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A recent bat survey reveals Bukit Barisan Selatan Landscape as a chiropteran diversity hotspot in Sumatra

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Bukit Barisan Selatan National Park is one of the last refuges protecting intact forest and a representative mammalian fauna in Sumatra. However, knowledge of bat diversity in the area is limited. From 2010 to 2012, 47 bat species were recorded through a series of surveys in 12 localities within and around the national park. An additional six species from the area were identified from the mammal collection of the Museum Zoologicum Bogoriense, Indonesia. At least seven of the species reported in this study are new records for Sumatra, including *Kerivoula krauensis*, *K. lenis*, *K. minuta*, *Murina rozendaali*, *Myotis horsfieldii*, *Myotis cf. borneoensis*, and *Rhinolophus borneensis/celebensis*. Moreover, a finding of two distinct morphs of *Chironax melanocephalus* coexisting in the study area indicates another possible undescribed species. With 60 species, we consider Bukit Barisan Selatan Landscape to be a Southeast Asian bat diversity hotspot and of critical importance in maintaining bat diversity in Sumatra.

Key words: Chiroptera, new record, lowland rainforest, Indonesia, identification keys, coffee agriculture

INTRODUCTION

Over a quarter of the world's bat species are found in Southeast Asia, where over 340 species make up nearly 30% of the mammalian fauna of the region (Kingston, 2013), and contribute significantly to species richness and endemism at both local and regional levels. For instance, at the local level, over 62 species are known from just a three km² area of lowland dipterocarp rainforest in peninsular Malaysia (Kingston *et al.*, 2003, 2006). At the regional level, more than 70 species have been recorded from the Philippines (of which 23 are endemic) (Ingle and Heaney, 1992; Esselstyn, 2007), 96 species from the island of Borneo (Struebig *et al.*, 2010), and 119 from Thailand (Bumrungsri *et al.*, 2006). Moreover, 7% of Southeast Asia's species have been described since 2000 (Kingston, 2013), and species discovery rates are likely to remain high, particularly with greater use of molecular techniques (e.g., Francis *et al.*, 2010; Khan *et al.*, 2010), and

collaborative efforts across species' ranges (Kingston, 2010).

Indonesia is an archipelago of more than 17,500 islands and hosts the highest reported species richness of bats for any country in the world, with the recently-described *Thoopterus suhaniahiae* (Maryanto *et al.*, 2012), revised *Myotis bartelsi* and *Myotis weberi* (Csorba *et al.*, 2014) bringing the count to 221 species (IUCN, 2013, but excluding *M. formosus* — see Csorba *et al.*, 2014). Within the archipelago, Sumatra supports the greatest mammalian diversity of any island (Suyanto *et al.*, 2002; Simmons, 2005), but few studies have focused on Sumatra's chiropteran diversity. Van Strien (1996) reviewed publications on Sumatra's mammal fauna and generated the first checklist for Sumatran bats and reported 65 species. Another 16 species were later suggested for Sumatra and nearby offshore islands (Suyanto *et al.*, 1998, 2002; Simmons, 2005; Boitani *et al.*, 2006). However, the 80 species currently recognized for the island is likely an underestimate as prior survey work did not deploy harp traps which

are particularly effective at capturing species of Hipposideridae, Rhinolophidae, Kerivoulinae, and Murinae in forest habitats (Kingston *et al.*, 2003). Lack of an identification key to Sumatra's bats may also have hampered inventory efforts. In addition, samples from Sumatra were unavailable for several recent regional revisions of bat taxa that have clarified taxonomic boundaries and species distributions elsewhere (e.g., Campbell *et al.*, 2004; Khan *et al.*, 2010; Murray *et al.*, 2012).

Sumatra has the greatest deforestation rate in Indonesia (Holmes, 2002). With an average deforestation of 542,000 ha per year between 1985 to 2008, Sumatra lost around 70% of its forest cover by 2010 (WWF, 2010; Margono *et al.*, 2012). Most forest remnants are along the Barisan mountain ridge in the western part of the island and in the peat lands in the east (WWF, 2010). However, to date, research and conservation efforts on the mammals of the Barisan mountain area have focused mostly on charismatic 'flagship species', such as the Sumatran tiger (*Panthera tigris sumatrae*), Sumatran elephant (*Elephas maximus sumatranus*), Sumatran rhinoceros (*Dicerorhinus sumatrensis*), and Sumatran orangutan (*Pongo abelii*) (WWF, 2007, 2010). Few data are available on the diversity and distribution of the small mammals, including bats, in the area.

In the present study, we focused on the bat fauna in and around Bukit Barisan Selatan National Park (BBSNP) of southwestern Sumatra. BBSNP together with Gunung Leuser National Park and Kerinci Seblat National Park is a World Heritage Site — The Tropical Rainforest Heritage of Sumatra (TRHS), designated to highlight the rainforest and biodiversity of Sumatra (UNESCO, 2004). We selected BBSNP for our surveys because bat species richness of paleotropical wet mountains usually peak at elevations less than 1,000 m a.s.l. (McCain, 2007), and of the three national parks of TRHS, BBSNP is the only lower elevation site, with 80% of the area under 1,000 m a.s.l. (UNESCO, 2004). However, prior to the present study, only 19 bat species were listed for BBSNP (UNESCO, 2004) with another six species found from dammar (*Shorea javanica*) agroforest adjacent to the park (Sibuea and Herdimanyah, 1993). Since no single survey method gives an unbiased estimation of species richness for any bat assemblage of Southeast Asia (Kingston, 2010), we applied multiple survey methods, including harp trapping, ground-level mist netting, roost surveys, and reviewed museum collections to maximize our understanding of bat species diversity of the study area.

MATERIALS AND METHODS

Study Area and Localities

Bats were surveyed in 12 localities in and around Bukit Barisan Selatan National Park (BBSNP), Lampung Province, Indonesia. Two sites were in the primary forest of BBSNP, one in disturbed forest, five sites were dominated by polyculture coffee plantations, and two by monoculture coffee plantations. We also surveyed one cave outside the park in a stream valley surrounded by disturbed forest and polyculture coffee plantations. Collectively we refer to these sites at the Bukit Barisan Selatan Landscape (BBSL). Surveys were conducted from July to August 2010, July to September 2011, and February to June 2012.

Bukit Barisan Selatan National Park (Fig. 1), with an area of 3,240 km², is the third largest protected area in Sumatra. BBSNP was first gazetted by the government of the Dutch East Indies as a natural reserve (South Sumatra I Natural Reserve) in 1935 and then as a national park by the Indonesian government in 1982 (Levan *et al.*, 2012). Although encroachment precipitated the loss or degradation of c. 28% of the natural forest by 2004, the park remains one of the last refuges with intact Sumatran lowland rainforest and supports more than 450 terrestrial vertebrate species, including 90 mammal species (WWF, 2007). With more than 750 plant species (WWF, 2007), forests of BBSNP are dominated by Dipterocarpaceae, Lauraceae, Myrtaceae, Annonaceae, and Fagaceae tree species (UNESCO, 2004). Based on floristic compositions and elevation ranges, the park can be divided into five natural habitats, including coastal forest (1% of total park area, near sea level), lowland rainforest (45%, 0–600 m a.s.l.), highland forest (34%, 600–1,000 m a.s.l.), submontane forest (17%, 1,000–1,500 m a.s.l.), and montane forest (3%, 1,500–c. 2,000 m a.s.l.) (UNESCO, 2004).

Forest localities

Sukabajar Forest (4°56'24"S, 103°53'24"E) — The forest is located between the eastern border of the middle section of Bukit Barisan Selatan National Park (BBSNP) and Lake Ranau. The vegetation is a disturbed forest mixed with bamboo stands along a small stream with an elevation of 704–1033 m a.s.l. It is the extension of the forest of BBSNP but managed by the local community of Sukabajar Village (Site 7, see below). Timber is frequently harvested by villagers for local use.

Sukaraja Forest (5°31'48"S, 104°27'35"E) — Sukaraja Forest is located in the southeastern section of BBSNP. Bats were trapped along a 1.5-km trail used for monitoring large mammals and birds by researchers of the Wildlife Conservation Society-Indonesia Program (WCS-IP). The major vegetation of the forest is mature dipterocarp forest, except at the edge, which is 30-yr forest re-growth on abandoned coffee plantations (Gaveau *et al.*, 2009). The trail has an elevation of 368–557 m a.s.l. and ends by a small stream with shallow water of around 0.5–1 m in depth.

Way Cangkok Forest (5°39'00"S, 104°24'00"E) — The Forest is located in the southwestern section of Bukit Barisan Selatan National Park. A research station was established by the WCS-IP and the Directorate General of Forest and Nature Conservation (PHKA) in 1997. The area around the station is at an elevation of from 36–100 m a.s.l. Two plots of ca. 900 ha were established by WCS-IP on the northern and southern banks of the Way Cangkok River for long-term monitoring of forest

phenology, and hornbill (Bucerotidae spp.) and primate populations. Three bat roosts were surveyed in and around the station, including two caves (Gimbar 1 and Gimbar 2) and a dormitory at the station. Trapping was mostly conducted in the northern plot, but a few mist nets were set up across the river.

Polyculture coffee plantation localities

Kuyung Arang Village (5°32'59"S, 104°26'23"E) — This village is adjacent to the entrance to Rhino Camp trail of BBSNP on its west and north sides and separated from Sukaraja Forest by a main road on its south and east sides. With an elevation of 581–633 m a.s.l., the vegetation is dominated by cocoa (*Theobroma cacao*) and robusta coffee (*Coffea canephora*) mixed with dammar tree (*Shorea javanica*), black pepper (*Piper nigrum*), and banana (*Musa* spp.). Some timber trees, fruit trees, and bamboo stands are planted as borders between plantations; a few small patches of rice paddy are adjacent to the core areas of cocoa and coffee plantations. Harp traps and mist nets were placed along trails within and at the edge of the coffee plantations.

Lombok Village (4°56'24"S, 103°56'23"E) — The area is about one km from the southeast shore of the Lake Ranau and has an elevation between 698–728 m a.s.l. Habitat is dominated by robusta coffee plantations mixed with avocado (*Persea americana*), a few kapok trees (*Ceiba pentandra*) and banana. Harp traps and mist nets were placed in the coffee plantations only.

Pemerihan Village (5°36'36"S, 104°24'00"E) — The village is around four km northeast from Sumber Rejo Village, and located adjacent to BBSNP and separated from the park by Way Pemerihan River. This area is at an elevation of around 50 m a.s.l. and the vegetation is dominated by coffee plantations mixed with cocoa, rubber trees, banana, and timber trees. The other main crop here is rice paddy (*Oryza* sp.). Harp traps were placed in the coffee plantations and mist nets were set up across Way Pemerihan River next to coffee plantations.

Sukabangar Village (4°56'24"S, 103°52'47"E) — The village is around 80 km northeast of Sukaraja Village. It is adjacent to the southwestern border of Lake Ranau with an elevation of between 596–654 m a.s.l. The habitat is dominated by coffee plantations mixed with avocado, black pepper, banana, bamboo (Bambusoideae spp.), and a few timber trees. Patches of rice paddies and grassland are adjacent to the coffee plantations. Instead of opening branches to increase exposure to sunlight, as in the other study sites, local farmers in this area plant coffee bushes at higher density to increasing the yield of berries. Harp traps and mist nets were set up in the coffee plantations only.

Sukaraja Village (5°31'11"S, 104°27'00"E) — The village is adjacent to the entrance to Sukaraja Forest. This area is at an elevation between 530–582 m a.s.l., the vegetation is dominated by cocoa plantations and coffee plantations mixed with cocoa, some fruit trees, and a few bamboo stands. Small patches of vegetables were cultivated among the plantations. Harp traps and mist nets were placed in the coffee plantations only.

Sumber Rejo Village (5°37'47"S, 104°22'12"E) — The village is adjacent to the entrance to Way Cangkok Forest and separated from the BBSNP by Way Pemerihan River. The area is at an elevation of 0–50 m a.s.l. and the vegetation is dominated by robusta coffee mixed with black pepper, cocoa, rubber tree (*Hevea brasiliensis*), various fruit and timber trees. Small patches of rubber plantations and grassland re-growing from abandoned plantations are found among the coffee plantations. Harp traps and mist nets were placed in the coffee plantations only.

Monoculture coffee plantation localities

Sidodadi Village (5°05'23"S, 104°09'35"E) — The village is located around 60 km north of Sukaraja Village and has an elevation of around 950 m a.s.l. This area is adjacent to the entrance to Talan Lima of BBSNP and separated by a small stream from the park. The vegetation is dominated by robusta coffee plantations with small patches of woody bushes among them. Harp traps and mist nets were placed in the coffee plantations.

Sumberjaya Village (5°00'35"S, 104°15'36"E) — The village is around 12 km north of Sidodadi Village. This area has an elevation of 900–1,050 m a.s.l. and is adjacent to an undisturbed rainforest at the top of the mountain. The habitat is dominated by coffee plantations with a few banana and kapok trees bordering the plantations. Several artificial ponds are located in the plantations at lower elevations. Harp traps and mist nets were placed along trails in the plantations and at the edge of ponds.

Roost locality

Sridadi cave (5°32'24"S, 104°24'35"E) — Around three km from Kuyung Arang Village, the cave is located under a huge rock in a stream valley. A colony of around 1,500 *Hipposideros larvatus* and one individual of *Miniopterus magnater* were found in the cave. The ground water level within the cave is around 30–60 cm. The major vegetation surrounding the cave includes secondary forest with bamboo as well as cocoa plantations mixed with coffee bushes and banana.

Surveys and Measurements

Four-bank harp traps with frame sizes of 2.4 m² (Francis, 1989) and 4.2 m² (Museum Zoologicum Bogoriense of the Indonesian Institute of Sciences, MZB-LIPI), and mist nets (9 and 12 m — Avinet Inc., Freeville, USA) were placed at ca. 50 m intervals along existing trails at ground level at all sites except the Sridadi cave. Harp traps and mist nets were open from 18:00 to 06:00 the next morning and from 18:00 to 22:00, respectively. Harp traps were checked at 19:00 and again at 06:00 the next day. Mist nets were checked every 15 minutes. Additional information of occurrence and roost localities were obtained from interviews with local farmers, and surveys of described roosts conducted. Four-bank harp traps and mist nets were set up near the entrances of caves for a maximum of one hour during daytime. Hand nets were used for species in small colonies to maximize completeness of inventory. Specimens collected by previous surveys from Lampung Province deposited at MZB-LIPI were examined to complete the species list of the study area.

All bats were identified by external characters following Corbet and Hill (1992), Suyanto (2001), Csorba *et al.* (2003), Yasuma *et al.* (2003), Kingston *et al.* (2006), Francis (2008), and recent publications on taxonomy of Southeast Asian bats. Voucher specimens of species that were new to the study area were taken and preserved in 70% ethanol in the field with a temporary field number, and were later deposited at MZB.

Nine external measurements were taken from live individuals and specimens, namely FA — forearm length, from the end of the elbow to the end of the wrist with wings folded; BM — body mass; HB — head and body length, from the tip of the snout to the anterior margin of the anus, ventrally; TL — tail length, from the tip of the tail to the anterior margin of the anus; TB — tibia length, from the knee joint to the ankle; HF — foot

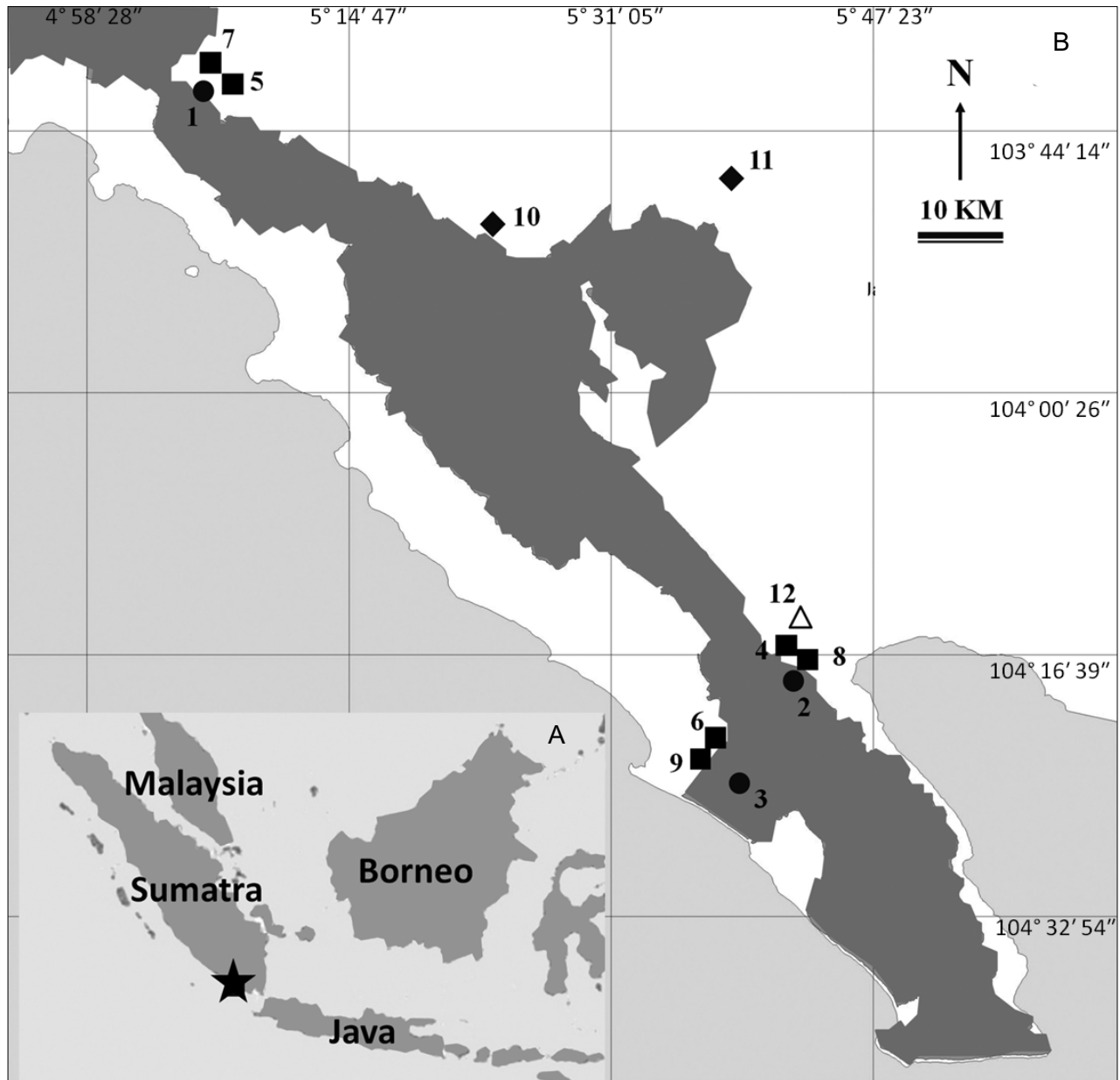


FIG. 1. A — The location of Bukit Barisan Selatan Landscape (marked as the black star) in Southeast Asia; B — Map of 12 study sites in Bukit Barisan Selatan Landscape. Filled circles: forested sites; filled squares: polyculture coffee plantations; filled diamonds: monoculture coffee plantations; open triangle: cave site. The shaded area refers to the territory of Bukit Barisan Selatan National Park. 1 — Sukabanjar Forest; 2 — Sukaraja Forest; 3 — Way Canguk Forest; 4 — Kuyung Arang Village; 5 — Lombok Village; 6 — Pemerihan Village; 7 — Sukabanjar Village; 8 — Sukaraja Village; 9 — Sumber Rejo Village; 10 — Sidodadi Village; 11 — Sumberjaya Village; 12 — Sridadi Cave

length, from the end of the heel to the end of the longest digit with the claw; TU — thumb length, from the end of the wrist to the extremity of the thumb with the claw; EL — ear length, from the base of tragus or antitragus to the tip of the pinna; TR — tragus length, from the base to the tip of the tragus. All length measurements were taken with calipers to a finest scale of 0.02 mm. Body mass was taken with 30 g Pesola spring balance to 0.25 g for species lighter than 30 g and with a 100 g Pesola spring balance to 0.5 g for species heavier than 30 g. However, to standardize the scale of data, all measurements in this paper are rounded to the first decimal place.

To assist with the identification of morphologically cryptic species of *Hipposideros* and *Rhinolophus*, full-spectrum recordings of echolocation calls were made for both genera with bats held in the hand ca. 30 cm from the microphone. A Pettersson D240X detector (Pettersson Elektronik AB, Uppsala, Sweden) (10× time expansion) with a sampling rate of 384 kHz outputting to a Samson Zoom H2 digital recorder (Samson Technologies Corporation, New York, USA) were used in 2010, and a Pettersson D1000X detector (Pettersson Elektronik AB) with sampling rates up to 768 kHz in 2011 and 2012. All recordings were analyzed with the software BatSound Pro, version 3.2

(Pettersson Elektronik AB), using the FFT size of 1,024 for the Hanning window. All survey methods, including specimen collection, were reviewed and approved by Texas Tech University Animal Care and Use Committee (approval number: 10021-05).

Species and common names of bats follow Simmons (2005) and revisions thereafter. Species records and distributions in Sumatra are derived primarily from the check lists of Sibuea and Herdimansyah (1993), van Strien (1996), Whitten *et al.* (2000), Suyanto *et al.* (2002), Simmons (2005), Southeast Asia Mammal Database (Boitani *et al.*, 2006), and the IUCN Red List of Threatened Species (IUCN, 2013). Names for species of uncertain identity and potential new species are following recommendations by Bengtson (1988) for open nomenclature. Data on the distribution, taxonomy, and ecology, if relevant, of each species are included in the notes. 'New record' refers to sites previously not listed for Lampung Province, new species records for Sumatra or potential undescribed species; 'new material' specifically applies to new voucher materials for MZB.

RESULTS

In total 53 species were identified, 47 confirmed species were recorded during the study and an additional six species discovered in the Museum Zoologicum Bogoriense (MZB) collection. Seven species were confirmed as new to Sumatra, and another five cannot currently be assigned to any known species (Table 1). A dichotomous key was created based upon observations and measurements of our samples and empirical data from the literature (Appendix).

SPECIES ACCOUNTS

Balionycteris maculata (Thomas, 1893) Spotted-winged fruit bat

New records

Lampung Province: Sukaraja Forest, Way Canguk Forest.

Previous records from Sumatra

Aceh Province: Aceh; North Sumatra Province: Leuser; Riau Province: Siak and Seberida; Bengkulu Province: Bengkulu (Maryanto, 2003).

Remarks

This was the smallest fruit bat species captured in the study area (Table 2). Individuals were recorded from primary forests only. Two individuals were captured with mist nets at an elevation of 50 m and 440 m a.s.l., respectively. The species can be distinguished from other Pteropodidae in the study area by smaller body size (Table 2) and appearance of white spots on the face and finger joints. Our

records are the most southern localities of the species in Sumatra.

Chironax melanocephalus (Temminck, 1825) Black-capped fruit bat

New records

Lampung Province: Sukabanjar Forest, Sukaraja Forest, Way Canguk Forest.

New material

Four individuals were collected as voucher specimens. Lampung Province: Sukaraja Forest, 1♂, 1♀ (MZB 35878, 35879); Sukabanjar Forest, 1♀ (MZB 35028); Way Canguk Forest 1♀ (MZB 35880).

Previous records from Sumatra

Aceh Province: Gunung Leuser (Maharadatunkamsi, 2012); North Sumatra Province: Bohorok (van Strien, 1996), Nias Island (Simmons, 2005), Tapanuli Utara, Tapanuli Selatan, Asahan (Maharadatunkamsi, 2012); Jambi Province: Regency of Sarolangun Bangko (Maharadatunkamsi, 2012), Muara Bungo (Sibuea and Herdimansyah, 1993); West Sumatra Province: Mininjau (Sibuea and Herdimansyah, 1993); Bengkulu Province: Gunung Bungkok, Bukit Jarum Kapahiang, Muara Aman, Lebong Selatan (Maharadatunkamsi, 2012); Lampung Province: Krui (Sibuea and Herdimansyah, 1993), Way Kambas (Maharadatunkamsi, 2012).

Remarks

Chironax melanocephalus was captured at an elevation of 50–855 m a.s.l. in lowland rainforest and disturbed forest in the survey area. Based on differences in cranial characters, fur color, and ear shape, Maharadatunkamsi (2012) recognized three subspecies of *C. melanocephalus* in Indonesia, (*C. m. melanocephalus* in Java and Sumatra, *C. m. tumulus* in Sulawesi, and *C. m. dyasae* in Kalimantan), and indicated that *C. m. melanocephalus* was the only subspecies in Sumatra. Nevertheless, two distinct morphological forms were found in this study. The first morph has round-tipped and shorter ears, smaller body size (Table 2), relatively weaker rostrum, and light gray or yellow underparts. The ear shape and rostrum are similar to those of *C. m. melanocephalus* and *C. m. tumulus* (as *Pteropus melanocephalus* in Temminck, 1825; Maharadatunkamsi, 2012) but the color differs on the underparts which is grayish brown in *C. m. melanocephalus* and brownish gray in *C. m. tumulus*. The second

TABLE 1. Continued

Family/species	SBF	SRF	WCF	KAV	LBV	PRV	SBV	SRV	SRJ	SDV	SJV	SDC
MEGADERMATIDAE												
<i>Megaderma spasma</i>	-	√	√	-	√	-	√	-	-	-	-	-
NYCTERIDAE												
<i>Nycteris tragata</i>	√	√	√	√	√	-	-	-	-	-	-	-
VESPERTILIONIDAE												
Kerivoulinae												
<i>Kerivoula hardwickii</i>	√	√	√	√	-	-	-	-	-	-	√	-
<i>K. krauensis</i> [§]	-	√	-	-	-	-	-	-	-	-	-	-
<i>K. lenis</i> [§]	-	√	-	-	-	-	-	-	-	-	-	-
<i>K. minuta</i> [*]	-	√	√	-	-	-	-	-	-	-	-	-
<i>K. papillosa</i>	√	-	√	-	-	-	-	-	-	-	-	-
<i>K. pellucida</i>	√	-	√	-	-	-	-	-	-	-	-	-
<i>Phoniscus atrox</i>	-	-	√	-	-	-	-	-	√	-	-	-
Murinae												
<i>Harpiocephalus harpia</i> [§]	-	-	√	-	-	-	-	-	√	-	-	-
<i>Murina peninsularis</i>	-	√	√	-	-	-	-	-	√	-	-	-
<i>M. rozendaali</i> [*]	-	-	√	-	-	-	-	-	-	-	-	-
<i>M. suilla</i>	-	-	√	-	-	-	-	-	-	-	-	-
Myotinae												
<i>M. cf. borneoensis</i> ^{* §}	-	-	√	-	-	-	-	-	-	-	-	-
<i>M. horsfieldii</i> [*]	-	-	√	-	-	-	-	-	-	-	-	-
<i>M. muricola</i>	-	√	-	√	-	√	√	-	√	-	-	-
<i>M. sp. 1</i>	-	-	-	√	-	√	√	-	√	-	-	-
<i>M. sp. 2</i>	-	-	√	-	-	√	-	-	-	-	-	-
Vespertilioninae												
<i>Glischropus sp.</i>	√	-	-	-	-	-	-	-	-	-	-	-
<i>Pipistrellus javanicus</i>	-	-	-	-	-	-	-	-	-	-	√	-
<i>P. stenopterus</i>	-	-	-	-	-	-	-	-	√	-	√	-
<i>Tylonycteris pachypus</i>	-	-	√	√	-	-	-	-	-	-	-	-
<i>T. robustula</i>	√	-	-	-	-	-	-	-	-	-	-	-
MINIOPTERIDAE												
<i>Miniopterus australis</i>	-	-	R	-	-	√	-	-	-	-	-	R
<i>M. magnater</i>	-	-	R	-	-	-	-	-	√	-	-	-
<i>M. pusillus</i>	-	-	R	-	-	-	-	-	√	-	-	-
EMBALLONURIDAE												
<i>Emballonura monticola</i>	-	-	R	-	-	-	-	-	-	-	-	-
No. of species recorded	15	24	41	18	15	6	11	17	25	4	7	2

morph has triangular-tipped and longer ears, larger body size, a more robust rostrum, and is gray on the underparts. The ear shape and rostrum are more characteristic of *C. m. dyasae* but the color differs on the underparts which is yellowish brown in *C. m. dyasae* (Maharadatunkamsi, 2012). Further detailed morphological and genetic analyses are necessary to clarify the taxonomic status of the two morphs.

Cynopterus brachyotis (Müller, 1838)
Lesser short-nosed fruit bat

New records

Lampung Province: Kuyung Arang Village, Lombok Village, Sidodadi Village, Sukabandar Village, Sukaraja Forest, Sukaraja Village, Sumberjaya Village, Sumber Rejo Village.

New material

Six individuals were collected as voucher specimens. Lampung Province: Sumberjaya Village, 1♀ (MZB 34971); Sumber Rejo Village, 4♂♂, 1♀ (MZB 34956, 34958, 34973, 34974, 35806).

Previous records from Sumatra

Throughout Sumatra (see detailed localities in Kitchener and Maharadatunkamsi, 1991).

Remarks

In our study area, the *C. brachyotis*-like bats exhibit two distinct morphological forms. One has ears with a straight or slightly notched posterior edge, and has a larger body size; the ears of the other morph have a curved margin to the posterior edge and body size is smaller (Table 2). The two morphs also differed in habitat use; whereas the larger morph was usually abundant in disturbed habitats but rare within forested habitats, the capture rate of the small morph was generally high in all surveyed habitats. Notably, in contrast to the irritable and noisy behaviors of other *Cynopterus* species, most individuals of the small *Cynopterus* were generally calm and silent either in nets or during processing.

Campbell *et al.* (2004) described five cytochrome *b* lineages of *C. brachyotis* complex in South and Southeast Asia, two of which were from the Sunda Shelf and described as Forest and Sunda lineages. The two Sunda Shelf *C. brachyotis* lineages also differ in body size and habitat use; *C. brachyotis* Forest lineage has a smaller forearm length (FA = 54.3–63.7 mm) and is associated with forest, contrasting with the larger *C. brachyotis*

Sunda lineage (FA = 60.0–70.0 mm) associated with disturbed habitats. Nevertheless, the authors did not assign either to *C. brachyotis* because they were not able to make comparisons with type material (Campbell *et al.*, 2004). Three following publications (Abdullah and Jayaraj, 2006; Jayaraj *et al.*, 2012; Fong *et al.*, 2013) confirmed the presence of two distinct morphs of ‘*C. brachyotis*’ in Malaysia and their ecological preferences in habitat. By a preliminary morphological comparison with the holotype of *C. brachyotis*, Abdullah and Jayaraj (2006) further suggested that Malaysia’s large morph was the nominate species and the small form is a different species. Interestingly, *C. minutus*, which was first described from the Mentawai Islands off the west coast of Sumatra, is similar in body size to the small forest *C. brachyotis* of Malaysia. *Cynopterus minutus* is commonly found on all the Greater Sunda Islands and is frequently sympatric with *C. brachyotis* (Kitchener and Maharadatunkamsi, 1991). Unlike the two Malaysian lineages, Kitchener and Maharadatunkamsi (1991) reported overlap in radius length of *C. minutus* (52.9–61.9 mm) and *C. brachyotis* (54.7–66.7 mm) in Indonesia. However, the authors included juveniles and subadults in their samples (Kitchener and Maharadatunkamsi, 1991), which may have smaller forearm lengths (Elangovan *et al.*, 2003). The taxonomic relationship between *C. minutus* and the small forest *C. brachyotis* remains unclear.

Given the above, we regard the two morphs of *C. brachyotis*-like bats in our study as different species, and assign the large morph to *C. brachyotis* (as *C. brachyotis* Sunda in Campbell *et al.*, 2004). Our samples of the small round-eared *Cynopterus* are comparable in forearm length (56.5–61.6 mm, \bar{x} = 57.2 mm) to both *C. minutus* (52.9–61.9 mm, \bar{x} = 57.5 mm — Kitchener and Maharadatunkamsi, 1991) and *C. brachyotis* Forest (54.3–63.7 mm, \bar{x} = 58.1 mm — Campbell *et al.*, 2004), and *C. cf. brachyotis* Forest (Jayaraj *et al.*, 2012). Similar to *C. minutus* in using both primary forest and disturbed habitats (IUCN, 2013), the small *Cynopterus* from BBSL is also a habitat generalist, which differs from *C. brachyotis* Forest, a forest specialist (Campbell *et al.*, 2004; Abdullah and Jayaraj, 2006; Jayaraj *et al.*, 2012). Although the previous studies do not provide for comparisons of behavior and ear shape in *C. minutus* and *C. brachyotis* Forest, we tentatively regard the small form as *C. minutus* based on similarities of body size and habitat use.

Cynopterus brachyotis (the large form) was the most abundant pteropodid species in the study

area. Capture rates were usually high in coffee plantations, forest edges and river habitats but low within forests. In our study area, *C. brachyotis* can be distinguished from *C. sphinx* by shorter ears (< 18.0 mm in *C. brachyotis* and > 18.0 mm in *C. sphinx*) and from *C. horsfieldii* by the absence of peg-like cusps on the lower cheek teeth and ear shape (straight or slightly notched at posterior edge in *C. brachyotis*, strongly notched in *C. horsfieldii*).

Cynopterus horsfieldii Gray, 1843
Horsfield's fruit bat

New records

Lampung Province: Kuyung Arang Village, Lombok Village, Sidodadi Village, Sukabangar Forest, Sukabangar Village, Sukaraja Forest, Sukaraja Village, Sumber Rejo Village.

New material

One individual was collected as a voucher specimen. Lampung Province: Sumber Rejo Village, 1♂ (MZB 34989).

Previous records from Sumatra

van Strien (1996) listed this species as present throughout Sumatra but without details of localities.

Remarks

Cynopterus horsfieldii was also a common pteropodid species in the survey area but less abundant than *C. brachyotis* and *C. minutus*. Abundance was higher in coffee plantations than in forest. It can be distinguished from other *Cynopterus* bats by the peg-like cusp on the 3rd and 4th lower cheek teeth.

Cynopterus ? minutus Miller, 1906
Minute fruit bat

New records

Lampung Province: Kuyung Arang Village, Lombok Village, Sidodadi Village, Sukabangar Forest, Sukabangar Village, Sukaraja Forest, Sukaraja Village, Sumberjaya Village, Sumber Rejo Village, Way Canguk Forest.

New material

Two individuals were collected as voucher specimens. Lampung Province: Sumber Rejo Village, 1♂, 1♀ (MZB 34988, 35881).

Previous records from Sumatra

Aceh Province: Kutacane, Simpang Kanan; North Sumatra Province: Nias Island (type locality),

Tapanuli Selatan; Bengkulu Province: Muara Amen, Lebag Selatan; Lampung Province: Sukadana (Kitchener and Maharadatunkamsi, 1991).

Remarks

Cynopterus minutus (see *C. brachyotis* account for justification of identification of this species) was common and the second most abundant pteropodid species after *C. brachyotis* in the study area. Individuals were generally abundant in all surveyed habitats, including coffee plantations, forest edge, and forests, but capture rates of this species in forest understory were higher than rates of other *Cynopterus* species. The species can be distinguished from other *Cynopterus* species by smaller body size (Table 2), ear shape, and behaviors (see *C. brachyotis* account).

Cynopterus sphinx (Vahl, 1797)
Greater short-nosed fruit bat

New records

Lampung Province: Lombok Village, Sukabangar Forest, Sukabangar Village, Sukaraja Village, Sumber Rejo Village.

Previous records from Sumatra

Throughout Sumatra (see detailed localities in Kitchener and Maharadatunkamsi, 1991).

Remarks

This species is the largest *Cynopterus* species in the survey area. Bats were trapped with mist nets mainly in coffee plantations, but occasionally in forest gaps.

Eonycteris spelaea (Dobson, 1871)
Lesser dawn bat

New records

Lampung Province: Kuyung Arang Village, Lombok Village, Sukabangar Village, Sidodadi Village, Sukaraja Village, Sukaraja Forest, Sumberjaya Village, Sumber Rejo Village, Way Canguk Forest.

New material

Two individuals were collected as voucher specimens. Lampung Province: Sumberjaya Village, 1♂, 1♀ (MZB 34959, 34960).

Previous records from Sumatra

North Sumatra Province: caves near Kotabuluh and Rampah (Whitten *et al.*, 2000); West Sumatra

TABLE 2. Measurements of nine external traits of 52 bat species. FA — forearm length, BM — body mass, HB — head and body length, TL — tail length, TB — tibia length, HF — hind foot length, TU — thumb length, TR — tragus length. Numbers denote minimum and maximum, and sample size; values in parentheses indicate measurements of specimens of this study; ‘—’: data not available. BMs for specimens were taken in the field. All measurements in mm, except for BM (in g)

Family/species	FA	BM	TB	HB	TL	TU	HF	EL	TR
PTEROPODIDAE									
<i>Balionycteris maculata</i>	41.0, 41.3, 2 (—)	12.5, 14.0, 2 (—)	13.7, 14.6, 2	48.5, 55.0, 2 (—)	— (—)	10.6, 11.9, 2 (—)	8.3, 9.0, 2 (—)	9.7, 10.0, 2	— (—)
<i>Chironax melanocephalus</i>	40.0, 43.4, 2 (41.9, 42.0, 2)	14.3, 15.0, 2 (14.0, 1)	15.4, 16.1, 2 (14.6, 15.0, 2)	50.2, 54.4, 2 (50.5, 51.3, 2)	— (—)	9.5–12.7, 3 (12.0, 12.2, 2)	9.3, 10.6, 2 (8.6, 9.6, 2)	9.3–11.0, 3 (8.9, 10.9, 2)	— (—)
Round-eared morph	41.2–46.9, 3	20.0–24.0, 3	17.3–17.6, 3	60.6–64.3, 3	—	12.4–12.6, 3	8.7, 10.1, 2	12.9–13.7, 3	—
Tipped-eared morph	(44.9, 46.9, 2)	(19.0, 20.0, 2)	(16.7, 17.5, 2)	(55.6, 64.2, 2)	(—)	(12.1, 13.3, 2)	(9.0, 10.7, 2)	(12.5, 13.0, 2)	(—)
<i>Cynopterus brachyotis</i>	64.0–72.7, 98 (66.4–69.5, 5)	35.0–66.0, 34 (30.1–62.0, 5)	20.9–29.4, 57 (22.5–26.7, 3)	95.3, 95.5, 2 (72.3, 92.9, 2)	12.5–18.5, 4 (16.2, 18.2, 2)	15.0–18.7, 3 (18.0, 19.2, 2)	12.3–14.6, 3 (14.9, 16.0, 2)	12.3–17.9, 96 (16.1, 18.1, 2)	— (—)
<i>C. horsfieldii</i>	69.1–75.6, 14 (71.5, 1)	60.0–69.0, 4 (—)	25.2, 29.5, 2 (26.2, 1)	— (92.6, 1)	— (13.8, 1)	— (20.8, 1)	— (15.0, 1)	16.1–21.4, 11 (18.6, 1)	— (—)
<i>C. sphinx</i>	62.4–78.7, 38 (—)	43.5–60.0, 4 (—)	26.3–33.5, 11 (—)	89.7, 1 (—)	15.6, 1 (—)	21.3, 1 (—)	19.5, 1 (—)	18.0–20.5, 38 (—)	— (—)
<i>C. ? minutus</i>	56.5–61.6, 40 (57.3, 58.3, 2)	28.0–37.0, 1 (—)	20.3–23.8, 17 (21.4, 21.5, 2)	67.6, 1 (71.9, 1)	— (13.9, 1)	17.2, 1 (15.8, 1)	15.4, 1 (11.8, 1)	13.0–17.5, 34 (14.9, 15.3, 2)	— (—)
<i>Eonycteris spelaea</i>	59.5–79.4, 41 (66.6, 73.8, 2)	40.0–62.0, 12 (58.0, 60.0, 2)	27.2–34.4, 14 (29.2, 33.3, 2)	85.2, 92.3, 2 (89.1, 89.7, 2)	12.7–16.2, 3 (17.2, 18.5, 2)	13.8, 15.5, 2 (14.2, 16.8, 2)	16.7–18.4, 3 (16.9, 17.0, 2)	15.9–19.1, 16 (17.8, 18.5, 2)	— (—)
<i>Macroglossus sobrinus</i>	43.2–46.2, 6 (42.3, 43.4, 2)	22.0–24.0, 4 (20.0, 1)	18.1–20.3, 4 (18.1, 18.9, 2)	64.7–72.1, 3 (61.1, 63.9, 2)	— (—)	9.8–12.6, 3 (10.7, 12.4, 2)	9.8, 12.0, 2 (10.5, 12.2, 2)	12.6–15.5, 6 (15.2, 15.9, 2)	— (—)
<i>Megaerops ecaudatus</i>	49.9–57.3, 15 (56.0, 56.8, 2)	25.0–30.0, 8 (25.5, 25.5, 2)	18.6–23.3, 15 (20.2, 23.0, 2)	60.0–78.9, 7 (59.3, 73.0, 2)	— (—)	11.8–17.3, 7 (15.6, 18.7, 2)	9.8–13.4, 6 (12.2, 13.5, 2)	13.6–17.0, 9 (14.8, 16.0, 2)	— (—)
<i>Rousettus amplexicaudatus</i>	77.1–85.2, 10 (—)	60.5–80.5, 3 (—)	34.7–39.3, 4 (—)	85.9–100.4, 3 (—)	16.4–18.8, 4 (—)	15.0–17.5, 4 (—)	14.9–19.7, 4 (—)	12.6–19.2, 6 (—)	— (—)
<i>R. leschenaultii</i>	81.3, 82.5, 2 (81.0, 81.3, 2)	70.0, 1 (71.0, 95.0, 2)	36.7, 38.0, 2 (35.6, 36.1, 2)	83.0, 92.8, 2 (87.6, 92.4, 2)	18.6, 20.3, 2 (12.2, 20.5, 2)	18.0, 19.3, 2 (12.2, 20.5, 2)	15.3, 16.1, 2 (18.6, 19.2, 2)	15.1, 17.3, 2 (17.0, 17.9, 2)	— (—)
HIPPOSIDERIDAE									
<i>Hipposideros ater</i>	38.2–39.5, 4 (38.4–40.3, 10)	5.55, 1 (4.8–5.3, 4)	17.0, 17.8, 2 (16.4–17.9, 10)	41.0, 1 (38.3–42.6, 10)	28.6, 1 (19.3–27.7, 10)	4.6, 1 (2.8–4.0, 10)	6.7, 1 (5.4–7.7, 10)	17.7, 1 (15.9–18.6, 10)	— (—)
<i>H. bicolor</i>	43.8–43.6, 5 (44.6–47.1, 10)	8.0, 8.3, 2 (8.3, 9.5, 2)	19.6–21.4, 3 (19.3–23.7, 10)	— (39.7–49.9, 10)	— (26.4–36.8, 10)	4.1, 1 (3.3–4.8, 9)	— (7.2–8.9, 10)	16.6, 1 (15.4–19.7, 10)	— (—)
<i>H. cervinus</i>	45.5–50.1, 23 (45.8–50.1, 7)	7.3–10.3, 5 (8.0, 8.0, 2)	17.7–18.9, 4 (18.0–18.7, 6)	47.0, 47.4, 2 (46.6–50.5, 6)	23.5–31.1, 13 (25.8–32.4, 6)	4.1, 4.6, 2 (3.5–4.5, 6)	5.0, 5.1, 2 (8.0–8.5, 6)	13.4–14.3, 3 (13.5–15.5, 6)	— (—)
<i>H. diadema</i>	85.4–90.4, 14 (83.8, 86.8, 2)	41.5–57.0, 11 (48.0, 52.0, 2)	30.0–36.0, 9 (31.4, 34.9, 2)	78.7–91.8, 8 (78.3, 81.1, 2)	44.3–52.6, 8 (48.2, 52.1, 2)	7.6–12.6, 6 (9.5, 11.1, 2)	10.4–15.5, 9 (16.7, 17.4, 2)	24.3–30.6, 8 (29.0, 29.8, 2)	— (—)
<i>H. doriae</i>	36.0–39.3, 4 (—)	4.5–5.3, 4 (—)	15.5–17.3, 4 (—)	31.5–42.8, 4 (—)	17.4–22.9, 4 (—)	5.3–7.0, 2 (—)	5.0–7.2, 4 (—)	12.8–18.9, 3 (—)	— (—)
<i>H. larvatus</i>	51.1–60.0, 561 (47.8–58.0, 12)	12.5–18.3, 83 (11.0–15.0, 5)	20.8–26.5, 12 (19.5–22.7, 8)	53.5–62.7, 12 (50.4–59.1, 8)	27.5–36.0, 12 (26.6–35.0, 8)	4.4–6.6, 12 (5.5–6.7, 8)	9.3–11.5, 11 (9.1–10.8, 8)	13.4–20.2, 13 (18.4–21.2, 8)	— (—)

TABLE 2. Continued

Family/species	FA	BM	TB	HB	TL	TU	HF	EL	TR
RHINOLOPHIDAE									
<i>Rhinolophus acuminatus</i>	46.1–50.9, 28 (47.5–50.6, 4)	12.0–16.5, 16 (12.3, 1)	20.2–23.9, 17 (21.0–23.5, 4)	48.0–57.0, 5 (45.1–54.3, 4)	20.5–25.9, 6 (22.8–27.4, 4)	4.4–7.2, 9 (5.1–6.3, 4)	9.2–11.2, 8 (9.8–11.4, 4)	16.6–21.6, 9 (17.1–19.0, 4)	– (–)
<i>R. affinis</i>	46.8–52.7, 229 (49.0–50.9, 7)	12.3–16.3, 31 (11.0, 1)	23.5–26.5, 13 (23.0–24.3, 6)	47.4–58.8, 9 (52.9–56.5, 3)	17.6–25.1, 8 (20.9–23.8, 6)	3.9–7.6, 10 (3.9–5.9, 6)	8.2–12.0, 10 (10.9–15.0, 6)	14.2–22.0, 11 (17.0–21.9, 6)	– (–)
<i>R. borneensis/celebensis</i>	41.7–46.3, 22 (42.9–45.7, 5)	7.0–9.5, 16 (8.0–9.5, 5)	18.5–20.6, 15 (18.4–20.4, 5)	38.8–50.4, 13 (39.9–48.5, 5)	20.7–29.5, 14 (21.5–25.0, 5)	4.0–8.8, 14 (4.4–7.3, 5)	5.7–10.3, 14 (8.3–10.0, 5)	15.0–22.5, 15 (15.9–18.9, 5)	– (–)
<i>R. lepidus/pusillus</i>	36.0–41.7, 45 (38.3–40.5, 4)	5.0–6.0, 5 (5.8, 6.5, 2)	15.3–16.7, 5 (15.3–16.9, 4)	35.9–40.5, 4 (36.8–42.0, 4)	17.6–22.5, 5 (16.1–21.4, 4)	3.2–3.5, 5 (3.0–5.2, 4)	6.4–8.3, 5 (8.3, 8.9, 2)	13.9–16.4, 5 (14.8–16.6, 4)	– (–)
<i>R. luctus</i>	– (63.5–65.0, 3)	– (30.5, 32.0, 2)	– (26.2–33.9, 3)	– (65.4–74.1, 3)	– (36.6–46.7, 3)	– (4.9–6.8, 3)	– (17.0–19.0, 3)	– (32.4–37.5, 3)	– (–)
<i>R. trifoliatus</i>	49.0–56.9, 18 (49.4–54.6, 3)	11.0–23.0, 16 (–)	23.0–28.7, 14 (38.2–40.5, 3)	49.8–60.2, 6 (47.8–56.7, 3)	25.7–36.5, 9 (38.2–40.5, 3)	4.0–7.7, 7 (3.3–5.2, 3)	11.2–13.5, 7 (12.0–12.6, 3)	24.1–27.4, 8 (24.7–30.3, 3)	– (–)
<i>R. sp. 1</i>	– (40.4, 1)	– (–)	– (16.2, 1)	– (32.2, 1)	– (16.2, 1)	– (3.1, 1)	– (7.2, 1)	– (13.8, 1)	– (–)
<i>R. sp. 2</i>	– (39.9, 1)	– (–)	– (16.2, 1)	– (40.0, 1)	– (15.9, 1)	– (3.5, 1)	– (8.2, 1)	– (13.5, 1)	– (–)
MEGADERMATIDAE									
<i>Megaderma spasma</i>	56.5–60.7, 6 (58.8, 1)	20.0–27.0, 5 (16.0, 1)	30.6–33.9, 6 (32.1, 1)	60.4–70.0, 6 (64.5, 1)	– (–)	8.9–10.1, 5 (10.6, 1)	16.8–19.7, 6 (17.4, 1)	30.0–35.6, 6 (35.7, 1)	16.8–21.2, 4 (19.0, 1)
NYCTERIDAE									
<i>Nycterus tragata</i>	47.7–51.3, 5 (49.9–51.3, 3)	16.0–19.0, 5 (16.5, 1)	28.0–30.4, 5 (28.0–29.4, 3)	53.7–60.8, 4 (51.5–53.9, 3)	65.2–71.2, 5 (68.5–71.9, 3)	9.0–9.8, 5 (9.7, 10.7, 2)	9.6–11.0, 5 (10.4–12.7, 3)	27.9–31.6, 5 (25.3–29.9, 3)	6.5, 7.0, 2 (6.5, 6.9, 2)
VESPERTILIONIDAE									
Kerivoulinae									
<i>Kerivoula hardwickii</i>	30.0–35.9, 44 (30.8–36.5, 7)	3.0–5.0, 40 (3.8–4.8, 3)	14.5–21.6, 39 (16.8–20.1, 7)	30.2–39.0, 37 (31.5–39.5, 7)	32.6–46.6, 37 (34.6–46.6, 7)	4.3–8.6, 35 (5.1–7.5, 6)	4.5–8.4, 34 (5.8–8.7, 7)	11.4–16.4, 40 (12.0–13.7, 7)	7.5–9.6, 5 (7.4–9.1, 6)
<i>K. krauensis</i>	– (30.6, 30.8, 2)	– (–)	– (14.9, 15.5, 2)	– (30.9, 34.4, 2)	– (34.3, 36.3, 2)	– (3.8, 4.5, 2)	– (5.7, 7.5, 2)	– (10.3, 10.4, 2)	– (5.9, 6.4, 2)
<i>K. lenis</i>	– (39.0, 1)	– (–)	– (19.4, 1)	– (43.3, 1)	– (45.7, 1)	– (8.9, 1)	– (6.5, 1)	– (14.5, 1)	– (10.0, 1)
<i>K. papillosa</i>	42.4–44.6, 9 (42.2, 43.5, 2)	8.75–11.5, 8 (–)	20.4–23.6, 8 (23.0, 23.3, 2)	47.6, 1 (45.4, 46.9, 2)	49.5, 1 (49.7, 50.5, 2)	7.9, 1 (7.9, 8.8, 2)	10.1, 1 (11.7, 12.5, 2)	15.2–18.1, 6 (14.4, 14.4, 2)	11.6, 1 (9.7, 10.8, 2)
<i>K. pellicuda</i>	29.9–31.9, 5 (29.7–31.4, 3)	4.3–5.5, 4 (3.5, 4.0, 2)	16.9–18.1, 4 (17.2, 19.5, 2)	30.2–40.0, 3 (35.2, 36.9, 2)	44.3–46.2, 3 (44.3, 49.9, 2)	4.7–4.9, 3 (5.2, 6.0, 2)	6.9, 7.6, 2 (8.1, 8.5, 2)	14.3–16.1, 4 (13.4–15.3, 3)	8.9–11.0, 3 (7.8–9.1, 3)
<i>K. minuta</i>	27.7–29.9, 9 (28.7, 1)	2.3–3.3, 8 (3.3, 1)	11.9–15.0, 6 (13.7, 1)	29.2–34.0, 7 (29.8, 1)	31.4–41.0, 7 (35.3, 1)	4.2–5.7, 7 (5.5, 1)	4.8–7.4, 7 (7.5, 1)	9.1–12.3, 7 (8.9, 1)	7.0, 1 (7.1, 1)
<i>Phoniscus atrox</i>	– (33.0, 33.5, 2)	– (–)	– (15.2, 15.5, 2)	– (33.9, 35.1, 2)	– (35.6, 49.1, 2)	– (4.9, 5.6, 2)	– (8.2, 8.2, 2)	– (9.3, 12.8, 2)	– (5.6, 7.2, 2)

TABLE 2. Continued

Family/species	FA	BM	TB	HB	TL	TU	HF	EL	TR
Murinae									
<i>Harpiocephalus harpia</i>	(48.2, 1)	(-)	(25.8, 1)	(59.9, 1)	(47.5, 1)	(10.6, 1)	(11.3, 1)	(14.7, 1)	(12.3, 1)
<i>Murina peninsularis</i>	37.5-39.2, 9 (35.0-39.4, 6)	8.3-12.0, 8 (10.0-11.5, 4)	19.3-21.4, 9 (19.3-21.1, 6)	43.4, 44.0, 2 (41.6-49.7, 5)	40.9-45.1, 5 (35.2-44.9, 6)	7.8-8.1, 4 (8.0-10.4, 6)	8.0-10.9, 4 (7.0-9.6, 6)	13.7-16.4, 7 (12.9-15.3, 6)	8.1-8.9, 3 (6.7-9.2, 5)
<i>M. rozendaali</i>	(29.9, 30.9, 2) 29.0-32.0, 4 (29.2-30.7, 3)	(4.0, 1) 4.3-4.8, 4 (4.0, 1)	(14.3, 18.0, 2) 13.8-16.4, 4 (14.0-15.7, 3)	(32.4, 39.1, 2) 33.0-40.4, 4 (31.4-36.0, 3)	(34.4, 39.0, 2) 29.7-34.0, 4 (28.1-34.2, 3)	(6.4, 8.2, 2) 41.9-42.0, 3 (6.1-6.3, 3)	(7.7, 9.3, 2) 6.6-7.3, 3 (6.3-8.5, 3)	(12.2, 13.4, 2) 11.2-13.4, 4 (12.0-12.6, 3)	(6.9, 7.6, 2) 6.7-8.5, 4 (6.2-7.3, 3)
Myotinae									
<i>Myotis cf. borneoensis</i>	(45.8, 1)	(-)	(19.0, 1)	(47.4, 1)	(48.4, 1)	(8.1, 1)	(10.5, 1)	(14.0, 1)	(7.4, 1)
<i>M. horsfieldii</i>	(36.4-40.2, 6) 33.1-35.6, 15 (34.9, 34.9, 2) 33.4-35.5, 7 (31.1-34.7, 3)	(7.5-10.0, 3) 4.0-4.8, 13 (4.5, 4.5, 2) 4.0-5.0, 6 (4.3, 1)	(16.8-18.3, 6) 15.0-16.9, 11 (16.3, 16.8, 2) 15.7-16.7, 5 (14.5-16.0, 3)	(42.5-53.3, 6) 35.5-39.3, 7 (37.8, 37.8, 2) 31.2-39.9, 5 (33.2-36.1, 3)	(38.3-43.7, 6) 32.8-44.1, 7 (38.7, 38.8, 2) 36.6-43.5, 5 (35.8-41.5, 3)	(5.8-7.7, 6) 3.9-4.5, 7 (4.8, 4.8, 2) 3.6-4.5, 5 (3.9-4.5, 3)	(8.3-12.1, 6) 4.7-8.0, 7 (7.6, 7.8, 2) 6.5-7.9, 5 (7.0-8.2, 3)	(13.5-15.8, 6) 11.0-14.0, 7 (11.8, 12.4, 2) 10.6-13.6, 5 (10.6-12.9, 3)	(6.3-7.8, 6) 5.5-5.8, 3 (5.3, 5.4, 2) 4.2-5.8, 4 (5.5-5.9, 3)
<i>M. sp. 2</i>	(38.1, 38.8, 2)	(-)	(17.5, 17.6, 2)	(44.6, 44.8, 2)	(38.5, 40.6, 2)	(6.7, 7.6, 2)	(11.2, 11.3, 2)	(12.3, 14.1, 2)	(7.9, 8.4, 2)
Vespertilioninae									
<i>Glischropus</i> sp.	(32.1, 1)	(4.8, 1)	(15.4, 1)	(38.3, 1)	(40.7, 1)	(5.2, 1)	(7.3, 1)	(13.5, 1)	(5.4, 1)
<i>Pipistrellus javanicus</i>	(33.6, 1)	(7.0, 1)	(12.4, 1)	(42.4, 1)	(32.3, 1)	(5.2, 1)	(7.4, 1)	(9.1, 1)	(5.3, 1)
<i>P. stenopterus</i>	(39.3-41.6, 4) 26.1-28.7, 21 (24.5-28.2, 3)	(15.5-20.3, 4) 3.8-4.8, 21 (3.8, 4.0, 2)	(15.6-17.8, 3) 12.1-13.9, 21 (10.3-13.1, 3)	(50.6-57.5, 4) 30.8-38.5, 20 (33.7-40.7, 3)	(36.7-41.7, 4) 21.5-30.9, 21 (21.5-29.7, 3)	(6.3-8.0, 4) 2.3-4.8, 21 (3.7-4.5, 3)	(10.5-12.1, 4) 4.6-6.5, 21 (5.8-6.8, 3)	(11.5-13.1, 4) 6.2-8.9, 21 (7.3-9.6, 3)	(3.2-3.8, 3) 3.3-4.8, 21 (5.0-6.3, 3)
<i>T. robustula</i>	(29.8, 1)	(7.8, 1)	(13.6, 1)	(44.9, 1)	(28.7, 1)	(4.8, 1)	(7.6, 1)	(9.6, 1)	(4.1, 1)
MINIOPTERIDAE									
<i>Miniapterus australis</i>	36.6-38.4, 12 (37.6-38.5, 3)	5.3-6.3, 12 (-)	14.4-15.5, 12 (14.8-16.0, 3)	36.6-44.4, 8 (39.1-40.0, 3)	41.2-46.1, 12 (35.4-44.3, 3)	3.3-4.9, 8 (4.7-4.9, 3)	5.4-8.3, 8 (4.7, 5.6, 2)	8.3-9.7, 8 (8.0-9.8, 3)	3.6-4.6, 8 (4.8-5.4, 3)
<i>M. magnater</i>	46.4-50.1, 31 (48.1-50.9, 4) 40.7-44.1, 19 (42.4-43.4, 3)	12.3-14.5, 26 (-) 7.0-9.5, 16 (7.8-8.3, 2)	21.1-22.2, 3 1(20-22.0, 4) 17.6-19.1, 18 (18.1-18.9, 3)	46.2-60.1, 12 (50.0-53.1, 4) 42.8-49.7, 9 (43.9-45.9, 3)	45.5-62.2, 24 (49.9-56.2, 4) 45.1-52.3, 17 (46.4-52.8, 3)	4.1-6.0, 13 (4.9-5.9, 4) 3.8-4.9, 9 (4.6-5.7, 3)	8.3-11.2, 13 (10.1, 10.1, 2) 6.9-8.4, 9 (8.1-9.4, 3)	9.7-12.7, 13 (10.5-12.4, 4) 8.7-11.1, 9 (7.0-11.3, 3)	4.5-6.2, 12 (5.2-6.3, 3) 4.3-5.0, 9 (5.4-6.1, 2)
EMBALLONURIDAE									
<i>Emballonura monticola</i>	43.4-45.0, 4 (42.1, 43.5, 2)	5.0, 5.0, 2 (5.3, 1)	17.0, 18.2, 2 (16.2, 17.2, 2)	39.4, 42.2, 2 (43.9, 47.1, 2)	12.8, 14.4, 2 (11.2, 14.6, 2)	4.2, 4.3, 2 (4.5, 5.4, 2)	6.7, 7.6, 2 (5.3, 6.4, 2)	8.0, 9.9, 2 (10.5, 11.5, 2)	4.2, 4.4, 2 (4.2, 4.4, 2)

Province: Mininjau (Sibuea and Herdimansyah, 1993); and throughout Sumatra as detailed in van Strien (1996).

Remarks

Eonycteris spelaea was common throughout the study area, but more abundant in coffee plantations than in forest. One individual was caught with mist nets above the Way Canguk River. It is easily distinguished from other pteropodids by the lack of a claw on the second finger. Individuals were observed feeding on flowers of kapok (*Ceiba pentandra*) and coconut palm (*Cocos nucifera*) in Sumber Rejo Village (JCCH, personal observation). It has been recorded roosting with *Rousettus* bats in a cave in Way Canguk Forest (MN, unpublished data).

Macroglossus sobrinus Andersen, 1911
Greater long-nosed fruit bat

New records

Lampung Province: Kuyung Arang Village, Sukaraja Forest, Sukaraja Village, Sumber Rejo Village.

New material

Two individuals were collected as voucher specimens. Lampung Province: Sumber Rejo Village, 2♂♂ (MZB 34967, 35837).

Previous records from Sumatra

West Sumatra Province: Mentawai Islands (Simmons, 2005).

Remarks

Macroglossus sobrinus was captured in both coffee plantations and forest. It can be distinguished from *E. spelaea* and *Rousettus* by smaller size and from the rest of pteropodid species by relatively narrower muzzle and longer tongue. An adult female with an infant were found roosting within the dead leaves of a banana tree in a coffee plantation in Sumber Rejo Village (JCCH, personal observation). It is distinguished from *M. minimus* by the absence of an internarial groove in the upper lip.

Megaerops ecaudatus (Temminck, 1837)
Temminck's tailless fruit bat

New records

Lampung Province: Kuyung Arang Village, Sukabanjar Village, Sukaraja Forest, Sukaraja Village, Sumber Rejo Village, Way Canguk Forest.

New material

Two individuals were collected as voucher specimens. Lampung Province: Sukaraja Village, 1♂, 1♀ (MZB 35004, 35005).

Previous records from Sumatra

West Sumatra Province: Mininjau (Sibuea and Herdimansyah, 1993), Padang (type locality, Simmons, 2005).

Remarks

All *M. ecaudatus* individuals in our study were captured in mist nets set at ground level at elevations up to 618 m a.s.l. in coffee plantations. Although most reports describing *M. ecaudatus* from forested habitats (Francis, 2008), records of *M. ecaudatus* in other disturbed habitats is recently reported by Sritongchuay *et al.* (2014) as well. One museum specimen (MZB 35003) indicates a presence of *M. ecaudatus* in Way Canguk Forest. It is distinguished from *M. wetmorei* by shorter tibia length and brown on the first phalanges of all fingers.

Pteropus ? vampyrus (Linnaeus, 1758)
Large flying fox

New records

Lampung Province: Lombok Village, Sukaraja Forest, Sukaraja Village, Sumberjaya Village, Sumber Rejo Village.

Previous records from Sumatra

Jambi Province: Muara Bungo; West Sumatra Province: Mininjau; Lampung Province: Krui, Rata Agung (Sibuea and Herdimansyah, 1993); as throughout Sumatra by van Strien (1996).

Remarks

Although we did not capture any *Pteropus*, four were observed flying in Lombok Village near sunset in late September 2011. Twenty-five individuals were also observed in Sukaraja Village flying south toward Sukaraja Forest from the northeast at around 18:00 in mid April 2012. The bats in the Sukaraja area were possibly from a roost on a small island in 'Watermelon Bay' (Teluk Semangka in Indonesian) near the north coast of southern Bukit Barisan Selatan Ridge (J. Yanto, personal communication). Three *Pteropus* species are currently known from Sumatra, namely *P. vampyrus* (large flying fox), *P. melanotus* (black-eared flying fox), and *P. hypomelanus* (variable flying fox) (Corbet and Hill, 1992; Simmons, 2005). *Pteropus melanotus* and

P. hypomelanus are only known from a few offshore islands in northern Sumatra (Simmons, 2005; Boitani *et al.*, 2006), but *P. vampyrus* has been reported throughout the island (van Strien, 1996), including BBSL (Sibuea and Herdimansyah, 1993) and nearby areas (this study, see below). Hence, we tentatively assign all observations of flying foxes to *P. vampyrus*.

Farmers throughout the study area reported in interviews that *P. vampyrus* gather in coffee plantations to roost and forage during the fruiting season. In the coastal area near Sumber Rejo-Way Canguk area, local people used kites with hooks on tethers to hunt commuting *P. vampyrus*. Villagers gathered at dusk and raised kites into the commuting route of bats until sunset. One to two black plastic bags were tied to the tethers to simulate flying bats and decrease the bats' awareness of the kites (JCCH, personal observation). Based on interviews with villagers, one to ten flying foxes were captured by the whole village each night in 2010; 30 years ago the average capture rate was as many as five bats per person per night. *P. vampyrus* were sold (2–20 USD per bat) as medicine for asthma at local markets near the study area.

Rousettus amplexicaudatus (Geoffroy, 1810)
Geoffroy's rousette bat

New records

Lampung Province: Lombok Village, Sukabandar Village, Sukaraja Village, Sumber Rejo Village, Way Canguk Forest.

Previous records from Sumatra

West Sumatra: Mentawai Islands; Bengkulu Province: Enggano Island; Lampung Province: Kalianda (Rookmaaker and Bergmans, 1981).

Remarks

All *R. amplexicaudatus* were caught with mist nets set at 564–722 m a.s.l. in coffee plantations, and in Way Canguk Forest.

Rousettus leschenaultii (Desmarest, 1820)
Leschenault's rousette

New records

Lampung Province: Lombok Village, Sukabandar Village, Sumber Rejo Village, Way Canguk Forest.

New material

Two individuals were collected as voucher specimens. Lampung Province: Lombok Village,

1 ♀ (MZB 35047); Lampung Province: Sukabandar Village, 1 ♂ (MZB 35046).

Previous records from Sumatra

Lampung Province: Kalianda (Rookmaaker and Bergmans, 1981; van Strien, 1996).

Remarks

All *R. leschenaultii* were caught with mist nets set at 603–702 m a.s.l. in coffee plantations, and in Way Canguk Forest. This medium-large pteropodid bat species can be distinguished from *R. amplexicaudatus* by the more elliptic crowns of the last lower cheek teeth.

Hipposideros ater Templeton, 1848
Dusky leaf-nosed bat

New records

Lampung Province: Kuyung Arang Village, Sumber Rejo Village.

New material

One individual was collected as a voucher specimen. Lampung Province: Way Canguk Forest, 1 ♀ (MZB 34983).

Previous records from Sumatra

Lampung Province: Way Canguk Forest (Khan, 2013).

Remarks

This small species can be distinguished from most *Hipposideros* by smaller body size (Table 2) and from *H. doriae* by presence of vertical septa in the posterior noseleaf. In comparison with species of the *bicolor*-group known for the Sunda Shelf, the body size and noseleaf shape were closest to those of *H. ater*, *H. cineraceus*, and *H. dyacorum* (Corbet and Hill, 1992; Yasuma *et al.*, 2003; Francis, 2008). The internarial septum is pinkish or grayish purple, and the top half of the ear is rounded, contrasting with the darkish septum and triangular ears of *H. dyacorum*. The internarial septum is swollen at the base and gradually narrows towards the top, a condition similar to *H. ater* from Pahang state of Malaysia and different from *H. cineraceus* from Pahang, in which the internarial septum is swollen at the middle (Kingston *et al.*, 2006) and *H. dyacorum* from Malaysia which is very narrow (Murray *et al.*, 2012). Khan's (2013) molecular analysis included one sample from Way Canguk Forest and found it to be genetically identical to the Java population of

H. ater (as *H. a. saevus*-1 by the author). In our study area, it is smaller than *H. bicolor* (see species account below) but bigger than *H. doriae*, and can be distinguished from *H. cervinus* by absence of lateral leaflets on the muzzle and smaller body size.

Hipposideros bicolor (Temminck, 1834)
Bicolored leaf-nosed bat

New record

Lampung Province: Sukaraja Forest, Sumber Rejo Village.

Previous records from Sumatra

North Sumatra Province: Bua Bua, Enggano Island (belong to Nias Islands) (as *H. gentilis major* in Andersen, 1918, but see Douangboubpha *et al.*, 2010); Lampung Province: Way Canguk Forest (Khan, 2013).

Remarks

This is a medium-sized species of the *bicolor* group with forearm length ranging from 43.8 to 47.1 mm ($n = 15$) and ear length from 15.4 to 19.7 mm ($n = 11$). There are two *bicolor*-group species from mainland Southeast Asia which overlap in forearm and ear length, namely *Hipposideros bicolor* (as *H. bicolor* 131 kHz in Kingston *et al.*, 2001) and *H. atrox* (as *H. bicolor* 142 kHz in Kingston *et al.*, 2001), which are both confirmed from Sumatra (Douangboubpha *et al.*, 2010). In the past, the similarity of external traits and the unclear taxonomic relationships among geographic populations has made identification in the field difficult. Previous studies suggest that peak frequency of the echolocation call (F_{MAXE} , frequency with maximum energy of a call) is a diagnostic trait distinguishing *H. bicolor* (127.0–134.4 kHz with a mean $[\bar{x}]$ of 131 kHz in Kingston *et al.*, 2006 and 129.0–135.1 kHz, $\bar{x} = 132.1$ kHz in Douangboubpha *et al.*, 2010) and *H. atrox* (138.0–144.0 kHz, $\bar{x} = 141$ kHz in Kingston *et al.*, 2006 and 135.1–146.7 kHz, $\bar{x} = 142.3$ kHz in Douangboubpha *et al.*, 2010). However, echolocation calls recorded in the present study (F_{MAXE} 133.0–138.4 kHz, $\bar{x} = 136.8$ kHz, $n = 7$) are partially in the acoustic mid-space between *H. bicolor* and *H. atrox*. Based on molecular analyses, Khan (2013) concluded that the *bicolor*-group bat from Way Canguk Forest is the same species as *H. bicolor* (*H. bicolor* 131 kHz) from Central Java, Borneo, and Peninsular Malaysia (as *H. bicolor*-2 in Khan, 2013, median values of F_{MAXE} : 131–133 kHz), although

echolocation data were unavailable for the Way Canguk bats in that study. In the present study, we tentatively assign all our *bicolor*-like bats as *H. bicolor*, as suggested by Khan (2013).

Hipposideros cervinus (Gould, 1854)
Fawn-colored leaf-nosed bat

New records

Lampung Province: Lombok Village, Sukaraja Forest, Sumber Rejo Village, Way Canguk Forest.

Previous records from Sumatra

North Sumatra Province: Sukaranda (upper Langkat) (Bates *et al.*, 2007a).

Remarks

This medium-sized hipposiderid bat can be easily distinguished from other *Hipposideros* in the study area by the presence of two lateral leaflets on the muzzle either side of the anterior nose leaf. In our surveys, most individuals were captured with harp traps set in the lowland primary rainforest of Way Canguk, and another six individuals were caught in coffee plantations. A single individual was recorded from Gimbar 2 cave of Way Canguk. Our records extend its distribution from northern Sumatra to the south.

Hipposideros diadema (É. Geoffroy, 1813)
Diadem leaf-nosed bat

New records

Lampung Province: Kuyung Arang Village, Sukaraja Forest, Sukaraja Village, Sumber Rejo Village, Way Canguk Forest.

New material

One individual was collected as a voucher specimen. Lampung Province: Way Canguk Forest, 1♂ (MZB 35839).

Previous records from Sumatra

North Sumatra Province: caves near Pengerukan (Whitten *et al.*, 2000).

Remarks

Hipposideros diadema was the largest hipposiderid species in the study area (Table 2). It can be easily distinguished from other *Hipposideros* by its larger body size and a distinct white, cream, or yellow flash along the side of each shoulder, which extends as a stripe down the side of the upperparts.

It is primarily a cave-roosting bat (Kingston *et al.*, 2006), and has been recorded roosting with *Rhinolophus affinis* at a cave in Penggerukan, North Sumatra (Whitten *et al.*, 2000). Our finding extends its distribution from northern Sumatra to the south.

Hipposideros doriae (Peters, 1871)
Bornean leaf-nosed bat

New records

Lampung Province: Sukabajar Forest, Sukaraja Forest.

New material

Three individuals were collected as voucher specimens. Lampung Province: Sukaraja Forest, 1♂, 2♀♀ (MZB 35801–35803).

Previous records from Sumatra

Aceh Province: Aceh (as *H. sabanus* in van Strien, 1996, but see Simmons, 2005).

Remarks

This was the smallest *Hipposideros* species (Table 2) in the survey area. It is distinct from other *Hipposideros* bats in the lack of vertical septa in the posterior noseleaf and smaller body size. All *H. doriae* were captured in forest with an elevation of 450 to 755 m. Our record is the most southern of its range in Sumatra.

Hipposideros larvatus (Horsfield, 1823)
Intermediate leaf-nosed bat

New records

Lampung Province: Kuyung Arang Village, Pemerihan Village, Sridadi cave, Sukaraja Forest, Sukaraja Village, Sumber Rejo Village, Way Canguk Forest.

New material

Two individuals were collected as specimens. Lampung Province: Sumber Rejo Village, 1♂, 1♀ (MZB 34980, 34981).

Previous records from Sumatra

North Sumatra Province: a cave near Sipegeh (Whitten *et al.*, 2000); and throughout Sumatra by van Strien (1996).

Remarks

Hipposideros larvatus was the most common and abundant insectivorous species in both forests

and plantations of the survey area. It was found roosting in Gimbar 1 and Sridadi caves with *Emballonura monticola* and *Miniopterus magnater* respectively. Previous studies report geographic variations in body size and F_{MAXE} of echolocation calls across the distribution range of *H. larvatus* (Kitchener and Maryanto, 1993; Thabab *et al.*, 2006). Our samples exhibit similar body size (FA 51.1–60.0 mm, 56.4 mm, $n = 479$) and F_{MAXE} (99–101 kHz) to populations in Peninsular Malaysia but differ from the populations in Myanmar, India, and China (see more details in Kitchener and Maryanto, 1993; Thabab *et al.*, 2006). In our study sites, it can be distinguished from all *Hipposideros* species, except *H. diadema*, by presence of three lateral leaflets, and from *H. diadema* by smaller body size and different color patterns.

Rhinolophus acuminatus Peters, 1871
Accuminate horseshoe bat

New records

Lampung Province: Kuyung Arang Village, Lombok Village, Sukabajar Forest, Sukaraja Forest, Sukaraja Village, Sumber Rejo Village, Way Canguk Forest.

New material

Two individuals were collected as voucher specimens. Lampung Province: Sumber Rejo Village, 1♂, 1♀ (MZB 34978, 34979).

Previous records from Sumatra

Aceh Province: Aceh (van Strien 1996); North Sumatra Province: Nias Island; Bengkulu Province: Enggano Island; Lampung Province: Kalianda, Kephian (Csorba *et al.*, 2003).

Remarks

This mid-sized *Rhinolophus* was common throughout the survey area. It was caught between 50–1014 m. a.s.l. in forests and coffee plantations. One to two individuals were found roosting under a bed in a wooden house surrounded by mixed coffee plantations in Sukaraja Village for at least 13 months. In the study area, it can be easily distinguished from other *Rhinolophus* species, except *R. lepidus*/*R. pusillus* (see species account below), by its triangular-tipped connecting process, and then can be separated from *R. lepidus*/*R. pusillus* by its longer forearm.

Rhinolophus affinis Horsfield, 1823
Intermediate horseshoe bat

New records

Lampung Province: Kuyung Arang Village, Lombok Village, Pemerihan Village, Sukabangar Forest, Sukaraja Forest, Sukaraja Village, Sumber Rejo Village, Way Canguk Forest.

New material

Two individuals were collected as voucher specimens. Lampung Province: Sumber Rejo, 1♂, 1♀ (MZB 34965, 34966).

Previous records from Sumatra

North Sumatra Province: a cave near Pengerukan (Whitten *et al.*, 2000); North and central Sumatra but without detailed localities (van Strien, 1996).

Remarks

Rhinolophus affinis was common throughout the survey area. It was caught between 50–895 m a.s.l. in forests and coffee plantations. One individual was caught with mist nets over the Way Canguk River.

Rhinolophus borneensis Peters, 1861/
R. celebensis K. Anderson, 1905

Bornean horseshoe bat/Sulawesi horseshoe bat

New records

New record to Sumatra; Lampung Province: Kuyung Arang Village, Lombok Village, Sukabangar Forest, Sukaraja Forest, Sukabangar Village, and Way Canguk Forest.

New material

Three individuals were collected as voucher specimens. Lampung Province: Sukaraja Forest, 1♂, 2♀♀ (MZB 35874–35876).

Remarks

This medium-sized *Rhinolophus* species was captured at an elevational of 50–923 m a.s.l. in forest and plantations in mountain areas. This species has a tapered or nearly parallel-sided sella, and a roughly rounded connecting process. Individuals are also characterized by orangey facial skin and bright yellowish or reddish-orange fur. Based on the characters above, this bat is most similar to *R. borneensis* and *R. celebensis* in the *megaphyllus* species group. The two *Rhinolophus* are hard to be distinguished externally and the taxonomic relationship between the two species is not clear.

The current identification is based upon their distribution ranges (Csorba *et al.*, 2003). *Rhinolophus borneensis* is known from Borneo and Java; *R. celebensis* from Java, Bali, Sulawesi, and Timor. Neither species has been recorded yet in Sumatra (Suyanto *et al.*, 2002; Simmons, 2005; also see Francis, 2008, for the revised status of mainland Southeast Asia populations). Hence, we are not able to assign our samples to either of the two species.

In our study area, it can be distinguished from *R. affinis* by its less concave sella, from the *pusillus* group (*R. acuminatus*, *R. lepidus*) by its roughly rounded connecting process, and from the *trifoliatus* group (*R. trifoliatus*, *R. luctus*) by the lack of lateral lappets and smaller body size. Noteworthy, variations in the connecting process (round and slightly pointed) and sella (nearly parallel, slightly concave, and slightly step-wised near base) were observed in individuals from Way Canguk Forest and Sukaraja Forest.

Rhinolophus lepidus Blyth, 1844/
R. pusillus Temminck, 1834

Blyth's horseshoe bat/Least horseshoe bat

New records

Lampung Province: Lombok Village, Pemerihan Village, Sukaraja Forest, Sukaraja Village, Way Canguk Forest.

New material

Four individuals were collected as specimens. Lampung Province: Pemerihan Village, 1♀ (MZB 35051); Sukaraja Forest, 1♂, 1♀ (MZB 35795, 35796); Way Canguk Forest, 1♀ (MZB 35798).

Previous records from Sumatra

North Sumatra Province: Deli for *R. lepidus* (van Strien, 1996); Medan for *R. pusillus* (Csorba *et al.* 2003).

Remarks

This small *Rhinolophus* can be distinguished from other *Rhinolophus* species either by its smaller body size or by the shape of the connecting process, which is triangular and pointed at the tip. The posterior noseleaf (lancet) is triangular and pointed at tip. The coloration is light brown, grayish brown, or orange tipped with buffy brown. Individuals are generally characterized by yellowish brown and yellow skin of the face. Based on the characters above, this bat is most similar to *R. lepidus* and *R. pusillus* in the *pusillus* species group. The two *Rhinolophus*

are hard to be distinguished externally and the taxonomic relationship between the two species is not clear (Csorba *et al.*, 2003). Some studies suggest that peak frequency (F_{MAXE}) is a diagnostic trait to distinguish *R. lepidus* and *R. pusillus* (Kingston *et al.*, 2000; Zhang *et al.*, 2009; Hughes *et al.*, 2010). However, the discrepancy in echolocation calls reported from those studies indicates there is no clear relationship between peak frequency and species (*R. lepidus* versus *R. pusillus*: 100 kHz and 92.5 kHz in Kingston *et al.*, 2000; 92–95 kHz and 100–111 kHz in Zhang *et al.*, 2009; 100.1 kHz and 112.5 kHz in Hughes *et al.*, 2010). Thus, we are not able to assign our samples to either of the two species. Individuals were captured with harp traps with an elevation from 50–507 m a.s.l. in lowland rainforest as well as plantations near forest in our study area. It was recorded roosting in the Gimbar 2 cave at Way Cangkok Forest, and using houses as night roosts and feeding sites in Pemerihan Village.

Rhinolophus luctus Temminck, 1834
Woolly horseshoe bat

New records

Lampung Province: Sumber Rejo Village, Way Cangkok Forest.

New material

Two bats were collected as voucher specimens. Lampung Province: Sumber Rejo Village, 2♂♂ (MZB 35808, 35809).

Previous records from Sumatra

North Sumatra (van Strien, 1996); Lampung Province: Krui (Sibuea and Herdimansyah, 1993).

Remarks

This was the largest *Rhinolophus* species in the study area (FA = 63.5 and 65.0 mm). Two adult males were captured with mist nets in a coffee plantation near the Way Pemerihan River in Sumber Rejo Village. An additional specimen in the MZB was collected by previous researchers from Way Cangkok Forest (labeled as *R. macrotis*, MZB 35757).

Rhinolophus trifoliatus Temminck, 1834
Trefoil horseshoe bat

New records

Lampung Province: Sukabanjar Forest, Sukaraja Forest, Sukaraja Village, Way Cangkok Forest.

New material

One adult female was collected. Lampung Province: Sukaraja Village, 1♀ (MZB 34997).

Previous records from Sumatra

North Sumatra Province: Toba highlands; Riau Province: Indragiri (van Strien, 1996).

Remarks

Rhinolophus trifoliatus is a large *Rhinolophus* which can be easily distinguished from other *Rhinolophus* by the light yellow coloration of its ears and noseleaf. In the survey area, we captured it between 50–609 m a.s.l. in forest and polyculture plantations. Our captures extend its distribution in Sumatra from the central region to the south.

Rhinolophus sp. 1

New record

Lampung Province: Way Cangkok Forest.

Remarks

A single adult female was collected previously from Way Cangkok Forest, but misidentified as a *R. lepidus* (MZB 31491). This is a small brown *Rhinolophus* with a FA of 40.4 mm. The lancet is blunted at the tip and barely hairy at the base. The connecting process is significantly reduced, which differs from triangular-tipped connecting process in *R. lepidus* and *R. pusillus*. The sella is nearly parallel on the sides and the end of the sella significantly protrudes beyond the tip of the connecting process. The noseleaf characteristics are similar to the *philippinensis* species group, but do not match any known species in this group (Csorba *et al.*, 2003). Further comparison with more species is necessary to identify this species.

Rhinolophus sp. 2

New record

Lampung Province: Way Cangkok Forest.

Remarks

A single adult male was collected by previous researchers from Way Cangkok Forest, but recognized as a *R. lepidus* (MZB 31493). It is a small brown *Rhinolophus* bat with a FA of 39.9 mm. The posterior noseleaf is nearly triangular, barely hairy at base, and with a long lancet blunted at the tip. The connecting process is round, differing from *R. lepidus*/*R. pusillus*, and the sella is tapered. This

species is morphologically similar to *R. malayanus* in Indo-Burma region (Csorba *et al.*, 2003), but not comparable to any species known from the Sunda Shelf. It is also similar to *R. stheno*, in noseleaf structure, but smaller in all external measurements. Further comparison with more species is necessary to identify the species.

Megaderma spasma (Linnaeus, 1758)
Lesser false vampire bat

New records

Lampung Province: Lombok Village, Sukabanjara Village, Sukaraja Forest, Way Canguk Forest.

New material

One individual was collected as a voucher specimen. Lampung Province: Way Canguk Forest, 1♀ (MZB 35838).

Previous records from Sumatra

North Sumatra Province: a cave near Batu Katak (Whitten *et al.*, 2000); Lampung Province: Krui (Sibuea and Herdimansyah, 1993).

Remarks

Megaderma spasma was caught with mist nets and harp traps between 50–642 m a.s.l. in primary rainforest, secondary forest, and coffee plantations. Individuals were observed flying < 0.5 m from ground before being trapped with mist nets in the field.

Nycteris tragata (Van der Hoeven, 1855)
Malayan slit-faced bat

New records

Lampung Province: Kuyung Arang, Lombok Village, Sukabanjara Forest, Sukaraja Forest, Way Canguk Forest.

Previous records from Sumatra

South Sumatra Province: Palembang (van Strien, 1996).

Remarks

Two and three individuals of *Nycteris* were caught with mist nets and harp traps, respectively, between 50–881 m a.s.l. in primary rainforest, secondary regrowth forest, and coffee plantations. The forearm lengths of our samples fall into the ranges of both *N. tragata* and *N. javanica* (Corbet and Hill, 1992). However, measurements of the greatest

length of skull (GLS) of three museum specimens from Way Canguk (MZB 35009, 35758, 35828) ranged from 22.1–22.8 mm, suggesting that they are *N. tragata* (GLS > 21.0 mm) rather than *N. javanica* (GLS < 21.0 mm) (G. Csorba, personal communication).

Kerivoula hardwickii (Horsfield, 1824)
Hardwicke's woolly bat

New records

Lampung Province: Kuyung Arang Village, Sukabanjara Forest, Sukaraja Forest, Sumberjaya Village, Way Canguk Forest.

New material

Four individuals were collected as voucher specimens. Lampung Province: Sukaraja Forest, 2♂♂ (MZB 35836, 35872); Sumberjaya Village, 1♀ (MZB 34961); Way Canguk Forest, 1♂ (MZB 35873).

Previous records from Sumatra

North and South Sumatra Provinces (van Strien, 1996); West Sumatra Province: Mentawai Islands (Simmons, 2005); Bengkulu Province: Enggano Island (Francis *et al.*, 2007).

Remarks

This is a small grayish-brown *Kerivoula* species commonly found in the study area. All individuals were caught between 50–995 m a.s.l. in forest, except two, which were trapped in coffee plantations. Comparing with known brown *Kerivoula* species on the Sunda Shelf, its forearm length and body mass fall into the range of *K. hardwickii* (Table 3). It was smaller than *K. papillosa*, and slightly larger than *K. whiteheadi*. It overlapped with *K. flora* and *K. lenis* in forearm length but can be separated from this species by body mass. (Table 3). In *K. whiteheadi* the first two upper premolars are elongated, which they are not in *K. hardwickii* (Yasuma *et al.*, 2003). In the present study, we assigned these bats to *K. hardwickii*, which is listed for Sumatra (Suyanto *et al.*, 2002; Simmons, 2005).

Kerivoula krauensis Francis, Kingston, and
Zubaid, 2007
Krau woolly bat

New record

New record to Sumatra, Lampung Province: Way Canguk Forest.

Remarks

Two adults of *K. krauensis* were collected by previous researchers from Way Canguk Forest (MZB 31480, 34995). This is the first record of this small *Kerivoula* species in Sumatra. The records extend the distribution of *K. krauensis* to the Greater Sunda islands after it was first described from Peninsular Malaysia (Francis *et al.*, 2007). It is distinguished from all known *Kerivoula* species in Sumatra by darker coloration and golden shiny tipped fur on upperparts (Yasuma *et al.*, 2003; Francis *et al.*, 2007) and from *Phoniscus atrox* by lack of a notch near the base of tragus at external margin and lack of a groove on the canine.

Kerivoula lenis Thomas, 1916
Lenis woolly bat

New records

New to Sumatra; Lampung Province: Way Canguk Forest.

Remarks

This is a medium-sized brown *Kerivoula*. One individual was collected by previous researchers from Way Canguk (MZB 35008). The forearm length of the bat falls into the range of *K. flora*, *K. lenis*, and *K. papillosa* (Table 3). Examination of the cranial characteristics of the specimen indicates that it resembled *K. lenis* from peninsular Malaysia Borneo, and from Thailand (B. Douangboubpha, personal communication). This is the first record of *K. lenis* for Sumatra.

Kerivoula minuta Miller, 1898
Least woolly bat

New records

New record to Sumatra; Lampung Province: Sukaraja Forest, Sukaraja Village, Way Canguk Forest.

New material

One individual was collected as a voucher specimen. Lampung Province: Way Canguk Forest, 1♂ (MZB 35889).

Remarks

This was the smallest *Kerivoula* in our study area (FA = 27.7–30.0 mm; Wt: 2.3–3.3 g). All individuals were caught with harp traps between 50–572 m a.s.l., in forest except one, which was trapped in the understory of a mixed coffee plantation. It is a light

reddish-brown bat with semi-translucent wing membranes. Body size is smaller than other *Kerivoula* species in the study area. The bats are externally similar to *K. minuta* and *K. intermedia*, two small species coexisting in some forests of Borneo and Peninsular Malaysia (Kingston *et al.*, 2003; Struebig *et al.*, 2010). These two *Kerivoula* species are almost morphologically identical but differ in body mass (2.0–3.0 g for *K. minuta* and 3.1–3.5 g for *K. intermedia*) and cranial measures (Khan *et al.*, 2010). Based on the measures of body mass, all our captures can be assigned to *K. minuta*, except one individual with a BM of 3.3 g, which falls into the range of *K. intermedia*. A detailed study of cranial traits of our sample collected also confirms the presence of *K. minuta* in our study area (B. Douangboubpha, personal communication). This is the first time the species has been recorded for Sumatra.

Kerivoula papillosa Temminck, 1840
Papillose woolly bat

New records

Lampung Province: Sukabajar Forest, Way Canguk Forest.

New material

Two individuals were collected as voucher specimens. Lampung Province: Way Canguk Forest, 1♂, 1♀ (MZB 35887, 35888).

Previous records from Sumatra

One individual was collected from Sumatra (van Strien, 1996), but no locality information was given.

Remarks

This is the largest *Kerivoulineae* species in the study area. All individuals were caught with harp traps between 50–1,033 m a.s.l. in forest. Individuals varied in color; while most individuals were brown or grayish-brown, others were yellowish-brown. We followed existing references allocating all *Kerivoula* with forearm length > 42.0 mm to *K. papillosa* (Table 3). Five individuals, both with FA = 40.6–41.5 mm, were not assigned to species as this falls within the range of both *K. lenis* and *K. papillosa* (Table 3). We did not consider *K. kachinensis*, another large brown *Kerivoula* species (FA = 40.1–43.2 mm; BM = 6.5–9.5 g) in Southeast Asia, because its distribution is restricted to the Indo-Burma region (Bates *et al.*, 2004; Soisook *et al.*, 2007).

TABLE 3. Selected external traits and distribution range of known grayish-brown *Kerivoula* species on the Sunda Shelf and this study. FA — forearm length (mm); BM — body mass (g); TB — tibia length (mm); ‘-’: data not available. Data in parentheses denote samples of this study

Species	FA ₁₋₇	BM ₁₋₇	TB _{1-2, 4-5}	Known distribution in Sunda Shelf _{1, 8-10}
<i>Kerivoula flora</i>	34.3–39.5	5.8–7.9	18.0–20.0	Vietnam, Thailand, Borneo
<i>K. hardwickii</i>	29.6–36.0 (29.0–36.5)	2.9–8.1 (3.0–5.0)	14.4–17.2 (16.8–20.1)	Peninsular Malaysia, Borneo, Java, Sumatra
<i>K. lenis</i>	33.0–42.0 (39.0)	6.7–6.9 (–)	18.2–20.7 (19.4)	Thailand*, Peninsular Malaysia, Borneo Sumatra (this study)
<i>K. papillosa</i>	37.0–48.9 (42.2–45.9)	6.0–13.0 (8.8–12.5)	18.6–23.8 (20.4–23.6)	Peninsular Malaysia, Borneo, Java, Sumatra
<i>K. whiteheadi</i>	28.0–29.4	3.0–6.2	–	Thailand, Peninsular Malaysia, Borneo

1 — Hendrichsen *et al.* (2001); 2 — Vanitharani *et al.* (2003); 3 — Yasuma *et al.* (2003); 4 — Bates *et al.* (2004); 5 — Bates *et al.* (2007b); 6 — Khan *et al.* (2010); 7 — Rossiter *et al.* (2012); 8 — Corbet and Hill (1992); 9 — Simmons (2005); 10 — Francis (2008); * — B. Douangboubpha, personal communication

Kerivoula pellucida (Waterhouse, 1845)
Clear-winged woolly bat

New records

Lampung Province: Sukabancar Forest, Way Canguk Forest.

Previous records from Sumatra

North Sumatra Province: Deli; Riau Province: Indragiri (van Strien, 1996).

Remarks

This small *Kerivoula* (FA = 28.9–33.0 mm; BM = 3.5–6.3 g) was caught with harp traps set between 50–732 m a.s.l. in forest. It can be easily distinguished from other *Kerivoula* species by the yellow and orange skin coloration, and translucent wing membrane (Kingston *et al.*, 2006). Our captures extend its distribution from central Sumatra to the south.

Phoniscus atrox Miller, 1905
Groove-toothed trumpet-eared bat

New records

Lampung Province: Sumber Rejo Village and Way Canguk Forest

Previous records from Sumatra

Riau Province: Kateman River (type locality, Simmons, 2005); West Sumatra Province: Mininjau; Lampung Province: Krui (Sibuea and Herdiman-syah, 1993).

Remarks

This small *Phoniscus* was caught with a harp trap in a coffee plantation near the border between Sumber Rejo and Way Canguk Forest. Three specimens come from the Way Canguk Forest (MZB 31519,

35010, 35011). It can be distinguished from *Kerivoula* species by the presence of a notch at the base of the tragus and a longitudinal groove on the outer face of the upper canines. It is smaller than *P. jagorii* (Kingston *et al.*, 2006).

Harpiocephalus harpia (Temminck, 1840)
Lesser hairy-winged bat

New record

Lampung Province: Way Canguk Forest.

Previous records from Sumatra

Only listed for Sumatra (van Strien, 1996; Suyanto *et al.*, 2002; Simmons, 2005), but no locality records given.

Remarks

A single male was collected by previous researchers from Way Canguk Forest (MZB 31483). This finding confirms the record of this large species of Murininae in Sumatra. It is a widespread species from India to Southeast Asia, China, and Taiwan (Simmons, 2005), but is rare across all its range. We do not consider it as *Harpiocephalus mordax*, because recent evidence suggests that *H. mordax* is an invalid name based on a female *H. harpia* (Matveev, 2005; Matveev and Csorba, 2007).

Murina peninsularis Hill, 1964
Peninsular tube-nosed bat

New records

Lampung Province: Sukaraja Forest.

New material

One bat was collected as a voucher specimen. Lampung Province: Sukaraja Forest: 1 ♀ (MZB 35799).

Previous records from Sumatra

Lampung Province: Way Canguk Forest (Soisook *et al.*, 2013 — material from the present study).

Remarks

Individuals of this medium-large *Murina* were captured with harp traps between 50–505 m a.s.l. in primary forests. The upperparts of the bat are orange-brown and the underparts grayish white. The crown area of the first upper premolar (P²) is approximately 80% of that of the second upper premolar (P⁴). The color pattern and the relatively larger P² suggest that this is a species of the *cyclotis* complex. Recent studies have recognized four species of the complex in the Southeast Asia, including *M. cyclotis*, *M. fionae*, *M. guilleni*, and *M. peninsularis* (Francis and Eger, 2012; Soisook *et al.*, 2013). Our samples have similar body size (FA = 35.0–39.4; BM = 8.3–12.0 g) to *M. fionae* (FA = 34.5–40.1 mm; BM = 6.6 g) and *M. peninsularis* (FA = 33.8–39.4 mm; BM = 5.5–11.9 g) but are larger than *M. cyclotis* (FA = 29.4–36.8 mm; BM = 5.0–6.1 g) and *M. guilleni* (FA = 35.0–39.4 mm; BM = 3.0–8.0 g) (Soisook *et al.*, 2013). Based on a DNA barcoding analysis of four samples from BBSNP (MZB35006, 35007, 35885, 35886), Soisook *et al.* (2013) confirmed the presence of *M. peninsularis* in Sumatra. It is likely that the records of *M. cyclotis* in Simmons (2005) refer to *M. peninsularis*.

Murina rozendaali Hill and Francis, 1984
Gilded tube-nosed bat

New record

New to Sumatra; Lampung Province: Way Canguk Forest.

New material

One bat was collected as a voucher specimen. Lampung Province: Way Canguk Forest, 1♂ (MZB 35884).

Remarks

One individual was caught with a harp trap in Way Canguk Forest. An additional sample of another male from Way Canguk Forest was found in the MZB (MZB 34991, FA = 30.9 mm), which is the first record from Sumatra. In the study area, *M. rozendaali* can be easily distinguished from other Murininae species by its smaller body size, except *M. suilla*. These two small *Murina* species can be distinguished by fur color and dental characters.

Fur on the upperparts in *M. rozendaali* is dark brown at the base with shiny golden tips, differing from buffy/gray and orange-brown of *M. suilla*. The ratio of the crown area of the first upper premolar to the crown area of the second upper premolar is two-thirds or more in *M. rozendaali*, but is half or less in *M. suilla* (G. Csorba, personal communication). *Murina aenea* is another species with similar coloration in the Sunda Shelf and has not been yet reported from Sumatra. The body size of *M. rozendaali* (FA 28–32 mm, BM 3.8–4.8 g) is smaller than *M. aenea* (FA 34–38 mm, BM 6.0–8.5 g) and the underparts are white-based rather than buffy brown in *M. aenea* (Francis, 2008). Our records extend its distribution on the Sunda Shelf from Peninsular Malaysia and Borneo to Sumatra (Simmons, 2005).

Murina suilla (Temminck, 1840)
Brown tube-nosed bat

New record

Lampung Province: Way Canguk Forest.

Previous records from Sumatra

Only listed for Sumatra (van Strien, 1996; Simmons, 2005), but no locality records given.

Remarks

Three individuals of *M. suilla* were captured in harp traps in Way Canguk Forest. Our captures were the first records of this small *Murina* species (FA = 28.4–33.0 mm; BM = 3.8–5.0 g) with a confirmed locality in Sumatra. *M. suilla* can be distinguished from *M. peninsularis* and *Harpiocephalus harpia* by the smaller body size and from *M. rozendaali* by differences in fur color and dental characters (see *M. rozendaali* account for details).

Myotis cf. borneoensis Hill and Francis, 1984
Bornean whiskered myotis

New record

New to Sumatra. Lampung Province: Way Canguk Forest.

Remarks

This is a medium-large brown *Myotis* species (FA = 45.8 mm) with wing membrane attached to the base of the toes. One adult male was collected by previous researchers from Gimbar 2 cave in Way Canguk Forest (MZB 35012). Comparing with known species on the Sunda Shelf, this bat most

likely belongs to the *montivagus* species complex, which has not been recorded yet in Sumatra. Based on differences in forearm length and craniodental characters, Görföl *et al.* (2013) recognized four species in the *montivagus* species complex from Asia, including *M. borneoensis*, *M. federatus*, *M. montivagus*, and *M. peytoni*. Only *M. borneoensis* (Borneo) and *M. federatus* (Peninsular Malaysia) were reported from the Sunda Shelf, with *M. montivagus* known from South China and North Myanmar, and *M. peytoni* from India (Görföl *et al.*, 2013). Our sample exhibits characteristics of each species except *M. federatus*, but we tentatively assign it to *M. borneoensis* based on cranial characters (separation between P² and P⁴ and the length of the anteorbital bridge) and distribution. Further comparison and molecular analyses are necessary to clarify the taxonomic status of this species. In our study area, it can be easily identified from other known *Myotis* species by its larger forearm length.

Myotis horsfieldii (Temminck, 1840)
Horsfield's myotis

New records

New to Sumatra; Lampung Province: Way Cangkuk Forest.

New material

Three individuals were collected as voucher specimens. Lampung Province: Way Cangkuk Forest, 1♂, 2♀♀ (MZB 35750–35752).

Remarks

It is a medium grayish-brown *Myotis* species (FA = 36.4–40.2 mm, $n = 6$) with wing membrane attached to the fifth metatarsal about 2 mm from the ankle. P³ is completely inline with or partially lingual to the tooththrow. The crown areas of P³ and P₃ are one-third to two-thirds that of P² and the first lower premolar (P₂), respectively. Three individuals were captured flying low over a slow-moving section of the Way Cangkuk River. Additional records from Gimbar 2 cave in Way Cangkuk Forest were in the MZB (MZB 31484, 35013, 35014). In the study area, it can be distinguished from other known *Myotis* species by the wing attachment position. Comparing with all known *Myotis* species of the Sunda Shelf, the body size, wing attachment point, and dental characteristics are most comparable to that of *M. horsfieldii* (Bates and Harrison, 1997; Kingston *et al.*, 2006), which has not been yet recorded from Sumatra (Simmons, 2005).

Myotis muricola (Gray, 1846)
Nepalese whiskered myotis

New records

Lampung Province: Kuyung Arang Village, Pemerihan Village, Sukabanjar Village, Sukaraja Forest, Sumber Rejo Village.

New material

Two bats were collected as voucher specimens. Lampung Province: Sumber Rejo Village, 1♂ 1♀ (MZB 34968, 34969).

Previous records from Sumatra

Lampung Province: Kalianda (van Strien, 1996); Jambi Province: Jambi (Wiantoro *et al.*, 2012).

Remarks

This was the most common *Myotis* species in our study area. It is a small brown bat with wing membrane attached at the base of the toes. Most individuals were captured with mist nets and harp traps between 50 to 600 m a.s.l. in coffee plantations. A few individuals were captured in the understory in the Sukaraja Forest and one individual was trapped around two meters above the Way Pemerihan River.

Myotis sp. 1

New records

Lampung Province: Kuyung Arang Village, Sukabanjar Village, Sumber Rejo Village.

New material

Three individuals were collected as voucher specimens. Lampung Province: Sumber Rejo Village, 2♂♂ (MZB 34970, 34990), Sukabanjar Village, 1♀ (MZB 35045).

Remarks

This is a small *Myotis* species (FA = 31.4–34.7 mm) with the wing membrane attached at the base of the toes. The fur is dark brown to black on the upperparts and grayish brown on the underparts. Some individuals have slightly shiny-tipped fur on the upperparts. The skull is generally flat and the second upper premolar is intruded from the tooththrow. In comparison to all known *Myotis* species of the Sunda Shelf, it is similar to *Myotis ater* in its cranial and dental characters, but differs in the range of forearm length (FA is 34.0–39.0 mm in *M. ater* — Kingston *et al.*, 2006). The body size and dental characters are similar to *M. siligorensis* (Yasuma *et*

al., 2003; Kingston *et al.*, 2006) but cranial characters differ (SW, unpublished data). Neither *M. ater* nor *Myotis siligorensis* have been recorded on the Sumatran main island although there is a record of *M. ater* from an offshore island in West Sumatra (Simmons, 2005). Further comparison and molecular analyses are necessary to clarify the taxonomic status of this species. In the study area, it was distinguished from other *Myotis* species, except *M. muricola*, by its smaller forearm length. It is indistinguishable from *M. muricola* externally, but can be differentiated by the tooth arrangement: the second upper premolar (P³) is in line with the tooththrow in *M. muricola* and displaced inwards such that the adjacent premolars are in contact or nearly so in *Myotis* sp. 1 (Corbet and Hill, 1992). Individuals were caught with both harp traps and mist nets at ground level in coffee plantations, and sometimes trapped with *M. muricola*.

Myotis sp. 2

New records

Lampung Province: Pemerihan Village, Way Canguk Forest.

New material

One individual was collected as a voucher specimen. Lampung Province: Pemerihan Village, 1♀ (MZB 35804).

Remarks

This is a brown, medium-sized *Myotis* species (FA = 38.1–38.8 mm). One bat was captured flying low over rivers of 10 m in width, surrounded by coffee plantations, and at an elevation less than 50 m a.s.l. An adult male was collected by previous researchers from Gimbar 2 cave in Way Canguk Forest (MZB 35805). The wing membrane narrows markedly near the ankle and forms a prolonged strip inserting to the metatarsus, which has been seen in *M. simus* from Paraguay (López-González *et al.*, 2001) and *Myotis* sp.1 from Taiwan (Huang *et al.*, 2008). P³ partially intrudes from the tooththrow, and P² and P⁴ are completely separated. The crown area of P³ is around one-third that of P² and the crown area of P₃ around half that of P₂. Comparing with known species on the Sunda Shelf, the bat is similar to *M. adversus*, *M. hasseltii*, and *M. horsfieldii* in body size and habitat use (Kingston *et al.*, 2006). However, the wing membranes attach directly to the ankle in *M. adversus* and *M. hasseltii*, and directly to the metatarsus in *M. horsfieldii*

(Bates and Harrison, 1997; Bates *et al.*, 2005). Moreover, P² is completely in line with the tooththrow in *M. adversus* and displaced inward in *M. hasseltii* (Yasuma *et al.*, 2003; Francis, 2008). Based on the traits compared, we are not able to assign it to any known species. Genetic analyses and comparisons with more species across a greater geographic range are necessary for species identification.

Glischropus sp.

New record

Lampung Province: Sukabajar Forest.

New material

One individual was collected as a voucher specimen. Lampung Province: Sukabajar Forest, 1♂ (MZB 35030).

Remarks

This was a small *Pipistrellus*-like bat (FA = 32.1 mm; BM = 4.8 g) caught with a harp trap adjacent to a small stream near the edge of disturbed forest at Sukabajar at an elevation of 743 m a.s.l. The only known *Glischropus* species in Sumatra, *G. tylopus*, is smaller in forearm length (27.9–30.9 mm). Instead, the forearm length falls into the size range of *G. bucephalus* (FA = 32.1–35.7 mm) in Cambodia and is similar to *G. javanus* (FA = 32.0 mm) in Java (Csorba, 2011). The fur is dark gray basally with light brown tips on the upperparts, and the fur of the underparts is dark brown at the base and grayish brown to the tips. The cranial and external characters of this *Glischropus* are more similar to *G. bucephalus* than the other two species (G. Csorba, personal communication). Genetic analysis and study of craniodental traits are necessary to confirm its taxonomic status.

Pipistrellus javanicus (Gray, 1838) Javan pipistrelle

New record

Lampung Province: Sumberjaya Village.

New material

One bat was collected as a voucher specimen. Lampung Province: Sumberjaya Village, 1♀ (MZB 34964).

Previous records from Sumatra

North Sumatra Province: Deli (van Strien, 1996).

Remarks

A single female was trapped with a mist net set between two artificial ponds surrounded by coffee plantation at c. 950 m a.s.l. Our record extends the distribution in Sumatra of this small *Pipistrellus* species from the north to the south.

Pipistrellus stenopterus (Dobson, 1875)
Narrow-winged pipistrelle

New records

Lampung Province: Sumberjaya Village, Sumber Rejo Village.

New material

Four individuals were collected as voucher specimens. Lampung Province: Sumber Rejo Village, 1♂ (MZB 35807); Sumberjaya Village, 1♂, 2♀♀ (MZB 34962, 34963, 34975).

Previous records from Sumatra

Lampung Province: Krui (Sibuea and Herdimansyah, 1993); North Sumatra Province: Bada village (van Strien, 1996).

Remarks

This is a large *Pipistrellus* species (Table 2). Three individuals were caught at c. 950 m a.s.l. with a mist net set between two artificial ponds surrounded by coffee bushes. Another individual was caught with a harp trap in a coffee-rubber mixed plantation at an elevation of ca. 50 m a.s.l. In our samples, the species seems to exhibit sexual dimorphism in color and size. The females had reddish-brown fur and a shorter tibia (15.6 and 16.2 mm), whereas the males were grayish brown and had a slightly longer tibia (16.6 and 17.8 mm).

Tylonycteris pachypus (Temminck, 1840)
Lesser bamboo bat

New record

Lampung Province: Kuyung Arang Village, Sidodadi Village, Way Canguk Forest.

New material

Two bats were collected as voucher specimens. Lampung Province: Kuyung Arang Village, 1♂, 1♀ (MZB 35048, 35049).

Previous records from Sumatra

South Sumatra Province: Palembang (van Strien, 1996).

Remarks

Individuals were captured near bamboo stands in coffee plantations of Kuyung Arang Village. The collection at MZB held an adult male (MZB 31518) from Way Canguk Forest. It is a very small species and can be distinguished from *Tylonycteris robustula* by lighter body mass and smaller forearm length (Table 2). Individuals were observed foraging at 10–15 m near the edge, and above the canopy, of coffee plantations (JCCH, personal observation).

Tylonycteris robustula Thomas, 1915
Greater bamboo bat

New record

Lampung Province: Sukabandar Forest.

New material

One bat was collected as a voucher specimen. Lampung Province: Sukabandar Forest, 1♂ (MZB 35029).

Previous records from Sumatra

Listed for North Sumatra, but no locality records given; South Sumatra Province: Palembang (van Strien, 1996).

Remarks

One male and one female were caught with a mist net set near a small stream and bamboo stand in a disturbed forest at an elevation of 711 m a.s.l. *T. robustula* has been reported roosting in the hollow internodes of bamboo stems (Kingston *et al.*, 2006). Our capture is the most southern locality of the species in Sumatra.

Miniopterus australis Tomes, 1858
Little long-fingered bat

New record

Lampung Province: Way Canguk Forest.

New material

One bat was collected as a voucher specimen. Lampung Province: Way Canguk Forest, 1♂ (MZB 35816).

Previous records from Sumatra

Only listed for northern Sumatra (Boitani *et al.*, 2006), but no locality records given.

Remarks

The records of *Miniopterus* species for Sumatra are not consistent among previous studies. van

Strien (1996) and Suyanto *et al.* (1998, 2002) listed three species for the island: *M. fuliginosus* (as *M. schreibersii* in the studies, but see Tian *et al.*, 2004), *M. magnater*, and *M. pusillus*. However, the records of *M. pusillus* (also see Whitten *et al.*, 2000) were not included in subsequent reviews (Corbet and Hill 1992; Simmons, 2005; Boitani *et al.*, 2006; IUCN, 2013). An additional species, *M. australis*, is listed for Sumatra by a few recent studies (Boitani *et al.*, 2006; IUCN, 2013). Due to similarities in appearance, the classification of *Miniopterus* remains uncertain, which makes species identification in the field difficult (Francis, 2008). In this study, we recognize three morphologically distinct species in our samples, and assign names to three of the four known species (see species accounts below). Further studies of craniodental measurements and genetic relationships are necessary to confirm our identifications.

Miniopterus australis is the smallest of the three recognized species from our study area. Comparing with known *Miniopterus* species in the Sunda shelf, the forearm length, body mass, and tibia length of the bat overlapped largely with *M. australis* from other localities, but were smaller than all other *Miniopterus* species (Table 4). Individuals were characterized by orange-yellow and flesh-colored skin of the face and tragus, which was not observed in the other two *Miniopterus* species in our study. Similar coloration is seen in *M. medius* from Peninsular Malaysia but not in *M. australis* from Borneo (J. Senawi, personal communication). However, coloration is seldom used as a diagnostic trait to identify cave-roosting insectivorous bats in Southeast Asia because variations in color among individuals and geographic populations are commonly found in many species. Although this color pattern is stable in our samples, in the present study,

we assign this species as *M. australis* solely based upon the body size. Individuals were recorded from caves in Way Canguk Forest and were found using the same roosts as *Miniopterus magnater*, *M. pusillus*, *Rhinolophus lepidus/pusillus*, *Hipposideros cervinus*, and *Myotis horsfieldii*. In the study area, *M. australis* can be easily distinguished from other known *Miniopterus* species by the skin color and the smaller size (Table 2). Our record is the first record of this species in BBSL and extends the distribution in Sumatra from the north to the south.

Miniopterus magnater (Sanborn, 1931)
Western long-fingered bat

New records

Lampung Province: Sumber Rejo Village, Sridadi village, Gimbar 2 caves in Way Canguk Forest.

Previous records from Sumatra

North Sumatra Province: Balige and Toba highlands (both next to Lake Toba) (van Strien, 1996).

Remarks

This is the largest *Miniopterus* species in our survey area (Table 2). The skin on the face and the tragus is dark brown. Comparing with known *Miniopterus* species in the Sunda shelf, the forearm length, body mass, and tibia length of the bat overlapped largely with *M. magnater* but were larger than all other *Miniopterus* species (Table 4). Thus, we assign our samples to *M. magnater*. Individuals were found roosting with *Miniopterus australis*, *M. pusillus*, *R. lepidus/pusillus*, and *Myotis horsfieldii* in cave Gambir 2 of Way Canguk Forest and with *H. larvatus* in Sridadi cave. Individuals were also captured in lowland coffee plantations as well as over the Way Pemerihan

TABLE 4. Selected external traits and distribution of known *Miniopterus* species on the Sunda Shelf and this study. FA — forearm length (mm), BM — body mass (g), TB — tibia length (mm). Data in parentheses denote samples of this study

Species	FA ₁₋₇	BM ₁₋₆	TB _{1, 2, 6}	Known distribution in Sunda Shelf _{3, 7-13}
<i>Miniopterus australis</i>	34.0–40.0 (36.6–38.5)	5.0–6.0 (5.3–6.3)	14.4–15.7 (14.8–16.0)	Borneo, Java, Sumatra
<i>M. fuliginosus</i> *	42.0–50.0	10.0–14.5	15.0–20.0	Overall the region, including Sumatra
<i>M. magnater</i>	46.0–53.0 (46.4–50.1)	12.0–15.0 (12.3–14.5)	19.0–21.5 (20.0–22.2)	Overall the region, including Sumatra
<i>M. medius</i>	38.0–44.5	8.0–10.0	14.0–16.0	Peninsular Malaysia, Borneo, Java
<i>M. pusillus</i>	39.0–45.0 (40.7–44.1)	7.0–11.0 (7.0–9.5)	16.5–18.0 (17.6–19.1)	Overall the region, including Sumatra

* — previously as *M. schreibersii*, but see Tian *et al.* (2004). 1 — Hendrichsen *et al.* (2001); 2 — Kingston *et al.* (2006); 3 — Francis (2008); 4 — Suyanto and Struebig (2007); 5 — Furey *et al.* (2012); 6 — Cheng *et al.* (2011); 7 — Corbet and Hill (1992); 8 — van Strien (1996); 9 — Whitten *et al.* (2000); 10 — Suyanto *et al.* (2002); 11 — Simmons (2005); 12 — Boitani *et al.* (2006); 13 — IUCN (2013)

River. Our capture extends its distribution from northern Sumatra to the south.

Miniopterus pusillus Dobson, 1876
Small long-fingered bat

New records

Lampung Province: Sumber Rejo Village, Way Cangkuk Forest.

Previous records from Sumatra

North Sumatra Province: a cave near Penerukan (Whitten *et al.*, 2000); caves near Bohorok (van Strien, 1996).

New material

One individual was collected as a voucher specimen. Lampung Province: Way Cangkuk Forest, 1♀ (MZB 35821).

Remarks

This is a medium-sized *Miniopterus* species. All individuals were captured in or near the Gimbar 2 cave within Way Cangkuk Forest, except one individual from Sumber Rejo Village. The skin on the face is dark brown and the tragus is pale white to grayish brown. It can be distinguished from *M. australis* by the larger size and skin coloration of the face and from *M. magnater* by the smaller body size (Table 2) in our study area. Comparing with other known *Miniopterus* species on the Sunda Shelf, its forearm length falls into the range of *M. pusillus* and *M. medius*, and partially overlaps with *M. fuliginosus*. It has a similar body mass range to *M. pusillus*, overlaps partially with *M. medius*, and lighter than *M. fuliginosus*. Its tibia length overlaps partially with *M. pusillus*, falls into the range of *M. fuliginosus*, and is longer than in *M. medius* (Table 4). Despite its slightly larger tibia length, we tentatively assign this bat as *M. pusillus* based upon its forearm length and body mass. Further comparison of craniodental characters and genetic analyses are necessary to confirm the identification of this species.

Emballonura monticola Temminck, 1838
Lesser sheath-tailed bat

New records

Lampung Province: Sukaraja Village, Sumber Rejo Village, Way Cangkuk Forest.

Previous records from Sumatra

North Sumatra Province: Nias Island; West Sumatra Province: Mentawai Islands (Simmons, 2005).

Remarks

In Way Cangkuk Forest, we recorded *E. monticola* roosting in the Gimbar 1 cave with *H. larvatus*, but using separate chambers, as well as under a dormitory of the WCS research station. Individuals identified by their distinctive echolocation calls were observed foraging closing to the height of the tree crown (10–15 m) at the edge of coffee plantations. It can be distinguished from *E. alecto* by the presence of a gap between the first two upper premolars (Corbet and Hill, 1996).

CONCLUSIONS

Our finding of 53 species, including the seven new island records, expands the Sumatra island list of bat species from 80 to 87. Together with previous records of *Aethalops alecto*, *Penthetor lucasi*, *Cheiromeles torquatus*, *Glischropus tylopus*, *Hipposideros cineraceus*, *H. galeritus*, and *Philetor brachypterus* (Sibuea and Herdimansyah, 1993; UNESCO, 2004), there are 60 bat species known from Bukit Barisan Selatan Landscape (BBSL). In addition, Sibuea and Herdimansyah (1993) listed *Nyctalus noctula* for BBSL. This record is more questionable as the nearest confirmed records come from northern mountain areas of Myanmar and Vietnam (Corbet and Hill, 1992; Francis, 2008), and no voucher specimen for Indonesia is known. Additionally, our finding of the two distinct morphs of *C. melanocephalus* indicates another possible new species. The records of the BBSL account for at least 63.2% of the Sumatran bat fauna (55 out of 87 species, excluding the five unidentified species) and 24.9% of the Indonesian inventory of 221 species. In comparison to bat species richness of other protected areas surveyed in Southeast Asia (Hendrichsen *et al.*, 2001; Struebig *et al.*, 2006, 2010, 2012; Kingston *et al.*, 2006; Sedlock *et al.*, 2008; Rahman *et al.*, 2010; Tingga *et al.*, 2012), BBS National Park, with 47 species, represents the second most species-rich area after Krau Wildlife Reserve (69 species — Kingston *et al.*, 2006) although the lower richness estimates at some of the other sites may reflect lesser sampling effort and restricted survey methods. Nonetheless, our results demonstrate that the BBSL is a chiropteran diversity hotspot in Southeast Asia.

Despite the great number of bat species reported in the present study, species richness of the BBSL might be still underestimated. First, species richness generally increases with increasing habitat heterogeneity (Rosenzweig, 1995). BBSNP covers

a variety of vegetation types and several fresh water systems with elevations > 1,500 m (WWF, 2007). In the present study, our surveys were only in forests and coffee plantations at the lower elevations of BBSL, potentially missing species that specialize in other habitats or higher elevations. For example, the gray fruit bat (*Aethalops alecto*), which is known from BBSNP previously (UNESCO, 2004), is found mostly in montane forest above 1,000 m a.s.l. in Southeast Asia (Francis, 2008). Second, our mist-nets and harp traps were set at ground level (up to six meters), and it is likely that species that forage and/or commute at greater heights were under-represented (e.g., Emballonuridae, Molossidae, Rhinopomatidae, Miniopteridae, *Pteropus* spp., *Dyacopterus spadiceus*, and *Megaerops wetmorei*) (Hodgkison *et al.*, 2004a; Francis, 2008). Third, our surveys were conducted mainly during dry seasons and this may have limited the representation of phytophagous bats. Annual production of flower and fruit in Southeast Asia's dipterocarp forests are influenced by precipitation (Corlett and Primack, 2011), and Hodgkison *et al.* (2004b) reported that temporal and spatial patterns of the capture rates of some phytophagous bats were associated with the variations in food resources in a Malaysian rainforest. Fourth, many vespertilionid bats readily avoid mist nets and harp traps (Kingston, 2009), particularly in semi-open habitats such as the coffee plantations, which are generally less complicated in structure and can provide more space for bats to make turns when they detect traps or nets. Acoustic surveys would likely expand our species list, as they have proved effective for detecting the presence of edge and open-space insectivorous species elsewhere in Southeast Asia (Pottie *et al.*, 2005; Phommexay *et al.*, 2011; Kingston, 2013).

We recorded 46 species across the three forested sites (excluding the four species recorded only from caves), which represented around 87% of our species inventory. Eighteen species were found only in forest (one-third of all species) (Table 1), primarily members of the Kerivoulinae and Murininae, which are considered to be forest specialists in the Southeast Asian tropics (Kingston *et al.*, 2003). Only five species were recorded exclusively in plantation sites (Table 1), all members of *Miniopterus*, *Myotis* and *Pipistrellus*, which are considered to be species foraging in gap and/or above vegetation (Kingston, 2013). Absence of these species in the forest sites may reflect a sampling bias, as they forage above the height of our traps in forest. With 41 species, the lowland rainforest at Way Canguk

was the most speciose site of our study. Although the sampling effort in Way Canguk is similar or less than our other sites, Way Canguk Forest still recorded the greatest species richness during trapping (32 species in this study, comparing with 4–26 species for the other sites — Table 1). Our results highlight the significance of forest in the BBS Landscape, especially the lowland rainforest, to the conservation of Sumatra's bat diversity.

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APPENDIX

Field key to the bats of Sumatra

Preface

With over 340 species, bats account for over a third of Southeast Asia's mammal diversity. Recent taxonomic and phylogenetic revisions make field identifications challenging, particularly in areas that lack identification keys, such as Sumatra. Here we present the first dichotomous key to Sumatra's 87 known bat species as well as the putative new species from this study. Our purpose is to provide bat researchers in Sumatra with a basic tool to identify captured living bats from their external morphology. However, our key is unlikely to capture the full variability of morphological measurements and diagnostic characters because samples sizes for most species in Sumatra are still small. Moreover, there are several instances in which species cannot be distinguished by external characters alone. In this case, we present the alternate species together and advocate the use of further craniodental comparisons from specimens and/or genetic analyses. We welcome feedback from users of the key to facilitate future updates.

External character abbreviations and measurement descriptions

FA (forearm length): from the end of the elbow to the end of the wrist with wings folded. BM (body mass). HB (head and body length): from the tip of the snout to the anterior margin of the anus, dorsally. TL (tail length): from the tip of the tail to the anterior margin of the anus. TB (tibia length): from the knee joint to the ankle. HF (foot length): from the end of the heel to the end of the longest digit with the claw, but not including the

hair. TU (thumb length): from the end of the wrist to the extremity of the thumb with the claw, but not including the hair. EL (ear length): from the base of tragus or antitragus to the tip of the pinna. TR (tragus length): from the base to the tip of the tragus. All length measurements are in mm and body mass is in grams.

Craniodental character abbreviations and measurement descriptions

P² (the first upper premolar), P³ (the second upper premolar), P⁴ (the third upper premolar), P₂ (the first lower premolar), P₃ (the second lower premolar), P₄ (the third lower premolar). 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 anterior alveolus of the upper canine. GLS (greatest length of skull): the greatest antero-posterior length of the skull, from the most projecting point at each extremity. MH (mandible height): coronoid height of mandible. CM³ (maxillary toothrow length): from the anterior part of the upper canine to the posterior part of the crown of the third upper molar. M³M³ (molar width): maximum distance between the outer borders of the third upper molars. All measurements are in mm.

Acoustic characters

F_{MAXE} (peak frequency): echolocation frequency with maximum energy (kHz), recorded with the bat at rest (resting frequency).

i. Key to families of Chiroptera (* denotes records in Sumatra but not in Bukit Barisan Selatan Landscape (BBSL))

- 1.1. Dog-like face; 2nd finger with claw (except genus *Eonycteris*); ear simple without tragus or antitragus, margin of ear forming ring Pteropodidae (ii)
- 1.2. Face not dog-like; 2nd finger without claw; ear complex with tragus inside or antitragus on the margin 2
- 2.1. Face complicated, with leaf-like structure or grooves on face 3
- 2.2. Face simple 6
- 3.1. Ear with antitragus 4
- 3.2. Ear with tragus 5
- 4.1. Intermediate noseleaf has a projection (sella) between nostrils; posterior noseleaf (lancet) more or less triangular; upper edge of antitragus rounded or flat Rhinolophidae (iii)
- 4.2. Intermediate noseleaf without a sella; posterior noseleaf generally flat; upper edge of antitragus pointed posteriorly (rounded in genus *Coelops**) Hipposideridae (iv)
- 5.1. Tragus long and bifurcate; without grooves on face; tail not visible externally; interfemoral membrane reduced; ears joined across the top of head Megadermatidae (v)
- 5.2. Tragus short and not bifurcated; groove runs down the center of the face, from between eyes to the nostrils; tail long, last caudal vertebra V or T shaped; interfemoral membrane large; ears not joined across head Nycteridae (vi)
- 6.1. Tail completely or almost fully enclosed within interfemoral membrane 7
- 6.2. Terminal part of tail protruding out of interfemoral membrane 8
- 7.1. Length of 1st phalange of 3rd finger < 40% of 2nd phalange; ear tip lower than the tip of hair on head or near so Miniopteridae (vii)
- 7.2. Length of 1st phalange of 3rd finger is about equal to 2nd phalange; ear tip exceed or close to the tip of hair on head Vespertilionidae (viii)
- 8.1. Tail protrudes from the dorsal surface of interfemoral membrane; 2nd finger without phalanges Emballonuridae (ix)
- 8.2. Free part of tail projects far from the free edge of interfemoral membrane; 2nd finger with phalange(s) 9
- 9.1. Tail thick, shorter than body length (from head to anus), about half of the tail free from interfemoral membrane; 2nd finger only has one reduced phalange Molossidae (x)
- 9.2. Tail whip-like, longer than body, most part of the tail free from interfemoral membrane; 2nd finger has two phalanges Rhinopomatidae* (xi)

ii. Key to species of Pteropodidae (* denotes records in Sumatra but not in BBSL)

- 1.1. No claw on 2nd finger 2
(genus *Eonycteris*)
- 1.2. Claw on 2nd finger 3
- 2.1. FA 59–80 mm; the crown of 1st upper premolar is about equal to the crown of 2nd upper incisor; 1st premolar sometimes absent *Eonycteris spelaea*
- 2.2. FA 75–83 mm; the crown of 1st upper premolar is distinctly larger than the crown of 2nd upper incisor ... *Eonycteris major**
- 3.1. Tail present but short 4
- 3.2. Tail absent or insignificant 14
- 4.1. One pair of lower incisors; FA 57–64 mm *Penthetor lucasi*
- 4.2. Two pairs of lower incisors 5
- 5.1. Upper postcanine teeth flat on crown surface and relative weak; five upper postcanine teeth (four in some individuals) ... 6
(genus *Rousettus*)
- 5.2. Upper postcanine teeth sharp and strong; three or four pairs of upper postcanine teeth 8
- 6.1. Back hairless; wings joined in spinal midline *Rousettus spinalatus**
- 6.2. Back well furred; wings not joined in spinal midline 7
- 7.1. The last lower postcanine teeth nearly circular; FA 78–87 mm *Rousettus amplexicaudatus*
- 7.2. The last lower postcanine teeth elliptic (length 1.5–2.0 to width); FA 78–87 mm *Rousettus leschenaultii*
- 8.1. Ear edge and finger whitish (in adult only); four pairs of upper postcanine teeth 9
(genus *Cynopterus*)
- 8.2. Ear edge and finger not whitish; three pairs of upper postcanine teeth 13
(genus *Dyacopterus**)
- 9.1. Peg-like cusp on the 3rd and 4th lower postcanine teeth; FA 68–76 mm *Cynopterus horsfieldii*
- 9.2. No peg-like cusp on the lower postcanine teeth 10
- 10.1. Ear length < 18 mm 11
- 10.2. Ear length > 18 mm 12
- 11.1. Ears straight or slightly notched at posterior edge; adults generally irritable and noisy; FA 59–73 mm.
..... *Cynopterus brachyotis*
- 11.2. Ears curved at posterior edge; adults generally calm and quiet; FA 52–62 mm *Cynopterus minutus*
- 12.1. Head reddish; FA 62–79 mm *Cynopterus sphinx**
- 12.2. Head blackish; FA 73–83 mm *Cynopterus titthaechelius**
- 13.1. FA 75–83 mm; smaller head (CBL 33.9–36.1 mm, MH 14.5–15.4 mm) *Dyacopterus spadiceus**
- 13.2. FA 81–92 mm; bigger head (CBL 36.5–37.1 mm, MH 15.4–16.3 mm)^a *Dyacopterus brooksi**
- 14.1. Small-medium sized, FA < 65 mm 15
- 14.2. Large, FA > 100 mm 22
(genus *Pteropus*)
- 15.1. Yellow/white spots on face and wings; FA 40–45 mm *Balionycteris maculata*
- 15.2. No spots on face and wings 16
- 16.1. Head light brown, light grayish brown, buffy brown or orange brown 17
- 16.2. Head dark, dark gray or dark grayish brown 20
- 17.1. Strong muzzle; short tongue, nostrils strongly tubular; ear edge darker and is contrasts to the rest part of pinna; postcanine teeth 4/5 18
(genus *Megaerops*)
- 17.2. Narrow muzzle; long tongue; nostrils not tubular; ear edge is similar color to the rest part of pinna; postcanine teeth 5/6 ... 19
(genus *Macroglossus*)
- 18.1. TB > 15 mm; first phalanges of 4th and 5th digits brown; FA 49–60 mm *Megaerops ecaudatus*
- 18.2. TB < 15 mm; first phalanges of both 4th and 5th digits whitish; white tufts on neck in some individuals known in peninsular Malaysia and Borneo populations, possible for Sumatra but unconfirmed; FA 45–52 mm *Megaerops wetmorei**
- 19.1. Internarial groove does not reach upper lip; FA 41–50 mm *Macroglossus sobrinus*
- 19.2. Internarial groove reaches upper lip and splits the lip into two; FA 39–44 mm *Macroglossus minimus**
- 20.1. One pair of lower incisors; head gray or dark grayish/reddish brown; FA 42–46 mm *Aethalops alecto*
- 20.2. Two pairs of lower incisors; face nearly black and in sharp contrast with the underparts of body; FA 39–49 mm 21
(genus *Chironax*)
- 21.1. Ear tip round, EL ≤ 11 mm; BM ≤ 15 g; FA 40–44 mm *Chironax melanocephalus* round-eared form
- 21.2. Ear tip pointed, EL > 12 mm; BM ≥ 19 g; FA 41–47 mm *Chironax melanocephalus* tipped-eared form
- 22.1. FA > 170 mm; BM > 680 g; interfemoral membrane narrowed in center; premolars without ledges ... *Pteropus vampyrus*
- 22.2. FA < 170 mm; interfemoral membrane not narrowed in center; premolars with ledges; recorded in western offshore islands only 23
- 23.1. Back blackish; FA 125–165 mm *Pteropus melanotus**
- 23.2. Back not blackish; FA 105–150 mm; BM < 300 g *Pteropus hypomelanus**

iii. Key to species of Rhinolophidae (* denotes records in Sumatra but not in BBSL, # marks records from BBSL only)

- 1.1. Sella with lateral lappets 2
- 1.2. Sella without lateral lappets 4
- 2.1. Nose and ears light yellow; FA 45–58 mm *Rhinolophus trifoliatus*
- 2.2. Nose and ears dark gray or brown 3
- 3.1. FA 58–80 mm; BM 26–37 g *Rhinolophus luctus*
- 3.2. FA 37–44 mm; BM 7–10 g *Rhinolophus sedulus**
- 4.1. Anterior noseleaf large and covers entire upper lip; sella wide and long; FA 39–50 mm *Rhinolophus macrotis**
- 4.2. Anterior noseleaf small and does not cover entire upper lip; sella narrow and short 5
- 5.1. Connecting process triangular, pointed at tip 6
- 5.2. Connecting process round at tip or reduced 7
- 6.1. FA 44–53 mm; BM 10–16 g *Rhinolophus acuminatus*
- 6.2. FA < 44 mm; BM ≤ 8 g *Rhinolophus lepidus/pusillus*
- 7.1. Connecting process relatively strong with a rounded central part 8
- 7.2. Connecting process weak and not rounded in the central part 11
- 8.1. Sides of sella concave at middle; FA 46–55 mm *Rhinolophus affinis*
- 8.2. Sella only slightly tapering, sides nearly parallel; FA ≤ 48 mm 9
- 9.1. TL 21–29 mm; FA 38–47 mm *Rhinolophus borneensis/celebensis#*
- 9.2. TL < 20 mm 10
- 10.1. TL 17–20 mm; FA 41–48 mm *Rhinolophus stheno**
- 10.2. TL 15.9 mm; FA 39.9 mm (*n* = 1) *Rhinolophus* sp. 2[#]
- 11.1. Connecting process distinctly arched; FA 42–54 mm *Rhinolophus arcuatus**
- 11.2. Connecting process flat; FA 40.4 mm (*n* = 1) *Rhinolophus* sp. 1[#]

iv. Key to species of Hipposideridae (* denotes records in Sumatra but not in BBSL; # marks records from BBSL only)

- 1.1. Ear rounded; tail and interfemoral membrane reduced; noseleaf with deep notch in anterior leaf; FA 34–47 mm *Coelops frithii**
- 1.2. Ear triangular or with pointed tip; tail short-moderate; no notch in anterior leaf 2
(genus *Hipposideros*)
- 2.1. 2–4 lateral leaflets 3
- 2.2. No lateral leaflets 7
- 3.1. 2 lateral leaflets 4
- 3.2. 3–4 lateral leaflets 6
- 4.1. Anterior edge of pinna haired for 1/2 length; tip of incisors convergent; endemic to Mentawai Islands *Hipposideros breviceps**
- 4.2. Anterior edge of pinna haired for 2/3 length; tip of incisors not convergent 5
- 5.1. Intermediate leaf narrower than posterior leaf; TL 21–28 mm; FA 44–52 mm *Hipposideros cervinus*
- 5.2. Intermediate leaf wider than posterior leaf; TL > 30 mm; FA 45–50 mm *Hipposideros galeritus#*
- 6.1. FA 76–90 mm; cream or orange markings on head, shoulder and lateral sides of back; 3–4 lateral leaflets *Hipposideros diadema*
- 6.2. FA 47–63 mm; fur brown, or gray brown, without pale markings over head and body; 3 lateral leaflets *Hipposideros larvatus*
- 7.1. Disk-like structure in internarial region of nose (between intermediate and anterior noseleaves); FA 46–49 mm *Hipposideros orbiculus**
- 7.2. No disk-like structure 8
- 8.1. Posterior leaf without internal septum; FA 33–40 mm *Hipposideros doriae*
- 8.2. Posterior leaf divided into four cells by three septa 9
- 9.1. Internarial septum not straight/tapered but more or less swollen 10
- 9.2. Internarial septum nearly straight or slightly tapered 11
- 10.1. Internarial septum slightly swollen at base and gradually narrowing toward top; FA 38–43 mm *Hipposideros ater*
- 10.3. Internarial septum swollen in the middle; FA 36–41 mm *Hipposideros cineraceus*
- 11.1. FA > 46 mm; TB > 20.5 mm; $F_{\text{MAXE}} < 135.1$ kHz *Hipposideros bicolor* (*H. bicolor* 131 kHz)
- 11.2. FA < 43.8 mm; TB < 19.3 mm; $F_{\text{MAXE}} > 139.0$ kHz *Hipposideros atrox* (*H. bicolor* 142 kHz)*
- 11.3. FA 43.8–46.0 mm and TB 19.3–20.5 mm and F_{MAXE} 135.1–139.0 kHz intermediate form (*Hipposideros atrox*/H. bicolor*)

v. Key to species of Megadermatidae

This family is represented by a single genus, *Megaderma* in Southeast Asia, and *M. spasma* is the only known species in Sumatra. Posterior noseleaf elliptic, round on the top, narrower than posterior edge of intermediate noseleaf, and the length is shorter than or subequal to the length of intermediate + anterior noseleaves; FA 52–63 mm; TB 30–35 mm; BM 16–30 g.

vi. Key to species of Nycteridae

This family is represented by a single genus, *Nycteris*, and *N. tragata* is the only known species in Sumatra.
FA 46–55 mm; BM 12–22 g; GLS > 21 mm.

vii. Key to species of Miniopteridae (* denotes records in Sumatra but not in BBSL)

- 1.1. TB > 20 mm; FA 46–53; BM 12–15 g *Miniopterus magnater*
- 1.2. TB < 20 mm 2
- 2.1. FA 34–40 mm; TB ≤ 16 mm; BM 5.0–6.5 g; skin of face pink and yellow *Miniopterus australis*
- 2.2. FA > 39 mm; TB ≥ 16.5 mm; BM ≥ 7 g; skin of the face dark brown 3
- 3.1. BM 7–10 g; FA 39–45 mm; TB 16.5–19.1 mm *Miniopterus pusillus*
- 3.2. BM 10–12.5 g; FA 42–50 mm; TB 16–20 mm *Miniopterus fuliginosus**

viii. Keys to subfamilies of Vespertilionidae (* denotes records in Sumatra but not in BBSL, # marks records from BBSL only)

- 1.1. Nostrils tubular, openings directed laterally subfamily Murinae (A)
- 1.2. Nostrils not tubular, openings directed frontally 2
- 2.1. Ear funnel-shaped; tragus very long, thin, and sharply pointed subfamily Kerivoulinae (B)
- 2.2. Ear shape various but not funnel-shaped; tragus shape and length various, but never as thin as in Kerivoulinae 3
- 3.1. Three pairs of upper premolars (two in *M. ridleyi*); tragus moderately pointed and only slightly bent forward subfamily Myotinae (C)
- 3.2. One or two pairs of upper premolars; tragus usually not pointed (if pointed, then very sharply bent forward; see *Scotophilus*) subfamily Vespertilioninae (D)

A. Keys to species of subfamily Murinae

- 1.1. FA 45–51 mm; 3rd upper molar reduced or absent *Harpiocephalus harpia*
- 1.2. FA < 40 mm; 3rd upper molar well developed 2
(Genus *Murina*)
- 2.1. FA 33–40 mm; BM 5.5–12.0 g *Murina peninsularis*
- 2.2. FA ≤ 32 mm; BM < 5.5 g 3
- 3.1. Upperparts dark brown, tipped with shining gold color; crown area of P² ≥ 2/3 of P⁴; FA 28–32 mm .. *Murina rozendaali*[#]
- 3.2. Upperparts pale brown to orange (some individuals have scattered guard hairs tipped with shining yellowish-gold color); crown area of P² ≤ 1/2 of P⁴; FA 27–32 mm *Murina suilla*

B. Keys to species of subfamily Kerivoulinae

- 1.1. Tragus has a notch near the base; upper canine with a longitudinal groove on outer face; FA 30–36 mm .. *Phoniscus atrox*
- 1.2. No notch in tragus; no groove on upper canine 2
(Genus *Kerivoula*)
- 2.1. Wing with orange and black markings; FA 34–39 mm *Kerivoula picta**
- 2.2. Wing pale brown or semi-translucent 3
- 3.1. Fur dark brown above with golden/bronze tips; FA 28–32 mm *Kerivoula krauensis*[#]
- 3.2. Fur orange, brown, buffy brown or grayish brown above, not tipped with gold/bronze 4
- 4.1. Nose, tragus, and genital region yellowish; lips, fingers, tail, and feet pink; wing semi-translucent; FA 28–33 mm *Kerivoula pellucida*
- 4.2. Color of the above parts brown- or grayish-based 5
- 5.1. TB < 15 mm; FA 25–32 mm; fur orange or brown *Kerivoula minuta*[#]
- 5.2. TB ≥ 14.5 mm; FA ≥ 30.0 mm; fur yellowish-brown, brown or grayish-brown 6
- 6.1. FA ≥ 42 mm; fur yellowish-brown, brown or grayish-brown *Kerivoula papillosa*
- 6.2. FA < 42 mm 7
- 7.1. FA 30.0–36.5 mm^b; fur grayish-brown *Kerivoula hardwickii*
- 7.2. FA 37–42 mm intermediate form (*Kerivoula lenis*[#]/*K. papillosa*)

C. Keys to species of subfamily Myotinae

- 1.1. Wing membrane with conspicuous black and orange coloration; FA 56–60 mm *Myotis hermani*^{*}
- 1.2. Wing membrane brown or gray-based; FA ≤ 46 mm 2
- 2.1. Wing membrane attached at the base of toes 3
- 2.2. Wing membrane attached to ankle or side of feet 7
- 3.1. FA 27–30 mm; 2 pairs of upper premolars; fur short and dense; BM 4.0–6.5 g *Myotis ridleyi*^{*}
- 3.2. FA > 30 mm; 3 pairs of upper premolars 4
- 4.1. FA 42–46 mm; BM 9–14 g *Myotis cf. borneoensis*[#]
- 4.2. FA ≤ 39 mm; BM ≤ 8 g 5

x. Key to Molossidae (* denotes records in Sumatra but not in BBSL)

- 1.1. Ear triangular; ear integument thin; FA 38 mm *Mormopterus doriae**
- 1.2. Ear rounded; ear integument thick 2
- 2.1. Naked, only scattered hairs; FA 65–85 mm; BM 115–180 g *Cheiromeles torquatus*
- 2.2. Hairy, fur thick; FA < 52 mm; BM < 30 g 3
- 3.1. Interaural band of skin thick, rises vertically at center, forming a pocket between ears; FA 44–49 mm
..... *Chaerephon johorensis**
- 3.2. Interaural band of skin thin, not raised at center, no interaural pocket 4
- 4.1. Dorsal fur predominantly reddish-brown; HF 11–13 mm; BM 16–22 g; one upper premolars; FA 41–46 mm . . . *Mops mops**
- 4.2. Dorsal fur predominantly grayish-brown; HF 8–9 mm; BM 10–18 g; two upper premolars (P² very small and unicuspid);
FA 40–50 mm *Chaerephon plicatus**

xi. Key to Rhinopomatidae (* denotes records in Sumatra but not in BBSL)

This family is represented by single genus, *Rhinopoma*. *R. microphylum** is the only species known in Sumatra, FA 62–75 mm; nostrils flat, no swellings.

^a — Data from a sample size of three individuals (Helgen *et al.*, 2007); ^b — The differentiation between *K. hardwickii*, *K. lenis*, and *K. papillosa* is complicated by some size overlap. Our keys of FA criteria are based on the preponderance of measurements, but the classifications of the three species remain unclear. See main text for more details; ^c — Genera *Arielulus* and *Hesperoptenus* are widely-distributed across the Sunda Shelf but have not been reported yet from Sumatra. *Arielulus* can be distinguished from other Vespertilioninae species by its dark upperparts tipped with orange and gold. *Hesperoptenus* can be distinguished from other Vespertilioninae species by its enlarged, caniniform first upper incisor, about half the height of the upper canine; second upper incisor small and behind first incisor in some species; ^d — The record of *Nyctalus noctula* in Sumatra by Sibuea and Herdimansyah (1993) is questionable (see detailed in the discussion of main text). *Nyctalus noctula* can be distinguished from other Vespertilioninae species by its mushroom-like tragus (short, broaden extensively at top) and larger body size (BM 32 g; FA 49–58 mm). In addition, *N. noctula* has two pairs of upper incisors, which one pair in similar body-sized *Scotophilus kuhlii*.