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Listening northward: first evidence of *Cormura brevirostris* (Wagner, 1843) (Emballonuridae, Chiroptera) in Honduras

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Abstract. Acoustic methods have revolutionized the study of bats in the Neotropics, but they have not been widely used in Central America. This is partly due to a lack of funding for recording equipment, training limitations, and the absence of open-source repositories of verified voucher reference files. Since 2020, passive acoustic surveys have been conducted throughout Honduras, providing new insights into ecological, relative abundance, and distribution of several species. Based on two recent exploratory passive acoustic surveys in southeastern Honduras, *Cormura brevirostris* (Wagner, 1843), Emballonuridae, is reported for the first time in this country, extending its known range approximately 160 km north of the previous record in Nicaragua.

Key words. Passive acoustic sampling, La Mosquitia, Lowland Tropical Forest, Mavita, Wagner's Sac-winged Bat, new distribution record

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Introduction

Acoustic surveys, both passive and active, have become an essential and standard complement to traditional capture methods for characterizing bat communities and serve as digital voucher records for what, when, and where species have been documented (Ochoa et al. 2000, 2025; MacSwiney et al. 2008; Miller et al. 2023). Once a species' vocal signature has been verified, the files serve as acoustic reference vouchers, thereafter useful for comparing and identifying the species throughout its range (Miller and Miller 2000; Miller et al. 2023). Species identifications of acoustic records have been verified using various methods, such as recording released, free-flying, light-tagged individuals that were captured and identified by hand, visual identification of bats using spotlights, recording at known roosts, recording within enclosures, and, in some cases, direct collection while recording (e.g. Miller et al. 2023).

Such surveys provide a cost-effective and non-invasive means of identifying species presence and composition, as well as estimating the relative abundance of species. The expanded use of acoustic surveys has broadened our knowledge of the distribution of species that avoid traditional capture methods (Borges-Jesús et al. 2023; Miller et al. 2023; Ochoa et al. 2025).

The first acoustic surveys in Honduras were conducted in October 1999 in the department of Colón, at Capiro and Calentura National Park (Miller and Miller 2000; Turcios-Casco in press), to assess the impact of Hurricane Mitch on the bat community. Over half of the 19 species documented during that survey were detected exclusively through acoustic methods. Since then, acoustic surveys have been included throughout the country (Turcios-Casco in press), significantly contributing to understanding bat distributions and relative abundance. The results of these acoustic surveys, however, have yet to be published, with few exceptions (e.g. Espinal et al. 2021).

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In the early 2010s, the Programa de Conservación de los Murciélagos de Honduras (PCMH) began incorporating acoustic sampling in bat surveys throughout the country, particularly in regions where the bat fauna was poorly documented (Hernández 2015; Turcios-Casco in press). These initiatives have enhanced understanding of bat diversity, relative abundance, and species distribution throughout Honduras. While many species known to occur in the country are reliably identified by their vocal signatures (Miller et al. 2024), others have yet to be verified acoustically. For example, many open space foraging molossids do not yet have confirmed vocal signatures as vouchers (e.g. the genera *Cynomops* Thomas, 1920; *Eumops* Miller, 1906, and *Molossus* É. Geoffroy Saint-Hilaire, 1805), unlike the genus *Promops* Gervais, 1856 (Ochoa et al. 2025). Many species of vespertilionids, such as the recently described *Rhogeessa bickhami* Baird, Marchán-Rivadeneira, Pérez & Baker, 2012 and *Rhogeessa menchuae* Baird, Marchán-Rivadeneira, Pérez & Baker, 2012 (Baird et al. 2012), have yet to be verified acoustically. Therefore, not all species in these groups can be reliably identified using acoustic methods. However, it is well known that vocal signatures exhibit family and genus traits (Ochoa et al. 2000). Therefore, files identified as sono-species serve as vouchers for when and where these yet-verified species are recorded. As the vocal signatures of these additional species are confirmed, the identifications of the sono-species voucher files can be reviewed and identifications updated to reflect the when, where, and relative abundance of known taxa. A recent example is the range extension of *Myotis riparius* Handley, 1960 (Trujillo et al. 2025) where archived voucher files with "sono-species" identifications were reviewed and identified as *M. riparius*. Thereby expanding the known range of the species in Honduras, El Salvador, and Belize.

Compiling verified reference calls from disparate sources and methods, lacking open-source reference files, or comparing published species accounts presenting often non-comparable, varied call parameter metrics from other areas to verify species identification from recorded material is time-intensive. To facilitate the use of acoustic methods in Honduras and enhance future species identification, a comprehensive acoustic identification key with detailed species accounts for the acoustically known bats of Honduras was compiled and published (Miller et al. 2024).

During recent exploratory acoustic surveys conducted in the department of Gracias a Dios, eastern Honduras, we obtained the first confirmed records of the emballonurid *Cormura brevirostris* (Wagner, 1843) for the country. Although the occurrence of this species in Honduras had been postulated based on habitat suitability and regional checklists (Mora 2016; Turcios-Casco et al. 2020; Díaz et al. 2021), it had yet to be verified. Herein, we present these new distributional records, including field observations and details on the acoustic identification of this species.

Methods

The new records were obtained during two exploratory surveys: on 8–9 December 2024, in Mavita, at the mouth of the Rus Rus River, located within the Warunta Conservation Area (14.7478°N, 84.4486°W; 20 m a.s.l.), and on May 9–12, 2025, along the Río Warunta in Warunta Conservation Area (15.0647°N, 84.3514°W; 12 m a.s.l.). These surveys passively recorded bats using two detectors: an Anabat Ranger (Titley Scientific), used in the Río Warunta, and a Songmeter Mini-bat (Wildlife Acoustics) used for the Mavita survey. All locations are in the southern La Mosquitia region of the Gracias a Dios department.

Detectors were mounted on trees at ~3 m from the ground, with omnidirectional microphones aiming towards open space over the rivers and an inland forested site. All files were recorded in full-spectrum mode, using the WAV (waveform audio file format). The Songmeter used the default sample rate of 256 kHz, with a maximum file length of 15 seconds (Wildlife Acoustics 2022). The Anabat Ranger was set for a sample rate of 320 kHz with a file length of 10 seconds (Titley Scientific 2025). Both detectors were set to record from dusk to dawn based on sunset and sunrise derived from internal GPS data. They were auto-triggered to record sounds in the range of bat calls detected by omnidirectional microphones, with recorded frequencies up to 128 kHz, suitable for detecting Neotropical species. Data was recorded onto Secure Digital (SD) storage cards and downloaded to a computer for processing.

Kaleidoscope Pro v. 5.6.8 (Wildlife Acoustics Inc., MA, USA) classifiers were used to scan the WAV files, utilizing a subset of species recognized to occur in Honduras, and provide suggested identifications. In addition to the identifications, noise filtering assigned "NOISE" to the identification field of those files that generally were not in the range of bat calls, such as sounds from wind and insects. Files with calls that did not match the algorithm call parameters for a specific species were assigned "NoID". For ease of data processing and management, the acoustic data files were converted from WAV to Zero Crossings (ZC) format using AnalookW v. 4.7.v (http://www.hoarybat.com). Fragmented

pulses not linked to complete identifiable sequences as specific species based on the preceding or following calls were excluded from the review.

While full-spectrum mode may, in many cases, display multiple harmonics simultaneously, these are highly dependent on how close the bat is to the microphone when recorded and are not always recorded (Titley Scientific 2025). Visualizing harmonics is unnecessary for identifying most species or extracting standard comparable call parameters from the dominant harmonic most often recorded (O'Farrell et al. 1999; O'Farrell and Miller 1999).

The utility and ease of identifying species using a ZC display from recorded calls are widely recognized (Titley Scientific 2025). Most acoustic software programs for bat calls, such as Kaleidoscope, AnalookW, Insight, BCID (https://www.batcallid.com/), and Myotisoft ZCANT (https://github.com/riggsd/zcant), include Zero-Crossings as an option. The U.S. Fish and Wildlife Service approves most of these for acoustic surveys of threatened and endangered species. Notably, most of the archived acoustic voucher records of Neotropical bats were originally recorded and verified in ZC format.

We used AnalookW v. 4.7 to manage the acoustic data and assign species identifications by matching call files to verified local signature files in the master call database, and in many cases, by visual recognition of the diagnostic calls and parameters based on over 30 years of experience of verifying acoustic vouchers and reviewing call files recorded throughout Central and South America and the Caribbean. This included adding critical metadata such as location names and GPS coordinates, the source of recordings, and species identifications, ensuring each acoustic file served as a voucher record. The AnalookW disperse utility was used to sort and group calls using the suggested identifications, facilitating the rapid manual vetting of acoustically similar calls within each group. For the purposes of this study, a "verified record" refers to matched verified and diagnostic calls of *Cormura brevirostris*, both in terms of call structure (i.e. pulses emitted in triplets) and the measurable call parameters. As the calls of this species are unique among species of Neotropical bats, there is no confusion in identification, and one of us (BM) manually vetted and identified the calls, without relying on automated identification algorithms. This ensures that all verified records are grounded in traceable, taxonomically validated acoustic evidence.

The first passive acoustic exploratory, at Mavita, consisted of 22 hours of recording, including 4,465 WAV files of raw data. After converting to ZC format and removing noise (non-bat calls), 4,377 files were manually reviewed, and species identifications were added. In the second exploratory survey, conducted along the Rio Warunta, the raw data obtained from the combined 80 hours of recordings totaled 10,317 WAV files, but this site had a very noisy environment. After converting to ZC format and removing noise (non-bat calls), 2,567 files were manually reviewed, and species identifications were added.

Species identifications were confirmed by comparing the diagnostic search-phase calls to published accounts, call files in a library of verified vocal signatures, and species-specific identification filters compiled from verified recordings throughout Central and South America since 1995 (Miller et al. 2024). It is common to record up to five species in a single 15-second acoustic file; therefore, manual vetting is crucial for identifying and differentiating multiple species within a single recording. Automated identification algorithms typically focus on determining the probability of pulse parameters of a single species from a complex of multiple species recorded. While helpful in suggesting identifications, results of automated algorithms require manual verification, as they frequently misidentify feeding buzz pulses of molossids as "identifiable calls" of vespertilionid species and often assign identifications of multiharmonic pulses of phyllostomids as vespertilionids. It is important to note that not all species occurring in the Neotropics have verified vocal signatures. Additionally, even for readily identified species with verified vouchers, Kaleidoscope Neotropical classifiers do not include all potential species for a given country; for example, *C. brevirostris* is not yet included, and its calls were identified by the algorithm as representing species of *Molossus*. In contrast, bespoke species identification filters based on verified vocal signatures in AnalookW can be used to scan all possible species.

After adding verified species codes to the files, the header data, which comprised each file's location metadata, was exported from AnalookW and imported into the Honduran Bat Data Management System (BDMS), a county-level subset of the master relational database with bespoke programming code that manages capture, historical museum, published, and acoustic bat records (Miller et al. 2024). The programming code parses records with multiple species identifications into unique records as they are added to the relational database.

Aside from visual identification of call shapes linked to families and genera, call parameters were extracted from the files representing the new records using the AnalookW Scan utility and species-specific call parameter filters. Species diagnostic parameters, such as the characteristic frequencies of

Table 1. Summary of call parameters of *Cormura brevirostris* extracted from verified calls in the master database. Call parameters are discussed in the methods section.

Parameters	N	Min	Max	Mean	St.Dev	10%	25%	Median	75%	90%
Dur	492	5.01	13.23	8.12	2.23	5.58	6.24	7.73	9.81	11.47
TBC	347	8.910	209.20	110.80	40.11	73.44	86.04	102.1	116.8	183.8
Fmin	492	22.10	33.61	27.69	2.86	23.92	24.54	27.78	30.59	31.36
Fmax	492	24.77	36.36	29.81	3.01	25.64	26.36	29.74	32.79	33.47
Fmean	492	24.16	34.83	29.04	2.87	25.01	25.83	29.05	31.95	32.65
FcH1	492	12.16	17.21	14.76	1.48	12.70	13.12	14.76	16.30	16.67
Fc	492	24.32	34.41	29.53	2.96	25.40	26.23	29.52	32.59	33.33
FcH3	492	36.48	51.62	44.29	4.43	38.11	39.35	44.28	48.89	50.00
Sc	492	−97.80	30.16	−10.80	6.92	−15.40	−13.00	−10.90	−8.99	−7.46
Pmc	492	0.00	15.50	0.94	1.72	0.00	0.00	0.30	1.20	2.60
BW	492	1.07	8.31	2.12	0.98	1.33	1.55	1.85	2.33	3.05

the dominant harmonics [Fc], were compared with summaries of archived verified voucher files (summaries included in Table 1 [Corbre] files are included in Supplementary Material 1). As Krebs (2014: 1–2) noted, "Not everything that can be measured should be", which applies to parameters that can be extracted from calls. Not all call parameters are helpful for species identification purposes. Not all call parameters are useful for species identification. We used two time-related parameters: the duration of each pulse [Dur] and the time between calls or interpulse interval [TBC], measured in milliseconds. Three measured frequency parameters included minimum frequency [Fmin], maximum frequency [Fmax], and characteristic frequency of the dominant harmonic [Fc], all measured in kiloHertz [kHz]. The characteristic slope [Sc] measured as octaves per second is also useful for evaluating call shapes. Additionally, several derived parameters are included: mean frequency [Fmean], band width [BW], the fundamental and third harmonics of the Fc [FcH1 and FcH3] measured in kHz. A final parameter is the Pmc, which is derived within the AnalookW program and defined as the Proportion of the Maximum frequency to the Characteristic frequency. The PMC is a useful parameter for separating species calls with little overall decrease in frequency, as are many emballonurids.

Species call summaries were computed using R (R Core team 2024) and include the number of pulses used [N], the minimum, maximum, mean, standard deviation, and, to evaluate the frequency range of calls, the 10th, 25th, 75th, and 90th percentiles of where parameters are most often encountered. The TBC parameters were adjusted to use times in the 90th percentile or less to avoid inflating interpulse times when bats flew beyond the range of the microphone cone of detection and returned.

We used data from the Map of Life (2025) to show the known distribution of the range for *C. brevirostris* (Figure 1), which is based on a compilation of sources, including expert review, and is harmonized from multiple sources, including vetted Global Biodiversity Information Facility (GBIF) records (https://www.gbif.org). We considered this the most current and definitive understanding of its range, rather than relying on a single source, such as the International Union for Conservation of Nature (Sampaio et al. 2016). Additional location records from Nicaragua are included, based on bat surveys conducted throughout the country using Martínez-Fonseca et al. (2020).

Results

Family Emballonuridae

***Cormura brevirostris* (Wagner, 1843)**

New records. HONDURAS — **Gracias a Dios** • La Mosquitia, Rus, Rus, Mavita; 14.7478°N, 84.4486°W; 20 m a.s.l.; 08.XII.2024 (05:35, 17:32) M.A. Turcios-Casco obs.; riparian forest within a moist tropical forest, 2 acoustic records • La Mosquitia, Warunta Conservation Area, Rio Warunta edge; 15.0647°N, 84.3514°W; 9 m a.s.l., 12.V.2025 (18:09, 18:13), 13.V.2025 (04:41, 04:49, 04:58) 5 acoustic records • Rio Warunta edge M.A. Turcios-Casco obs.; 500 m inland within a moist tropical forest, 15.06485°N, 84.3530°W; 12 m a.s.l., 11.V.2025 (05:01), 13.V.2025 (04:57, 04:58, 04:59) four acoustic records • Rio Warunta edge M.A. Turcios-Casco obs.; 500 m inland within a moist tropical forest.

Identification. Barclay (1983) was the first to report on the calls of *C. brevirostris*, and they are now well known (Jung et al. 2007; Jakobsen et al. 2012; Barataud et al. 2013) with the characteristic frequency (Fc) of the diagnostic triplets ranging from 24 to 35 kHz referred to as the "do-re-mi-bat," with the three increasing frequency pulses, differentiating it from other species (Moss and Surlykke 2001). This distinctive pattern (Figure 2) of three ascending frequency modulation pulses was readily recognized

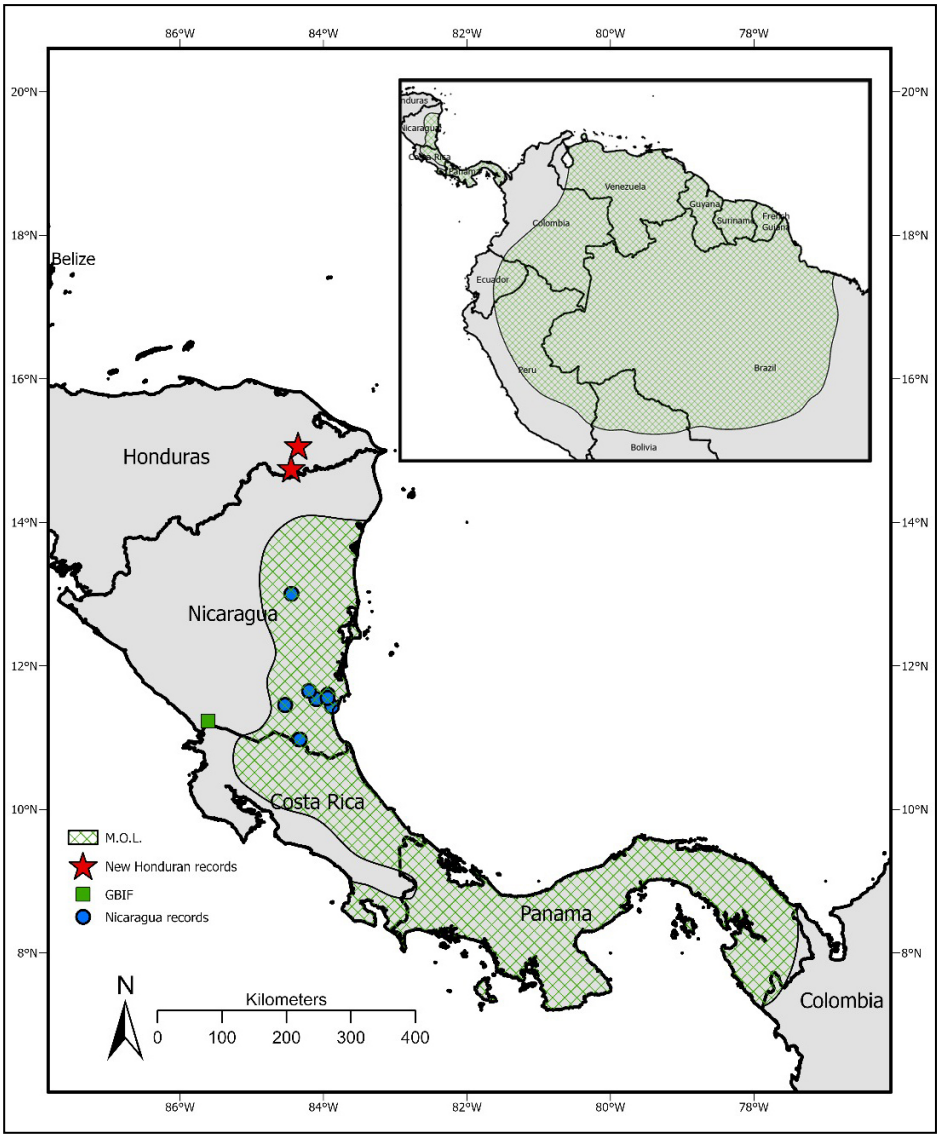

Figure 1. Locality records of *Cormura brevirostris* in Honduras (red stars), based on the present study and Nicaragua, from Martínez-Fonseca et al. (2020) (blue dots) and GBIF (green square; vouchers deposited at the American Museum of Natural History). The green-hatched areas show the species' distribution according to the Map of Life (2025). The inset highlights the entire range, showing its discontinuous distributions in Central and South America.

from both sites (see Table 1 for a summary of call parameters). Calls also matched call files in the master call database, which were verified and recorded elsewhere, for example, Barataud et al. (2013) and Costa Rica (LaVal pers. comm.).

Remarks. Call sequences of *C. brevirostris* were discovered during manual vetting of the acoustic survey data from the Mavita survey. The diagnostic vocal signature of *C. brevirostris* was identified from two acoustic files recorded at Mavita. The first was recorded at 05:35 on the morning of 8 December 2024, and was misclassified by the auto-identification algorithm as *Molossus molossus* (Pallas, 1766) (Molossidae). The second record was obtained early on the survey night of 8 December 2024, at 17:32. Diagnostic calls were also identified from files recorded at the two Rio Warunta sites. The characteristic three-pulse sequences were recognized from both sites (Figure 2). The automated algorithm misidentified the first file as part of an *M. molossus* sequence, and the second was flagged as "NoId", meaning it could not assign an identification. The auto identification errors were manually corrected and confirmed by comparing the new files with archived voucher call files from the master database.

Discussion

Acoustic monitoring is a valuable and cost-effective way to detect rare or poorly documented species. It is expanding the understanding of bat diversity, relative abundance, and habitat preferences in Honduras, often revealing patterns and species previously undetected using traditional methods. One example is *Cormura brevirostris*, the only species in the genus *Cormura* Peters, 1867 (Bernard 2003; Gardner 2008; Simmons and Cirranello 2025). This mainly crepuscular (Bernard 2003; Wilson and Mit-

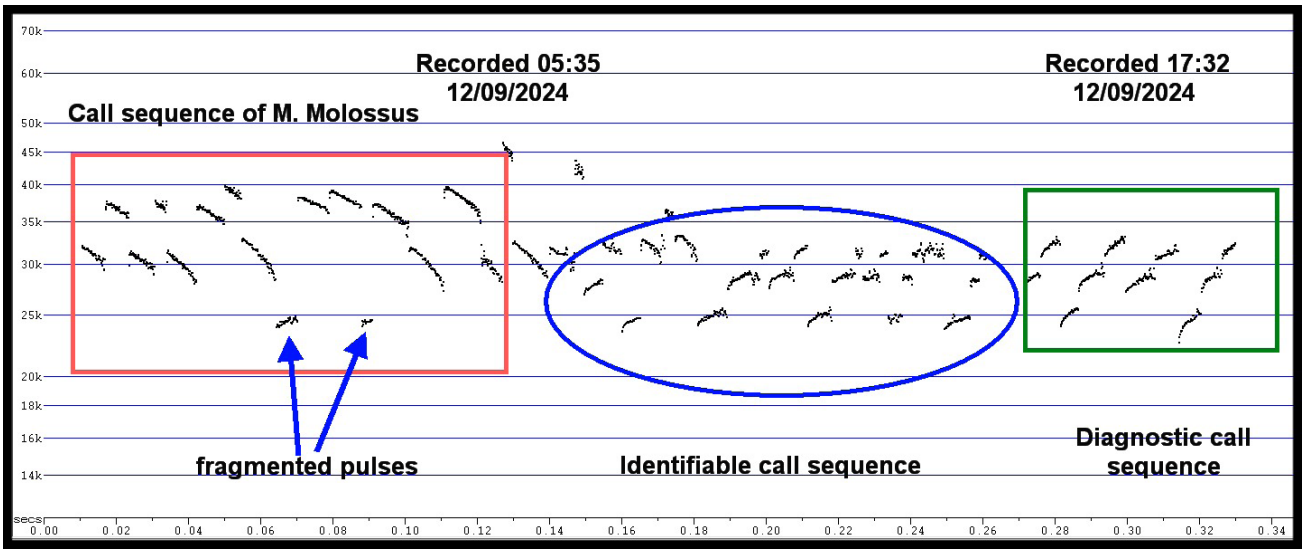

Figure 2. A composite of two recorded sequences of the verified calls of *Cormura brevirostris* from Gracias a Dios department, Honduras. The ones on the left display multiple species in the recording; the red boxes isolate the calls from those of *Molossus molossus*. On the right is another sequence recorded in the absence of other species. Frequency of the knee (Fc) as a log scale is the Y axis (kHz), and the time between pulses is on the X axis, shown in compressed mode with the interpulse times visually removed.

termeier 2019) and edge-foraging species (Kalko 1995; Surlykke and Kalko 2008) avoids urban environments and is typically found in lowland areas and tropical evergreen forests (Bernard 2003; Jung and Kalko 2011; Wilson and Mittermeier 2019). Its known range spans from Nicaragua south and east of the Andes, including the Guianas, west of the Andes in Ecuador, across Amazonian Peru, the Amazon Basin to Mato Grosso in Brazil, and northern Bolivia (Bernard 2003; Sampaio et al. 2016; Wilson and Mittermeier 2019). The first records from the northern limit of *Cormura* were in Nicaragua and reported from the department of Matagalpa by Allen (1910), who identified specimens as *Peropteryx* Peters, 1867 (Medina-Fitoria and Martínez-Fonseca 2019). In the last century, only a limited number of additional records have been documented, primarily along the northern border of the Indio-Maiz Biosphere Reserve in the southern Caribbean lowlands (Martínez-Fonseca et al. 2020).

The present records of *C. brevirostris* in Gracias a Dios, the first for Honduras, reveal a gap in the distribution of this species in the northeastern region of Nicaragua, but this may only be a data gap. Field surveys in this region have been limited, as has been the case in southeastern Honduras. Habitat suitability in Nicaragua may influence the distribution of this species, as it prefers broadleaf lowland moist forests (with an annual precipitation of 2000–5000 mm; Martínez-Fonseca et al. 2024a), as found in the eastern versant of the country (Martínez-Fonseca et al. 2024a). While its presence has been noted in transitional zones to drier areas (e.g. Rivas isthmus, in the Nicaragua Lake basin; Sunyer 2009), *C. brevirostris* is absent from the Caribbean Pine Savanna (*Pinus caribaea* Morelet). This vegetational formation, also known as the Miskitu pine forest, covers a large area along the eastern coastal zone of the country, up to 70 km inland (Incer 1975), reducing the habitat available for the species. As bat surveys expand into this area, including acoustic sampling, we expect this and other species to be verified in northern Nicaragua, especially in the Bosawás Biosphere Reserve. Recent improvements in roads and connectivity may create opportunities for surveys to address existing knowledge gaps, although the prolonged political and social instability that has made safe access difficult for decades remains ongoing (Martínez-Fonseca et al. 2024b).

Threats to *C. brevirostris* and other bat species in Honduras and Nicaragua primarily stem from habitat degradation, fragmentation, and destruction, driven mainly by the expansion of agriculture and livestock farming. To combat these threats throughout Mesoamerica, a significant conservation initiative is underway to protect the remaining five great forests, including the La Mosquitia region shared by Honduras and Nicaragua (WCS Honduras-Nicaragua 2025). This region, characterized in Honduras by *P. caribaea* and tropical moist forests (Holdridge 1978), encompasses territories inhabited by the Indigenous Miskitus people. While bats ("sakankis" in the Miskitu language) are often viewed as bad omens by them, associated with macabre concepts, efforts are underway to raise awareness of their ecological importance, especially in Mavita. In this region, the Miskitu community is key to the conservation of the Scarlet Macaw, *Ara macao* (Linnaeus, 1758), Honduras' national bird, and their efforts to prevent illegal nest poaching have also contributed to the protection of other threatened species (Turcios-Casco et al. 2025).

Early confusion regarding vocal signature of *C. brevirostris* was clarified by Jung et al. (2007), correcting Kalko (1995), who initially attributed calls of *Centronycteris centralis* to *C. brevirostris* and identified those of this latter species as *Peropteryx* spp. The two *C. brevirostris* acoustic records reported here exhibit call parameters consistent with those published by Jung et al. (2007), and these records extend the species' northern range by ~160 km from the northernmost known locality in Nicaragua. The historical records from Penas Blancas (Martínez-Fonseca et al. 2020), available in the database of the American Museum of Natural History mammal collection (W.B. Richardson, 21 and 24 May 1909), indicate that the species may occur further west in Nicaragua, but additional field work is required to verify the species presence there (GBIF.org 2025; Figure 1). As previously noted, *C. brevirostris* was expected to occur in Honduras (Mora 2016; Turcios-Casco et al. 2020; Díaz et al. 2021), but very few bat surveys have been conducted in the southeastern region of this country, especially in the contiguous forest of La Mosquita, between Honduras and Nicaragua (Medina-Fitoria et al. 2020). Other species such as *Thyroptera discifera* (Lichtenstein & Peters, 1854), *Cyttarops alecto* Thomas, 1913, and *Furipterus horrens* (F. Cuvier, 1828) may also be found in this region, due to the similarity of the habitat characterization within its distribution in regard to the Caribbean lowlands of La Mosquitia (Martínez-Fonseca et al. 2020 and Medina-Fitoria et al. 2020). Adding *C. brevirostris* along with the recent record of *Molossus pretiosus* Miller, 1902 from Roatán, in the Islas de la Bahía department, within the Caribbean islands of Honduras (Turcios-Casco et al. 2024), brings the number of confirmed bat species known to occur in Honduras to 115.

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Additional information

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

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Author contributions

Conceptualization: MATC, BM. Data curation: BM. Formal analysis: MATC, BM. Funding acquisition: MATC. Investigation: MATC, BM, JGMF. Methodology: MATC, BM, JGMF. Resources: MATC, BM, JGMF. Supervision: BM. Visualization: MATC. Project administration: MATC. Software: MATC, BM, JGMF. Validation: BM. Writing – original draft: MATC, BM, JGMF. Writing – review and editing: MATC, BM, JGMF.

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Data availability

Call files for the *Cormura brevirostris* records are provided in Supplementary Material 1 as Zero Crossing files. The call parameter summary is included in the manuscript. Note that call files may include multiple identified species and notes on call types indicated by prefixes of the 6-letter species codes. These include, but are not limited to, h = harmonics beyond the dominant, b = feeding buzz, f = fragment and identifiable pulse, and s = social calls. A list of call files with file names and the new record species codes, dates, and location names is included. These call files should be viewed using a compressed time scale with the X-axis set to 10 ms tick marks and the Y-axis (frequency scale) set from 15–110 kHz using a logarithmic scale.

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