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## Short Note

Matthew J. Struebig\*, Joe Chun-Chia Huang, Nor Zalipah Mohamed, Sephy Noerfahmy, Caroline R. Schöner, Michael G. Schöner and Charles M. Francis

# Forest surveys extend the range of the Krau woolly bat (*Kerivoula krauensis*) in the Malay-Thai Peninsula, Borneo and Sumatra

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**Abstract:** *Kerivoula krauensis* was formally described in 2007 and until recently was only known from tropical forest in central peninsular Malaysia. We report four new records, which, together with recent published collections, extend the known range for this species to peat-swamps, lowland and montane forests in Borneo and Sumatra (Brunei and Indonesia), and further north on the Malay peninsula, including Thailand. External body measurements and cranial data match well with those from the type locality, although echolocation call parameters differ – most likely due to technological improvements in recording devices. The species remains patchily distributed and rarely encountered, despite substantial sampling effort.

**Keywords:** Kerivoulinae; range extension; Southeast Asia; tropical forest; Vespertilionidae.

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\*Corresponding author: **Matthew J. Struebig**, Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Canterbury, CT2 7NR, UK, e-mail: m.j.struebig@kent.ac.uk.

<http://orcid.org/0000-0003-2058-8502>

**Joe Chun-Chia Huang:** Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79409, USA

**Nor Zalipah Mohamed:** School of Marine and Environmental Sciences, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

**Sephy Noerfahmy:** Fauna and Flora International Indonesia Programme, Komplek Universitas Nasional Blok 1 Lt. 4, Jakarta, Indonesia

**Caroline R. Schöner and Michael G. Schöner:** Zoological Institute and Museum, University of Greifswald, J.-S.-Bach-Str. 11/12, 17489 Greifswald, Germany

**Charles M. Francis:** Environment Canada, Canadian Wildlife Service, National Wildlife Research Centre, Ottawa, Ontario, Canada K1A 0H3

The woolly bats of the genus *Kerivoula* are a group of vespertilionids distributed across the African and Asian tropics and subtropics, and are represented by 15 currently recognised Asiatic species (Bates et al. 2004, Simmons 2005, Bates et al. 2007, Francis et al. 2007). *Kerivoula* species are characterised by their long woolly fur, funnel-like ears and elongated rostrum (Francis 2008). Most species are considered forest specialists, using high-frequency and broad-band echolocation calls that are adapted for prey detection and sensory perception within dense and cluttered vegetation (Kingston et al. 1999, Schmieder et al. 2010).

Historically, the taxonomy, ecology and distribution of this group were poorly documented, and most *Kerivoula* species were considered rare or difficult to capture. With renewed bat research efforts in Southeast Asia since the 1990s, however, it is now increasingly routine to utilise harp traps in forest surveys (Francis 1990, Kingston et al. 2003), and as a result some *Kerivoula* species are now known to be amongst the most frequently encountered bats in rainforest assemblages (Kingston et al. 2003). Three new Asiatic *Kerivoula* have been described in the last decade (Bates et al. 2004, Bates et al. 2007, Francis et al. 2007), the most distinctive of which is the Krau woolly bat, *Kerivoula krauensis* (Francis et al. 2007).

*Kerivoula krauensis* (Francis et al. 2007) was first captured in 1991 at Kuala Lompat (3°42'54" N, 102°16'78" E), in Krau Wildlife Reserve, peninsular Malaysia, but was not formally described as a species until 2007. External discriminating characters from other taxa included distinctive pelage colour (dark brown with shiny golden tips) and minor dental differences, though external and cranial measurements overlapped substantially with other small *Kerivoula*. However, genetic analyses confirmed around 11% divergence from other congeners making it a clear separate taxon, and one that is recognisable from the distinctive pelage coupled with external measurements (Francis et al. 2007). The formal description is based on

holotype material at the Natural History Museum London, paratypes at the Senckenberg Museum Frankfurt and the Department of Wildlife and National Parks Malaysia, together with field measurements from 56 individuals captured and released at several sites within Krau Wildlife Reserve between 1996 and 2004. Given the number of individuals detected in Krau, and the absence of records elsewhere despite extensive survey effort in forest blocks across Malaysia (Struebig et al. 2008, Lim et al. 2014), the species has been considered rare and endemic to the 137,000 ha forest block of Krau Wildlife Reserve in the centre of the Malay Peninsula. More recently, the species has been reported from extreme southern Thailand (Douangboubpha et al. 2014), and Sumatra (Huang et al. 2014), but with only 1 or 2 individuals at each site.

Here we review the distribution of *Kerivoula krauensis* following intensive forest surveys in Thailand, Indonesia, Malaysia and Brunei over the last 10 years. The extent of occurrence now includes six additional sites to Krau Wildlife Reserve, including four described here for the first time in Sumatra, Borneo and the Malay Peninsula (Figure 1). All individuals were captured in harp traps and were recognised by distinct fur pelage and external measurements. In some instances specimens and genetic samples have been collected to confirm identification, and echolocation call parameters have been quantified at two sites.

In peninsular Malaysia surveys were undertaken at Sekayu Recreational Forest (4°57'00" N, 102°57'00" E) in

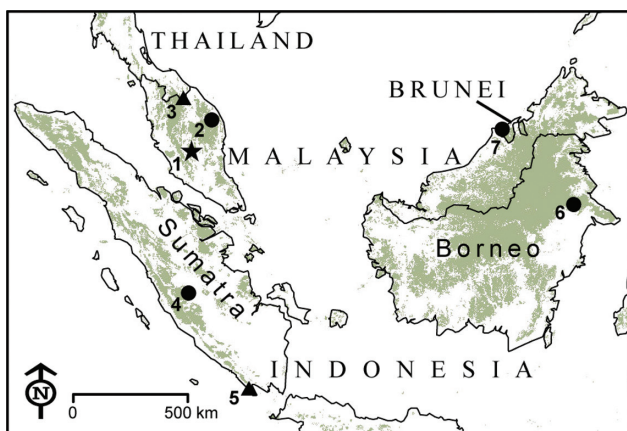
the Hulu Terengganu Tambahan Forest Reserve, south of Kuala Berang in Terengganu state (N.Z.M) in February 2010. One adult female *Kerivoula krauensis* individual was captured alongside 68 other insectivorous bats in mature lowland dipterocarp rainforest. The specimen (NZM3228) is deposited at the General Biology Laboratory, Universiti Malaysia Terengganu, Terengganu, Malaysia.

In peninsular Thailand, an adult male individual was captured in 2013 at Hala-Bala Wildlife Sanctuary (5°48'10" N, 101°49'45" E) in Narathiwat Province in similar habitat near to a swamp and a small stream (Douangboubpha et al. 2014). This specimen was collected and is housed within the Princess Maha Chakri Sirindhorn Natural History Museum, Hat Yai, Thailand (PSUZC-MM2013.50).

In Sumatra an adult male was captured over a stream in montane (ca 1600 m.a.s.l) logged-over forest at Napal Melintang (1°23'22" S, 106°53'48" E) in Sarolangun district, Jambi province in March 2014 (by S.N). The individual was subsequently released. The immediate vicinity of the trap was characterised by forest gaps and large strangler fig trees, and the wider landscape comprises limestone karst. This follows two adult specimens collected in mature lowland dipterocarp forest at Way Canguk (5°39'00" S, 104°24'00" E) ca 0–50 m. a.s.l. in Bukit Barisan Selatan National Park, Lampung province (Huang et al. 2014). These specimens (MZB 31480, 34995) are housed in Museum Zoologicum Bogoriense in Bogor, Indonesia.

In Borneo an adult male was captured in logged lowland dipterocarp forest at Sungai Lesan Protection Forest (1°36'36" N, 117°10'12" E), in the Kelai district of Berau, East Kalimantan, Indonesia in April 2005 (by M.J.S). The individual was captured and deposited in the collection of Museum Zoologicum Bogoriense (MZB 26934). Subsequently, surveys in Brunei Darussalam found an adult female individual in the Badas peat swamp forest (4°35'00" N, 114°23'00" E) in 2014 (by C.R.S. and M.G.S.), which was released.

All individuals we captured closely resemble the diagnostic characters of *Kerivoula krauensis* first described by Francis et al. (2007). Dorsal fur is dark brown, long and woolly with shiny golden tips. The ventral fur is slightly shorter with greyish-white tips (matching examples provided in Francis et al. 2007, and Douangboubpha et al. 2014). External measurements (forearm length and body mass) compare favourably with those described from individuals at the type locality (Table 1), as do cranial measurements (Table 2). The frequency range of echolocation calls from the female individual of the Brunei site differs markedly from those reported from the type locality on the Malay peninsula, but this likely reflects differences in recording equipment, which can now record at



**Figure 1:** Distribution of *Kerivoula krauensis* in insular Southeast Asia. Malaysia: Krau Wildlife Reserve (1) (Francis et al. 2007) and Sekayu Recreational Forest (2); Thailand: Hala-Bala Wildlife Sanctuary (3) (Douangboubpha et al. 2014); Indonesia: Napal Melintang (4) and Bukit Barisan Selatan National Park, Sumatra (5) (Huang et al. 2014); and Sungai Lesan Protection Forest, Kalimantan (6); Brunei: Badas Forest Reserve (7). Type locality is indicated by a star, recently published records by triangles, and new records by circles. Shaded areas indicate forest cover in 2010 (Miettinen et al. 2011).

**Table 1:** External measurements and echolocation call parameters of *Kerivoula krauensis* bats captured in the Malay peninsula, Borneo and Sumatra, together with measurements from the type locality in Krau Wildlife Reserve, Malaysia (Francis et al. 2007).

Source	Malay peninsula: Pahang, Malaysia (Francis et al. 2007)	Malay peninsula: Narathiwat, Thailand (Douangboubpha et al. 2014); and Terengganu, Malaysia (this study)	Borneo (this study)	Sumatra (this study and Huang et al. 2014)
Forearm (mm)	29♂♂: 28.2–33.3 27♀♀: 28.9–32.1	2♂♂: 30.8, 31.5	1♂♂: 28.0 1♀♀: 34.0	2♂: 29.4–30.6 1♀: 30.8
Mass (g)	29♂♂: 2.0–4.5 27♀♀: 2.0–4.5	2♂♂: 3.2, 4.1	1♂: 2.0 1♀: 2.3	1♂: 3.0
Tibia (mm)	–	1♂: 14.6	1♂: 13.0 1♀: 14.6	2♂: 13.9–14.9 1♀: 15.5
Start freq. (kHz)	3: 174±6	1♂: 225±9	1♀: 210±17	–
End freq. (kHz)	3: 50±11	1♂: 51±4	1♀: 60±10	–
Peak freq. (kHz)	–	1♂: 147±9	1♀: 137±23	–
Duration (ms)	3: 2.4±0.8	1♂: 3.3±0.4	1♀: 2.3±0.5	–

Echolocation call parameters in Francis et al. (2007) were not partitioned by sex.

**Table 2:** Skull measurements (in mm) of *Kerivoula krauensis* specimens from Borneo and Sumatra, together with mean measurements from three specimens from the type locality in Krau Wildlife Reserve, Malaysia (Francis et al. 2007).

Source	Malay peninsula: Kuala Lumpur (Francis et al. 2007)	Thai peninsula: Hala-Bala (Douangboubpha et al. 2014)	Borneo: Sungai Lesan (this study)	Sumatra: Way Canguk, (2 individuals; this study)
CBL	11.7	12.5	–	11.7, 12.1
CCL	11.4	12.0	11.4	11.3, 11.6
CM <sup>3</sup>	5.0	5.0	4.9	4.9, 5.9
M <sup>3</sup> M <sup>3</sup>	5.0	5.1	5.0	4.7, 5.1
C <sup>1</sup> C <sup>1</sup>	3.0	3.0	3.0	2.8
ZW	8.0	8.1	7.2	7.6, 8.9
BW	6.8	7.0	6.4	6.5, 6.7
CM <sub>3</sub>	5.3	5.2	5.1	5.1, 5.4

CBL, Condylbasal length from back of occipital condyles to front of premaxillaries; CCL, condylcanine length from back of occipital condyles to anterior face of canines at crowns; CM<sup>3</sup>, distance from anterior of canine to back of third upper molar at the crowns; M<sup>3</sup>M<sup>3</sup>, distance across outside of upper molars; C<sup>1</sup>C<sup>1</sup>, distance across outside of upper canines; ZW, zygomatic width; BW, braincase width; CM<sub>3</sub>, distance from anterior of lower canine to back of third lower molar.

higher frequencies than when the species was formally described. For this individual calls were recorded using an Avisoft UltrasoundGate 116Hn (sampling rate 750 kHz) attached to a condenser microphone (CM16/CMPA). The animal was recorded on release in a flight tent as the animal flew towards the microphone. All 86 calls were analyzed manually with SASLab Pro (256 FFT, FlatTop window, 87.5% overlap).

DNA barcodes were obtained from tissue samples from the Kalimantan individual (specimen MZB 26934; GenBank accession KU146863) and one of those from Sumatra (MZB 31480; KU146862). In comparison with the sequence of one of the paratypes from Krau (SMF 83824; HM540742; Francis et al. 2007), the Kalimantan specimen differed by only 0.5%, while the Sumatra specimen differed by only 1%. These differences are well within normal

intra-specific variation from the same site in other species of this genus. They are much less than the differences between any other currently recognised species in this genus (10% or greater), and also less than intra-specific differences between peninsular Malaysia and Borneo for several other *Kerivoula* (Francis et al. 2010). Records can be accessed at <http://dx.doi.org/10.5883/DS-MSKRR>.

Our bat surveys reveal the Krau Woolly bat to be more widely distributed across Greater Sunda than previously thought. The current range of *Kerivoula krauensis* now includes the islands of Borneo and Sumatra as well as the Malay-Thai peninsula south of the Isthmus of Kra. Six recent records (including four described for the first time here) place the species on national mammal inventories of Brunei, Indonesia and Thailand, as well as Malaysia where it was first described. Additional records are likely



to arise as bat field research continues in these regions. We speculate that the Krau Woolly bat could also inhabit forests north of the Isthmus of Kra, and possibly in Java, as similar-sized *Kerivoula* taxa are known to co-occur in these regions (e.g. *K. hardwickii*).

However, our review also highlights the low detection frequency of this species, even in harp traps, which are the most effective technique for capturing insectivorous bat species in the forests of the palaeotropics. At the type locality in Krau Wildlife Reserve *Kerivoula krauensis* constituted <0.4% of captures over a 3 year survey that amassed over more than 14,000 individual bats (Francis et al. 2007). Our cumulative sampling effort across Borneo, Sumatra and the Malay peninsula, combined with that of other researchers (e.g. Lim et al. 2014), is comparable to that undertaken in Krau, and confirms that the species is indeed very rarely encountered. Such low detection could reflect true rarity in the forests of Sunda, or an ineffective sampling technique. It is possible, for example, that *K. krauensis* rarely frequents the forest understorey where harp traps are typically set, and instead utilises other forest strata.

Based on the habitat of the type locality and absence of *Kerivoula krauensis* in degraded forest patches surrounding the Krau Wildlife Reserve, Francis et al. (2007) proposed that large tracts of continuous forest may be required to sustain viable populations of the species. Most additional localities described here are also within large forest blocks that are afforded protection for conservation or watershed management. These forests include peat-swamp and montane forest, as well as lowland dipterocarp forest from which the species was originally described. The presence of *K. krauensis* in a logged-over forest in Jambi, Sumatra suggests the species could perhaps tolerate some forest disturbance, although related bat taxa are known to exhibit substantial declines following logging elsewhere in Southeast Asia (Struebig et al. 2013).

Currently, *Kerivoula krauensis* is listed as data deficient by the IUCN (Chiozza 2008), although an update is due in 2016. From almost a decade of field research in Southeast Asia since the formal description in 2007, the species can be considered to exhibit a patchy forest distribution, and is probably very rare. Given the high rates of land-use change underway in Southeast Asia (Hansen et al. 2013), and the species only being reported from large tracts of forest, we consider *K. krauensis* to be highly threatened. Very little is known about the ecology of this bat species, and so sampling challenges notwithstanding, further research is warranted on roosting and foraging ecology, which in turn could lend insights into the conservation requirements of this elusive mammal species.

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## References

- Bates, P.J.J., M.J. Struebig, S.J. Rossiter, T. Kingston, S.S.L. Oo and K.M. Mya. 2004. A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Myanmar (Burma). *Acta Chiropterol.* 6: 219–226.
- Bates, P.J.J., M.J. Struebig, B.D. Hayes, N.M. Furey, K.M. Mya, V.D. Thong, P.D. Tien, N.T. Son, D.L. Harrison, C.M. Francis and G. Csorba. 2007. A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Southeast Asia. *Acta Chiropterol.* 9: 323–337.
- Chiozza, F. 2008. *Kerivoula krauensis*. The IUCN Red List of Threatened Species, version 2015.2. Downloaded on 25 June 2015.
- Douangboubpha, B., S. Bumrungsri, P. Soisook, S. Karapan and P.J.J. Bates. 2014. The discovery of *Kerivoula krauensis* (Chiroptera: Vespertilionidae) in southern peninsular Thailand provides new information on the distribution and conservation status of this data deficient species. *Songklanakarin J. Sci. Technol.* 36: 577–582.
- Francis, C.M. 1990. Trophic structure of bat communities in the understorey of lowland dipterocarp rain forest in Malaysia. *J. Trop. Ecol.* 6: 421–431.
- Francis, C.M. 2008. A guide to the mammals of Southeast Asia. New Holland Publishers, London, UK. pp. 392.
- Francis, C.M., T. Kingston and A. Zubaid. 2007. A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from peninsular Malaysia. *Acta Chiropterol.* 9: 1–12.

- Francis, C.M., A.L. Borisenko, N.V. Ivanova, J.L. Eger, B.K. Lim, A. Guillen-Servant, S.V. Kruskop, I.J. Mackie and P.D.N. Herbert. 2010. The role of DNA barcodes in understanding and conservation of mammal diversity in Southeast Asia. *PLoS One* 5: e12575.
- Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A. Tyukavina, D. Thau, S.V. Stehman, S.J. Goetz, T.R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C.O. Justice and J.R.G. Townshend. 2013. High-resolution global maps of 21st-century forest cover change. *Science* 342: 850–853.
- Huang, J.C.C., E.L. Jazdzzyk, N. Meyner, I. Maryanto, Maharadatunkamsi, S. Wiantoro and T. Kingston. 2014. A recent bat survey reveals Bukit Barisan Selatan Landscape as a chiropteran diversity hotspot in Sumatra. *Acta Chiropterol.* 16: 413–449.
- Kingston, T., G. Jones, A. Zubaid and T.H. Kunz. 1999. Echolocation signal design in Kerivoulinae and Murininae (Chiroptera: Vespertilionidae) from Malaysia. *J. Zool.* 249: 359–374.
- Kingston, T., C.M. Francis, A. Zubaid and T.H. Kunz. 2003. Species richness in an insectivorous bat assemblage from Malaysia. *J. Trop. Ecol.* 19: 67–79.
- Lim, L.-S., A. Mohd-Adnan, A. Zubaid, M.J. Struebig and S.J. Rossiter. 2014. Diversity of Malaysian insectivorous bat assemblages revisited. *J. Trop. Ecol.* 30: 111–121.
- Miettinen, J., C. Shi, W.J. Tan and S.C. Liew. 2011. 2010 land cover map of insular Southeast Asia in 250-m spatial resolution. *Remote Sensing Lett.* 3: 11–20.
- Schmieder, D.A., T. Kingston, R. Hashim and B.M. Siemers. 2010. Breaking the trade-off: rainforest bats maximize bandwidth and repetition rate of echolocation calls as they approach prey. *Biol. Lett.* 6: 604–609.
- Simmons, N. 2005. Chiroptera. In: (D.E. Wilson and D.M. Reeder, eds.) *Mammal species of the World: a taxonomic and geographic reference*. The John Hopkins University Press, Baltimore, MD. pp. 312–529.
- Struebig, M.J., T. Kingston, A. Zubaid, A. Mohd-Adnan and S.J. Rossiter. 2008. Conservation value of forest fragments to Palaeotropical bats. *Biol Conserv.* 141: 2112–2126.
- Struebig, M.J., A. Turner, E. Giles, F. Lasmana, S. Tollington, H. Bernard and D. Bell. 2013. Quantifying the biodiversity value of repeatedly logged rainforests: gradient and comparative approaches from Borneo. *Adv. Ecol. Res.* 48: 183–224.