Bat diversity in oligotrophic forests of southern Borneo

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Appendix 1 Bat species captured in oligotrophic forests of Tanjung Puting and Sebangau National Parks, with details of their external measurements. Measurement data refers to bats captured during this study (pooled across sites) and does not include specimens at the Museum Zoologicum Bogoriense or *Pteropus vampyrus*. ¥ indicates species that were not captured, but their presence has been confirmed at the site by specimens in the MZB.

	No. of individuals captured		External measurements mean ± SD (min–max, n)					
			Forearm length (mm)		Body mass (g)		Tibia length (mm)	
Species	Tanjung Puting	Sebangau	M	F	M	F	M	F
Pteropodidae								
Dyacopterus spadiceus	1			72.5		62.0		28.0
Balionycteris maculata	15	¥	39.0 ± 1.8 (38.0–41.0, 4)	38.6 ± 1.6 (35.9–41.2, 11)	11.4 ± 2.2 (10.0–15.0, 4)	11.9 ± 1.4 (10.0–14.0, 4)	13.3 ± 1.8 (12.0–14.5, 2)	13.8 ± 1.3 (12.0–16.0, 7)
Cynopterus brachyotis	8	¥	55.6 ± 3.4 (53.2–58.0, 2)	57.6 ± 2.2 (55.0–60.9, 6)	22.3 ± 0.4 (22.0–22.5, 2)	25.8 ± 1.4 (23.5–27.0, 5)	19.5 ± 2.1 (18.0–21.0, 2)	20.8 ± 1.2 (19.0–22.0, 6)
Megaerops wetmorei[1]	¥	1		51.7				
Macroglossus minimus	1			37.7		10.0		
Emballonuridae								
Emballonura monticola	12		44.1 ± 1.2 (42.8–45.7, 5)	44.2 ± 0.8 (43.3–45.1, 4)	5.0 ± 0.4 (4.5–5.5, 5)	5.6 ± 0.5 (5.0–6.0, 4)	17.0 ± 0.3 (16.6–17.50, 5)	17.0 ± 0.4 (16.5–17.5, 4)
Megadermatidae								
Megaderma spasma	2		51.1	54.4	17.0	20.5	30.5	31.0
Nycteridae								
Nycteris tragata[2]	8		48.2 ± 1.1 (47.1–50.1, 5)	45.6 ± 5.3 (39.5–49.5, 3)	14.6 ± 0.7 (14.0–15.5, 5)	16.0 ± 2.0 (14.0–18.0, 3)	26.2 ± 3.1 (21.0–29.0, 5)	27.3 ± 0.6 (27.0–28.0, 3)
Rhinolophidae								
Rhinolophus sedulus	40		41.8 ± 1.4 (39.3–42.8, 26)	42.6 ± 1.0 (40.7–44.6, 14)	9.6 ± 0.9 (8.0–11.0, 26)	11.1 ± 1.0 (9.5–13.0, 14)	20.7 ± 1.0 (19.0–22.0, 11)	21.1 ± 1.0 (20.0–23.0, 6)
Rhinolophus trifoliatus	58	1	50.3 ± 1.6 (47.2–53.4, 33)	52.7 ± 1.5 (50.1–55.8, 22)	13.4 ± 1.2 (11.5–17.0, 33)	15.2 ± 1.3 (13.0–18.5, 22)	24.8 ± 0.9 (23.5–26.0, 10)	25.6 ± 0.7 (24.5–27.5, 5)
Rhinolophus luctus?[3]	2		52.9	52.6	20.0	22.5	29.5	28.7
Hipposoderidae								
*Hipposideros ridleyi***	5		46.5 ± 1.5 (45.4–47.5, 2)	47.8 ± 1.3 (46.5–49.0, 3)	9.5 ± 0.0 (9.5, 2)	9.2 ± 0.8 (8.5–10.0, 3)	20.0 ± 0.0 (20.0, 2)	20.7 ± 1.5 (19.0–22.0, 3)
*Hipposideros doriae**[4]	1			35.6		5.5		17.0
Vespertilionidae								
Myotis muricola	1	5	36.1 ± 0.5 (35.4–36.4, 4)	36.0 ± 0.1 (35.9–36.1, 2)	5.8 ± 0.3 (5.5–6.0, 4)	6.5 ± 0.7 (6.0–7.0, 2)		

Appendix 1 (*Continued*)

Species	No. of individuals captured		External measurements mean ± SD (min–max, n)					
			Forearm length (mm)		Body mass (g)		Tibia length (mm)	
	Tanjung Puting	Sebangau	M	F	M	F	M	F
Myotis hasseltii	1			36.3		7.0		17.0
Murina suilla	18	3	29.3 ± 0.9 (27.5–30.6, 14)	29.6 ± 0.7 (28.8–30.5, 5)	4.0 ± 0.3 (3.0–4.5, 14)	3.8 ± 0.3 (3.5–4.0, 5)	14.3 ± 1.0 (13.0–16.0, 10)	14.3 ± 0.5 (14.0–15.0, 5)
*Murina cyclotis**	2			37.8 ± 1.5 (36.7–38.8, 2)		11.3 ± 2.5 (9.5–13.0, 2)		20.0 ± 1.4 (19.0–21.0, 2)
*Murina rozendaali***	3		31.4 ± 0.7 (30.6–32.0, 3)		5.3 ± 0.7 (4.8–6.0, 3)		17.3 ± 2.3 (15.0–19.5, 3)	
*Murina aenea***	1		34.1		6.0		17.0	
Kerivoula minuta[5]	10	8	28.2 ± 0.6 (27.0–29.2, 16)	28.6 ± 0.0 (28.6, 2)	2.4 ± 0.2 (2.0–2.5, 16)	2.5 ± 0.0 (2.5, 2)	14.3 ± 0.6 (14.0–15.0, 3)	
Kerivoula intermedia	276	23	28.4 ± 0.6 (26.9–31.0, 80)	29.6 ± 0.8 (26.6–32.0, 175)	3.0 ± 0.2 (2.75–4.0, 80)	3.2 ± 0.4 (2.75–4.0, 175)	13.8 ± 0.3 (13.5–14.0, 3)	14.5 ± 0.6 (13.5–15.0, 31)
Kerivoula papillosa (small)/*K. lenis*[6]	7		39.2 ± 0.7 (38.3–40.0, 5)	37.7 ± 0.3 (37.5–37.9, 2)	7.8 ± 0.8 (7.0–9.0, 5)	8.3 ± 2.5 (6.5–10.0, 2)	19.7 ± 0.6 (19.0–20.5, 5)	20.3 ± 1.8 (19.0–21.5, 2)
Kerivoula papillosa (large)	54	1	42.1 ± 1.0 (40.1–44.5, 51)	43.1 ± 1.2 (40.4–45.1, 141)	9.6 ± 0.6 (8.5–11.0, 51)	10.0 ± 1.2 (6.0–12.0, 136)	21.8 ± 1.5 (17.0–23.0, 13)	22.9 ± 1.5 (20.0–26.0, 15)
Kerivoula hardwickii	10	3	31.6 ± 0.8 (30.9–32.5, 4)	32.1 ± 1.0 (30.7–33., 8)	3.8 ± 0.3 (3.5–4.0, 4)	3.9 ± 0.4 (3.0–4.0, 7)	16.8 ± 0.3 (16.5–17.0, 4)	17.8 ± 0.9 (17.0–19.0, 5)
Kerivoula pellucida	9	1	29.5 ± 0.5 (29.0–29.9, 4)	30.1 ± 1.5 (27.9–31.5, 4)	4.3 ± 0.3 (4.0–4.5, 4)	4.5 ± 0.3 (4.0–5.0, 4)	16.3 ± 1.2 (15.0–17.0, 3)	18.0
*Phoniscus atrox**	3		33.0 ± 0.5 (32.6–33.3, 2)	34.3	5.3 ± 0.4 (5.0–5.5, 2)	4.0	15.3 ± 0.4 (15.0–15.5, 2)	15.5

*,**New records for Kalimantan and Indonesia, respectively; discussed further in Appendix 2.

[1]A female *Megaerops* was captured carrying a pup in Tanjung Puting and could not be positively identified to species without causing stress. However, specimens subsequently examined in Museum Zoologicum Bogoriense (MZBM22156, 22157, 26268 and 26269) confirm the presence of *M. wetmorei* at both sites.

[2]Listed as *Nycteris javanica* in Payne & Francis (1998) but assigned to *N. tragata* following Corbet & Hill (1992) and Simmons (2005).

[3]Adult individuals provisionally identified as *Rhinolopus luctus* were actually intermediate in size (forearm length and body mass) between *R. luctus* and *R. sedulus* (according to measurements summarised in Payne & Francis, 1998, and Corbet & Hill, 1992) and may represent a distinct taxon. A specimen of a female individual is stored in the University of Palangkaraya (MS040711.1).

[4]Listed as *Hipposideros sabanus* by Payne & Francis (1998) and Corbet & Hill (1992) but assigned to *H. doriae* following Simmons (2005).

[5]*Kerivoula intermedia* and *minuta* are difficult to distinguish in the hand and were therefore separated by body mass (*K. intermedia* ⩾ 2.75 g; range: 2.75–4.0 g; *K. minuta* ⩾ 2.5 g; range: 2.0 – 2.5 g).

[6]Adult individuals of *Kerivoula papillosa* vary extensively in size (Payne & Francis 1998) so were divided into arbitrary size classes based on forearm length (small < 40.0 mm; large ⩾ 40.0 mm) following Kingston *et al.* (1999). The smallest individual (forearm length = 37.7 mm) was later confirmed as *Kerivoula lenis* based on skull size relative to *K. papillosa* (see Appendix 2). This is a new record for Indonesia.

Appendix 2 Review of bat species captured in Tanjung Puting National Park, Central Kalimantan, that are new records for Indonesia or Kalimantan. Systematics and distributions are based on Simmons (2005).

Hipposideros doriae, Bornean leaf-nosed bat
The individual captured in Tanjung Puting National Park is the first record for Kalimantan. Elsewhere in Borneo it is only known from Lawas in Sarawak; Gomantong and Tabin in Sabah (Payne & Francis, 1998), and Batu Apoi National Park in Brunei (Kofron, 2002). Elsewhere it is limited to Peninsular Malaysia and Sumatra. One individual was found dead in a harp trap set in the forest understorey, the specimen of which (MS040527) is currently stored in the University of Palangkaraya. It is easily distinguished from other Bornean leaf-nosed bats by the absence of septa in the posterior noseleaf. The size of the specimen (FA 35.6 mm; mass 5.5 g) is similar to individuals captured elsewhere in Borneo (34–37 mm). This species is listed as *H. sabanus* by Payne & Francis (1998) and Corbet & Hill (1992) but assigned to *H. doriae* following Simmons (2005).

Hipposideros ridleyi, Ridley's leaf-nosed bat
The five individuals captured in harp traps set in Tanjung Puting National Park represent the first records for Indonesia. Elsewhere in Borneo *H. ridleyi* is known only from Kubah National Park in Sarawak (Abdullah *et al*., 1997); Sepilok Forest Reserve, Kinabalu National Park, Tabin, and Menggalong in Sabah (Payne & Francis, 1998) and Batu Apoi National Park in Brunei (Kofron, 2002). Otherwise it is only known from a small number of locations in Peninsular Malaysia. This species is easily distinguished from other known Bornean leaf-nosed bats by the presence of an elaborate noseleaf with an enlarged internarial disc. In their taxonomic review of this species Francis *et al*. (1999) also recognized two sibling species described from Sumatra and Peninsular Malaysia (*H. orbiculus*) and Laos (*H. rotalis*). These species differ from *H. ridleyi* by echolocation call structure and skull parameters and also by the shape of the noseleaf. Although small morphological differences were recognized, Bornean specimens examined from Sabah were assigned to *H. ridleyi*. Individuals captured in Tanjung Puting National Park are similar to this form in noseleaf shape, although some are smaller (FA 45.4 & 46.5 mm compared to 47–49 mm given by Payne & Francis, 1998).

Kerivoula lenis, Lenis's woolly bat
The individual confirmed as *K. lenis* in Tanjung Puting represents the first record of this species in Indonesia. This species is only confirmed from Sepilok Forest Reserve in Sabah, Peninsular Malaysia, and India but may be much more widespread (Vanitharani *et al*., 2003). *K. lenis* has only recently been resurrected from its subspecific status of *K. papillosa* (Vanitharani *et al*., 2003). Payne & Francis (1998) and Kingston *et al*. (1999) both recognized an extensive size range of adult *Kerivoula papillosa*. We therefore divided *K. papillosa* into arbitrary size classes based on forearm length (small < 40.0 mm; large $\geqslant 40.0$ mm) based on echolocation call structure differences reported by Kingston *et al.* (1999). The smallest individual (a mature adult male, FA 37.7 mm) died accidentally, the specimen of which is stored in the University of Palangkaraya (MS040618). The skull was extracted and compared with a specimen of a large (mature adult male, FA 44.2 mm) *K. papillosa* that had been killed by villagers in a house adjacent to Tanjung Puting (MS070626). In agreement with specimens described in Vanitharani *et al*. (2003) the skull of our *K. lenis* specimen is absolutely smaller than that of the *K. papillosa* from the same locality: greatest skull length 16.71, 18.57 mm; condylo-basal length 15.48, 17.42 mm; zygomatic breadth 10.60, 11.45 mm; breadth of braincase 7.55, 8.12 mm; maxillary toothrow length 6.59, 7.34 mm; posterior palatal width 6.13, 6.69 mm; mandibular toothrow length 7.39, 8.22 mm; mandible length 11.88, 13.72 mm.

Phoniscus atrox, Groove-toothed woolly bat
The three individuals captured in Tanjung Puting National Park are new records for Kalimantan. In Borneo it has only been recorded in Sabah at Sepilok, Tabin, Madai, Pulau Balembangan (Payne & Francis, 1998) and Danum Valley (Kingston & Hodgkison, 1994). Elsewhere it is recorded from Peninsular Thailand/Malaysia and Sumatra. *Phoniscus* is now recognized as being distinct from *Kerivoula* (Simmons, 2005), being distinguished by a notch at the base of the tragus (which is completely absent in *Kerivoula*). Other distinguishing external features of *Phoniscus* include muzzle shape and golden tips to the fur. Individuals captured in Tanjung Puting and Krau Wildlife Reserve, Peninsular Malaysia have a distinct smell resembling horse manure (M. Struebig, pers. obs). P. *atrox* is distinguished from *P. jagorii* by size, the latter species being much larger. One female individual captured (FA 34.3 mm) was slightly larger than those known from Sabah (FA 31–33 mm).

Murina aenea, Bronze tube-nose bat
The single individual captured near Camp Wilkie in Tanjung Puting National Park is the first record of this species in Indonesia. It has a narrow distribution, having been recorded from only three areas in Sabah (Sepilok, Segarong and the Crocker Range; Payne & Francis, 1998) and Peninsular Malaysia. Species within the vespertilionid subfamily Murininae are easily distinguished from other vespertilionids by their tubular nostrils. *M. aenea* is similar in size to *M. cyclotis* but is distinguished by having dark fur with bronze/brown tips (the latter species having orange fur with a pale-grey base). The fur colour of *M. rozendaali* is distinct in having shiny yellow tips to dark fur. The individual captured in Tanjung Puting National Park was slightly smaller (FA 34.1 mm) than those listed from Sabah (FA 35–38 mm).

Murina cyclotis, Round-eared Tube-Nose bat
Individuals captured in Tanjung Puting are the first records for Kalimantan. In north Borneo it is known from Gunung Mulu in Sarawak; Sepilok, Tabin, Gomantong (Payne & Francis, 1998) and Danum Valley (Kingston & Hodgkison, 1994) in Sabah, and Tasek Merimbum and Batu Apoi National Park in Brunei (Kofron, 2002). It has a wide distribution ranging from India to the Philippines and Lesser Sunda Islands. Of the two individuals captured in harp traps one was killed by ants, the specimen for which (MS040627) is stored in the University of Palangkaraya. The size of these individuals (FA 36.7–38.8 mm) compares favourably with those recorded in Sabah (FA 34–41 mm). It is distinguished from other *Murina* by having orange fur with a pale grey base, and is distinguished from *Harpiocephalus* by dentition.

Murina rozendaali, Gilded tube-nose bat
The three individuals captured are the first records for Indonesia. Like *M. aenea* this species is limited to Borneo and Peninsular Malaysia and is known from only a few localities: Sepilok, Poring, Gomantong and Tepadong (Payne & Francis, 1998) and Danum Valley (Kingston & Hodgkison, 1994) in Sabah. See the comments for *M. aenea* for distinguishing features. Individuals captured (FA 30.6–31.5 mm) compare favourably in size with those captured in Sabah (FA 31–34 mm). All were male and possessed a swollen gland at the base of the tail.