New records of Pygmy Round-eared Bat, *Lophostoma brasiliense* Peters, 1867 (Chiroptera, Phyllostomidae), and updated distribution in Colombia

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**Abstract**

*Lophostoma brasiliense* Peters, 1867 has a wide distribution in the Neotropical region, with records extending from southern Mexico to central Paraguay and Brazil. In Colombia the distribution of this species seems to be discontinuous, due to a scarcity of records, which also makes it difficult to know about its threats and conservation status. Here, we report three new localities from Amazonia, Andean and Orinoquia regions. We updated the distribution and performed ecological niche modelling that suggest a wider presence of this species on the Caribbean and the Orinoquia region. Finally, we added some ecological notes about this species.

**Keywords**

Bats, biogeography, ecological niche modelling, geographical distribution, Phyllostominae.

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**Introduction**

The Neotropical bat genus *Lophostoma* d’Orbigny, 1836 (Phyllostomidae, Phyllostominae) has a wide distribution from southern Mexico to southwestern Paraguay (Simmons 2005). This genus includes seven species, of which four occur in Colombia: *Lophostoma silvicolum* d’Orbigny, 1836 distributed throughout the country at an elevational range from 10 to 940 m a.s.l.; *Lophostoma occidentale* (Davis & Carter, 1978) recorded in Cauca, Valle del Cauca and Chocó departments in the Pacific region in western Colombia between 10 and 100 m a.s.l.; *Lophostoma carrikeri* (Allen, 1910) in the Orinoquia and Amazonia regions, between 45 and 700 m a.s.l., and *Lophostoma brasiliense* Peters, 1867 with records in different regions at elevations between 10 and 1100 m a.s.l. (Mantilla-Meluk et al. 2009; Solari et al. 2013).

*Lophostoma brasiliense* is an insectivorous bat widely distributed in the Neotropical region, with records from southern Mexico to central Paraguay and Brazil (Simmons 2005). In Colombia, it has been recorded in the Caribe region: Cesar (Muñoz-Saba 2009), La Guajira (Mantilla-Meluk et al. 2009) and Sucre (Galván-Guevara 2010); the Pacific region: Choco (Asprilla-Aguilar et al. 2010).
collections (Table 1). Aellen (1970) made the first record of this species in Colombia, citing the species as *Tonta\textit{tia minuta*} Goodwin, 1942 from a southwestern locality near Ecuador; however, he did not include voucher specimens. Lemke et al. (1982) later reported the occurrence of the species in “Finca El Buque” (Villavicencio, Meta) as *Tonta\textit{tia brasiliense*} (Peters, 1867). The voucher specimen was deposited at the Field Museum of Natural History, Chicago, USA (FMNH 121251). Alberico et al. (2000) summarized information from museum specimens on the species’ distribution and Mantilla-Meluk et al. (2009) and Solari et al. (2013) later increased the number of records but some regions continued to be underrepresented.

### Table 1. Localities of occurrence of *L. brasiliense* in Colombia.

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>Department</th>
<th>Locality</th>
<th>Altitude a.s.l. (m)</th>
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</table>

The voucher specimens are deposited in the following institutions: Colección de Mamíferos Instituto Alexander von Humboldt (IAvH), Colección Zoológica Universidad del Tolima (CZUT), Colección de Mamíferos Universidad del Valle (UV), Museo de Historia Natural Universidad de Caldas (MHN-UCa), Instituto de Ciencias Naturales (ICN), Colección de Mamíferos Universidad del Chocó (CMCH), Museo de Historia Natural Universidad Distrital Francisco José de Caldas (MUD), Museo de Ciencias Naturales de La Salle-Medellín (CSJ-M), Colección Zoológica Universidad de Narino (PSO-CZ), Colección de Mamíferos Universidad Industrial de Santander (UIS-M), Colección de Mastozoología Museo de Historia Natural Universidad de los Andes (ANDES-M), National Museum of Natural History (NMNH), and Field Museum Natural History (FMNH).
Ecological niche modelling (ENM) methods can help identifying the most suitable areas for a species in a given range. ENMs have been used extensively in the Neotropics to help with conservation assessments (Prieto-Torres and Finilla-Butrago 2017), identifying distributional gaps (Oliveira et al. 2017), and guiding future research and conservation plans (Rheingantz et al. 2014). Field validation of these methods supports their predictions and indicates good utility, especially when resources are limited (West et al. 2016). Given the lack of sampling in some areas of Colombia, ENM techniques may be useful to estimate *L. brasiliense*’s distribution and areas most important for its study and conservation.

Here, we report three new localities for *L. brasiliense* in the Amazonia, Andean and Orinoquia regions through recent captures in: El Vergel, Leticia municipality (Amazonas department), the municipality of El Líbano (Tolima department) and a specimen deposited in the mammal collection at Institute Alexander von Humboldt (IAvH) coming from Arauca (Arauca department). In addition, we update the distribution of *L. brasiliense* in Colombia and we perform ENMs to estimate the potential distribution of this species to guide future field surveys. Finally, we add some ecological notes that contribute to the knowledge of natural history of this species.

Methods

Field collections were carried out by the authors between 2016 and 2019 in Natura Park Reserve, Leticia municipality, Amazonas department and Santa Librada Agricultural Reserve, El Líbano municipality, Tolima department. We used seven mist nets (12 m long) which were randomly located in different microhabitats inside the study areas. The individuals were collected following the procedures described by the American Society of Mammalogists (Sikes et al. 2016), and the specimens were deposited in the Natural History Museum of the Universidad Distrital Francisco José de Caldas (MUD) and in the Natural History Museum of the Universidad de los Andes (ANDES-M), Colombia. Identifications followed Williams and Genoways (2008) and Díaz et al. (2016), and the specimens were compared with others in ANDES-M, IAvH, MHN-UCa, and MUD.

We compiled a database of Colombian occurrence records of *Lophostoma brasiliense* from an exhaustive search in online databases (i.e., Mammal Networked Information System [http://manisnet.org/], Scopus [https://www.scopus.com/], Web of Science [http://webofknowledge.com/], Sistema de Información sobre Biodiversidad de Colombia [http://sibcolombia.net/], Arctos database [https://arctos.database.museum/], Global Biodiversity Information Facility [https://www.gbif.org/], SpeciesLink [http://splink.cria.org.br/], and literature. We also reviewed specimens from national natural history collections (Table 1) and made measurements (following Velazco and Gardner 2012) using digital calipers with an accuracy of 0.01 mm. Colombian ecoregions and biogeographic provinces (Hernández-Camacho et al. 1992; Dinerstein et al. 2017) were determined for all records.

We prepared a map showing the potential distribution of *L. brasiliense* using an ensemble modelling approach in the sdm R package (Naimi and Araujo 2016) with five modelling algorithms: Maxent, GAM, Random Forest, Support Vector Machine, and Boosted Regression Tree. The current distribution map for *L. brasiliense* was downloaded from the International Union for the Conservation of Nature (IUCN 2017; version 2017-1) and buffered to 250 km to act as a training and prediction mask. The occurrence points were spatially filtered by 3 km to reduce spatial autocorrelation using SDM-Toolbox in ArcGis (Brown 2014). For environmental variables, we used 19 bioclimatic variables (Fick and Hijmans 2017), elevation (Amatulli et al. 2018), distance to freshwater (produced by us), and the approximate percentage of broad-leafed evergreen forest (Tuanmu and Jetz 2014). The variables were then extracted by a mask equivalent to the IUCN distribution map and buffered to 200 km (since some recent records were found to be outside of the previous distribution map). These variables were then imported to R program, version 3.6.2 (R Core Team 2019) and tested for collinearity using the variance inflation factor (Vif) tests (variables with a Vif of 10 or greater were removed in a stepwise fashion, starting with the highest Vif) and pairwise plots. If two or more variables were collinear (Pearson correlation >0.7), the most ecologically relevant was retained and the others were excluded. The remaining variables were then tested using the “get variable importance function” in the sdm package (Naimi and Araujo 2016) in R during initial prototype models, with low-importance variables removed (<5%) to improve model reliability. All models were assessed using the True Skill Statistic (TSS.Stat: True Skill Statistic for predictive accuracy evaluation in the sdm package [Naimi and Araujo 2016]), and 20% of presence points were withheld for testing the models in each run. The models were also weighted by their TSS scores to emphasize the predictions of the most accurate models at the prediction stage. After the final model ensemble was produced, a reclassification was performed using the threshold value (calculated by sdm package based on the value of suitability, which maximises the sum of specificity and sensitivity) to act as an indicator of whether a pixel is suitable or unsuitable.

Results

Family Phyllostomidae
Subfamily Phyllostominae

*Lophostoma brasiliense* Peters, 1867

Pygmy Round-eared Bat

**New records.** COLOMBIA • 1 ♂; Amazonas, Leticia municipality, Vereda El Vergel, Natura Park Reserve; 03.8648°S, 070.2060°W; 77 m a.s.l.; 27 Apr. 2019;
Sebastián García-R leg.; ANDES-M 2324. • 1 ♂, 1 ♀; Tolima, El Libano municipality, Vereda La Honda, Santa Librada Agroecological Reserve; 04.8758°N, 075.0225°W; 800–1100 m a.s.l.; 25 Jan. 2016; Diego A. Esquivel, Sergio Peña, and Carlos Aya-Cuero leg.; MUD 1140, MUD 1141. • 1 ♀; Arauca, Arauca municipality, Finca La Tormenta, Caño Salas; 06.8121°N, 071.0755°W; 136 m a.s.l.; Gabriel Pantoja leg.; IAvH 9459.

Identification. Lophostoma brasiliense is easily recognized from other species of Lophostoma by its overall size, forearm (34–40.5 mm) and greatest length of skull (18.7–21.6 mm), which are diagnostic characters described by Williams and Genoways (2008), Díaz et al. (2016), Solari et al. (2019) and shared by other specimens from ANDES-M, IAVH, MHN-UCa, and MUD collections (Appendix 1). The specimens presented blackish-brown coloration on the dorsum and pale brown ventral fur (Fig. 1), which contrasts with the white abdominal fur of other species, such as L. carrikeri and L. kalkoae (Velazco and Gardner 2012). The individuals lack the small wart-like granulations on head, wings, and legs, which are typical of L. schulzi Genoways & Williams, 1980. Lophostoma brasiliense is unlikely to be confused with L. occidentale or L. silvicolum, as both species are moderately large (AB > 50, GLS > 25). Lophostoma brasiliense can be confused with some species of Micronycteris Gray, 1866 that have dark abdominal fur. However, Lophostoma presents a pair of lower incisors and Micronycteris presents two pairs, and the chin in Lophostoma has a row of dermal papillae arranged in a “U” shape, while in Micronycteris the dermal papillae are arranged in a “V”. Lophostoma brasiliense has a short and robust skull, an undeveloped sagittal crest, a weak post-orbital constriction, and a straight dental arch (Fig. 2). We present a table of external and craniodental measurements of the new records (Table 2).

Distribution. We update the distribution of L. brasiliense in Colombia and confirm its occurrence from 36 records in 18 departments in six biogeographic provinces (Hernández-Camacho et al. 1992): Peri-Caribbean Arid Belt, Chocó-Magdalena biogeographic province, Nor-Andean, Orinoco, Guyana, and Amazonia. The distribution of L. brasiliense includes six Colombian ecoregions (Fig. 3), with the largest number of records occurring in Montane forests of the Andean mountain range and in the Orinoquia region (Fig. 3; Table 1).

Potential distribution. Environmental data to build the models were reduced to four variables: elevation, distance to freshwater, precipitation of driest month (Bio14), and percentage broad-leaved evergreen forest cover. The model accuracy was acceptable with TSS values for all models being > 0.45 and all AUC > 0.75 (Table 3). The model predicts areas with a high suitability of habitat and those areas with suitability above a calculated threshold (Fig. 4A, B) in the Caribbean and the Orinoquia region and some areas in the inter-Andean valleys of Colombia.

Ecological notes. Our specimens were captured in primary and secondary forests. We collected the MUD 1140 and MUD 1141 specimens in a humid tropical forest where the vegetation includes L. acuminata (Ruiz and Pav.), Ochroma pyramidale (Cav. ex Lam.), Carludovica palmata Ruiz and Pav., Annona cherimola (Miller), Cecropia peltata Loefl, Heliconia bihai Linnaeus, Theobroma cacao Linnaeus, and the fruit trees Mangifera Linnaeus and Citrus Linnaeus. Other bat species collected with L. brasiliense were Anoura geoffroyi (Gray, 1838), Glossophaga soricina (Pallas, 1766), Phyllostomus hastatus (Pallas, 1767), and Peropteryx macrotis (Wagner, 1843). The ANDES-M 2324 specimen

Figure 1. Individual of Lophostoma brasiliense (MUD 1140) captured in El Libano-Tolima, Colombia. A. Ventral view. B. Lateral view. Scale bars = 1 cm.
was captured in a primary forest near Mocagua Island in the Amazonas River. Other bat species collected were *Artibeus gnomus* (Handley, 1987), *Gardnerycteris crenulatum* (É. Geoffroy Saint Hilaire, 1803), *Lophostoma silvicolum* (d’Orbigny, 1836), *Phyllostomus elongatus* (É. Geoffroy Saint Hilaire, 1810), and *Rhinophylla pumilio* (Peters, 1865).

In the Andean region, some specimens reviewed by us (MHNU-Ca 1014, MHNU-Ca 1016, and MUD 0073) were captured in areas with secondary vegetation and with strong human intervention, while others occupied Andean humid forest relicts (ANDES-M 1863 and CZUT 1731). In the Orinoquia region, *L. brasiliense* has been reported in gallery forests and in wetlands near primary and secondary forests (Estrada-Villegas and Ramírez 2013) and open savanna (IAvH 9459). Information about habitats in the Chocó and Caribbean regions of the country is scarce.

**Discussion**

Previous studies showed *L. brasiliense* with a heterogeneous and discontinuous distribution, associated mainly with the eastern mountain range in Colombia (Mantilla-Meluk et al. 2009; Solari et al. 2013). However, we fill the gap for this species in southern Colombian Amazonia, East Orinooco, and the Andes mountain range, which is one of the most sampled regions in Colombia. The small number of records from Amazonia (*n* = 6), Chocó (*n* = 2), and the Caribbean (*n* = 2) regions may be due to the lack of inventories in these areas. In Colombia, there is little information...
about the ecosystems occupied by *L. brasiliense*; herein, we recognize it in diverse ecosystems such as primary and secondary forests (Lemke et al. 1982; Muñoz-Saba 2009), tropical dry forest (Galván-Guevara 2010; Garcés et al. 2016), savanna in the eastern plains (Estrada-Villegas and Ramírez 2013), and rainforest (Asprilla-Aguilar et al. 2016). Some records are from lands used for crops and extensive livestock (Garcés et al. 2016), suggesting a possible adaptation to anthropic environments.

The records reported here not only represent the first records of the species for the Amazonas, Tolima, and Arauca departments but also represents a short elevational range extension of the species in Colombia. Previous records indicated that *L. brasiliense* is present at elevations from 100–1100 m a.s.l.; however, the MUD 0073 specimen was found at 1300 m a.s.l., in Paime, Cundinamarca department, which increases the elevational range by 200 m, with most records (83%; *n* = 29) below 600 m. Our record in the Amazonia region increases the range of *L. brasiliense* by approximately 510 km from the nearest and previously southernmost known locality. Distributional limits in the northern part of Colombia

**Figure 3.** Records of *Lophostoma brasiliense* in Colombia. The circles show previous records; the red stars show the new records from the present study.
are unknown, but curiously, this area (Colombian Caribbean) is predicted to have the most habitat suitability for the species but presents very few records.

Other records in La Guajira, Huila (Mantilla-Meluk et al. 2009) and Valle del Cauca (Solari et al. 2013) could not be confirmed from the literature or voucher specimens. Therefore, these locations were not considered in this study and still need to be confirmed.

The ENM-based potential distribution maps have some innate uncertainties. Firstly, we modelled the distribution across the IUCN distribution map buffered to 250 km. This may prove to be an underrepresentation of the true distribution of this species if new specimens are found outside this zone, and by contrast it may be overly generous (areas predicted as environmentally suitable may not be inhabited by *L. brasiliense* due to biogeographic and stochastic processes, local factors, or dispersal limitations). Also, although extremely useful, online databases such as GBIF can include misidentified specimens. Secondly, ENM methods themselves have some statistical weaknesses, (even when all precautions, such as spatial rarefaction are taken into account) and our prediction may change if more records are discovered. Variable selection can also impact ENM results (Velez-Liendo et al. 2014), although our model used both climatic and resource/shelter proxy (distance to freshwater and percentage broadleaved forest cover) variables to alleviate this issue. Therefore, our maps should only be used as estimations and not considered perfect representations of the potential distribution of *L. brasiliense* in Colombia.

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**Authors’ Contributions**

DAE, APL, SGR, DB examined and identified the specimens from collections and wrote the manuscript.

**References**


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Appendix

Specimens used for comparisons. Sex: female (f), male (m).

*Lophostoma carrikeri* (*n* = 1): COLOMBIA: Casanare: Munchia, Vereda Piedecuesta, Finca Las Canarias, 1 m (IAvH 7112).

*Lophostoma brasiliense* (*n* = 4): COLOMBIA: Casanare: Paz de Ariporo, Corregimiento La Hermosa, Finca Nicaragua, 1 m (IAvH 7858); Choco: Riosucio, Parque Nacional Natural Los Katios, Vereda Sautatá, 1 m (IAvH 4493); Santander: Bolivar, Serrania de las Quinchas, Caño La Guina, 1 f (ANDES-M 1863); Cimitarra, Vereda San Juan, Rio San Juan, 1 m (MHN-UCa 1016).

*Lophostoma silvicolum* (*n* = 2): COLOMBIA: Caldas: Norcasia, Vereda El Jagual, Finca Venecia, 1 m (MHN-UCa 745); Meta: Parque Nacional Natural La Macarena, 1 f (IAvH 1991).