Bat echolocation in South Asia

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Journal of Threatened Taxa

Open Access

10.11609/jott.2025.17.11.27787-28010
www.threatenedtaxa.org

26 November 2025 (Online & Print)
17(11): 27787–28010
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

40 Years zooreach Zoo Outreach Organisation

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

Srivari Illam, No. 61, Karthik Nagar, 10th Street, Saravanampatti, Coimbatore, Tamil Nadu 641035, India
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Cover: A male Scarlet Skimmer perching on vegetation by the banks of a waterbody. Ink and watercolour illustration by Ananditha Pascal.

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 November 2025 | 17(11): 27897–27931

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.9550.17.11.27897-27931

#9550 | Received 11 December 2024 | Final received 20 October 2025 | Finally accepted 22 October 2025

ARTICLE

Bat echolocation in South Asia

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Abstract: The study of echolocation traits can assist in developing robust tools for the detection and monitoring of bats. The advent of non-invasive and passive acoustic monitoring techniques has increased the availability of echolocation data including in highly diverse regions, such as South Asia, where 145 of the 155 extant bat species are known to use laryngeal, nasal, or lingual echolocation. However, information remains disperse with no existing review of the state of echolocation knowledge in this region. Here we present a review that collates and catalogues echolocation data to facilitate access and reveal general patterns and knowledge gaps. We conducted a systematic review that returned 35 peer-reviewed publications containing echolocation data to which we added ~6,000 unpublished recordings from various collections (including the open-source ChiroVox database). We created a foundational database reporting on six standard echolocation functional traits to be used in identification. The dataset provides data for ~60% (n = 86) of the echolocating bat species in South Asia, with 299 distinct observations (unique combinations of recording techniques, equipment, and conditions for a given species). Mapping data locations we describe spatial biases and propose priority regions for future work in areas where species richness is high, but echolocation knowledge is limited or completely absent. These priority regions largely fell within the Western Ghats and Eastern Ghats of India, northeastern India, and Sri Lanka, with smaller clusters in peninsular, western, and eastern India. Our review offers a first assessment and a ready-to-use echolocation dataset for bats in South Asia. We hope this motivates an appraisal of functional trait data collection in diverse and data-poor regions and facilitates future research.

Keywords: Acoustic monitoring, biodiversity hotspots, functional traits, knowledge gaps, research priorities, species identification.

Editor: H. Raghuram, Sri S. Ramasamy Naidu Memorial College, Sattur, India. **Date of publication:** 26 November 2025 (online & print)

Citation: Srinivasulu, A., C. Srinivasulu, B. Srinivasulu, D. Senapathi & M. González-Suárez (2025). Bat echolocation in South Asia. *Journal of Threatened Taxa* 17(11): 27897–27931. https://doi.org/10.11609/jott.9550.17.11.27897-27931

Funding: University of Reading International PhD Studentship (GS21-026).

Competing interests: The authors declare no competing interests.

Author details & **Author contributions:** See end of this article.

Acknowledgements: AS was funded by a University of Reading (UK) International Research PhD Studentship [GS21-026]. AS, MGS and DS thank the University of Reading (UK) for their research facilities and support. CS and BS thank Osmania University, Hyderabad (India) for the necessary facilities. BS acknowledges research funding from UGC, New Delhi. CS acknowledges research support for field studies from DST-SERB, UGC-UKIERI, DST-UKIERI, ANRF and MoE-RUSA, Govt. of India. We also thank our various collaborators, colleagues, and friends for sharing their information, resources, and data, and we are grateful for their support in this work.

INTRODUCTION

South Asia is a large subcontinent comprising Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka, sometimes referred to as the Indian subcontinent. Spanning approximately five million square kilometres, it is bounded by the Himalaya, Hindukush, and Dhaula Dhar mountains to the north, and the Arabian Sea, Lakshadweep Sea, Bay of Bengal, and Indian Ocean to the south. It supports a wide diversity of bats, with 155 species currently described (Srinivasulu et al. 2025). Bats in this region can be found across a wide range of habitats and locations with some species distributed across the entire subcontinent, while others are restricted to single localities (Bates & Harrison 1997; Srinivasulu & Srinivasulu 2012). Owing to their status as ecological indicators and contributors of essential ecosystem services (Jones et al. 2009; Stathopoulos et al. 2018), it is important to understand the diversity, distribution, and traits of bats, and harness suitable tools and methods to effectively monitor changes that can inform management and conservation action.

A widely used approach to detect and monitor bats is based on listening to and analysing echolocation calls (Kunz & Parsons 2009; Fraser et al. 2020; Russ 2021). Echolocation is used for communication and navigation by many taxa including bats, and bat echolocation is unique in its highly complex and diverse design which allows it to not only be used to recognise and identify taxa, but also to understand their ecological function and diversity (Kunz & Parsons 2009; Stathopoulos et al. 2018). Using complex nasal, laryngeal, or facial structures in combination with highly specialised ear neuroanatomy, echolocating bats are able to perceive their environment in a high level of detail, including the range, direction, size, texture, and in many cases the type of objects in their surroundings, especially at night when vision is less effective (Jones 2005; Sulser et al. 2022). Echolocating behaviour has allowed some species to evolve more complex flight patterns, varied diets, and highly specialised ecological interactions, and varies between species to a high degree. Different types of echolocation calls have very different impacts on the flight behaviour and dietary choices of species, which also in turn have impacts on the evolution of their echolocation (Jones 2005). For instance, narrowband echolocation tends to favour longer calls and the detection of targets, while broadband echolocation favours shorter calls, and the localisation of targets in space. Traits describing echolocation (in terms of frequency, call shape, inter-pulse interval, number of passes, duration) have been used in the past to classify taxa and understand their habitat use, diet, and niche breadth, as each taxon has a unique combination of these traits, which often also vary over the taxon's distribution.

In South Asia, 145 bat species are known to use either mouth-emitted or nose-emitted laryngeal echolocation, or click-based lingual echolocation (Bates & Harrison 1997; Srinivasulu & Srinivasulu 2012). Several studies have separately collected, described, and classified echolocation calls from various species in South Asia (most recently including Chakravarty et al. 2020; Raman et al. 2020; Raman & Hughes 2020; Shah & Srinivasulu 2020; Saikia et al. 2020, 2021, 2025; Sharma et al. 2021; Devender & Srinivasulu 2022; Kusuminda et al. 2022; Singh & Sharma 2023; Srinivasulu & Srinivasulu 2023; Saikia & Chakravarty 2024; Sail & Borkar 2024). With the advent of non-invasive passive acoustic monitoring alongside the development of automated call extraction and classification methodologies, echolocation data has become more readily available, and data collection methods are becoming more accessible (López-Baucells et al. 2019; Roemer et al. 2021; Froidevaux et al. 2023), expanding the potential for using echolocation calls in biodiversity monitoring, and research in comparison to morphological characters, which require invasive sampling, and physical handling of animals.

The exploration of functional trait data variations across species, geography, and time has been used effectively to answer ecological questions in many contexts, sometimes offering greater explanatory power than comparable indices of diversity (Kearney et al. 2021; Stewart et al. 2023). Functional trait data (including echolocation for bats) is often collected at local and community levels, and only recently have these data collection & analysis techniques been adapted to continental, and global scales (Etard et al. 2020; Migliavacca et al. 2021; Görföl et al. 2022). Adapting trait-based methods to larger scales and wider species groups comes with the problem of data completeness – trait analyses often rely on incomplete data, which can lead to biases, and uncertainty in inference (Toussaint et al. 2021; Stewart et al. 2023) – this paucity in trait knowledge is referred to as the Raunkiæran shortfall (Malaterre et al. 2019; Gonçalves-Souza et al. 2023). Some estimates of functional diversity are robust enough to withstand data incompleteness in a majority of species (up to 70% in the case of richness and divergence; Stewart et al. 2023), and new methods of imputation are being developed, and advanced to account for missing data (Johnson et al. 2021). Still, it is vital to collect, and catalogue functional trait data in widely accessible dynamic databases, with the aim of quantifying intraspecific variation, and capturing the depth of functional diversity in a group (Stewart et al. 2023). Certain morphological traits in bats are well-reported and relatively consistent - for instance, most species descriptions report the forearm length, and the lengths of the first & second phalanges of the second & third metacarpals (in South Asia often following Bates & Harrison 1997 and Srinivasulu et al. 2010). Various craniodental measurements including condyle-canine length and the lengths of the upper & lower toothrows are also widely used morphometrics to identify species. The translation of such characters to function becomes clear when the diet, behaviour, and life-history of the species is known (Norberg & Rayner 1987; Santana et al. 2010, 2012; Arbour et al. 2019; Luo et al. 2019; Zou et al. 2022). There have been some studies on the wing morphology of bats in comparison to their echolocation (Zou et al. 2022), distribution (Luo et al. 2019), and ecological interactions (Wood & Cousins 2023), but an overview of the state of knowledge for functional traits in bats is lacking in South Asia, especially, for echolocation trait data.

In this study, we assess the current knowledge on South Asian bat echolocation to assess the degree of Raunkiæran shortfall and further our understanding of bat species, and trait diversity in this region, by compiling published & unpublished call data from South Asian echolocating bat species. We assess the taxonomic, functional, and geographic variations in the data, comparing across studies, regions, equipment, and recording conditions, and bring it together into a foundational large-scale dataset, which can be expanded with new data in the future. Using this dataset, we describe the current knowledge gaps, and potential biases in the available echolocation information, and identify knowledge priority regions (i.e., areas with relatively large diversity of extant echolocating bat species but from which little or no call data has been reported) in order to aid future research, and conservation of bats in South Asia.

METHODS

Collation of peer-reviewed literature

To assess the current state of knowledge on bat echolocation in South Asia, we first reviewed the existing literature. We conducted an initial naïve search by querying the Semantic Scholar, Google Scholar, and SCOPUS databases using their respective query syntax to recover any publications including all of: the terms "echolocation", "call", or "acoustic", the name of each echolocating bat genus (based on Srinivasulu et al. 2025), the names of all the countries in South Asia, and the term "kHz*" to filter publications where frequency information is given (Table 1). In the case of the Great Evening Bat *Ia io* and the Particoloured Bat *Vespertilio murinus*, we used the entire species name as the relevant search term on all databases, as their respective generic names recovered many irrelevant results. In the case of the genus *Cnephaeus*, we also queried for *Eptesicus*, as before Cláudio et al. (2023) all species currently assigned to *Cnephaeus* in South Asia were assigned to *Eptesicus*. The search was conducted using Publish or Perish v8.17 (Harzing 2007) to allow for repeatable and consistent querying. The studies recovered through the naïve search were then imported into the systematic review software, Rayyan (Ouzzani et al. 2016) for further evaluation, and screening. We initially excluded any irrelevant texts, then excluded any texts with no relevant data, and those which were not peer-reviewed (including preprints), then assessed the full texts of each included study to exclude studies with unclear or absent data and also recover any additional sources from cited references. The process of the literature search and screening was recorded using a PRISMA flow diagram (Supplementary Material 1). The family Pteropodidae was excluded from the naïve search; although some bats in the genus *Rousettus* are known to use tongue-click echolocation (Waters & Vollrath 2003; Holland et al. 2004; Yovel et al. 2011; Smarsh et al. 2021), these calls tend to fall within the audible frequencies, are fundamentally different to echolocation calls seen in other echolocating bats, and are difficult to distinguish from noise, and identify accurately in passive acoustic monitoring, requiring much more detailed analysis.

For our final screening, we used three filters: first, we only selected studies focused on exploration- and orientation-based calls in the species' typical habitat – these are most useful for species identification (Kunz & Parsons 2009) compared to social, and interaction calls, which can differ significantly, and are considered less useful (Pfalzer & Kusch 2003; López-Bosch et al. 2021). Second, studies were filtered based on appropriate recording conditions (contexts in which recordings were made), depending on the call types. We selected studies reporting calls recorded in free flight, after release, or hand-held conditions for species which use constant-frequency (CF) echolocation (Rhinolophids and hipposiderids). As calls are known to vary greatly between recording conditions in non-CF species (Fraser

Table 1. List of search terms and strings used for each database in the literature search.

Database	Search string format
Google Scholar	"*Genus*" AND (“echolocation" OR "call" OR "acoustic") AND "kHZ" AND intitle: ("Afghanistan" OR "Bangladesh" OR "Bhutan" OR "India" OR "Nepal" OR "Pakistan" OR "Sri Lanka")
SCOPUS	Keywords: "*Genus*" AND (“echolocation" OR "call" OR "acoustic") AND "kHZ" Title words: ("Afghanistan" OR "Bangladesh" OR "Bhutan" OR "India" OR "Nepal" OR "Pakistan" OR "Sri Lanka")
SemanticScholar	"*Genus*" AND "echolocation" OR "call" OR "acoustic" AND "kHz" AND ("afghanistan" OR "bangladesh" OR "bhutan" OR "india" OR "nepal" OR "pakistan" OR "sri lanka")

et al. 2020), for these species we considered only studies reporting calls recorded after release or in free flight (once identity was confirmed), and excluded hand-held recordings unless no other information was available (as happened for one species, see Results). Third, we selected studies that provided numeric information for all of the following four call characters: frequency of maximum energy (FMAXE, defined as the frequency containing the highest energy in the call, in kHz), highest frequency (HF, the highest frequency value of the call, in kHz), lowest frequency (LF, the lowest frequency value of the call, in kHz), and duration (D, the duration of a single call, in milliseconds). From D, HF, and LF we then calculated bandwidth (B, the difference between the highest and lowest frequencies of a call, in kHz), and sweep rate (SR, the ratio between the bandwidth and the duration, with higher values representing steeper calls).

Collation of unpublished data

Additional data were obtained by searching for echolocating bat species found in South Asia on ChiroVox, a large open-access database of original bat call recordings (Görföl et al. 2022) with highly detailed metadata on detectors used, and recording conditions. We also compiled unpublished calls from various surveys conducted between 2000 and 2023 by the authors, and collaborators. For these unpublished calls, we gathered metadata on recording condition, detectors used, and the geolocation of the recording. All unpublished calls were then analysed in Batsound Pro v4.0 (FFT size 512, Hanning window; Pettersson Elektronik AB) for full-spectrum or time-expansion recordings, and AnalookW (default parameters; Titley Scientific) for zero-crossing recordings. We selected calls with high signal-to-noise ratio (assessed using the visual clarity of the call signal in the spectrogram), choosing 3–5 ‘passes’ (where a pass is defined as a single sequence of 3 or more signals signifying a single crossing of the bat through the zone of detection; following Fraser et al. 2020), and selecting 5–10 ‘pulses’ (defining a pulse as a single call signal with a clearly identifiable start and end, and at least one clearly visible harmonic) from each set depending on the signal-to-noise ratio. We followed well-defined pre-existing methods (e.g., Jones et al. 2000; Holland et al. 2004; Papadatou et al. 2008; Hackett et al. 2017; Srinivasulu et al. 2017; Chakravarty et al. 2020; Fraser et al. 2020; López-Bosch et al. 2021; Rai et al. 2021; Győrössy et al. 2024; Saikia et al. 2025) to extract the call characters FMAXE, HF, LF, and D from unpublished recordings, then deriving the character B from HF & LF, and SR from B & D as described above. Where recordings were available for peer-reviewed published data, we prioritised the published data.

Dataset of call parameters

For call description and cataloguing, we organised the collected published and unpublished data into ‘observations’, where each observation was defined as a unique combination of call parameters, location, detector used, and recording condition for any given species. This allows us to not only compare the call parameters of various species, but also assess intra-specific differences caused by using different detectors in different recording conditions, and in different regions. As such, a published study used as a source may contain multiple unique observations depending on the diversity of species, locations, recording conditions, and detectors used.

Based on visual assessment of call shape and grouping similar call characters, we identified major sonotypes. All assessed calls from both published and unpublished data could be classified based on a visual assessment into the sonotypes, but many species showed overlapping call characters that do not permit unambiguous species-level classification. To further support species identification, a comprehensive dataset was generated describing seven main variables for each identified observation: HF (in kHz), LF (in kHz), B (in kHz), FMAXE (in kHz), D (in milliseconds), SR (in kHz/milliseconds), number of pulses recorded, and sonotype (Figure 1). From published sources, we used the average values, and standard deviations for each parameter as published; from unpublished data, we summarised all recordings made as part of the single observation into mean, and standard deviation values for each parameter. We also collected eight metadata variables for each observation, describing: the detector used, the country & region where the recording was made, the identified taxonomic family and species name, the species' IUCN status as of January 2025, and the full citation or source information for the data. We also classified recording conditions for published data based on the available information written in the source publication's methodology; conditions were classified into one of five categories: hand-held (where the recording was made while the bat was held in hand), flight-clutter (recordings made in free flight in a cluttered environment), flight-open (recordings made in free flight in an open environment), release-clutter (recordings made shortly after the bat was released in a cluttered environment), release-open (recordings made shortly after the bat was released in an open environment).

Traits, distribution, and knowledge gaps

The comprehensive dataset of echolocation observations allowed us to explore the availability of call data across taxonomic families (Srinivasulu et al. 2025), IUCN status as of January 2025 (IUCN 2025), call families, methodologies (detector and conditions as described by the data collectors), and data sources (published, unpublished, ChiroVox), and assess representation, potential biases, and knowledge gaps in trait data.

We explored spatial coverage in available call data, and proposed priority areas for future bat call data collection. We used QGIS v3.40.6 and the *terra* package (Hijmans 2024) in R 4.4.1 (R Core Team 2024) to match the locations of all collected observations onto a 0.5° x 0.5° grid covering South Asia. From this map, we estimated the per-cell metric 'species with call data' (SCD) as the number of distinct species with at least one observation reported in each grid cell. We then matched occurrence point localities from a dataset of compiled published and unpublished distribution data (expanded from Srinivasulu et al. 2024) to the same 0.5° x 0.5° grid to calculate the per-cell metric 'species richness' as the number of distinct bat species reported as occurring in each cell. Finally, we characterised 'echolocation knowledge ratio' (EKR) as the proportion of species in a cell for which at least one observation was available. EKR values could range from 0 representing no echolocation knowledge for any extant echolocating species, to 1 representing at least one observation reported for each extant echolocating species, and were calculated per-cell using the formula:

$$\text{Echolocation knowledge ratio} = \frac{\text{Species with call data}}{\text{Species richness}}$$

Finally, regional priorities for future data collection were identified by classifying grid cells into three species richness categories: none (no echolocating bats present), low (< 10 species present), or high (≥ 10 species); and three EKR categories: none (EKR = 0), low (0 < EKR < 0.25), and high (EKR ≥ 0.25, representing more than ¼ of extant echolocating bat species in that cell with available call data). Based on combinations of these categories we defined six cell types that represent potential research priorities and opportunities. In particular, we classified all areas with species richness = none as no species recorded/unknown species richness, where the priority would be basic biodiversity surveys in these areas to ascertain true species diversity. We then separated areas with low species richness into three categories depending on EKR values: Low survey priority areas are those with EKR = 0, where future studies are needed but not a top priority, both to assess the true species richness in the region, and to collect echolocation data for known species; low knowledge priority areas are those with low EKR where, future studies could be valuable to supplement echolocation data, and potentially understand the true species richness in the region; and good knowledge, areas with high EKR where future work could expand from existing knowledge to study behaviour, diet, or implement passive acoustic monitoring (Darras et al. 2025). Finally, we also separated areas of high species richness into three categories depending on EKR values: High survey priority are those areas where despite the occurrence of many species we found no echolocation data (EKR = 0) and thus, areas we see as key locations for targeted studies to prioritise collecting echolocation data; High knowledge priority areas are those with low EKR that present good opportunities to collect echolocation data for more species; and good knowledge areas, as above, reflect those with high EKR where future work could focus on more detailed studies. Each of these priority categories represent regions that are best suited for various types of research questions and can be associated with separate potential research actions (Table 2). We show the locations of areas within these categories using a bivariate choropleth map generated in QGIS v3.40.6.

Table 2. Priority categories for regions across South Asia, based on their Species Richness and Echolocation Knowledge Ratio (EKR).
*For all levels of species richness knowledge, true species diversity may be underestimated especially in unstudied areas. Gathering more data on extant species diversity is thus a universal priority in all categories.

Priority category	Research opportunity	Species richness	EKR	Knowledge gaps	Data collection priority	
					Biodiversity	Echolocation
No species recorded/ Unknown species richness	Discovery	None	None	True diversity may be underestimated in unstudied areas*.	High priority in unstudied areas	If species are detected
Low Survey Priority	Biodiversity and echolocation knowledge	Low (< 10 spp.)	None	Lack of echolocation data.	Medium priority in unstudied areas	Medium priority
High Survey Priority	Priority echolocation research	High (≥ 10 spp.)	None	Lack of echolocation data.	Low priority	High priority
Low Knowledge Priority	Biodiversity knowledge	Low	Low (0 – 0.25)	Limited echolocation data.	Medium priority in unstudied areas	Low priority
High Knowledge Priority	Echolocation research	High	Low	Limited echolocation data.	Low priority	Medium priority
Good Knowledge	Deepen knowledge	Low or High (> 0 species)	High (≥ 0.25)	True diversity may be underestimated in understudied areas*. Echolocation knowledge strong, but incomplete.	Medium priority in understudied areas	Low priority Potential for other studies using echolocation (e.g., behaviour, diet, interactions)

RESULTS

Collation of existing knowledge

The initial searches of the Semantic Scholar, Google Scholar, and SCOPUS databases resulted in an initial set of 76 publications (Supplementary Material 1), including duplicates, and irrelevant studies. After the screening process, we selected a final set of 35 peer-reviewed publications for further assessment. From these publications, we recovered a total of 185 unique observations of 86 species from India, Pakistan, Nepal, and Sri Lanka (Supplementary Material 2). From the ChiroVox database, we recovered seven unique observations of five species across Bangladesh. Finally, from our analysis of a total of 6,190 unpublished calls, we recovered a total of 107 unique observations of 36 species from India. This resulted in a combined database of 299 observations of 86 species across Bangladesh, India, Nepal, Pakistan, Sri Lanka, sourced from published, and unpublished data (Supplementary Material 3).

From our assessment of the call shape and characters of all collected calls, we grouped South Asian bat echolocation calls into eight sonotypes (Figure 1; Supplementary Material 3). These sonotypes are defined within the context of South Asian bat echolocation:

1. Short Constant Frequency (SCF; genus *Hipposideros*; 68 observations of 13 species): pulses comprising a short (< 15 ms) constant frequency (CF) component followed by a steep frequency-modulated (FM) downward sweep.

2. Long Constant Frequency (LCF; genus *Rhinolophus*; 56 observations of 11 species): pulses comprising a CF component preceded and followed by a FM downward sweep.

3. Frequency Modulation (FM; genera *Harpiocephalus*, *Hesperoptenus*, *Kerivoula*, *Miniopterus*, *Murina*, *Myotis*, *Phoniscus*, and *Submyotodon*; 58 observations of 28 species): pulses comprising a short and steep, broadband FM component (in cluttered free flight) or a short and relatively steep FM component (in open flight).

4. Frequency Modulation with Quasi-CF (FM-QCF; genera *Arielulus*, *Cnephaeus*, *Eudiscopus*, *Hypsugo*, *Mirostrellus*, *Nyctalus*, *Pipistrellus*, *Scotophilus*, and *Tylonycteris*; 50 observations of 20 species): pulses comprising a short and relatively steep FM component (in cluttered flight), or a short and relatively shallow FM component (in open flight), both followed by a distinct short and shallow quasi-CF component; call shape sometimes resembles a hockey stick.

5. Long Multiharmonic (LMH; genera *Mops*, *Otomops*, *Rhinopoma*, *Tadarida*, *Taphozous;* 44 observations of 10 species): calls of long duration (> 5 ms) with one or occasionally more harmonics seen; number of harmonics seen depends on distance of the bat from the detector. These calls are hard to distinguish from each other based on call shape and characters alone; species range and habitat must be considered when inferring species presence based on these calls. The degree of clutter also impacts the sweep rate (slope) and the general shape of the call: for instance, free-flying *Mops plicatus* from Sigiriya (Sri Lanka; Kusuminda

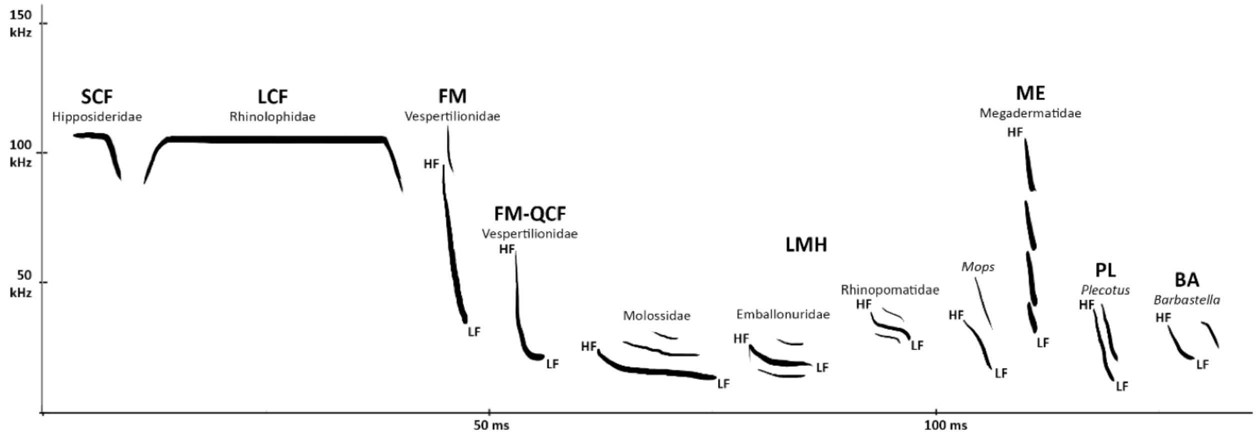

Figure 1. Representative spectrograms of echolocation sonotypes of South Asian bats. Highest frequency (HF) and lowest frequency (LF) are indicated for frequency modulated calls.

& Yapa 2017) called using characteristically-shaped long yet steep multiharmonic pulses (Figure 1).

6. Megadermatid (ME; genera *Lyroderma* and *Megaderma*; 16 observations of 2 species): characteristic short (duration often < 2 ms) and broadband (BW often > 50 kHz) pulses of three or more harmonics of similar amplitude seen close together.

7. Plecotine (PL; genus *Plecotus*; 2 observations of 2 species): relatively short (duration < 5 ms) multiharmonic calls comprising downward sweeps of one or two harmonics of almost equal amplitude (Chakravarty et al. 2020). Call shape & characters tend to overlap both within the genus, and with other FM, and FM-QCF species.

8. Barbastelle (BA; genus *Barbastella*; 2 observations of 1 species, *B. darjelingensis*): calls vary highly based on environmental clutter, flight behaviour, and vegetation structure (see Denzinger et al. 2001), ranging from short steep narrowband multiharmonic FM pulses as recorded by Chakravarty et al. (2020) and Wordley (2014), to characteristic alternating FM pulses of two distinct shapes, and amplitudes (Denzinger et al. 2001; Seibert et al. 2015). Barbastelle pulses are of relatively low amplitude (< 110 dB; Lewanzik et al. 2023), but this is not fully explored in South Asia.

HF may vary greatly, especially in broadband FM & FM-QCF calls, due to atmospheric attenuation and the distance between the bat and the detector. Additionally, both HF & LF, and also B & D, and thus SR greatly vary based on the degree of clutter in the location where the bat is flying, ranging from shallow and low-SR calls in open areas to steep and high-SR calls in cluttered areas.

Variations in call characters

The echolocation data for several species were highly varied based on geography, in some cases including distinct phonic types of the same species, possibly indicating cryptic diversity – more detailed call data is required to establish more robust diagnostic boundaries for species identity. Thabah et al. (2006) reported two distinct phonic types of *Hipposideros larvatus* in Meghalaya, India, each using an FMAXE of around 85 kHz and 98 kHz, respectively. They did not report the durations of these distinct calling types and thus it is hard to infer whether this may be an artifact of environmental clutter or a distinct group of individuals. Similarly, Chattopadhyay et al. (2010) reported a distinct phonic type of *Rhinolophus rouxii* from across Tamil Nadu, India, calling at an FMAXE of around 94 kHz. This is higher than seen elsewhere in southern India – e.g., 82 kHz reported from Kerala by Raman & Hughes (2020) – and Sri Lanka – e.g., 74 kHz reported across the country by Kusuminda et al. (2018). A similarly high frequency (92 kHz) was reported from the Valparai Plateau in the southern Western Ghats (Wordley 2014), we also report similarly high frequencies (91–94 kHz) from the southern Western Ghats in Kerala (Supplementary Material 3). This distinct phonic type was assigned the name *Rhinolophus indorouxii* by Chattopadhyay et al. (2012), however this species is a nomen nudum and therefore synonymised under *R. rouxii*.

There is also considerable variation and overlap in the call characters of many species, especially FM and FM-QCF bats. In our experience (and corroborated by published data), we have found that the calls of *Pipistrellus ceylonicus* tend to vary widely across its distribution, with mean FMAXE values ranging around

35–45 kHz. Saikia et al. (2025) have reported *Pipistrellus babu* from Himachal Pradesh, India, calling at an average FMAXE of 40 kHz, which falls within the range for *P. ceylonicus*. Hence, in cases such as these, care must be taken to either confirm species-level identity through other means or to refer to call identities as pertaining to species-groups. Additionally, Raghuram et al. (2014) report calls of *Pipistrellus tenuis* from Kudremukh National Park (Karnataka, India) at an FMAXE of 38 kHz. These calls were recorded only in flight and could be misidentified, instead representing *P. ceylonicus*, as they are very different from the expected FMAXE around 50 kHz for *P. tenuis* (Supplementary Material 3). Finally, there is a high degree of inconsistency in megadermatid call characters between regions (Supplementary Material 3). This is likely due to the characteristic short multiharmonic nature of the calls, and that the FMAXE tends to fall within one or more harmonics. More investigation is needed to ascertain the various situations in which specific harmonics are produced with more energy, and thus we recommend treating echolocation calls of megadermatids (including those presented in this study) with care.

Intraspecific variability in call characters differed between species – enough data was available to assess intraspecific variations in characters recorded in the same recording condition for 31 species; It is important to note that our collected data does not account for variations between detectors and other such impacting factors, and much more detailed data is needed to analyse such variations. The most data-rich species were *Hipposideros speoris* (15 observations) and *Rhinolophus rouxii* (12 observations; variation detailed above). Duration in all calls varied between recording conditions – as different environmental structures and degrees of clutter impact pulse duration and inter-pulse interval (Fraser et al. 2020) – but remained relatively consistent between locations within species, with shorter calls sometimes associated with higher mean FMAXE; however, this relationship was not consistently observed. Variation of mean FMAXE in most CF species was under 5 kHz between locations, with some notable exceptions. For instance, in cluttered flight recordings, the mean FMAXE of the Havelock Island population of *Hipposideros gentilis* is approximately 10 kHz higher than its sister Andaman Islands populations (Srinivasulu et al. 2017); in cluttered flight recordings recorded on the Pettersson D500X, the mean FMAXE of Indian *Hipposideros speoris* varied between 128 kHz in Andhra Pradesh and 138 kHz in Telangana (present study); and mean FMAXE in cluttered flight recordings of Indian *Rhinolophus rouxii* in Kerala was 10–12 kHz higher than those recorded in Karnataka and Maharashtra on the same detectors (Pettersson D500X and Wildlife Acoustics SM3BAT respectively; present study). In FM bats, FMAXE variation was under 10 kHz (except in the case of *Miniopterus phillipsi*, for which the mean FMAXE in Maharashtra, India, recorded on a Wildlife Acoustics SM3 was 18 kHz lower than calls recorded on a Pettersson D500X in a different location in Maharashtra and calls recorded on a Pettersson M500 in Uva, Sri Lanka; Kusuminda et al. 2022; present study). HF, LF, and D (and consequently B) all varied widely between locations in some species, in the same recording conditions. This may be due to differing attenuation of calls based on various conditions present in the recording location including foliage and habitat structure, flight elevation, and individual variations, but could also reflect difficulties in establishing species identity based on calls alone, especially in regions of overlapping distribution of species with similar calls.

Patterns and gaps in metadata

The published data comprised 185 observations of 86 species, of which the calls of Kelaart's pipistrelle *Pipistrellus ceylonicus* were reported by the most studies – seven in total, of which six were from India and one from Sri Lanka. Of the 86 species, 43 were reported only in one study each (50%; Supplementary Material 3). The data were mostly distributed in India (26 out of 35 studies; 74%), and the greatest number of studies per region was six studies from the south Indian state of Karnataka (Chattopadhyay et al. 2012; Raghuram et al. 2014; Srinivasulu et al. 2015, 2016; Deshpande & Kelkar 2015; Srinivasulu & Srinivasulu 2023). The greatest number of total unique observations reported from any region was from Uttarakhand (n = 34; Chakravarty 2017; Chakravarty et al. 2020; Singh & Sharma 2023).

Unfortunately, detailed information was lacking in some published studies. For instance, Raman & Hughes (2020) compiled the calls of 48 species from the Western Ghats, but recording locations were not provided. Kusuminda et al. (2022) described the new species Phillips' Bent-winged Bat *Miniopterus phillipsi* but provided only the FMAXE and no other characters from Sri Lanka, similarly to those of *Hipposideros larvatus* from Meghalaya, reported by Thabah et al. (2006). Unpublished data was found for 36 species from the authors' field recordings across India, which were analysed according to consistent standardised methods (see Methods). All of these species were previously reported in published data, but our unpublished data covers some spatial gaps in the distribution of

Table 3. Number of echolocation observations recorded in each recording condition (rows), described by sonotype (columns).

Recording Condition vs Sonotype		Sonotype							
		SCF	LCF	FM	FM-QCF	LMH	ME	PL	BA
Recording Condition	Flight – Clutter	28	27	19	13	18	10	0	0
	Flight – Open	18	6	10	19	15	2	0	0
	Release – Clutter	5	6	15	9	1	3	0	1
	Release – Open	2	3	3	11	10	1	2	1
	Hand-held	15	15	1	0	0	0	0	0
	Total	68	57	48	52	44	16	2	2

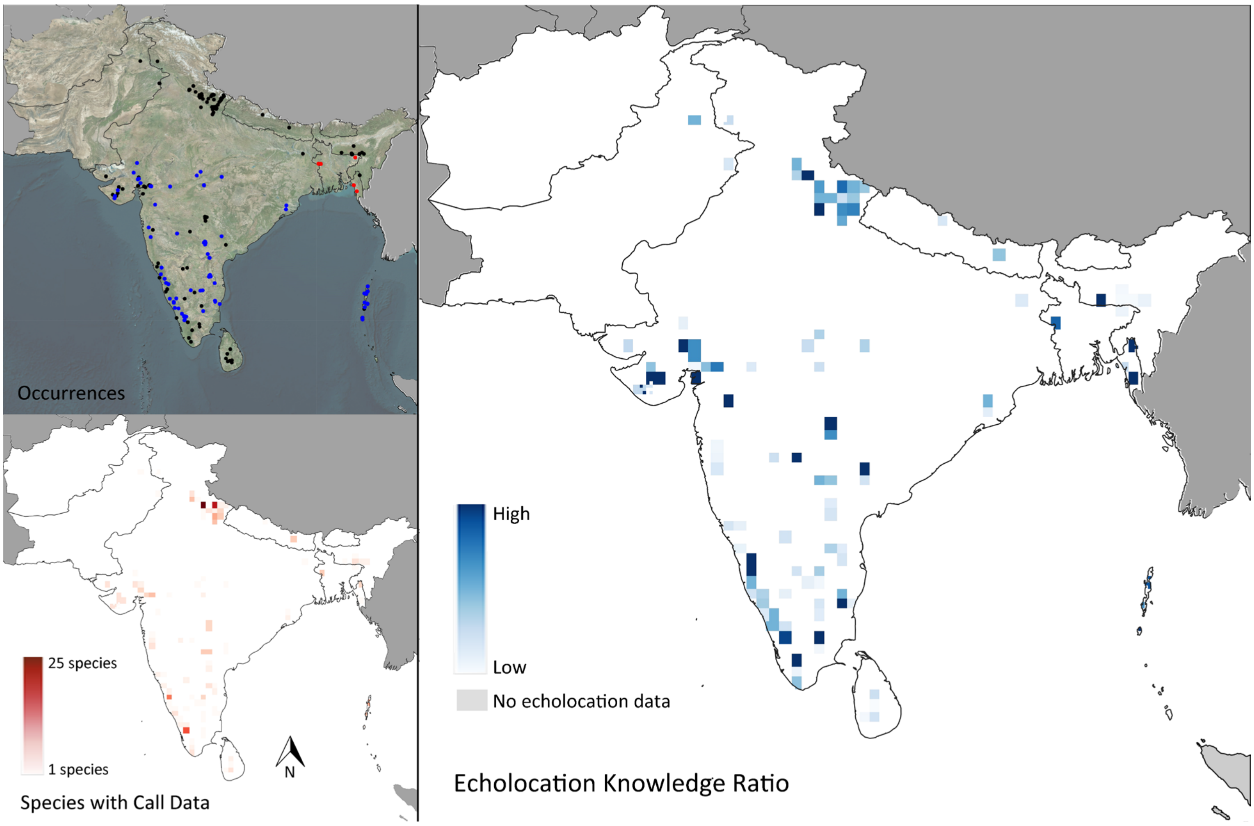

Figure 2. Maps of the study area indicating occurrences (where each point represents a location where echolocation data was recorded; black, blue and red points represent published, newly reported, and ChiroVox data, respectively); species with call data (where darker red colours represent more species with call data per cell); and echolocation knowledge ratio (where darker blue colours represent a higher echolocation knowledge ratio, and grey cells are those with no echolocation data recorded for any species).

knowledge, especially in Peninsular India (Figure 2). Additional unpublished records were found on the ChiroVox database and were distributed in India, and Bangladesh. The calls from India corresponded to those published in Chakravarty et al. (2020), and thus, we prioritised published information, and the calls from Bangladesh included in this study represented six species recorded in various conditions (Supplementary Material 3; Figure 2).

Nearly three-quarters of the species for which echolocation data was found (63 out of 86 species) are assessed as Least Concern (LC) in the IUCN Red List (IUCN 2025), with eight others listed in more at-risk categories (Hodgson's Myotis *Myotis formosus* and Painted Bat *Kerivoula picta* as 'Near Threatened'; Durga Das' Roundleaf Bat *Hipposideros durgadasi*, Rickett's Big-footed Myotis *Myotis pilosus*, and Mandelli's Myotis *Myotis sicarius* as 'Vulnerable'; Pomona Roundleaf Bat

Hipposideros pomona and the Andaman Horseshoe Bat *Rhinolophus cognatus* as 'Endangered'; and the Kolar Roundleaf Bat *Hipposideros hypophyllus* as 'Critically Endangered'. Of the 19 remaining species with echolocation data, eight are 'Data Deficient', and 11 have not been assessed yet (NA; Supplementary Material 3; Figure 3). There were more species with echolocation data than without in all Red List assessment categories except NT (two species with data and four species without data) and DD (eight species with data and 10 species without data; Supplementary Material 3; Figure 3). Approximately two-thirds of all extant LC, NA, and EN species, and all extant VU and CR species, have echolocation data.

It is vital to understand the variations in echolocation data that arise due to differences in the recording location, as both the degree of clutter in the environment and the specific type of recording (hand-held, in-flight, or at-release) greatly influence the shape and parameters of echolocation calls for certain species (Hiryu et al. 2006; Fraser et al. 2020). Of the 299 unique observations, 185 observations corresponding to 64 species (around 61% of the total data) were recorded in flight in either cluttered or open environments – usually in-situ near the bats' roosts or foraging sites, or in clearings, and open fields (Figure 3; Table 3). Many of these species (31 species) were urban-resilient vespertilionids recorded in urban/semi-urban ecotone areas (e.g., Kelaart's Pipistrelle *Pipistrellus ceylonicus*), forest-associated vespertilionids recorded in clearings (e.g., Horsfield's Myotis *Myotis horsfieldii*), scrubland-associated hipposiderids (e.g., Schneider's Roundleaf Bat *Hipposideros speoris*), or high-flying molossids (e.g., Egyptian Free-tailed Bat *Tadarida aegyptiaca*). Release calls made up 83 observations corresponding to 61 species – the process of recording these involved capturing the bat, confirming its identity, and then releasing it either in a cluttered (40 observations of 33 species) or open environment (43 observations of 37 species). The remaining 31 observations of 19 species were recorded while the bat was held in hand – these species were all CF bats, excepting the Kachin Woolly Bat *Kerivoula kachinensis* from Meghalaya, India (Uttam Saikia et al. 2020), a FM species for which no other recording was available (Table 3; Table 4; Supplementary Material 3). For 16 species (*Eudiscopus denticulus*, *Harpiocephalus harpia*, *Hippsosideros ater*, *Hipposideros lankadiva*, *Kerivoula crypta*, *K. picta*, *Miniopterus magnater*, *Mops plicatus*, *Myotis pilosus*, *Myotis sicarius*, *Otomops wroughtoni*, *Pipistrellus babu*, *Rhinolophus macrotis*, *Tadarida aegyptiaca*, *Tylonycteris fulvida*, *Tylonycteris malayana*), the only observations available were recorded in-flight, in all cases after the species identity was confirmed (Supplementary Material 3). Despite flight data being the most accurate representation of the species' actual echolocation calls, the data for these 16 species must be used with caution as misidentification is possible in areas with multiple species.

Distribution and knowledge gaps

Most of the published data was distributed across mainland India, with additional locations in the Andaman Islands and the Lakshadweep Islands, as well as in Nepal, Pakistan, and Sri Lanka (Figure 2). Most localities were in northern India (Himachal Pradesh and Uttarakhand states), western India (Gujarat), and peninsular India (Andhra Pradesh, Karnataka, Kerala, Maharashtra, Tamil Nadu, and Telangana states; Figure 2). Some data was also distributed in eastern India (Bihar, Meghalaya, and Mizoram states). New data reported as part of this study was mostly distributed in peninsular India, with some records from central India (Madhya Pradesh; Figure 2). Especially in the Western Ghats and the Deccan Plateau, unpublished data covered gaps in the existing published data. Unpublished ChiroVox data was only distributed in Bangladesh and was also the only data we found from the country (Figure 2).

Species with Call Data (SCD; the number of distinct species with at least one observation reported in each grid cell; see Methods) varied across South Asia, with hotspots of call data richness in Uttarakhand (India; 25 species near Dehradun and 15 species near Kedarnath Wildlife Sanctuary), the southern Western Ghats (India; 14 species in the Valparai Plateau), and the central Western Ghats (India; 12 species in and around Kudremukh National Park). It must be noted that, as the resolution of the spatial analyses is relatively coarse (0.5° approximately corresponding to 50 km on average in South Asia), each hotspot represents a very wide region of approximately 2,500 km^2. Echolocation Knowledge Ratio (EKR; the proportion of extant echolocating species in each cell for which echolocation data was found) also ranged across the region, with much of South Asia having at least one reported echolocating species but no echolocation data (Figure 3). Similarly to SCD, hotspots where EKR was 1 – i.e. all the reported echolocating species had echolocation data available – were seen in India: in Gujarat, Himachal Pradesh, central coastal Karnataka, the Western Ghats in Kerala, northern & southeastern Maharashtra, the Khasi & Garo Hills in Meghalaya, the Eastern Ghats & Nilgiris in Tamil Nadu, northern & eastern Telangana, and Uttarakhand; and in the eastern Chittagong Division of Bangladesh (Figure 2).

More than 90% of the study area was either classified as having ‘No Species Recorded/Unknown Species Richness’ (i.e., there is no knowledge of either species richness or echolocation data from the region; 65%; approximately 3.4 million km^2; Table 2), or as low survey priority regions (i.e., regions with low species richness and no EKR; 27%; approximately 1.4 million km^2; Table 2). These regions are widespread across South Asia, comprising almost all of Afghanistan and Bangladesh, all of Bhutan, large areas of northern & central India, western Nepal, central & southern Pakistan, and northern Sri Lanka (Figure 4). Regions of ‘good knowledge’ (i.e., regardless of high or low species richness, more than ¼ of the extant echolocating bats have echolocation data reported; Table 2) only comprised around 3% of the study area (approximately 165,000 km^2). These regions were seen in large contiguous clusters south of the Himalaya (Himachal Pradesh and Uttarakhand, India) and in the central & southern Western Ghats (Karnataka and Kerala, India). Smaller fragmented clusters were seen across the region, including in the Indus Valley and Hindukush Range (Punjab, Pakistan), western & central India (Gujarat and Madhya Pradesh), peninsular India (Maharashtra, Odisha, Tamil Nadu, and Telangana), northeastern India (Meghalaya), eastern Nepal (Bagmati), western Bangladesh (Rajshahi), and southeastern Bangladesh (Chittagong; Figure 4). Regions of ‘low knowledge priority’ (i.e., where species richness and EKR are low) comprised 1.6% of South Asia (approximately 85,000 km^2), and were seen in small, fragmented clusters across the entire study region, with a higher density in peninsular India (Figure 4).

Regions of ‘high knowledge priority’ (i.e., where the per-cell echolocating species richness is more than 10 species, but EKR is less than ¼; Table 2) comprised 1% of the study area (around 54,000 km^2). These regions were mostly seen in contiguous clusters with regions of ‘high survey priority’ (where the per-cell echolocating species richness is more than 10 species, but no echolocation knowledge exists for any of them from that cell; Table 2), which comprised 2.6% of the study area (around 135,000 km^2; Figure 4). Combined clusters of ‘high knowledge priority’ and ‘high survey priority’ were seen in northeastern India, the Western Ghats, the Eastern Ghats, the Brahmani-Mahanadi doab (Odisha, India), and in the Central, Sabaragamuwa, Southern, Uva, and Western provinces of Sri Lanka (Figure 4). Regions of ‘moderate knowledge priority’ alone were seen in southern India (Tamil Nadu and Kerala), northern India (Uttarakhand), and western India (Gujarat;

Table 4. Number of echolocation observations recorded in each recording condition (rows), described by the detector used (columns).

	Recording Condition vs Detector	Detector														
		Anabat SD1	Anabat Walkabout	Pettersson D240X	Pettersson D500X	Pettersson D980	Pettersson D1000X	Pettersson M500-384	Pettersson M500	Wildlife Acoustics EchoMeter Touch 2	Wildlife Acoustics EchoMeter Touch 2 Pro	Wildlife Acoustics SM3BAT	Wildlife Acoustics SM4BAT	Ultrasound-Advice S25	Ultrasound-Advice SM2	Ultrasound-Advice U30
Recording Condition	Flight – Clutter	14	16	4	27	11	5	1	11	2	2	19	0	0	0	3
	Flight – Open	10	5	7	13	1	1	16	2	1	0	12	0	0	1	1
	Release – Clutter	1	7	0	22	0	2	1	0	0	0	2	5	0	0	0
	Release – Open	2	22	0	10	0	0	0	0	0	0	9	0	0	0	0
	Hand-held	9	8	0	3	0	4	0	2	0	0	1	0	4	0	0
	Total	36	58	11	75	12	12	18	15	3	2	43	5	4	1	4

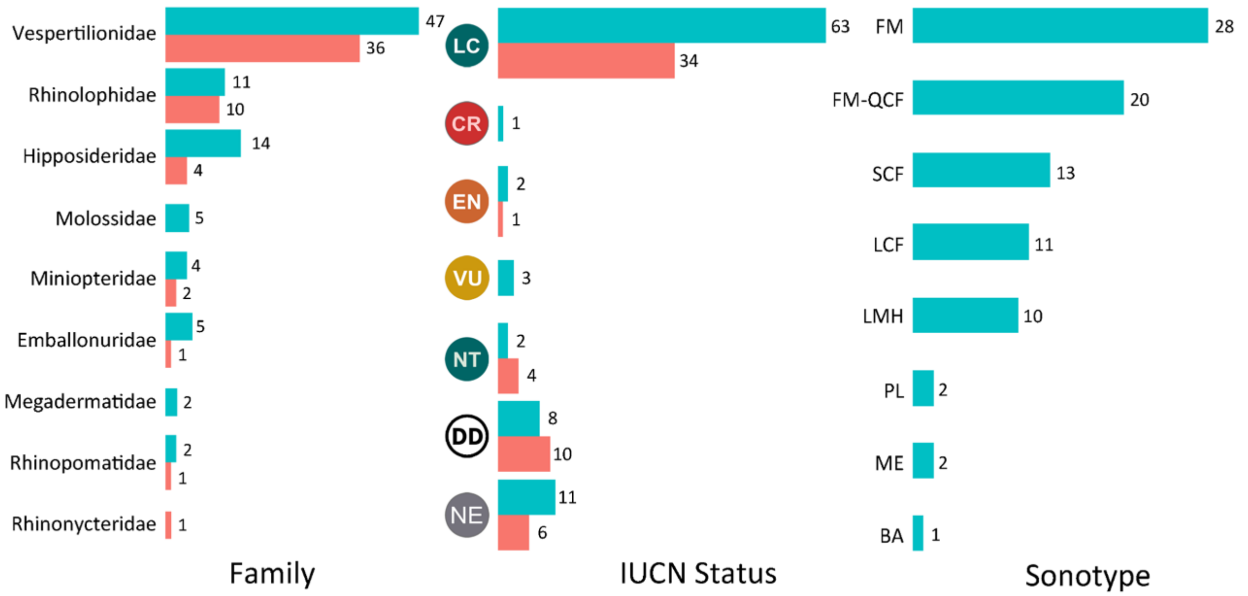

Figure 3. South Asian bat species with echolocation data (in blue) and without echolocation data (in red) in each taxonomic family, IUCN status, and sonotype; numbers next to bars represent individual species.

Figure 4). Finally, regions of 'high survey priority' alone were seen in various regions of Afghanistan (Faryab, Kabul, Kandahar, and Nangarhar provinces), India (Assam, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Mizoram, Nagaland, Rajasthan, Sikkim, Tamil Nadu, Telangana, Uttarakhand, and West Bengal states), Nepal (Bagmati, Gandaki, and Koshi provinces), Pakistan (Khyber Pakhtunkhwa and Punjab provinces), and the disputed territories of Gilgit-Baltistan and Azad Kashmir (Figure 4).

DISCUSSION

This study reviews bat echolocation research in South Asia, collating 299 unique observations of echolocation characters for 86 species by integrating published literature, unpublished recordings, and data from the ChiroVox database. It is the first compilation of its kind for South Asia, exploring data gaps, geographic variations (species characters differing from location to location), and situational variations (species characters being collected using various combinations of techniques, equipment, and conditions) in the echolocation characters for bats, supporting the development of non-invasive acoustic monitoring techniques in the region. It also identifies geographic regions of high and low echolocation knowledge density, importantly identifying research priority regions – where species diversity is relatively high and echolocation knowledge is low – for the prioritisation of future research efforts to increase our knowledge of bat echolocation in South Asia.

Data represented nearly all families, without strong taxonomic biases, except in the case of Hipposideridae (which only lack data for four out of 18 extant species) and Emballonuridae (which only lack data for one out of six extant species). No echolocation data has been reported from South Asia for the Trident Bat *Triaenops persicus*, the only species representing the family Rhinonycteridae in the region. In some small families (Molossidae and Megadermatidae) data were found for all species. Most observations represented species in Vespertilionidae, the most diverse family in the region with 84 extant species, of which we have data for 48. Vespertilionid bats are highly diverse, and some species are widespread across the region; species like Kelaart's Pipistrelle *Pipistrellus ceylonicus* and Least Pipistrelle *Pipistrellus tenuis* are commonly found in or near human settlements (Bates & Harrison 1997), increasing the likelihood of recording their echolocation during surveys that are not targeted or species-specific. However, just over half of the species in this family are represented in our echolocation dataset, representing a large knowledge gap of 36 species from one family alone. Despite their widespread distribution and high diversity (Bates & Harrison 1997; Srinivasulu & Srinivasulu 2012), much is still unknown about vespertilionid species, and future species-specific research must be directed towards this family.

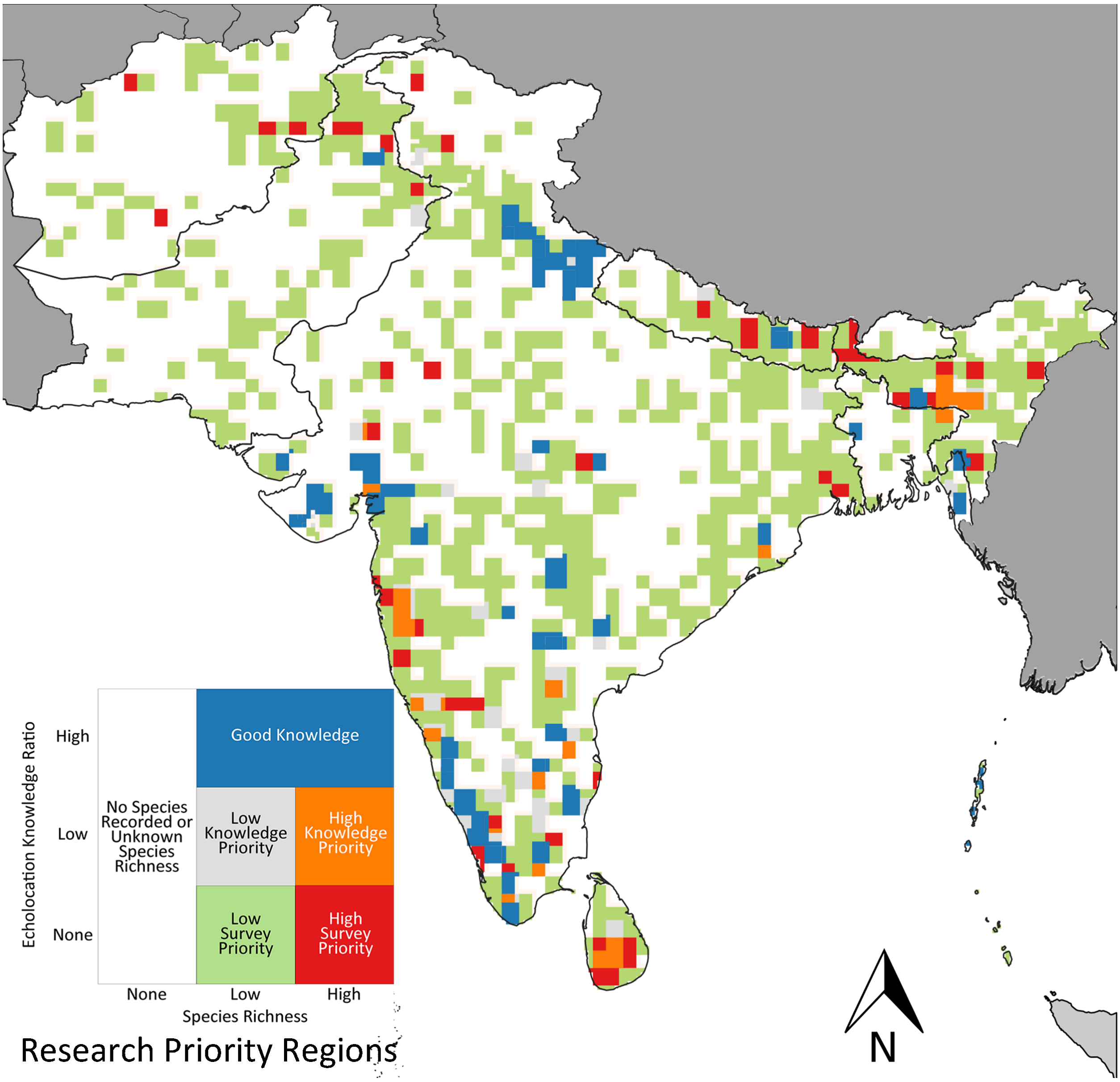

Figure 4. Bivariate map representing research priority regions, based on combinations of species richness and echolocation knowledge ratio. Cells with 0, <10 species, and ≥10 species are represented as none, low, and high species richness, respectively; cells with 0, <0.25, and ≥0.25 echolocation knowledge ratio are classified as none, low, and high, respectively.

Data were also available for species in various categories of extinction risk (IUCN Red List status), although we note that data was unavailable for four of the six species listed as Near Threatened, 10 out of the 18 Data Deficient species, and six out of the 17 species Not Evaluated. Additionally, 34 out of the 97 Least Concern species have no data; surveys targeted towards filling these gaps are vital. It is also important to note that over 60% of the observations in our dataset (n = 185) were collected in flight after species identity was confirmed using physical identification and (in most cases) release calls were recorded (Supplementary Material 3). For 16 species however, flight calls were the only call type available, either in published or unpublished data (*see* Results; Supplementary Material 3; Table 3). Care must be taken to ensure the species identity of an individual is established firmly before recording free-flying calls, as while call data from free-flying bats is more representative of actual calls recorded during acoustic monitoring, reference calls cannot be published based on echolocation-derived species identity alone due to variations in call characters. Ideally, an individual must be identified to species level, and both release and flight calls (and in the case of CF bats hand-held calls) must be recorded from the individual in as quiet a location as possible. If possible, multiple detectors (calibrated appropriately according to each detector's specific settings and the recording conditions, as different detectors and different calibrations can introduce variation; Adams et al. 2012) and multiple recording conditions may also be employed to capture a breadth of data. In regions where reference calls are available however, calls based on release and free-flight (which were recorded on the same detector in the same condition; Table 4) can be used as references to identify bats at least to sonotype- and family-level, though the authors advise caution with species-level identification using ambiguous and overlapping species characters.

The availability of echolocation data was highly varied across South Asia. In many regions, limited or no data was available, and most of the study area has low species richness but no echolocation data. However, in some parts of South Asia, especially in northeastern, northern, western, and peninsular India, all occurring species had echolocation data reported (Figure 4). Many more records were obtained from India than other countries, but this may be due in part to the size of the country itself, and due to all our unpublished data being from central, western, and peninsular India. We did not find published echolocation data for many extant species in large regions of Afghanistan, Bangladesh, Nepal, Pakistan, and Sri Lanka, even those which have relatively high species richness, but ChiroVox data covered several species across Bangladesh. Within India as well, the Gangetic Plains, the northern Deccan and central India, the Nilgiri Hills, the central Western Ghats, and northeastern India have relatively sparse echolocation data despite being relatively species-rich (Bates & Harrison 1997; Srinivasulu & Srinivasulu 2012). Data availability may be affected in some cases by the accessibility of study sites to researchers, a bias which is not uncommon in empirical data (González-Suárez et al. 2012; Hughes et al. 2021), but there are variations across the region. In Tamil Nadu, Uttarakhand, and Telangana, there are clusters of high data density near Madurai, Dehradun, and Hyderabad, all which contain major academic institutions – however, there are also regions like Valparai, the Garo and Khasi Hills, and most of the Gujarat peninsula, where this bias of availability is not seen (Figure 4). There are also sites of special interest, like Kolar in southern India, where the presence of the Critically Endangered Kolar Roundleaf Bat *Hipposideros hypophyllus*, has promoted site- and species-specific surveys since 2014 (Srinivasulu et al. 2014, 2016). To support future surveys and data collection, we identified 'high survey priority' and 'high knowledge priority regions' (with low or high species richness but low or no call data availability) where field surveys could lead to new data for several species. Two main priority areas fall in the Western Ghats and Sri Lanka and the Himalaya hotspots of biodiversity (Myers et al. 2000). Surveys in these areas of high ecological importance could contribute to expand our understanding of bat echolocation and diversity. Itis important to keep in mind that regions of high echolocation knowledge ratio (classified as good knowledge) still do not necessarily represent areas where we have enough data to be able to identify species to high certainty from echolocation calls alone – more work is needed to understand trait variations, and the specific identification boundaries between species based on echolocation must be analysed in further detail before we can truly confirm that the knowledge in regions identified as 'good knowledge' is enough for species-level identification. Future efforts to gather echolocation data should combine site- and species-targeted surveys with clear knowledge priorities, and our study identifies groups and areas where those efforts may be directed based on the priority of the study.

Research using functional traits to examine species interactions in ecosystems has been consistently advancing, starting with studies by early ecologists including Elton, Hutchinson, and Raunkiær (Malaterre et al. 2019). Recent work has developed newer protocols for the standardisation of functional traits in invertebrates (Moretti et al. 2017) and birds (Tobias et al. 2022), and the evaluation of the impact of anthropogenic activities on functional diversity (Carmona et al. 2021). Despite this breadth of research, the use of functional traits in animal studies has been criticised for its arbitrariness (Kearney et al. 2021), and the need for structured approaches to the collection, collation, and selection of trait data has often been recommended (Gonçalves-Souza et al. 2023). Echolocation has been long known as a vital trait in bat biology (Griffin 1953). Variation in echolocation traits has been explained using several non-exclusive hypotheses including relationships with body size, nasal chamber and laryngeal size, and evolutionary arms-races between hearing-moths and bats (Castro et al. 2024). However, this variation has not been truly quantified or explored across large groups of species, and we only know a small fraction of the echolocation characters of echolocating bat species across the world, especially in regions of high diversity such as South Asia. While our study attempts to reduce this gap by collecting and assessing the state of knowledge for bat echolocation in South Asia, it is deeply limited by the lack of depth in the data itself. The collected data comprises recordings from a limited set of recording conditions, and with the amount of data we have collected it is not possible to fully explore the breadth of all variations in species calls across geography, recording scenarios, and detectors used, amongst other factors. Thus, we only recommend using the collated data as a guideline, to follow standard methodology to collect new data, and to prioritise surveys towards regions of high knowledge and survey priorities in order to collect as much new information as possible and improve the state of echolocation knowledge in this region.

Key to effective conservation planning is a deep understanding of a study region's species diversity, including their distribution and traits (Margules & Pressey 2000). The dataset of echolocation observations and sonotypes in this study offer a foundational knowledge base for bats in South Asia which we hope will form a base for future research. Species-level trait data for South Asian bats is sorely lacking, yet trait data is key to understand the functional dimension of biodiversity (Cernansky 2017; Stewart et al. 2023), which is being eroded (Carmona et al. 2021), and is linked to important ecosystems services and functions (Cadotte et al. 2011). This study aids in the compilation of echolocation call characteristics for South Asian bats contributing understanding to an important dimension of bat functional traits (see Denzinger & Schnitzler 2013). We hope that our research promotes further interest in trait research and data compilation. Moving forward, our bat echolocation database and additional analysis of research priority regions in South Asia can support more targeted research and species- and site-specific survey planning, leading to positive long-term impacts on data collection and collation, conservation prioritisation, and policymaking.

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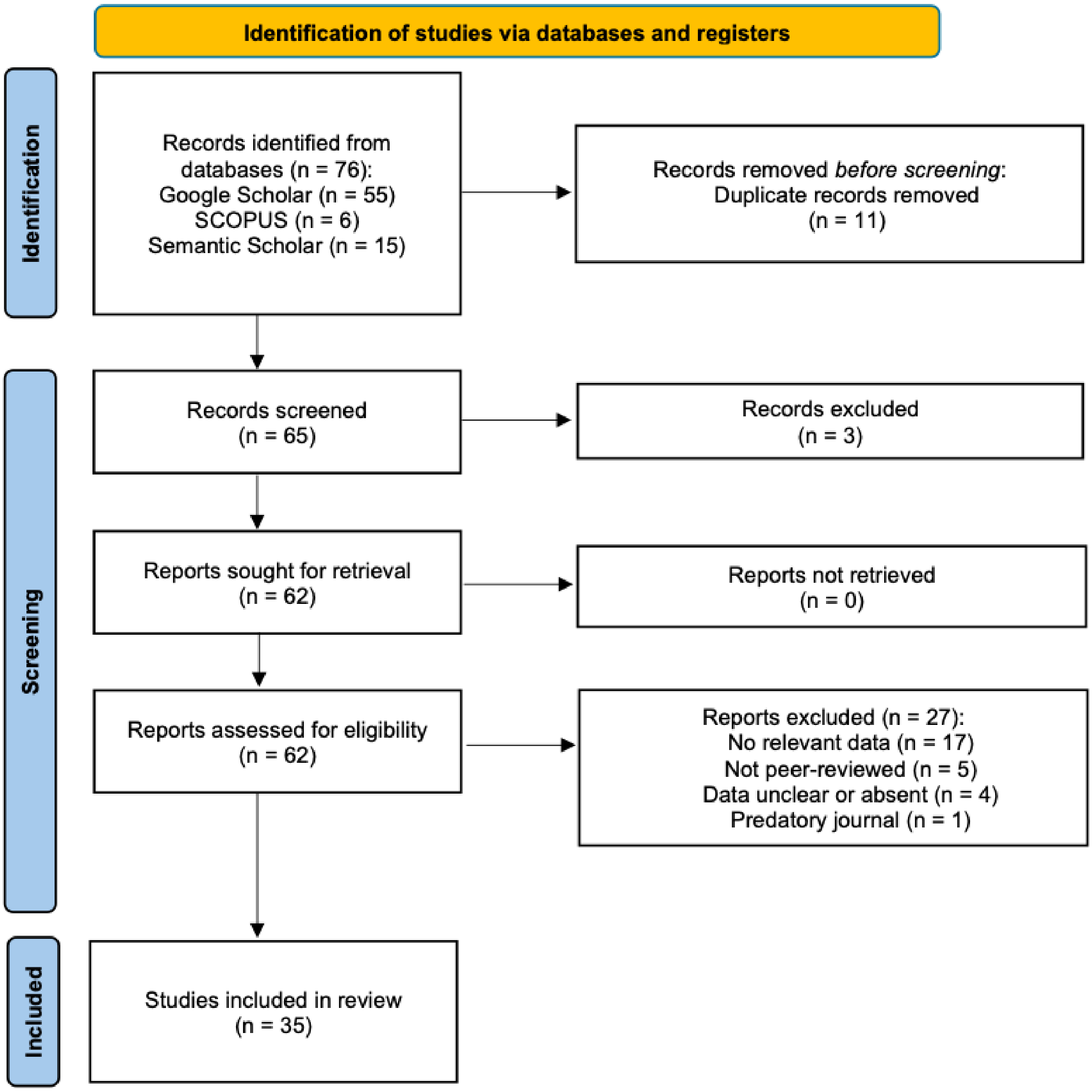

Supplementary Material 1. PRISMA flow diagram of the systematic literature search used to gather data for this study.

Supplementary Material 2. List of species included in the study, with sources from which echolocation data was acquired for each.

Family	Species	Source
Vespertilionidae	*Arielulus circumdatus*	Chakravarty et al. 2020
Vespertilionidae	*Barbastella darjelingensis*	Wordley et al. 2014; Chakravarty et al. 2020; Saikia et al. 2025
Vespertilionidae	*Cnephaeus pachyomus*	Saikia et al. 2025
Vespertilionidae	*Cnephaeus serotinus*	Chakravarty et al. 2020
Vespertilionidae	*Cnephaeus tatei*	Chakravarty et al. 2020
Vespertilionidae	*Eudiscopus denticulus*	Saikia et al. 2021
Vespertilionidae	*Harpiocephalus harpia*	Raghuram et al. 2014; Raman & Hughes 2020
Vespertilionidae	*Hesperoptenus tickelli*	Wordley et al. 2014; Srinivasulu et al. 2017; present study
Hipposideridae	*Hipposideros armiger*	Chakravarty et al. 2020; Rai et al. 2021
Hipposideridae	*Hipposideros ater*	Raman & Hughes 2020; present study
Hipposideridae	*Hipposideros diadema*	Srinivasulu et al. 2017; present study
Hipposideridae	*Hipposideros durgadasi*	Srinivasulu et al. 2016; present study
Hipposideridae	*Hipposideros fulvus*	Srinivasulu et al. 2015; Petchiammal et al. 2019; Raman & Hughes 2020; present study
Hipposideridae	*Hipposideros brachyotus*	Raghuram et al. 2014; Srinivasulu et al. 2015; Srinivasulu & Srinivasulu 2017; Shah & Srinivasulu 2020; Raman & Hughes 2020; present study
Hipposideridae	*Hipposideros gentilis*	Srinivasulu et al. 2017; present study
Hipposideridae	*Hipposideros hypophyllus*	Srinivasulu et al. 2016; present study
Hipposideridae	*Hipposideros lankadiva*	Srinivasulu et al. 2015; present study
Hipposideridae	*Hipposideros grandis*	Srinivasulu et al. 2017; present study
Hipposideridae	*Hipposideros larvatus*	Thabah et al. 2006
Hipposideridae	*Hipposideros pomona*	Wordley et al. 2014; Petchiammal et al. 2019; Raman & Hughes 2020; present study
Hipposideridae	*Hipposideros speoris*	Pavey et al. 2001; Srinivasulu et al. 2015; Petchiammal et al. 2019; Raman & Hughes 2020; Devender & Srinivasulu 2022; present study
Vespertilionidae	*Hypsugo affinis*	Saikia et al. 2025
Vespertilionidae	*Hypsugo savii*	Saikia et al. 2025
Vespertilionidae	*Kerivoula crypta*	Raman & Hughes 2020
Vespertilionidae	*Kerivoula kachinensis*	Saikia et al. 2020
Vespertilionidae	*Kerivoula picta*	Sripathi et al. 2006
Megadermatidae	*Lyroderma lyra*	Raghuram et al. 2014; Devender & Srinivasulu 2022; Singh & Sharma 2023; ChiroVox; present study
Megadermatidae	*Megaderma spasma*	Wordley et al. 2014; Srinivasulu et al. 2017; Raman & Hughes 2020; present study
Miniopteridae	*Miniopterus fuliginosus*	Chakravarty et al. 2020
Miniopteridae	*Miniopterus magnater*	Saikia et al. 2020
Miniopteridae	*Miniopterus phillipsi*	Wordley et al. 2014; Srinivasulu & Srinivasulu 2017; Kusuminda et al. 2022; present study
Miniopteridae	*Miniopterus srinii*	Wordley et al. 2014; Raman & Hughes 2020; Srinivasulu & Srinivasulu 2023; present study
Vespertilionidae	*Mirostrellus joffrei*	Chakravarty et al. 2020; Saikia & Chakravarty 2024
Molossidae	*Mops plicatus*	Deshpande & Kelkar 2015; Kusuminda & Yapa 2017
Vespertilionidae	*Murina aurata*	Chakravarty et al. 2020; Saikia et al. 2025
Vespertilionidae	*Murina cyclotis*	Raghuram et al. 2014; Chakravarty et al. 2020
Vespertilionidae	*Murina huttoni*	Chakravarty et al. 2020; Saikia et al. 2025
Vespertilionidae	*Murina leucogaster*	Chakravarty et al. 2020
Vespertilionidae	*Myotis annectans*	Chakravarty et al. 2020; Saikia & Chakravarty 2024
Vespertilionidae	*Myotis blythii*	Chakravarty et al. 2020
Vespertilionidae	*Myotis formosus*	Rai et al. 2021
Vespertilionidae	*Myotis himalaicus*	Chakravarty et al. 2020; Saikia et al. 2025
Vespertilionidae	*Myotis horsfieldii*	Wordley et al. 2014; Srinivasulu et al. 2017; present study
Vespertilionidae	*Myotis longipes*	Chakravarty et al. 2020

Family	Species	Source
Vespertilionidae	*Myotis montivagus*	Wordley et al. 2014; Saikia & Chakravarty 2024
Vespertilionidae	*Myotis muricola*	Chakravarty et al. 2020; Saikia et al. 2025
Vespertilionidae	*Myotis nipalensis*	Chakravarty et al. 2020
Vespertilionidae	*Myotis peytoni*	Srinivasulu & Srinivasulu 2017; Raman & Hughes 2020; present study
Vespertilionidae	*Myotis pilosus*	Saikia et al. 2020
Vespertilionidae	*Myotis sicarius*	Saikia et al. 2025
Vespertilionidae	*Nyctalus leisleri*	Chakravarty et al. 2020; Saikia et al. 2025
Vespertilionidae	*Nyctalus montanus*	Chakravarty et al. 2020
Vespertilionidae	*Nyctalus noctula*	Rai et al. 2021
Molossidae	*Otomops wroughtoni*	Ruedi et al. 2014; Deshpande & Kelkar 2015
Vespertilionidae	*Phoniscus jagorii*	Raman & Hughes 2020; Raman et al. 2020
Vespertilionidae	*Pipistrellus babu*	Saikia et al. 2025
Vespertilionidae	*Pipistrellus ceylonicus*	Raghuram et al. 2014; Wordley et al. 2014; Kusuminda et al. 2017; Chakravarty et al. 2020; Raman & Hughes 2020; Shah & Srinivasulu 2020; Devender & Srinivasulu 2022; present study
Vespertilionidae	*Pipistrellus coromandra*	Raghuram et al. 2014; Srinivasulu et al. 2017; Raman & Hughes 2020
Vespertilionidae	*Pipistrellus javanicus*	Srinivasulu et al. 2017; present study
Vespertilionidae	*Pipistrellus tenuis*	Raghuram et al. 2014; Chakravarty et al. 2020; Devender & Srinivasulu 2022; present study
Vespertilionidae	*Plecotus homochrous*	Chakravarty et al. 2020
Vespertilionidae	*Plecotus wardi*	Chakravarty et al. 2020
Rhinolophidae	*Rhinolophus affinis*	Chakravarty et al. 2020; Saikia & Chakravarty 2024; Saikia et al. 2025
Rhinolophidae	*Rhinolophus andamanensis*	Srinivasulu et al. 2017; present study
Rhinolophidae	*Rhinolophus beddomei*	Raghuram et al. 2014; Wordley et al. 2014; Srinivasulu et al. 2015; Kusuminda et al. 2019; Raman & Hughes 2020; Sail & Borkar 2024; present study
Rhinolophidae	*Rhinolophus cognatus*	Srinivasulu et al. 2017; present study
Rhinolophidae	*Rhinolophus lepidus*	Raghuram et al. 2014; Wordley et al. 2014; Chakravarty et al. 2020; Raman & Hughes 2020; Saikia et al. 2025; ChiroVox; present study
Rhinolophidae	*Rhinolophus macrotis*	Saikia et al. 2025
Rhinolophidae	*Rhinolophus pearsonii*	Chakravarty et al. 2020; Rai et al. 2021
Rhinolophidae	*Rhinolophus perniger*	Chakravarty et al. 2020; Saikia et al. 2025; present study
Rhinolophidae	*Rhinolophus pusillus*	Chakravarty et al. 2020
Rhinolophidae	*Rhinolophus rouxii*	Chattopadhyay et al. 2010; Chattopadhyay et al. 2012; Raghuram et al. 2014; Wordley et al. 2014; Kusuminda et al. 2019; Raman & Hughes 2020; present study
Rhinolophidae	*Rhinolophus sinicus*	Chakravarty et al. 2020; Rai et al. 2021; Saikia et al. 2025
Rhinopomatidae	*Rhinopoma hardwickii*	Srinivasulu & Srinivasulu 2017; Shah & Srinivasulu 2020; Devender & Srinivasulu 2022; present study
Rhinopomatidae	*Rhinopoma microphyllum*	Shah & Srinivasulu 2020; present study
Emballonuridae	*Saccolaimus saccolaimus*	Present study
Vespertilionidae	*Scotophilus heathii*	Wordley et al. 2014; Chakravarty et al. 2020; Shah & Srinivasulu 2020; Devender & Srinivasulu 2022; present study
Vespertilionidae	*Scotophilus kuhlii*	Javid et al. 2014; Raghuram et al. 2014; Wordley et al. 2014; Devender & Srinivasulu 2022; present study
Vespertilionidae	*Submyotodon caliginosus*	Chakravarty et al. 2020; Saikia et al. 2025
Molossidae	*Tadarida aegyptiaca*	Deshpande & Kelkar 2015; present study
Molossidae	*Tadarida insignis*	Deshpande & Kelkar 2015; Chakravarty 2017; Chakravarty et al. 2020; Sharma et al. 2021
Emballonuridae	*Taphozous longimanus*	Shah & Srinivasulu 2020; present study
Emballonuridae	*Taphozous melanopogon*	Srinivasulu et al. 2017; Shah & Srinivasulu 2020; Devender & Srinivasulu 2022; present study
Emballonuridae	*Taphozous nudiventris*	Shah & Srinivasulu 2020; present study
Emballonuridae	*Taphozous perforatus*	Mahmood-ul-Hassan et al. 2012
Vespertilionidae	*Tylonycteris fulvida*	Raman & Hughes 2020
Vespertilionidae	*Tylonycteris malayana*	Srinivasulu et al. 2017; present study

Supplementary Material 3. Character matrix of 299 observations of 86 species, including descriptors (IUCN Red List status, Country, Region, Detector, Recording Condition, Sonotype), six call characters (HF, LF, B, FMAXE, D, SR), and the number of recordings analysed (N) for each observation.

Family	Species	Observation ID	Source	Year	IUCN Status	Country	Region	Detector	Recording Condition	Sonotype	HF	LF	B	FMAXE	D	SR	N
Vespertilionidae	Arielulus circumdatus	Ar_circ_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	44.8	26.8	18	28.9	9.1	1.98	1
Vespertilionidae	Barbastella darjelingensis	Ba_darj_1	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	BA	36.46 ± 1.42	20.84 ± 0.4	15.62 ± 0.91	29.23 ± 2.2	4.37 ± 0.72	3.57 ± 1.26	15
Vespertilionidae	Barbastella darjelingensis	Ba_darj_2	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	BA	37.3	26.2	11.1	33.4	2.1	5.28	3
Vespertilionidae	Barbastella darjelingensis	Ba_darj_3	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Open	BA	42.73 ± 4.8	21.44 ± 2.15	21.29 ± 3.475	32.62 ± 5.96	6.37 ± 1.71	3.34 ± 0.67	10
Vespertilionidae	Cnephaeus pachyomus	Cn_pach_1	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Release - Clutter	FM-QCF	57.87	23.48	34.39	32.02	2.71	12.69	1
Vespertilionidae	Cnephaeus serotinus	Cn_sero_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	50 ± 4.45	22.9 ± 0.89	27.1 ± 2.67	29.7 ± 1.5	3.7 ± 0.73	7.32 ± 0.01	2
Vespertilionidae	Cnephaeus tatei	Cn_tate_1	Chakravarty et al. 2020	2020	DD	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	46.5	25.3	21.2	29.5	5.2	4.08	1
Vespertilionidae	Eudiscopus denticulus	Eu_dent_1	Saikia et al. 2021	2021	LC	India	Meghalaya	Anabat Walkabout	Flight - Open	FM-QCF	104.82 ± 2.7	53.12 ± 5.79	51.7 ± 4.25	56.81 ± 2.86	4.75 ± 0.63	10.88 ± 0.4	2
Vespertilionidae	Harpiocephalus harpia	Ha_harp_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	FM	111.5	32.5	79	57	1	79	1
Vespertilionidae	Harpiocephalus harpia	Ha_harp_2	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	FM	115.8 ± 3.46	41.1 ± 1.17	74.7 ± 2.32	88.1 ± 0.86	1.7 ± 0.27	43.94 ± 0.01	6
Vespertilionidae	Hesperoptenus tickelli	He_tick_1	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	FM	58.16 ± 2.34	20.22 ± 1.31	37.94 ± 1.83	28.32 ± 1.76	5.06 ± 0.7	7.5 ± 2.61	15
Vespertilionidae	Hesperoptenus tickelli	He_tick_2	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	Anabat SD1	Release - Open	FM	51.18 ± 2.57	26.39 ± 1.56	24.79 ± 2.07	35.27 ± 6.25	4.7 ± 1.12	5.27 ± 0.17	26
Vespertilionidae	Hesperoptenus tickelli	He_tick_3	Present study	2025	LC	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	FM	51.18 ± 2.58	26.39 ± 1.57	24.79 ± 3.29	35.27 ± 6.26	4.71 ± 1.13	5.26 ± 25.31	26
Hipposideridae	Hipposideros armiger	Hi_armi_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Hand-held	SCF				68.2 ± 1.9	7.8 ± 0.3		5
Hipposideridae	Hipposideros armiger	Hi_armi_2	Rai et al. 2021	2021	LC	Nepal	Bagmati	SM4BAT	Release - Clutter	SCF				69.25 ± 0.37	7.81 ± 0.85		120
Hipposideridae	Hipposideros ater	Hi_ater_1	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	SCF				164.9 ± 0.69	3.8 ± 0.49		10
Hipposideridae	Hipposideros ater	Hi_ater_2	Present study	2025	LC	India	Pondicherry	M500	Flight - Clutter	SCF				165.72 ± 1.16	4.11 ± 1.14		45
Hipposideridae	Hipposideros ater	Hi_ater_3	Present study	2025	LC	India	Tamil Nadu	M500	Flight - Clutter	SCF				164.38 ± 1.45	4.04 ± 0.94		70
Hipposideridae	Hipposideros brachyotus	Hi_brac_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	SCF				126.7 ± 2.1	6.5 ± 1.4		6
Hipposideridae	Hipposideros brachyotus	Hi_brac_2	Srinivasulu et al. 2015	2015	LC	India	Karnataka	Anabat SD1	Flight - Open	SCF				112.48 ± 3.65	4.81 ± 0.46		10
Hipposideridae	Hipposideros brachyotus	Hi_brac_3	Srinivasulu & Srinivasulu 2017	2017	LC	India	Kerala	D500X	Hand-held	SCF				113.54 ± 0.43	6.65 ± 0.65		9

Family	Species	Observation ID	Source	Year	IUCN Status	Country	Region	Detector	Recording Condition	Sonotype	HF	LF	B	FMAXE	D	SR	N
Hipposideridae	Hipposideros brachyotus	Hi_brac_4	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	SCF				114.2 ± 0.37	6.3 ± 0.59		18
Hipposideridae	Hipposideros brachyotus	Hi_brac_5	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Hand-held	SCF				108.64 ± 1.03	5.8 ± 0.55		49
Hipposideridae	Hipposideros brachyotus	Hi_brac_6	Present study	2025	LC	India	Kerala	D500X	Flight - Clutter	SCF				113.79 ± 1.05	5.95 ± 1.28		50
Hipposideridae	Hipposideros brachyotus	Hi_brac_7	Present study	2025	LC	India	Tamil Nadu	M500	Flight - Clutter	SCF				114.99 ± 0.11	6.49 ± 0.44		20
Hipposideridae	Hipposideros brachyotus	Hi_brac_8	Present study	2025	LC	India	Gujarat	D500X	Release - Clutter	SCF				113.56 ± 0.29	5.68 ± 0.57		9
Hipposideridae	Hipposideros diadema	Hi_diad_1	Srinivasulu et al. 2016	2016	LC	India	Andaman & Nicobar Islands	Anabat SD1	Hand-held	SCF				59.08 ± 0.24	4.77 ± 0.62		5
Hipposideridae	Hipposideros diadema	Hi_diad_2	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	Anabat SD1	Hand-held	SCF				59.08 ± 0.24	4.77 ± 0.62		5
Hipposideridae	Hipposideros diadema	Hi_diad_3	Present study	2025	LC	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	SCF				59.08 ± 0.23	4.77 ± 0.59		10
Hipposideridae	Hipposideros durgadasi	Hi_durg_1	Srinivasulu et al. 2016	2016	VU	India	Karnataka	D500X	Release - Open	SCF				175.1 ± 0.33	7.96 ± 0.94		10
Hipposideridae	Hipposideros durgadasi	Hi_durg_2	Present study	2025	VU	India	Karnataka	D500X	Flight - Clutter	SCF				171.2 ± 0.55	6 ± 1.1		116
Hipposideridae	Hipposideros durgadasi	Hi_durg_3	Present study	2025	VU	India	Karnataka	D500X	Flight - Open	SCF				170.52 ± 0.63	6.17 ± 0.91		116
Hipposideridae	Hipposideros fulvus	Hi_fulv_1	Srinivasulu et al. 2015	2015	LC	India	Karnataka	Anabat SD1	Flight - Open	SCF				155.69 ± 2.09	3 ± 1.02		184
Hipposideridae	Hipposideros fulvus	Hi_fulv_2	Petchiammal et al. 2019	2019	LC	India	Tamil Nadu	Anabat SD1	Hand-held	SCF				142 ± 0.4	7.4 ± 1.5		
Hipposideridae	Hipposideros fulvus	Hi_fulv_3	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	SCF				151.3 ± 0.4	4.2 ± 0.19		10
Hipposideridae	Hipposideros fulvus	Hi_fulv_4	Present study	2025	LC	India	Andhra Pradesh	M500	Flight - Clutter	SCF				152.47 ± 0.2	4.83 ± 0.58		82
Hipposideridae	Hipposideros fulvus	Hi_fulv_5	Present study	2025	LC	India	Maharashtra	D500X	Flight - Clutter	SCF				150.68 ± 0.19	2.99 ± 0.38		10
Hipposideridae	Hipposideros fulvus	Hi_fulv_6	Present study	2025	LC	India	Telangana	Anabat SD1	Flight - Clutter	SCF				155.69 ± 2.08	3 ± 1.02		368
Hipposideridae	Hipposideros fulvus	Hi_fulv_7	Present study	2025	LC	India	Karnataka	D500X	Flight - Open	SCF				154.13 ± 0.39	4.76 ± 0.54		31
Hipposideridae	Hipposideros gentilis	Hi_gent_1	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	D500X	Hand-held	SCF				126.5 ± 4.17	5.61 ± 1.84		90
Hipposideridae	Hipposideros gentilis	Hi_gent_2	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	Anabat SD1	Hand-held	SCF				137.45 ± 2.1	3.18 ± 0.37		15
Hipposideridae	Hipposideros gentilis	Hi_gent_3	Present study	2025	LC	India	Andaman & Nicobar Islands	D500X	Flight - Clutter	SCF				126.85 ± 4.66	5.07 ± 1.57		194
Hipposideridae	Hipposideros gentilis	Hi_gent_4	Present study	2025	LC	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	SCF				125.75 ± 10.73	4.25 ± 1.68		24
Hipposideridae	Hipposideros gentilis	Hi_gent_5	Present study	2025	LC	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Open	SCF				133.82 ± 4.75	3.25 ± 1.17		14

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Hipposideridae	Hipposideros grandis	Hi_gran_1	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	Anabat SD1	Hand-held	SCF				94.06 ± 2.21	5.95 ± 0.7		69
Hipposideridae	Hipposideros grandis	Hi_gran_2	Present study	2025	LC	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	SCF				93.71 ± 3.78	5.88 ± 1.19		132
Hipposideridae	Hipposideros grandis	Hi_gran_3	Present study	2025	LC	India	Andaman & Nicobar Islands	SM3BAT	Flight - Clutter	SCF				93.84 ± 4.1	5.85 ± 1.27		109
Hipposideridae	Hipposideros grandis	Hi_gran_4	Present study	2025	LC	India	Andaman & Nicobar Islands	SM3BAT	Release - Clutter	SCF				93.09 ± 1.53	6.03 ± 0.7		23
Hipposideridae	Hipposideros hypophyllus	Hi_hypo_1	Srinivasulu et al. 2016	2016	CR	India	Karnataka	D500X	Release - Open	SCF				103.9 ± 0.82	6.3 ± 1.07		15
Hipposideridae	Hipposideros hypophyllus	Hi_hypo_2	Present study	2025	CR	India	Karnataka	D500X	Flight - Clutter	SCF				105.11 ± 0.49	7.56 ± 1.1		149
Hipposideridae	Hipposideros hypophyllus	Hi_hypo_3	Present study	2025	CR	India	Karnataka	D500X	Flight - Open	SCF				105.11 ± 0.49	7.56 ± 1.1		149
Hipposideridae	Hipposideros lankadiva	Hi_lank_1	Srinivasulu et al. 2015	2015	LC	India	Telangana	Anabat SD1	Flight - Open	SCF				78.33 ± 5.28	8.87 ± 3.47		427
Hipposideridae	Hipposideros lankadiva	Hi_lank_2	Present study	2025	LC	India	Andhra Pradesh	M500	Flight - Clutter	SCF				81.33 ± 0.62	8.74 ± 1.13		38
Hipposideridae	Hipposideros lankadiva	Hi_lank_3	Present study	2025	LC	India	Madhya Pradesh	SM3BAT	Flight - Clutter	SCF				81.91 ± 0.12	7.96 ± 0.61		18
Hipposideridae	Hipposideros lankadiva	Hi_lank_4	Present study	2025	LC	India	Odisha	D500X	Flight - Clutter	SCF				78.78 ± 0.59	15.25 ± 3.05		42
Hipposideridae	Hipposideros lankadiva	Hi_lank_5	Present study	2025	LC	India	Telangana	Anabat SD1	Flight - Clutter	SCF				77.84 ± 5.87	8.9 ± 3.48		201
Hipposideridae	Hipposideros lankadiva	Hi_lank_6	Present study	2025	LC	India	Telangana	D500X	Flight - Open	SCF				78.26 ± 0.21	14.79 ± 0.65		14
Hipposideridae	Hipposideros lankadiva	Hi_lank_7	Present study	2025	LC	India	Telangana	Anabat SD1	Flight - Open	SCF				77.84 ± 5.87	8.9 ± 3.48		201
Hipposideridae	Hipposideros larvatus	Hi_larv_1	Thabah et al. 2006	2006	LC	India	Meghalaya	Ultrasound Advice S25	Hand-held	SCF				83.7 ± 1.76			12
Hipposideridae	Hipposideros larvatus	Hi_larv_2	Thabah et al. 2006	2006	LC	India	Meghalaya	Ultrasound Advice S25	Hand-held	SCF				85.1 ± 0.72			10
Hipposideridae	Hipposideros larvatus	Hi_larv_3	Thabah et al. 2006	2006	LC	India	Meghalaya	Ultrasound Advice S25	Hand-held	SCF				96.7 ± 2.05			22
Hipposideridae	Hipposideros larvatus	Hi_larv_4	Thabah et al. 2006	2006	LC	India	Meghalaya	Ultrasound Advice S25	Hand-held	SCF				97.96 ± 2.12			15
Hipposideridae	Hipposideros pomona	Hi_pomo_1	Wordley et al. 2014	2014	EN	India	Tamil Nadu	D500X	Release - Clutter	SCF				126.337 ± 1.25	8.13 ± 0.94		6
Hipposideridae	Hipposideros pomona	Hi_pomo_2	Petchiammal et al. 2019	2019	EN	India	Tamil Nadu	Anabat SD1	Hand-held	SCF				130 ± 0.2	8.8 ± 1.2		
Hipposideridae	Hipposideros pomona	Hi_pomo_3	Raman & Hughes 2020	2020	EN	India	Kerala	M500-384	Flight - Open	SCF				122.4 ± 3.65	6.3 ± 0.92		193
Hipposideridae	Hipposideros pomona	Hi_pomo_4	Present study	2025	EN	India	Kerala	M500	Flight - Clutter	SCF				123.58 ± 2.28	6.22 ± 1.18		78
Hipposideridae	Hipposideros speoris	Hi_speo_1	Pavey et al. 2001	2001	LC	Sri Lanka	Central	Ultrasound Advice U30	Flight - Clutter	SCF				130.12 ± 1.52	6.88 ± 0.44		3

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Hipposideridae	Hipposideros speoris	Hi_speo_10	Present study	2025	LC	India	Andhra Pradesh	M500	Flight - Clutter	SCF				135.8 ± 2.77	6.54 ± 1.34		199
Hipposideridae	Hipposideros speoris	Hi_speo_11	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Clutter	SCF				124.75 ± 0.21	6.77 ± 0.47		10
Hipposideridae	Hipposideros speoris	Hi_speo_12	Present study	2025	LC	India	Telangana	D500X	Flight - Clutter	SCF				138.21 ± 0.02	8.56 ± 0.47		19
Hipposideridae	Hipposideros speoris	Hi_speo_13	Present study	2025	LC	India	Telangana	Anabat SD1	Flight - Clutter	SCF				137.52 ± 3.79	6.13 ± 1.22		460
Hipposideridae	Hipposideros speoris	Hi_speo_14	Present study	2025	LC	India	Telangana	D500X	Flight - Open	SCF				138.21 ± 0.02	8.56 ± 0.47		19
Hipposideridae	Hipposideros speoris	Hi_speo_15	Present study	2025	LC	India	Gujarat	SM3BAT	Release - Clutter	SCF				124.75 ± 0.21	6.77 ± 0.47		10
Hipposideridae	Hipposideros speoris	Hi_speo_2	Pavey et al. 2001	2001	LC	Sri Lanka	Central	Ultrasound Advice U30	Flight - Clutter	SCF				128.39 ± 2.18	6.86 ± 1.13		11
Hipposideridae	Hipposideros speoris	Hi_speo_3	Pavey et al. 2001	2001	LC	Sri Lanka	Central	Ultrasound Advice U30	Flight - Clutter	SCF				130.55 ± 0.4	8.07 ± 0.49		3
Hipposideridae	Hipposideros speoris	Hi_speo_4	Pavey et al. 2001	2001	LC	Sri Lanka	Central	Ultrasound Advice U30	Flight - Open	SCF				131.19 ± 2.18	7.59 ± 0.73		6
Hipposideridae	Hipposideros speoris	Hi_speo_5	Srinivasulu et al. 2015	2015	LC	India	Telangana	Anabat SD1	Flight - Open	SCF				138.88 ± 4.02	6.09 ± 1.21		469
Hipposideridae	Hipposideros speoris	Hi_speo_6	Petchiammal et al. 2019	2019	LC	India	Tamil Nadu	Anabat SD1	Hand-held	SCF				136 ± 0.3	8.1 ± 1.6		
Hipposideridae	Hipposideros speoris	Hi_speo_7	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	SCF				125.4 ± 4.79	5.6 ± 1.26		161
Hipposideridae	Hipposideros speoris	Hi_speo_8	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Open	SCF				133.57 ± 4.27	7.19 ± 1.44		20
Hipposideridae	Hipposideros speoris	Hi_speo_9	Present study	2025	LC	India	Andhra Pradesh	D500X	Flight - Clutter	SCF				128.01 ± 1.21	8.22 ± 0.94		32
Vespertilionidae	Hypsugo affinis	Hy_affi_1	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Release - Clutter	FM-QCF	66.63 ± 3.88	25.89 ± 0.63	40.74 ± 2.255	30.51 ± 0.45	4.67 ± 0.52	8.72 ± 0.49	10
Vespertilionidae	Hypsugo savii	Hy_savi_1	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Release - Clutter	FM-QCF	82.34	29.2	53.14	42.11	2.75	19.32	1
Vespertilionidae	Kerivoula crypta	Ke_cryp_1	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	FM	183.3 ± 5.49	92.1 ± 6.81	91.2 ± 6.15	132.2 ± 20.18	1.7 ± 0.58	53.65 ± 0	88
Vespertilionidae	Kerivoula kachinensis	Ke_kach_1	Saikia et al. 2020	2020	LC	India	Meghalaya	Anabat Walkabout	Hand-held	FM	212.7 ± 18	84 ± 2.7	128.7 ± 10.35	109.2 ± 1.3	3.3 ± 0.4	39 ± 0.88	10
Vespertilionidae	Kerivoula picta	Ke_pict_1	Sripathi et al. 2006	2006	NT	India	Tamil Nadu	Ultrasound Advice SM2	Flight - Open	FM	140.21 ± 14.13	103.57 ± 14.86	36.64 ± 14.5	115.81 ± 14.81	0.58 ± 0.18	63.17 ± 80.56	74
Megadermatidae	Lyroderma lyra	Ly_lyra_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	ME	116.15 ± 4.31	33.7 ± 0.14	82.45 ± 2.225	45.8 ± 1.4	0.8 ± 0.28	103.06 ± 0.01	2
Megadermatidae	Lyroderma lyra	Ly_lyra_10	Present study	2025	LC	India	Telangana	D500X	Flight - Clutter	ME	99 ± 9.94	34 ± 1.41	65 ± 9.01	43.15 ± 0.93	1.87 ± 0.18	34.76 ± 5.56	13
Megadermatidae	Lyroderma lyra	Ly_lyra_11	Present study	2025	LC	India	Telangana	D500X	Release - Clutter	ME	99 ± 9.94	34 ± 1.41	65 ± 9.01	43.15 ± 0.93	1.87 ± 0.18	34.76 ± 5.56	13
Megadermatidae	Lyroderma lyra	Ly_lyra_2	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Open	ME	34.9 ± 0.17	25.06 ± 0.51	9.84 ± 0.34	31.9 ± 0.75	3.86 ± 0.15	2.55 ± 2.27	3

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Megadermatidae	Lyroderma lyra	Ly_lyra_3	ChiroVox	2023	LC	Bangladesh	Rajshahi Division	D1000X	Flight - Clutter	ME	76.01 ± 16.27	36.82 ± 2.29	39.19 ± 16.07	41.35 ± 1.04	1.86 ± 0.30	21.07 ± 53.57	67
Megadermatidae	Lyroderma lyra	Ly_lyra_4	ChiroVox	2023	LC	Bangladesh	Sylhet Division	D1000X	Flight - Clutter	ME	81.91 ± 12.37	37.39 ± 3.75	44.51 ± 11.77	44.26 ± 2.49	2.09 ± 0.34	21.3 ± 34.62	72
Megadermatidae	Lyroderma lyra	Ly_lyra_5	ChiroVox	2023	LC	Bangladesh	Chittagong Division	D1000X	Release - Clutter	ME	72.33 ± 14.07	36.17 ± 1.72	36.16 ± 14.35	43.35 ± 0.83	3 ± 0.39	12.05 ± 14.75	6
Megadermatidae	Lyroderma lyra	Ly_lyra_6	Singh & Sharma 2023	2023	LC	India	Uttarakhand	Echometer Touch 2	Flight - Clutter	ME	108.2 ± 2.51	30.76 ± 1.37	77.44 ± 1.94	50.29 ± 9.18	0.9 ± 0.85	86.04 ± 0.02	20
Megadermatidae	Lyroderma lyra	Ly_lyra_7	Present study	2025	LC	India	Karnataka	D500X	Flight - Clutter	ME	89.17 ± 7.21	33.28 ± 1.97	55.89 ± 7.26	43.02 ± 1.74	2.65 ± 0.57	21.09 ± 12.74	36
Megadermatidae	Lyroderma lyra	Ly_lyra_8	Present study	2025	LC	India	Maharashtra	D500X	Flight - Clutter	ME	79.62 ± 18.65	26.77 ± 9.86	52.85 ± 18.05	43.86 ± 2.78	2.7 ± 0.79	19.57 ± 0.1	30
Megadermatidae	Lyroderma lyra	Ly_lyra_9	Present study	2025	LC	India	Odisha	D500X	Flight - Clutter	ME	93.25 ± 11.13	32.25 ± 3.65	61 ± 11.07	45.34 ± 4.31	1.58 ± 0.38	38.61 ± 18.42	20
Vespertilionidae	Megaderma spasma	Me_spas_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	ME	106.6 ± 5.3	30.2 ± 8.3	76.4 ± 6.8	69.2 ± 9.4	1 ± 1	76.4 ± 6.8	3
Megadermatidae	Megaderma spasma	Me_spas_2	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	ME	99.79 ± 12.37	38.87 ± 2.3	60.92 ± 7.34	55.9 ± 12.3	2.06 ± 0.32	29.57 ± 22.94	5
Megadermatidae	Megaderma spasma	Me_spas_3	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	D500X	Release - Open	ME	67.03 ± 1.86	14.9 ± 0.68	52.13 ± 1.27	21.87 ± 2.36	3.77 ± 0.39	13.83 ± 3.26	21
Megadermatidae	Megaderma spasma	Me_spas_4	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	ME	114.5 ± 5.78	35.8 ± 0.76	78.7 ± 3.27	56 ± 12.04	1.1 ± 0.37	71.55 ± 0.01	26
Megadermatidae	Megaderma spasma	Me_spas_5	Present study	2025	LC	India	Karnataka	D500X	Flight - Clutter	ME	89.02 ± 12.73	35.12 ± 4.64	53.91 ± 12.88	50.05 ± 7.25	1.99 ± 0.46	27.09 ± 6.26	43
Miniopteridae	Miniopterus fuliginosus	Mi_fuli_1	Chakravarty et al. 2020	2020	NA	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	88.9 ± 10	47 ± 2.2	41.9 ± 6.1	53.1 ± 1.3	3.8 ± 0.8	11.03 ± 7.63	11
Vespertilionidae	Mirostrellus joffrei	Mi_joff_1	Chakravarty et al. 2020	2020	DD	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	70.5	33.9	36.6	43.8	2.1	17.43	1
Vespertilionidae	Mirostrellus joffrei	Mi_joff_2	Saikia & Chakravarty 2024	2024	DD	India	Mizoram	Anabat Walkabout	Flight - Clutter	FM-QCF	45.07 ± 5.36	27.61 ± 0.27	17.46 ± 2.815	29.78 ± 0.48	9.08 ± 0.93	1.92 ± 0.88	15
Miniopteridae	Miniopterus magnater	Mi_magn_1	Saikia et al. 2020	2020	LC	India	Meghalaya	Anabat Walkabout	Flight - Open	FM	117.6 ± 6.7	39 ± 0.7	78.6 ± 3.7	46.5 ± 1.5	4.9 ± 0.7	16.04 ± 5.29	10
Miniopteridae	Miniopterus phillipsi	Mi_phil_1	Wordley et al. 2014	2014	NA	India	Tamil Nadu	D500X	Release - Clutter	FM	93.67 ± 13.86	48.29 ± 1.32	45.38 ± 7.59	52.03 ± 1.92	4 ± 1.03	11.34 ± 7.37	31
Miniopteridae	Miniopterus phillipsi	Mi_phil_2	Srinivasulu & Srinivasulu 2017	2017	NA	India	Kerala	D500X	Release - Open	FM	97.61 ± 10.35	45.8 ± 2.13	51.81 ± 6.24	53.19 ± 1.65	4.08 ± 1.03	12.7 ± 208	9
Miniopteridae	Miniopterus phillipsi	Mi_phil_3	Kusuminda et al. 2022	2022	NA	Sri Lanka	Uva	M500	Flight - Clutter	FM				52.8 ± 0.72			15
Miniopteridae	Miniopterus phillipsi	Mi_phil_4	Present study	2025	NA	India	Maharashtra	D500X	Flight - Clutter	FM	94.32 ± 18.47	45.65 ± 1.09	48.67 ± 18.44	52.35 ± 1.62	5.63 ± 1.36	8.64 ± 23.44	27
Miniopteridae	Miniopterus phillipsi	Mi_phil_6	Present study	2025	NA	India	Kerala	D500X	Release - Clutter	FM	97.62 ± 10.35	45.81 ± 2.14	51.81 ± 9.88	53.19 ± 1.66	4.08 ± 1.03	12.7 ± 329.33	26
Miniopteridae	Miniopterus srinii	Mi_srin_1	Wordley et al. 2014	2014	NA	India	Tamil Nadu	D500X	Release - Clutter	FM	110.92 ± 10.16	58.12 ± 1.98	52.8 ± 6.07	64.13 ± 3.19	3.66 ± 1.33	14.43 ± 0.21	4
Miniopteridae	Miniopterus srinii	Mi_srin_2	Raman & Hughes 2020	2020	NA	India	Kerala	M500-384	Flight - Open	FM	129.6 ± 7.3	57.9 ± 2.01	71.7 ± 4.66	67.8 ± 3.56	3 ± 0.94	23.9 ± 4.96	532

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Miniopteridae	Miniopterus srinii	Mi_srin_3	Srinivasulu & Srinivasulu 2023	2023	NA	India	Karnataka	D500X	Release - Open	FM	130 ± 11.16	58.38 ± 1.43	71.62 ± 6.3	77.62 ± 7.98	4.18 ± 1.16	17.13 ± 39.38	230
Miniopteridae	Miniopterus srinii	Mi_srin_4	Present study	2025	NA	India	Karnataka	D500X	Flight - Clutter	FM	134.8 ± 28.19	48.96 ± 8.6	85.84 ± 26.09	74.62 ± 8.28	5.88 ± 1.84	14.6 ± 7.25	25
Miniopteridae	Miniopterus srinii	Mi_srin_5	Present study	2025	NA	India	Karnataka	D500X	Release - Clutter	FM	131.98 ± 23.05	53.02 ± 8.16	78.95 ± 22.71	73.28 ± 7.59	6.18 ± 1.91	12.78 ± 2.98	43
Molossidae	Mops plicatus	Mo_plic_1	Deshpande & Kelkar 2015	2015	LC	India	Kerala	D240X	Flight - Open	LMH	35.88 ± 6.36	19.76 ± 2.91	16.12 ± 4.64	23.65 ± 3.08	12.31 ± 4.03	1.31 ± 1.15	54
Molossidae	Mops plicatus	Mo_plic_2	Deshpande & Kelkar 2015	2015	LC	India	Maharashtra	D240X	Flight - Open	LMH	35.88 ± 6.36	19.76 ± 2.91	16.12 ± 4.64	23.65 ± 3.08	12.31 ± 4.03	1.31 ± 1.15	54
Molossidae	Mops plicatus	Mo_plic_3	Kusuminda & Yapa 2017	2017	LC	Sri Lanka	Central	M500	Flight - Open	LMH	39.7 ± 1.15	17.8 ± 0.57	21.9 ± 0.86	27.6 ± 1.35	7.7 ± 0.75	2.84 ± 0.01	10
Vespertilionidae	Murina aurata	Mu_aura_1	Chakravarty et al. 2020	2020	DD	India	Uttarakhand	Anabat Walkabout	Release - Clutter	FM	111.7	80.6	31.1	97.2	0.8	38.88	1
Vespertilionidae	Murina aurata	Mu_aura_2	Saikia et al. 2025	2025	DD	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	FM	159.8 ± 6.7	51.74 ± 11.74	108.06 ± 9.22	88.91 ± 6.68	3.44 ± 2.34	31.41 ± 27.12	10
Vespertilionidae	Murina cyclotis	Mu_cycl_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	FM	135.5	49.5	86	89.2	1.4	#VALUE!	1
Vespertilionidae	Murina cyclotis	Mu_cycl_2	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Clutter	FM	120.1	68.8	51.3	95.4	1.8	28.5	1
Vespertilionidae	Murina huttoni	Mu_hutt_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Clutter	FM	107.5 ± 10.45	63.8 ± 10.28	43.7 ± 10.37	83 ± 17.13	1.2 ± 0.09	36.42 ± 0.04	2
Vespertilionidae	Murina huttoni	Mu_hutt_2	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	FM	117.5	49.82	67.68	62.82	2	33.84	1
Vespertilionidae	Murina leucogaster	Mu_leuc_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	98.9	59.3	39.6	69.3	0.9	44	1
Vespertilionidae	Myotis annectans	My_anne_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	61.3 ± 10.09	36.22 ± 0.96	25.08 ± 5.53	41.91 ± 0.55	3.33 ± 0.91	7.53 ± 6.08	3
Vespertilionidae	Myotis annectans	My_anne_2	Saikia & Chakravarty 2024	2024	LC	India	Mizoram	Anabat Walkabout	Flight - Clutter	FM	68.69 ± 7.79	32.27 ± 1.1	36.42 ± 4.445	35.74 ± 2.02	7.24 ± 1.96	5.03 ± 0.46	15
Vespertilionidae	Myotis blythii	My_blyt_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	51.4	18.5	32.9	35.4	2.1	15.67	1
Vespertilionidae	Myotis formosus	My_form_1	Rai et al. 2021	2021	NT	Nepal	Bagmati	SM4BAT	Release - Clutter	FM	108.89 ± 3.12	36.77 ± 1.23	72.12 ± 2.175	44.6 ± 3.28	3.73 ± 0.65	19.34 ± 0.27	13
Vespertilionidae	Myotis himalaicus	My_hima_1	Chakravarty et al. 2020	2020	NA	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	96.8 ± 3.15	47.9 ± 3.13	48.9 ± 3.14	68 ± 3.86	2.52 ± 0.17	19.4 ± 0.82	4
Vespertilionidae	Myotis himalaicus	My_hima_2	Saikia et al. 2025	2025	NA	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	FM	82.26 ± 6.69	35.28 ± 1.91	46.98 ± 4.3	40.16 ± 2.62	5.69 ± 1.77	8.26 ± 5.58	36
Vespertilionidae	Myotis horsfieldii	My_hors_1	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	FM	91.23 ± 15.27	41.6 ± 2.65	49.63 ± 8.96	53.8 ± 5.14	2.57 ± 0.6	19.31 ± 14.93	59
Vespertilionidae	Myotis horsfieldii	My_hors_2	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	D500X	Flight - Open	FM	104.29 ± 5.13	42.28 ± 4.29	62.01 ± 4.71	64.77 ± 3.91	3.27 ± 0.49	18.96 ± 9.61	34
Vespertilionidae	Myotis horsfieldii	My_hors_3	Present study	2025	LC	India	Andaman & Nicobar Islands	D240X	Flight - Clutter	FM	97.3 ± 26.17	49.35 ± 4.47	47.96 ± 30.18	56.76 ± 1.99	3.93 ± 1.17	12.2 ± 1.06	23
Vespertilionidae	Myotis horsfieldii	My_hors_4	Present study	2025	LC	India	Andaman & Nicobar Islands	D500X	Flight - Clutter	FM	94.49 ± 23	45.06 ± 12.09	49.43 ± 29.03	57.81 ± 2.41	5.57 ± 3.47	8.87 ± 19.21	35

Family	Species	Observation ID	Source	Year	IUCN Status	Country	Region	Detector	Recording Condition	Sonotype	HF	LF	B	FMAXE	D	SR	N
Vespertilionidae	Myotis horsfieldii	My_hors_5	Present study	2025	LC	India	Karnataka	D500X	Flight - Clutter	FM	99.52 ± 7.02	42.52 ± 1.74	57 ± 7.69	58.7 ± 4.96	2.43 ± 0.37	23.46 ± 24.32	46
Vespertilionidae	Myotis longipes	My_long_1	Chakravarty et al. 2020	2020	DD	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	98.4 ± 11.79	60.6 ± 3.6	37.8 ± 7.7	70 ± 2.46	2.9 ± 0.37	13.03 ± 0.21	10
Vespertilionidae	Myotis montivagus	My_mont_1	Wordley et al. 2014	2014	DD	India	Tamil Nadu	D500X	Release - Clutter	FM	81.23 ± 14.67	44.95 ± 1.37	36.28 ± 8.02	49.9 ± 2.09	2.57 ± 0.57	14.12 ± 14.07	3
Vespertilionidae	Myotis montivagus	My_mont_2	Saikia & Chakravarty 2024	2024	DD	India	Mizoram	Anabat Walkabout	Flight - Clutter	FM	95.01 ± 4.52	43.23 ± 1.01	51.78 ± 2.765	50.1 ± 3.12	2.6 ± 0.26	19.92 ± 0.03	15
Vespertilionidae	Myotis muricola	My_muri_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	104.7 ± 2.09	47.8 ± 3.66	56.9 ± 2.88	51.9 ± 2.51	4 ± 0.5	14.22 ± 5.76	2
Vespertilionidae	Myotis muricola	My_muri_2	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	FM	110.11	43.37	66.74	55.17	3	22.25	1
Vespertilionidae	Myotis nipalensis	My_nipa_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	112.1	59.9	52.2	67.3	2.4	21.75	1
Vespertilionidae	Myotis peytoni	My_peyt_1	Srinivasulu & Srinivasulu 2017	2017	DD	India	Kerala	D500X	Release - Open	FM	84.37 ± 1.18	40.62 ± 1.18	43.75 ± 1.18	48.53 ± 0.68	3.58 ± 0.26	12.22 ± 4.54	8
Vespertilionidae	Myotis peytoni	My_peyt_2	Raman & Hughes 2020	2020	DD	India	Kerala	M500-384	Flight - Open	FM	88.9 ± 7.37	39.9 ± 1.38	49. ± 4.38	48.5 ± 1.31	2.9 ± 0.92	16.9 ± 0.41	54
Vespertilionidae	Myotis peytoni	My_peyt_3	Present study	2025	DD	India	Karnataka	Anabat SD1	Flight - Clutter	FM	82.88 ± 7.16	44.42 ± 2.33	38.47 ± 6.29	47.75 ± 3.29	2.37 ± 0.53	16.23 ± 11.87	20
Vespertilionidae	Myotis peytoni	My_peyt_4	Present study	2025	DD	India	Karnataka	D500X	Release - Clutter	FM	86.58 ± 9.76	38.92 ± 1.08	47.67 ± 9.13	50.14 ± 1.91	2.85 ± 0.63	16.73 ± 14.49	12
Vespertilionidae	Myotis peytoni	My_peyt_5	Present study	2025	DD	India	Karnataka	Anabat SD1	Release - Clutter	FM	82.43 ± 7.06	44.18 ± 2.14	38.25 ± 6.39	47.29 ± 2.63	2.41 ± 0.52	15.87 ± 12.29	19
Vespertilionidae	Myotis peytoni	My_peyt_6	Present study	2025	DD	India	Kerala	D500X	Release - Clutter	FM	84.57 ± 1.13	40.86 ± 1.07	43.71 ± 1.38	48.54 ± 0.74	3.53 ± 0.23	12.38 ± 6	7
Vespertilionidae	Myotis pilosus	My_pilo_1	Saikia et al. 2020	2020	VU	India	Meghalaya	Anabat Walkabout	Flight - Open	FM	60.7 ± 4.4	29.8 ± 1	30.9 ± 2.7	34.9 ± 0.7	6.9 ± 0.5	4.48 ± 5.4	10
Vespertilionidae	Myotis sicarius	My_sica_1	Saikia et al. 2025	2025	VU	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	FM	71.96	33.14	38.82	37.41	5.12	7.58	1
Vespertilionidae	Nyctalus leisleri	Ny_leis_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	58.7 ± 9.09	27.4 ± 2.24	31.3 ± 5.67	34.2 ± 1.72	3.4 ± 0.84	9.21 ± 0.01	9
Vespertilionidae	Nyctalus leisleri	Ny_leis_2	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Open	FM-QCF	52.95 ± 9.34	24.35 ± 2.04	28.6 ± 5.69	27.3 ± 2.32	11.56 ± 2.8	2.47 ± 0.25	5
Vespertilionidae	Nyctalus montanus	Ny_mont_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	47.5 ± 7.93	21.9 ± 2.69	25.6 ± 5.31	28.4 ± 1.15	3 ± 1	8.53 ± 5.31	5
Vespertilionidae	Nyctalus noctula	Ny_noct_1	Rai et al. 2021	2021	LC	Nepal	Bagmati	SM4BAT	Release - Clutter	FM-QCF	35.64 ± 1.67	19.4 ± 0.55	16.24 ± 1.11	22.92 ± 0.77	12.35 ± 1.97	1.31 ± 0.56	2
Molossidae	Otomops wroughtoni	Ot_wrou_1	Ruedi et al. 2014	2014	DD	India	Meghalaya	D240X	Flight - Clutter	LMH	18.5	12.4	6.1	15.3	3	2.03	1
Molossidae	Otomops wroughtoni	Ot_wrou_2	Deshpande & Kelkar 2015	2015	DD	India	Karnataka	D240X	Flight - Clutter	LMH	24.9 ± 2.31	13 ± 0.98	11.9 ± 1.65	16.15 ± 0.93	11.97 ± 4.3	0.99 ± 0.38	310
Molossidae	Otomops wroughtoni	Ot_wrou_3	Deshpande & Kelkar 2015	2015	DD	India	Karnataka	D240X	Flight - Open	LMH	21.5 ± 3.05	12.76 ± 0.99	8.74 ± 2.02	15.12 ± 0.65	23.09 ± 2.5	0.38 ± 0.01	46
Vespertilionidae	Phoniscus jagorii	Ph_jago_1	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	FM	140.8 ± 4.14	80.7 ± 2.79	60.1 ± 3.47	113.7 ± 4.86	1.3 ± 0.15	46.23 ± 0.03	8

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Vespertilionidae	Phoniscus jagorii	Ph_jago_2	Raman et al. 2020	2020	LC	India	Kerala	M500-384	Release - Clutter	FM	140.88 ± 4.14	80.75 ± 2.79	60.13 ± 3.47	113.79 ± 4.86	1.39 ± 0.15	43.26 ± 23.13	15
Vespertilionidae	Pipistrellus babu	Pi_babu_1	Saikia et al. 2025	2025	NA	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	FM-QCF	82.26 ± 6.69	35.28 ± 1.91	46.98 ± 4.3	40.16 ± 2.62	5.69 ± 1.77	8.26 ± 5.58	36
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	FM-QCF	101.7 ± 2	32.8 ± 0.4	68.9 ± 1.2	44 ± 4	1.4 ± 0.4	49.21 ± 3	4
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_10	Present study	2025	LC	India	Telangana	SM3BAT	Flight - Open	FM-QCF	47.94 ± 6.89	32.53 ± 1.13	15.4 ± 6.28	35.39 ± 1.21	9.18 ± 1.43	1.68 ± 0.65	41
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_2	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Open	FM-QCF	60.8 ± 11.5	35.1 ± 6	25.7 ± 8.75	37.8 ± 8.4	8.6 ± 1.5	2.99 ± 1.5	3
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_3	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	FM-QCF	59.45 ± 9.11	35.57 ± 1.62	23.88 ± 5.37	38.64 ± 1.99	2.57 ± 0.6	9.29 ± 8.95	23
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_4	Kusuminda et al. 2017	2017	LC	Sri Lanka	Central	M500	Flight - Open	FM-QCF	64.88 ± 7.28	31.96 ± 0.73	32.92 ± 4	37.21 ± 0.66	9.04 ± 0.98	36.41 ± 4.08	25
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_5	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Clutter	FM-QCF	67 ± 10.05	36.9 ± 0.9	30.1 ± 5.48	41.4 ± 1.51	4.3 ± 1.93	7 ± 0.01	21
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_6	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Clutter	FM-QCF	77.6 ± 1.08	34.7 ± 0.27	42.9 ± 0.68	42.3 ± 2.43	2.5 ± 0.37	17.16 ± 0.02	9
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_7	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	FM-QCF	46.5 ± 4.51	36.63 ± 1.97	9.87 ± 3.24	38.09 ± 1.94	7.72 ± 1.13	1.28 ± 1.85	40
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_8	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Open	FM-QCF	43.84 ± 5.81	34.9 ± 3.11	8.94 ± 4.46	35.46 ± 3.24	8.7 ± 1.45	1.03 ± 0.01	79
Vespertilionidae	Pipistrellus ceylonicus	Pi_ceyl_9	Present study	2025	LC	India	Telangana	Anabat SD1	Flight - Open	FM-QCF	46.57 ± 6.43	25.72 ± 10.37	20.86 ± 11.77	34.78 ± 1.56	7.68 ± 5.12	2.72 ± 14.75	184
Vespertilionidae	Pipistrellus coromandra	Pi_coro_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	FM-QCF	122.8 ± 3.9	38.8 ± 3	84 ± 3.45	50.2 ± 3.6	1.6 ± 0.4	52.5 ± 12.5	6
Vespertilionidae	Pipistrellus coromandra	Pi_coro_2	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	D500X	Release - Clutter	FM-QCF	57.78 ± 1.82	40.73 ± 0.96	17.05 ± 1.39	42.35 ± 0.86	5.86 ± 0.31	2.91 ± 4.48	12
Vespertilionidae	Pipistrellus coromandra	Pi_coro_3	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	FM-QCF	95.5 ± 13.18	49.8 ± 1.97	45.7 ± 7.58	65.7 ± 6.59	1.1 ± 0.36	41.55 ± 0.02	12
Vespertilionidae	Pipistrellus javanicus	Pi_java_1	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	D500X	Release - Open	FM-QCF	74.49 ± 5.64	39.71 ± 0.92	34.78 ± 3.28	43.64 ± 0.65	4.56 ± 0.57	7.63 ± 5.75	28
Vespertilionidae	Pipistrellus javanicus	Pi_java_2	Present study	2025	LC	India	Andaman & Nicobar Islands	D500X	Flight - Open	FM-QCF	60.63 ± 9.15	42.17 ± 2.16	18.46 ± 9.45	42.56 ± 2.17	1.14 ± 0.62	16.19 ± 15.24	27
Vespertilionidae	Pipistrellus tenuis	Pi_tenu_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	95 ± 5.94	49.6 ± 0.41	45.4 ± 3.18	54.6 ± 1.75	3.4 ± 0.91	13.35 ± 0	2
Vespertilionidae	Pipistrellus tenuis	Pi_tenu_2	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Open	FM-QCF	55.16 ± 3.83	48.96 ± 1.28	6.2 ± 2.555	49.8 ± 1.42	7.84 ± 1.27	0.79 ± 203.7	79
Vespertilionidae	Pipistrellus tenuis	Pi_tenu_3	Present study	2025	LC	India	Karnataka	D500X	Flight - Open	FM-QCF	72.28 ± 9.57	48.22 ± 0.88	24.06 ± 9.21	51.65 ± 1.06	6.61 ± 1.33	3.64 ± 27.91	18
Vespertilionidae	Pipistrellus tenuis	Pi_tenu_4	Present study	2025	LC	India	Telangana	D500X	Flight - Open	FM-QCF	74.58 ± 2.06	47.08 ± 0.28	27.5 ± 2.11	50.93 ± 0.48	6.03 ± 1.13	4.56 ± 0.85	24
Vespertilionidae	Pipistrellus tenuis	Pi_tenu_5	Present study	2025	LC	India	Telangana	Anabat SD1	Flight - Open	FM-QCF	59.99 ± 8.41	40.41 ± 17.25	19.58 ± 20.97	50.35 ± 1.89	5.65 ± 3.36	3.47 ± 2.69	242
Vespertilionidae	Plecotus homochrous	Pl_homo_1	Chakravarty et al. 2020	2020	DD	India	Uttarakhand	Anabat Walkabout	Release - Open	PL	37 ± 7.45	27 ± 9.89	10 ± 8.67	31.3 ± 7.12	1.9 ± 1.39	5.26 ± 0.18	4

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Vespertilionidae	Plecotus wardi	Pl_ward_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	PL	40 ± 2.69	26.9 ± 1.79	13.1 ± 2.24	31.3 ± 1.72	1.8 ± 0.39	7.28 ± 0.01	4
Rhinolophidae	Rhinolophus affinis	Rh_affi_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Hand-held	LCF				88 ± 0.3	24.3 ± 7.2		7
Rhinolophidae	Rhinolophus affinis	Rh_affi_2	Saikia & Chakravarty 2024	2024	LC	India	Mizoram	Anabat Walkabout	Flight - Clutter	LCF				88.79 ± 0.2	46.08 ± 5.2		15
Rhinolophidae	Rhinolophus affinis	Rh_affi_3	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	LCF				79.65	46		1
Rhinolophidae	Rhinolophus andamanensis	Rh_anda_1	Srinivasulu et al. 2017	2017	NA	India	Andaman & Nicobar Islands	D500X	Release - Open	LCF				57.65 ± 0.56	46.63 ± 8.59		156
Rhinolophidae	Rhinolophus andamanensis	Rh_anda_2	Present study	2025	NA	India	Andaman & Nicobar Islands	D500X	Flight - Clutter	LCF				57.29 ± 0.64	46.43 ± 9.9		95
Rhinolophidae	Rhinolophus andamanensis	Rh_anda_3	Present study	2025	NA	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	LCF				57.68 ± 1.19	34.52 ± 8.18		44
Rhinolophidae	Rhinolophus andamanensis	Rh_anda_4	Present study	2025	NA	India	Andaman & Nicobar Islands	D500X	Flight - Open	LCF				57.16 ± 1.14	40.5 ± 13.61		22
Rhinolophidae	Rhinolophus andamanensis	Rh_anda_5	Present study	2025	NA	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Open	LCF				57.68 ± 1.19	34.52 ± 8.18		44
Rhinolophidae	Rhinolophus andamanensis	Rh_anda_6	Present study	2025	NA	India	Andaman & Nicobar Islands	D500X	Release - Open	LCF				57.9 ± 0.07	43.85 ± 1.82		13
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	LCF				38.6 ± 0.14	53.1 ± 6.3		2
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_10	Present study	2025	LC	India	Karnataka	Anabat SD1	Flight - Clutter	LCF				42.12 ± 0.15	37.07 ± 11.37		28
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_11	Present study	2025	LC	India	Kerala	SM3BAT	Flight - Clutter	LCF				42.89 ± 0.09	59.63 ± 6.71		30
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_2	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	LCF				42.81 ± 0.53	47.7 ± 13.62		2
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_3	Srinivasulu et al. 2015	2015	LC	India	Karnataka	Anabat SD1	Hand-held	LCF				43.37 ± 0.28	92.94 ± 24.26		20
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_4	Srinivasulu et al. 2015	2015	LC	India	Karnataka	Anabat SD1	Hand-held	LCF				41.07 ± 3.34	92.26 ± 8.7		12
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_5	Kusuminda et al. 2019	2019	LC	Sri Lanka	Central, Northwestern, Sabaragamuwa, Uva	M500	Hand-held	LCF				52.7 ± 0.2	56.2 ± 3.3		4
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_6	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	LCF				43.5 ± 0.87	65.2 ± 8.93		62
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_7	Sail & Borkar 2024	2024	LC	India	Goa	Echometer Touch 2	Flight - Clutter	LCF				41 ± 0.01	84.11 ± 7.6		20
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_8	Present study	2025	LC	India	Andhra Pradesh	M500	Flight - Clutter	LCF				41.71 ± 0.06	92.85 ± 21.25		41
Rhinolophidae	Rhinolophus beddomei	Rh_bedd_9	Present study	2025	LC	India	Karnataka	D500X	Flight - Clutter	LCF				38.91 ± 1.11	63.39 ± 14		58
Rhinolophidae	Rhinolophus cognatus	Rh_cogn_1	Srinivasulu et al. 2017	2017	EN	India	Andaman & Nicobar Islands	D500X	Hand-held	LCF				89.92 ± 1.5	53.08 ± 9.38		37

Family	Species	Observation ID	Source	Year	IUCN Status	Country	Region	Detector	Recording Condition	Sonotype	HF	LF	B	FMAXE	D	SR	N
Rhinolophidae	Rhinolophus cognatus	Rh_cogn_2	Present study	2025	EN	India	Andaman & Nicobar Islands	D500X	Flight - Clutter	LCF				89.34 ± 1.86	49.17 ± 5.54		46
Rhinolophidae	Rhinolophus cognatus	Rh_cogn_3	Present study	2025	EN	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	LCF				84.55 ± 3.54	17.3 ± 6.29		40
Rhinopomatidae	Rhinopoma hardwickii	Rh_hard_1	Srinivasulu & Srinivasulu 2017	2017	LC	India	Kerala	D500X	Release - Open	LMH	37.05 ± 0.46	26.66 ± 0.94	10.39 ± 0.7	32.48 ± 0.75	2.21 ± 0.44	4.7 ± 1.59	12
Rhinopomatidae	Rhinopoma hardwickii	Rh_hard_2	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	LMH	34.52 ± 2.4	28.23 ± 3.58	6.29 ± 2.99	31.32 ± 0.93	3.86 ± 1.48	1.63 ± 2.06	58
Rhinopomatidae	Rhinopoma hardwickii	Rh_hard_3	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Clutter	LMH	34.54 ± 2.45	27.84 ± 0.64	6.7 ± 1.545	31.32 ± 0.95	3.74 ± 1.49	1.79 ± 0.37	55
Rhinopomatidae	Rhinopoma hardwickii	Rh_hard_4	Present study	2025	LC	India	Andhra Pradesh	M500	Flight - Clutter	LMH	59.25 ± 17.8	28.95 ± 1.86	30.31 ± 18.96	33.2 ± 0.87	1.76 ± 0.41	17.22 ± 21.85	59
Rhinopomatidae	Rhinopoma hardwickii	Rh_hard_5	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Clutter	LMH	80.79 ± 15.11	24.59 ± 6.87	56.2 ± 12.56	33.04 ± 0.44	4.5 ± 0.58	12.49 ± 0.01	23
Rhinopomatidae	Rhinopoma hardwickii	Rh_hard_6	Present study	2025	LC	India	Kerala	D500X	Flight - Clutter	LMH	47.59 ± 20.89	26.68 ± 2.32	20.92 ± 21.27	32.56 ± 0.88	2.47 ± 0.74	8.47 ± 1.72	64
Rhinopomatidae	Rhinopoma hardwickii	Rh_hard_7	Present study	2025	LC	India	Kerala	SM3BAT	Flight - Clutter	LMH	91.56 ± 10	26.89 ± 1.96	64.67 ± 11.48	33.02 ± 0.62	2.96 ± 0.83	21.85 ± 1.78	9
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_1	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	LCF				95.2 ± 1.4	32.2 ± 9.4		5
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_10	Present study	2025	LC	India	Gujarat	SM3BAT	Release - Open	LCF				104.98 ± 0.11	38.18 ± 6.4		11
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_11	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	LCF				100	24.42		1
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_2	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	LCF				102.31 ± 1.81	25.23 ± 11.38		35
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_3	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Hand-held	LCF				106.3 ± 4.3	30.2 ± 11.8		3
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_4	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	LCF				102.5 ± 1.82	30.1 ± 11.74		369
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_5	ChiroVox	2023	LC	Bangladesh	Rajshahi Division	D1000X	Flight - Open	LCF				109.2 ± 1.96	31.78 ± 12.69		82
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_6	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Clutter	LCF				104.95 ± 0.09	42.12 ± 7.08		41
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_7	Present study	2025	LC	India	Madhya Pradesh	Echometer Touch 2 Pro	Flight - Clutter	LCF				102.69 ± 1.78	36.09 ± 10.29		70
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_8	Present study	2025	LC	India	Maharashtra	SM3BAT	Flight - Clutter	LCF				97.64 ± 0.83	43.14 ± 13.53		50
Rhinolophidae	Rhinolophus lepidus	Rh_lepi_9	Present study	2025	LC	India	Odisha	D500X	Flight - Clutter	LCF				98.77 ± 1.47	49.76 ± 6.97		40
Rhinolophidae	Rhinolophus macrotis	Rh_macr_1	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	LCF				62.36	18		1
Rhinopomatidae	Rhinopoma microphyllum	Rh_micr_1	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	LMH	31.45 ± 1.11	25.18 ± 1.42	6.27 ± 1.27	29.03 ± 0.89	4.21 ± 1.25	1.49 ± 1.08	51
Rhinopomatidae	Rhinopoma microphyllum	Rh_micr_2	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Clutter	LMH	64.94 ± 12.45	22.86 ± 4.6	42.07 ± 12.17	28.79 ± 1.71	6.32 ± 2.14	6.66 ± 15.5	45

Family	Species	Observation ID	Source	Year	IUCN Status	Country	Region	Detector	Recording Condition	Sonotype	HF	LF	B	FMAXE	D	SR	N
Rhinopomatidae	Rhinopoma microphyllum	Rh_micr_3	Present study	2025	LC	India	Madhya Pradesh	SM3BAT	Flight - Clutter	LMH	53.94 ± 9.1	20.06 ± 5.93	33.89 ± 11.19	28.4 ± 0.81	3.24 ± 0.59	10.46 ± 2.02	16
Rhinopomatidae	Rhinopoma microphyllum	Rh_micr_4	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Open	LMH	64.94 ± 12.45	22.86 ± 4.6	42.07 ± 12.17	28.79 ± 1.71	6.32 ± 2.14	6.66 ± 15.5	45
Rhinolophidae	Rhinolophus pearsonii	Rh_pear_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Hand-held	LCF				61.25 ± 0.3	42.5 ± 5.1		4
Rhinolophidae	Rhinolophus pearsonii	Rh_pear_2	Rai et al. 2021	2021	LC	Nepal	Bagmati	SM4BAT	Release - Clutter	LCF				59.93 ± 0.02	25.72 ± 0.63		24
Rhinolophidae	Rhinolophus perniger	Rh_pern_1	Chakravarty et al. 2020	2020	NA	India	Uttarakhand	Anabat Walkabout	Hand-held	LCF				31.3	82.2		1
Rhinolophidae	Rhinolophus perniger	Rh_pern_2	Present study	2025	NA	India	Madhya Pradesh	Echometer Touch 2 Pro	Flight - Clutter	LCF				36.08 ± 0.08	54.58 ± 5.62		60
Rhinolophidae	Rhinolophus perniger	Rh_pern_3	Saikia et al. 2025	2025	NA	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	LCF				31.06	36		1
Rhinolophidae	Rhinolophus pusillus	Rh_pusi_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Hand-held	LCF				111.5	28.6		1
Rhinolophidae	Rhinolophus pusillus	Rh_pusi_2	ChiroVox	2023	LC	Bangladesh	Chittagong Division	D1000X	Hand-held	LCF				101.76 ± 0.04	35.32 ± 1.77		56
Rhinolophidae	Rhinolophus rouxii	Rh_roux_1	Chattopadhyay et al. 2010	2010	LC	India	Tamil Nadu	D1000X	Hand-held	LCF				93.9 ± 0.5	46.1 ± 8.9		621
Rhinolophidae	Rhinolophus rouxii	Rh_roux_10	Present study	2025	LC	India	Kerala	SM3BAT	Flight - Clutter	LCF				93.24 ± 0.1	24.71 ± 9.82		21
Rhinolophidae	Rhinolophus rouxii	Rh_roux_11	Present study	2025	LC	India	Maharashtra	SM3BAT	Flight - Clutter	LCF				80.89 ± 0.03	65 ± 4.62		39
Rhinolophidae	Rhinolophus rouxii	Rh_roux_12	Present study	2025	LC	India	Karnataka	D500X	Release - Clutter	LCF				81.56 ± 0.25	54.38 ± 10.1		40
Rhinolophidae	Rhinolophus rouxii	Rh_roux_2	Chattopadhyay et al. 2012	2012	LC	India	Karnataka	D1000X	Hand-held	LCF				82.1 ± 0.84	42.7 ± 9.84		45
Rhinolophidae	Rhinolophus rouxii	Rh_roux_3	Chattopadhyay et al. 2012	2012	LC	India	Tamil Nadu	D1000X	Hand-held	LCF				94.14 ± 0.37	41.51 ± 5.25		52
Rhinolophidae	Rhinolophus rouxii	Rh_roux_4	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	LCF				80 ± 0.1	41.4 ± 10.2		6
Rhinolophidae	Rhinolophus rouxii	Rh_roux_5	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	LCF				92.08 ± 1.06	24.44 ± 12.1		41
Rhinolophidae	Rhinolophus rouxii	Rh_roux_6	Kusuminda et al. 2019	2019	LC	Sri Lanka	Central, Northwestern, Sabaragamuwa, Uva	M500	Hand-held	LCF				74 ± 1.1	54.9 ± 6.9		19
Rhinolophidae	Rhinolophus rouxii	Rh_roux_7	Raman & Hughes 2020	2020	LC	India	Kerala	M500-384	Flight - Open	LCF				81.6 ± 1.7	34.6 ± 13.8		161
Rhinolophidae	Rhinolophus rouxii	Rh_roux_8	Present study	2025	LC	India	Karnataka	D500X	Flight - Clutter	LCF				81.56 ± 0.25	54.38 ± 10.1		40
Rhinolophidae	Rhinolophus rouxii	Rh_roux_9	Present study	2025	LC	India	Kerala	D500X	Flight - Clutter	LCF				91.48 ± 1.43	26.74 ± 12.14		74
Rhinolophidae	Rhinolophus sinicus	Rh_sini_1	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Hand-held	LCF				87.9	42.1		1

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Rhinolophidae	Rhinolophus sinicus	Rh_sini_2	Rai et al. 2021	2021	LC	Nepal	Bagmati	SM4BAT	Release - Clutter	LCF				83.78 ± 3.55	31.57 ± 7.39		66
Rhinolophidae	Rhinolophus sinicus	Rh_sini_3	Saikia et al. 2025	2025	LC	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	LCF				86.91	33		1
Vespertilionidae	Scotophilus heathii	Sc_heat_1	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	FM-QCF	60.12 ± 5.21	37.65 ± 1.12	22.47 ± 3.17	41.2 ± 1.87	2.4 ± 0.54	9.36 ± 0.06	16
Vespertilionidae	Scotophilus heathii	Sc_heat_2	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	FM-QCF	52.5 ± 15.28	34.1 ± 2.22	18.4 ± 8.75	37.9 ± 4.74	6.7 ± 3.77	2.75 ± 0.01	3
Vespertilionidae	Scotophilus heathii	Sc_heat_3	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	FM-QCF	55.89 ± 8.68	35.13 ± 3.4	20.76 ± 6.04	37.42 ± 3.89	3.1 ± 0.9	6.7 ± 6.71	12
Vespertilionidae	Scotophilus heathii	Sc_heat_4	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Open	FM-QCF	50.48 ± 7.2	41.83 ± 5.33	8.65 ± 6.265	43.24 ± 4.96	7.08 ± 3.34	1.22 ± 779.41	30
Vespertilionidae	Scotophilus heathii	Sc_heat_5	ChiroVox	2023	LC	Bangladesh	Rajshahi Division	D1000X	Flight - Clutter	FM-QCF	61.3 ± 7.18	33.7 ± 2.44	27.6 ± 8.14	41.5 ± 1.69	3.30 ± 0.99	8.36 ± 8.22	146
Vespertilionidae	Scotophilus heathii	Sc_heat_6	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Clutter	FM-QCF	69.73 ± 13.9	34.19 ± 3.89	35.55 ± 12.33	39.07 ± 4.2	17.09 ± 12.41	2.08 ± 0.97	66
Vespertilionidae	Scotophilus heathii	Sc_heat_7	Present study	2025	LC	India	Telangana	Anabat SD1	Flight - Clutter	FM-QCF	68.29 ± 5.95	32.7 ± 12.54	35.59 ± 14.78	41.02 ± 3.58	2.05 ± 2.14	17.36 ± 34.14	141
Vespertilionidae	Scotophilus heathii	Sc_heat_8	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Open	FM-QCF	62.55 ± 8.6	30.48 ± 2.99	32.07 ± 7.44	34.61 ± 2.35	30.57 ± 6.44	1.05 ± 1.16	28
Vespertilionidae	Scotophilus kuhlii	Sc_kuhl_1	Javid et al. 2014	2014	LC	Pakistan	Punjab	D1000X	Flight - Clutter	FM-QCF	103.5 ± 12.3	50.6 ± 1	52.9 ± 6.65	56.9 ± 3.6	2.5 ± 0.5	21.16 ± 13.3	25
Vespertilionidae	Scotophilus kuhlii	Sc_kuhl_2	Raghuram et al. 2014	2014	LC	India	Karnataka	D980	Flight - Clutter	FM-QCF	117.4 ± 9.2	41 ± 0.6	76.4 ± 4.9	52.8 ± 4.6	8.2 ± 0.5	9.32 ± 9.8	3
Vespertilionidae	Scotophilus kuhlii	Sc_kuhl_3	Wordley et al. 2014	2014	LC	India	Tamil Nadu	D500X	Release - Clutter	FM-QCF	56.67 ± 2.06	43.53 ± 0.76	13.14 ± 1.41	45.26 ± 0.77	2.96 ± 0.38	4.44 ± 3.71	2
Vespertilionidae	Scotophilus kuhlii	Sc_kuhl_4	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Open	FM-QCF	50.52 ± 2.32	47.27 ± 1.09	3.25 ± 1.705	48.17 ± 1.68	8.85 ± 1.43	0.37 ± 1639.53	64
Vespertilionidae	Scotophilus kuhlii	Sc_kuhl_5	ChiroVox	2023	LC	Bangladesh	Rajshahi Division	D1000X	Flight - Clutter	FM-QCF	73.5 ± 11.1	37.2 ± 2.93	36.4 ± 12.00	46.8 ± 2.54	3.36 ± 0.57	10.83 ± 21.05	174
Vespertilionidae	Scotophilus kuhlii	Sc_kuhl_6	Present study	2025	LC	India	Madhya Pradesh	SM3BAT	Flight - Clutter	FM-QCF	66.28 ± 3.6	41.2 ± 1.73	25.09 ± 3.93	44.45 ± 1.41	10.91 ± 2.13	2.3 ± 1.85	33
Vespertilionidae	Submyotodon caliginosus	Su_cali_1	Chakravarty et al. 2020	2020	NA	India	Uttarakhand	Anabat Walkabout	Release - Open	FM	96.3	46.8	49.5	60.3	3	16.5	1
Vespertilionidae	Submyotodon caliginosus	Su_cali_2	Saikia et al. 2025	2025	NA	India	Himachal Pradesh	Anabat Walkabout	Flight - Clutter	FM	115.01	53.6	61.41	58.28	5.62	10.93	1
Molossidae	Tadarida aegyptiaca	Ta_aegy_1	Deshpande & Kelkar 2015	2015	LC	India	Karnataka	D240X	Flight - Open	LMH	24.44 ± 4.86	16.67 ± 2.67	7.77 ± 3.77	19.44 ± 2.31	15.5 ± 4.86	0.5 ± 0.9	120
Molossidae	Tadarida aegyptiaca	Ta_aegy_2	Deshpande & Kelkar 2015	2015	LC	India	Kerala	D240X	Flight - Open	LMH	24.44 ± 4.86	16.67 ± 2.67	7.77 ± 3.77	19.44 ± 2.31	15.5 ± 4.86	0.5 ± 0.9	120
Molossidae	Tadarida aegyptiaca	Ta_aegy_3	Deshpande & Kelkar 2015	2015	LC	India	Maharashtra	D240X	Flight - Open	LMH	24.44 ± 4.86	16.67 ± 2.67	7.77 ± 3.77	19.44 ± 2.31	15.5 ± 4.86	0.5 ± 0.9	120
Molossidae	Tadarida aegyptiaca	Ta_aegy_4	Present study	2025	LC	India	Telangana	D500X	Flight - Clutter	LMH	28.11 ± 2.62	16.56 ± 1.13	11.56 ± 2.4	20.59 ± 1.54	14.82 ± 2.62	0.78 ± 0.92	9
Molossidae	Tadarida aegyptiaca	Ta_aegy_5	Present study	2025	LC	India	Andhra Pradesh	D500X	Flight - Open	LMH	26.29 ± 0.65	17.56 ± 0.39	8.73 ± 0.59	19.81 ± 0.61	14.88 ± 2.36	0.59 ± 0.25	8

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Molossidae	Tadarida aegyptiaca	Ta_aegy_6	Present study	2025	LC	India	Telangana	D500X	Flight - Open	LMH	27.53 ± 2.47	16.79 ± 1.06	10.74 ± 2.53	20.29 ± 1.42	15.37 ± 2.59	0.7 ± 0.98	12
Molossidae	Tadarida aegyptiaca	Ta_aegy_7	Present study	2025	LC	India	Telangana	SM3BAT	Flight - Open	LMH	26.58 ± 0.63	17.6 ± 0.49	8.98 ± 0.54	20.06 ± 0.64	13.6 ± 1.52	0.66 ± 1.04	5
Molossidae	Tadarida insignis	Ta_insi_1	Deshpande & Kelkar 2015	2015	LC	India	Bihar, Kerala	D240X	Flight - Open	LMH	14.29 ± 3.39	10.11 ± 1.29	4.18 ± 2.34	12.47 ± 1.28	19.5 ± 12.92	0.21 ± 0.37	67
Molossidae	Tadarida insignis	Ta_insi_2	Chakravarty 2017	2017	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	LMH	23.8 ± 4.3	12.7 ± 0.9	11.1 ± 2.6	14.9 ± 0.73	12.8 ± 2.3	0.87 ± 1.13	34
Molossidae	Tadarida insignis	Ta_insi_3	Chakravarty et al. 2020	2020	LC	India	Uttarakhand	Anabat Walkabout	Release - Open	LMH	31.6 ± 2.27	9.9 ± 1.01	21.7 ± 1.64	15.6 ± 0.58	8.4 ± 1.24	2.58 ± 0.03	6
Molossidae	Tadarida insignis	Ta_insi_4	Sharma et al. 2021	2021	LC	Nepal	Gandaki	Echometer Touch 2	Flight - Open	LMH	16.2 ± 2.1	10.9 ± 0.9	5.3 ± 1.5	13	20.7 ± 1	0.25 ± 1.5	420
Emballonuridae	Taphozous longimanus	Ta_long_1	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	LMH	32.85 ± 0.87	25.25 ± 1.32	7.6 ± 1.1	30.35 ± 1.07	3.98 ± 0.74	1.91 ± 0.14	15
Emballonuridae	Taphozous longimanus	Ta_long_2	Present study	2025	LC	India	Gujarat	M500	Flight - Clutter	LMH	33.41 ± 1.28	25.07 ± 1.18	8.34 ± 1.94	30 ± 1.08	4.48 ± 1.03	1.86 ± 31.33	22
Emballonuridae	Taphozous longimanus	Ta_long_3	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Clutter	LMH	34.63 ± 1.16	24.7 ± 0.53	9.93 ± 1.12	29.23 ± 0.45	5.54 ± 0.62	1.79 ± 0.19	7
Emballonuridae	Taphozous melanopogon	Ta_mela_1	Srinivasulu et al. 2017	2017	LC	India	Andaman & Nicobar Islands	Anabat SD1	Release - Open	LMH	34.01 ± 0.54	26.47 ± 0.95	7.54 ± 0.75	28.16 ± 1.7	3.33 ± 0.75	2.26 ± 1	18
Emballonuridae	Taphozous melanopogon	Ta_mela_2	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	LMH	31.33 ± 1.04	22.72 ± 1.42	8.61 ± 1.23	27.5 ± 0.52	6.01 ± 1.44	1.43 ± 0.52	42
Emballonuridae	Taphozous melanopogon	Ta_mela_3	Devender & Srinivasulu 2022	2022	LC	India	Telangana	SM3BAT	Flight - Open	LMH	25.05 ± 2.77	19.33 ± 1.56	5.72 ± 2.165	20.68 ± 1.3	11.67 ± 1.52	0.49 ± 108.55	79
Emballonuridae	Taphozous melanopogon	Ta_mela_4	Present study	2025	LC	India	Andaman & Nicobar Islands	D240X	Flight - Clutter	LMH	34.5 ± 2.87	26.17 ± 3.53	8.33 ± 5.28	32.42 ± 1.85	10.83 ± 4.8	0.77 ± 0.06	24
Emballonuridae	Taphozous melanopogon	Ta_mela_5	Present study	2025	LC	India	Andaman & Nicobar Islands	D500X	Flight - Clutter	LMH	30.08 ± 3.13	24.67 ± 1.58	5.42 ± 2.93	26.82 ± 1.57	18.33 ± 5.81	0.3 ± 0.16	24
Emballonuridae	Taphozous melanopogon	Ta_mela_6	Present study	2025	LC	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	LMH	32.92 ± 2.35	25.45 ± 2.14	7.46 ± 1.45	26.83 ± 3	4.35 ± 2.07	1.71 ± 6.43	46
Emballonuridae	Taphozous melanopogon	Ta_mela_7	Present study	2025	LC	India	Karnataka	D500X	Flight - Clutter	LMH	37.57 ± 7.26	20.43 ± 1.51	17.13 ± 6.58	27.87 ± 1.62	5.41 ± 1.71	3.17 ± 9.27	60
Emballonuridae	Taphozous nudiventris	Ta_nudi_1	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	LMH	31.2 ± 1.04	23.39 ± 1.16	7.81 ± 1.1	27.55 ± 0.65	6.19 ± 1.53	1.26 ± 2.08	35
Emballonuridae	Taphozous nudiventris	Ta_nudi_2	Shah & Srinivasulu 2020	2020	LC	India	Gujarat	SM3BAT	Release - Open	LMH	28.25 ± 0.87	23.48 ± 0.85	4.77 ± 0.86	26.16 ± 0.46	6.35 ± 1.59	0.75 ± 1.46	35
Emballonuridae	Taphozous nudiventris	Ta_nudi_3	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Clutter	LMH	42.34 ± 8.48	17.94 ± 5.59	24.39 ± 11.06	42.39 ± 62.03	7.11 ± 1.77	3.43 ± 1.38	16
Emballonuridae	Taphozous nudiventris	Ta_nudi_4	Present study	2025	LC	India	Maharashtra	SM3BAT	Flight - Clutter	LMH	40.66 ± 9.25	19.81 ± 4.11	20.84 ± 10.77	25.64 ± 0.41	8.63 ± 1.98	2.41 ± 0.79	25
Emballonuridae	Taphozous nudiventris	Ta_nudi_5	Present study	2025	LC	India	Gujarat	SM3BAT	Flight - Open	LMH	31.16 ± 0.91	21.91 ± 0.43	9.25 ± 1.01	25.61 ± 0.5	9.46 ± 0.65	0.98 ± 0.02	8
Emballonuridae	Taphozous perforatus	Ta_perf_1	Mahmood-ul-Hassan et al. 2012	2012	LC	Pakistan	Punjab	D1000X	Release - Clutter	LMH	31.4 ± 0.7	25.6 ± 0.5	5.8 ± 0.6	30 ± 0.4	14.2 ± 2.7	0.41 ± 0.22	15

Family	Species	Observation ID	Source	Year	IUCN Status	Country	Region	Detector	Recording Condition	Sonotype	HF	LF	B	FMAXE	D	SR	N
Vespertilionidae	Tylonycteris fulvida	Ty_fulv_1	Raman & Hughes 2020	2020	NA	India	Kerala	M500-384	Flight - Open	FM-QCF	132.1 ± 2	60.5 ± 1.7	71.6 ± 1.85	72.8 ± 0.79	1.1 ± 0.08	65.09 ± 0.11	7
Vespertilionidae	Tylonycteris malayana	Ty_mala_1	Srinivasulu et al. 2017	2017	NA	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Open	FM-QCF	89.28 ± 8.99	39.14 ± 2.06	50.14 ± 5.53	42.12 ± 3.92	1.88 ± 0.65	26.67 ± 8.51	54
Vespertilionidae	Tylonycteris malayana	Ty_mala_2	Present study	2025	NA	India	Andaman & Nicobar Islands	Anabat SD1	Flight - Clutter	FM-QCF	89.28 ± 9	39.14 ± 2.06	50.14 ± 9.04	42.12 ± 3.93	1.89 ± 0.65	26.53 ± 13.91	54
Vespertilionidae	Tylonycteris malayana	Ty_mala_3	Present study	2025	NA	India	Andaman & Nicobar Islands	D500X	Flight - Open	FM-QCF	89.28 ± 9	39.14 ± 2.06	50.14 ± 9.04	42.12 ± 3.93	1.89 ± 0.65	26.53 ± 13.91	54

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Author contributions: AS led the conceptualisation, methodology, investigation, formal analysis, data curation, visualisation, writing, and funding acquisition for the study. CS and BS contributed to conceptualisation, investigation, data curation, and writing. DS contributed to methodology, validation, writing, and supervision. MGS contributed to conceptualisation, methodology, formal analysis, visualisation, writing, and funding acquisition.

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

Print copies of the Journal are available at cost. Write to:
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Journal of Threatened Taxa

www.threatenedtaxa.org

OPEN ACCESS

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

November 2025 | Vol. 17 | No. 11 | Pages: 27787–28010
Date of Publication: 26 November 2025 (Online & Print)
DOI: 10.11609/jott.2025.17.11.27787-28010

Articles

Communications

Short Communications

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