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A new species of *Murina* (Chiroptera: Vespertilionidae) from sub-Himalayan forests of northern Myanmar

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Abstract

A new species of *Murina* of the *suilla*-type is described from the Hkakabo Razi Landscape, Kachin, Upper Myanmar, an area that is currently being nominated as a World Heritage Site. The new species is a small vespertilionid, with a forearm length of 29.6 mm, and is very similar to *M. kontumensis*, which was recently described from Vietnam. However, it is distinguishable by a combination of external and craniodental morphology and genetics. The DNA Barcode reveals that the new species clusters sisterly to *M. kontumensis* but with a genetic distance of 11.5%. A single known specimen of the new species was collected from a lowland forest area in the plains of the Hkakabo Razi landscape, south-eastern Himalaya. Additional information on ecology, echolocation, and conservation are included. The high cryptic diversity of the genus *Murina* in Southeast Asia, as well as the Hkakabo Razi Landscape being a bat diversity hotspot, is highlighted.

Key words: cryptic species, Hkakabo Razi, Myanmar, new species, Southeast Asia

Introduction

Myanmar's Hkakabo Razi Landscape (hereafter HRL), also known as Hkakaborazi Region, in Kachin, which is currently being nominated by the Myanmar Government as a Natural World Heritage Site, comprises two major protected areas, Hkakabo Razi National Park (HKNP) and Hponkan Razi Wildlife Sanctuary (HPWS). It is located in the south-eastern sub-Himalayan region, where three major biodiversity hotspots, 'Indo-Burma', 'Himalaya' and 'Mountains of southwest China' overlap (Renner 2011). There are previous reports on the status of large mammals from the region (Rabinowitz & Saw Tun Khaing 1998; Rao *et al.* 2011), including a new species of Leaf Deer, *Muntiacus putaoensis* (Rabinowitz *et al.* 1999). However, in terms of small mammals, particularly bats, this is one of the most neglected regions of the world. The most recent study of bats from the HRL dates from the early 1930s when the Earl of Cranbrook and Frank Kingdon-Ward undertook a trans-boundary expedition from Tibet to Myanmar in 1931, and Ronald Kaulback collected mammal specimens in Myanmar-Tibet-Assam frontier in 1933. The results of these expeditions were later published in Hill (1962) with the report of nine species of bats from the area of HRL (see also Bates *et al.* 2000).

Between February and March 2016, an international faunal survey team (PS, MK, SSLO, AP, MSR, SCR), supported by UNESCO and Myanmar's Ministry of Natural Resources and Environmental Conservation, in preparation for the area's nomination as World Heritage, undertook a scientific field expedition in three localities of HPWS, and seven in both HKNP and an area located directly south of HKNP, which is currently being gazetted as an extension of HKNP. During the field trip, representative materials of each bat species were collected. Specimens were thoroughly examined, compared with specimens of similar species in natural history museums, and genetic

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samples were analysed. A single male specimen provisionally identified from the field as *Murina* cf. *kontumensis* Son *et al.*, 2015, from HKNP, turned out to be specifically distinct, and is thus described herein as new species to science.

Material and methods

Analysed specimens. Specimens of *Murina* spp. housed in natural history museums, including the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Thailand (PSUZC); Institute of Ecology and Biological Resources, Vietnam (IEBR); Natural History Museum, London (BMNH); Harrison Institute, UK (HZM); Smithsonian National Museum of Natural History (USNM), were examined for morphological comparison. Comparative specimens are listed in Appendix.

A single male specimen of the new species, labelled as '*Murina* sp.2 (*kontumensis?*)', was captured in a mist net set at the margin between a grassland and a lowland plain semi-evergreen forest. The area is in the proposed Southern Extension of the Hkakabo Razi National Park. It is large and flat with an elevation between 400 and 600 m a.s.l. The trapping site is located on the west bank of the Malikha River and connected to the southern edge of the huge forest complex of the Hkakaborazi Mountain, which is the south-eastern part of the Himalaya. The surrounding vegetation comprises lowland mixed deciduous and semi-evergreen forest with a large annually burnt pastureland. The new species was collected along with several other vespertilionids from the same locality (see Ecology section).

Measurements. External measurements were taken with a dial calliper to the nearest 0.1 mm in the field. Craniodental measurements were taken with a digital calliper (to the nearest 0.01 mm) and with a graticule in the eyepiece of a stereo microscope for the baculum. The definitions of measurements follow Soisook *et al.* (2013) unless otherwise stated. All measurements are in mm except for MASS which is in grams: MASS: weight of the bat (newly sacrificed)—taken with a Pesola scale to the nearest 1.0 g; FA: forearm length, from the extremity of the elbow to the extremity of the carpus with the wings folded; E: ear length, from the lower border of the external auditory meatus to the tip of the pinna; TRG: tragus length, as ear length but to the tip of the tragus; HB: head and body length, from the tip of the snout to the base of the tail, dorsally; TL: tail length, from the tip of the tail to its base adjacent to the anus; TIB: length of tibia, from the knee joint to the ankle; HF: hind foot length, from the extremity of the heel behind the os calcis to the extremity of the longest digit, not including the hair or claws; GTL: greatest length of skull, the greatest antero-posterior length of the skull, taken from the most projecting point at each extremity; STOTL: total length of skull - from the anterior rim of the alveolus of the first upper incisor to the most projecting point of the occipital region; CBL: condylobasal length, from the exoccipital condyle to the anterior part of the upper incisor; CCL: condylo-canine length, from an exoccipital condyle to the front of the canine; ZB: zygomatic breadth, the greatest width of the skull across the zygomatic arches; PC: width of post orbital constriction; BB: breadth of braincase, greatest width of the braincase; MW: mastoid width—greatest width across the mastoid region; BCH: braincase height—from the basisphenoid at the level of the hamular processes to the highest part of the skull, including the sagittal crest (if present), $C–M^3$: maxillary toothrow length, from the front of the upper canine to the back of the crown of the third upper molar; $C^1–C^1$: greatest anterior palatal width measured across the outer borders of the canines, taken at the widest part; $M^3–M^3$: greatest width across the upper molars—taken across the outer crowns of the last upper molars; $C–M_3$: mandibular toothrow length, from the front of the lower canine to the back of the crown of the third lower molar; M: mandible length, from the most posterior part of the condyle to the most anterior part of the mandible; CPH: least height of the coronoid process—from the tip of the coronoid process to the apex of the indentation on the inferior surface of the ramus adjacent to the angular process; BL: greatest length of the baculum—measured from the most posterior to the most anterior part.

Echolocation call recordings and analysis. Calls were recorded from this individual while it was flying freely in a small tent with a Pettersson D-1000X ultrasound detector set in 10x time-expansion mode and a sampling rate of 768 kHz. Calls were transferred to a computer for analysis in BatSound – Sound Analysis Version 4.1.4 (Pettersson Electronics and Acoustic AB). The call characters measured included start frequency (*sf*), the frequency at the beginning of the call; highest frequency (*hf*); and terminal frequency (*tf*), the frequency at the end of the call, all measured by measurement curser in the spectrogram; the frequency of maximum energy (*fmaxe*), measured in the power spectrum (in kHz); call duration (*d*), the time from the beginning to ending point of a pulse measured in the spectrogram; and inter-pulses interval (*ipi*), the time between the ending point of a pulse and the beginning point of the following pulse measured in the spectrogram (in ms). Five good signal to noise ratio calls were selected for analysis.

Genetic analysis. Tissue samples were collected from the wing membrane or liver of newly sacrificed bats and stored in absolute ethanol. The DNA Barcode (mtCOI) extraction, amplification and sequencing followed the protocols as outlined in Soisook *et al.* (2016). Public data available from the Barcode of Life Data System (BOLD) and GenBank were included in the analyses (see Appendix). The phylogenetic relationship was examined by Bayesian inference using GTR+I+G model and was carried out in MrBayes 3.2 (Ronquist *et al*. 2012). The Monte Carlo Markov Chains (MCMC) was simulated for 10,000,000 generations and sampled every 1,000 generations, with a 25% burn in. The tree was reconstructed in FigTree 1.4.2 (http://tree.bio.ed.ac.uk/software/figtree/). Genetic divergence (%) between species was calculated using the Kimura-2-parameter model (K2P), which was performed in MEGA 6 (Tamura *et al.* 2013).

Systematic description

***Murina hkakaboraziensis* sp. nov.**
(Figs. 1–4; Table 1)

Holotype. Adult male, field number PS160218.6, (to be subsequently deposited at the Zoological Collection of the University of Mandalay (UMZC), Myanmar), body in alcohol, skull and baculum extracted.

Type locality. Myanmar, Kachin, Putao Township, Hkakabo Razi National Park (proposed southern extension), 6 km north of Mali Raing Village, 27°37'19" N, 97°22'13" E, 510 m a.s.l., collected on 18 February 2016, by Pipat Soisook, Sai Sein Lin Oo and Awatsaya Pimsai.

Diagnosis. A small tube-nosed bat with a FA of 29.6 mm. The external appearance is characterised by generally orange-brown pelage on the dorsal and whitish-grey on the ventral side; with long bright golden tip guard hairs on the dorsal side, most densely on the top of the head and the forehead. In the skull, the forehead profile rises smoothly to the braincase, which is relatively high but not dome-shaped. The sagittal crest and lambdoid crest are absent. The upper canine exceeds the posterior upper premolar in height and is slightly more than half of its crown area. The mesostyles on the first and second upper molars are well developed. The talonids of both first and second lower molars are equal to that of their respective trigonids in size.

Etymology. The species is named after the Hkakabo Razi Landscape, where the only known specimen was collected. The proposed English name is 'Hkakabo Razi Tube-nosed Bat'.

Description. This is a very small vespertilionids with a FA of 29.6 mm and HB of 35.5 mm (Table 1). The pinna is rounded, with 17.0 mm in height, and is without distinct emargination on the posterior border. The tragus is relatively short, shorter than half of the pinna (Fig. 1a), with a height of 7.5 mm (Table 1). The body is covered with long hairs, particularly on the head (Fig. 1a). The most distinctive feature of the pelage is long bright golden hairs over the back of the head (Fig. 1a). The face and forehead are covered with very short dark brown hairs. The pelage on the dorsal side is greyish-brown basally and orange-brown at the tips (Fig. 1b); the very long and bright golden guard hairs are sparsely distributed over the back and tail membrane, but are more plentiful on the head (Fig. 1a). The pelage on the ventral side is very dark at the base, followed by grey in the middle and with a whitish-grey tip (Fig. 1c). The wing membrane is attached to the base of the claw of the outer toe. The foot is relatively large, 8.6 mm, which is more than half of the tibia length (Table 1).

In the skull, the small and shortened first upper premolar (P^2) indicates that this species belongs to the *suillia*-type. The GTL and CCL are 13.82 mm and 12.35 mm, respectively (Table 2). The rostrum is deep and bulbous. The interorbital region is deeply concave when viewed from above. The lateral profile of the forehead rises gradually and smoothly to the braincase (Fig. 2a). The braincase is relatively high (BH 6.02 mm) but not domed in shape. The sagittal crest and lambdoid crest are absent (Fig. 2a). Each zygoma is thin and without a dorsal process. The upper toothrows converge anteriorly (Fig. 2a); C^1–C^1 is 62.6% of M^3–M^3. The C–M^3 is 4.75 mm (Table 2). The inner upper incisor (I^2) is slightly longer than the outer one (I^3) and is about half the crown area (Fig. 2a). The secondary cusp of the I^3 is well developed and is about half the height of the main cusp. The I^3 is relatively large, its crown area is about two-thirds that of the upper canine (C^1) and subequal to that of the posterior upper premolar (P^4) (Fig. 2a). The C^1 is rounded in shape and without a lingual cusp at its base. It is about two-thirds that of P^4 in crown area. In the lateral view, the C^1 slightly exceeds the P^4 in height (Fig. 2a). The anterior upper premolar (P^2) is small, broader than long. It is slightly less than half that of the P^4 in crown area and about half the height (Fig. 2a). The labial surface of the first (M^1) and second (M^2) upper molars is W-shaped (Fig. 2a). The mesostyles of both M^1 and M^2 are well developed.

TABLE 1. Mean±standard deviation (SD), minimum-maximum values of mass and external measurements of *M. hkakaboraziensis* sp. nov. and other comparative *Murina* species. Total sample size of male and female are given. Sample sizes that differs from stated sample size are in brackets. List of specimens in the Appendix.

Species	*n* Sex	MASS	FA	E	TRG	HB	TL	TIB	HF
M. hkakaboraziensis	♂	3.4	29.6	17.0	7.5	35.5	30.1	15.5	8.6
sp. nov.	(holotype)								
M. kontumensis	♀	5.0	32.3	18.7	7.4	40.0	38.5	16.2	7.6
	(holotype)								
M. harpioloides	♂	-	28.9	11.3	6.0	32.1	20.2	12.1	6.8
	♀	-	28.4	10.1	5.4	34.2	20.7	11.6	6.4
M. eleryi	*2*♂	-	27.7 [1]	11.8 [1]	5.6 [1]	-	26.5 [1]	13.9 [1]	5.6 [1]
	5♀	5.5 [1]	29.0, 30.4	12.0, 12.4	5.7, 6.1	35.9, 37.8	31.7, 32.6	13.2, 14.8	7.4, 7.5
M. walstoni	*2*♂	5.2 [1]	28.1, 33.4	11.9, 14.5	6.8, 8.2	34.8, 45.4	31.0, 33.6	15.1, 15.9	6.8, 7.0
	5♀	5.1 [1]	32.8±2.9	13.6±1.5	7.5±0.4	42.6±1.5	33.2±1.1	16.2±0.9	7.6±0.5
			29.4–34.7 [3]	12.5–14.7 [2]	7.3–7.8 [2]	41.6–43.6 [2]	32.4–33.9 [2]	15.3–17.0 [3]	6.9–8.0 [3]
M. feae	*12*♂	4.7±0.3	30.1±0.8	11.9±2.6	6.17 [1]	38.1±2.6	34.3±3.3	17.0±0.3	5.9±1.4
		4.5–5.0 [3]	29.0–31.5 [9]	8.2–14.0 [4]	-	35.0–41.4 [4]	31.0–39.0 [4]	16.7–17.5 [4]	5.1–8.0 [4]
	14♀	5.2±0.3	32.0±2.2	12.8±1.5	6.8±0.8	41.2±3.0	35.8±4.4	17.5±1.2	7.1±0.7
		5.0–5.4 [2]	28.6–36.0 [12]	9.7–14.5 [9]	5.7–7.5 [5]	39.5–48.0 [7]	28.2–40.4 [10]	16.0–19.5 [11]	5.8–7.8 [11]
M. ussuriensis	*2*♀	-	26.7 [1]	-	-	-	-	-	-

TABLE 2. Mean±standard deviation (SD), minimum–maximum values of craniodental measurements of *M. hkakaboraziensis* sp. nov. and other comparative *Murina* species. Sex and total sample size are given. Sample sizes that differs from stated sample size are in brackets. List of specimens in the Appendix.

Species	*n* Sex	GTL	STOTL	CBL	CCL	ZB	PC	BB	MW
M. hkakaboraziensis	♂	13.82	14.03	13.05	12.35	7.74	3.68	6.70	6.98
sp. nov.	(holotype)								
M. kontumensis	♀	15.30	14.90	14.16	13.7	8.70	4.02	7.35	7.47
	(holotype)								
M. harpioloides	♂	14.70	14.61	13.28	12.50	8.44	4.34	7.46	7.55
	♀	14.34	14.18	13.10	12.54	8.29	4.15	7.12	7.28
M. eleryi	*2*♂	14.15, 14.37	14.21	12.91±0.10	12.35±0.25	7.92±0.20	4.15±0.02	6.88±0.14	7.10±0.09
		[2]	[1]	12.84–13.03	12.09–12.59	7.69–8.05	4.13–4.16	6.74–7.02	7.04–7.21
	5♀	14.75±0.50	14.12	13.57±0.36	12.84±0.27	8.19±0.14	4.13±0.19	6.99±0.05	7.29±0.04
		14.17–15.04	[1]	13.17–13.88	12.54–13.05	8.05–8.32	3.99–4.35	6.95–7.05	7.25–7.33
M. walstoni	*2*♂	14.48, 15.73	-	13.03, 14.74	12.35, 13.94	7.69, 9.04	7.08, 7.50	7.05, 7.65	4.16, 4.20
	5♀	16.13±0.22	-	14.66±0.19	13.89±0.18	9.13±0.21	4.21±0.12	7.53±0.13	7.83±0.19
		15.89–16.37	-	14.43–14.90 [4]	13.68–14.11 [4]	8.93–9.42 [4]	4.08–4.37 [4]	7.37–7.68 [4]	7.68–8.11 [4]
M. feae	*12*♂	15.38±0.13	-	14.00±0.13	13.36±0.15	8.64±0.14	4.34±007	7.45±0.16	7.36±0.14
		15.25–15.55 [6]	-	13.77–14.14 [6]	13.10–13.54 [6]	8.438.75 [6]	4.24–4.40 [6]	7.17–7.62 [7]	7.18–7.55 [5]
	14♀	16.07±0.56	-	14.72±0.52	14.01±0.47	8.84±0.34	4.43±0.19	7.50±0.32	7.56±0.18
		14.71–16.74 [13]	-	13.66–15.58 [13]	12.96–14.78 [13]	8.35–9.43 [12]	4.12–4.86 [13]	6.77–8.12 [13]	7.25–7.94 [13]
M. ussuriensis	*2*♀	14.70, 15.39	14.17 [1]	13.11, 14.50	12.30 [1]	7.75, 8.57	4.09, 4.35	6.85, 7.27	7.07 [1]
M. beelzebub	*1*♀	16.62	16.37	15.22	14.59	9.77	4.86	8.28	8.04
	1♀	16.74	16.43	15.7	14.86	9.36	4.83	8.14	7.96
M. puta	*2*♀	17.67, 17.93	17.02, 17.29	16.78, 17.14	16.04, 16.29	9.68, 10.54	4.50, 4.68	7.69, 7.99	
M. leucogaster	*1*♀	19.03	18.78	18.03	17.22	11.36	5.18	8.71	9.59

……*continued on the next page*

TABLE 2. (Extended)

Species	*n* Sex	BCH	$C–M^3$	$C^1–C^1$	$M^3–M^3$	$C–M_3$	M	CPH
M. hkakaboraziensis	♂	6.02	4.75	3.24	5.18	5.15	9.59	2.95
sp. nov.	(holotype)							
M. kontumensis	♀	6.51	5.00	3.64	5.33	5.49	10.68	3.98
	(holotype)							
M. harpioloides	♂	6.70	4.50	3.20	4.95	5.02	10.16	3.72
	♀	6.66	4.46	-	4.88	4.97	-	-
M. eleryi	*2*♂	5.90±0.33	4.48±0.09	3.23±0.11	4.83, 4.90	5.04±0.09	9.53±0.01	3.08±0.03
		5.60–6.25	4.38–4.54	3.14–3.35	[2]	4.95–5.13	9.52–9.54	3.06–3.11
	5♀	5.79±0.28	4.68±0.15	3.53±0.08	5.07±0.13	5.13±0.19	9.81±0.13	3.31±0.13
		5.61–6.11	4.55–4.84	3.46–3.62	4.96–5.21	4.98–5.34	9.67–9.91	3.18–3.43
M. walstoni	*2*♂	6.05, 6.10	4.50, 5.40	3.28, 4.05	4.63, 5.50	4.92, 5.83	9.44, 11.02	2.83, 4.21
	5♀	6.18±0.17	5.34±0.10	3.94±0.05	5.47±0.22	5.86±0.18	11.19±0.30	3.91±0.19
		6.03–6.42 [4]	5.24–5.47 [4]	3.88–4.01 [4]	5.17–5.69 [4]	5.59–6.01 [4]	10.84–11.54 [4]	3.65–4.08 [4]
M. feae	*12*♂	6.01±0.14	4.99±0.11	3.67±0.11	5.22±0.16	5.33±0.07	10.07±0.15	3.36±0.16
		5.80–6.19 [6]	4.81–5.17 [8]	3.51–3.82 [7]	5.03–5.47 [7]	5.24–5.44 [6]	9.84–10.29 [6]	3.16–3.56 [5]
	14♀	6.36±0.21	5.18±0.22	3.72±0.17	5.30±0.17	5.59±0.22	10.14±2.06	3.75±0.32
		6.06–6.79 [13]	4.83–5.59 [13]	3.53–4.09 [13]	5.04–5.60 [13]	5.26–6.00 [13]	3.73–11.40 [12]	3.20–4.36 [12]
M. ussuriensis	*2*♀	5.78, 5.89	4.57 [1]	3.17 [1]	5.24 [1]	5.23, 5.48	10.58 [1]	4.02 [1]
M. beelzebub	*1*♀	7.14	5.32	3.89	5.73	5.92	11.28	3.87
	1♀	6.94	5.32	3.58	5.60	5.75	11.61	4.47
M. puta	*2*♀	7.07, 7.12	5.97, 6.06	4.35, 4.73	5.73, 6.37	6.56, 6.85	12.62, 12.80	4.66, 5.01
M. leucogaster	*1*♀	7.18	6.16	4.99	6.68	6.87	13.93	5.35

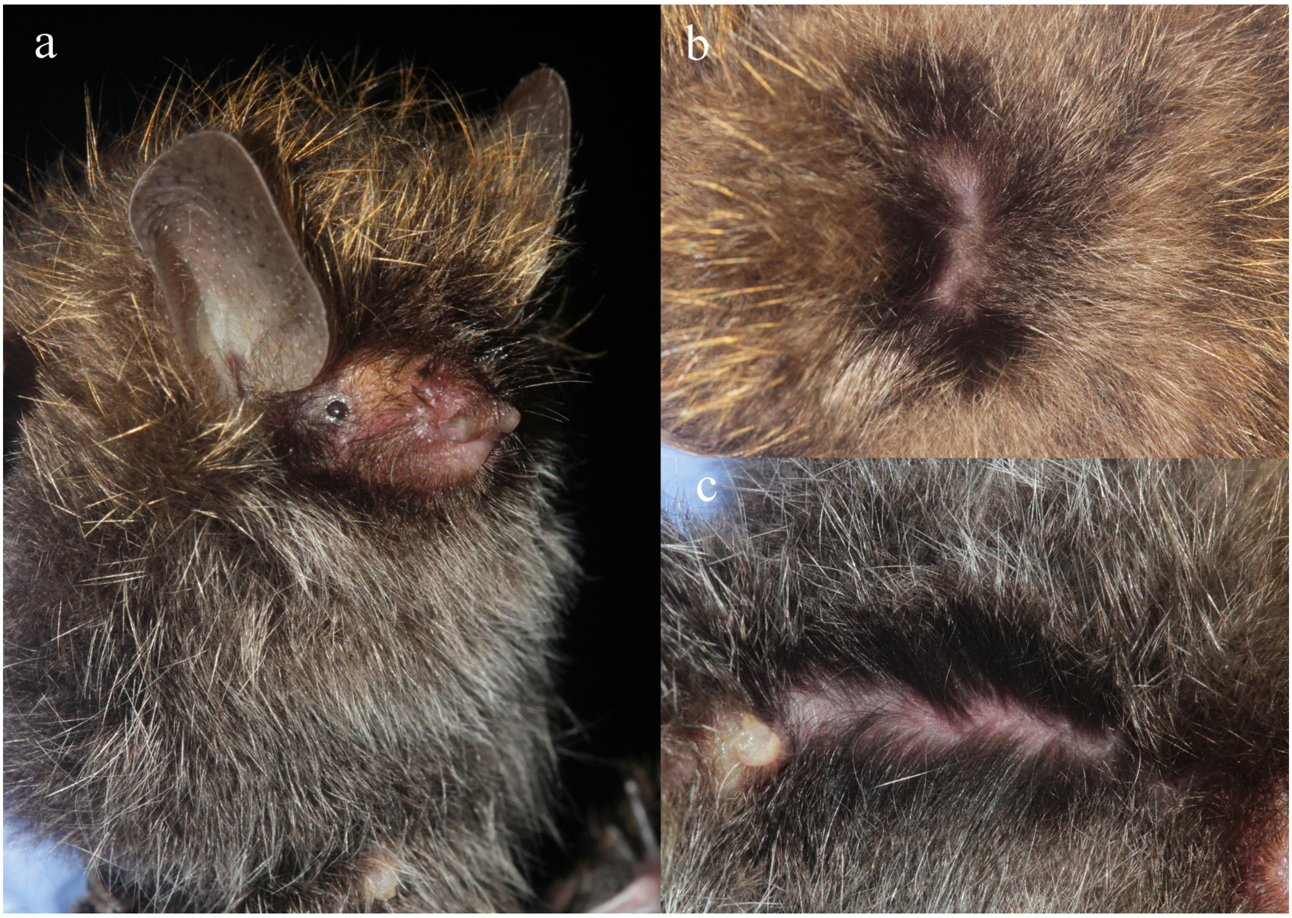

FIGURE 1. The appearance of the face, ear and pelage (a), dorsal pelage (b), and ventral pelage (c) of *M. hkakaboraziensis* **sp. nov.**, ♂PS160218.6, holotype, from Kachin, Myanmar.

In the mandible, the toothrow length (C-M_3) is 5.15 mm. The lower canine (C_1) is relatively small, but exceeds the anterior (P_2) and the posterior lower premolar (P_4) in both height and crown area (Fig. 2a). The cingulum of the C_1 is well-defined and possesses a small anterior cusp. The anterior lower premolar (P_2) is slightly more than half that of the C_1 and about two-third that of the P_4 in height. Its crown area is about half that of the C_1 and two-thirds of the P_4 (Fig. 2a). The P_4 is about two-thirds that of the C_1 in both height and crown area. The first and second molars (M_1 and M_2) are relatively large in comparison with the C_1, such that the C_1 is only about slightly more than half the crown area of the M_1 and M_2. The crown area of the talonid of both M_1 and M_2 is about equal to that of its respective trigonid (Fig. 2a). The coronoid process is projected slightly forward and relatively low with a CPH of 2.95 mm (Table 2).

The baculum is very small with a total length of 0.8 mm and 0.6 mm in width (Fig. 3). It is somewhat rectangular in shape and without constriction (Fig. 3). The dorsal side is arch upward.

Echolocation. Currently, for *M. hkakaboraziensis* **sp. nov.**, echolocation calls are only known from the holotype. Unfortunately, the calls were relatively faint and it was not possible to record a good signal of the initial hook. This made it impossible to measure the start frequency (*sf*) accurately. Nevertheless, it is possible to describe that this *Murina* emits broadband frequency modulated (FM) signals typical of the genus with a highest frequency (*hf*) of 164.0–169.0 kHz. The energy is distributed almost evenly throughout the pulse, with an *fmaxe* between 148.5 and 152.8 kHz. The terminal frequency (*tf*) varied from 62.0–70.0 kHz. The call duration (*d*) was 3.0–3.8 ms and the inter-pulses interval (*ipi*) was 69.1–75.3 ms. Echolocation characters indicate that this species, as many other *Murina*, is a forest-adapted species. However, based on the habitat of the capture site (see below), it is likely that it is adaptable to forage around edges between forest and open space.

Genetics. The Bayesian analysis phylogram based on DNA barcode reveals that several species in the subfamily Murininae are paraphyletic (Fig. 4). The single specimen of *M. hkakaboraziensis* **sp. nov.** clustered in a distinct but monophyletic clade with *M. kontumensis* from south-central Vietnam (Fig. 4). However, it has a genetic distance, based on COI, of 11.5% from *M. kontumensis*. This estimate evolutionary divergence is relatively large for intraspecific variation within *Murina* species, but it is typical between morphologically similar sister species, e.g. *M. chrysochaetes* vs *M. harpioloides* (11.9%; Eger & Lim, 2011). It is interesting to note that based on COI sequences the specimens of *M.* cf. *eleryi* from the same locality as the new species, although clustered closely with other specimens of *M. eleryi*, form a distinct clade and are more similar with *M. balaensis* from peninsular Thailand (K2P 9.3%) than with specimens from elsewhere in Indo-China (10.5%) (Fig. 4). It is very likely that *M. eleryi* has a complex biogeographic pattern, as mentioned in Son *et al.* (2015). Further study may demonstrate that the population of '*M.* cf. *eleryi'* in the Hkakaborazi Landscape has a distinct genetic structure, reflecting its demographic history, e.g. paleo-refuges, and that it is another undescribed cryptic species (P. Soisook, unpublished data).

Comparison with similar species. *Murina hkakaboraziensis* **sp. nov.** differs from *Murina* species in the *cyclotis*-type in having relatively small P^2. Among species with a *suilla*-type morphology, it can be separated from most species by a combination of its relatively small size (FA 29.6 mm; GTL 13.82 mm – Table 1 and 2), and pelage colour, having grey hairs on the belly and orange-brown hairs on the back with long golden guard hairs on the head and back. It is relatively similar in body size to *M. harpioloides* and *M. chrysochaetes*; it also shares the character of having golden hairs. However, it differs genetically and in other details of the pelage colouration and craniodental morphology. *Murina harpioloides* has a more orange colouration and the sagittal and lambdoid crests, although very weak, are present (Kruskop & Eger 2008; Son *et al.* 2015); they are absent in *M. hkakaboraziensis* **sp. nov.** In *M. chrysochaetes*, the ventral pelage has golden hairs as on the dorsal side (Eger & Lim 2011), but in *M. hkakaboraziensis* **sp. nov.**, the golden hairs are only apparent on the dorsal side (Fig. 1). The slope of the forehead of *M. chrysochaetes* is abrupt and the braincase is high and dome-shaped (Eger & Lim 2011), but the forehead profile of the new species gradually slopes up to the braincase, which although relatively high, is not dome-shaped (Fig. 2a). The pelage appearance of the new species is also somewhat similar to *Harpiola isodon* and *M. lorelieae*, but both of them have a larger body size and differ in the shape of the cranium (Kuo *et al.* 2006; Eger & Lim 2011; Son *et al.* 2015).

Murina hkakaboraziensis **sp. nov.** is most similar to the Vietnamese *M. kontumensis,* which was very recently described from south-central highland of Vietnam (Son *et al.* 2015). However, *M. hkakaboraziensis* **sp. nov.** has a more plentiful and well-defined longer bright golden guard hair (Fig. 1a). Besides the bright golden guard hairs, the colouration of the pelage on the dorsal and ventral sides are also different. In *M. kontumensis*, the general impression of the hairs are brownish-grey on the dorsal side and light brown on the ventral side, whereas *M. hkakaboraziensis* **sp. nov.**, is orange-brown on the dorsal side (Fig. 1b) and whitish-grey on the ventral side (Fig. 1c). There is no contrasting whitish collar around the neck of *M. hkakaboraziensis* **sp. nov.** (Fig. 1a), but this whitish collar is very obvious in *M. kontumensis* (Son *et al.* 2015, figure 3A). The wing membrane of the new species is attached about 2 mm above the base of the claw of the outer toe, whereas it attached to the base of the claw in *M. kontumensis* (Son *et al.* 2015, figure 3H). In the cranium, the lateral profile of the interorbital region of *M. kontumensis* rises abruptly to the forehead, but rises smoothly and gradually in *M. hkakaboraziensis* **sp. nov.** (Fig. 2). The sagittal crest of *M. kontumensis* is well-defined but it is absent in the new species (Fig. 2). In the dentition, the secondary cusp of the I^3 of *M. hkakaboraziensis* **sp. nov.** is very well developed and is about half the height of the main cusp, but in *M. kontumensis* this cusp is very poorly developed and is less than one-third the height of the main cusp (Fig. 2b). The posterior upper premolar (P^4) of *M. hkakaboraziensis* is somewhat square (Fig. 2a) and larger in crown area than that of *M. kontumensis,* which is rectangular, broader than long (Fig. 2b). Subsequently, the upper canine (C^1) of *M. hkakaboraziensis* **sp. nov.** appears to be relatively smaller in crown area than in *M. kontumensis* when comparing to the P^4.

Ecology and distribution. The new species, *M. hkakaboraziensis* **sp. nov.**, was collected in a mist net set at the edge of a lowland semi-evergreen forest at the transition zone to an open space grassland, which undergoes an annual burn (Fig. 5). The new species was the only bat captured in the mist net. However, on the same night, four other insectivorous bats, *Rhinolophus affinis*, *R. pusillus*, *Aselliscus stoliczkanus* and *Hipposideros pomona* were captured in nearby mist nets and harp traps. Four other vespertilionids, *M. cyclotis*, *M. feae, M.* cf. *eleryi, Kerivoula hardwickii*, and *K. furva* were also captured in the same area on other nights. Currently, the new species is only known from the holotype collected from the type locality in the Hkakabo Razi Landscape, Kachin, northern Myanmar.

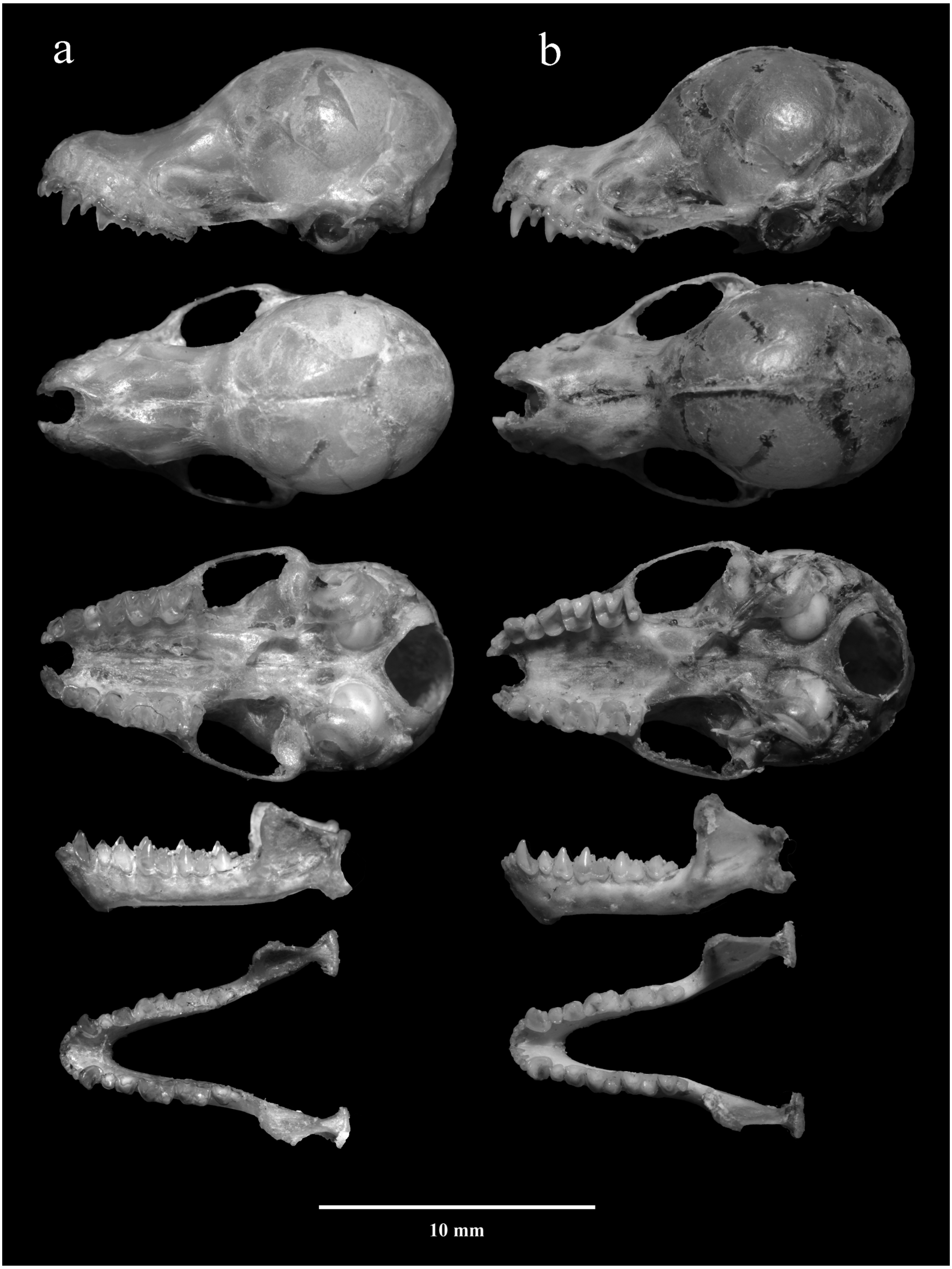

FIGURE 2. Comparison of the skull of *M. hkakaboraziensis* **sp. nov.**, ♂PS160218.6, holotype, from Kachin, Myanmar (a), and *M. kontumensis* ♀IEBR-M5697, holotype, from Kon Tum, Vietnam (b).

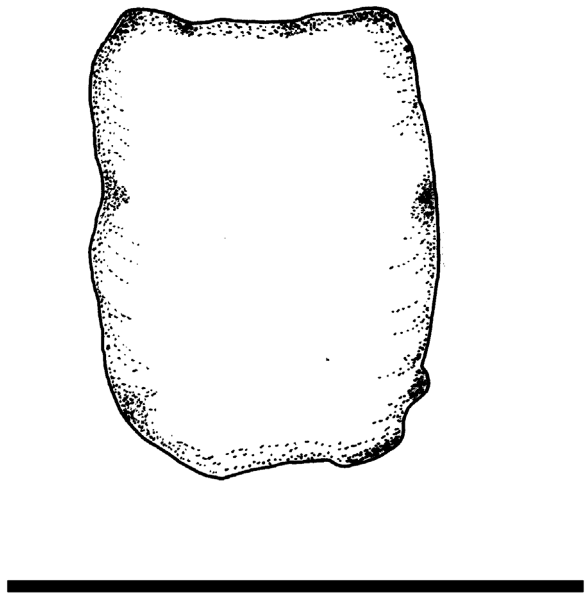

FIGURE 3. The dorsal side of the baculum of *M. hkakaboraziensis* **sp. nov.**, ♂PS160218.6, holotype, from Kachin, Myanmar. Scale = 1 mm. Drawing by PS.

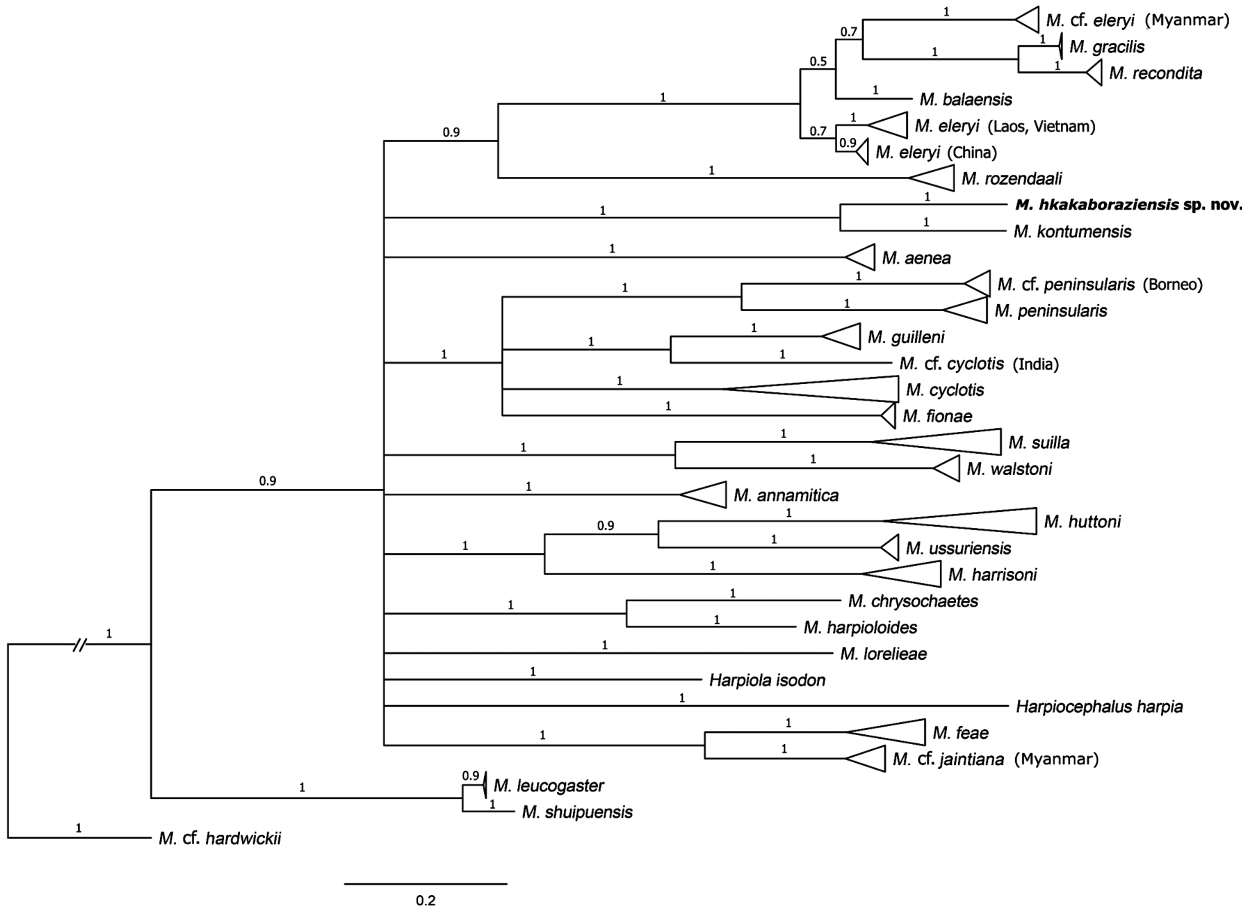

FIGURE 4. Bayesian tree based on GTR+I+G of 157 COI sequences of bats in the subfamily Murininae with a *Kerivoula* cf. *hardwickii* as an outgroup. The posterior probabilities of branch support are shown on branches.

FIGURE 5. The edge of a lowland semi-evergreen forest at the transition zone to an open space grassland where the specimen of *M. hkakaboraziensis* **sp. nov.** was captured. Photograph by SSLO.

Discussion

The discovery of *M. hkakaboraziensis* **sp. nov.**, as well as a recently described *Kerivoula furva* (Kuo *et al.* 2017), indicates that the Hkakabo Razi Landscape is extremely understudied in terms of bats. Based only on a single scientific expedition in 2016, 37 species of bats were recorded from HRL (P. Soisook, unpublished data) representing approximately 40% of bats in Myanmar. Nevertheless, the 2016 expedition focused only on a limited geographical area and elevation of the HRL. Future surveys to cover the variety of habitats, particularly at the higher elevations, would be of interest.

The vespertilionid community in the HRL appears to be a geographical connection and a unique mix of species those found widespread in the Indochinese Region (e.g. *M. cyclotis*, *M. feae, M.* cf. *eleryi, K. kachinensis, K. hardwickii*, and *K. furva*), and those from the Indian Region (e.g. *M.* cf. *jaintiana, M.* cf. *pluvialis*). It indicates the importance of primary forests, and ongoing biogeographical processes of the HRL, underlining the significance of Myanmar's endeavour to nominate the area as a Natural World Heritage Site.

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APPENDIX

List of specimens examined in Table 1 (museum numbers), and genetic materials used in figure 4 (Genbank or BOLD numbers in brackets).

Murina hkakaboraziensis—*Myanmar*: ♂PS160218.6 (holotype) [MF537343], Kachin.

M. kontumensis—*Vietnam*: ♀IEBR-M5697 (holotype) [KT820760], Kon Tum.

M. harpioloides—*Vietnam*:, ♂IEBR-M-5860, ♀IEBR-M-5806, ♀ZMMU S-173401 [HM540975], Lam Dong.

M. walstoni—*Vietnam*: ♀HNHM.2008.23.15, Dak Lak; ♂field number VN014-S102, ♀field number B-16, exact locality not known.—*Laos*: ♀BMNH.1999.50, Gnommalat, Khammouan; [ABBM390-05], [ABBM391-05], Vientiane; [BM210-03], [BM163-03], [BM170-03], Champasak; [ABBM079-05], [ABBM081-05], [ABBM086-05], Attapu.—*Thailand*: ♂PSUZC-MM2013.17, Klong Lan, Kamphaeng Phet; ♀PSUZC-MM2006.181, Na Haew, Loei.—*Cambodia*: ♀HNHM.2010.20.1 (holotype), Veun Sai, Ratanakiri.

M. feae—*Myanmar*: ♂BMNH.16.3.26.85, ♂BMNH.16.3.26.86, ♂BMNH.16.3.26.86, ♀BMNH.16.3.26.88, Chindwin; ♂BMNH.50.486, Nam Tamai, Kachin; ♀HZM.3.39984, ♀HZM.2.35960, Bhamo, Kachin.—*Vietnam*: ♂field number NF.050207.1, ♀field number NF.071206.2, Bac Kan; ♀field number T.270607.3, Cho Don, Bac Kan; ♀HZM.1.31524, ♀HZM.1.31780 [ABBM430-05], Nghe An; ♂field number B13, ♀011-T18 (T122), ♀field number VN 04-112, ♀field number XS-47, exact locality not known; [BM363-04], Quang Nam.—*Thailand*: ♂BMNH.82.163, BMNH.82.165, Chom Thong, Chiang Mai; ♂PSUZC-MM2006.180, ♀PSUZC-MM2006.7, Na Haew, Loei; ♂PSUZC-MM2011.26, ♀PSUZC-MM2011.25 [BTSEA022-13], ♂PSUZC-MM2011.27 [BTSEA021-13], Chiangdao, Chiang Mai.—*Laos*: [BM309-04], [ABBM396-05], [BM320-04], [ABBM405-05], [ABBM307-04], Khammouan; [ABBM185-05], Attapu; [ABBM260-05], Houaphan; [ABBM363-05], Vientiane.—*Cambodia*: ♀HNHM.2005.81.36, ♀HNHM.2005.81.50, Mondulkiri.

M. eleryi—*Vietnam*: ♀HZM.1.39006 (paratype), Na Rai, Bac Kan; ♀field number T120 (ROM field no.29013), exact locality not known; ♂field number T.241107.1, Phu Yen, Son La.—*Thailand*: ♂BMNH.82.162, Chom Thong, Chiang Mai.

M.* cf. *eleryi—*Myanmar*: ♂field number PS160217.27 [MF537345], ♀field number PS160217.6 [MF537344], Kachin.

M. gracilis—*Taiwan*: [KJ198568, KJ198569, KJ198570].

M. recondita—*Taiwan*: [KJ198689, KJ198690, KJ198691]

M. balaensis—*Thailand:* [ACG5529], Narathiwat.

M. rozendaali—*Thailand*: ♂PSUZC-MM2012.206, ♂PSUZC-MM2012.207, ♂PSUZC-MM2012.208, ♂field number PS130824.3, ♂field number PS130824.4, ♂field number PS130824.6, ♂field number PS130824.7, Wang, Narathiwat.—*Malaysia*: ♂BMNH.83.360 (holotype), ♀BMNH.84.2025, Gomantong, Sabah; ♂BMNH.1999.300, ♂BMNH.1999.301, Pahang; ♂TTU-M 108241, Kinabalu, Sabah.—*Indonesia*: ♂MZB26735, Kaltim, Kalimantan; ♂MZB34991, Lampung, Sumatra.

M. aenea—*Thailand*: [BTSEA032-13; BTSEA033-13], Narathiwat.—*Indonesia*: [ABBID024-09], Kalimantan.—*Brunei*: [MSSEA065-10], Sungai Ingei.

M.* cf. *peninsularis.—*Indonesia*: [ABBID042-09], Kalimantan.—*Brunei*: [MSSEA065-10], no exact locality.

M. peninsularis—*Thailand*: [BTSEA015-13], Phatthalung; [BTSEA016-13], [BTSEA020-13], [BTSEA019-13], Krabi; [BTSEA035-13], [BTSEA036-13], [BTSEA037-13], Songkhla; [BTSEA047-13], [BTSEA024-13], [BTSEA030-13], Narathiwat.—*Malaysia*: [ABBSI080-05], [BM468-04], [BM485-04], Pahang.—*Indonesia*: [BTSEA002-13], [BTSEA004-13], [BTSEA005-13], [BTSEA006-13], Sumatra.

M. guilleni—*Thailand*: [BTSEA011-13], [BTSEA013-13], Trang; [BTSEA045-13], Satun; [BTSEA014-13], Surat Thani; [ABBM062-05], Krabi.

M.* cf. *cyclotis—*India*: [ABBM421-05], Tamil Nadu.

M. cyclotis—*Laos*: [BTSEA038-13], [BM056-03], Vientiane; [ABBM389-05], [BM110-03], Khammouan; [ABBM298-05], [ABBM297-05], Louangphrabang; [ABBM255-05], Houaphan; [BM159-03], Champasak; [ABBM154-05], [ABBM119-05], Attapu.—*Vietnam*: [ABBM456-05], [BM339-04], Lang So'n;—*China*: [ABBM448-05], [ABBM461-05], [ABBM447-05], [ABBM460-05], Guangxi.

M. fionae—*Laos*: [BM318-04], Khammouan;—*Vietnam*: [BM366-04], Quang Nam.

M. suilla—*Malaysia*: [ABBM394-05], [ABBM409-05], [ABBM300-04], Sabah.—*Thailand*: [BTSEA031-13], Narathiwat; [BTSEA010-13]; Trang; [BTSEA018-13], [BTSEA017-13], Krabi.—*Indonesia*: [BTSEA001-13], [BTSEA007-13], [BTSEA008-13], Sumatra; [ABBID025-09], Java.

M. annamitica—*Thailand*: [BTSEA023-13], Chiang Mai.—*Laos*: [ABBM351-05], Louang Namtha; [BM308-04], [BM316-04], [ABBM404-05], [BM319-04], Khammouan.

M. huttoni—*Vietnam*: [BM624-04], Phu Khanh;—*Laos*: [BM306-04], [BM311-04], Khammouan.—*China*: [BM380-04], [BM390-04], Hunan.

M. ussuriensis—*Russia*: [JF442850], Dolinsk; [JF442847], Partizansk.

***M. harrisoni*—*China*: [ABBM463-05], [ABBM462-05], Guangxi.—*Laos*: [ABBM296-05], Louangphrabang.—*Vietnam*: [BM536-04], [ABBM444-05], [ABBM443-05], Dac Lac.

***M. chrysochaetes*—*China*: [ABBM452-05], Guangxi.

***M. lorelieae*—*China*: [JN082179], Guangxi.

***M. jaintiana*—*Myanmar*: [MF537346], [MF537347], [MF537348], [MF537349], [MF537350], Kachin.

***M. leucogaster*—*China*: [ABBM450-05], [ABBM451-05], Guangxi.

***M. shuipuensis*—*China*: [JN082180], Guizhou.

***Harpiola isodon*—*Vietnam*: [HM540286], Kon Tum.

***Harpiocephalus harpia*—*Thailand*: [BTSEA025-13], Narathiwat.

***Kerivoula* cf. *hardwickii*—*Myanmar*: [MF537351], Kachin.