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On a small collection of bats (Chiroptera) from western Sabah (North Borneo, East Malaysia)

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Abstract. New records of bats from three sites situated in the western part of the Malaysian state of Sabah (North Borneo) are presented. Besides some common species (*Cynopterus brachyotis*, *C. horsfieldii*, *Megaerops ecaudatus*, *Balionycteris maculata*, *Aethalops aequalis*, *Macroglossus minimus*, *Rhinolophus borneensis*, *R. trifoliatus*, *Hipposideros dyacorum*, *H. cervinus*, *H. diadema*, *Myotis muricola*), several rather rare forms were also recorded. *Cynopterus minutus* and *Hipposideros doriae* are reported from the territory of Sabah for the first time, *Cynopterus sphinx* for the second time. *Arielulus cuprosus* was found for the first time after its description from another site in Sabah and remains a Sabahan endemic. Some notes on ecology, morphology and taxonomy of several collected taxa are added.

Oriental Region, Chiroptera, fauna.

Introduction

Bat fauna of Borneo is relatively well known. According to many recent authors (e.g., Medway 1977, Kobayashi et al. 1980, Francis 1989, Koopman 1989, Kitchener & Mahardatunkamsi 1991, Corbet & Hill 1992, Abdullah et al. 1997a, Payne & Francis 1998, Francis & Hill 1998, Kofron 2002, Suyanto & Struebig 2007, etc.), occurrence of around hundred bat species was documented from the island, i.e. about 9% of the world bat fauna *sensu* Simmons (2005). However, some Bornean bat species are known just from a few individuals or even from one (type) specimen and moreover, further cryptic diversity of the bat fauna should be still expected considering the island's isolation (cf. Hulva & Horáček 2006).

Although the area of the Malaysian State of Sabah is well documented from the zoological point of view in comparison to other parts of the island of Borneo (Kalimantan, Sarawak, Brunei) and the mammal research has a long tradition there (cf. Harrison 1964), several Bornean bat species have not yet been recorded from this territory. For example, among megabats, *Cynopterus minutus* Miller, 1906 remains known only from Kalimantan and Brunei (Kitchener & Maharadatunkamsi 1991, Kofron 1997) and *Megaerops wetmorei* Taylor, 1934 only from Brunei (Payne & Francis 1998). The emballonurid *Taphozous theobaldi* Dobson, 1872 was reported solely from southern Kalimantan (Hill et al. 1990) and the molossid *Mops mops* (Blainville, 1840) only from Sarawak (Abdullah et al. 1997a). Concerning other bat families, e.g. three *Rhinolophus* species, four *Hipposideros* species, *Coelops robinsoni* Bonhote, 1908, *Kerivoula jagorii* (Peters, 1866), *Pipistrellus macrotis* (Temminck, 1878), *Hesperoptenus doriae* (Peters, 1868), *Miniopterus pusillus* Dobson, 1876, have not yet been found in Sabah (Payne & Francis 1998). As a result of two field trips to western Sabah, a small collection of bat specimens was gathered, including representatives of some rather rare species. Brief information concerning these records is presented here.

Methods

Bats were collected at three sites of the western part of Sabah (see below), with the help of all common techniques of field bat study (mist-netting, hand-netting, collecting in caves). During mist-netting, the nets were installed at all sites at the ground level, i.e. in the "understorey" stratum of the tropical forest (S1, S2). In a cave the bats were collected only once at Batu Punggul, hand-netting with a butterfly-net was used only exceptionally. The specimens were collected by Mr. Vilém Borůvka in May 1995 (deposited in SMO) and by the author in April–May 1999 (deposited in NMW).

Museum material was used in the morphological analyses (see Abbreviations and Terminology for the dimensions taken), the examined specimens are listed in Appendix 1. The specimens were measured in a standard way using mechanical or optical calipers, according to Benda et al. (2004b). Bacula were extracted in 6% solution of KOH and coloured with alizarin red. Statistical analyses were performed using the Statistica 6.0 software.

Study Sites

1. **Gunung Emas** (= Mount Emas), 53 km by road from Kota Kinabalu in the direction of Tambunan, 05° 50' N, 116° 20' E, ca. 1800 m a. s. l. (Pantai Barat Dist.). A mountain resort surrounded by a montane "misty" forest with scattered small patches of secondary habitats (clearings, secondary forests, gardens, pastures) (Figs. 1, 2). The bats were netted in a relatively sparse forest on slopes of the Crocker Range. Collecting site of six bat species (Table 1); of other mammals also *Hylomys dorsalis* Thomas, 1888, *Crocidura* cf. *foetida* Peters, 1870, *Tupaia montana* Thomas, 1892, *Dremomys everetti* (Thomas, 1890), and *Leopoldamys sabanus* (Thomas, 1887) were collected.

2. **Sapulut**, 04° 42' N, 116° 29' E, ca. 250 m a. s. l. (Pedalaman Dist.). Small but extensive village at the confluence of the Sabakong and Sapulut Rivers surrounded by pastures and secondary forests in different stages of succession (Figs. 3, 4). The bats were netted in a secondary forest with rather dense (mostly bamboo) undergrowth and with trees ca. 15–25 m in height. Site where 10 bat species were documented (Table 1); of other mammals also *Tupaia glis* (Diard, 1820), *Viverra tangalunga* Gray, 1832, *Sundasciurus lowii* (Thomas, 1892), *Maxomys whiteheadi* (Thomas, 1894), and *Rattus exulans* (Peale, 1848) were collected and/or observed.

3. **Batu Punggul** (= Punggul Rock), 04° 38' N, 116° 37' E, ca. 500 m a. s. l. (Pedalaman Dist.). A huge limestone outcrop towering nearly 300 m above the Sapulut River, surrounded by (predominantly) primary rainforests (Figs. 5, 6). Collecting site of 11 bat species (Table 1); of other mammals also *Tarsius bancanus* Horsfield, 1821, *Macaca fascicularis* (Raffles, 1821), *Maxomys surifer* (Miller, 1900), and *Rattus exulans* (Peale, 1848) were collected and/or observed. Most of the bats were netted in the forest, several individuals were hand-netted in caves of the Punggul Rock.

Abbreviations and Terminology

Dimensions. G = weight; LC = head and body length; LCd = tail length; LAt = forearm length; LA = ear length; LCr = greatest length of skull (incl. praemaxillae also in Rhinolophidae and Hipposideridae); LCb = condylobasal length; LCc = condylocanine length; LaZ = zygomatic width; LaI = width of the interorbital constriction; LaInf = infraorbital width of rostrum; LaPo = width of the postorbital constriction; LOn = orbito-nasal length of rostrum; LaN = braincase width; ANc = height of braincase; ACr = largest skull height incl. tympanic bullae; CC = rostral width across the upper canines; MM = rostral width across the last upper molars; CMs = length of the upper tooth-row incl. the canine and the last molar; LMd = condylar length of mandible; ACo = height of the coronoid process; CMi = length of the lower tooth-row incl. the canine and the last molar.

Collections. BMNH = Natural History Museum, London, United Kingdom; CUP = Department of Zoology, Charles University, Prague, Czech Republic; MNHN = National Museum of Natural History, Paris, France; MSNG = Civil Natural History Museum Giacomo Doria, Genoa, Italy; NMW = Natural History Museum, Vienna, Austria; SMF = Senckenberg Research Institute and Museum, Frankfurt am Main, Germany; SMO = Silesian Museum Opava, Czech Republic; ZFMK = Zoological Institute and Museum Alexander Koenig, Bonn, Germany; ZIN = Zoological Institute of the Russian Academy of Sciences, Saint-Petersburg, Russia; ZMB = Zoological Museum of the Humboldt University, Berlin, Germany.

Other Abbreviations. ad = adult; A = alcoholic specimen; G = pregnant; juv = juvenile; L = lactating; sad = subadult; S = skull; Sk = skeleton; ♀ = female; ♂ = male.

Geographic Terminology. The name Kalimantan is used for the Indonesian part of Borneo, while the name Borneo is used for the whole island. In this sense, the island of Borneo consists of four main political and/or geographical parts, i. e. Sabah, Sarawak, Brunei and Kalimantan. In the case of other Sunda islands, English names are used (e.g. Sumatra instead of Sumatera, Celebes of Sulawesi, etc.). In the comparison report concerning morphometric variation in the genus *Myotis*, the simplified term Indochina is used for the area of the whole Indochinese Peninsula including Thailand and Malaya, while the term India for the whole area of the Indian Subcontinent *sensu* Bates & Harrison (1997).

Species List

P t e r o p o d i d a e

Cynopterus brachyotis (Müller, 1838)

Material. **Gunung Emas**, May 1995, 2 ♂♂ sad (SMO sa01 [S], sa02 [S+B]). – **Sapulut**, 23 April 1999, 3 ♂♂ ad, 1 ♂ sad, 1 ♀ ad (NMW 61371–61375 [S+A]); 25 April 1999, 2 ♂♂ ad, 1 ♂ sad, 1 ♂ juv, 2 ♀♀ ad L, 2 ♀♀ sad (NMW 61376–61378, 61380–61383 [S+A], 61379 [A]); 26 April 1999, 3 ♂♂ ad, 1 ♂ sad, 2 ♀♀ ad (NMW 61384, 61385 [S], 61386, 61387, 61389 [S+A], 61388 [S+Sk]); 27 April 1999, 1 ♂ ad (NMW 61390 [S]); 28 April 1999, 1 ♂ ad (NMW 61391 [S+A]). – **Batu Punggul**, 30 April 1999, 1 ♂ juv (NMW 61443 [A]); 2 May 1999, 1 ♂ ad, 1 ♀ ad (NMW 61444, 61445 [S+A]).

Released Bats. **Sapulut**, 25 April 1999, 2 ♂♂ sad, 1 ♀ ad, 1 ♀ sad; 26 April 1999, 3 ♂♂ ad, 2 ♂♂ sad, 1 ♀ ad L, 2 ♀♀ ad, 2 ♀♀ sad; 27 April 1999, 1 ♂ sad, 1 ♀ ad, 2 ♀♀ sad; 28 April 1999, 1 ♂ sad. – **Batu Punggul**, 2 May 1999, 5 ♂♂ sad, 1 ♀ sad.

Cynopterus brachyotis belongs to the most common fruit bats in all parts of Borneo, including offshore islands (Stuebing et al. 1989, Payne & Francis 1998, Nor 1996, Abdullah & Hall 1997, Suyanto & Struebig 2007, etc.). In the secondary habitats at Sapulut, this fruit bat was an absolutely dominant bat species in the whole catch, making up two thirds of the netted bat individuals (Table 1); it also represents almost a half of the number of recorded bats from all three sites (78.5% of the bats of the genus *Cynopterus*). Certainly a part of this recorded dominance was affected by the method used (cf. Zubaid 1994a), however, it also shows the relatively high ecological plasticity of this bat. In the catch, all age classes were recorded (see Material), including two juveniles. One of them was certainly brought to the net by its mother as it was still blind and its forearm was 27.7 mm long, i.e. 38.7% of the average adult length (cf. Table 2). However, among 58 *C. brachyotis* netted at Sapulut in April 1999, only 10 adult females were present and only three females were lactating; numerous subadult bats of both sexes were present too. It suggests continuous year-round reproduction of this fruit bat in Borneo.

Francis et al. (1984) recorded *C. brachyotis* to be dominant in netting samples from mangrove forests of the Samunsan Wildlife Sanctuary (Sarawak), making up 87.0% of all bats, however in other habitats of this area as well as in the Bako National Park they found it rather exceptionally (0–12.5%). Abdullah & Hall (1997) recorded this bat to be an important part of bat communities of almost all forest strata at Mt. Kinabalu (Sabah) and Lambir Hills (Sarawak) and Abdullah et al. (1997b) found it absolutely dominant in the nettings made in plantations at Pontianak, Kalimantan, where it represented 89.4% of all netted bats. Similar results from *C. brachyotis* nettings undertaken in various habitats of Luzon, the Philippines, were obtained by Mudar & Allen (1986). Kofron (1997) did not find *C. brachyotis* in primary forests of Brunei, while it was very common in secondary habitats there and in mangrove forests. Similarly, Rickart et al. (1993) found it less common in primary forests than in secondary habitats of Philippines. However, we found *C. brachyotis* to make up almost a quarter of recorded bat individuals in the primary forest at Batu Punggul. Similarly, Zubaid (1993) found *C. brachyotis* both in primary and secondary lowland forests in Malaya, although in secondary forests this species represented 32.1% of the netted bats, while in primary forests only 5.2%.

Payne & Francis (1998) suggested the altitudinal limit of distribution of this bat in Borneo at 1600 m a. s. l. (at least 1250 m in the Philippines according to Heaney et al. 1998). This level is shifted by here presented record from Gunung Emas to the altitudes of around 1800 m. *C. brachyotis* seems to occur at these montane levels (at least) accidentally and/or seasonally as our record from one catch could suggest.

Figs. 1–4. Study sites. 1, 2 – Gunung Emas, montane "misty" forest. 3, 4 – pastures and secondary forests at Sapulut.
Obr. 1–4. Studované lokality. 1, 2 – Gunung Emas, horský "mlžný" les. 3, 4 – pastviny a druhotné lesy okolo Sapulutu.

Baculum preparations from the Sabahan *C. brachyotis* (Fig. 7) concur well in shape with the described bacula originating in various parts of the species distribution range (see Krutzsch 1959, 1962, Heller & Volleth 1989, Kitchener & Maharadatumkamsi 1993, Bates & Harrison 1997, etc.).

Cynopterus minutus Miller, 1906

Material. **Gunung Emas**, May 1995, net. 1 ♂ ad (SMO sa11 [S+B]). – **Sapulut**, 26 April 1999, 1 ♀ sad (NMW 61392 [S+A]); 28 April 1999, 1 ♀ sad (NMW 61393 [S+A]). – **Batu Punggul**, 3 May 1999, 1 ♂ ad, 1 ♀ sad (NMW 61446, 61447 [S+A]).

Table 1. Review of the recorded bat species and their numbers per a locality. In *italics* in brackets [], numbers of released bats
Tab. 1. Přehled počtů a druhů zaznamenných netopýrů na jednotlivých lokalitách. *Kursivou* v závorkách [] jsou uvedeny počty vypuštěných jedinců

species \ site druh \ místo	Gunung Emas n	 %	Sapulut n	 %	Batu Punggul n	 %	total / celkem n	 %
Cynopterus brachyotis	2	14.3	21[*19*]	66.7	3[*6*]	22.0	51	44.4
Cynopterus minutus	1	7.1	2	3.3	2	4.9	5	4.3
Cynopterus sphinx	–		3	5.0	–		3	2.6
Cynopterus horsfieldii	–		5[*1*]	10.0	–		6	5.2
Megaerops ecaudatus	1	7.1	2	3.3	1	2.4	4	3.5
Balionycteris maculata	–		–		1	2.4	1	0.9
Aethalops aequalis	8	57.1	–		–		8	7.0
Macroglossus minimus	1	7.1	2	3.3	2	4.9	5	4.3
Rhinolophus borneensis	–		1	1.7	7	17.1	8	7.0
Rhinolophus trifoliatus	–		–		1	2.4	1	0.9
Hipposideros doriae	1	7.1	–		–		1	0.9
Hipposideros dyacorum	–		–		5	12.2	5	4.3
Hipposideros cervinus	–		2	3.3	1	2.4	3	2.6
Hipposideros diadema	–		1	1.7	10	24.4	11	9.6
Myotis muricola	–		1	1.7	–		1	0.9
Arielulus cuprosus	–		–		2	4.9	2	1.7
total species / celkem druhů	6		10		11		16	
total individuals* / celkem kusů	14		60		41		115	

*including the released bats / včetně vypuštěných netopýrů

Figs. 5, 6. Study sites; Batu Punggul. 5 – Punggul Rock and gallery forest above the Sapulut River. 6 – view from one of the numerous caves of the Punggul Rock to surrounding primary forests.
Obr. 5, 6. Studované lokality; Batu Punggul. 5 – skála Batu Punggul a galeriový les nad řekou Sapulut. 6 – pohled z jedné z jeskyní skály Batu Punggul na okolní primární prales.

The name *Cynopterus minutus* was most often considered a junior synonym of *C. brachyotis* (Müller, 1838) (Corbet & Hill 1992, Koopman 1993). Hill (1983) and Koopman (1994) considered it a name of subspecies of *C. brachyotis* occurring in the Nias island off the western Sumatra shore. Finally, Kitchener & Mahardatunkamsi (1991) in their comprehensive revision of Indo-Malaysian representatives of the genus *Cynopterus* Cuvier, 1824, proposed a separate species status of *C. minutus*, well distinguishable from other *Cynopterus* species on the basis of its smaller size, and also suggested a broader distribution of this form within the Oriental Region. The separate position of *C. minimus* was accepted by some subsequent authors (e.g., Kofron 1997, 2002, Simmons 2005).

The size relations among the fruit bats of the genus *Cynopterus* collected in Sabah are presented in Figs. 8, 9 and Table 2. Although in external dimensions *C. minutus* overlaps with *C. brachyotis* (Fig. 8) – explaining why this species remained overlooked for a long time – the comparison of skull dimensions (Fig. 9) clearly separated a group of extremely small specimens. These specimens correspond in size with *C. minutus* as defined by Kitchener & Maharadatunkamsi (1991) (Table 2). Among the newly collected specimens of *C. minutus* both adults and subadults were present;

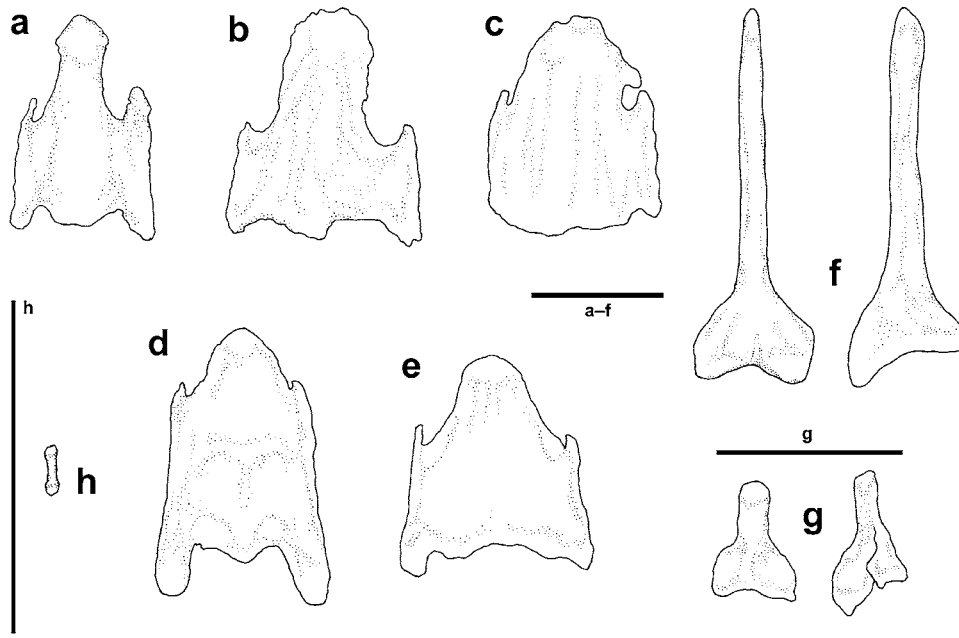

Fig. 7. Bacula preparations of selected bats from Sabah. Scale bars = 1 mm; a–e, h – dorsal views; f, g – ventral (left) and lateral (right) views.
Fig. 7. Preparáty penisových kostí vybraných netopýrů ze Sabahu. Měřítka = 1 mm; a–e, h – dorsalní pohledy; f, g – ventralní (nalevo) a lateralní (napravo) pohledy.
Legend / legenda: a – *Cypterus brachyotis*, Sapulut, NMW 61381; b – *Cypterus brachyotis*, Sapulut, NMW 61391; c – *Cypterus minutus*, Batu Punggul, NMW 61446; d – *Cypterus sphinx*, Sapulut, NMW 61396; e – *Cypterus horsfieldii*, Sapulut, NMW 61368; f – *Rhinolophus borneensis*, Batu Punggul, NMW 61436; g – *Arielulus cuprosus*, Batu Punggul, NMW 61438; h – *Hipposideros dyacorum*, Batu Punggul, NMW 61423.

Table 2. Biometric data on the examined species sets of the genus *Cynopterus*
Tab. 2. Biometrické údaje o vyšetřených souborech kaloňů rodu *Cynopterus*

	n	**M**	min	max	SD	*n*	**M**	min	max	SD
	Cynopterus brachyotis					*Cynopterus minutus*				
LAt	*47*	**58.73**	54.0	62.0	1.794	*4*	**55.69**	54.3	58.1	1.644
LA	*47*	**15.09**	13.4	16.7	0.782	*4*	**14.75**	14.1	15.1	0.473
LCr	*23*	**27.40**	26.42	28.38	0.538	*5*	**26.19**	25.80	26.53	0.337
LCb	*23*	**26.11**	25.23	26.78	0.451	*5*	**24.86**	24.40	25.33	0.417
LaZ	*23*	**18.28**	17.47	19.12	0.420	*5*	**17.65**	16.95	18.25	0.473
LaI	*23*	**5.31**	4.67	6.02	0.308	*5*	**5.29**	4.98	5.52	0.198
LaPo	*23*	**6.00**	5.20	6.66	0.416	*5*	**6.50**	5.82	7.22	0.575
LOn	*23*	**6.09**	5.62	6.47	0.215	*5*	**5.42**	5.32	5.48	0.063
LaN	*23*	**12.09**	11.63	12.83	0.344	*5*	**11.78**	11.42	12.18	0.276
CC	*23*	**6.14**	5.73	6.58	0.220	*5*	**5.90**	5.62	6.17	0.201
MM	*23*	**8.43**	8.05	8.75	0.218	*5*	**8.17**	7.92	8.47	0.233
CMs	*23*	**9.28**	8.78	9.97	0.258	*5*	**8.76**	8.50	8.95	0.189
LMd	*23*	**20.45**	19.83	21.08	0.301	*5*	**19.30**	18.95	19.55	0.239
CMi	*23*	**10.17**	9.76	10.70	0.236	*5*	**9.66**	9.57	9.73	0.061
	Cynopterus horsfieldii					*Cynopterus sphinx*				
LAt	*6*	**67.50**	61.2	71.1	3.528	*3*	**64.07**	63.1	65.3	1.124
LA	*6*	**17.15**	16.1	17.7	0.686	*3*	**17.13**	16.7	17.6	0.451
LCr	*5*	**29.24**	28.82	29.65	0.380	*3*	**29.02**	28.63	29.52	0.456
LCb	*5*	**27.96**	27.62	28.32	0.263	*3*	**27.55**	27.17	27.77	0.333
LaZ	*5*	**19.20**	18.47	20.20	0.656	*3*	**18.26**	17.95	18.65	0.357
LaI	*5*	**5.65**	5.13	5.95	0.320	*3*	**5.84**	5.42	6.25	0.415
LaPo	*5*	**6.16**	5.73	6.58	0.309	*3*	**6.31**	5.77	7.22	0.790
LOn	*5*	**6.62**	6.35	6.78	0.171	*3*	**6.69**	6.38	6.97	0.297
LaN	*5*	**12.75**	12.40	13.32	0.419	*3*	**12.28**	11.75	12.62	0.465
CC	*5*	**6.29**	5.96	6.52	0.250	*3*	**6.17**	6.05	6.35	0.161
MM	*5*	**8.59**	8.22	8.82	0.248	*3*	**8.39**	8.17	8.52	0.192
CMs	*5*	**9.70**	9.37	10.17	0.309	*3*	**9.65**	9.47	9.80	0.166
LMd	*5*	**21.95**	21.37	22.23	0.342	*3*	**21.74**	21.32	21.97	0.362
CMi	*5*	**10.68**	10.38	10.95	0.220	*3*	**10.64**	10.55	10.77	0.115

the subadult individuals had completely ossified intersphenoidal suttures and lacked cartilaginous parts in wing joints (this applies also to the compared specimens of *C. brachyotis*).

Fig. 10 gives a comparison of skull shapes of the Sabahan *C. minutus* and *C. horsfieldii*; note the relatively high and short rostrum in the former species. Baculum of *C. minutus* from Batu Punggul (Fig. 7) is a relatively broad and simple plate without heavy structured lateral margins. However, in *C. minutus* from different islands of the Sunda Archipelago, Kitchener & Maharadatumkamsi (1993) showed rather wide variation in the baculum size and shape, including the triangular shapes with lateral projections typical also for other *Cynopterus* species (Fig. 7).

In our catch of *Cynopterus* bats, those of *C. minutus* represented 7.7%. *C. minutus* seems to be a regular but accessory component of chiropteran communities of all basic terrestrial habitats of Borneo. Kitchener & Maharadatunkamsi (1991) mentioned this species to be found only in the Greater Sunda islands, i.e. Sumatra (incl. Nias Island, the type locality), Borneo, Celebes, and westernmost Java. From Borneo they mentioned this species from seven sites in all parts of

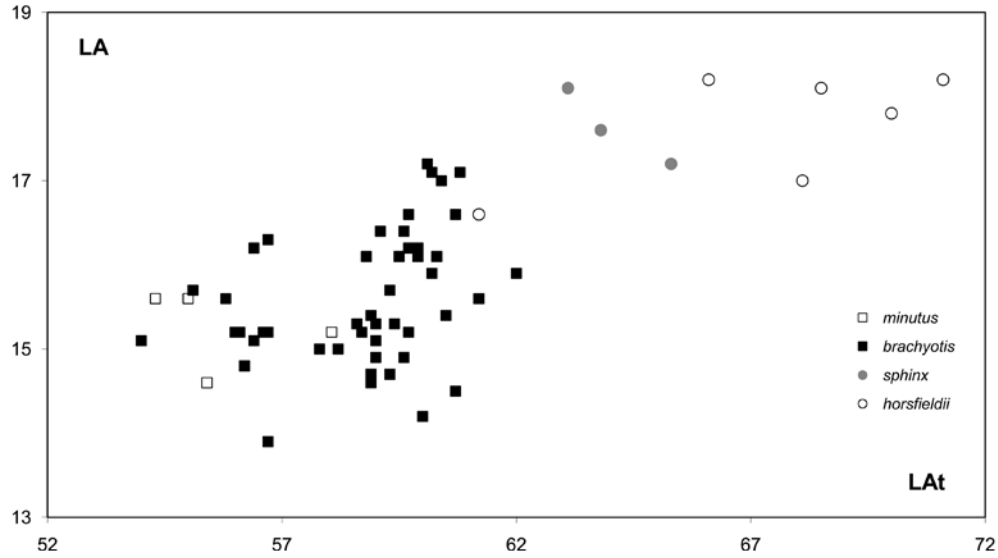

Fig. 8. Bivariate plot of external dimensions of the examined *Cynopterus* individuals (incl. the released bats): forearm length (LAt) against the ear length (LA).
Obr. 8. Graf externích rozměrů vyšetřených jedinců kaloňů rodu *Cynopterus* (včetně vypuštěných kusů): délka předloktí (LAt) oproti délce ucha (LA).

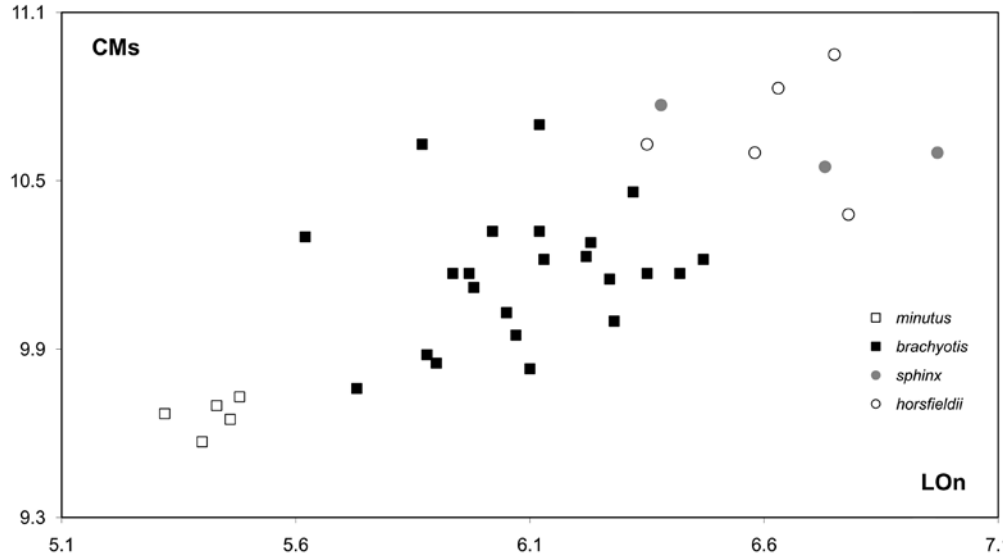

Fig. 9. Bivariate plot of cranial dimensions of the collected *Cynopterus* samples: orbito-nasal length of rostrum (LOn) against the upper tooth-row length (CMs).
Obr. 9. Graf lebečních rozměrů kolektovaných jedinců kaloňů rodu *Cynopterus*: orbitonasální délka rostra (LOn) oproti délce horní zubní řady (CMs).

Kalimantan only. In addition, Kofron (1997) recorded *C. minutus* at two sites in the territory of Brunei. Here mentioned records from three sites represent the first findings of *C. minutus* from Sabah as well as from the whole Malaysian part of Borneo.

Kofron (1997) provided some ecological data on *C. minutus* from Brunei. He netted this species only in the primary rainforest and in adjacent areas, unlike its close relative *C. brachyotis*, which was found in other habitats, including secondary and mangrove forests, gardens etc., but never in the rainforest. Our three record sites of *C. minutus* represent three basic types of Bornean terrestrial habitats: montane, secondary and primary forests, where this bat was always netted together with its congener *C. brachyotis*.

Cynopterus sphinx (Vahl, 1797)

Material. **Sapulut**, 26 April 1999, 1 ♂ ad, 1 ♂ sad (NMW 61394 [S+Sk], 61395 [S+A]); 28 April 1999, 1 ♂ ad (NMW 61396 [S+A]).

Payne & Francis (1998) reported only one record of *Cynopterus sphinx* from Borneo, from the province of Central Kalimantan. Kitchener & Maharadatunkamsi (1991) mentioned a male specimen from [Mount] Kinabalu among the revised museum material. Our records from Sapulut document the second site of this bat in Sabah and the third in Borneo, respectively, and also its relative rarity in the island. The area of Borneo represents the eastern margin of the distribution range of this rather west-Oriental faunal element (Corbet & Hill 1992).

The baculum preparation extracted from one Sabahan specimen of *C. sphinx* (Fig. 7) conforms in shape to that described by Krutzsch (1962), but somewhat differs from the bacula depicted by Martins (1978), Kitchener & Maharadatumkamsi (1993) and Bates & Harrison (1997).

Cynopterus horsfieldii Gray, 1843

Material. **Sapulut**, 23 April 1999, 1 ♂ ad, 1 ♀ ad (NMW 61366, 61367 [S+A]); 27 April 1999, 1 ♂ ad, 1 ♂ sad (NMW 61368, 61369 [S+A]); 28 April 1999, 1 ♀ ad L (NMW 61370 [S+A]).

Released Bats. **Sapulut**, 26 April 1999, 1 ♀ ad L.

Although *Cynopterus horsfieldii* was first reported from Borneo (Sabah) by Kobayashi et al. (1980), already Payne & Francis (1998) considered it to be a common bat in all parts of the island (see also Abdullah et al. 1997b); Suyanto & Struebig (2007) reported ten record sites. In our catch *C. horsfieldii* is present only from one site, however, as the second most numerous representative of the genus *Cynopterus* (11.8% in Sapulut and 9.2% in the whole catch from Borneo).

The preparation of baculum of the Sabahan *C. horsfieldii* (Fig. 7) concurs well in shape with the described bacula originating in other parts of the species distribution range (Krutzsch 1959, Heller & Volleth 1989).

Megaerops ecaudatus (Temminck, 1837)

Material. **Gunung Emas**, 19 April 1999, 1 ♂ sad (NMW 61353 [S+B]). – **Sapulut**, May 1995, 1 ♀ ad (SMO sa07 [S+A]); 28 April 1999, 1 ♀ sad (NMW 61398 [S+A]). – **Batu Punggul**, 2 May 1999, 1 ♂ sad (NMW 61442 [S+A]).

Payne & Francis (1998) mentioned nine sites of occurrence of *Megaerops ecaudatus* from Borneo and four from Sabah (Mt. Kinabalu, Danum, Tawau, Tenom). We recorded this species in all

sampled localities, but one or two individuals per site only. *M. ecaudatus* seems to represent an accessory component of bat communities of all basic terrestrial habitats of the island.

Balionycteris maculata (Thomas, 1893)

Material. **Batu Punggul**, 1 May 1999, 1 ♀ sad (NMW 61437 [S+A]).

Suyanto & Struebig (2007) reported 32 sites of occurrence of *Balionycteris maculata* from Borneo and 14 from Sabah. Most of these sites represent lowland areas affected by human impact (larger settlements). The recorded individual was netted in rather primary habitats at Batu Punggul, in similar conditions as in the relatively close Tabin Wildlife Reserve (Stuebing et al. 1989). This species seems to represent a faunal element occurring in lowlands, without any considerable respect to anthropogenic changes of their environment.

Aethalops aequalis Aellen, 1938

Material. **Gunung Emas**, May 1995, 2 ♂♂ ad, 1 ♀ ad (SMO sa05, sa06, sa12 [S+B]); 19 April 1999, 2 ♂♂ juv, 1 ♀ ad (NMW 61354–61356 [S+A]); 20 April 1999, 1 ♀ juv (NMW 61357 [S+A]); 22 April 1999, 1 ♂ juv (NMW 61358 [S+A]).

Hill (1983) and Payne & Francis (1998) considered this species confined to montane forests of Borneo at the altitudes of above 500 m a. s. l. (up to 2700 m on Mt. Kinabalu). All Bornean records are known from the main mountain range in the northwestern part of the island; Payne & Francis (1998) reviewed two record sites from Sarawak and two from Sabah (the type locality Mt. Kinabalu and the Crocker Range). Kitchener et al. (1993) added a record from Rinangisan and Kofron (2002) records from Brunei. Our records also come from this range only, which conforms to the above characteristic – at Gunung Emas (1800 m a. s. l.) individuals of this species represented more than a half of netted bats. In April 1999, four bats of the five netted were juveniles with cartilaginous parts in wing joints, however, their forearm size was similar to that of adults (see Appendix 2).

Although Payne & Francis (1998) and precedent modern authors (e.g. Hill 1983, Boeadi & Hill 1986, Koopman 1989, 1993, 1994, Corbet & Hill 1992) considered the Bornean populations of this species to represent a subspecies of *A. alecto* (Thomas, 1923) (a species occurring in Malaya and the Sundas from Sumatra to Lombok), here we follow the taxonomic opinion by Kitchener et al. (1993). It implies that *A. aequalis* is endemic to the mountains of northwestern Borneo (see also Simmons 2005).

Macroglossus minimus (Geoffroy, 1810)

Material. **Gunung Emas**, 22 April 1999, 1 ♀ sad (NMW 61359 [S+A]). – **Sapulut**, May 1995, 1 ♂ ad (SMO sa04 [S]); 25 April 1999, 1 ♀ sad (NMW 61397 [S+A]). – **Batu Punggul**, 2 May 1999, 1 ♀ sad (NMW 61440 [S+A]); 4 May 1999, 1 ♀ sad (NMW 61441 [S+A]).

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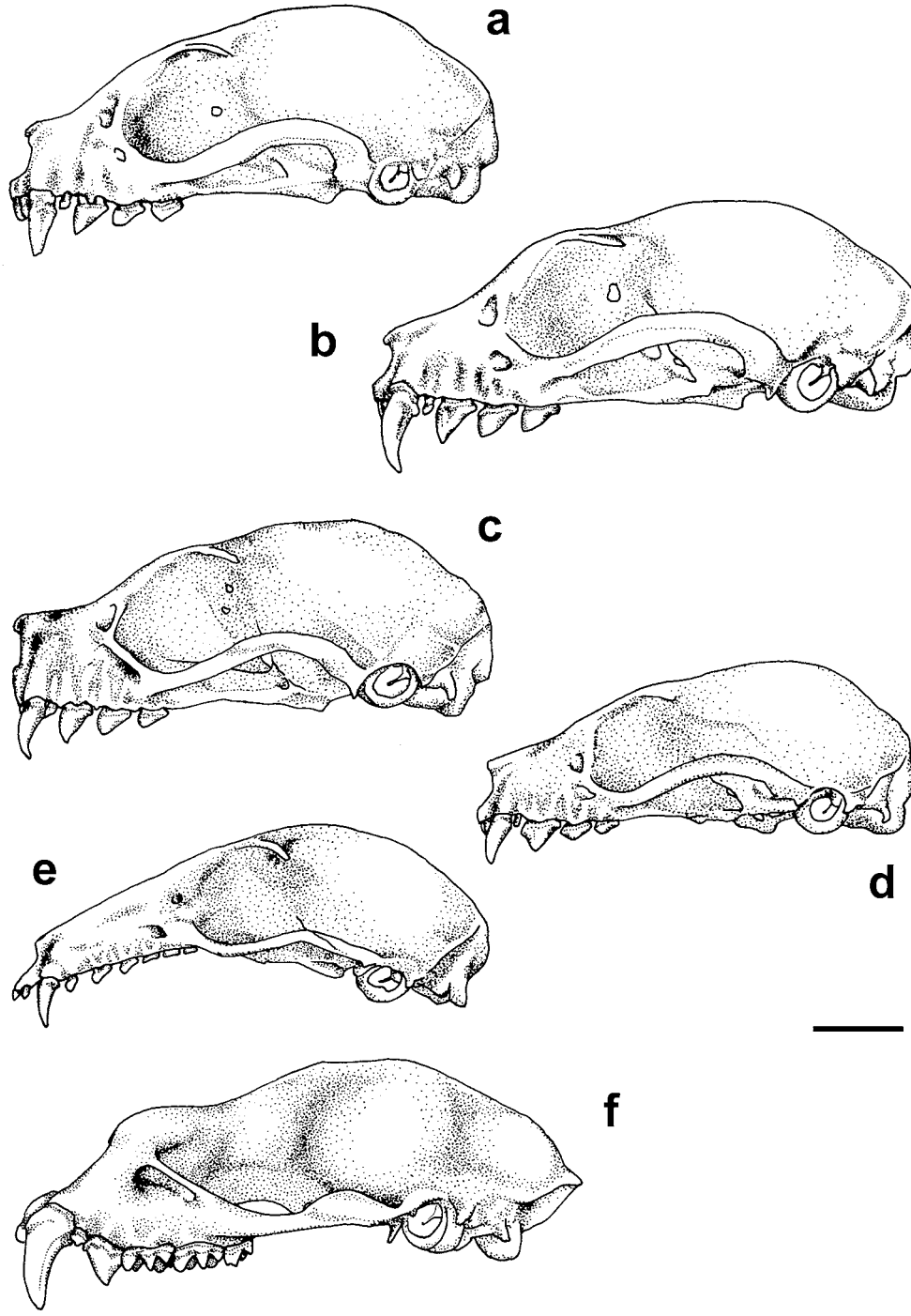
Fig. 10. Skulls of bats from Sabah; larger forms. Scale bar = 5 mm.
Obr. 10. Lebky netopýrů ze Sabahu; větší formy. Měřítko = 5 mm.
Legend / legenda: a – *Cynopterus minutus* (♂ NMW 61446); b – *Cynopterus horsfieldii* (♂ NMW 61368); c – *Megaerops ecaudatus* (♂ NMW 61442); d – *Aethalops aequalis* (♀ NMW 61355); e – *Macroglossus minimus* (♀ NMW 61359); f – *Hipposideros diadema* (♂ SMO sa03).


a
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f

Payne & Francis (1998) mentioned 12 sites of occurrence of *Macroglossus minimus* in Borneo and five from Sabah (Kota Kinabalu, Witti Range, Sepilok, Sukau, Tawau); Stuebing et al. (1989) added a record from the Tabin Wildlife Reserve and Nor (1996) recorded this species in three offshore islands at the northern tip of Borneo. In our catch this bat was present at all sampled sites, however, one or two individuals per site only.

Abdullah & Hall (1997) recorded *M. minimus* to be an important part of the bat community of forests at Mt. Kinabalu (559 m a. s. l.). In the nettings made in plantations at Pontianak, Kalimantan, this bat species made up 3.4% of all netted bats (Abdullah et al. 1997b). *M. minutus* seems to represent a regular accessory component of bat communities of all basic terrestrial habitats in the island. Similar results from nettings in various environments were obtained also in Malaya by Zubaid (1993) and in the Philippines by Mudar & Allen (1986) and Rickart et al. (1993).

Payne & Francis (1998) suggested the altitudinal limits of distribution of this bat in Borneo from the sea level (mangrove forests) up to 1000 m a. s. l. The known upper limit of occurrence in Borneo was significantly shifted by the presented record from Gunung Emas to the altitude of ca. 1800 m, however, Heaney et al. (1998) mentioned the upper limit of even 2250 m in the Philippines.

Rhinolophidae

Rhinolophus borneensis Peters, 1861

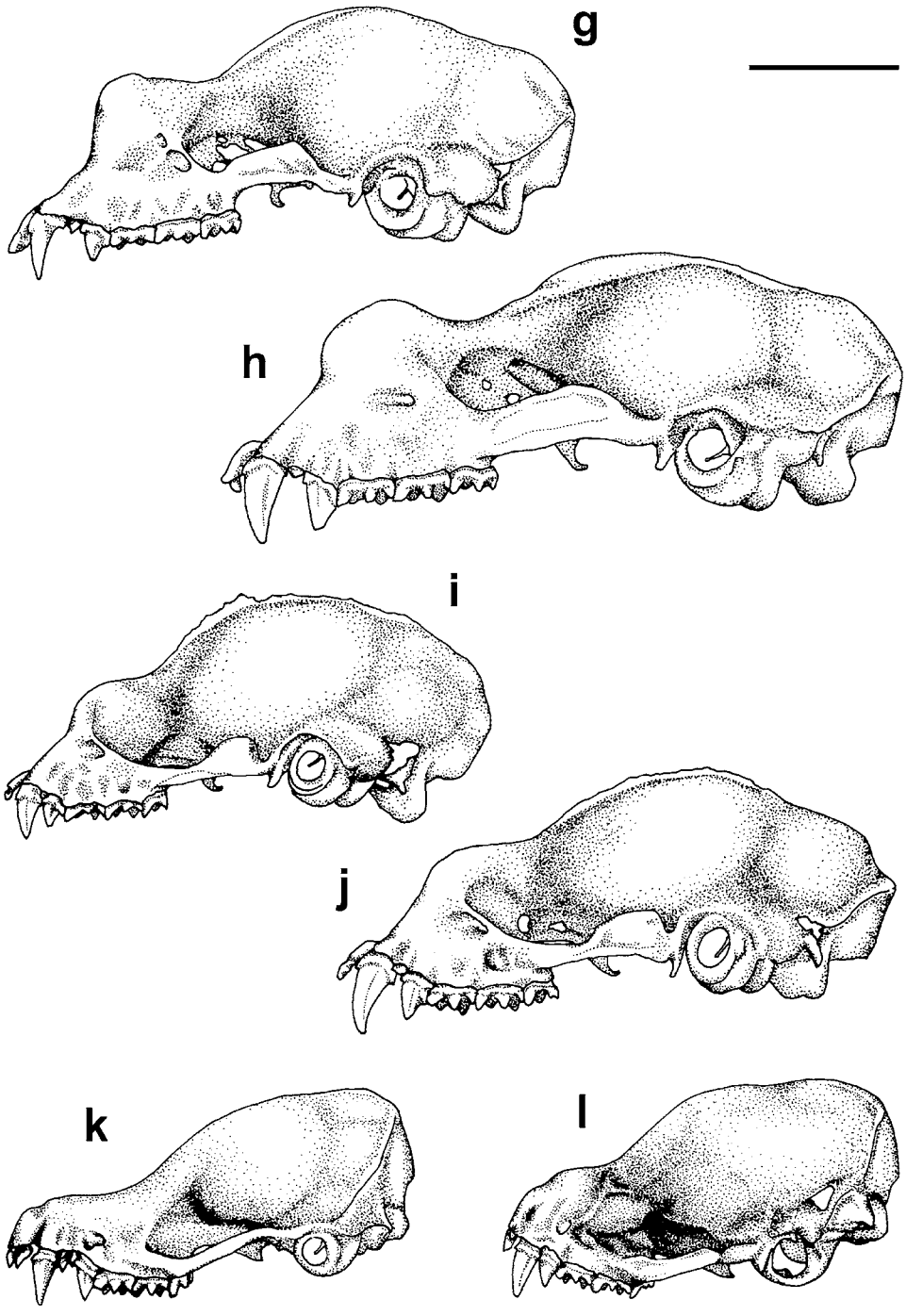
Material. **Sapulut**, 23 April 1999, 1 ♀ ad G (NMW 61365 [S+A]). – **Batu Punggul**, 3 May 1999, 1 ♀ ad L, 4 ♀♀ ad G, 1 ♀ sad (NMW 61430–61435 [S+A]; Figs. 11, 12); 4 May 1999, 1 ♂ sad (NMW 61436 [S+A]).

According to Payne & Francis (1998) and Suyanto & Struebig (2007), *Rhinolophus borneensis* is a common species in Borneo, while in other parts of the Oriental Region it is found only rarely (cf. Zubaid 1994b, Nor 1996, Borissenko & Kruskop 2003). It was previously reported from four sites in Sabah, including Sapulut (Payne & Francis 1998). Its presence at the latter site was also confirmed by our netting of a pregnant female (crown-rump length of the foetus 24.4 mm). A cave colony of ca. 100 individuals was found in the Tinahas cave; it is a small karstic spring localised at the eastern edge of the limestone outcrop of Batu Punggul. Among six bats sampled in this cave in early May, four were pregnant females and one was a lactating female.

Most probably, the baculum of *R. borneensis* is described here for the first time (cf. Csorba et al. 2003: xxxi). Its morphology is similar to those of other horseshoe bats, the bone is composed of two parts, a basal cone and a distal shaft (Fig. 7). The whole baculum is 2.92 mm long, its basal cone is horizontally 0.95 mm wide and dorso-ventrally 0.92 mm wide. It is rather heavily built, with massive and broad basal cone and relatively short and laterally flattened distal shaft. The distal tip of the shaft bears a small dorsal widening.

→

Fig. 10 (continued). Skulls of bats from Sabah; smaller forms. Scale bar = 5 mm.
Obr. 10 (pokračování). Lebky netopýrů ze Sabahu; menší formy. Měřítko = 5 mm.
Legend / legenda: g – *Rhinolophus borneensis* (♀ NMW 61433); h – *Rhinolophus trifoliatus* (♂ NMW 61429); i – *Hipposideros dyacorum* (♂ NMW 61426); j – *Hipposideros cervinus* (♂ NMW 61428); k – *Myotis muricola* (♀ SMO sa10); l – *Arielulus cuprosus* (♀ NMW 61439).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Figs. 11, 12. Bornean horseshoe bat (*Rhinolophus borneensis*); frontal and lateral views on the head and noseleaf.
Obr. 11, 12. Vrápenec bornejský (*Rhinolophus borneensis*); frontální a laterální pohled na hlavu a nosní lístek.

Rhinolophus trifoliatus Temminck, 1834

Material. **Batu Punggul**, 3 May 1999, 1 ♂ ad (NMW 61429 [S+A]; Figs. 13–15).

Payne & Francis (1998) reported *Rhinolophus trifoliatus* to be known from most of the area of Borneo, it was most frequently caught in the understorey of primary lowland forests. Nor (1996) found this species in mangrove forests of the Malawali island at the northern tip of Borneo. Circumstances of our record conform to the habitat requirements mentioned by Payne & Francis (1998), a single individual was netted in the understorey of primary forest at Batu Punggul. Similar results were mentioned also by Abdullah & Hall (1997).

Figs. 13–15. Trefoil horseshoe bat (*Rhinolophus trifoliatus*); frontal, semilateral and lateral views on the noseleaf.
Obr. 13–15. Vrápenec trojlistý (*Rhinolophus trifoliatus*); frontální, semilaterální a laterální pohled na nosní lístek.

Hipposideridae

Hipposideros doriae (Peters, 1871)

Material. **Gunung Emas**, 20 April 1999, 1 ♂ ad (NMW 61352 [S+A]).

Hipposideros doriae has been known from an unlocalised record of several individuals in Sarawak presented by Marquis Giacomo Doria; on the basis of one of these bats the species was described by Peters (1871), see also Hill (1963), and Corbet & Hill (1992). However, Payne & Francis (1998) did not mention this species among the Bornean mammals. Here presented record is the first finding of the species in Sabah as well as the first record from Borneo after the description (Benda 2000, cf. Peters 1871).

Based on a revision of the available material, Benda (2000) proposed conspecific relationship of *H. doriae* and *H. sabanus* Thomas, 1898, described from Lawas, northern Sarawak (Thomas 1898). However, such arrangement was suggested already by Hill (1963) and Corbet & Hill (1992), who however tentatively accepted separate status of *H. sabanus*. Anyway, *H. doriae* (incl. *H. sabanus*) remains known from three records from Borneo, besides some isolated findings from northern Sumatra and Malaya (for details see Benda 2000). Some ecological data and more external dimensions concerning the collected specimen were noted by Benda (2000).

As noted by Turni & Kock (2008), Benda (2000) erroneously identified the pair of specimens (male and female, ZMB 4007/1 and 4007/2) deposited in ZMB as syntypes and designated these individuals as lectotype and paralectotype, although Peters (1971) clearly described a sole male specimen (ZMB 4007) as a basis for his description. Therefore, this latter bat represents the holotype of *Phylorhina doriae* (= *Hipposideros doriae*) by monotypy and the type series is composed of this holotype only, with no paratypes existing (cf. Turni & Kock 2008). According to Rode (1941), another specimen from the Doria collection, supposed to be a paratype, is deposited in MNHN. The author examined two other alcohol specimens labelled as cotypes of *Phylorhina doriae* in MSNG, from where originated also the specimen mentioned by Rode (1941). However, designation of all these 'paratypes' or 'cotypes' was unsubstantial and in variance with the description by Peters (1871). A question why the respective additional specimens in the Berlin, Paris and Genoa collections were labelled as types remains open. Anyway, according to the labelling, all these specimens were collected by Marquis Doria from one site or region and are all labelled to originate in Sarawak. The presented specimen thus actually represents the first record of the species after its description and the first one in Sabah, as noted above and by Benda (2000). The second record of this bat from Borneo (under *H. sabanus*) was published by Kofron (2002) from Brunei.

Hipposideros dyacorum Thomas, 1902

Material. **Batu Punggul**, 2 May 1999, 4 ♂♂ ad, 1 ♀ sad (NMW 61423–61427 [S+A]; Fig. 16).

According to Suyanto & Struebig (2007), *Hipposideros dyacorum* is known from Borneo from six localities throughout Sabah and from eight sites out of Sabah; it was recorded also in the Sabahan offshore island of Balambangan (Nor 1996) and in Bruinei (Kofron 2002). Our record was made in the main cave of the Punggul Rock, where five specimens were hand-netted from a roosting colony of ca. 100 individuals.

The baculum of *H. dyacorum* is an extremely small bone, a simple stick 0.14 mm long with slight widenings on both tips (Fig. 7).

Hipposideros cervinus (Gould, 1863)

Material. **Sapulut**, May 1995, 1 ♂ ad, 1 ♀ ad (SMO sa08, sa09 [S+A]). – **Batu Punggul**, 3 May 1999, 1 ♂ sad (NMW 61428 [S+A]; Fig. 17).

Payne & Francis (1998) reported *Hipposideros cervinus* to be found in all cave systems investigated in Sabah and Sarawak; it was also found in two offshore islands of Sabah (Nor 1996) as well as at 14 sites in Kalimantan (Suyanto & Struebig 2007, see also Jenkins & Hill 1981) and one in Brunei (Kofron 2002). We visited only one underground system in Sabah, the limestone outcrop of Batu Punggul. However, no larger colony of this bat was found there, all the recorded bats were netted in primary and secondary forests.

Hipposideros diadema (Geoffroy, 1813)

Material. **Sapulut**, May 1995, 1 ♂ ad (SMO sa03 [S]). – **Batu Punggul**, 30 April 1999, 1 ♂ ad, 4 ♀♀ ad L, 1 ♀ sad (NMW 61413–61418 [S+A]); 1 May 1999, 2 ♀♀ ad L (NMW 61419 [S+A], 61420 [S]); 3 May 1999, 1 ♀ sad (NMW 61421 [S]); 5 May 1999, 1 ♀ ad (NMW 61422 [S+A]; Fig. 18).

According to Payne & Francis (1998), *Hipposideros diadema* is a common bat species in Sabah and Sarawak, reported also from Brunei and from three sites in Kalimantan (seven by Suyanto & Struebig 2007); it was recorded also in offshore islands of Borneo (Tomes 1859, Nor 1996). We found it at two sites only, however, at Batu Punggul it was a dominant microbat species among the evidenced bats (38.5% of individuals). In the cave system at the latter site no nursery colony of this cave-dwelling bat was discovered, although the possible presence of a colony was indicated by prevalence of lactating females among the individuals netted (in April 1999, six lactating females and four other bats were netted in a forest understorey at Batu Punggul).

Figs. 16–18. Leaf-nosed bats (*Hipposideros* spp.) from Borneo, frontal views on the noseleafs. 16 – Dayak leaf-nosed bat (*Hipposideros dyacorum*). 17 – Fawn-coloured leaf-nosed bat (*Hipposideros cervinus*). 18 – Diadem leaf-nosed bat (*Hipposideros diadema*).
Figs. 16–18. Pavrápenci (*Hipposideros* spp.) z Bornea, frontální pohledy na nosní lístky. 16 – pavrápenec dajácký (*Hipposideros dyacorum*). 17 – pavrápenec jelení (*H. cervinus*). 18 – pavrápenec diadémový (*H. diadema*).

V e s p e r t i l i o n i d a e

Myotis muricola (Gray, 1846)

Material. **Sapulut**, May 1995, 1 ♀ ad (SMO sa10 [S]).

Other Bornean material examined. Borneo, Sabah, Tabin Wildlife Reserve, 30 June 1995, 1 ♀ ad (SMF 83724 [S]), leg. C. M. Francis. – Borneo, caves at Long Lahr, Barahr, 1 ♂ ad (BMNH 51.161e [S]), date and collector unlisted. – Borneo, Selimbau, date unlisted, 1 ♀ ad (BMNH 23.1.2.17. [S+A]) leg. N. A. Lorentz.

According to Payne & Francis (1998), Francis & Hill (1998) and Suyanto & Struebig (2007), *Myotis muricola* represents a common bat species in the whole island. This statement was confirmed also by other authors (e.g. Abdullah et al. 1997, Kofron 2002). Surprisingly, in our collection of almost a hundred bats only one specimen of *M. muricola* is present.

The Bornean samples of *M. muricola* were compared with conspecific samples (*sensu* Simmons 2005) coming from the continental Asian distribution range and from Sumatra (Tables 3, 4) and this comparison suggested a peculiar position of the Bornean populations. The Bornean samples were shown to be larger in skull size than the bats from NE India, Indochina and Sumatra and substantially larger than the bats from NW India. The small NW Indian form is traditionally assigned to the subspecies *M. muricola caliginosus* (Tomes, 1859) (Hill 1983, Koopman 1994, Bates & Harrison 1997, Simmons 2005). Since the Bornean and NW Indian bats differed in size

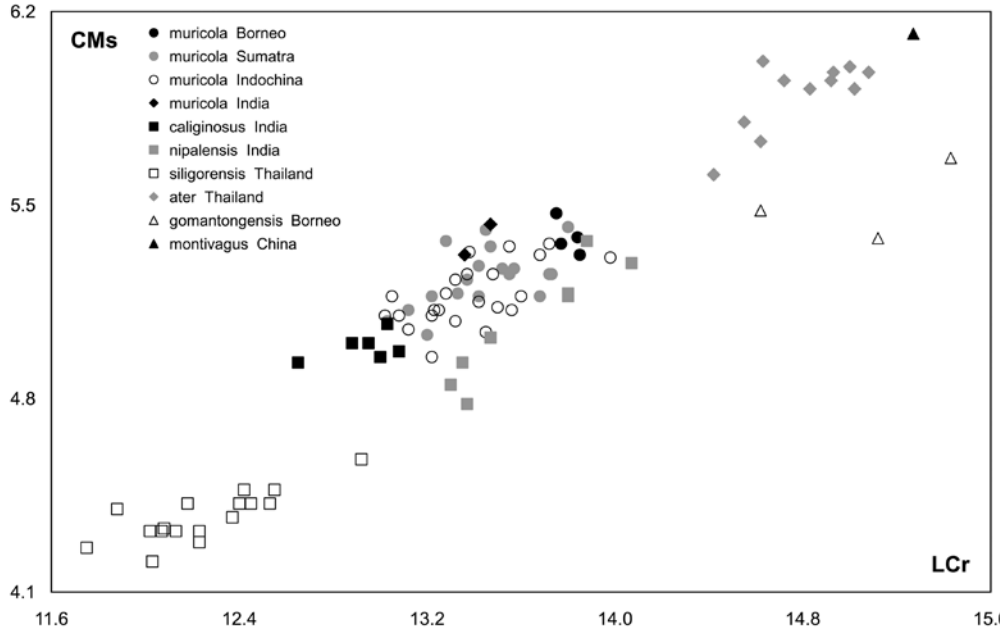


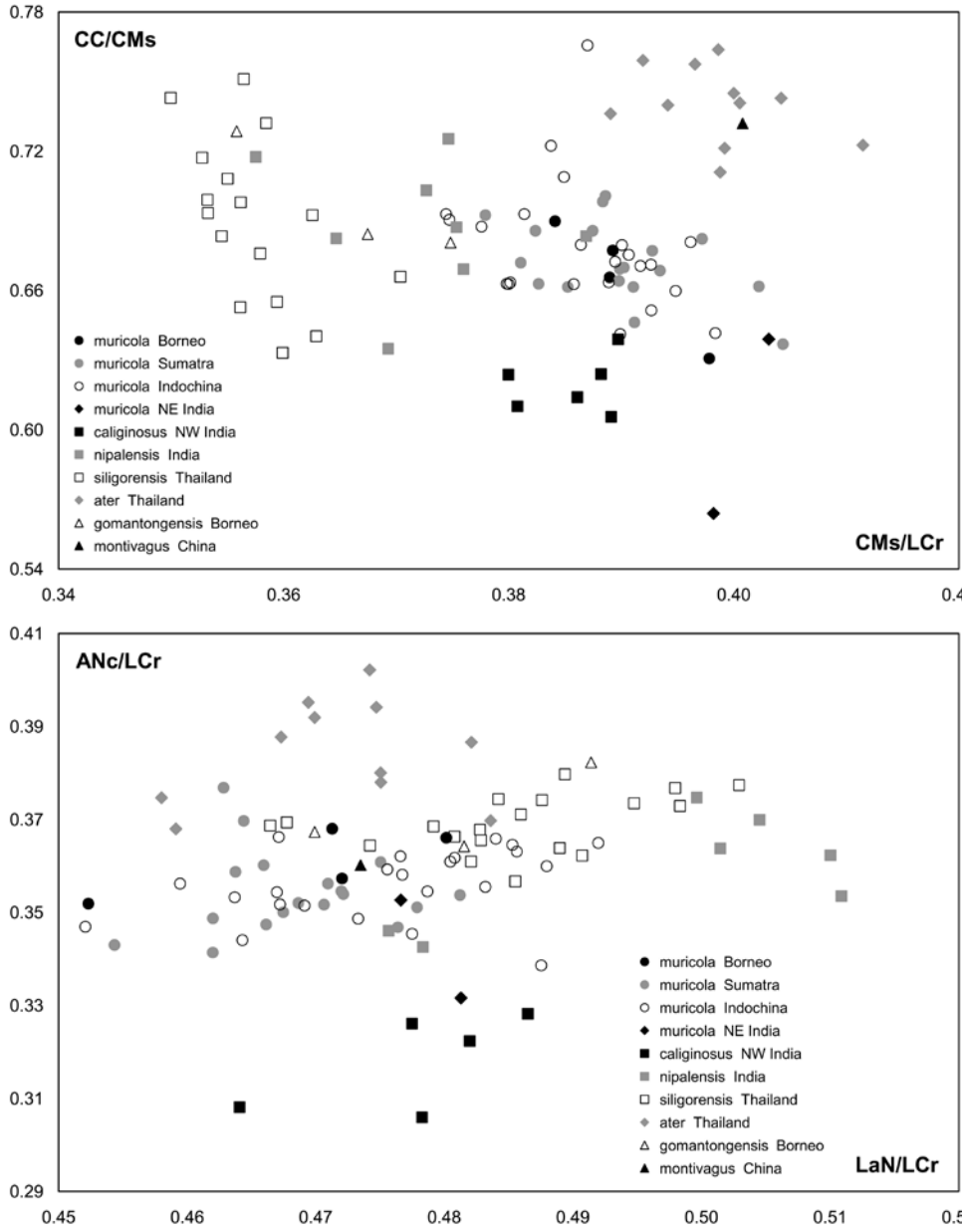
Fig. 19. Bivariate plot of cranial dimensions of the examined *Myotis* populations (*mystacinus/muricola* complex) from South Asia): greatest length od skull (LCr) against the upper tooth-row length (CMs).
Obr. 19. Graf lebečních rozměrů srovnávaných populací rodu *Myotis* komplexu *mystacinus/muricola* z jižní Asie: největší délka lebky (LCr) oproti délce horní zubní řady (CMs).

Table 3. Biometric data on the comparation sets of *Myotis muricola* (except for *caliginosus*)
Tab. 3. Biometrické údaje o srovnávaných souborech netopýrů nepálských (*Myotis muricola*), kromě formy *caliginosus*

	n	**M**	min	max	SD	*n*	**M**	min	max	SD	*n*	**M**	min	max	SD
	Nepal					Thailand					Cambodia & Vietnam				
LAt	*0*	–	–	–	–	*11*	**35.32**	33.6	37.1	1.064	*4*	**35.60**	35.0	36.0	0.432
LCr	*2*	**13.42**	13.36	13.47	0.078	*12*	**13.36**	13.08	13.72	0.207	*4*	**13.59**	13.28	13.98	0.292
LCb	*2*	**12.91**	12.85	12.97	0.085	*12*	**12.83**	12.45	13.25	0.223	*5*	**12.96**	12.73	13.33	0.234
LaZ	*1*	**7.92**	–	–	–	*10*	**8.74**	8.42	8.93	0.156	*3*	**8.68**	8.55	8.87	0.167
LaI	*2*	**3.37**	3.33	3.40	0.049	*12*	**3.19**	2.98	3.42	0.125	*5*	**3.21**	3.10	3.33	0.109
LaInf	*2*	**3.32**	3.16	3.48	0.226	*12*	**3.62**	3.48	3.86	0.137	*5*	**3.51**	3.38	3.67	0.118
LaN	*2*	**6.43**	6.42	6.43	0.007	*12*	**6.32**	6.13	6.45	0.094	*5*	**6.36**	6.19	6.48	0.111
ANc	*2*	**4.59**	4.43	4.75	0.226	*11*	**4.72**	4.48	4.83	0.096	*5*	**4.77**	4.58	4.85	0.111
ACr	*0*	–	–	–	–	*11*	**5.87**	5.65	6.05	0.141	*4*	**5.88**	5.71	6.03	0.145
CC	*2*	**3.24**	3.00	3.47	0.332	*12*	**3.54**	3.27	3.92	0.168	*5*	**3.46**	3.40	3.52	0.058
MM	*2*	**5.39**	5.15	5.63	0.339	*12*	**5.61**	5.32	5.86	0.160	*5*	**5.49**	5.28	5.62	0.143
CMs	*2*	**5.38**	5.32	5.43	0.078	*12*	**5.15**	4.95	5.36	0.117	*5*	**5.19**	5.13	5.31	0.071
LMd	*2*	**9.93**	9.88	9.98	0.071	*11*	**10.00**	9.68	10.28	0.186	*5*	**10.04**	9.88	10.45	0.238
ACo	*2*	**2.84**	2.73	2.94	0.148	*11*	**2.95**	2.82	3.18	0.111	*5*	**2.81**	2.64	2.91	0.101
CMi	*2*	**5.74**	5.73	5.75	0.014	*11*	**5.55**	5.39	5.76	0.138	*5*	**5.55**	5.43	5.77	0.131
	Sumatra					Malaya					Borneo				
LAt	*16*	**34.24**	31.7	36.0	1.070	*9*	**35.27**	34.4	37.2	0.900	*0*	–	–	–	–
LCr	*18*	**13.44**	13.03	13.80	0.218	*8*	**13.28**	13.02	13.55	0.213	*4*	**13.80**	13.75	13.85	0.050
LCb	*18*	**12.81**	12.47	13.27	0.236	*8*	**12.74**	12.55	13.08	0.185	*4*	**13.30**	13.22	13.37	0.065
LaZ	*18*	**8.64**	8.32	8.88	0.167	*7*	**8.70**	8.40	8.83	0.151	*4*	**8.82**	8.68	9.08	0.187
LaI	*20*	**3.21**	2.93	3.43	0.133	*9*	**3.25**	3.07	3.37	0.099	*4*	**3.20**	3.07	3.32	0.117
LaInf	*20*	**3.52**	3.23	3.67	0.124	*9*	**3.52**	3.23	3.67	0.129	*4*	**3.67**	3.61	3.78	0.078
LaN	*19*	**6.29**	6.12	6.53	0.107	*8*	**6.36**	6.25	6.47	0.089	*4*	**6.47**	6.26	6.65	0.161
ANc	*19*	**4.75**	4.55	5.17	0.146	*8*	**4.77**	4.68	4.90	0.085	*4*	**4.98**	4.87	5.07	0.100
ACr	*17*	**5.84**	5.50	6.12	0.170	*7*	**5.82**	5.72	5.92	0.077	*3*	**6.08**	5.88	6.32	0.224
CC	*20*	**3.49**	2.87	3.68	0.177	*7*	**3.48**	3.42	3.53	0.048	*4*	**3.58**	3.45	3.67	0.096
MM	*20*	**5.54**	5.05	5.78	0.162	*8*	**5.63**	5.58	5.72	0.056	*4*	**5.65**	5.32	5.86	0.231
CMs	*20*	**5.22**	4.88	5.42	0.129	*8*	**5.19**	5.04	5.35	0.110	*4*	**5.38**	5.32	5.47	0.063
LMd	*20*	**9.95**	9.05	10.43	0.288	*9*	**9.92**	9.32	10.07	0.230	*4*	**10.42**	10.37	10.51	0.064
ACo	*20*	**2.82**	2.45	3.12	0.163	*9*	**2.95**	2.88	3.05	0.056	*4*	**2.96**	2.87	3.07	0.086
CMi	*20*	**5.55**	5.17	5.72	0.127	*9*	**5.52**	5.40	5.62	0.093	*3*	**5.87**	5.83	5.90	0.036

in a similar way from the NE Indian, Indochinese and Sumatran bats (see Fig. 19), the Bornean populations of *M. muricola* might also represent a separate subspecies as the NW Indian form is considered.

Therefore, to describe mutual position of particular *M. muricola* populations and also their relations to other species of the genus *Myotis*, the samples of *M. muricola* were further compared with samples of species of the *mystacinus/muricola* complex from the Oriental Region (see Corbet & Hill 1992, Koopman 1994, Francis & Hill 1998, Bates et al. 1999, Hendrichsen et al. 2001, Borissenko & Kruskop 2003 for the content of the complex); viz. *M. nipalensis* (Dobson, 1871), *M. siligorensis* (Horsfield, 1855), *M. ater* (Peters, 1866), *M. gomantongensis* Francis et Hill, 1998, and *M. montivagus* (Dobson, 1874) (Table 4). Although the comparative material available for the comparison was rather limited (see Appendix 1), the comparison clearly grouped



Figs. 20, 21. Bivariate plots of cranial dimensions of the examined *Myotis* populations (*mystacinus/muricola* complex) from South Asia). 20 – relative length of rostrum (CMs/LCr) against relative width of rostrum over the upper canines (CC/CMs). 21 – relative width of braincase (LaN/LCr) against relative height of braincase (ANc/LCr).
Obr. 20, 21. Grafy lebečních rozměrů srovnávaných populací rodu *Myotis* komplexu *mystacinus/muricola* z jižní Asie. 20 – relativní délka rostra (CMs/LCr) oproti relativní šířce rostra přes horní špičáky (CC/CMs). 21 – relativní šířka mozkovny (LaN/LCr) oproti relativní výšce mozkovny (ANc/LCr).

Table 4. Biometric data on the comparation sets of the genus *Myotis* of the *mystacinus/muricola* complex
Tab. 4. Biometrické údaje o srovnávaných souborech netopýrů rodu *Myotis* komplexu *mystacinus/muricola*

	n	**M**	min	max	SD	*n*	**M**	min	max	SD	*n*	**M**	min	max	SD
	M. caliginosus, India					*M. gomantongensis*, Borneo					*M. nipalensis*, India				
LAt	*0*	–	–	–	–	*3*	**42.20**	41.7	43.1	0.781	1	**37.20**	–	–	–
LCr	*6*	**12.93**	12.65	13.08	0.154	*3*	**15.06**	14.62	15.43	0.409	8	**13.63**	13.30	14.07	0.291
LCb	*6*	**12.39**	12.24	12.60	0.136	*3*	**14.21**	13.97	14.50	0.268	7	**12.93**	12.34	13.45	0.362
LaZ	*3*	**7.97**	7.65	8.20	0.287	*2*	**9.95**	9.78	10.12	0.240	0	–	–	–	–
LaI	*7*	**3.22**	2.92	3.45	0.199	*3*	**3.68**	3.53	3.83	0.150	8	**3.46**	3.25	3.73	0.165
LaInf	*7*	**3.10**	2.73	3.25	0.172	*3*	**4.40**	4.37	4.47	0.058	8	**3.67**	3.30	4.03	0.246
LaN	*6*	**6.20**	6.05	6.37	0.132	*3*	**7.24**	6.87	7.43	0.323	8	**6.76**	6.35	7.05	0.207
ANc	*6*	**4.12**	3.87	4.25	0.144	*3*	**5.59**	5.37	5.78	0.207	8	**4.88**	4.62	5.02	0.125
ACr	*4*	**5.09**	4.90	5.20	0.129	*3*	**6.91**	6.65	7.12	0.240	5	**6.02**	5.75	6.23	0.181
CC	*7*	**3.02**	2.58	3.15	0.197	*3*	**3.84**	3.73	3.92	0.100	8	**3.49**	3.13	3.75	0.198
MM	*6*	**5.08**	4.45	5.28	0.312	*3*	**6.43**	6.35	6.57	0.122	7	**5.57**	5.35	5.84	0.162
CMs	*7*	**4.96**	4.77	5.07	0.093	*3*	**5.51**	5.38	5.67	0.147	8	**5.07**	4.78	5.37	0.212
LMd	*6*	**9.35**	8.77	9.58	0.295	*3*	**10.94**	10.83	11.02	0.098	8	**9.80**	9.25	10.18	0.330
ACo	*6*	**2.59**	2.21	2.77	0.207	*3*	**3.31**	3.28	3.32	0.023	8	**2.83**	2.50	3.00	0.163
CMi	*6*	**5.33**	5.10	5.54	0.142	*3*	**5.97**	5.80	6.12	0.162	8	**5.40**	5.00	5.80	0.278
	M. siligorensis, Thailand					*M. ater*, Thailand					*M. montivagus*, China, type				
LAt	*19*	**31.72**	30.0	33.2	0.872	*11*	**38.98**	37.3	40.9	0.896			–		
LCr	*19*	**12.24**	11.75	12.92	0.273	*12*	**14.83**	14.42	15.27	0.249			15.27		
LCb	*18*	**11.35**	10.92	11.88	0.273	*12*	**14.33**	13.95	14.60	0.204			14.57		
LaZ	*10*	**6.99**	6.70	7.25	0.172	*9*	**10.31**	10.12	10.57	0.155			–		
LaI	*20*	**2.80**	2.62	2.97	0.085	*12*	**3.50**	3.37	3.73	0.124			3.73		
LaInf	*20*	**3.14**	2.83	3.48	0.143	*12*	**4.12**	3.96	4.30	0.127			4.30		
LaN	*19*	**5.94**	5.63	6.34	0.176	*12*	**7.00**	6.83	7.27	0.167			7.23		
ANc	*19*	**4.52**	4.33	4.68	0.093	*12*	**5.67**	5.48	5.92	0.168			5.50		
ACr	*17*	**5.64**	5.47	5.93	0.121	*8*	**6.97**	6.73	7.20	0.147			6.73		
CC	*18*	**3.02**	2.82	3.32	0.157	*12*	**4.37**	4.13	4.53	0.115			4.48		
MM	*20*	**4.59**	4.32	5.03	0.192	*12*	**6.51**	6.28	6.61	0.102			6.50		
CMs	*19*	**4.39**	4.21	4.74	0.121	*12*	**5.92**	5.61	6.12	0.139			6.12		
LMd	*19*	**8.48**	8.12	8.97	0.228	*12*	**11.37**	10.93	11.78	0.222			11.78		
ACo	*20*	**2.04**	1.90	2.21	0.083	*12*	**3.56**	3.41	3.85	0.123			3.85		
CMi	*20*	**4.68**	4.38	5.15	0.168	*12*	**6.36**	6.15	6.48	0.108			6.48		

the samples into several clusters according to their skull size and skull morphotypes, see Table 5 and Figs. 20–22.

In the comparison of skull dimensions and ratios representing the skull shape, the Bornean samples were shown to pose a very similar morphotype to Indochinese and Sumatran samples of *M. muricola*, while the Indian samples (*caliginosus*) were the most distinct within the species range. The Bornean, Sumatran and Indochinese samples of *M. muricola* were similar to each other in their skull shape and differed only slightly in their size. However, they were substantially distinct from the NW Indian samples in the relative width of rostrum and relative height of braincase, being significantly larger in both dimensions, and in the relative width of braincase, being smaller. The NW Indian samples thus represent a skull morphotype, completely dissimilar from the morphotypes of *M. muricola* occurring in NE India and SE Asia and the morphotypes of all other compared species (*M. nipalensis*, *M. siligorensis*, *M. ater*, *M. gomantongensis*, *M. monti-*

vagus). Thus, the NW Indian population assigned to *M. muricola* can hardly represent a species identical with any of them and is here tentatively considered a separate species, *M. caliginosus* (Tomes, 1859). Although the NE Indian population of *M. muricola* (which should be considered nominotypical, as its sample set consists also of the type of *M. muricola*) differed from SE Asian samples in some points, it conforms to them well in skull size and braincase shape.

The comparison of skull ratios also uncovered two distinct morphotypes in *M. nipalensis*, suggesting presence of more than only one taxon within the Indian range of this form (although the compared samples were very limited to be able to make any resolute statement). On the other hand, *M. montivagus* was shown to be very similar in its skull size and shape to *M. ater* from Thailand, and may thus represent a closely positioned taxon (however, more abundant sampling and profound analysis is needed to sort out such a notion, see also Hill & Francis 1984). Nevertheless, the samples of *M. ater* differed substantially in skull size and shape from those of *M. muricola* s.l., and these forms cannot be considered conspecifics (cf. Hill 1983, Hill & Francis 1984, Corbet & Hill 1992, Bates & Harrison 1997, Francis & Hill 1998, etc.; contra Koopman & Gordon 1992 and Koopman 1994). Similarly, the samples of *M. nipalensis* (formerly a part of *M. mystacinus* (Kuhl, 1817), see Benda & Tsytsulina 2000 and Simmons 2005) differed in skull shape from those of *M. muricola* s.l. and these forms cannot be considered conspecifics (cf. Hill 1983, Heller & Volleth 1989, Corbet & Hill 1992, Bates & Harrison 1997; contra Medway 1978 and many precedent authors).

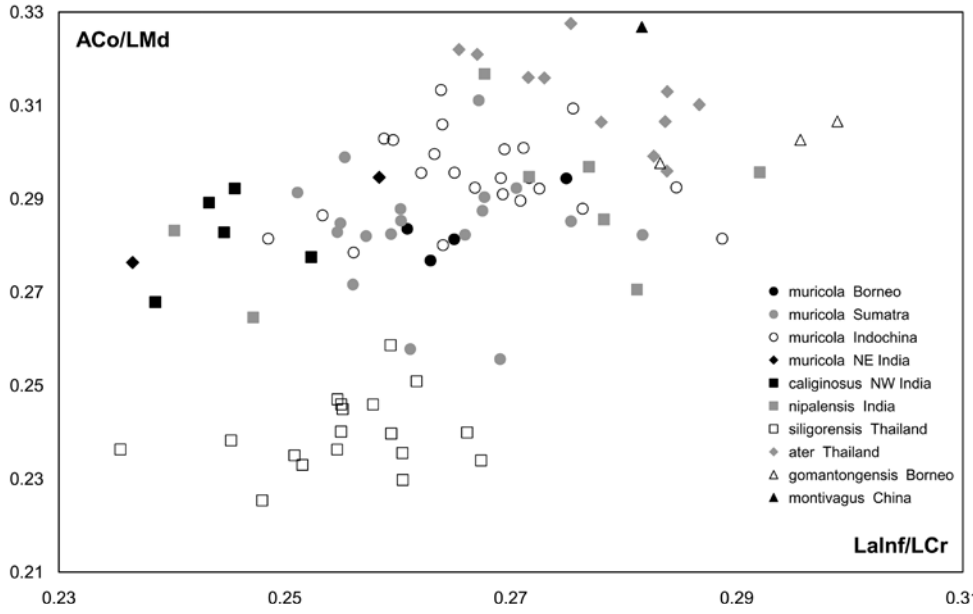


Fig. 22. Bivariate plot of cranial dimensions of the examined *Myotis* populations (*mystacinus/muricola* complex) from South Asia): relative width of rostrum over infraorbital foramens (LaInf/LCr) against relative height of cornoid processes (ACo/LMd).

Obr. 22. Graf lebečních rozměrů srovnávaných populací rodu *Myotis* komplexu *mystacinus/muricola* z jižní Asie: relativní šířka rostra přes podočnicové otvory (LaInf/LCr) oproti relativní výšce mandibuly (ACo/LMd).

Table 5. Summary of cranial characters (dimensions and relative dimensions) of the compared populations and/or taxa of the genus *Myotis*; +, – expression of the character considering the main character state: L = large, M = medium, S = small (see also Figs. 19–22)
Tab. 5. Přehled lebečních znaků (rozměrů a relativních rozměrů) srovnávaných populací či taxonů rodu *Myotis*; +, – projev znaku v rámci základní charakteristiky znaku: L = velký, M = prostřední, S = malý (viz také obr. 19–22)

population \ character populace \ znak	skull size velikost lebky	rostrum length délka rostra	rostrum width (CC) šířka rostra (CC)	rostrum width (Inf) šířka rostra (Inf)	braincase width šířka mozkovny	braincase height výška mozkovny	coronoid height koronoid. výška
muricola [Borneo]	M+	M+	M	M	S	M	M
muricola [Sumatra]	M	M+	M	M	S	M	M
muricola [Indochina]	M	M+	M	M	S	M	M
muricola [NE India]	M	L	S	S	M	M	M
caliginosus [NW India]	M–	M	S	S	M–	S	M
nipalensis [India]	M	S	M	S×L	L×M	M	M
siligorensis [Indochina]	S	S	L	S	L	M	S
ater [Thailand]	L	L	L	L	S+	L	L
gomantongensis [Borneo]	L	S	M	L	M+	M	M
montivagus [China]	L	L	L	L	M	M	L

Statistical analysis of skull dimensions of the samples of *M. muricola* s.str., selected by the above-discussed comparison (i.e. without the specimens of *M. caliginosus* from NW India), uncovered another hidden variation within this species. The principal component analysis (not figured; PC1=41.53% of variance; PC2=12.75%) and the canonical analysis resulting from the discriminant function analysis of the whole series of cranial dimensions (Fig. 23; CV1=64.45% of variance; CV2=19.51), grouped the geographical sample sets into three clusters; (1) NE Indian samples, (2) Sumatran, Cambodian and Vietnamese samples, and (3) Bornean, Malayan and Thailandese samples. While the separation of Indian (nominotypical) samples was partially suggested already by the comparison of skull shapes based on dimensional ratios (see Table 5 and Figs. 19–22), the clear morphological division of SE Asian samples is rather surprising, since there is no obvious character separating these groups, only their combination revealed by statistical methods.

Heller & Volleth (1989) observed two ecological morphs of *M. muricola* in Malaya differing in their roost preferences; a cave dwelling morph and a morph roosting in rolled up banana leaves. However, it is difficult to prove whether these ecomorphs correspond with the forms defined by the statistical analysis and whether these forms live in sympatry similarly as the ecomorphs suggested by Heller & Volleth (1989). Although the presented comparisons are too tentative to resolve taxonomy of *M. muricola* in the Oriental Region, mainly because of the apparent scarcity of available comparative material from a sufficiently wide part of the distribution range, a short review of precedent opinions can roughly depict the hitherto knowledge of intraspecific variation and possible applicability of the presented preliminary results.

Corbet (1978) was first to suggest the separate species status for *M. muricola*. Hill (1983) revised the taxonomic situation in the *mystacinus/muricola* complex and confirmed the Corbet's (1978) opinion concerning position of *M. muricola* and suggested a similar status also for *M. ater*. Hill (1983) also roughly delineated intraspecific variation of the former species, reporting larger individuals from the populations of Thailand, Malaya, Borneo, Java, Lesser Sunda Islands and Amboina (all denoted as *M. m. muricola*) and smaller individuals from the Philippines and

Celebes (*M. muricola browni* and *M. m. herrei*), NW India (*M. m. caliginosus*) and from the Nias Island (*M. m. niasensis*). Corbet & Hill (1992) and Simmons (2005) considered *M. muricola* a polytypic species containing a large amount of named forms (*caliginosus* Tomes, 1859, *lobipes* Peters, 1867, *blanfordi* Dobson, 1871, *moupinensis* Milne-Edwards, 1872, *niasensis* Lyon, 1916, *latirostris* Kishida, 1932, *browni* Taylor, 1934, *herrei* Taylor, 1934, *patriciae* Taylor, 1934, *orii* Kuroda, 1935). While Corbet & Hill (1992) resigned to depict any subspecific arrangement of the species, Simmons (2005) suggested eight subspecies within the species; viz. *muricola* (incl. *lobipes*), *browni*, *caliginosus* (incl. *blanfordi*), *herrei*, *latirostris* (incl. *orii*), *moupinensis*, *niasensis*, and *patriciae*.

However, several of these subspecies/populations cannot be assigned to *M. muricola* any more. In their molecular genetic analysis of the genus *Myotis*, Stadelmann et al. (2007) described significant differences among the taxa *muricola*, *browni* and *latirostris*. *M. muricola* was shown to be genetically more closely positioned to *montivagus*, than to *browni* or *latirostris*, which also were significantly distinct from each other. According to these findings, Zhang et al. (2010) considered the form *M. browni* a separate species. The above described analysis showed *M. caliginosus* to be rather a separate taxon than a part of the *M. muricola* species content. Moreover, besides their genetic and morphological relationships, the forms *browni*, *latirostris*, *caliginosus*, *niasensis*, and *patriciae* were described as small-sized (Hill 1983, Corbet & Hill 1992, Francis & Hill 1998, present analysis) and their names could hardly be applicable for the larger SE Asian forms of *M. muricola*, incl. the Bornean representatives.

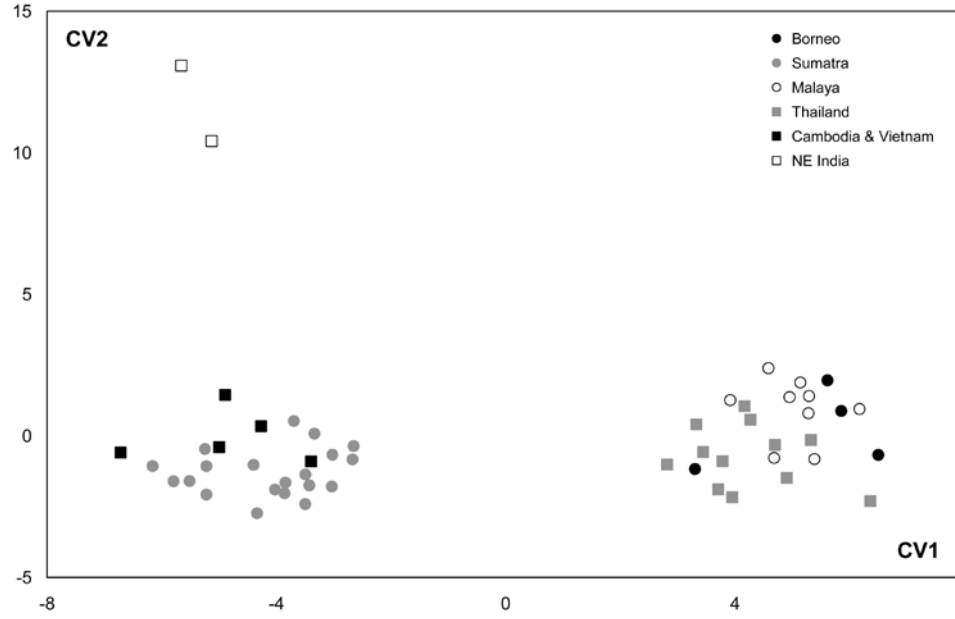


Fig. 23. Bivariate plot of cranial dimensions of the examined geographical sets of *Myotis muricola* s.str.: results of discriminant analysis (see text for details).
Obr. 23. Graf lebečních rozměrů srovnávaných zeměpisných vzorků netopýra nepálského (*Myotis muricola* s.str.): výsledky diskriminační analysy (podrobnosti viz text).

To be concluded, according to the relevant reviews (Corbet & Hill 1992, Simmons 2005), only two names seem to remain available for the two distinct larger morphotypes from SE Asia, *Vespertilio lobipes* Peters, 1867 described form Arakan, Burma, and *Vespertilio moupinensis* Milne-Edwards, 1872 described from Sichuan, China. However, also a necessity of description of a new taxon cannot be rejected.

Arielulus cuprosus (Hill et Francis, 1984)

Material. **Batu Punggul**, 30 April 1999, 1 ♂ ad (NMW 61438 [S+A]; Fig. 24); 2 May 1999, 1 ♂ ad (NMW 61439 [S+A]).

Pipistrellus cuprosus was described by Hill & Francis (1984) on the basis of two males collected at Sepilok, northeastern Sabah, in April 1983. This record remained the only known evidence of this species (see Francis & Hill 1986, Payne & Francis 1998). Although only two collected specimens existed, they were examined several times (Francis & Hill 1986, Hill & Harrison 1987, Corbet & Hill 1992, Csorba & Lee 1999, etc.). Csorba & Lee (1999) revised systematic position of this species within the subgenus *Arielulus* Hill et Harrison, 1987 and suggested to raise this subgenus to genus level and to include the species *P. cuprosus* into it. The genus is now composed of five species, four of them are non-Bornean; *A. aureocollaris* (Kock et Storch, 1996), *A. circumdatus* (Temminck, 1840), *A. societatis* (Hill, 1972), *A. torquatus* Csorba et Lee, 1999, and *A. cuprosus*. This opinion was supported by Csorba et al. (1999) and Eger & Theberge (1999) and accepted by Simmons (2005).

Our new specimens from Batu Punggul represent the second record of the species. Thus, *A. cuprosus* remains an endemic of Sabah known from only four specimens originating in two rather lowland localities. The size and shape of baculum extracted from the newly collected bat (Fig. 7) roughly correspond with that from the holotype described by Hill & Francis (1984) and

Fig. 24. Coppery sprite (*Arielulus cuprosus*) from Batu Punggul
Obr. 24. Netopýr měděný (*Arielulus cuprosus*) z lokality Batu Punggul.

Hill & Harrison (1987). In its shape this bone well resembles bacula from other representatives of the genus *Arielulus* (Heller & Volleth 1984, Hill & Francis 1984, Hill & Harrison 1987, Csorba & Lee 1999, Eger & Theberge 1999).

Conclusions

New records of 16 bat species from three sites situated in the western part of the state of Sabah are presented (Table 1). Besides some common species, we recorded also several rather rare forms. *Cynopterus minutus* and *Hipposideros doriae* were found in the territory of Sabah for the first time, *Cynopterus sphinx* for the second time. *Arielulus cuprosus* is reported for the first time after its description from another site in Sabah and remains a Sabahan endemic.

The sampled localities covered three of the four main habitats of Borneo, montane forest (Gunung Emas), primary lowland forest (Batu Punggul) and secondary forest combined with anthropogenic habitats (Sapulut). (Only the mangrove forest was not visited.) The collecting site of Gunung Emas, situated at the altitude of ca. 1800 m in the Crocker Range near Kota Kinabalu, represents a newly documented altitudinal margin for several lowland bat species in Borneo, although it is a typical locality of montane fauna (collecting site of typical montane terrestrial mammals, viz. *Hylomys dorsalis*, *Tupaia montana*, and *Dremomys everetti*). It suggests that the montane habitats at ca. 1800 m a. s. l. may represent – at least seasonally or even exceptionally – suitable ecosystems for some lowland dwellers. Of six bat species recorded at Gunung Emas, one or two could be considered as typical of the montane forests (*Aethalops aequalis*, *Megaerops ecaudatus* ?), while two or three other species rather of lowlands (*Cynopterus brachyotis*, *C. minutus* ?, *Macroglossus minimus*).

On the other hand, in comparison with the other two sites, Gunung Emas was found to be the weakest site concerning the bat fauna recorded. The site of Batu Punggul showed the highest diversity of bats (almost twice higher than in Gunung Emas), and the site of Sapulut the highest abundance (more than four times higher than in Gunung Emas). However, these differences are easy to explain; Batu Pungul is a primary habitat containing also karstic phenomena which effectively concentrates bat diversity, and the secondary habitats at Sapulut obviously express ecotonal effect of its mosaic-like anthropogenic landscape.

Souhrn

O malé kolekci netopýrů ze západního Sabahu (severní Borneo, východní Malajsie). V přehledu jsou uvedeny nové nálezy celkem 16 druhů netopýrů ze tří lokalit ležících v západní část malajsijského spolkového státu Sabah na severu ostrova Borneo. Tyto lokality pokrývají všechny hlavní biotopy Bornea s výjimkou mangrovového lesa: horský les, primární nížinný prales a mosaiku sekundárních biotopů kolem extensivní vesnice. Kromě dokumentace řady obecných anebo častěji evidovaných druhů, mezi které patří kaloň krátkouchý (*Cynopterus brachyotis*), kaloň indonéský (*Cynopterus horsfieldii*), kaloň bezocasý (*Megaerops ecaudatus*), kaloň skvrnitokřídlý (*Balionycteris maculata*), kaloň bornejský (*Aethalops aequalis*), kaloň malý (*Macroglossus minimus*), vrápenec bornejský (*Rhinolophus borneensis*), vrápenec trojlistý (*Rhinolophus trifoliatus*), pavrápenec dajácký (*Hipposideros dyacorum*), pavrápenec jelení (*Hipposideros cervinus*), pavrápenec diadémový (*Hipposideros diadema*) či netopýr nepálský (*Myotis muricola*), byly učiněny i nálezy některých spíše vzácných druhů. Kaloň maličký (*Cynopterus minutus*) a pavrápenec malajský (*Hipposideros doriae*) jsou tak hlášeni z území Sabahu vůbec poprvé, kaloň krátkonosý (*Cynopterus sphinx*) podruhé. Netopýr měděný (*Arielulus cuprosus*) byl zaznamenán poprvé od svého popisu v roce 1984 učiněného na základě nálezu z jiného místa v Sabahu (Sepilok) a zůstává tak sabahanským endemitem. K přehledu je připojeno také něco poznámek k ekologii, morfologii a taxonomii některých druhů.

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Appendix 1

List of the examined material of the genus *Myotis*

***Myotis ater* (Peters, 1866)**

Thailand: 1 ♂♂, 10 ♀♀ (SMF 88662–88671, 88688 [S+A]), Doi Pha Hom Park, Amphol Mae Ali, Chiang Mai Province, 25–27 April 1987, collector unlisted.

***Myotis caliginosus* (Tomes, 1859)**

India: 1 ♀ (BMNH 7.1.1.512 [S+B], type of *Vespertilio caliginosus* Tomes, 1859), India, date unlisted, leg. R. F. Tomes. – **India/Nepal**: 1 ♂, 1 ♀ (BMNH 75.10.27.1, 75.10.27.2 [S+A], cotypes of *Vespertilio blanfordi* Dobson, 1871), Himalayas, date unlisted, leg. W. T. Blanford. – **Pakistan**: 4 ♀♀ (BMNH 71.1574–71.1577 [S]), Muree Hills, Dunga Dali (Hazara), 7600', 13 April 1871, collector unlisted.

***Myotis gomantongensis* Francis et Hill, 1998**

Malaysia: 3 ♀♀ (SMF 83729–83731 [S+A], paratypes of *Myotis gomantongensis* Francis et Hill, 1998), Borneo, Sabah, Gomantong Caves, 29 June 1995, leg. C. M. Francis.

***Myotis montivagus* (Dobson, 1874)**

China: 1 ♀ (BMNH 76.3.10.5 [S], cotype of *Vespertilio montivagus* Dobson, 1874), Hotha, Yunnan, date and collector unlisted.

***Myotis muricola* (Gray, 1846)**

Cambodia: 2 ♂♂, 2 ♀♀ (CUP CAM 09–12 [S+A]), Siem Reap, 15 March 1999, leg. I. Horáček. – **Malaysia**: 3 ♂♂, 1 ♀ (SMF 18317, 44668, 50491, 50496 [S+B]), Bukit Lagong Res., Selangor, 4 April 1955, 25 June 1967, and 9 June 1973, leg. & ded. Inst. Med. Res. Kuala Lumpur and G. Nikolaus; – 1 ♂ (SMF 18289 [S+B]), Kepong, Selangor, 8 September 1950, ded. Inst. Med. Res. Kuala Lumpur; – 3 ♀♀ (SMF 18322, 18324, 18327 [S+B]), Ulu Langat, Selangor, 12 March and 31 December 1954, ded. Inst. Med. Res. Kuala Lumpur; – 1 ♂ (SMF 69339 [S+B]), Ulu Gombak, Field St. Centre, NW of Kuala Lumpur, 9 March 1981, leg. O. von Helversen. – **Nepal**: 1 ♀ (BMNH 45.1.8.143 [S+A], type of *Vespertilio muricola* Gray, 1846), Nepal, Kathmandu Valley, date unlisted, leg. B. H. Hodgson; – 1 ♀ (SMF 58413 [S]), Thodung, near Those, Ranechap Dist., 3200 m, 8 April 1973, leg. J. Mertens. – **Indonesia**: 10 ♂♂, 10 ♀♀ (NMW 39402–39404, 39461–39473 [S+B], 39423, 39475, 39481, 40379 [S]), vicinity of Medan, Sumatera Utara, November 1981, leg. H. Kern. – **Thailand**: 1 ♀ (SMF 88680 [S+B]), Bam Tham, Khung Ching, Ta Sa La, Nakhom Si Thammra, 8 June 1986, collector unlisted; – 2 ♂♂ (SMF 88675, 88676 [S+B]), Doi Pha Hom Pok, Mai Ai, Chiang Mai Province, 27 April 1987, collector unlisted; – 1 ♂, 1 ♀ (SMF 52780 [S], 75338 [S+B]), Chanthaburi, Prui, Phanguia, 26 May 1977 and 18 April 1988, leg. H. Felten; – 1 ♂ (SMF 88678 [S+B]), Chinat, Sanburi Province, January 1999, collector unlisted; – 1 ♀ (SMF 88679 [S+B]), Laroporo, Bankok, 1 November 1975, collector unlisted; – 1 ♂, 1 ♀ (SMF 66156, 70212 [S+B]), Phu Reu Prot. Stat., Dan Sai, Loei Province, 25 January 1981, 7 November 1984, collectors unlisted; – 1 ♀ (SMF 88677 [S+B]), Rayong Province, January 1999, collector unlisted; – 1 ♂ (SMF 88976 [S+B]), Thailand (undef.), January 1999, collector unlisted; – 1 ♀ (SMF 88681 [S+B]), Thung Chalee Wild Sanctuary, Khuraburi, Phang Nga, 18 May 1987, collector unlisted. – **Vietnam**: 1 ind. (ZIN 5930 [S]), Saigon, 1894, collector unlisted.

***Mytis nipalensis* (Dobson, 1871)**

Afghanistan: 1 ♂ (ZFMK 97.131 [S+B]), Payhman bei Kabul, 19 April 1962, leg. J. Niethammer. – **Bhutan**: 3 ♂♂, 2 ♀♀ (BMNH 16.7.29.37–16.7.29.41 [S]), Duars, Hasimara, date and collector unlisted. – **India**: 1 ♀ (BMNH 23.9.1.12. [S]), Chirot, Pattan, Lahul, Punjab, date and collector unlisted. – 1 ♀ (BMNH 26.3.1.1. [S+B], holotype of *Myotis meinertzhageni* Thomas, 1926), junction of Nubra and Shyok Rivers, Ladak, date unlisted, leg. Meinertzhagen.

***Myotis siligorensis* (Horsfield, 1855)**

India: 1 ♀ (BMNH 79.11.21.125 [S+B]), type of *Vespertilio siligorensis* Horsfield, 1855), Siliguri, 'Nepal', date unlisted, leg. B. H. Hodgson. – **Thailand**: 6 ♂♂, 6 ♀♀ (SMF 53285, 53288–53292, 53296–53299, 53310, 53320 [S+B]), Bau Tham Tap Tao, 25 km SSW Fang, Prov. Chiang Mai, 16–18 June 1977, leg. H. Felten; – 5 ♂♂, 2 ♀♀ (CUP CAM 53–59 [S+A]), Sai Yok, Wang Badon Cave, 1 May 1999, leg. I. Horáček.

Appendix 2

Basic biometric data on the collected specimens, see pp. 74–76.

No.	sex	LC	LCd	LAt	LA	G	LCr	LCb	LaZ	LaI	LaN	CMs	LMd	CMi
Cynopterus brachyotis														
NMW 61371	♂	83	11	60.0	13.7	30.1	28.08	26.45	18.18	5.32	11.67	9.51	20.27	10.28
NMW 61372	♂	81	9	60.1	16.7	27.3	27.82	26.21	18.45	5.42	12.20	9.20	20.67	10.22
NMW 61373	♀	82	11	56.6	14.7	27.3	27.03	25.65	17.95	5.72	11.75	9.51	20.27	10.32
NMW 61374	♂	79	11	58.6	14.8	28.2	27.43	26.28	17.55	5.38	11.92	9.62	20.92	10.63
NMW 61375	♂	84	10	59.7	14.7	23.2	27.76	26.70	18.00	5.08	12.25	9.51	20.73	10.23
NMW 61376	♀	86	11	61.2	15.1	27.7	27.03	26.02	18.33	6.02	12.02	9.11	20.28	10.12
NMW 61377	♀	83	9	56.7	13.4	26.6	27.03	25.98	17.86	5.02	11.75	9.27	20.48	10.03
NMW 61378	♂	84	11	56.7	15.8	25.0	27.52	26.00	18.05	5.22	12.27	9.10	20.43	10.15
NMW 61379	♂ juv	44	4	22.7	8.9	4.9								
NMW 61380	♀	84	15	58.7	14.7	30.2	27.51	26.23	18.32	5.10	12.43	9.02	20.22	10.00
NMW 61381	♂	82	12	55.8	15.1	24.2	26.92	25.63	18.03	5.42	12.34	9.00	19.95	9.83
NMW 61382	♂	81	11	56.7	14.7	26.0	27.58	25.93	19.12	5.17	12.25	9.97	20.36	10.70
NMW 61383	♀	82	12	60.3	15.6	29.2	28.07	26.75	18.67	5.42	12.10	9.38	21.08	10.17
NMW 61384	♂	83	13	56.1	14.7	25.1	26.42	25.48	18.32	5.03	12.13	9.03	19.83	10.17
NMW 61385	♂	88	11	55.1	15.2	27.1	27.85	26.48	18.33	5.27	12.07	9.05	20.68	9.95
NMW 61386	♂	82	12	60.2	15.4	25.0	26.62	25.58	18.15	4.67	11.78	9.15	20.53	9.85
NMW 61387	♂	81	12	59.1	15.9	25.2	27.35	25.57	18.75	5.13	12.62	9.08	20.48	9.88
NMW 61388	♀	88	12	59.6	14.4	29.3	28.17	26.78	19.07	5.72	12.75	9.23	20.62	10.17
NMW 61389	♂	85	11	60.7	16.1	27.2	28.38	26.77	18.62	5.18	12.83	9.43	20.82	10.46
NMW 61390	♂	83	12	59.0	14.8	27.0	27.62	26.35	18.17	5.22	11.75	9.26	20.25	10.17
NMW 61391	♂	87	13	58.2	14.5	26.4	27.02	25.75	18.32	5.45	11.63	9.38	20.13	10.30
NMW 61443	♂ juv	71	8	51.1	14.2	16.1								
NMW 61444	♂	84	13	59.4	14.8	28.0	27.22	26.25	18.00	4.93	11.97	8.78	20.26	9.76
NMW 61445	♀	85	11	62.0	15.4	29.3	27.25	26.35	18.76	5.47	11.98	9.35	20.50	10.32
SMO sa02	♂	–	–	–	–	–	26.47	25.23	17.47	5.82	11.68	9.45	20.68	10.22
Cynopterus minutus														
NMW 61392	♀	76	12	59.1	14.6	24.3	26.32	2465	17.68	5.37	11.82	8.85	19.55	9.67
NMW 61393	♀	80	10	55.4	14.1	22.7	25.80	24.40	17.53	4.98	11.80	8.95	19.17	9.68
NMW 61446	♂	83	11	55.0	15.1	24.2	26.45	25.33	18.25	5.27	11.67	8.50	19.40	9.57
NMW 61447	♀	77	11	54.3	15.1	19.0	25.87	24.65	17.82	5.52	12.18	8.88	19.43	9.73
SMO sa11	♂	–	–	58.8	–	–	26.53	25.28	16.95	5.32	11.42	8.63	18.95	9.65
Cynopterus sphinx														
NMW 61394	♂	86	13	59.5	15.6	26.1	28.90	27.72	17.95	5.42	11.75	9.47	21.97	10.55
NMW 61395	♂	96	8	65.3	16.7	33.6	28.63	27.17	18.65	6.25	12.47	9.80	21.32	10.77
NMW 61396	♂	94	12	63.8	17.1	35.9	29.52	27.77	18.18	5.85	12.62	9.67	21.92	10.60

No.	sex	LC	LCd	LAt	LA	G	LCr	LCb/c	LaZ	LaI	LaN	CMs	LMd	CMi
Cynopterus hosfieldii														
NMW 61366	♀	93	12	71.1	17.7	38.1	28.98	28.32	18.88	5.77	12.40	9.37	22.10	10.38
NMW 61367	♂	89	9	61.2	16.1	29.5	29.63	27.96	19.43	5.95	12.48	10.17	21.93	10.95
NMW 61368	♂	94	13	66.1	17.7	35.5	29.65	28.07	20.20	5.13	13.08	9.53	22.23	10.60
NMW 61369	♂	96	10	68.1	16.5	39.0	29.12	27.62	19.02	5.58	13.32	9.60	21.37	10.63
NMW 61370	♀	90	12	70.0	17.3	39.0	28.82	27.82	18.47	5.82	12.48	9.82	22.12	10.83
Megaerops ecaudatus														
NMW 61353	♂	82	–	52.8	15.2	25.0	26.18	24.92	17.70	5.65	11.37	8.66	19.10	9.66
NMW 61398	♂	82	–	53.9	13.9	24.7	26.20	25.32	17.45	4.88	11.38	8.55	19.43	9.42
NMW 61442	♂	84	–	53.7	15.0	22.7	25.88	25.05	16.88	5.33	12.07	8.35	19.35	9.25
SMO sa07	♀	–	–	–	–	–	26.84	–	17.12	5.25	11.72	8.81	20.12	9.63
Balionycteris maculata														
NMW 61437	♀ juv	61	–	41.4	10.0	12.8	20.92	–	14.12	4.67	9.92	7.52	15.48	7.88
Aethalops aequalis														
NMW 61354	♂ juv	69	–	42.3	10.8	15.6	22.47	21.47	13.98	4.45	10.35	7.15	16.35	8.00
NMW 61355	♀	71	–	45.2	10.5	18.0	23.88	23.05	14.97	4.55	10.72	7.18	17.68	8.22
NMW 61356	♂ juv	67	–	43.2	10.0	14.1	22.68	21.48	14.08	4.51	10.83	7.03	16.58	7.88
NMW 61357	♀ juv	72	–	44.3	10.4	16.9	23.35	22.46	14.57	4.68	10.67	6.90	17.47	7.82
NMW 61358	♂ juv	73	–	46.0	11.3	17.5	24.02	22.87	15.67	5.12	11.02	7.47	17.95	8.45
SMO sa05	♂	–	–	–	–	–	24.27	23.28	15.82	5.13	10.98	7.62	18.02	8.47
SMO sa06	♂	–	–	–	–	–	24.09	23.12	15.38	5.05	10.16	7.26	17.69	8.33
SMO sa12	♀	–	–	44.4	–	–	23.31	22.52	14.67	4.82	10.50	7.58	17.38	8.08
Macroglossus minimus														
NMW 61359	♀	72	5	39.8	12.0	15.5	26.17	24.92	13.58	4.43	10.75	8.98	19.82	10.27
NMW 61397	♀	71	6	41.1	13.1	15.8	26.42	25.00	13.90	4.72	11.26	8.63	19.61	9.33
NMW 61440	♀	58	–	39.2	12.7	12.5	23.68	21.65	12.10	3.90	10.95	7.33	17.17	7.22
NMW 61441	♀	67	4	39.4	13.2	12.5	24.43	22.92	12.73	4.40	10.82	7.93	18.33	9.15
SMO sa04	♂	–	–	–	–	–	27.02	25.23	14.53	4.68	11.58	9.53	20.35	10.90
Rhinolophus borneensis														
NMW 61365	♀	62	25	44.4	21.4	12.2	–	16.95	9.43	2.58	8.07	7.05	12.47	7.55
NMW 61430	♀	57	22	41.5	17.8	9.2	19.38	16.20	9.32	2.62	7.78	6.72	12.15	7.42
NMW 61431	♀	56	21	44.9	17.9	12.5	19.65	16.31	9.62	2.55	8.21	7.10	12.33	7.65
NMW 61432	♀	58	23	42.9	17.6	12.4	19.30	16.28	9.30	2.38	7.95	7.05	12.02	7.47
NMW 61433	♀	55	23	45.2	18.2	11.0	19.20	16.42	9.12	2.20	7.85	7.07	12.08	7.48

No.	sex	LC	LCd	LAt	LA	G	LCr	LCb/c	LaZ	LaI	LaN	CMs	LMd	CMi
Rhinolophus borneensis														
NMW 61434	♀	54	23	42.6	18.3	7.8	19.57	16.51	9.05	2.48	7.87	6.76	12.12	7.35
NMW 61435	♀	57	22	44.8	19.5	11.8	19.49	16.23	9.08	2.31	7.65	6.90	12.05	7.43
NMW 61436	♀	54	22	42.8	19.0	10.2	20.07	16.71	9.72	2.17	8.07	7.25	12.65	7.76
Rhinolophus trifoliatus														
NMW 61429	♂	64	33	50.0	25.8	12.1	23.02	20.12	11.38	1.76	9.17	8.37	15.18	9.03
Hipposideros diadema														
NMW 61413	♀	97	52	85.3	27.9	45.0	31.52	27.91	17.95	3.58	11.88	12.67	22.11	13.65
NMW 61414	♀	96	50	84.2	28.5	45.2	31.47	28.05	18.21	3.32	11.97	12.55	22.57	13.80
NMW 61415	♀	99	48	85.7	27.2	41.8	32.15	28.02	18.35	3.43	12.17	12.62	22.42	13.63
NMW 61416	♀	99	53	84.6	29.3	43.1	30.92	27.72	18.30	4.18	12.27	12.88	22.42	14.05
NMW 61417	♂	103	49	85.0	27.2	49.5	32.07	28.71	18.97	3.62	12.17	13.47	23.42	14.80
NMW 61418	♀	94	52	80.9	27.4	42.0	31.07	26.95	18.37	3.28	11.95	12.58	22.10	13.77
NMW 61419	♀	96	48	84.2	28.3	48.2	31.98	28.42	18.96	3.37	12.20	13.18	23.43	14.43
NMW 61420	♀	96	47	86.0	27.5	43.1	31.93	27.38	18.47	3.32	12.12	12.92	22.38	13.89
NMW 61421	♀	98	47	84.9	26.4	43.7	31.18	27.23	18.12	3.47	11.88	12.43	22.48	13.70
NMW 61422	♀	96	49	84.1	25.3	45.2	31.35	27.43	18.32	3.58	11.53	12.43	21.92	13.56
SMO sa03	♂	–	–	–	–	–	30.33	26.72	16.15	3.65	11.53	12.67	21.93	13.88
Hipposideros dyacorum														
NMW 61423	♂	51	21	41.0	17.4	6.6	16.40	13.98	9.26	2.20	7.74	5.46	10.48	6.02
NMW 61424	♂	52	21	39.0	16.6	6.5	16.12	13.92	9.18	2.28	7.78	5.52	10.16	6.00
NMW 61425	♂	50	20	40.6	16.6	6.8	16.63	13.98	9.25	2.18	7.79	5.47	10.17	5.84
NMW 61426	♂	50	22	39.8	16.5	6.8	16.25	13.67	8.95	2.25	7.42	5.22	9.77	5.42
NMW 61427	♀	53	23	42.7	17.4	7.2	16.47	14.25	9.15	2.20	7.35	5.52	10.43	6.03
Hipposideros cervinus														
NMW 61428	♂	60	24	49.9	16.5	11.0	18.31	15.68	10.11	2.73	8.12	6.83	12.10	7.42
SMO sa08	♀	–	–	49.8	–	–	19.97	16.38	10.12	2.64	8.05	6.82	12.48	7.27
SMO sa09	♂	–	–	46.0	–	–	18.32	15.36	9.93	2.67	8.23	6.52	11.50	7.00
Myotis muricola														
SMO sa10	♀	–	–	34.0	–	–	13.75	13.37	8.68	3.27	6.48	5.47	10.43	5.83
Arielulus cuprosus														
NMW 61438	♂	50	36	36.2	11.6	6.8	13.56	12.68	–	3.96	7.62	4.82	9.62	5.23
NMW 61439	♂	48	40	35.8	11.3	6.4	13.32	12.73	9.63	3.93	7.37	7.75	9.63	5.12