

Results of a recent bat survey in Upper Myanmar including new records from the Kachin forests

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Recent studies have shown the importance of Myanmar for the conservation of bat diversity. In March–April, 2003, twenty-five localities in Kachin and Shan States and Mandalay and Sagaing Divisions in Upper Myanmar were surveyed using mist nets and harp traps. Of the twenty-three bat species collected, thirteen were recorded from two localities in Kachin State, one of which has already been described as a new species, *Kerivoula kachinensis*, and a further two (a *Rhinolophus* and a *Kerivoula*) are putative new species. *Murina tubinararis*, *Murina cyclotis* and *Rhinolophus shameli* were recorded for the first time in Myanmar for over 65 years, while our records of *Rhinolophus steno* and *Rhinolophus malayanus* are the most northern localities for these species in Myanmar. Species are discussed individually with external, cranial and dental measurements summarised. We also present descriptive statistics for echolocation calls recorded from five taxa. This represents the first bat survey of northern Myanmar forests for nearly 70 years. Kachin is already known to support high biodiversity and these recent records confirm the importance of its forests for the conservation of Myanmar's mammal fauna.

Key words: Chiroptera, Myanmar, Burma, distribution, harp traps, biodiversity, conservation

INTRODUCTION

Myanmar has a significant role to play in the conservation of biodiversity in South-east Asia (Dinerstein and Wikramanayake, 1993; MacKinnon, 1997; Rao *et al.*, 2002). However, as a consequence of political isolation and financial restraints many aspects of field-based studies have been neglected since the late 1930s and most of the studies that have been conducted by in-country scientists have not been published

in international journals. Although it is thought likely that Myanmar would support a substantial diversity of bats (Hutson *et al.*, 2001), studies concerned with the bat fauna have only recently developed beyond the scope of the colonial expeditions at the beginning of the 1900s (Bates *et al.*, 2000). The Mandalay University bat group has conducted a series of studies within the Mandalay area, whilst ten international bat surveys and a number of smaller field studies have been undertaken since 1999 by

the Harrison Institute and Yangon University at a range of locations throughout the country. These studies have resulted in a much greater understanding of bat distributions, systematics and habitat preferences and have increased the number of bat species recorded from Myanmar from 87 to 94 (Bates *et al.*, 2000, 2001, 2004a, 2004b; Pearch *et al.*, 2003). Although a range of habitat types have been sampled for bats, and in particular those associated with limestone karst, to date no detailed studies of these animals in forest habitats has been undertaken.

Given the rapid loss of forest biodiversity elsewhere in Asia (Whitmore, 1997), the substantial forested areas remaining in Myanmar may be some of the last refuges for this country's native mammal fauna. As much as 34% of Myanmar's land area is still forested (Leimgruber *et al.*, 2003a), and the country holds 40% of the intact wildlands remaining in mainland Asia (Leimgruber *et al.*, 2003b). Despite this, efforts to evaluate the biodiversity value of Myanmar's forests have been slow to develop, and surveys of bats using modern trapping techniques have not been undertaken. In particular, the full potential for harp traps to capture palaeotropical insectivorous bats has only recently been realized (Francis *et al.*, 1989, 1990; Rautenbach *et al.*, 1996). Unlike many of their neotropical counterparts, insectivorous forest species are capable of detecting and avoiding mist nets. The use of harp traps in forest habitats can greatly increase the known bat fauna, even in localities with a long history of bat research (e.g., Kingston *et al.*, 2003).

Here we report the results of a survey of 25 sites in Upper Myanmar. Harp traps were deployed at all sites with particular emphasis on the forest habitats of Myanmar's northernmost state, Kachin. This region is one of the most densely forested and inaccessible parts of mainland Southeast Asia

(Brunner *et al.*, 1998), and has recently been identified as supporting high mammal diversity (Rabinowitz and Khaing, 1998).

MATERIALS AND METHODS

Bat surveys were conducted at 25 localities throughout Kachin and Shan States, and Mandalay and Sagaing Divisions during March and April 2003. Four-bank harp traps (Francis, 1989) were used at forest sites, where they were set across trails or streams about 50 m apart. Traps were opened from 18:00–22:00 hours. At cave roosts, bats were caught at evening emergence using harp traps and mist nets (70 denier nylon, three or four shelves, 36 mm mesh size). Bats were collected, held individually in cloth bags and identified using Bates *et al.* (2000), Bates and Harrison (1997), Corbet and Hill (1992), and Lekagul and McNeely (1977). Voucher specimens, which are stored in 70% alcohol, were taken for further study at the Harrison Institute and the Zoology Department of Mandalay University. Echolocation calls (resting frequencies) were recorded for five *Rhinolophus* and *Hipposideros* species with a Pettersson D980 detector sampling at 400 kHz. Animals were held (ca. 30 cm) from the microphone for recording. Time-expanded (10×) outputs were recorded on a Sony WM-D6C Walkman cassette recorder and analysed using BatSound Pro Version 5. Power spectra were used to derive the frequency of maximum energy (kHz) and a single randomly selected call was measured for each individual.

Localities

Around Mandalay (Mandalay and Sagaing Divisions) — Surveys focused around the cities of Inwa (Awa) and Mandalay, which are located in Myanmar's central Dry Zone and are home to a large proportion of the country's human population. Agriculture has been practiced in the area for many centuries and in consequence there is little natural vegetation. A number of the caves surveyed around Mandalay were located in close proximity to religious monuments, which afforded some degree of protection from disturbance. Bats were caught at the following sites:

- (1) Wangaber (Lahing Gu) caves, Yankin Hill, Mandalay Division (21°59'N, 96°10'E). Two small limestone caves were visited next to the Wungaber. *Hipposideros larvatus* and *H. pomona* were captured;
- (2) Bagayar Kyaung monastery, Inwa, Mandalay Division (21°50'N, 95°58'E). A colony of approximately 500 bats were seen flying in the basement and

prayer room of this old teak monastery. *H. pomona* was captured.

(3) Maha Aungmye Bonzan (Ok Kyaung) monastery, Inwa, Mandalay Division (21°51'N, 95°59'E). A large brick-and-stucco disused monastery near the Myitnge river. The ground floor has large number of exits and a resident colony of *Taphozous melanopogon* and *H. pomona* was identified by sight.

(4) Shew Say Thi monastery, Sagaing Division. This is a small monastery located about 1 km east of the Mandalay-Lashio road north of Sataung. While the surrounding landscape is heavily cultivated, resident monks protect the immediate area of the monastery. Within the main grounds of the village stand several large tamarind trees, used as a roost by a large colony (> 1,000) of flying-foxes. The colony was provisionally identified as *Pteropus giganteus* based on size and colouration.

Htonbo, Mandalay Division — located within the Dry Zone ca. 50 km east of Mandalay, this is a predominantly lowland area with undulating hills (< 1,000 m elevation) throughout, and steep scarp slopes at the western margin of the Shan Plateau. The area is sparsely populated, but heavily cultivated or managed for cattle. Although much of the lowland is fluvial sand, there are isolated limestone outcrops. Htonbo is one of a number of towns in the area that has attracted substantial commercial mining interest in recent years. Cave surveys were conducted in the townships of Patheingyi and Pwin Oo Lwin (Maymyo), as well as Htonbo.

(1) Payataung (Pagoda Hill) cave, Patheingyi Township (21°53'N, 96°13'E). A warm and humid cave underneath a temple at the top Pagoda Hill near Htonbo town. Access is via the Htonbo limestone mine approximately 500 m from the Htonbo road and surrounding cultivated plains. The temple of Payataung affords protection to the cave from intensive limestone mining in the immediate area. There is one main entrance with a number of caverns, one of which is used for meditation by the resident monks. *Rhinolophus shameli*, *H. pomona* and *H. larvatus* were caught at the cave entrance. Individuals initially identified as *R. malayanus* were captured in the deeper recesses of the cave but are now considered to represent a distinct taxon. *Pipistrellus coromandra* was caught outside the cave.

(2) Kabani cave, Htonbo Township (21°56'N, 96°13'E). A cave with a relatively cool air temperature situated about 200 m up the west-facing slope of a large limestone valley 2 km from Ye Ma village. Much of the slopes are scree with small patches of scrub vegetation in shaded areas. Within the valley

there is local cultivation of banana, sugarcane and sunflower around Ye Ma, and large mango, lychee and grape plantations nearby. The cave has one main entrance (about 5 × 5 m), which leads into a cavern 15 m long, 6 m wide and 6 m high. There is a side cavern that extends upwards about 5 m. A number of tunnels extend vertically with the largest one about 4 m wide and extending 20 m to a narrow roof exit. In 2000, a large colony of *T. melanopogon* (> 500 individuals) was recorded at this site (Aye Aye Nwe, authors' unpubl. data). Although one individual was seen in a crevice, and a number were seen flying in the main roof tunnel, the colony had clearly declined. The cave has a history of guano and bat collection.

(3) Kho Nan Shin caves, Pwin Oo Lwin (Maymyo) Township (21°44'N, 96°20'E). Two caves about 20 m apart set at 150 m up limestone hill. A shrine in the lower cave has recently been renovated and extended, which has probably resulted in the reduction of the resident bat colony reported by local people. The upper cave has one large entrance (12 m × 6 m) with small side chambers (< 0.4 m high). A side chamber (4 × 4 m) extends upwards about 10 m with at least three small chambers (< 1 m high). *Taphozous melanopogon*, *H. pomona* and *R. malayanus* were caught. The cave is estimated to support a small colony of 30–40 individuals of the latter species in the deep recesses of the upper chamber.

Myingyan District, Mandalay Division — surveys were conducted in the Popa Mountain Park in Kyauk Padaung Township approximately 50 km southeast of Bagan (Pagan). This area of 23,215 ha surrounds the Popa volcano and has an elevation of between 300 and 1,518 m a.s.l. It has been protected since 1993 and is managed by the Forestry Department for watershed protection. Despite being one of two protected areas in Myanmar to include a buffer zone, the integrity of the park is compromised by encroachment of permanent agricultural settlements and collection of non-timber forest products (Rao *et al.*, 2002). This reddish-brown clay area was formerly covered with moist mixed-deciduous forest, although this has now largely disappeared through cutting and clearance. The slopes of the volcano are currently a mix of deciduous, hill and scrub forest with some patches of evergreen forest particularly in the crater. Of four sites visited, bats were only encountered at the following:

(1) Ye-nge Spring Forestry Guesthouse (20°54'N, 95°14'E) located in a small patch of evergreen forest containing a freshwater spring near the centre of the park. The vegetation is dense in places but is generally quite patchy with a low and uneven

canopy. *Cynopterus sphinx* was caught in mist nets set next to fruiting fig trees (*Ficus oppositifolia*).

(2) Laung Taw Ka Thapa shrine, Preserved Forest Area (20°54'N, 95°12'E). Located near the base of the volcanic plug near Popa village, this large brick shrine was built within a natural cave in a sandstone cliff in the 1970s. There is a central walkway, of which several rooms containing Buddha images and regalia. The shrine was being renovated during our visit, but a large colony (> 700 bats) was seen moving between chambers. Over 100 individuals of *H. larvatus* and a small number of *H. pomona* were caught.

Naunghkio (Nawngcho), Northwest Shan State — Shan State covers almost a quarter of Myanmar and is the most mountainous area in the country. This state also constitutes the largest part of the Northern Indo-Chinese biogeographic zone in Myanmar (Tun Yin, 1993). The region is cooler than the central plains with average temperatures between 15 and 30°C. According to local residents, mixed deciduous forest was abundant during the 1980s, but has all but disappeared. Much of the existing forested areas are heavily exploited for firewood, and other land is intensively cultivated. Surveys were concentrated at sites within Naunghkio (Nawngcho) township:

(1) Saya San cave, Hokho village (22°24'N, 96°30'E). This cave system is in a limestone rock outcrop approximately 1 km outside Hokho village and 40 km from Naunghkio. In the immediate area of the cave is a patch of evergreen vegetation, but the general landscape is under small-scale cultivation with some silk and coffee plantations. Hokho villagers collect rocks and boulders outside the cave, but inside the cave is protected as a shrine. There are at least six small entrances to the cave system leading to a low cavern flooded with water in places. *Hipposideros larvatus* and *H. armiger* were caught and a dead specimen of *Megaderma lyra* found near the entrance to the cave.

(2) Innwine cave and waterfall (22°10'N, 96°43'E). About 20 km east of Naunghkio off the Mandalay-Lashio road is a deep, vegetated gorge, through which a small river forms the Innwine waterfall. The gorge runs through a sugarcane and orange tree plantation that extends about 2 km past the gorge to a large limestone cave underneath burnt scrubland. Land surrounding the cave was heavily deforested or burnt at the time of the visit and a few small forest fires were seen in the distance. There are two main entrances that extend near vertically to a central cavern about 30 m high, 30 m wide and 100 m long, with a number of small side-chambers. Guano is collected commercially under license from the Forestry Department. Guano is extensive, at least 2 m deep in

places. The cave supports a large colony of bats (> 5,000) including *Hipposideros lylei*, *Rousettus leschenaulti* and *Eonycteris spelaea*. *Hipposideros larvatus* was also caught in a patch of forest at the base of the waterfall.

Bhamo (Ban-Maw), Kachin State — Although much of the Kachin's subtropical forests have been cleared, fragments of varying sizes remain both inside and outside forest reserves managed by the Forestry Department. Bhamo is a small town on the Ayeyawaddy River near the Chinese border and is the administrative centre for surrounding forest reserves. There is small-scale agriculture in the area as well as logging and extensive agro-forestry of bamboo. Bats were captured at two sites within travelling distance to Bhamo town:

(1) Namdee Hill, Bhamo Township (24°34'N, 97°07'E). Located near the settlement of Shet Shar on the eastern bank north of the first defile of the Ayeyawaddy River. Evergreen forest covers the hill and the immediate area, but changes to mixed-deciduous forest further away from the river. At the time of the visit approximately 2 ha of forest were being cleared for shifting cultivation at the edge of the river. There are a number of bamboo groves within the forest and two limestone caves near the top of the hill about 700 m from the forest edge. Local people reported that guano is infrequently collected from the caves, which are used for meditation 3–4 times per year by visiting monks. *Eonycteris spelaea* was seen in the main cavern and *Aselliscus stoliczkanus* and *H. larvatus* were captured. In the forest surrounding the caves harp traps caught the following species: *A. stoliczkanus*, *H. larvatus*, *H. pomona*, *R. pearsoni*, *R. shameli*, *R. malayanus*, *Rhinolophus* sp., *R. pusillus*, *R. stheno*, *Kerivoula kachinensis*, *Kerivoula* sp., *K. hardwickii*, and *Murina tubinaris*.

(2) Madanyan village, Manse Township (24°01'N, 97°19'E) is situated on the Burma Road, south of Bhamo. Madanyan is a large forest reserve across a wide valley containing mixed-deciduous forest with small patches of evergreen. At the time of the survey many areas were being cleared by fire for bamboo and banana plantations, and logging was reported by the local Forestry Department. *Rhinolophus pusillus*, *M. tubinaris*, *M. cyclotis* and *Kerivoula hardwickii* were captured in a patch of forest next to a large stream.

Specimens and Measurements

A total of 23 bat species were identified during this survey. External measurements (Table 1) were

taken from live individuals and specimens. They include FA: forearm length, from the extremity of the elbow to the extremity of the carpus with wings folded; MASS: body mass taken with a 60 g pesola balance; HB: head and body length, from the tip of the snout to the base of the tail, dorsally; TB: tibia length, from the knee joint to the ankle; TAIL: tail length, from the tip of the tail to its base adjacent to the anus; HF: foot length, from the extremity of the heel to the extremity of the longest digit, not including the hair or claws; E: ear length, from the lower border of the external auditory meatus to the tip of the pinna. The following cranial and dental measurements are included for nineteen specimens that are currently being studied at the Harrison Institute (see Table 2). GTL: greatest length of skull, the greatest antero-posterior length of the skull, taken from the most projecting point at the extremity; CCL: condylo-canine length, from the exoccipital condyle to the alveolus of the anterior canine; ZB: zygomatic breadth, the greatest width of the skull across the zygomatic arches; BB: breadth of braincase, greatest breadth of the braincase at the posterior roots of the zygomatic arches; PC: post-orbital constriction; C-M³: maxillary tooth-row length, from the alveolus of the upper canine to the back of the crown of the third upper molar; M³-M³: palatal width, taken across the outer borders of the third upper molar at the widest part; C-M₃: mandibular toothrow length, from the alveolus of the lower canine to the back of the crown of the third lower molar; C¹-C¹: greatest anterior palatal width measured across the outer borders of the canines at the widest part; MDL: mandible length, from the posterior part of the condyle to the anterior part of the mandible.

The calls of five taxa were recorded (see Table 3). Data on the known distribution of each species are included as well as comments on the taxonomy, ecology and conservation status, where relevant. 'New record' refers to sightings and to individuals captured and positively identified in the field, but for which voucher specimens are not available to study at the Harrison Institute. 'New material' specifically applies to voucher material at the Harrison Institute.

SPECIES REVIEW

Pteropus ? giganteus Brunnich, 1782
Indian flying-fox

New record

Sagaing Division: Shew Say Thi monastery.

Previous records from Myanmar

Mandalay Division (Bates *et al.*, 2000); Rakhine State: Naung Hla Village (HZM collection); Bago Division (Bates *et al.*, 2000). In reality, this species is much more widespread than the paucity of specimen data implies.

Comments

The colony from Shew Say Thi monastery was provisionally identified as *P. giganteus* based on size and colouration.

Rousettus leschenaulti Desmarest, 1820
Fulvous fruit bat

New record

Shan State: Innwine cave and waterfall.

Previous records from Myanmar

Mandalay Division (Bates *et al.*, 2000); Rakhine State: Nga Myat Nar Temple, 24 km west of Pyay (HZM collection, and Pearch *et al.*, In press); Yangon Division: Yangon city (P. J. J. Bates, pers. comm); Kayin State: Weibyan Cave (HZM); Mon State: Sad-dan-Sin Cave (HZM); Mawlamyine [Moulmein: = *R. amplexicaudatus* in Agrawal and Sinha (1973) but see Rookmaaker and Bergmans (1981)]. Specimens from Tanintharyi Division: Tagoot (= *R. leschenaulti* in Wroughton, 1915) are now referred to *R. amplexicaudatus* (Hill and Thonglongya, 1972).

Comments

Fourteen individuals were collected with a forearm length ranging from 74.4–89.7 mm and a body mass of 63.5–124.0 g. None was available for study at the Harrison Institute.

Cynopterus sphinx Vahl, 1797
Short-nosed fruit bat

New record

Mandalay Division: Ye-nge Spring Forestry Guesthouse.

TABLE 1. External measurements (in mm) and conservation status of the 20 known species of bat captured during the survey, including forearm (FA), body mass (MASS, in g), head-body length (HB), tibia length (TB), hind foot length (HF), tail length and ear length; n^s indicates the number of male or female specimens taken. Numbers in parentheses indicate the number of individuals from which measurements were taken. Conservation status: LR: lc, Low Risk; Least Concern; LR: nt, Low Risk: Near Threatened, following IUCN (2002)

Species	Conservation status	n	FA	MASS	n^s	HB	TB	TAIL	HF	Ear
Pteropodidae										
<i>Rousettus</i>	LR:lc	7♂♂	82.1–89.7	102.0–124.0	7♂♂	133.0 (1)	41.5	10.4 (1)	16.5 (1)	19.5–22.0
<i>leschenaulti</i>		7♀♀	74.4–80.0	63.5–89.0	7♀♀	–	–	–	–	19.0–21.0
<i>Cynopterus sphinx</i>	LR:lc	5♀♀	63.5–76.9	22.0–56.0	–	–	–	–	–	–
<i>Eonycteris spelaea</i>	LR:lc	4♂♂	67.0–74.5	53.5–79.5	2♂♂	79.5–118.0	30.0–34.0	20.0–25.0	17.0–18.0	18.0–22.0
Rhinolophidae										
<i>Rhinolophus pearsoni</i>	LR:lc	1♀	53.1	17	1♀	58.0	20.0	20.0	11.0	24.5
<i>R. stheno</i>	LR:lc	1♂	44.3	6.5	1♂	43.0	20.8	14.5	6.0	16.5
		1♀	44.9	6.0	1♀	46.0	21.9	19.0	7.6	17.5
<i>R. malayanus</i>	LR:lc	2♂♂	38.9–40.0	6.0	1♂	44.0	16.5	22.0	7.0	17.5
		3♀♀	38.8–40.0	5.5–7.0(2)	–	–	–	–	–	–
<i>R. pusillus</i>	LR:lc	1♂	37.1	6.0	1♂	38.0	15.6	17.0	6.5	16.0
		3♀♀	35.5–37.6	5.0–8.0	2♀♀	37.0–39.0	14.5–15.0	18.0–18.5	6.3–7.0	15.0–15.5
<i>R. shameli</i>	LR:nt	2♂♂	43.9–45.4	8.0	1♂	50.0	22.4	21.0	9.0	19.0
		1♀	45.6	8.75	–	–	–	–	–	–
Hipposideridae										
<i>Aselliscus</i>	LR:lc	1♂	41.0	6.0	–	–	–	–	–	–
<i>stoliczkanus</i>		5♀♀	38.1–43.2	5.0–7.0	2♀♀	42.4	19.0–20.0	35.0	6.0–7.0	11.0–12.0
<i>Hipposideros armiger</i>	LR:lc	14♀♀	90.0–96.3	42.5–59.5	2♀♀	–	40.0	–	–	33.0–36.0
<i>H. larvatus</i>	LR:lc	49♂♂	56.8–69.3	15.0–26.0	1♂	–	–	–	–	22.0(1)
		31♀♀	55.8–65.2	14.0–22.0	–	–	–	–	–	–
<i>H. lylei</i>	LR:nt	3♀♀	74.3–75.1	30.5–41.5	1♀	85.0	32.0	51.0	16.0	28.0
<i>H. pomona</i>	LR:lc	14♂♂	38.4–40.8	5.5–7.8	7♂♂	–	–	–	–	19.0–23.0
		18♀♀	38.7–42.8	5.5–7.0	2♀♀	41.0–48.0	18.0–19.8	25.0–31.0	7.0	23.0–27.0
Megadermatidae										
<i>Megaderma lyra</i>	LR:lc	1♂	65.9	40.0	1♂	93.0	34.0	–	21.0	32.0

TABLE 1. Continued

Species	Conservation status	<i>n</i>	FA	MASS	<i>n</i> ^s	HB	TB	TAIL	HF	Ear
<i>Murina cyclotis</i>	LR:lc	1 ♀	33.9	6.5	1 ♀	50.0	17.2	35.0	7.0	16.0
	LR:lc	1 ♂	29.6	4.0	1 ♂	48.0	16.2	34.0	6.0	13.0
<i>Kerivoula hardwickii</i>	LR:lc	2 ♀ ♀	30.0–30.7	5.0–6.0	1 ♀	40.0	17.7	34.0	7.5	12.0
	–	5 ♀ ♀	31.8–34.9	3.0–5.0	1 ♀	35.0	16.1	37.0	6.5	11.5
<i>K. kachinensis</i>	–	1 ♀	41.3	7.0	1 ♀	48.0	21.8	54.0	10.0	13.5
<i>Pipistrellus coromandra</i>	LR:lc	1 ♂	30.7	–	1 ♂	36	13.1	32	5.4	8.9
<i>Taphozous melanopogon</i>	LR:lc	14 ♂ ♂	58.2–66.8	22.3–30.5	–	–	–	–	–	–
	–	6 ♀ ♀	63.7–65.8	30.0(1)	–	–	–	–	–	–

Vespertilionidae

Emballonuridae

Previous records from Myanmar

Shan and Rakhine States, and Sagaing, Mandalay and Tanintharyi Divisions (Pearch *et al.*, 2003); Mon State: Kyaik-Kha-Mi (HZM; and J. P. P. Bates *et al.*, unpubl. data).

Comments

Five female specimens were captured at a fruiting fig tree (*Ficus oppositifolia*); none is available for study at the Harrison Institute. The variation in forearm length (63.5–76.9 mm) and body mass (22–56 g) suggests that *C. brachyotis* (Muller, 1838) may also be present in the sample; this latter taxon is currently only recorded with certainty from Rakhine State. For further details of the systematics of *Cynopterus* in Myanmar see Pearch *et al.* (2003).

Eonycteris spelaea Dobson, 1871
Dawn bat

New record

Shan State: Innwine cave and waterfall.

Previous records from Myanmar

Rakhine State (Pearch *et al.*, 2003); Yangon Division: Yangon (YU); Kayin State (Bates, 2003); Mon State (Bates, 2003); Kyaik-Kha-Mi (YU); Tanintharyi Division: Tagoot (Wroughton, 1915); Mar-laka cave, Shingyein cave (YU/HZM).

Comments

Four specimens were collected with a forearm length of 67.0–74.5 mm and a body mass of 53.5–79.5 g. It is easily identifiable amongst the local fruit bat species by the absence of a claw on the second digit. All specimens from Myanmar are referable to the nominate race *E. s. spelaea*. This species was present at Innwine cave despite the commercial extraction of guano.

Taphozous melanopogon Temminck, 1841
Black-bearded tomb bat

TABLE 2. Cranial and dental measurements (in mm) of the 11 known species of bat collected as specimens during the survey, including greatest length of skull (GTL), skull length (SL), condylo-canine length (CCL), zygomatic breadth (ZB), breadth of braincase (BB), post orbital constriction (PC), maxillary toothrow length (C–M³), palatal breadth (M³–M³), mandibular toothrow length (C–M₃), anterior palatal width (C¹–C¹) and mandible length (MDL)

Species	<i>n</i>	GTL	CCL	ZB	BB	PC
Rhinolophidae						
<i>Rhinolophus pearsoni</i>	1♀	24.2	20.8	11.8	9.6	2.6
<i>R. stheno</i>	1♂	19.4	16.0	8.7	8.0	2.3
	1♀	19.4	16.1	9.1	8.1	2.0
<i>R. malayanus</i>	1♂	18.3	15.5	8.5	8.1	2.4
<i>R. pusillus</i>	1♂	16.6	13.8	7.7	7.2	2.5
	2♀	15.2, 16.2	13.3, 13.5	7.2, 7.5	7.3, 7.5	2.1, 2.3
<i>R. shameli</i>	1♂	20.6	17.3	9.4	8.5	2.4
Hipposideridae						
<i>Aselliscus stoliczkanus</i>	2♀	15.8	13.3, 13.5	7.3, 7.5	6.3, 6.5	2.0
<i>Hipposideros pomona</i>	2♀	17.0, 17.6	14.8, 15.2	8.7	7.8, 8.1	2.5, 2.9
Vespertilionidae						
<i>Murina cyclotis</i>	1♀	16.71	14.76	9.72	7.53	4.28
<i>M. tubinaris</i>	1♂	15.75	13.43	8.31	7.09	4.12
	1♀	15.94	13.68	–	7.19	4.30
<i>Kerivoula hardwickii</i>	1♀	13.84	12.39	–	6.66	3.32
<i>K. kachinensis</i>	1♀	17.10	15.50	10.20	7.80	3.50
<i>Pipistrellus coromandra</i>	1♂	12.32	10.96	7.80	6.18	3.34

New records

Mandalay Division: Maha Aungmye Bonzan; Kabani cave.

Previous records from Myanmar

Mandalay Division (Bates and Harrison, 1997; Bates *et al.*, 2000), Yankin Hill (HZM/YU), Kho Nan Shin cave (HZM/YU); Rakhine State (Pearch *et al.*, 2003); Kayin State (Bates *et al.*, 2000); Tanintharyi Division: Tagoot (Wroughton, 1915); Talintut cave (HZM/YU).

Comments

Forearm length for the twenty individuals seen during the expedition ranged from 58.2–66.8 mm and body mass from 22.3–30.5 g.

Megaderma lyra E. Geoffroy, 1810
Greater false vampire

New record

Shan State: Innwine cave.

Previous records from Myanmar

Shan State, Bago and Sagaing Divisions (Bates *et al.*, 2000); Kayin State and Mon States (P. J. J. Bates *et al.*, unpubl. data).

Comments

A dead specimen with a forearm length of 65.9 mm was found near the entrance to the cave.

Rhinolophus pearsoni Horsfield, 1851
Pearson's horseshoe bat

New material

Kachin State: Namdee Hill, 11.4.2003, 1 ♀ (MA030411:2).

Previous records from Myanmar

Kachin, Shan, and Mon States are included in Bates *et al.* (2004b).

Comments

Distinguished by its smaller size (Tables 1 and 2) from the morphologically similar

TABLE 2. Extended

Species	C–M ³	M ³ –M ³	C–M ₃	C ¹ –C ¹	MDL
Rhinolophidae					
<i>Rhinolophus pearsoni</i>	9.6	8.9	10.4	6.2	16.5
<i>R. stheno</i>	7.1	6.6	7.6	4.3	11.9
	7.2	6.6	7.6	4.3	12.0
<i>R. malayanus</i>	6.7	5.9	7.7	4.1	11.6
<i>R. pusillus</i>	6.0	5.6	6.4	3.9	10.5
	5.9, 6.0	5.3, 5.6	6.2, 6.3	3.4, 3.9	10.1, 10.2
<i>R. shameli</i>	7.8	7.0	8.4	5.0	13.5
Hipposideridae					
<i>Aselliscus stoliczkanus</i>	5.4, 5.5	5.4, 5.5	6.1, 6.5	3.3, 3.4	9.4, 9.6
<i>Hipposideros pomona</i>	5.9, 6.0	5.7, 5.9	6.2, 6.3	3.3, 3.4	10.3, 10.6
Vespertilionidae					
<i>Murina cyclotis</i>	5.53	5.64	6.12	4.3	11.38
<i>M. tubinaris</i>	4.97	5.03	5.57	3.53	9.94
	5.08	5.11	5.53	3.72	10.52
<i>Kerivoula hardwickii</i>	5.38	4.93	5.97	3.22	9.70
<i>K. kachinensis</i>	6.80	6.40	7.10	4.17	12.70
<i>Pipistrellus coromandra</i>	4.30	5.25	4.61	3.90	8.59

R. yunanensis (SL = 24.60–27.25 mm; C–M³ = 10.14–11.24 mm, based on Csorba *et al.*, 2003). *Rhinolophus pearsonii* is a relatively common species in southern/South-East Asia.

Rhinolophus malayanus Bonhote, 1903
North Malayan horseshoe bat

New material

Kachin State: Namdee Hill, 11.4.2003, 1 ♂ (MA030411:5).

Previous records from Myanmar

Shan, Kayin and Mon States and Mandalay Division are included in Bates *et al.* (2004b).

Comments

Measurements are included in Tables 1 and 2. *Rhinolophus malayanus* was first collected from Myanmar in 1999 (Bates *et al.*, 2000). It appears to be a widespread and common species in the limestone karst areas of eastern and southern Myanmar.

Rhinolophus sp.

New material

Kachin State: Namdee Hill, 11.4.2003, 1 ♀ (MA030411:6).

Comments

This specimen and others associated with it, which have been collected from a range of localities elsewhere in Myanmar are currently being studied prior to possible publication as a new species to science.

Rhinolophus stheno Andersen, 1905

Lesser brown horseshoe bat

New material

Kachin State: Namdee Hill, 11.4.2003, 2 ♂♂ (MA030411:8/18).

Previous records from Myanmar

Mon State and Mandalay Division are included in Bates *et al.* (2004b).

Comments

Measurements are included in Tables 1 and 2. The diagnostic characters, including the greater length of the tibiae and of

the second phalanx of the third digits, by which *R. stheno* can be distinguished from *R. malayanus*, are discussed in detail in Bates *et al.* (2000 and 2004b). First collected in November, 2002, this appears to be a less common species than *R. malayanus* in Myanmar. The recent record from Kachin State extends its range nearly 250 km to the north in Myanmar. It is also the most northern locality for this species from throughout its range in Southeast Asia (Csorba *et al.*, 2003).

Rhinolophus pusillus Temminck, 1834
Least horseshoe bat

New material

Kachin State: Namdee Hill, 11.4.2003, 1 ♂ (MA030411:15); 2 ♀♀ (MA030411:13/16).

Previous records from Myanmar

Kachin and Shan States and Sagaing and Bago Divisions are included in Bates *et al.* (2004b).

Comments

A small rhinolophid (Tables 1 and 2) typified by its triangular-shaped superior connecting process. A full description is included in Csorba *et al.* (2003) and its taxonomic status in Myanmar is discussed in Bates *et al.* (2004b). It is a widespread species in Myanmar.

Rhinolophus shameli Tate, 1943
Shamel's horseshoe bat

New material

Kachin State: Namdee Hill, 11.4.2003, 1 ♂ (MA030411:0).

New records

Mandalay Division: Payataung cave.

Previous records from Myanmar

Sagaing Division are included in Bates *et al.* (2004b).

Comments

Measurements are included in Tables 1 and 2. The diagnostic characters by which *R. shameli* can be distinguished from the morphologically similar *R. coelophyllus* Peters (1867) are discussed in Bates *et al.* (2004b). Its mean call frequency is equal to 74.7 kHz (Table 3). It compares favourably to the 76.0 kHz call frequency of hand-held individuals from Lao PDR (Francis and Habersetzer, 1998). This recent record from Kachin State is the first for Myanmar since the first decade of the 20th century (Bates *et al.*, 2004b).

Hipposideros larvatus Horsfield, 1823
Horsfield's leaf-nosed bat

New records

Kachin State: Namdee Hill; Shan State: Saya San cave; Mandalay Division: Laung Taw Ka Thapa shrine; Payataung (Pagoda Hill) cave; Wangaber (Lahing Gu) caves.

Previous records from Myanmar

Kachin State: U Daung Taung Gu (HZM/YU); Sagaing Division: Nanda-Ya Ma Chaung (HZM/YU); Mandalay Division (Bates *et al.*, 2000); Shan State (Bates *et al.*, 2000), Montawa Cave (HZM/YU); Rakhine State (Pearch *et al.* 2003), Bar Min Gu (HZM/YU); Bago Division (Bates *et al.*, 2000); Mon State (Bates *et al.*, 2000); Tanintharyi Division: Tagoot (Wroughton,

TABLE 3. Descriptive statistics for resting frequency echolocation calls recorded from five taxa

Species	n	Call frequency (kHz)	
		$\bar{x} \pm SD$	min-max
<i>Rhinolophus shameli</i>	2	74.7 \pm 0.28	74.5–74.9
<i>Hipposideros armiger</i>	14	66.0 \pm 0.67	65.2–67.1
<i>H. larvatus</i>	51	92.7 \pm 1.35	89.2–95.2
<i>H. lylei</i>	3	67.2 \pm 0.52	66.6–67.5
<i>H. pomona</i>	22	134.9 \pm 1.42	132.1–137.2

1915); Katalu Village (HZM/YU); Lei Kyet village (HZM/YU).

Comments

A medium-sized species of *Hipposideros*. Forearm length and body mass for 80 specimens of both sexes ranged between 55.8–69.3 mm and body mass between 14.0–26.0 g. It is widespread and common in Myanmar.

Hipposideros armiger Hodgson, 1835
Great Himalayan leaf-nosed bat

New records

Shan State: Saya San cave.

Previous records from Myanmar

Kachin State (Anthony, 1941), (LACM), U Daung Taung Gu (HZM/YU); Sagaing Division and Shan and Chin States (Bates and Harrison, 1997); Kayin and Mon States (P. J. J. Bates *et al.*, unpubl. data).

Comments

This is a large species of *Hipposideros*. Forearm length and body mass for 14 ♀♀ ranged between 90.0–96.3 mm and body mass between 42.5–59.5 g. It is widely distributed throughout Myanmar and is particularly associated with caves.

Hipposideros lylei Thomas, 1913
Shield-faced roundleaf bat

New records

Shan State: Innwine cave and waterfall.

Previous records from Myanmar

Shan and Kayin States (Robinson *et al.*, 2003).

Comments

This species is intermediate in size between *H. larvatus* and *H. armiger*. Forearm length and body mass for three female indi-

viduals ranged between 74.3–75.1 mm and body mass between 30.5–41.5 g.

Hipposideros pomona Andersen, 1918
Andersen's leaf-nosed bat

New material

Kachin State: Namdee Hill, 11.4.2003, 2 ♀♀ (MA030411:9/20).

New records

Mandalay Division: Wangaber caves, Bagayar Kyaung monastery, Maha Aungmye Bonzan monastery, Payataung cave, Kho Nan Shin caves, Laung Taw Ka Thapa shrine.

Previous records from Myanmar

Sagaing, Mandalay and Magway Divisions and Shan State (Bates and Harrison, 1997).

Comments

Forearm length and body mass for 30 individuals ranged between 38.4–41.9 mm and body mass between 5.5–7.8 g. It is common in many parts of Myanmar and is particularly associated with caves.

Aselliscus stoliczkanus Dobson, 1871
Stoliczka's trident bat

New material

Kachin State: Namdee Hill, 11.4.2003, 2 ♀♀ (MA030411:1/19).

Previous records from Myanmar

Kachin State (Bates *et al.*, 2000); Shan State: Gotkeik gorge cave; Sanite cave No. 2 (YU/HZM); Mon State (Bates *et al.*, 2000).

Comments

This species has to date only been found in limestone karst areas of Myanmar. Where present, the colonies appear to be large, with hundreds if not thousands of individuals.

Pipistrellus coromandra Gray, 1838
Coromandel pipistrelle

New material

Mandalay Division: Pagoda Hill, 12.3.2003, 1 ♂ (MN2).

Previous records from Myanmar

Kachin State (Anthony, 1941 and Smithsonian Institution/LACM). Specimens previously referred to this species from Shan State [Pyaunggaung in Ryley (1914) were subsequently referred to *P. paterculus* by Wroughton (1916)] and from Bago Division: [Bago = Pegu in Wroughton and Davidson (1918)] and Tanintharyi Division: [Myeik = Mergui in Lindsay (1926)] were subsequently included in a new species *P. peguensis* by Sinha (1969).

Comments

This is a small species of pipistrelle (Tables 1 and 2), whose external measurements can be confused with *P. tenuis* (Temminck, 1840). The cranial and dental measurements are usually larger than those of this latter species (Bates and Harrison, 1997).

Murina cyclotis Dobson, 1872
Round-eared tube-nosed bat

New material

Kachin State: Madanyan Forest, 12.4.2003, 1 ♂ (MA030411:1).

Previous records from Myanmar

Kachin State (Anthony, 1941 and Bates and Harrison, 1997); Chin State (Bates and Harrison, 1997).

Comments

The recent specimen from Myanmar is comparable in size (Tables 1 and 2) to those from India included in Bates and Harrison (1997) and following Corbet and Hill

(1992) is referred to the nominate race *M. c. cyclotis*. The hairs of the dorsal pelage have orange-brown tips, with mid-grey roots; the ventral surface is pale creamy-brown with grey hair roots. The ears are broadly rounded and without an emargination on their posterior borders. In the lower dentition, P_2 is about equal in crown area to the trigonid of M_1 . This species is considered a forest specialist and is known to actively avoid mist nets (Kingston *et al.*, 2003). The recent specimen from Kachin is the first to be collected in Myanmar since the Vernay-Cutting Expedition of 1938–39 (Anthony, 1941).

Murina tubinaris Scully, 1881
Scully's tube-nosed bat

New material

Kachin State: Namdee Hill, 11.4.2003, 1 ♂ (MA030411:17).

Previous records from Myanmar

Kachin State: Nam Tamai Valley (Bates and Harrison, 1997).

Comments

The two recent specimens from Myanmar are both relatively small (Tables 1 and 2) when compared to those from India included in Bates and Harrison (1997). However, in all other characters they are comparable and are included in the nominate race *M. t. tubinaris*. The hairs of the dorsal pelage are tri-coloured with dark grey tips, light grey mid-parts and dark grey roots; on the ventral surface the hair tips are pale with contrasting dark grey roots. The ears are broadly rounded and with a small emargination on their posterior borders. In the lower dentition, P_2 is about half the crown area of the trigonid of M_1 . Like *M. cyclotis*, we consider this species a forest specialist. The recent specimens from Namdee Hill are the first collected in Myanmar since those of Ronald

Kaukback from Kachin State in 1933 (Hill, 1962).

Kerivoula kachinensis Bates *et al.*, 2004a
Kachin woolly bat

Previous material

Kachin State: Namdee Hill, 11.4.2003, 1 ♀ (MA030411:3). See Bates *et al.* (2004a).

Comments

This is a large *Kerivoula* characterised by a distinctly flattened braincase.

Kerivoula sp.

New material

Kachin State: Namdee Hill, 11.4.2003, 2 ♀ ♀ (MA030411:1/3).

Comments

These specimens are currently being studied prior to possible publication as a new species to science.

Kerivoula ? hardwickii Horsfield, 1824
Hardwicke's forest bat

New material

Kachin State: Namdee Hill, 11.4.2003, 1 ♂ (MA030411:3 and MA030411:7).

Comments

Measurements are given in Tables 1 and 2. The specimen is relatively small compared to those included in Bates and Harrison (1997; see also Vanitharani *et al.*, 2003).

DISCUSSION

With one new, and two putative new, species of bat, the results of this survey suggest that there is still considerable scope for further bat research in both the central and more remote regions of Myanmar. Whilst

the putative rhinolophid species is primarily characterised by its small size, the two putative new species of Kerivouline bats show highly characteristic morphological and morphometric differences.

The records of *R. stheno* and *R. malayanus* represent the most northern localities in Myanmar currently known for these species, whilst those of *M. cyclotis*, *M. tubinaris*, and *R. shameli* are the first Myanmar records for these species for over 65 years (Bates *et al.*, 2000). Thirteen of the bat species encountered during this survey were captured in forested areas in Kachin State, six exclusively so, including the three *Kerivoula*. The areas surveyed in Kachin were heavily disturbed and represent only a fraction of the forest remaining in Myanmar, yet they support a relatively high diversity of bats compared to caves elsewhere in the country (P. J. J. Bates, unpubl. data). We believe this diversity reflects the use of harp traps, which are particularly effective at capturing species that can actively detect and avoid mist nets by being highly manoeuvrable and competent echolocators (Francis, 1989; Rautenbach *et al.*, 1996). Mist net avoidance is achieved by the most common bat families of Old World forests (the Rhinolophidae and Hipposideridae, and vespertilionids in the subfamilies Kerivoulineae and Murininae — Francis, 1989), which rely on specialised echolocation signals to find prey in the cluttered forest vegetation (Neuweiler, 1990; Kingston *et al.*, 1999). It is therefore likely that previous surveys of Myanmar have undersampled this community, as is the case elsewhere in the region (e.g., in Malaysia — Kingston *et al.*, 2003).

Kachin State holds one of Southeast Asia's last large tracts of relatively undisturbed forest (Leimgruber, 2003a). Although the isolation of these frontier forests has meant that logging has been slow to develop, satellite data show that forest

clearing has more than tripled in recent years due to unsustainable logging and collection of non-timber forest products (Brunner *et al.*, 1998). The hunting and trading of wildlife products is reported to be of particular concern in this region with extensive cross-border trade to China and Thailand (Rabinowitz and Khaing, 1998; Rao *et al.*, 2002). Indeed, local people near Madanyan forest reserve reported selling bats as well as tiger, deer and bear products, to Chinese merchants. Trade in other areas visited appears to be more local, with bats (*Eonycteris*, *Rousettus* and *Taphozous* in particular) being skinned and sold as sparrow — a national delicacy. In their Global 200 assessment of the world's ecoregions based on biological distinctiveness and conservation status, Olson and Dinerstein (1997) described northeastern Myanmar and adjacent areas of China as vulnerable and critically endangered respectively. Indeed, the few protected areas in Kachin are failing to conserve this region's unique biodiversity (Rao *et al.*, 2002). With two new species recently identified (Amato *et al.*, 1999; Bates *et al.*, 2004a), and potentially a further two from this study, further surveys of other forest areas using a range of collection techniques are clearly needed to provide further information regarding diversity, distribution and basic ecology of Myanmar's mammals.

GAZETTEER

Mandalay Division: Kho Nan Shin cave 21°44'N, 96°20'E;
 Mandalay Division: Yankin Hill 21°59'N, 96°10'E;
 Rakhine State: Bar Min Gu, 20°36'N, 93°11'E;
 Kachin State: U Daung Taung Gu; 24°09'N, 96°58'E;
 Shan State: Montawa Cave 21°59'N 96°10'E;
 Sagaing Division: Nanda-Ya Ma Chaung 21°54'N, 95°59'E;
 Tanintharyi Division: Katalu Village 12°29'N, 98°24'E;
 Tanintharyi Division: Lei Kyet village 12°30'N, 98°24'E;
 Tanintharyi Division: Marlaka cave, 12°29'N, 99°03'E;

Tanintharyi Division: Shingyein cave, 12°19'N, 99°01'E;
 Tanintharyi Division: Talintut cave, 12°19'N, 99°03'E.

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LITERATURE CITED

- AGRAWAL, V. C., and Y. P. SINHA. 1973. Studies on the bacula of some oriental bats. *Anatomischer Anzeiger*, 133: 180–192.
- AMATO, G., M. G. EGAN, and A. RABINOWITZ. 1999. A new species of muntjac, *Muntiacus putaoensis* (Artiodactyla: Cervidae) from Northern Myanmar. *Animal Conservation*, 2: 1–7.
- ANDERSEN, K. 1905. On some bats of the genus *Rhinolophus*, with remarks on their mutual affinities, and descriptions of twenty-six new forms. *Proceedings of the Zoological Society of London*, 2: 75–145.
- ANDERSEN, K. 1918. Diagnoses of new bats of the families Rhinolophidae and Megadermatidae.

- Annals and Magazine of Natural History, 2: 374–384.
- ANTHONY, H. E. 1941. Mammals collected by the Vernay-Cutting Burma Expedition. Field Museum of Natural History, Zoological Series, 27: 37–123.
- BATES, P. J. J., and D. L. HARRISON. 1997. Bats of the Indian Subcontinent. Harrison Zoological Museum Publications. 258 pp.
- BATES, P. J. J., TIN NWE, M. J. PEARCH, KHIN MAUNG SWE, SI SI HLA BU, and THANDA TUN. 2000. A review of bat research in Myanmar (Burma) and results of a recent survey. Acta Chiropterologica, 2: 53–82.
- BATES, P. J. J., TIN NWE, KHIN MAUNG SWE, and SI SI HLA BU. 2001. Further new records of bats from Myanmar (Burma), including *Craseonycteris thonglongyai* Hill 1974 (Chiroptera: *Craseonycteridae*). Acta Chiropterologica, 3: 33–41.
- BATES, P. J. J., M. J. STRUEBIG, S. J. ROSSITER, T. KINGSTON, SAI SEIN LIN OO, and KHIN MYA MYA. 2004a. A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Myanmar (Burma). Acta Chiropterologica, 6: 219–226.
- BATES, P. J. J., MAR MAR THI, TIN NWE, SI SI HLA BU, KHIN MIE MIE, NYO NYO, AYE AYE KHAING, NU NU AYE, THIDA OO and I. MACKIE. 2004b. A review of *Rhinolophus* (Chiroptera: Rhinolophidae) from Myanmar, including three species new to the country. Acta Chiropterologica, 6: 23–48.
- BONHOTE, J. L. 1903. Anthropological and zoological results of an expedition to Perak and the Siamese Malay states, 1901–1902. Undertaken by Nelson Annandale and Herbert C. Robinson. Report on the mammals. Zoology. Fasciculi Malayenses, 1: 1–44.
- BRUNNER, J., K. TALBOTT, and C. ELKIN. 1998. Logging Burma's frontier forests: resources and the regime. World Resources Institute, Washington D.C., 55 pp.
- BRUNNICH, M. T. 1782. Dyrenes Historie og Dyre-Samlingen udi Universitetets Natur-Theater. Band 1. Kobenhavn, xxxviii + 76 pp.
- CORBET, G. B., and J. E. HILL. 1992. The mammals of the Indomalayan Region. Oxford University Press, Oxford, 488 pp.
- CSORBA, G., P. UJHELYI, and N. THOMAS, 2003. Horseshoe bats of the World. Alana Books, Belfast, 160 pp.
- DESMAREST, A. G. 1820. Mammalogie, ou descriptions des especes de mammiferes [Encyclopedie methodique. Histoire naturelle]. Part 1. Agasse, Paris, viii + 276 pp.
- DINERSTEIN, N., and E. D. WIKRAMANAYAKE. 1993. Beyond 'hotspots': how to prioritize investments to conserve biodiversity in the Indo-Pacific Region. Conservation Biology, 7: 53–65.
- DOBSON, G. E. 1871. On some new species of Malayan bats from the collection of Dr Stoliczka. Proceedings of the Asiatic Society of Bengal, 1871: 105–108.
- DOBSON, G. E. 1872. Notes on some bats in the north-western Himalaya. Proceedings of the Asiatic Society of Bengal, (1872): 208–210.
- FRANCIS, C. M. 1989. A comparison of mist nets and two types of harp traps used for capturing bats. Journal of Mammalogy, 70: 865–870.
- FRANCIS, C. M. 1990. Trophic structure of bat communities in the understorey of lowland dipterocarp rain forest in Malaysia. Journal of Tropical Ecology, 6: 421–431.
- FRANCIS, C. M., and J. HABERSETZER. 1998. Interspecific and intraspecific variation in the echolocation call frequency and morphology of horseshoe bats, *Rhinolophus* and *Hipposideros*. Pp. 169–179, in Bat biology and conservation (T. H. KUNZ and P. A. RACEY, eds.). Smithsonian Institution Press, Washington D.C., 365 pp.
- GEOFFROY (-SAINT HILAIRE), E. 1810. Sur les phyllostomes et les megadermes. Annales du Muséum National d'Histoire Naturelle, Paris, 15: 157–198.
- GRAY, J. E. 1838. A revision of the genera of bats (Vespertilionidae), and the description of some new genera and species. Magazine of Zoology and Botany, 2: 483–505.
- HILL, J. E. 1962. Notes on some insectivores and bats from Upper Burma. Proceedings of the Zoological Society of London, 139: 119–137.
- HILL, J. E., and K. THONGLONGYA. 1972. Bats from Thailand and Cambodia. Bulletin British Museum (Natural History) Zoology, 22: 173–196.
- HODGSON, B. H. 1835. Synopsis of the Vespertilionidae of Nipal. Journal of the Asiatic Society of Bengal, 4: 699–701.
- HORSFIELD, T. 1821–1824. Zoological researches in Java and the neighbouring islands. Kingbury, Parbury and Allen, London, unpaginated.
- HORSFIELD, T. 1851. A catalogue of the Mammalia in the museum of the East India Company. PUBLISHER, London, 212 pp.
- HUTSON, A. M., S. P. MICKLEBURGH, and P. A. RACEY. 2001. Microchiropteran bats: global status survey and conservation action plan. IUCN/SSC Chiroptera Specialist Group. IUCN, Gland, 259 pp.
- KINGSTON, T., G. JONES, A. ZUBAID, and T. H. KUNZ. 1999. Echolocation signal design in Kerivoulinae and Murininae (Chiroptera: Vespertilionidae)

- from Malaysia. *Journal of Zoology (London)*, 249: 359–374.
- KINGSTON, T., C. M. FRANCIS, A. ZUBAID, and T. H. KUNZ. 2003. Species richness in an insectivorous bat assemblage from Malaysia. *Journal of Tropical Ecology*, 19: 67–79.
- LEIMGRUBER, P., D. S. KELLY, M. STEININGER, J. BRUNNER, T. MÜLLER, and M. SONGER. 2003a. Forest cover change patterns in Myanmar 1990–2000. Report to Conservation International and the United States Fish and Wildlife Service. Smithsonian Institution and Conservation International, Washington D.C.
- LEIMGRUBER, P., J. B. GAGNON, C. WEMMER, D. S. KELLY, M. A. SONGER, and E. R. SELIG. 2003b. Fragmentation of Asia's remaining wildlands: implications for Asian elephant conservation. *Animal Conservation*, 6: 347–359.
- LEKAGUL, B., and J. A. MCNEELY. 1977. Mammals of Thailand. Association for the Conservation of Wildlife, Bangkok, 758 pp.
- LINDSAY, H. M. 1926. Report No 39: Mergui Archipelago. Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. *Journal of the Bombay Natural History Society*, 30: 42–48.
- MACKINNON, J. 1997. Protected areas systems review of the Indo-Malayan realm. The Asian Bureau of Conservation Ltd/World Conservation Monitoring Centre, Cambridge, 198 pp.
- MULLER, S. 1838. Over eenige nieuwe zoogdieren van Borneo. *Tijdschrift voor Natuurlijke Geschiedenis en Physiologie*, 5: 134–150.
- NEUWEILER, G. 1990. Auditory adaptations for prey capture in echolocating bats. *Physiological Review*, 70: 615–641.
- OLSON, D. M., and E. DINERSTEIN. 1997. The Global 200: A representation approach to conserving the Earth's distinctive ecoregions. World Wildlife Fund, Washington D.C., 176 pp.
- PEARCH, M. J., KHIN MIE MIE, P. J. J. BATES, TIN NWE, KHIN MAUNG SWE, and SI SI HLA BU. 2003. First record of bats (Chiroptera) from Rakhine State, Myanmar (Burma). *Natural History Bulletin of the Siam Society*, 51: 241–259.
- PETERS, W. CH. 1867. On some mammals collected by Capt. A. C. Beavan, C.M.Z.S., at Mulmein, Burma. *Proceedings of the Zoological Society of London*, (1866): 426–430.
- RAO, M., A. RABINOWITZ, and S. T. KHAING. 2002. Status review of the protected-area system in Myanmar, with recommendations for conservation planning. *Conservation Biology*, 16: 360–368.
- RAUTENBACH, I. L., M. B. FENTON, and M. J. WHITING. 1996. Bats in riverine forest and woodlands: a latitudinal transect in southern Africa. *Canadian Journal of Zoology*, 74: 312–322.
- ROBINSON, M. F., P. D. JENKINS, C. M. FRANCIS, and A. J. C. FULFORD. 2003. A new species of the *Hipposideros pratti* group (Chiroptera, Hipposideridae) from Lao PDR and Vietnam. *Acta Chiropterologica*, 5: 31–48.
- ROOKMAAKER, L. C., and W. BERGMANS. 1981. Taxonomy and geography of *Rousettus amplexicaudatus* (Geoffroy, 1810) with comparative notes on sympatric congeners (Mammalia, Megachiroptera). *Beaufortia*, 31: 1–29.
- RYLEY, K. V. 1914. Report No 14, North Shan States. Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. *Journal of the Bombay Natural History Society*, 22: 710–725.
- SCULLY, J. 1881. On the mammals of Gilgit. *Proceedings of the Zoological Society of London*, (1881): 197–209.
- SINHA, Y. P. 1969. A new pipistrelle bat (Mammalia: Chiroptera: Vespertilionidae) from Burma. *Proceedings of the Zoological Society, Calcutta*, 22: 83–86.
- TATE, G. H. H. 1943. Results of the Archbold Expeditions No 49. Further notes on the *Rhinolophus philippinensis* group (Chiroptera). *American Museum Novitates*, 1219: 1–5.
- TEMMINCK, C. J. 1834. Over een geslacht der vleugelhartige zoogdieren *Bladneus* genaamd. (*Rhinolophus* Geoff., Cuv. Illig. Desm.; *Vespertilio* Linn., Erxleb.; *Noctilio* Kuhl). *Tijdschrift voor Natuurlijke Geschiedenis en Physiologie*, 1: 1–30.
- TEMMINCK, C. J. 1835, 1840, 1841. Monographies de mammalogie, ou description de quelques genres de mammiferes, dont les especes sont observees dans les differents musee de l'Europe. Tome 2. G. Dufour and E. D'Ocagne, Libraires, Paris, 392 pp.
- THOMAS, O. 1913. Some new Ferae from Asia and Africa. *Annals and Magazine of Natural History*, 12: 88–92.
- VAHL, M. 1797. Beskrivelsi paa tre nye Arter Flagermuse. *Skrifter Naturh-Selsk, København*, 4: 121–138.
- VANITHARANI, J., A. RAJENDRAN, P. J. J. BATES, D. L. HARRISON, and M. J. PEARCH. 2003. A taxonomic reassessment of *Kerivoula lenis* Thomas, 1916 (Chiroptera: Vespertilionidae) including a first record from peninsular India. *Acta Chiropterologica*, 5: 49–60.
- WHITMORE, T. C. 1997. Rainforest disturbance, disappearance and species loss. Pp. 3–12, *in* Tropical

- forest remnants: ecology, management and conservation of fragmented communities (W. F. LAURANCE and R. O. BIERREGAARD, eds.). University of Chicago Press, Chicago, 632 pp.
- WROUGHTON, R. C. 1915. Report No 17: South Tenasserim, Burma. Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. *Journal of the Bombay Natural History Society*, 23: 695–720.
- WROUGHTON, R. C. 1916. Report No 20: Chindwin River. Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. *Journal of the Bombay Natural History Society*, 24: 291–316.
- WROUGHTON, R. C., and W. M. DAVIDSON. 1918. Report No 29: Pegu. Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. *Journal of the Bombay Natural History Society*, 25: 472–481.

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