-14.64) 10	14.67 (13.80-15.61) 50	14.50 (13.79-15.25) 34
COH	4.04	3.74	5.37 (4.69-5.90) 23	5.17 (4.39-5.79) 11	5.36 (4.48-6.34) 48	5.26 (4.78-5.66) 32
MANDL	7.25	6.88 (6.82-6.94) 2	8.38 (7.45-9.23) 23	8.02 (7.17-8.38) 10	8.41 (7.68-8.86) 50	8.32 (7.52-8.89) 34
GLS	19.78	19.07 (18.70-19.43) 2	21.83 (20.51-22.97) 23	21.58 (20.30-22.73) 11	22.05 (20.81-23.37) 51	21.82 (20.93-22.74) 35
CIL	15.35	15.26 (14.99-15.52) 2	17.83 (16.36-19.01) 23	17.53 (15.86-18.50) 11	18.07 (17.03-19.12) 51	17.81 (16.97-18.89) 35
PL	8.64	8.42 (8.03-8.81) 2	9.13 (8.00-9.90) 23	9.00 (7.45-9.88) 11	9.24 (8.44-10.14) 51	9.19 (8.32-10.19) 35
BH	7.68	7.31 (7.11-7.51) 2	8.41 (7.61-8.89) 23	8.23 (7.93-8.55) 11	8.45 (7.79-8.93) 51	8.20 (7.43-8.58) 35
BB	8.41	8.12 (7.85-8.38) 2	9.32 (8.87-10.01) 23	9.11 (8.82-9.55) 11	9.39 (8.77-9.80) 51	9.12 (8.65-9.65) 35
POB	5.24	5.06 (4.93-5.19) 2	5.41 (4.91-5.79) 23	5.32 (5.09-5.55) 11	5.45 (5.03-5.85) 51	5.27 (4.90-5.63) 35
MFB	4.98	5.18 (4.93-5.42) 2	5.82 (5.52-6.34) 23	5.72 (5.32-6.13) 10	5.83 (5.07-6.35) 50	5.74 (5.21-6.38) 35
C-C	4.25	3.96 (3.94-3.98) 2	4.64 (4.20-4.88) 23	4.43 (4.08-4.61) 11	4.62 (4.07-5.05) 51	4.40 (4.09-4.76) 35
MTRL	6.30	6.14 (5.99-6.28) 2	7.20 (6.42-7.82) 23	7.12 (7.10-7.34) 10	7.22 (6.65-7.79) 48	7.19 (6.47-7.87) 35
BPM	3.78	3.59 (3.54-3.63) 2	4.34 (3.77-4.70) 22	4.25 (3.88-4.78) 11	4.41 (3.87-4.93) 51	4.31 (3.71-4.90) 35
BM	6.89	6.79 (6.58-7.00) 2	7.82 (7.30-8.39) 23	7.85 (7.13-8.42) 10	7.82 (7.04-8.47) 48	7.69 (7.00-8.27) 35
FA	35.98	34.83 (34.33-35.32) 2	39.44 (35.34-42.55) 23	39.86 (36.13-42.02) 11	40.87 (37.82-44.47) 51	41.41 (38.42-44.64) 35
E	13.98	17.06 (17.04-17.08) 2	19.24 (16.50-20.76) 21	19.25 (17.38-21.55) 7	19.79 (17.32-21.99) 47	19.75 (17.72-22.94) 29
Ti	16.91	14.70 (14.38-15.02) 2	17.59 (14.31-19.74) 23	17.37 (15.97-20.06) 10	18.46 (16.06-20.39) 51	18.29 (15.40-20.59) 31

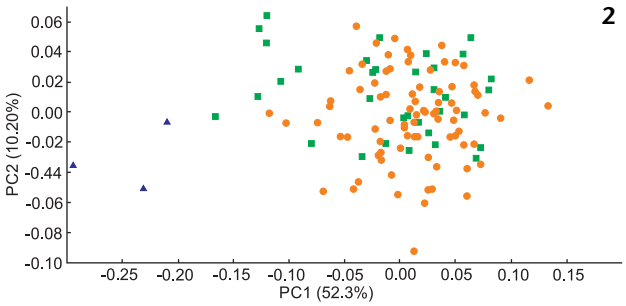
Table 2. Morphological characters useful for identification of Brazilian populations of *C. benkeithi*, *C. brevicauda*, and *C. perspicillata*.

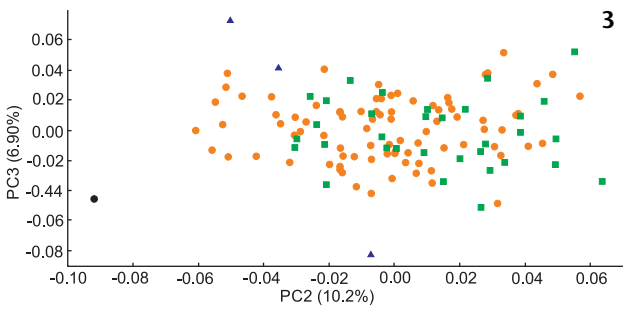
Characters	*C. benkeithi*	*C. brevicauda*	*C. perspicillata*
Banding of individual hair in the dorsal fur	Little marked or absent	Evident, with a large well marked black base	Less conspicuous, proximal dark colored band not as evidently marked as the other two bands
Length of dorsal fur	Short	Long	Short
Fur on dorsal forearm	Absent	Present	Present
Forearm lenght (mm)	34-36	36-42	37-44

We recorded two new locality records for *C. benkeithi*; Parauapebas, PA, and Vitória do Xingu, PA, eastern Amazon (Appendix 1, Fig. 1), and one for *C. brevicauda* in the semideciduous forests of Corumbá, Mato Grosso do Sul, Midwestern Brazil (Appendix 1, Fig. 1).

We did not detect sexual dimorphism in size for the species analyzed ($p < 0.01$). Morphometric variation for *C. benkeithi*, *C. brevicauda*, and *C. perspicillata* are overall within the expected range according to the data available in literature (Table 1).

Most of the morphometric variation can be explained by the first three components in the PCA (PC1 = 52,2%, PC2 = 10,2% and PC3 = 6.9%) (Table 3). The plot of the components PC1 x PC2 show a clear separation of *C. benkeithi* from the other two species analyzed (Fig. 2). The PC1 x PC2 and PC2 x PC3 did not display a clear separation between *C. brevicauda* and *C. perspicillata* (Figs 2, 3).





Figures 2–3. Scatter plot of the three first principal component scores of a principal component analysis based on 17 cranial and external measurements from *C. benkeithi* (black triangles), *C. brevicauda* (gray squares) and *C. perspicillata* (black dots): (2) PC 1 x PC 2; (3) PC2 x PC 3.

Table 3. Vector correlation coefficients (loadings) between original variables and principal components (PC1, PC2 and PC3) for analysis including *Carollia benkeithi*, *C. brevicauda*, and *C. perspicillata*. Values in boldface indicate vector correlations with magnitudes > 0.50. Descriptionn of the measurements are in the text.

Characters	PCA loadings		
	PC 1	PC 2	PC 3
ML	0.212	-0.086	-0.118
COH	0.315	0.294	**-0.681**
MANDL	0.287	-0.116	0.004
GLS	0.210	-0.030	-0.017
CIL	0.255	-0.037	-0.036
PL	0.240	-0.105	-0.133
BH	0.193	0.060	0.071
BB	0.153	0.143	0.117
POB	0.145	-0.041	0.189
MFB	0.206	0.121	0.016
C-C	0.190	0.277	0.280
MTRL	0.260	-0.115	-0.029
BPM	0.257	**0.575**	0.453
BM	0.181	0.234	-0.005
FA	0.252	-0.246	0.009
E	0.275	-0.001	-0.232
Ti	0.370	**-0.548**	0.326

Similar patterns were observed in linear measurements (Table 1), and these two species largely overlap in all measurements for skull characters. *Carollia brevicauda* is overall slightly smaller than *C. perspicillata* and several small individuals had non overlapping measurements with the smaller *C. perspicillata*. The two morphometric characters that can be used to help in the differentiation of *C. brevicauda* from *C. perspicillata* are forearm length (FA) and tibia length (TI) (Table 1; $p < 0.01$).

DISCUSSION

Based on our revisionary work of Brazilian specimens of *Carollia*, we expanded the distribution of *C. benkeithi* to approximately 420 km to the east and 663 km to the southeast, and the distribution of *C. brevicauda* 580 Km to the east. Other than that, the distribution for the three species of *Carollia* (*C. perspicillata*, *C. brevicauda*, and *C. benkeithi*) is in agreement with the literature (e.g., McLellan and Koopman 2008).

A few measurements may be used for species determination of *Carollia* species together with other characters, but linear morphometry alone was not efficient to separate among them. Some external characters previously discussed for the variation of *C. benkeithi*, *C. brevicauda* and *C. perspicillata* (Pine 1972, Lim and Engstrom 2001, Solari and Baker 2006, McLellan and Koopman 2008) were helpful for separating among these species within our sampling, including the dorsal hair banding, the length of dorsal fur between shoulders, the presence of fur in the forearm, and the forearm length. On the other hand, the length of the tibia was highly overlapping, and not useful to distinguish between *C. brevicauda* and *C. perspicillata* as it was for other parts of the distribution of these species such as the Iwokrama park, Guyana (Lim and Engstrom 2001). It is worthy to mention that the overlapping variation of tibia length detected in our sampling of *C. brevicauda* and *C. perspicillata* includes the specimens from Porto Trombetas, which is also a locality of the Guiana shield. Accordingly, size alone may be not enough to separate *C. benkeithi* from the smaller individuals of *C. brevicauda* based on our sampling. We suggest that the absence of hair coat in the posterior portion of forearm is a simple and effective character to identify the species *C. benkeithi*.

Dental characters used by Zurc and Velazco (2010) related to the tooth variation of Colombian individuals of *Carollia* were all variable and overlapping in our Brazilian specimens, and again not useful to distinguish between *C. brevicauda* and *C. perspicillata*. Those characters included variation in the trigonid of the first inferior molar (Colombian *C. brevicauda* have a trigonid thinner than the talonid and *C. perspicillata* has the trigonid and talonid of approximately the same size), variation in the mandibular tooth series (long and robust teeth for Colombian *C. brevicauda*, and thin and elongated teeth for Colombian *C. perspicillata*), and variation of the third molar morphology (posterior part of the third molar more elongated longitudinally in relation to the anterior part in Colombian *C. perspicillata*).

Reports on the occurrence of sexual dimorphism in size for *Carollia* have been controversial in the literature. Sexual dimorphism in size for species of *Carollia* has been reported for Pine (1972) and McLellan (1984) but it has not been detected in specimens from Ecuador (Jarrín et al. 2010) as well as in our sampling of Brazilian specimens. Some authors assumed the absence of sexual dimorphism (Zurc and Velazco 2010, López-Aguirre et al. 2015). Jarrín et al. (2010) however suggested the occurrence of variation in the cranial shape of Ecuadorian males and females of *Carollia* based on geometric morphometrics.

The difficulties to identifying useful discrete characters to differentiate among species of *Carollia* are related to the variation of characters along their geographic distribution resulting in problems for the taxonomy and species delimitation within the genus. Accordingly, several authors described characters to separate among species of *Carollia*, which were useful but generally limited to a certain part of the species distribution (Pine 1972, McLellan 1984, Lim and Engstrom 2001, Jarrín et al. 2010, McLellan and Koopman 2008, Zurc and Velazco 2010, Ruelas 2017).

Data from some studies suggest that the articulation of skull and mandible, particularly the bone surface where the masticatory muscles are inserted is highly variable for *Carollia* species encompassing 80% of the cranial variation for the genus (McLellan 1984, López-Aguirre et al. 2015). According to López-Aguirre et al. (2015) Andean populations of *C. brevicauda* and *C. perspicillata* have differences in the skull in relation to other regions in Colombia. Geometric morphometrics may be needed to elucidate if the shape of the skull varies according to geographic patterns along the eastern part of the distribution of those species.

Several other species of *Carollia* have been described over the last decades based on molecular data with relatively little morphological delimitation often making it difficult the identification of the species based on morphology only (Baker et al. 2002, Solari and Baker 2006, Zurc and Velazco 2010). Studies based on molecular data analyzes including several Brazilian specimens recovered a well-supported clade of individuals of *C. brevicauda* from the Amazon including the Guiana Shield, sister to a clade of *C. perspicillata* (Pavan et al. 2011, Velazco 2013). The study of Pavan et al. (2011) was a molecular phylogeny of *Carollia* including 30 specimens from the Brazilian southeastern Atlantic forest locations, all of them *C. perspicillata*. We have identified both species, *C. brevicauda* and *C. perspicillata* from the Atlantic forest based on morphological characters, including specimens from Espírito Santo state, where it comes the type species of *C. brevicauda*. *Carollia brevicauda* seems to be less common than *C. perspicillata* along the distribution of *Carollia* in Brazil, perhaps justifying its absence from the study of Pavan et al. (2011), but ideally studies combining molecular and morphology of a larger sample from the Atlantic forest *Carollia* would be useful to resolve species delimitation within the genus particularly at this part of the distribution of the genus.

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Appendix 1. List of the examined material used in this study.

Carollia benkeithi: Pará – Parauapebas: VCT 4698, male, VCT 4710, female; Vitória do Xingu: MPEG 41122, female.

Carollia brevicauda: Bahia – Caetité: VCT 2912, male, VCT 2916, male, uncatalogued. Espírito Santo – Domingos Martins: PCH 183, male, uncatalogued; Guaçuí: UFMG 5052, male; Linhares: UFMG 5065, female, UFMG 5068, male; Mimoso do Sul: UFMG 5071, female; São José do Calçado: UFMG 5091, male. Mato Grosso do Sul – Corumbá: VCT 6071, male, uncatalogued. Minas Gerais – Brumadinho: VVM 02, male, VVM 67, male, uncatalogued; Jequitaí: UFMG 5025, male; Mariana: VCT 5296, female, VCT 5315, female, VCT 5381, male, VCT 6003, male, uncatalogued; Marliéria: UFMG 1060, female, UFMG 3341, female; Pará – Altamira: MPEG 41056, male; Canaã dos Carajás: VCT 1381, male, VCT 1383, male, VCT 1840, male, VCT 1847, male, uncatalogued; Paragominas: VCT 1013, female, uncatalogued; Parauapebas: VCT 1092, male, VCT 1150, male, VCT 4490, male, VCT 6202, male, uncatalogued; Porto Trombetas: UFMG 3219, female, UFMG 3237, female, VCT 0482, female, VCT 2887, male, uncatalogued; Xinguara: VCT 3834, male, uncatalogued. Rio de Janeiro – Silva Jardim: UFMG 1604, female.

Carollia perspicillata: Amazonas – Manaus: UFMG 3751, female, UFMG 5281, male, UFMG 5282, female. Bahia – Caetité: VCT 2908, female, VCT 2914, male, uncatalogued; Macarani: UFMG 4820, male. Espírito Santo – Guaçuí: UFMG 5053, male; Linhares: UFMG 5066, female, UFMG 5067, female;

Mimoso do Sul: UFMG 5073, female; Sooretama: UFMG 4744, male, UFMG 4745, male, UFMG 4746, female, UFMG 4747, female. Maranhão – Cândido Mendes: UFMG 3719, male, UFMG 3720, male, UFMG 3723, male, UFMG 3726, male, UFMG 3728, male, UFMG 3733, male, UFMG 5325, male; São Luiz: VCT 0314, female, VCT 0319, male, VCT 0340, male, uncatalogued; Mato Grosso – Aripuanã: UFMG 5321, male. Mato Grosso do Sul – Corumbá: VCT 6066, uncatalogued, male. Minas Gerais – Belo Horizonte: UFMG 3495, male, UFMG 3743, male; Conceição do Mato Dentro: UFMG 4837, female, UFMG 4838, male, UFMG 4839, male, UFMG 4841, female; Cordisburgo: UFMG 0514, male; Jequitaí: UFMG 5022, female, UFMG 5023, male; Mariana: VCT 5293, male; Matutina: UFMG 4676, female, UFMG 4677, male; Patrocínio: UFMG 4731, female, UFMG 4733, male, UFMG 4734, female; Várzea da Palma: UFMG 2357, female, UFMG 2358, female. Pará – Altamira: VCT 1600, female; Anapu: VCT 1532, female; Canaã dos Carajás: BOC 05, male, BOC 09, female, BOC 21, male, BOC 26, male, BOC 382, female, BOC 387, male, BOC 435, female, BOC 452, male, VCT 1377, male, VCT 1857, female, uncatalogued; Curionópolis: UFMG 4622, male, UFMG 4623, male, UFMG 4624, male, UFMG 4628, female, UFMG 4629, female, UFMG 4663, female; Paragominas: VCT 0963, male/, VCT 0972, male, VCT 0982, male, VCT 1006, female; Parauapebas: VCT 4383, female, VCT 4700, male, VCT 6183, female, VCT 6184, female, VCT 6205, male, VCT 6207, female, VCT 6211, male, VCT 6245, male, uncatalogued; Porto Trombetas: UFMG 3193, female, UFMG 3223, male, UFMG 3229, male, UFMG 3230, male, UFMG 3253, female, UFMG 3266, female, UFMG 3223, male, VCT 2826, male, VCT 2875, female, uncatalogued; Vitória do Xingu: VCT 1498, male, VCT 1550, male, VCT 2487, male; Xinguara: VCT 3870, male, uncatalogued.

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