ORIGINALL ARTICLE

New geographic record of Peters’s Trumpet-eared Bat *Phoniscus jagorii* (Peters, 1866) from India

Sreehari Raman¹,²,³,* Akhil Padmarajan⁴, Liju Thomas⁵, Arya Sidharthan⁵, Alice C. Hughes⁶,²,⁶,*

¹ Center for Integrative Conservation, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglin, Mengla, Yunnan Province, 666303, PR China.
² University of Chinese Academy of Sciences, Beijing 100049, PR China.
³ Department of Wildlife Sciences, College of Forestry, Kerala Agricultural University, KAU P.O. (680656), Vellanikkara, Thrissur, Kerala, India.
⁴ Rani Bhavan, Muttappalam, Perumugzhi P.O., Chirayinkeezhu, 695305, Thiruvananthapuram, Kerala, India.
⁵ School of Ocean Science and Technology, Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi, Kerala, India.
⁶ Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences, Menglin, Mengla, Yunnan, 666303, PR China.
*Corresponding author: ach_conservation2@hotmail.com
DOI: https://doi.org/10.14709/BarbJ.13.1.2020.12

Keywords: Chiroptera, echolocation, new record, Vespertilionidae, Western Ghats

received: January, 6th 2020
accepted: July, 31st 2020

INTRODUCTION

The genus * Phoniscus* includes *Phoniscus atrox*, *P. papuensis*, *P. jagorii* and *P. aerosa* (Hill 1965, Corbet & Hill 1992, Simmons & Cirranello 2020). *Phoniscus* was previously classified within the genus *Kerivoula* owing to their morphological similarity and long woolly fur (Gray 1842, Miller 1905). Hill (1965) separated *Phoniscus* from *Kerivoula* due to differences in the shape of the tragus, fur and dental morphology. The group is largely distributed in Southeast Asia (SEA), except *P. aerosa* which is known from South Africa and *P. papuensis* from Papua and the eastern coast of Australia.

*Phoniscus jagorii* has characteristic four-banded hairs with dark grey base followed by buff band, dark brown, and golden tips along with shiny yellow hairs across the body, forearm and fingers (Hill 1965, Corbet & Hill 1992). The species inhabits lowland rainforest, as well as dry dipterocarp and semi-evergreen forests (Oo et al. 2019). The previously known range of this species was limited to SEA, including both the mainland and the Malayan archipelago (Simmons 2005, Thong et al. 2006, Francis 2008, Oo et al. 2019 – Fig. 1). Later, a road-killed specimen of this species was collected from Sri Lanka (7.724550°N and 81.212600°E) on 9th August 2015; around 2100 km west of the nearest known range across the Andaman Sea and Bay of Bengal (Edirisinghe et al. 2018).

Here we present a new record of *P. jagorii* from South Asia, the first record from India and the second record outside SEA. We discuss the morphology, vocalisation and the possible colonisation routes that assisted in the movement of the taxon between South Asia and SEA.

MATERIALS AND METHODS

Study area

In the southern Western Ghats (WG), several field surveys were conducted at Nelliyampathy Hills of Nenmara forest division between July 2017 and June 2018. The study area is a reserve forest on the western slopes of the WG (10°25′–10°49′N, 76°26′–76°54′E) with a total extent of 348.86 sq.km. The elevation ranges from 40 m to 1633 m, and majority of the landscape is covered by tropical wet...
evergreen, semi-evergreen, moist deciduous, grasslands, shola forests, and plantations of cardamom, coffee, tea and rubber (Ramachandran & Suganthesakthivel 2010). Recently a comprehensive bat survey was conducted by Wordley et al. 2014, 2015, 2017 in Valparai, which is ~50km from Nelliyampathy Hills and documented 17 bat species. Apart from this study, no detailed bat surveys had previously been undertaken in this region.

Bat sampling and echolocation call recordings

Sampling was carried out at varying elevations using two harp traps of 1.5 m width, 2.2 m height, 7.5 cm between each of four frames, 2.5 cm between vertical monofilament fishing lines for an overall trapping effort of 864 trap hours (6 days × 6 stations × 2 traps × 12 hours) between July 2017 and June 2018. Identification followed available keys (Francis 2008) using standard morphometric measurements and other morphological characters. Echolocation calls were recorded after releasing bats inside a mosquito net made of nylon mesh (dimension of 2 m length × 2 m breadth × 2 m height) using a full spectrum M500-384 ultrasound detector (Pettersson Elektronik AB, frequency range 1–384kHz). Thirty pulses with the highest signal to noise ratio were selected from the recording and nine call parameters such as start frequency (Fstart), end frequency (Fend), call duration (D), Inter-pulse interval (IPI), frequency of maximum energy (FmaxE), Bandwidth (BW) and duty cycle (DC) were measured using BatSound (ver. 3.31, Pettersson Elektronik AB). We calculated mean values and standard deviations of all the nine call parameters. After collecting acoustic data, the individual was euthanised following the standard protocol (Sikes et al. 2011), and the specimen was deposited in the wet collections of the Department of Wildlife Sciences, College of Forestry, Kerala Agricultural University.

DNA sequencing and analysis

DNA was extracted from thigh muscle tissues using the DNeasy Blood and Tissue kit (Qiagen, Hilden, Germany. Catalog No. 69504) following the manufacturer’s protocol. The polymerase chain reaction was performed to amplify the mitochondrial cytochrome oxidase 1 (CO1) gene using the primer pair VF1 and VR1 (Ivanova et al. 2006). COI was used due to the availability of comparable material from other parts of SEA (Francis et al. 2010). PCR amplification was done with a reaction profile of 95°C for 180s; 35 cycles of 94°C for 60s, 55°C for 60s, and 72°C for 60s and finally 72°C for 300s, and the PCR products were outsourced for sequencing. The sequence generated as part of the present study was deposited in GenBank (Accession Number: MN255825). Publicly available COI sequences of P. jagorii (Francis et al. 2010 –HM541207 to HM541216 and HM541206) and Kerivoula lenis (KY034131) were downloaded from NCBI (http://www.ncbi.nlm.nih.gov), and P. atrox (ABBID027, ABBID067) from BOLD (http://www.boldsystems.org) database. Kerivoula lenis (Chiroptera: Vespertilionidae) was used as an outgroup. The integrity of the sequences was checked using BLAST (Altschul et al. 1990). Sequences were aligned using Clustal Omega (https://
www.ebi.ac.uk/Tools/msa/clustalo/ – Madeira et al. 2019), and evolutionary analysis was conducted in MEGA 7 (Kumar et al. 2016). The evolutionary history was inferred by using the Maximum Likelihood method based on the Tamura-Nei model (Tamura & Nei 1993). The tree with the highest log likelihood -1681.14) was generated. The percentage of trees in which the associated taxa clustered together is shown next to the branches. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the Maximum Composite Likelihood (MCL) approach, and then selecting the topology with superior log likelihood value. A discrete Gamma distribution was used to model evolutionary rate differences among sites (5 categories (cn93+G, parameter = 0.3340)). The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 14 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. There were a total of 647 base pairs in the final dataset. Evolutionary analyses were conducted in MEGA7 (Kumar et al. 2016).

### RESULTS

**Morphology**

On 18 July 2017, a single adult female *P. jagorii* was trapped in a harp trap at 2000 h set across a dirt-road passing through an evergreen forest patch at Nelliyampathy hills (10°31’57”N, 76°40’8”E) at an elevation of 679 m (Fig. 1). The body mass of the collected adult female was found to be 7.5 g and standard measurements (in mm) are given in Table 1A. Body hairs appear to have characteristic four colour bands starting from the dark brown or blackish-brown base, followed by buff, then brown, and finally golden or whitish-yellow tips.

**Echolocation calls**

*P. jagorii* emits low DC broadband frequency modulated (FM) calls with an FmaxE of 113.79kHz (Fig. 2). Various echolocation call parameters (mean, standard deviation and range) are given in Table 1B.

### Table 1 - A: External measurements (in mm) of *Phoniscus jagorii* recently collected from Nelliyampathy Hills, southern WG, peninsular India. B: Echolocation call parameters and its Mean ± SD (minimum–maximum). Fstart, Fend and FmaxE are in kHz. D and IPI are in ms. DC is calculated by (D/IPI)x100.

| Variables                              | Measurements (mm) |
|----------------------------------------|-------------------|
| Forearm length                         | 38.2              |
| Head-body length                       | 42.09             |
| Tail                                   | 45.22             |
| Ear                                    | 15.13             |
| Tibia                                  | 16.54             |
| Hindfoot                               | 9.82              |
| Thumb                                  | 12.06             |
| Third metacarpal                       | 34.58             |
| First phalanx of the third metacarpal  | 16.2              |
| Second phalanx of the third metacarpal | 20.71             |
| Fourth metacarpal                      | 33.52             |
| First phalanx of the forth metacarpal  | 12.83             |
| Second phalanx of the forth metacarpal | 11.06             |
| Fifth metacarpal                       | 33.84             |
| First phalanx of the fifth metacarpal  | 11.01             |
| Second phalanx of the fifth metacarpal | 10.28             |
| Wingspan (tip-tip)                    | 290.0             |

| Variables                              | Values             |
|----------------------------------------|--------------------|
| Start frequency (Fstart)               | 140.88 ± 4.14 (134.25–146.34) |
| End frequency (Fend)                   | 80.75 ± 2.79 (78.0–86.08)     |
| Frequency of maximum energy (FmaxE)    | 113.79 ± 4.86 (105.34–120.40) |
| Band width (BW)                        | 60.14 ± 4.49 (53.76–65.29)    |
| Duration (D)                           | 1.39 ± 0.15 (1.22–1.62)       |
| Inter-pulse interval (IPI)             | 15.62 ± 2.13 (11.62–18.07)    |
| Duty cycle (DC)                        | 9.02 ± 1.60 (7.67–11.76)      |
DISCUSSION

The recent discovery of *P. jagorii* in the evergreen forests of WG confirms the presence of this species in peninsular India. The present record is approximately 600 km from the nearest known location in Sri Lanka and 2850 km from the closest populations in mainland SEA (Myanmar) (Oo et al. 2019). The size and external morphology of the individual collected from WG and the Sri Lankan specimen falls within the size range of SEA population (Francis 2008). *P. jagorii* is known to be a low-flyer (Thong et al. 2006), and distributed in primary to moderately disturbed semi-evergreen forest where it has previously been recorded in SEA (Oo et al. 2019). Despite 72 trapping nights in Nenmara forest division, we were only able to record single individual suggesting this species, is a rare species in this region.

**Echolocation calls**

The low duty cycle echolocation calls of *P. jagorii* are similar to the calls produced by Kerivoulinae and Murininae (Kingston et al. 1999, Schmieder et al. 2010, 2012) and are successful in tracking arthropods in the dense rainforest understory (Schnitzler et al. 2003, Schmieder et al. 2010). Echolocation calls can vary geographically within a species (Aspetsberger et al. 2003, Yoshino et al. 2006, Armstrong & Coles 2007, Gillam & McCracken 2007, Chen et al. 2009, Hughes et al. 2010, Wordley et al. 2014, Zhang et al. 2018) and the extent of call variability over a wider geographical area can help to identify cryptic species and evolutionarily significant units (ESUs) that can contribute in conservation planning (Crandall et al. 2000, Davidson-Watts et al. 2006, Bickford et al. 2007, Frankham 2010). However, the
frequency (FmaxE) emitted by the captured individual was within the frequency limit 94.4–124.1kHz that has been previously recorded from its known distribution range (Kingston et al. 1999, Thong et al. 2006, Schmieder et al. 2010, 2012).

Phylogenetic relationship and possible colonisation passages

The affinity of peninsular Indian species with those from the eastern Himalayan or Malayan region has been observed since Hora’s (1949) Satpura hypothesis. The similarity was also validated by various biogeographic studies on different taxa (Karanth 2003, Puri et al. 2016, Garg & Biju 2019). Westward colonisation of Malayan fauna began when the Indian plate joined mainland Eurasia during mid-Eocene, around 45 million years ago (Chapman & Reiss 1992), and the dispersal rate peaked during mid-Miocene (Klaus et al. 2016). The Eastern Himalaya is often considered as a ‘gateway’ that bridges Indian subcontinent with the rest of Asia (Mani 1974). Due to continued changing climatic conditions and tectonic movements, the dispersal rate started decreasing from 14 Mya (Patnaik 2011, Klaus et al. 2016). Few possible passages have been suggested to explain the dispersal of species from the eastern Himalayas to the Western Ghats (Fig.1). ‘Satpura hypothesis’ (Hora 1949) suggested a specific colonisation route through the wet forests of Satpura Hill ranges in central India for species to disperse between the two mountain ranges. Areas that lie to the north of the Satpura range and the ‘Brij area’ may have acted as corridors (Diliger 1952). The Satpura hypothesis has been supported by observations from various freshwater fish species (Hora 1944, Silas 1952, Daniels 2001, Negi et al. 2017), birds (Ali 1949, Srinivasan & Prashanth 2006, Wagh et al. 2011); and certain plants (Jain et al. 2000, Kuttapetty et al. 2014, Sen et al. 2019). However, the hypothesis has been debated due to the relationship with species in peninsular India with Shivalik and western Himalayan species suggesting a possible colonisation route through the Aravalli Hill ranges–‘Medlicott- Blanford theory’ (Medlicott & Blanford 1879, Daniels 2001). Another proposed colonisation route is between Eastern Himalaya and WG through the Eastern Ghats (Abdulali 1949, Mani 1974), and this view is supported by the distribution of 13 bird species (for example, Coprimalagrus atripennis, Alcedo meninting, Merops leschenaultia – Srinivasan & Prashanth 2006). However, in the absence of comprehensive bat surveys from the Aravallis, Satpura Hills, and the Eastern Ghats, it is hard to tell which of the above routes is most likely. P. jagorii might have colonised Sri Lanka from peninsular India when the sea level dropped as a result of global glaciation and drying during the Eocene-Oligocene boundary, i.e., about 34 Mya (Salamy & Zachos 1999, Liu et al. 2009). This may have facilitated the movement of taxa between peninsular India and Sri Lanka (Jacob 1949, Bossuyt et al. 2004, Biswas & Pawar 2006, Meegaskumbura et al. 2019). We, therefore, recommend that intensive surveys be undertaken in potential habitats in peninsular India, followed by comprehensive genetic studies to elucidate the colonisation patterns of bats in India.

CONCLUSION

The recent discovery of P. jagorii in peninsular India shows that there is still much to learn about the species and others in this region. Phylogenetic analysis shows no significant differentiation across its distributional range, indicating the similarities between South Asian population of P. jagorii with that of SEA. We recommend further inventories across the region for a better understanding of the species range, and therefore provide baseline information for the long-term conservation of the elusive species.

ACKNOWLEDGEMENTS

We thank the Kerala Forests and Wildlife Department for granting permit for fieldwork (Order # WL10-14322/2017, 2018). Akhil Das and Mohammed Faizal are acknowledged for their help in the field. We thank Dr. Rajeeve Raghavan for giving permission to access the molecular lab of Kerala University of Fisheries and Ocean Studies. We thank Keerthi Vijayan and Raveendranathanpillai Sanil for helping in phylogenetic analysis; Catharina Karlsson and Krizler C. Tanalgo for their valuable inputs while preparing the manuscript. We are grateful to IDEA WILD for providing bat detector. This project is sponsored by UCAS scholarship for international students. This project is also supported by Chinese National Natural Science Foundation (Grant No. U1602265, Mapping Karst Biodiversity in Yunnan), the Strategic Priority Research Program of the Chinese Academy of Sciences (Grant # XDA20050202), the West Light Talent Program of the Chinese Academy of Sciences (Grant # Y9X011B01), the Chinese Academy of Sciences Southeast Asia Biodiversity Research Center fund (Grant # Y42K111B01) through Landscape Ecology Group, CIC, XTBG.

REFERENCES

ABDULALI, H. (1949). Some peculiarities of avifaunal distribution in peninsular India. Proc. Nat. Inst. Sci. India, 15(8): 387-393.

ALI, S. (1949). The Satpura Trend as an ornithological highway. Proc. Nat. Inst. Sci. India, 15(8): 379-387.

ALTSCHUL, S. F., GISH, W., MILLER, W., MYERS, E. W. & LIPMAN, D. J. (1990). Basic local alignment search tool. Journal of Molecular Biology, 215(3): 403-410. https://doi.org/10.1016/0022-2836(90)90890-3

ARMSTRONG, K. N. & COLES, R. B. (2007). Echolocation call frequency differences between geographic isolates of Rhinoniceris aurantia (Chiroptera: Hipposideridae): implications of nasal chamber size. Journal of Mammalogy, 88(1): 94-104. https://doi.org/10.1644/06-MAMM-A-115R1.1

ASPETSBERGER, F., BRANDSEN, D. & JACOBS, D. S. (2003). Geographic variation in the morphology, echolocation and diet of the little free-tailed bat, Chaerophon pumilus (Molossidae). African Zoology, 38(2): 245-254. https://doi.org/10.1080/15627020.2003.11407278
BICKFORD, D., LOHMAN, D. J., SODHI, N. S., NG, P. K. L., MEIER, R., WINKER, K., INGRAM, K. K. & DAS, I. (2007). Cryptic species as a window on diversity and conservation. *Trends in Ecology & Evolution*, 22(3): 148-155. https://doi.org/10.1016/j.tree.2006.11.004

BISWAS, S. & PAWAR, S. S. (2006). Phylogenetic tests of distribution patterns in South Asia: towards an integrative approach. *J. Biosci.*, 31: 95-113. https://doi.org/10.1007/BF02705240

BOSSUYT, F., MEEGASKUMBURA, M., BEENAERTS, N., GOWER, D. J., PETHIYAGODA, R., ROELANTS, K., MANNAERT, A., WILKINSON, M., BAHIR, M. M., MANAMENDRA-ARACHCHI, K. et al. (2004). Local endemism within the Western Ghats-Sri Lanka biodiversity hotspot. *Science*, 306(5695): 479-481. https://doi.org/10.1126/science.1100167

CHAPMAN, J. L. & REISS, M. J. (1992). Ecology: principles and applications. ed.: Cambridge University Press. Cambridge, New York, United States of America, 294 pp.

CHEN, S.-F., JONES, G. & ROSSITER, S. J. (2009). Determinants of ecolocalization call frequency variation in the Formosan lesser horseshoe bat (*Rhinolophus monoceros*). *Proc. R. Soc. B.*, 276(1674): 3901-3909. https://doi.org/10.1098/rspb.2009.1185

CORBET, G. B. & HILL, J. E. (1992). The mammals of the Indomalayan region: a systematic review. ed.: Oxford University Press. Oxford, United Kingdom, 488 pp.

CRANDALL, K. A., BININDA-EMONDS, O. R. P., MACE, G. M. & WAYNE, R. K. (2000). Considering evolutionary processes in conservation biology. *Trends in Ecology & Evolution*, 15(7): 290-295. https://doi.org/10.1016/S0169-5347(00)01876-0

DANIELS, R. J. R. (2001). Endemic fishes of the Western Ghats and the Satpura hypothesis. *Current Science*, 81(3): 240-244.

DAVIDSON-WATTS, I., WALLS, S. & JONES, G. (2006). Differential habitat selection by *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus* identifies distinct conservation needs for cryptic species of echolocating bats. *Biological Conservation*, 133(1): 118-127. https://doi.org/10.1016/j.biocon.2006.05.027

DILGER, W. C. (1952). The Brij hypothesis as an explanation for the tropical faunal similarities between the Western Ghats and the eastern Himalayas, Assam, Burma, and Malay. *Evolution*, 6(1): 125-127. https://doi.org/10.2307/2405509

EDIRISINGHE, G., SURASINGHE, T., GABADAGE, D., BOTEJUE, M., PERERA, K., MADAWALA, M., WEERAKOON, D. & KARUNARATHNA, S. (2018). Chiropteran diversity in the peripheral areas of the Maduru-Oya National Park in Sri Lanka: insights for conservation and management. *ZooKeys*, 784: 139-162. https://doi.org/10.3897/zookeys.784.25562

FRANCIS, C. M. (2008). A guide to the mammals of Southeast Asia. ed.: Princeton University Press & Oxford. Princeton, New Jersey, United States of America & Oxford, United Kingdom, 392 pp.

FRANCIS, C. M., BORISENKO, A. V., IVANOVA, N. V., EGER, J. L., LIM, B. K., GUILLEN-SERVENT, A., KRUSKOP, S. V., MACKIE, I. & HEBERT, P. D. N. (2010). The role of DNA barcodes in understanding and conservation of mammal diversity in southeast Asia. *PloS One*, 5(9): e12575. https://doi.org/10.1371/journal.pone.0012575

FRANKHAM, R. (2010). Challenges and opportunities of genetic approaches to biological conservation. *Biological Conservation*, 143(9): 1919-1927. https://doi.org/10.1016/j.biocon.2010.05.011

GARG, S. & BIJU, S. D. (2019). New microhydrid frog genus from peninsular India with southeast Asian affinity suggests multiple Cenozoic biotic exchanges between India and Eurasia. *Sci. Rep.*, 9: 1906. https://doi.org/10.1038/s41598-018-38133-x

GILLAM, E. H. & MCCracken, G. F. (2007). Variability in the echolocation of *Tadarida brasiliensis*: effects of geography and local acoustic environment. *Animal Behaviour*, 74(2): 277-286. https://doi.org/10.1016/j.anbehav.2006.12.006

GRAY, J. E. (1842). XXXVII - Description of some new genera and fifty unrecorded species of Mammalia. *Annals and magazine of natural history*, 10(65): 255-267. https://doi.org/10.1080/03745484209445232

HILL, J. E. (1965). Asiatic bats of the genera *Kerivoula* and *Phoniscus* (Vespertilionidae), with a note on *Kerivoula aerosa* Tomes. *Mammalia*, 29(4): 524-556. http://doi.org/10.1515/mamm.1965.29.4.524

HORA, S. L. (1944). On the Malayan affinities of the freshwater fish fauna of Peninsular India and its bearing on the probable age of the Garo-Rajmahal Gap. *Proc. Nat. Inst. Sci. India*, 10: 423-439.

HORA, S. L. (1949). Symposium on the Satpura hypothesis of the distribution of the Malayan fauna and flora to Peninsular India. *Proc. Nat. Inst. Sci. India*, 15(8): 309-314.

HUGHES, A. C., SATASOOK, C., BATES, P. J. J., SOISOOK, P., Srittongchuay, T., Jones, G. & Bumrungsri, S. (2010). Echolocation call analysis and presence-only modelling as conservation monitoring tools for Rhinolophoid bats in Thailand. *Acta Chiropterologica*, 12(2): 311-327. https://doi.org/10.3161/150811010X537891

IVANOVA, N. V., DEWAARD, J. R., SOISOOK, P., Srittongchuay, T., JONES, G. & BUMRUNGSRI, S. (2010). An inexpensive, automation- friendly protocol for recovering high-quality DNA. *Molecular Ecology Notes*, 6(4): 998-1002. https://doi.org/10.1111/j.1471-8286.2006.01428.x

JACOB, K. (1949). Land connections between Ceylon and Peninsular India. *Proc. Nat. Inst. Sci. India*, 15: 341-343.
SILAS, E. G. (1952). Further studies regarding Hora’s Satpura hypothesis. Taxonomic assessment and levels of evolutionary divergences of fishes with the so-called Malayan affinities in peninsular India. Proc. Nat. Inst. Sci. India, 18(5): 423-448.

SIMMONS, N. B. (2005). Order Chiroptera. In: Mammal Species of the World, 3rd edition. ed.: The Johns Hopkins University Press. Baltimore, Maryland, p.312-525.

SIMMONS, N. B. & CIRRANELLO, A. L. (2020). Bat species of the world: a taxonomic and geographic database.

SRINIVASAN, U. & PRASHANTH, N. S. (2006). Preferential routes of bird dispersal to the Western Ghats in India: an explanation for the avifaunal peculiarities of the Biligirirangan Hills. Indian Birds, 2(4): 114-119.

TAMURA, K. & NEI, M. (1993). Estimation of the number of nucleotide substitutions in the control region of mitochondrial DNA in humans and chimpanzees. Molecular Biology and Evolution, 10(3): 512–526. http://doi.org/10.1093/molbev/mgs069

THONG, V. D., BUMRUNGSRI, S., HARRISON, D. L., PEARCH, M. J., HELGEN, K. M. & BATES, P. J. J. (2006). New records of Microchiroptera (Rhinolophidae and Kerivoulineae) from Vietnam and Thailand. Acta Chiropterologica, 8(1): 83-93. https://doi.org/10.3161/1733-5329(2006)8[83:NROMRA]2.0.CO;2

WAGH, G. A., WADATKAR, J. S. & RAJJ, K. (2011). Preferential dispersal of Malabar Pied Hornbill from Himalayas to Western Ghats is through the Satpuda Hills, Central India. The Raffles Bulletin of Zoology, 24: 69-72.

WORDLEY, C. F., FOUI, E. K., MUDAPPA, D., SANKARAN, M. & ALTRINGHAM, J. D. (2014). Acoustic Identification of Bats in the Southern Western Ghats, India. Acta Chiropterologica, 16(1): 213-222. https://doi.org/10.3161/150811014X683408

WORDLEY, C. F., SANKARAN, M., MUDAPPA, D. & ALTRINGHAM, J. D. (2015). Landscape scale habitat suitability modelling of bats in the Western Ghats of India: Bats like something in their tea. Biological Conservation, 191: 529-536. https://doi.org/10.1016/j.biocon.2015.08.005

WORDLEY, C. F. R., SANKARAN, M., MUDAPPA, D. & ALTRINGHAM, J. D. (2017). Bats in the Ghats: Agricultural intensification reduces functional diversity and increases trait filtering in a biodiversity hotspot in India. Biological Conservation, 210(A): 48-55. https://doi.org/10.1016/j.biocon.2017.03.026

YOSHINO, H., MATSUMURA, S., KINJO, K., TAMURA, H., OTA, H. & IZAWA, M. (2006). Geographical variation in echolocation call and body size of the Okinawan least horseshoe bat, Rhinolophus pumilus (Mammalia: Rhinolophidae), on Okinawa-jima Island, Ryukyu Archipelago, Japan. Zoological Science, 23(8): 661-667. http://doi.org/10.2108/zsj.23.661

ZHANG, C., JIANG, T., LU, G., LIN, A., SUN, K., LIU, S. & FENG, J. (2018). Geographical variation in the echolocation calls of bent-winged bats, Miniopterus fuliginosus. Zoology, 131: 36-44. https://doi.org/10.1016/j.zool.2018.05.005