Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

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

COMMUNICATION

TAXONOMIC AND ECOLOGICAL NOTES ON SOME POORLY KNOWN BATS (MAMMALIA: CHIROPTERA) FROM MEGHALAYA, INDIA

Uttam Saikia, Adora Thabah & Manuel Ruedi

26 February 2020 | Vol. 12 | No. 3 | Pages: 15311–15325
DOI: 10.11609/jott.5264.12.3.15311-15325

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 February 2020 | 12(3): 15311–15325
ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)
DOI: https://doi.org/10.11609/jott.5264.12.3.15311-15325
#5264 | Received 23 July 2019 | Final received 18 November 2019 | Finally accepted 11 February 2020
PLATINUM OPEN ACCESS

COMMUNICATION

Taxonomic and ecological notes on some poorly known bats (Mammalia: Chiroptera) from Meghalaya, India

Uttam Saikia [1], Adora Thabah [2] & Manuel Ruedi [3]

[1] Zoological Survey of India, North Eastern Regional Centre, Risa Colony, Shillong, Meghalaya 793003, India.
[2] Solar View Cottage, Upper Mawprem, Shillong, Meghalaya 793002, India.
[3] Department of Mammalogy and Ornithology, Natural History Museum of Geneva, BP 6434, 1211 Geneva 6, Switzerland.
[1] uttamzsi@gmail.com (corresponding author), [2] abatty1@googlemail.com, [3] Manuel.Ruedi@ville-ge.ch

Abstract: The chiropteran diversity of Meghalaya State is very high with 65 reported species. Taxonomic and ecological information on many of these bat species, however, are scant or largely outdated. We reinforce the records on five poorly known bat species in Meghalaya, viz., *Megaerops niphanae*, *Myotis pilosus*, *Kerivoula kachinensis*, *Miniopterus magnater*, & *Miniopterus pusillus*, critically evaluate their taxonomic assignment, and provide detailed morphometric data for further comparisons. For three of these species, we also provide echolocation call data that are reported for the first time in India. Together, these new data highlight the need for a more robust and critical examination of the rich bat fauna existing in the foothills of the Himalaya.

Keywords: Biometrics, Chiroptera, echolocation call.

Abbreviations: ZSIS—Collections of the Zoological Surveys of India, Shillong | Fhi—highest frequency (in kHz) | Flo—lowest frequency (in kHz) | FmaxE—frequency of maximum energy (in kHz).

Editor: Paul Racey, University of Exeter, Cornwall Campus, UK. **Date of publication:** 26 February 2020 (online & print)

Citation: Saikia, U., A. Thabah & M. Ruedi (2020). Taxonomic and ecological notes on some poorly known bats (Mammalia: Chiroptera) from Meghalaya, India. *Journal of Threatened Taxa* 12(3): 15311–15325. https://doi.org/10.11609/jott.5264.12.3.15311-15325

Funding: The work of US is institutionally supported by Zoological Survey of India.

Competing interests: The authors declare no competing interests.

Ethics statement: All animals were handled according to the recommendation of the American Society for Mammalogy. Since bats are not legally protected in India (except for two species which are outside the purview of the present study) and our sampling sites were located outside protected areas, no approval from the state forest department was necessary for specimen collection. We, however, sought verbal approval from the local authorities to conduct this research and collection of vouchers

Author details: Uttam Saikia is working as Scientist-C in Zoological Survey of India, Shillong and is interested in the systematics of the bat fauna of India with special reference to northeastern India. Adora Thabah studied the diversity and ecology of bats in Meghalaya for her PhD thesis. She has worked as a freelance ecologist and now continues to survey these mammals and tries to develop action plan to protect them. Manuel Ruedi is interested in the systematics position and biogeographic origin of bats from the Old World. He uses a combination of morphological and molecular approaches to reconstruct their evolution.

Author contribution: US, MR and AT conducted the field surveys, recorded the calls and identified the specimens. MR analyzed the ultrasounds. US and MR wrote the manuscript.

Acknowledgements: US is thankful to Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata for providing institutional facilities and constant support for small mammalian research. US and MR are also deeply thankful to Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata for facilitating institutional collaboration between ZSI and MHNG, Geneva. Facilities and assistances rendered by the officers-in-charge and staff members of ZSI, Shillong and Solan is also appreciated. Survey permission and logistic supports provided by Meghalaya Forest Department is also thankfully acknowledged. MR and AT express their gratitude to the organizers and participants of the "Caving in the Abode of the Clouds Project", especially the Meghalaya Adventures Association for logistic support and friendship.

INTRODUCTION

A variety of factors like geological age, past and present climatic conditions or unique biogeographic history have shaped the present faunal composition of northeastern India (Pawar et al. 2007). The Meghalaya subtropical forest ecoregion covering the state of Meghalaya and the adjacent areas of Assam is recognized as one of the most species-diverse area in the Indomalayan region (Wikramanayake et al. 2002) with more than 165 species of mammals (Rodgers & Panwar 1988; Das et al. 1995; Saikia et al. 2018); and a total of 162 species of mammals in Meghalaya State (Lyngdoh et al. 2019). Meghalaya harbours numerous caves of which nearly a thousand have been scientifically explored and mapped during the "Caving in the Abode of the Clouds" project (Prokop & Arbenz 2015). Caves serve as a major roosting place for many bat species since they offer a relatively stable microclimate, protect them from unfavourable environmental conditions and reduce predatory pressure (Kunz 1982). Availability of suitable roosts is a critical factor that largely determines diversity and distribution of bats (Kunz 1982; Arita 1993). Thus, the state with abundant caves especially in the limestone belt offers plentiful roosting opportunities for cave roosting bats. Indeed, 65 species of bats have been recorded so far from the state, including several recent discoveries resulting from explorations conducted during the above-mentioned caving project (Ruedi et al. 2012a,b; Saikia et al. 2017, 2018; Thong et al. 2018). Some older records from the state pertain to exceptionally rare species, such as *Eptesicus tatei* or *E. pachyotis* which have hardly been reported again in India since their discovery (Bates & Harrison 1997; Mandal et al. 2000), and several additions to the list emerged from a critical re-examination of vouchered specimens of apparently widespread taxa, such as those in the *Murina cyclotis* group (Ruedi et al. 2012a). Other additions such as *Tylonycteris fulvida* or *T. malayana* (Tu et al. 2017), or *Hypsugo joffrei* (Saikia et al. 2017) emerged from a recent update of their former taxonomic assignation, but a number of other species were only mentioned in diverse reports, without proper taxonomic or biometric description (Ruedi et al. 2012b; Saikia 2018; Saikia et al. 2018). This underscores the need for further data in a number of poorly known bats of Meghalaya with scant information on taxonomy, distribution and ecology. Such information is particularly important in the context of the continued degradation of natural ecosystems in Meghalaya (Sarma & Barik 2011; Swer & Singh 2013). In this communication, we present biometric information for *Megaerops niphanae*, *Myotis pilosus*, *Kerivoula kachinensis*, *Miniopterus magnater*, and *M. pusillus* from Meghalaya and also provide for three of them, a description of their echolocation calls that will aid their further monitoring in the wild.

MATERIALS AND METHODS

Study area

The northeast Indian state of Meghalaya lies within 25.021–26.130 ^{0}N latitude and 89.830–92.802^{0}E longitude and has an area of 22,429km^{2} (Anonymous 2005). Geologically, Meghalaya mostly consists of a stable structural block called the Shillong Plateau, with a maximum height of 1,950m. A sedimentary sequence called the Jaintia group lies to the south of this plateau and is a mixture of limestone, sandstone and coal deposits (Tringham 2012). The state receives a high annual rainfall with an average of 2,689mm in the eastern parts and 7,196mm in central and western Meghalaya (Haridarshan & Rao 1985). Due to high rainfall, the rainwater absorbed into the ground reacts with the limestone and dissolves it, ultimately creating an extensive network of underground drainage systems, including caves. Such caves are developed intermittently along the whole limestone belt of the state and also in sandstone and quartzite areas of southern Meghalaya (Tringham 2012). The state has a recorded forest cover of 76.4% of the total geographic area of which 43.8% consists of very dense and moderately dense forest (Forest Survey of India 2017). The vegetation in the state can be characterised as tropical evergreen forest, tropical semi-evergreen forest, tropical moist and dry deciduous forest, subtropical pine forest, temperate forest, grasslands and savannas (Haridarshan & Rao 1985).

Field sampling

During the course of speleological explorations conducted between 2011–2018 in various parts of Meghalaya by the team of the "Caving in the Abode of the Clouds" project, we captured bats by using a two-bank harp trap or mist nets erected across presumed flight paths. These capture devices were usually placed in front of cave entrances or in the surrounding forests. Captured bats were kept individually in cotton bags, sexed, measured, preliminarily identified (following Bates & Harrison 1997) and photographed before being released in the same place. A few animals were kept for further examination as vouchered specimens.

These animals were euthanized with chloroform vapour and transferred to 70% ethanol for preservation. The preserved carcasses and prepared skulls were later deposited in the collections of the Zoological Survey of India, Shillong (ZSIS). All animals were handled according to the standards recommended by the American Society of Mammalogists (Sikes et al. 2011).

Comparative material consisting of four *Miniopterus fuliginosus* from Himachal Pradesh deposited in the collections of the Zoological Survey of India was also examined. Standard sets of external and craniodental measurements were obtained with digital callipers accurate to the nearest 0.1 and 0.01 mm, respectively. The baculum of the male specimen of *Myotis pilosus* was prepared by macerating the dissected penis in 6% KOH solution and stained with Alizarin Red S (Topal 1958). The prepared baculum was measured and photographed under a stereo zoom microscope with 40–50 x magnification and using the software Leica Application Suite, Version 3.

The acronyms for measurements are: tail length (T), ear length (E), tragus length (Tr), hindfoot length, including claw (HF c.u), forearm length (FA), tibia length (Tb), greatest length of skull including incisors (GTLi) and excluding incisors (GTL), condylobasal length (CBL), condylocanine length (CCL), maxillary toothrow length (CM^3), width across third molars (M^3M^3), width across canines (C^1C^1), zygomatic breadth (ZB), postorbital constriction (POC), breadth of braincase (BB), mastoid breadth (MAB), length of mandible including incisors (MLi) and excluding incisors (ML), mandibular toothrow length (CM_3), and coronoid height (COH). These measurements generally follow definitions by Bates & Harrison (1997).

Bioacoustics

For three of the species (*Myotis pilosus, Miniopterus magnater* and *Kerivoula kachinensis*), we recorded echolocation calls while individuals were either flying free in front of the cave just prior to capture (former two species), or while the animal was held in the hand (latter species). Recordings were done with an Anabat Walkabout bat detector (Titley Scientific, UK) working at a sampling rate of 500kHz. The calls were later analyzed on spectrograms generated with the program BatSound Pro v4.2.1 (Pettersson Elektronik, Upsala, Sweden), using a FFT hanning window size set at 1024 samples. For each call the following parameter were measured: frequency of maximum energy (FmaxE, expressed in kHz) and duration of the pulse (in ms); highest (Fhi) and lowest frequency (Flo) of the pulse (expressed in kHz); and interpulse duration (in ms). For each recording (one per species), statistics were calculated based on a sequence of 10 pulses characterized by a high signal to noise ratio.

RESULTS

Systematic account

***Megaerops niphanae* Yenbutra & Felton, 1983**
Ratanaworabhan's Fruit Bat

New material: One adult female, ZSIS-455, 17.ii.2018, Kyrshai (25.840^{0}N, 91.322^{0}E; 100m), West Khasi Hills.

Description and taxonomic notes: A relatively small species of pteropodid bat with a characteristic short and broad muzzle with slightly tubular nostrils (inset of Image 1). The ears have no white markings and the species has a very short tail. It is the largest among the four species known under the Indo-Chinese genus *Megaerops* (Mandal et al. 1993). The fur of the captured individuals was soft, greyish-brown dorso-ventrally. The ears, wings and interfemoral membranes were light brown. The small tail of about 11mm was entirely enclosed within the interfemoral membrane. The larger size (FA > 60.0mm) and the presence of a short internal tail are diagnostic characters distinguishing it from *M. ecaudatus* (Yenbutra & Felton 1983) which possibly is also distributed in the eastern parts of northeastern India (see Discussion).

Craniodental characters: The skull rises gradually to the midpoint almost in a straight line before descending sharply and in dorsal view the rostrum appears squarish in outline (Image 1). There is a wide interorbital groove and the spine-like projections come out from the orbital margins. The second upper incisor is reduced and only one incisor is present in each hemi-mandible. The upper canine is strong and curved inward. The first upper premolar is minute. Only one molar in the upper jaw and two in the lower jaw are present. Skull measurements of the female ZSIS-455 are given in Table 1 and confirm that the species is much larger than the other species in the genus *Megaerops* (e.g., GTL 29.0mm).

Ecological notes: A prepubertal female and an adult female in non-reproductive state were caught in mist nets placed in a secondary forest with bamboos in Kharkhana area of East Jaintia Hills during mid-February 2014. Both animals were photographed and released on the spot. Another female was caught in a harp trap set in the Kyrshai area, the West Khasi Hills, Meghalaya, in February 2018 and retained as a voucher specimen (ZSIS-

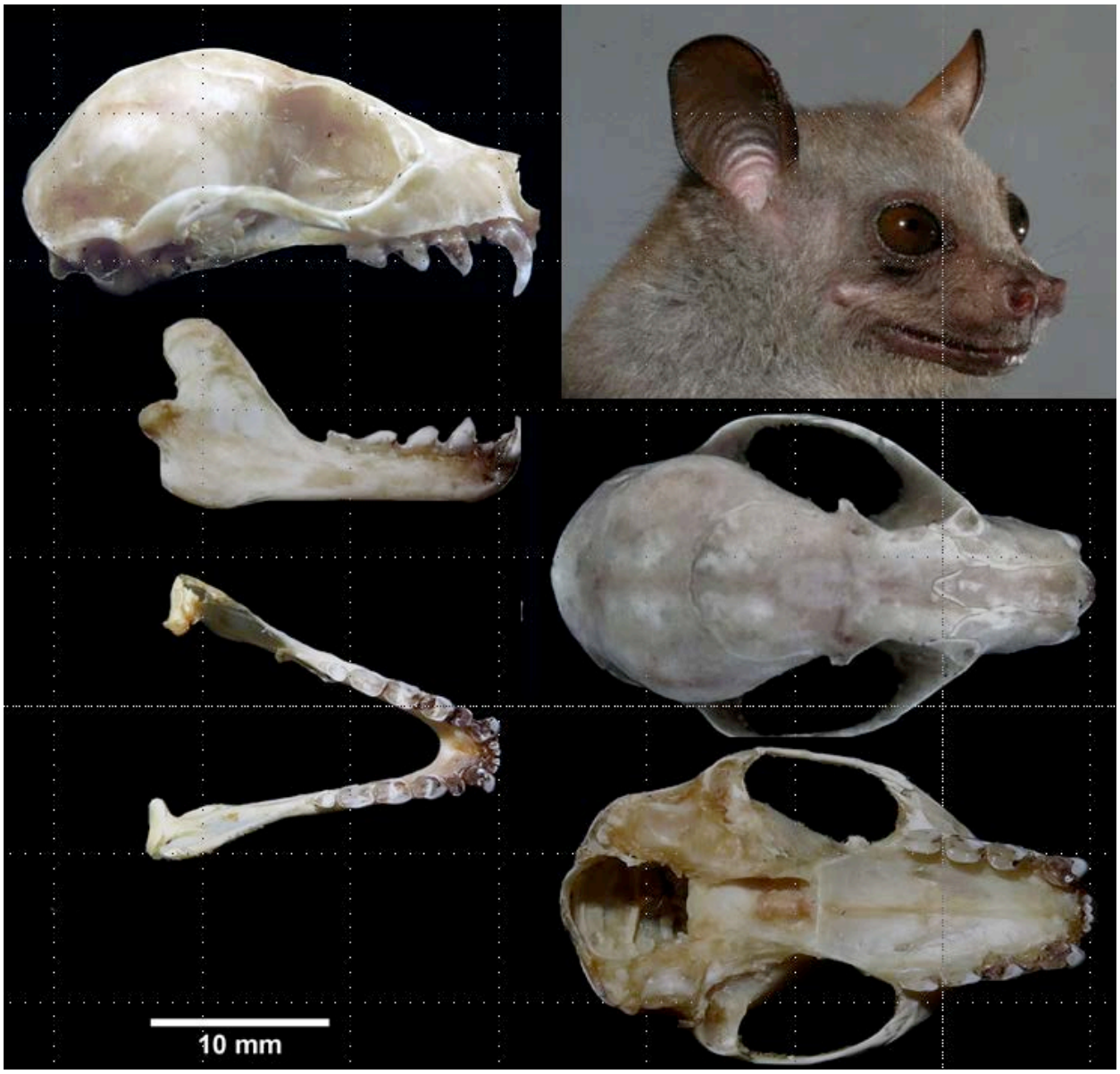

Image 1. Dorsal, ventral & lateral view of cranium and lateral & ventral view of mandible of *Megaerops niphanae* (specimen ZSIS-455). The inset illustrates a live specimen captured and released in Kharkhana, Jaintia Hills, Meghalaya. © U. Saikia & M. Ruedi (inset).

455). The animal was caught in the vicinity of a village and other bats, presumably from the same species were seen feeding on a fig tree *Ficus racemosa* on the bank of river Khri (Kulsi). The village is surrounded by mixed deciduous forests. The Kyrshai specimen did not show any apparent sign of pregnancy or lactation. In Thailand, this species is found at 140–240 m in a variety of habitats including pristine tropical forest and farmland adjacent to forests (Bates et al. 2008b). In Bangladesh, this bat was recorded in an orchard in a heavily urbanized area (Islam et al. 2015).

***Myotis pilosus* (Peters, 1869)**

Rickett's Big-footed Myotis

New material: One male, 28.ii.2015, ZSIS-396, Phlang Karuh Cave (25.188^{0}N, 91.618^{0}E; 80m), Shella, East Khasi Hills; one male and one female, 17.ii.2018, ZSIS-480, 481, Krem Dam (25.297^{0}N, 91.584^{0}E; 545m), Mawsynram, East Khasi Hills.

Description and taxonomic notes: This is one of the largest species of *Myotis,* the average forearm length of the examined Indian specimen was 53.4mm (51.1–54.3 mm; Table 2). The dorsal side is light brown, the ventral greyish. The membranes are dark brown with lighter

Table 1. External and craniodental measurements of *Megaerops niphanae* from northeastern India and Bangladesh. The legend of abbreviations can be found in the Material and Methods section. For external measurements of the Meghalaya individuals, we report data from three females (two released), while the skull measurements pertain to single female specimen ZSIS-455.

Measurements (in mm)	Meghalaya (present study)	Manipur (Mandal et al. 1993)	Mizoram (Mandal et al. 1997)	Arunachal P. (Das 2003)	Bangladesh (Islam et al. 2015)
TL	11	-	-	-	-
E	18.4–19.5	17.5–19.2	17.2–18.5	14.7–20.1	16.0
FA	60.0–64.2	59–59.4	58.0–62.3	54.0–64.6	58.3
TB	24.2–25.9	22.3–27	23–25.7	20.9–27.2	23.9
HF (c.u.)	14.2–14.8	14.0	12.0–13.7	11.0–14.0	10.6
GTL	29.0	26.3–28.0	27.9–28.7	26.6–29.7	28.4
GTLi	29.1	-	-	-	-
CCL	26.8	-	24.4–27.1		26.5
ZB	17.7	17.6–17.8	17.7–18.8	16.3–19.5	18.8
BB	12.9	12.4	12.0–12.3	11.6–13.1	
MAB	13.3	-	-	-	11.3
POC	5.5	5.0	5.2–6.0	4.7–5.7	
CM^3	9.8	8.3–8.6	9.1	8.0–9.5	8.7
M^3M^3	8.7	7.9–8.3	8.3–8.6	7.6–8.9	8.7
C^1C^1	6.0	5.3–5.7	5.4	3.0–5.8	5.8
M^1M^3	6.5	-	-	-	-
ML	21.0	19.0–20.0	20.4–20.9	17.7–20.2	20.9
MLi	22.0	-	-	-	-
CM_3	10.8	-	-	-	9.6
M_1M_3	6.1	-	-	-	-

interfemoral membranes (especially on the ventral side). The uropatagium is essentially naked. The muzzle is dark brown and both lips have a few whiskers, especially on the sides. The ears are relatively long with concave anterior border and convex posterior margin. The margin of the tragus is almost straight; its tip is bluntly pointed (inset of Image 2). The feet are very large (18mm) with sharp curved claws. The wing membrane attaches to the ankles slightly above the tibio-tarsal joint.

Craniodental characters: This large *Myotis* has an average skull length of 20.2mm in the examined specimens (Table 2). The skull profile is relatively flat and long (Image 2). The rostrum is broad and has a shallow depression in the middle. The nasal notch is V-shaped. The braincase elevates gradually from the rostrum and appears almost horizontal in lateral profile. The sagittal crest is scarcely visible, auditory bullae are small and zygomata are thin. Upper incisors are bicuspidate with a shorter secondary cusp. There is a gap between the posterior incisor and the canine. The length of the canine considerably exceeds the length of the third premolar. The second premolar is intruded from the toothrow. Lower molars are myotodont.

Baculum structure: The baculum of the ZSIS-480 specimen is longish with a broad base and tapers towards the tip forming a blunt cone (Image 3). The base has a prominent keel on the dorsal surface which runs for about two-third of the length of the baculum. Like other members of *Myotis*, the baculum is minute with a length of 0.77mm and a breadth at the base of 0.21mm.

Echolocation calls: Echolocation calls are typical of myotinae, brief (duration 6.9±0.5, range 6.4–7.9 ms) and frequency modulated (Figure 1). Pulses recorded in front of the cave had a sigmoidal shape, started at around 61kHz (Fhi 60.7±4.4, range 50.1–65.5 kHz), ended at around 30kHz (Flo 29.8±1.0, range 28.4–31.7 kHz), and showed a marked maximum of energy at 35kHz (FmaxE 34.9±0.7, range 34–36.2 kHz). Interpulse intervals were short (78.1±10.8, range 64–105 ms). These call characteristics are comparable to those measured by Ma et al. (2003) for Chinese exemplars of *M. pilosus*.

Ecological notes: In our study, *M. pilosus* were found to roost in caves traversed by large river systems. In

Image 2. Dorsal, ventral and lateral view of cranium and lateral and ventral view of mandible of *Myotis pilosus* (specimen ZSIS-354). The inset illustrates the live specimen captured in Phlang Karu Cave, East Khasi Hills, Meghalaya. © U. Saikia & M. Ruedi (inset).

Krem Dam (near Mawsynram, East Khasi Hills) a small colony of this bat was present but the roost itself could not be seen, as it was located deep within the crevices of the cave ceiling, in the upper level of the cave passage. These bats were observed at dusk to be trawling over the calm waters flowing within the cave. Dietary analysis of *M. pilosus* from this cave revealed that fish constituted a significant portion of its diet in the drier months from December to March (Thabah 2006). Very little bat activity was noted in the same cave in February while the temperature dropped below 10^0C.

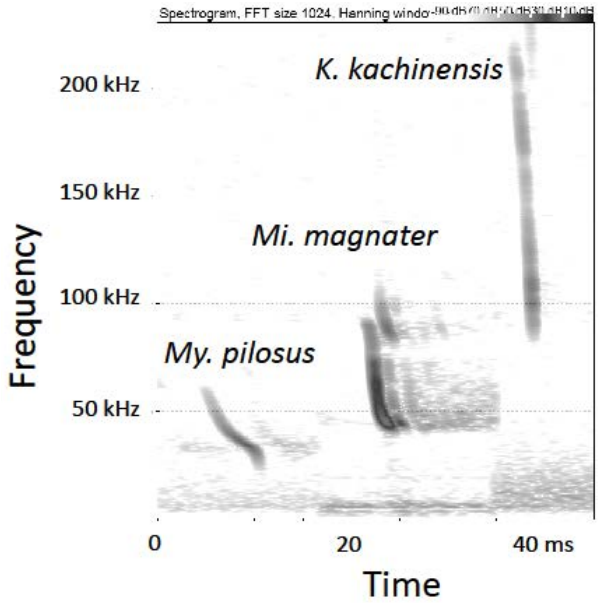

Figure 1. Spectrograms of echolocation calls of *Myotis pilosus*, *Miniopterus magnater*, and *Kerivoula kachinensis* recorded in Meghalaya and visualized with the program BatSound. These bats were recorded while flying near cave entrances or while hand-held (for *K. kachinensis*).

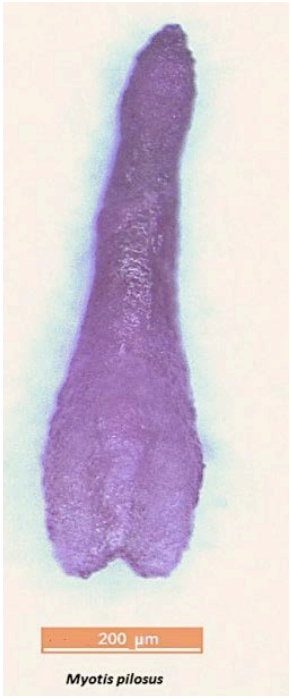

Image 3. Dorsal profile of the baculum of *Myotis pilosus* (specimen ZSIS-480).

***Kerivoula kachinensis* Bates et al., 2004**
Kachin Woolly Bat

New material: One female, 14.ii.2018, ZSIS-454, Sakwa (25.239^{0}N, 92.692^{0}E; 1,150m), East Jaintia Hills; one female, 20.ii.2011, ZSIS-571, Laitkynsew (25.215^{0}N, 91.664^{0}E; 815m), East Khasi Hills District.

Description and taxonomic notes: It is a relatively large species of *Kerivoula* with an average forearm length of 40.8mm in Meghalayan specimens. Fur colouration is overall dark and ochraceous brown, showing little contrast between the upper and under parts. Individual hairs have light brown tips with a shiny appearance while the roots are dark brown (Image 4). Ears are broad and oval-shaped and have scattered hairs on the internal surface. The tragus is thin, long and pointed with a straight anterior margin and slightly concave posterior margin and reach almost two third of the ear length (Image 4A). Wings attach to the base of toes. In our specimens, the fifth metacarpal is the longest (44.5–46.6 mm) followed by the fourth (43.4–44.3 mm) and the third (41.4–41.6 mm), which slightly exceeds the length of forearm (40.3–41.4 mm). The second phalanx of the third metacarpal exceeds the length of first phalanx. As no male individual from India could be examined so far, these metric wing characters may not apply to both sexes, especially because several *Kerivoula* species are sexually dimorphic. An oval and whitish fleshy callosity

Image 4. Portrait (A), dorsal (B) and ventral pelage (C) of *Kerivoula kachinensis* from Laitkynsew, Meghalaya (specimen ZSIS-571). Note the ochraceous brown tips and dark brown hair roots of both dorsal and ventral hairs. © M. Ruedi.

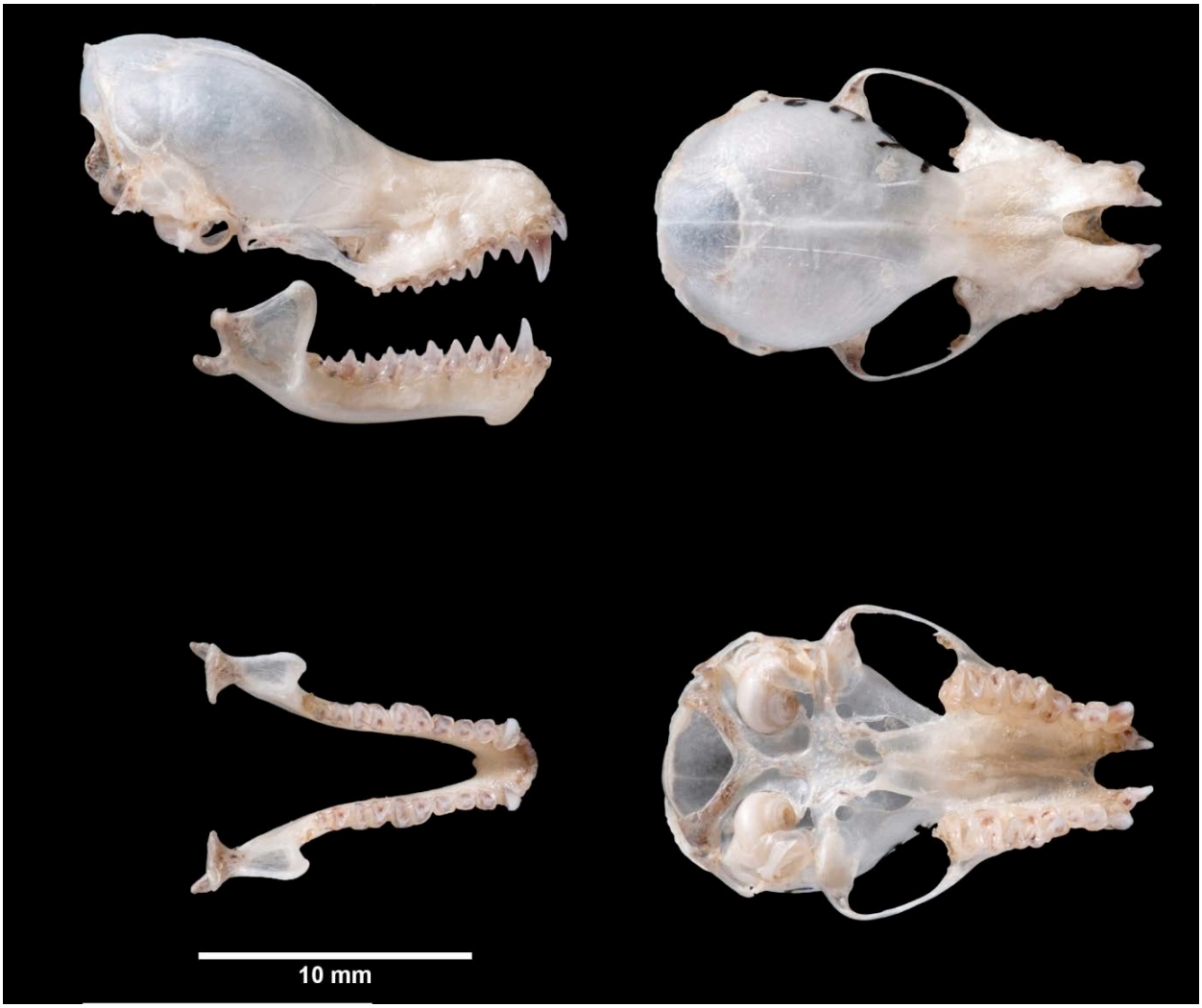

Image 5. Dorsal, ventral & lateral view of cranium and lateral & ventral view of mandible of *Kerivoula kachinensis* from Laitkynsew, Meghalaya (specimen ZSIS-571). © M. Ruedi.

of 3.7–4.1 mm length is present on the joint of the first digit in each wing of our specimens.

Craniodental characters: The skull of the two collected individuals is broad and distinctly flattened (Image 5). Such flattening of skull is not known in any of the other large *Kerivoula* and distinguishes it from the similar-looking *K. lenis* (Bates et al. 2004). The nasal notch in the rostrum is V-shaped. The coronoid process of each mandible is well developed and much exceeds the condyle in height. The upper incisors are unicuspid and about equal in crown area. Each has a cingulum on the postero-internal border. The second incisor is about half the length of the first. The canine is without a longitudinal groove on the outer surface and without a posterior cutting edge, unlike in other Asiatic congeners (Bates et al. 2004). Skull dimensions are presented in Table 2 and are very similar to those reported for female *K. kachinensis* from southeastern Asia (Soisook et al. 2007).

Echolocation calls: Calls were typical of Kerivoulinae (Douangboubpha et al. 2016), very brief (duration 3.3±0.4, range 2.5–3.8 ms) and extremely frequency modulated (Figure 1). The recorded pulses started very high, at around 213 kHz (Fhi 212.7±18.0, range 165.4–225.9 kHz) and ended at around 30kHz (Flo 84.0±2.7, range 80.8–89.3 kHz), thus showing a remarkably broad band width (128.7±16.7, range 84.2–142.5 kHz). The frequency of maximum energy was not sharply defined, at around 110kHz (FmaxE 109.2±1.3, range 107.4–111.7 kHz). Interpulse intervals were short (13.4±2.0, range 10.4–16.1 ms). As the single bat recorded was hand-held, it is likely that these calls characteristics are not typical of free-flying animals, as they would generally emit longer, less frequency modulated calls and at

Table 2. External and craniodental measurements (mean and range in parenthesis) of *Myotis pilosus* based on two released and three voucher specimens (ZSIS-354, 480, 481) and of *Kerivoula kachinensis* (two voucher females ZSIS-454 and 571) from Meghalaya. Measurements for female *K. kachinensis* from southeastern Asia (Soisook et al. 2007) are given for comparison.

Measurements (in mm)	*My. pilosus*	*Ke. kachinensis*	*Ke. kachinensis* (Soisook et al. 2007)
TL	45.2 (42.0–48.0)	(48.0–50.0)	58.3 (55.8–61.0)
E	19.6 (17.5–20.5)	(10.7–14.0)	14.9 (13.2–16.0)
TR	8.0 (7–9)	(6.9–8.1)	-
FA	53.4 (51.1–54.3)	(40.3–41.4)	41.7 (40.1–42.6)
TB	20.8 (20.3–21.3)	(20.9–23.1)	23.1
HF (c.u.)	18.5 (17.2–19.6)	(8.2–8.5)	9.1 (8.6–9.4)
GTL	19.8 (19.7–19.9)	(16.3–16.6)	
GTLi	20.20 (20.2–20.2)	(17.0–17.5)	(17.3–18.4)
CCL	17.90 (17.8–18.0)	(15.4–15.5)	(15.5–16.1)
ZB	12.90 (12.8–13.0)	(10.2–10.6)	(10.7–11.0)
BB	9.65 (9.6–9.7)	(8.1–8.4)	(8.1–8.2)
MAB	10.06 (9.8–10.3)	(8.6–8.7)	(8.4–8.4)
POC	4.83	(3.6–3.6)	(3.6–3.7)
CM^3	7.86 (7.8–7.9)	(6.7–6.8)	(6.7–7.2)
M^3M^3	8.50 (8.5–8.6)	(6.2–6.5)	-
C^1C^1	5.82 (5.7–5.9)	(4.3–4.4)	-
M^1M^3	4.65 (4.5–4.9)	(3.5–3.9)	-
ML	15.24 (15.2–15.3)	(12.0–12.6)	-
MLi	15.55 (15.4–15.8)	(12.2–12.8)	(12.9–13.0)
CM_3	8.53 (8.5–8.5)	(7.2–7.5)	(7.3–7.6)
M_1M_3	5.07 (5.0–5.1)	(4.0–4.2)	-

longer intervals.

Ecological notes: In Laitkynsew, this bat was caught in a harp trap in a tropical evergreen forest patch near the village. Other bats recorded in this forest included *Rhinolophus pearsoni, R. macrotis, Hipposideros pomona, Murina pluvialis* and *M. jaintiana*. In Sakwa, a single individual was caught just outside a cave, in a harp trap with very little bat activity at the time, in a mixed evergreen forest dominated by bamboo.

***Miniopterus magnater* Sanborn, 1931**

Western Bent-winged Bat

New material: Four males and three females, 12.xi.2014, ZSIS-298 to 304, Krem Labit, Shnongrim (25.359^{0}N, 92.512^{0}E; 1,050m), East Jaintia Hills District; two females, 19.ii.2015, ZSIS-351,352, above a river to the east of Umlyngsha (25.209^{0}N, 92.272^{0}E; 675m), East Jaintia Hills District; one male and one female, 21.iii.2018, ZSIS-460, 461, Siju Cave (25.351^{0}N, 90.684^{0}E; 130m), South Garo Hills.

Description and taxonomic notes: This is the largest among the three *Miniopterus* species found in India with a mean forearm length of 50.6mm (range 48.8–52.4 mm) measured in 72 individuals from Meghalaya (Table 3). This exceeds the mean value of 47.0mm (range 44.7–49.6 mm) reported by Bates & Harrison (1997) for "*M. schreibersii*" from the Indian subcontinent, a species now considered as *M. fuliginosus* (Maeda et al. 1982; Appleton et al. 2004). The later values are indeed coherent with those measured in nine *M. fuliginosus* from Himachal Pradesh (Table 3), and are thus also smaller than those of *M. magnater* for most external characters. The third species, *M. pusillus* is much smaller (FA 43 mm or less). The examined specimens of *M. magnater* from Meghalaya have dark brown to blackish dorsal pelage (Image 6). Ears, wings and interfemoral membranes were dark brown. As in its congeners, the second phalanx of the third metacarpal is unusually long with an average length of 39.3mm.

Craniodental characters: Craniodental measurements also support a strong differentiation between *M. magnater* and *M. fuliginosus* in India, with

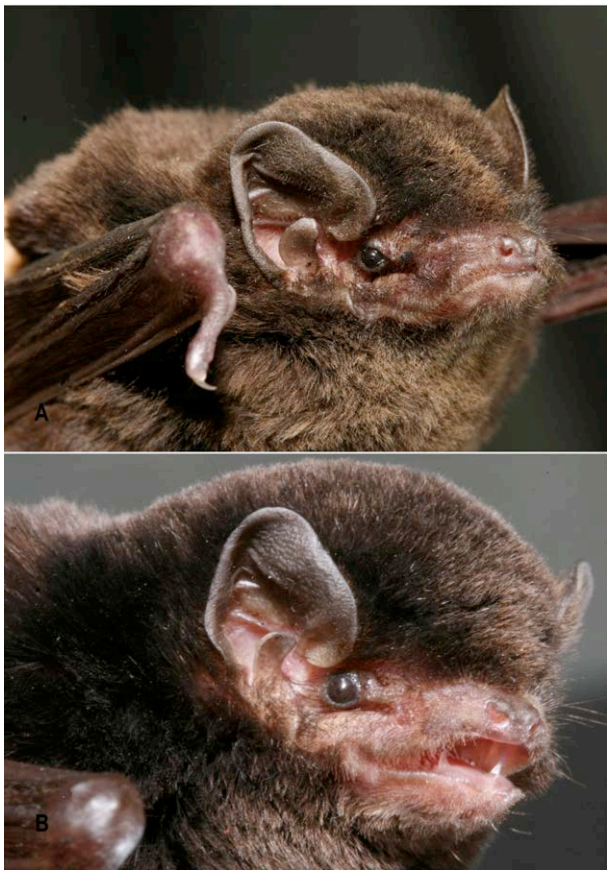

Image 6. Portraits of (A) *Miniopterus magnater* (released individual) and (B) *M. pusillus* from Umlyngsha, Meghalaya (specimen ZSIS-570). Note the darker facial tone in *M. magnater* and pinkish one in *M. pusillus*. Animals are not to scale. © M. Ruedi.

no overlap of values between those two species (Table 3). Again, the measurements given by Bates & Harrison (1997) for the Indian subcontinent likely correspond to those of *M. fuliginosus* (e.g., mean CCL 14.1mm, range 13.6–14.8 mm; and mean CM^3 6.1mm, range 5.8–6.3 mm), not to *M. magnater* (mean CCL 15.56mm, range 15.4–15.7 mm; mean CM^3 6.85mm, range 6.8–7.1 mm). The dentition of *M. magnater* was strong with prominent canines (Image 7).

Bacular structure: We found no baculum in the male specimens examined, which is the prevalent situation in the genus *Miniopterus* (Topal 1958; Schultz et al. 2016).

Echolocation calls: The structure of the echolocation calls of *M. magnater* recorded free-flying in front of a cave (Figure 1) were typical of miniopterine bats (Wordley et al. 2014; Srinivasulu & Srinivasulu 2017), with a brief (4.9±0.7, range 3.5–5.7 ms) and strongly frequency-modulated sweep terminated by a narrow band tail. The recorded pulses of *M. magnater* started at 118kHz (Fhi 117.6±6.7, range 109.7–129.7 kHz), ended at 39kHz (Flo 39.0±0.7, range 37.9–40.1 kHz), and had a broad band width (78.7±7.0, range 70.1–91.8 kHz). The frequency of maximum energy was marked at 47kHz (FmaxE 46.5±1.5, range 44.5–49.6 kHz) and interpulse intervals were short (69.4±10.1, range 54–94 ms). These characteristics are similar to those reported for *M. fuliginosus* (Wordley et al. 2014; Srinivasulu & Srinivasulu 2017), except for a shorter band width (mean 44.4 vs 78.7 kHz) and a higher frequency at maximum energy (52.0 vs 46.5 kHz), consistent with the smaller size of this species compared to *M. magnater* (Table 3).

***Miniopterus pusillus* Dobson, 1876**
Nicobar Long-fingered Bat

New material: One female, 16.ii.2011, ZSIS-570, near the Umlyngsha Village (25.208^{0}N, 92.271^{0}E; 690m), East Jaintia Hills.

Description and taxonomic notes: This is the smallest amongst the three *Miniopterus* species from the Indian subcontinent (Table 3). An adult female was caught in a mist net placed across a river near the village of Umlyngsha, East Jaintia Hills District. Externally, the animal had slightly lighter fur colour (lighter brown) when compared to the dark brownish individuals of *M. magnater* (Image 6A). The face was also lighter, flesh-coloured; the ears also appeared more delicate, without any obvious fold (Image 6B). The forearm length of the Meghalaya specimen was 43.0mm and had a tibia length of 17.6mm which were much smaller than in the other two congeners from India (Table 3).

Craniodental characters: The skull dimensions of our specimen are considerably smaller than in other *Miniopterus* from India (Table 3), but similar to those given by Bates & Harrison (1997). The dentition is much more delicate too, particularly the smaller canines and molars (Image 8), compared to that of *M. magnater* (Image 7). Unfortunately, no ultrasound recordings could be done with the only caught specimen, but the characteristics for the species recorded in southern India can be found elsewhere (Wordley et al. 2014).

DISCUSSION

The bat fauna of the northeastern Indian state of Meghalaya is astonishingly diverse with well over half of the 127 bat species reported from India (Saikia 2018; Saikia et al. 2018). While some distribution information on the bat species of Meghalaya is available (Ruedi et al. 2012b; Saikia et al. 2018), taxonomic and ecological information is scant (Sinha 1999a). A number of bat

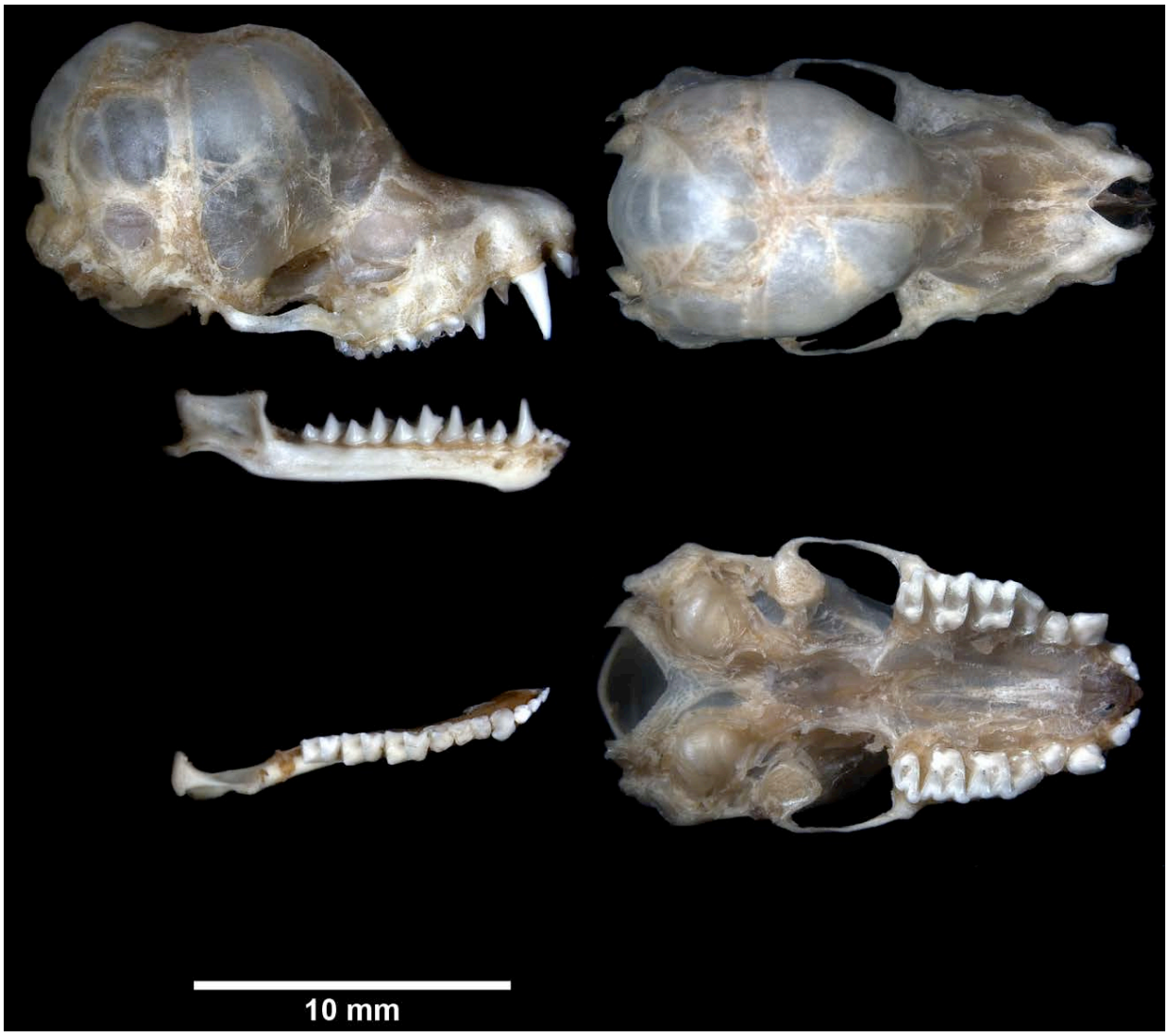

Image 7. Dorsal, ventral & lateral view of cranium and lateral & ventral view of mandible of *Miniopterus magnater* specimen from Siju Cave (specimen ZSIS-461). © U. Saikia.

species like *Eptesicus pachyotis, Myotis horsfieldii*, or *Scotomanes ornatus* are known from Meghalaya only by old records, while a few like *M. niphanae*, *Hypsugo joffrei*, *K. kachinensis, M. magnater, M. pusillus, M. pilosus* or *M. altarium* have only recently been recorded from the state (Ruedi et al. 2012a,b; Saikia et al. 2017, 2018; Thong et al. 2018). Among these newly recorded bats from Meghalaya, *K. kachinensis, M. magnater*, and *M. pilosus* are not known from any other parts of India. Even for species like *M. niphanae* and *M. pusillus* which are known from some other parts of the country, taxonomic and biological information are lacking. Therefore, any information on biology and ecology of these lesser known bat species will contribute to a better understanding of the bat fauna of the country.

Ratanaworabhan's Fruit Bat *M. niphanae* is one of the least common and most poorly known pteropodids found in Meghalaya. The similar-looking *M. ecaudatus* is smaller, with a forearm length of 51.5–56 mm and condylobasal length of 24.0–26.3 mm (Yenbutra & Felton 1983), and has no tail (Francis 1989). It is believed to live in southeastern Asia, however, considering the unusually large range of forearm length (52–63 mm) reported for specimens of *M. niphanae* in northeastern India (Mandal et al. 1993, 1997; Bates & Harrison 1997), Saha (1984), and Bates et al. (2008a) suggest that some of those records may in fact represent *M. ecaudatus*, not *niphanae*. Likewise, the surprisingly large variations of morphological and craniodental measurements given by Das (2003) for Arunachal Pradesh specimens (Table 1)

Image 8. Dorsal, ventral & lateral view of cranium and lateral & ventral view of mandible of *Miniopterus pusillus* specimen from Umlyngsha, Meghalaya (specimen ZSIS-570). © M. Ruedi.

also may represent a mixture of both species. Therefore, besides *M. niphanae* which we document here for Meghalaya, *M. ecaudatus* may also exist in India at least in the easternmost parts of the country.

Since its description from Myanmar (Bates et al. 2004), the Kachin Woolly Bat *K. kachinensis* was reported only from southeastern Asia (Thong et al. 2006; Soisook et al. 2007) until Ruedi et al. (2012b) mentioned its first occurrence in India, but without any taxonomic or metric information. Measurements of the present specimens from Meghalaya are thus the first for the country, and conform well to those of specimens from southeastern Asia (Table 2). Individuals were also caught in dense forest patches as in other parts of its range in southeastern Asia (Bates et al. 2004; Thong et al. 2006; Soisook et al. 2007).

Sinha (1999a,b) reported the presence of *Miniopterus schreibersii fuliginosus* (=*M. fuliginosus*) from Siju Cave in Meghalaya and also provided biometric details of specimens collected from that cave. We, however, recently noted that the mensural data of the Siju *Miniopterus* provided by Sinha, and those from all other large specimens from Meghalaya likely corresponded to that of the larger species *M. magnater* (Ruedi et al. 2012b). We have re-examined and re-measured the specimens from Siju Cave collected by Sinha and confirm that they all represent *M. magnater*. Considering that *M. magnater* is widespread and common at least in the Jaintia and Garo hills (Saikia et al. 2018), and that none of the examined specimens from Meghalaya could be positively assigned to *M. fuliginosus*, it is possible that the latter does not occur in this state.

Rickett's Big-footed Myotis *M. pilosus* is known to be distributed in China, Hong Kong, Vietnam, and Lao PDR (Csorba & Bates 2008). Thabah (2006), however, reported the occurrence of this species (as *M. ricketti*) from Phlang Karuh Cave (Nogtrai) in Meghalaya and till now was known only from this single locality in India.

Table 3. External and craniodental measurements of three *Miniopterus* species found in India. Reported values for *M. magnater* are based on 12 voucher specimens (five males and seven females) and 60 released individuals from Meghalaya. For *M. fuliginiosus*, values are based on six voucher specimens and three released animals from Himachal Pradesh. For *M. pusillus*, only one voucher specimen (female ZSIS-570) was considered.

Measurements (in mm)	*Mi. magnater* Meghalaya	*Mi. fuliginosus* Himachal Pradesh	*Mi. pusillus* Meghalaya
TL	57.0 (54.0–60.0)	58.1 (55.5–60.0)	51.0
E	12.9 (10.5–14.2)	11.4 (9.5–12.9)	11.0
TR	5.7 (4.1–6.8)	5.5 (5.5–5.5)	4.8
FA	50.6 (48.8–52.4)	48.6 (47.5–50.2)	43.0
TB	21.6 (20.4–22.5)	20.4 (20.0–21.0)	17.6
HF (c.u.)	9.5 (9.0–10.4)	10.7 (10–11.2)	7.6
GTL	16.73 (16.5–16.8)	15.69 (15.6–15.8)	13.9
GTLi	17.05 (16.9–17.1)	16.10 (15.9–16.2)	14.0
CCL	15.66 (15.5–15.9)	14.63 (14.5–14.9)	12.7
ZB	9.82 (9.8–10.2)	9.05 (8.9–9.2)	7.9
BB	8.57 (8.5–8.7)	8.19 (8.1–8.4)	7.4
MAB	9.33 (9.2–9.5)	8.96 (8.9–9.0)	8.0
POC	4.29 (4.2–4.4)	4.01 (4.0–4.1)	3.5
CM^3	6.85 (6.8–7.1)	6.23 (6.1–6.5)	5.3
M^3M^3	7.46 (7.0–7.7)	6.86 (6.8–7.0)	5.8
C^1C^1	5.23 (5.2–5.3)	4.85 (4.8–4.9)	4.1
M^1M^3	3.85 (3.9–3.9)	3.58 (3.6–3.6)	3.1
ML	12.81 (12.7–12.9)	11.60 (11.3–11.9)	9.9
MLi	13.19 (12.9–13.3)	11.78 (11.5–12.2)	10.0
CM_3	7.28 (7.2–7.4)	6.75 (6.7–6. 8)	5.6
M_1M_3	4.21 (4.0–4.4)	4.05 (4.0–4.1)	3.6
CoH	2.90 (2.8–3.0)	2.70 (2.7–2.7)	2.4

We could observe or collect specimens of this species from a few other localities like Krem Dam in Mawsynram and Amarsang in West Khasi Hills District of Meghalaya. Additionally, we examined a preserved male specimen collected from a cave near Larket Village (25.374^{0}N, 92.627^{0}E) in East Jaintia Hills District (Khlur Mukhim, in litt.). This species is, thus, more widely distributed in western Meghalaya, albeit in small numbers. The bats in the cave at Nongtrai were observed cohabiting with other species such as *Myotis siligorensis*, *Ia io*, *Hipposideros armiger*, *H. lankadiva*, and *Rhinolophus pearsonii*. It was also found to roost in the cave crevices outside the cave entrance during the colder months of December and January. More recently (2016 and onwards), this important cave has been disturbed due to limestone mining in a nearby location. As a consequence, some of the passages have collapsed and underground spaces have become increasingly unstable over the years, which led a substantial proportion of the roosting bats to abandon this cave. A similar and worrying situation prevails in the Siju Cave, which used to hold large populations of bats, mainly *Eonycteris* and *Miniopterus* (Sinha 1999a), but during two recent visits (March 2017 and March 2018) we did not observe any large colonies of these bats. Regular monitoring and population surveys in these important cave roosts are required to quantify this decline and to take conservation measure to protect them from further degradation.

REFERENCES

Anonymous (2005). State of the environment report, 2005: Meghalaya. Department of Environment and Forest, Government of Meghalaya, 76pp.

Appleton, B.R., J.A. Mckenzie & I. Chirstidis (2004). Molecular systematics and biogeography of the Bent-wing Bat complex *Miniopterus schreibersii* (Kuhl, 1817) (Chiroptera: Vespertilionidae). *Molecular Phylogenetics and Evolution* 31: 431–439.

Arita, H. (1993). Conservation biology of the cave roosting bats of Mexico. *Journal of Mammalogy* 74: 693–704.

Bates, P., M. Struebig, S. Rossiter, T. Kingston, S. Oo & K. Mya (2004).

A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Myanmar (Burma). *Acta Chiropterologica* 6: 219–226. https://doi.org/10.3161/001.006.0203

Bates, P.J.J. & D.L. Harrison (1997). *Bats of the Indian Subcontinent*. Harrison Zoological Museum, Sevenoaks, UK, 258pp.

Bates, P., S. Bumrungsri, A. Suyanto & C. Francis (2008a). *Megaerops ecaudatus*. The IUCN Red List of Threatened Species 2008: e.T12946A3400872. Downloaded on 21 February 2020. https://doi.org/10.2305/IUCN.UK.2008.RLTS.T12946A3400872.en

Bates, P., S. Bumrungsri, C. Francis, S. Molur & C. Srinivasulu (2008b). *Megaerops niphanae*. The IUCN Red List of Threatened Species 2008: e.T12947A3401078. Downloaded on 21 February 2020. https://doi.org/10.2305/IUCN.UK.2008.RLTS.T12947A3401078.en

Csorba, G. & P. Bates (2008). *Myotis pilosus*. *The IUCN Red List of Threatened Species* 2008: e.T14193A4418772. Downloaded on 11 July 2018. https://doi.org/10.2305/IUCN.UK.2008.RLTS.T14193A4418772.en

Das, P.K. (2003). Studies on some Indian Chiroptera from West Bengal. *Records of the Zoological Survey of India, Occasional Paper* 217: 1–164.

Das, P.K., R.K. Ghose, T.K. Chakroborty, T.P. Bhattacharyya, T.P. & M.K. Ghosh (1995). Mammalia. pp. 143–180. In: Director (ed.). *Fauna of Meghalaya Part I, State Fauna Series 4*. Zoological Survey of India, 669pp.

Dobson, G.E. (1876). Notes on nine species of Indian and Indo-Chinese Vespertilionidae with remarks on the synonymy and classification of some other species of the same family. *Proceedings of the Asiatic Society of Bengal*: 210–215.

Douangboubpha, B., S. Bumrungsri, C. Satasook, W. Wanna, P. Soisook & P.J.J. Bates (2016). Morphology, genetics and echolocation calls of the genus *Kerivoula* (Chiroptera: Vespertilionidae: Kerivoulinae) in Thailand. *Mammalia* 80: 21–47.

Haridarshan, K. & R.R. Rao (1985). *Forest Flora of Meghalaya*. Bishen Singh Mahendra Pal Singh, Dehradun, 937pp.

Islam, M.N., A.H. Shaikat, K.M.F. Islam, S.K. Shil, S. Akter, M.M. Rahman, M.M. Hassan, A. Islam, S.A. Khan & N. Furey (2015). First record of Ratanaworabhans's Fruit Bat *Megaerops niphanae* Yenbutra & Felten, 1983 (Chiroptera: Pteropodidae) from Bangladesh. *Journal of Threatened Taxa* 7(11): 7821–7824. https://doi.org/10.11609/JoTT.o4387.7821-4

Forest Survey of India (2017). State of Forest Report 2017, Forest Survey of India, Dehradun, 363pp.

Francis, C.M. (1989). Notes on fruit bats (Chiroptera, Pteropodidae) from Malaysia and Brunei, with the description of a new subspecies of *Megaerops wetmorei* Taylor, 1934. *Canadian Journal of Zoology* 67(12): 2878–2882.

Kunz, T.H. (1982). Roosting ecology of bats, pp. 1–55. In: Kunz T.H. (ed.). *Ecology of Bats*. Plenum Press, New York, 425pp.

Lyngdoh, A.W., H.N. Kumara, P.V. Karunakaran & S. Babu (2019). A review on status of mammals in Meghalaya, India. *Journal of Threatened Taxa* 11(15): 14955–14970. https://doi.org/10.11609/jott.5192.11.15.14955-14970

Ma, J., G. Jones, S. Zhang, J. Shen, W. Metzner, L. Zhang & B. Liang (2003). Dietary analysis confirms that Rickett's Big-footed Bat (*Myotis ricketti*) is a piscivore. *Journal of Zoology* 261: 245–248.

Mandal, A.K., A.K. Poddar & T.P. Bhattacharyya (1993). Records of *Megaerops niphanae* Yenbutra and Felten, 1983 (Mammalia Chiroptera: Pteropodidae), *Hiposideros lankadiva* Kelaart, 1850 and *Hipposideros armiger armiger* (Hodgson, 1833) (Chiroptera: Rhinolophidae) from Manipur, India, with taxonomic notes. *Records of the Zoological Survey of India* 93(3–4): 355–359.

Mandal, A.K, A.K. Poddar & T.P. Bhattacharyya (1997). Some new records of bats from Mizoram, India. *Records of the Zoological Survey of India* 96(1–4): 7–13.

Mandal, A.K, A.K. Poddar & T.P. Bhattacharyya (2000). Further new records of bats from Mizoram, India. *Records Zoological Survey of India* 98(2): 147–154.

Maeda K. (1982). Studies on the classification of *Miniopterus* in Eurasia, Australia and Melanesia. Honyurui Kagaku (Mammalian Science) Suppl. 1. Mammal Research Association, Japan, 176pp.

Pawar, S., M.S. Koo, C. Kelley, M.F. Ahmed, S. Chaudhury & S. Sarkar (2007). Conservation assessment and prioritization of areas of northeast India: Priorities for amphibians and reptiles. *Biological Conservation* 136: 346–361.

Prokop, P. & T. Arbenz (2016). Landscape and landforms of the Meghalaya plateau. pp. 18–25. In: Arbenz, T. (ed.) *Cave pearls of Meghalaya. A cave inventory covering Jaintia Hills, Meghalaya, India - Volume 2. North Shnongrim Ridge and the Liat Prah cave system*. Replika Press, India, 344pp.

Rodgers , W.A. & S.H. Panwar (1988). Biogeographical classification of India. New Forest, Dehra Dun, India, 608pp.

Ruedi, M., J. Biswas & G. Csorba (2012a). Bats from the wet: Two new species of tube-nosed bats (Chiroptera: Vespertilionidae) from Meghalaya, India. *Revue suisse de Zoologie* 119(1): 111–135.

Ruedi, M., J. Biswas, O.M. Chachula & T. Arbenz (2012b). A winter survey of bats from the Jaintia Hills with a synopsis of their diversity in Meghalaya, pp. 87–105. In: Arbenz, T. (ed.). *Cave pearls of Meghalaya. A cave inventory covering Jaintia Hills, Meghalaya, India. Volume 1: Pala Range and Kopili River*. Replika Press, India, 265pp.

Saha, S.S. (1984). Occurrence of the tail-less fruit bat, *Megaerops ecaudatus* (Temminck, 1837), in Namdapha, Tirap District, Arunachal Pradesh: an addition to the Indian fauna (Mammalia: Chiroptera: Pteropodidae). *Bulletin of the Zoological Survey of India* 61(3): 343–344.

Saikia, U. (2018). A review of chiropterological studies and a distributional list of the bat fauna of India. *Records of the Zoological Survey of India* 118(3): 242–280.

Saikia, U., A. Thabah, O.M. Chachula & M. Ruedi (2018). The bat fauna of Meghalaya, Northeast India: Diversity and Conservation, pp. 263–286. In: Sivaperuman, C. and K. Venkataraman (eds.). *Indian Hotspots: Vertebrate Faunal Diversity, Conservation and Management*. Vol 2. Springer Nature Singapore Pvt Ltd., Singapore, 354pp.

Saikia U., G. Csorba & M. Ruedi (2017). First records of *Hypsugo joffrei* (Thomas, 1915) and the revision of *Philetor brachypterus* (Temminck, 1840) (Chiroptera: Vespertilionidae) from the Indian subcontinent. *Revue suisse de Zoologie* 124(1): 83–89.

Sarma, K. & S.K. Barik (2011). Coal mining impact on vegetation of the Nokrek Biosphere Reserve, Meghalaya, India. *Biodiversity* 12(3): 154–164.

Schultz, N., M. Lough-Stevens, E. Abreu, T. Orr & M. Dean (2016). The baculum was gained and lost multiple times during mammalian evolution. *Integrative and Comparative Biology* 56(4): 644–656.

Sikes, R., W.l. Gannon, & the Animal Care and Use Committee of the American Society of Mammalogists (2011). Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *Journal of Mammalogy* 92(1): 235–253.

Sinha, Y.P. (1999a). Bats of the Siju Cave, South Garo Hills District, Meghalaya: Taxonomy and Bionomics. *Records of the Zoological Survey of India* 97: 101–122.

Sinha, Y.P. (1999b). Contribution to the knowledge of bats (Mammalia: Chiroptera) of north east hills, India. *Records of the Zoological Survey of India. Occasional Paper* 174: 1–52.

Soisook, P., S. Bumrungsri, A. Dejtaradol, C.M. Francis, G. Csorba, A. Gullien-Servent & P.J.J. Bates (2007). First records of *Kerivoula kachinensis* (Chiroptera: Vespertilionidae) from Cambodia, Lao PDR and Thailand. *Acta Chiropterologica* 9(2): 339–345.

Srinivasulu, B. & C. Srinivasulu (2017). A first record of three hitherto unreported species of bats from Kerala, India with a note on *Myotis peytoni* (Mammalia: Chiroptera: Vespertilionidae). *Journal of Threatened Taxa* 9: 10216–10222. http://doi.org/10.11609/jott.3324.9.5.10216-10222

Swer, S. & O.P. Singh (2003). Coal mining impacting water quality and aquatic biodiversity in Jaintia Hills District of Meghalaya. *ENVIS Bulletin Himalayan Ecology* 11: 26–33.

Thabah, A. (2006). The diversity of bats in Meghalaya, north east India with emphasis on the species found in Phlang Karu Cave in Nongtrai

and Tem dibai Cave in Sohbar. PhD Thesis. University of Bristol, UK, 177pp.

Thong, V.D., S. Bumrungsri, D.L. Harrison, M.J. Pearch, K.M. Helgen & P.J.J. Bates (2006). New records of Microchiroptera (Rhinolophidae and Kerivoulinae) from Vietnam and Thailand. *Acta Chiropterologica* 8: 83–93.

Thong, V.D., X. Mao, G. Csorba, P.J.J. Bates, M. Ruedi, N.V. Viet, D.N. Loi, P.V. Nha, O.M. Chachula, O.M., T.A. Tuan, N.T. Son, D. Fukui, V.T. Tu & U. Saikia (2018). First records of *Myotis altarium* (Chiroptera: Vespertilionidae) from India and Vietnam. *Mammal Study* 43: 67–73.

Topal, G. (1958). Morphological studies on the os penis of bats in the Carpathian basin. *Annales Historico-Naturales Musei Nationalis Hungarici* L(IX): 331–342.

Tringham, M.E. (2012). Geology, pp. 16–19. In: Arbenz T. (ed.). *Cave Pearls of Meghalaya. A Cave Inventory Covering Jaintia Hills, Meghalaya, India. Volume 1: Pala Range and Kopili River*. Replika Press, India, 265pp.

Tu, V.T., G. Csorba, M. Ruedi, N.M. Furey, N.T. Son, V.D. Thong, C. Bonillo & A. Hassanin (2017). Comparative phylogeography of bamboo bats of the genus *Tylonycteris* (Chiroptera, Vespertilionidae) in southeast Asia. *European Journal of Taxonomy* 274: 1–38. https://doi.org/10.5852/ejt.2017.274

Wikramanayake, E., E. Dinerstein, C.J. Loucks, D.M. Olson, J. Morrison & J. Lamoreaux (2002). *Terrestrial Ecoregions of Indo-Pacific: A Conservation Assessment*. Island Press, Washington DC, 643pp.

Wordley, C.F.R., E.K. Foui, D. Mudappa, M. Sankaran & J.D. Altringham (2014). Acoustic identification of bats in the southern Western Ghats, India. *Acta Chiropterologica* 16: 213–222.

Yenbutra, S. & H. Felten (1983). A new species of the fruit bat genus *Megaerops* from SE-Asia (Mammalia: Chiroptera: Pteropodidae). *Senckenbergische Naturforschende* 63(1–3): 1–11.

www.threatenedtaxa.org

PLATINUM OPEN ACCESS

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

February 2020 | Vol. 12 | No. 3 | Pages: 15279–15406
Date of Publication: 26 February 2020 (Online & Print)
DOI: 10.11609/jott.2020.12.3.15279-15406

Publisher & Host

Member