

NOTEWORTHY MICROCHIROPTERAN RECORDS FROM THE BUKIT TIMAH AND CENTRAL CATCHMENT NATURE RESERVES, SINGAPORE

T. M. Leong^{1*} and K. K. P. Lim²

¹Central Nature Reserve, National Parks Board,
601 Island Club Road, Singapore 578775

²Raffles Museum of Biodiversity Research, Department of Biological Sciences
National University of Singapore, S6 Science Drive 2, #03-01, Singapore 117600
(*Corresponding author: leong_tzi_ming@nparks.gov.sg, baniarana@gmail.com)

INTRODUCTION

In Singapore, the most concerted efforts to study the native bat diversity in recent times must have been conducted by Shirley A. Pottie in the early 1990s, who focused on the ecology and behaviour of the microchiroptera (insect-eating bats) for her M.Sc. dissertation at the Department of Biological Sciences, National University of Singapore, under the supervision of David J. W. Lane (Pottie, 1996; Pottie et al., 2005). This was being carried out in tandem with an extensive faunal survey at the Bukit Timah and Central Catchment Nature Reserves and her findings were a valuable contribution to the overall compilation for the vertebrate species list (Teo & Rajathurai, 1997), in which 17 bat species (four megachiroptera, 13 microchiroptera) were reported.

Beginning in early 2008, the National Parks Board (NParks) embarked on a series of follow-up faunal surveys within the Bukit Timah and Central Catchment Nature Reserves, in an attempt to monitor the diversity and population status of various taxonomic groups including the bats (order Chiroptera; suborders Megachiroptera and Microchiroptera). Mist nets and harp traps were employed at multiple sites to capture bats at the most suitable locations. Our captures from the harp traps, in particular, proved to be most fruitful and have resulted in: (1) the rediscovery of a species previously thought to be extinct (*Hipposideros bicolor*), and (2) a new bat record for Singapore (*Kerivoula hardwickii*). The details and discussion for the status/discovery of each microchiropteran species are presented here.

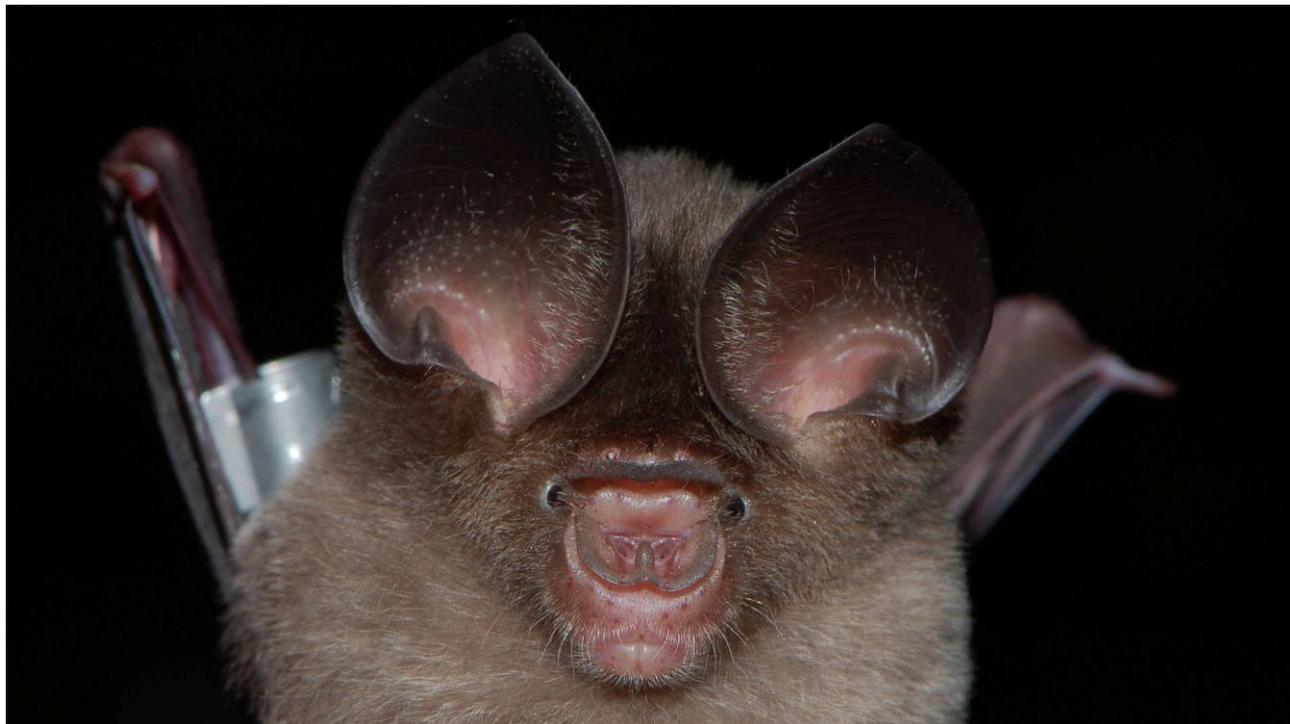


Fig. 1. Front view of a female *Hipposideros bicolor* (family Hipposideridae) first captured and tagged at the Bukit Timah Nature Reserve (BTNR) on the night of 27 Jun.2008. Note aluminium arm-band (FRIM #3682) on right forearm. Its forearm length was 46.0 mm and body weight was 8.5 g. (Photograph by: Celine Low).



Fig. 2. Side view of the same female *Hipposideros bicolor* (FRIM #3682), recaptured at the exact same site (North View Path) in the BTNR on the night of 25 Oct.2008, approximately four months later. It was examined and subsequently released. (Photograph by: Kelvin K. P. Lim).

***HIPPOSIDEROS BICOLOR* (TEMMINCK, 1834) (FAMILY HIPPOSIDERIDAE)**

The vernacular name for *Hipposideros bicolor* is the bicoloured roundleaf bat (Francis, 2008). It may be distinguished from its congeners by the following combination of characters: upperparts greyish brown, underparts buffy white, fur with white bases, ears large and round, ears and flight membrane brown, noseleaf pink, small and simple, lacking lateral leaflets and with straight internarial septum. This forest-dwelling, insectivorous species is distributed from southern Thailand, down the Malay Peninsula, Sumatra, Java, Borneo, Sulawesi, the Philippines and many adjacent islands (Kingston et al., 2006; Francis, 2008).

Hipposideros bicolor was first recorded from Singapore on the basis of two adult specimens, both skins, at The Natural History Museum (London) (Dobson, 1878: 150–151, as “*Phyllorhina bicolor*”). One was purchased (possibly from a native), while the other was acquired by the famed naturalist and explorer, Alfred Russel Wallace.

No other specimen was reported from Singapore since, and the original record was subsequently quoted by Flower (1900) and its occurrence in Singapore was mentioned by other authors (e.g., Medway, 1983; Khan, 1992). Yang et al. (1990) considered this species (as *Hipposideros bicolor atrox* Andersen) along with the fawn-coloured roundleaf bat, *Hipposideros cervinus* (Gould) and the Ridley’s roundleaf bat, *Hipposideros ridleyi* Robinson & Kloss, as having indeterminate status in Singapore. Because of the complete absence of recent records for more than a century, Pottie et al. (2005) and Lane et al. (2006) considered all three *Hipposideros* species to be extinct in Singapore. However, Baker & Lim (2008), preferred to leave the *Hipposideros* species with an indeterminate status.



Fig. 3. Close-up detail (dorsal view) of the characteristic bicoloured fur (pale base, greyish brown ends) in *Hipposideros bicolor*, hence its name, from the BTNR. (Photograph by: Celine Low, 25 Oct.2008).

In the present Bukit Timah and Central Catchment Nature Reserves survey, bats identified as *Hipposideros bicolor* were eventually obtained on two occasions at the same site in the Bukit Timah Nature Reserve (BTNR). They represent a rediscovery of this species in Singapore after more than 130 years. The first representative was found in a harp trap deployed along the North View Path at the BTNR on 27 Jun.2008. The individual was retrieved just past midnight (28 Jun.2008) and identified by visiting guest researcher, Christine Fletcher [Forest Research Institute Malaysia (FRIM)]. The female bat was examined and banded by Fletcher, who determined that it belonged to the 131 kHz (kilohertz) phonic type (Kingston et al., 2006) within the *Hipposideros bicolor* species complex. This individual was measured to have a forearm length of 46.0 mm and weight of 8.5 g. It was tagged with a light-weight aluminium band (FRIM #3682) on its right forearm and subsequently released (Fig. 1). In the same harp trap, a male specimen of *Rhinolophus lepidus* (family Rhinolophidae) was also captured, banded (FRIM #3683) and released.

During another nocturnal survey on 25 Oct.2008, three bats identified as *Hipposideros bicolor* were captured in a harp trap set at the same site (North View Path, BTNR) around 2130 hrs. All three were female, including a recapture of the same individual first encountered on 28 Jun.2008 (FRIM #3682, Fig. 2). All three bats exhibited the typical bicoloured fur of the species (Fig. 3), as previously demonstrated to us by Fletcher. Apart from the recaptured individual, the two other females were measured to have forearm lengths of 46.0 and 43.5 mm, respectively. The former (Fig. 4) was subsequently preserved as a voucher specimen and deposited at the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (ZRC.4.8183, fresh weight: 10.5 g, faecal pellets also preserved).

According to Corbet & Hill (1992: 107) four subspecies of *Hipposideros bicolor* are recognised: (1) *Hipposideros bicolor atrox* Andersen throughout the Malay Peninsula (including Singapore), and Sumatra; (2) *Hipposideros bicolor major* Andersen on the west Sumatran islands of Nias and Enggano; (3) *Hipposideros bicolor erigens* Lawrence in the Philippines; and the nominate form (4) *Hipposideros bicolor bicolor* is found in Java, the Lesser Sunda Islands and Borneo. *Hipposideros bicolor* was described in 1834 from Java by Temminck as “*Rhinolophus*” *bicolor*. It is possible that with recent investigations employing molecular and acoustic techniques, *Hipposideros bicolor* is likely to comprise a larger complex of individually distinct taxa. For instance, in Peninsular Malaysia, *Hipposideros bicolor* contains two morphologically, genetically, and acoustically distinct taxa for which taxonomic nomenclature is yet to be sorted out. According to Kingston et al. (2006), they are readily differentiated by their echolocation calls, but added that those adults with forearm lengths under 43 mm and tibia lengths under 19 mm can confidently be assigned to the form whose calls average 142 kHz. Those with forearm lengths above 45 mm, and tibia lengths over 20 mm are the larger form,



Fig. 4. Female *Hipposideros bicolor* (ZRC.4.8183, forearm: 46.0 mm, fresh weight: 10.5 g), one of three individuals of this bat species encountered on the night of 25 Oct.2008. (Photograph by: Leong Tzi Ming).

whose calls average 131 kHz. Although they can be distinguished by adult size, those specimens whose measurements fall in the zone of overlap can only be reliably identified by the call. There are, however, subtle differences which can be detected if the two are placed side by side. The 131 kHz form has a slightly flatter and more pinkish noseleaf, while the noseleaf of the 142 kHz form is more grey and curved up along the edges (Francis, 2008). From their sizes, the recent Singapore specimens were assigned to the 131 kHz form. It is not clear to which form the two specimens from The Natural History Museum belong to.

Hipposideros bicolor is an insectivorous species which forages in the understorey of lowland and hill primary rain forest. It is known to roost in caves or tunnels, and also in crevices between large boulders, sometimes in large colonies (Kingston et al., 2006; Francis, 2008). Although roost sites for this species have yet to be found for Singapore, crevices between boulders are available within, and along the fringes of the BTNR. The recapture of FRIM #3682 four months later is clear evidence that *Hipposideros bicolor* is a resident species in Singapore. It is not known why this species was not obtained during the bat surveys conducted in the 1990s, even though harp traps were already being used (Pottie et al., 2005). It may be possible that the traps were not placed in habitats or flight paths frequented by this species.

***KERIVOULA HARDWICKII* (HORSFIELD, 1824) (FAMILY VESPERTILIONIDAE)**

The vernacular name for *Kerivoula hardwickii* is Hardwicke's woolly bat (Francis, 2008). This species differs from its congeners in possessing the combination of these characters: ears funnel-shaped with long and pointed tragus, tragus without notching; fur long and woolly, the hairs with dark grey bases; upperparts grey-brown, underparts paler and more greyish; wing membrane uniformly brown and opaque; canine tooth without groove; nostrils not tubular; forearm length of adults between 29–34 mm, tibia length 16–18 mm, tail length 40–50 mm, ear length 12–14 mm, weight between 3.5–6.0 g (Kingston et al., 2006; Francis, 2008). Bats of the genus *Kerivoula* are characterised by their relatively small size, funnel-shaped ears, long and pointed tragus without notching, long and woolly fur, ungrooved canine teeth, and nostrils that are not tubular. They are confined to forest habitats, and eight species are known from Peninsular Malaysia (Kingston et al., 2006).

In Singapore, the first encounter with *Kerivoula hardwickii* was with a single specimen captured in a harp trap at Upper Seletar Reservoir forest on the night of 25 Jul.2008, at around 2100 hrs. It was caught together with three *Rhinolophus lepidus* (family Rhinolophidae). The same harp trap later caught three *Rhinolophus trifolius* individuals when checked at 2330 hrs. The male *Kerivoula hardwickii* was photographed (Fig. 5), then measured to have a forewing length of 31.8 mm, and subsequently preserved as a voucher specimen (ZRC.4.8173, fresh weight 4.2 g). Its identity was confirmed by Tigga Kingston (Texas Tech University) shortly after.



Fig. 5. Male *Kerivoula hardwickii* (family Vespertilionidae: subfamily Kerivoulinae) from Upper Seletar Reservoir forest, captured on the night of 25 Jul.2008 (ZRC.4.8173, forearm: 31.8 mm, fresh weight: 4.2 g). (Photograph by: Leong Tzi Ming).

At a later survey conducted on the night of 9 Aug.2008 at Upper Peirce Reservoir forest, three examples of *Kerivoula hardwickii* were obtained from two separate harp traps set 300 m apart along a transect. In the first harp trap (checked at 2130 hrs), a female *Kerivoula hardwickii* was found (Figs. 6, 7; forearm length: 34.5 mm), together with five *Rhinolophus lepidus* (two males, three females) and one *Rhinolophus trifoliatatus* (male). All bats were temporarily kept in individual cotton cloth bags to prevent subsequent recapture. In the second harp trap (checked at 2230 hrs), a second *Kerivoula hardwickii* was found (male, forearm: 34.9 mm), together with four *Rhinolophus lepidus* (three females, one juvenile – sex undetermined). When the first trap was revisited at 2330 hrs, a third *Kerivoula hardwickii* was caught (female, forearm: 35.5 mm). All bats were eventually released on-site at the end of the survey.



Fig. 6. Female *Kerivoula hardwickii* from the Upper Peirce Reservoir forest (forearm length: 34.5 mm), one of three individuals (two females, one male) of this bat species captured on the night of 9 Aug.2008. (Photograph by: Leong Tzi Ming).

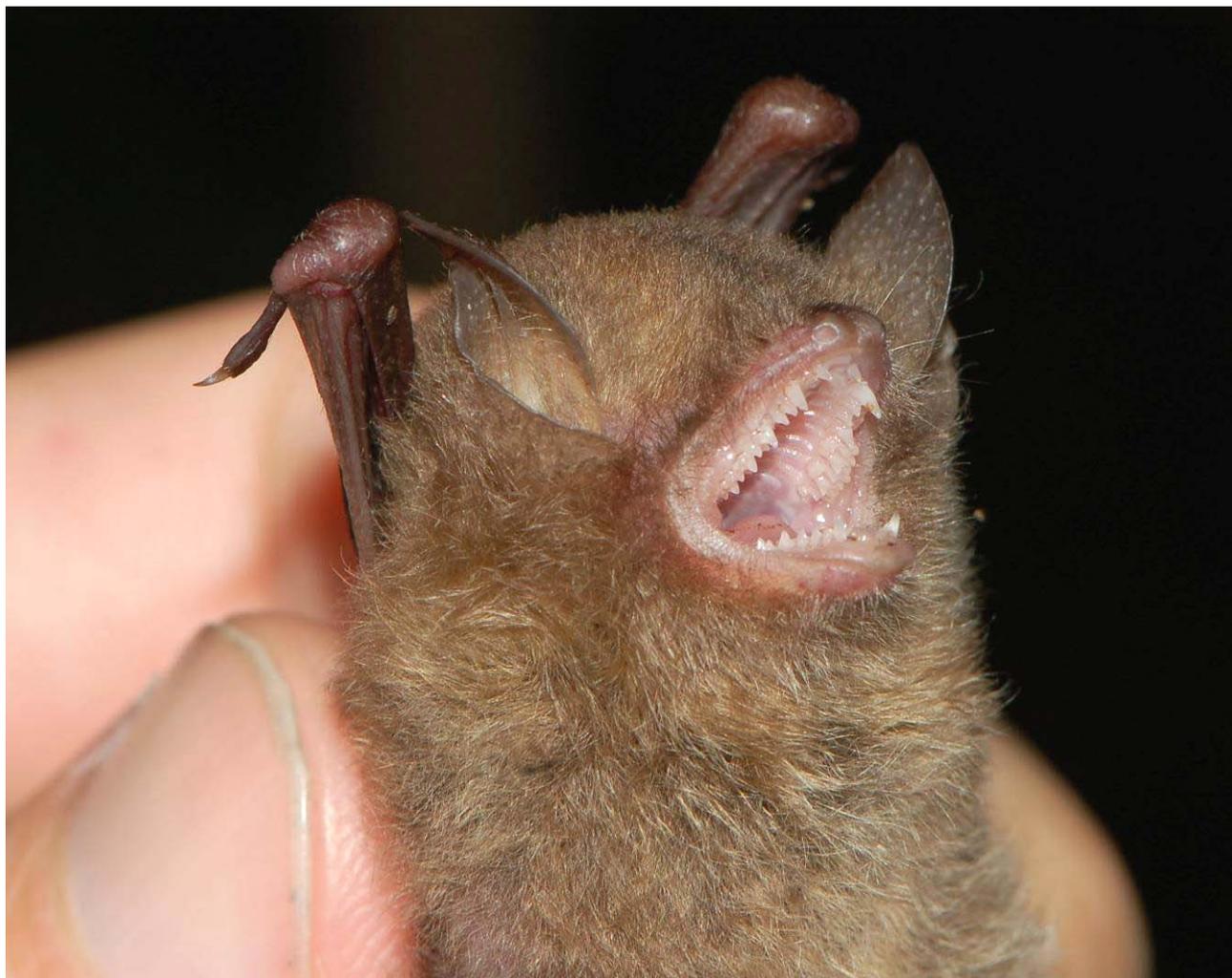


Fig. 7. Head close-up of female *Kerivoula hardwickii* from Upper Peirce Reservoir forest (9 Aug.2008). (Photograph by: Leong Tzi Ming).

On the night of 24 Jan.2009, harp trapping efforts at the Upper Seletar Reservoir forest produced two examples of *Kerivoula hardwickii*. The first was a female (forearm: 33.0 mm) retrieved in the first trap at 2215 hrs. The second was also a female (forearm: 31.6 mm) found in the second trap at 2235 hrs. It was captured together with two *Rhinolophus trifolius* (one male, one female). On the night of 14 Feb.2009, harp traps established along the Chestnut Track forest confirmed our predictions of the occurrence of *Kerivoula hardwickii* in the area, as it is contiguous with the forests of Upper Seletar Reservoir, as well as the Upper Peirce Reservoir. In the first trap (checked at 2130 hrs), a female *Kerivoula hardwickii* (forearm length: 33.2 mm) was captured, together with one *Rhinolophus trifolius* (female) and nine *Rhinolophus lepidus* (five males, four females). In the second trap (checked at 2210 hrs), two examples (one male, one female) of *Kerivoula hardwickii* were found (forearm lengths of male and female: 33.2 mm and 34.0 mm, respectively). A single male *Rhinolophus lepidus* was also found in the same trap. All bats were released thereafter.

Kerivoula hardwickii was first described from Java, and is known from Sumatra, Borneo, Sulawesi, the Philippines, and many of the smaller Indonesian islands, up through Peninsular Malaysia, Thailand, Cambodia, Vietnam, Laos, southern China, Myanmar, India and Sri Lanka (Corbet & Hill, 1992) and appears to be the most widely distributed representative of the genus in Southeast Asia (Francis, 2008). As with many widespread species, recent genetic analyses suggest that *Kerivoula hardwickii* is a species complex that needs to be reviewed and revised (Francis, 2008). It is interesting to note that bats of the genus *Kerivoula* were not recorded in the past in mainland Singapore, despite their being relatively common and diverse in Peninsular Malaysia. Lane et al. (2006) ascribed the absence of past records to the taxon's ability to avoid mist nets.

DISCUSSION

In the past five years alone, there has been an encouraging surge of research and conservation efforts directed at bats in this region, with a progressive climb in the number of new microchiropterans being named. For example, at least three

new species of *Hipposideros* have been described: *Hipposideros scutinares* Robinson et al. (2003) (Laos and Vietnam), *Hipposideros khaokhouayensis* Guillén-Servent & Francis (2006) (Laos), and *Hipposideros boeadii* Bates et al. (2007a) (Sulawesi, Indonesia). Another three new species of *Kerivoula* have also been described: *Kerivoula kachinensis* Bates et al. (2004) (Myanmar), *Kerivoula krauensis* Francis et al. (2007) (Peninsular Malaysia), and *Kerivoula titania* Bates et al. (2007b) (Cambodia). Undoubtedly, the intensive employment of harp traps in the field would have improved the yield of microchiropterans.

In the Bukit Timah and Central Catchment Nature Reserves of Singapore, it is hoped that further survey efforts involving the use of harp traps will provide us with a more accurate picture as to the population size and status of certain microchiropteran species that appear to be largely confined to the remnant forest habitats in the heart of the island.

ACKNOWLEDGEMENTS

We are most grateful to the lively Christine Fletcher and her assistant, Joann Christine a/p Luruthusamy [Forest Research Institute Malaysia (FRIM)], for generously sharing their bat expertise and enthusiasm with our survey team. We are honoured to have Dato' Dr. Abd. Latif bin Mohmod (Director General, FRIM) grant his encouraging support in allowing Christine and Joann to participate in and contribute to our faunal survey. We thank Tigga Kingston (Texas Tech University) for her confirmation of the identity of *Kerivoula hardwickii*. The dedicated team of Central Nature Reserve (CNR), National Parks Board staff and volunteer surveyors were of invaluable assistance, with their overflowing energy, interest, and initiative. Particularly worthy of mention are Aminurashid and Mishak Shunari (CNR staff), plus Vilma D'Rozario, Celine Low, Subaraj Rajathurai, Tony O'Dempsey, and Chan Kwok Wai (volunteer surveyors). We thank Celine Low for her permission to feature her photographic records. We thank an anonymous reviewer for swift response and most encouraging comments.

LITERATURE CITED

- Baker, N. & K. K. P. Lim, 2008. *Wild Animals of Singapore. A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes*. Draco Publishing and Distribution Pte. Ltd. and Nature Society (Singapore), 180 pp.
- Bates, P. J. J., M. J. Struebig, S. J. Rossiter, T. Kingston, Sai Sein Lin Oo & Khin Mya Mya, 2004. A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Myanmar (Burma). *Acta Chiropterologica*, **6**(2): 219–226.
- Bates, P. J. J., S. J. Rossiter, A. Suyanto & T. Kingston, 2007a. A new species of *Hipposideros* (Chiroptera: Hipposideridae) from Sulawesi. *Acta Chiropterologica*, **9**(1): 13–26.
- Bates, P. J. J., M. J. Struebig, B. D. Hayes, N. M. Furey, Khin Mya Mya, D. T. Vu, D. T. Pham, T. S. Nguyen, D. L. Harrison, C. M. Francis & G. Csorba, 2007b. A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Southeast Asia. *Acta Chiropterologica*, **9**(2): 323–337.
- Corbet, G. B. & J. E. Hill, 1992. *The Mammals of the Indomalayan Region: A Systematic Review*. Natural History Museum Publications & Oxford University Press. 488 pp.
- Dobson, G. E., 1878. *Catalogue of the Chiroptera in the Collection of the British Museum*. xlii + 567 pp., 30 pls.
- Flower, S. S., 1900. On the Mammalia of Siam and the Malay Peninsula. *Proceedings of the Zoological Society of London*, 1900 [3 Apr.]: 306–379.
- Francis, C. M., T. Kingston & A. Zubaid, 2007. A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Peninsular Malaysia. *Acta Chiropterologica*, **9**(1): 1–12.
- Francis, C. M., 2008. *A Field Guide to the Mammals of Southeast Asia*. New Holland Publishers (UK) Ltd., 392 pp.
- Guillén-Servent, A. & C. M. Francis, 2006. A new species of bat of the *Hipposideros bicolor* group (Chiroptera: Hipposideridae) from Central Laos, with evidence of convergent evolution with Sundaic taxa. *Acta Chiropterologica*, **8**(1): 39–61.
- Khan, M. M., 1992. *Mammalia Semenanjung Malaysia* (Mammals of Peninsular Malaysia). Jabatan Perlindungan Hidupan Liar dan Taman Negara, Semenanjung Malaysia (Department of Wildlife and National Parks, Peninsular Malaysia). xiv + 182 pp. [Text in Malay].
- Kingston, T., B. L. Lim & Zubaid Akbar, 2006. *Bats of Krau Wildlife Reserve*. Penerbit Universiti Kebangsaan Malaysia. 145 pp.
- Lane, D. J. W., T. Kingston & B. P. Y.-H. Lee, 2006. Dramatic decline in bat species richness in Singapore, with implications for Southeast Asia. *Biological Conservation*, **131**: 584–593.
- Medway, Lord, 1983. *The Wild Mammals of Malaya (Peninsular Malaysia) and Singapore. 2nd Edition*. Oxford University Press, Kuala Lumpur. xxiii + 131 pp.
- Pottie, S. A., 1996. Studies on the ecology and behaviour of insectivorous bat species in Singapore. M. Sc. Thesis, National University of Singapore. 126 pp.
- Pottie, S. A., D. J. W. Lane, T. Kingston & B. P. Y.-H. Lee, 2005. The microchiropteran bat fauna of Singapore. *Acta Chiropterologica*, **7**(2): 237–247.

- Robinson, M. F., P. D. Jenkins, C. M. Francis & J. C. Fulford, 2003. A new species of the *Hipposideros pratti* group (Chiroptera: Hipposideridae) from Lao PDR and Vietnam. *Acta Chiropterologica*, **5**(1): 31–48.
- Teo, R. C. H. & S. Rajathurai, 1997. Mammals, reptiles and amphibians in the Nature Reserves of Singapore: Diversity, abundance and distribution. *Gardens' Bulletin Singapore*, **49**(2): 353–425.
- Yang C. M., K. Yong & K. K. P. Lim, 1990. Wild mammals of Singapore. In: Chou L. M. & P. K. L. Ng (eds.), *Essays in Zoology*. Papers commemorating the 40th Anniversary of the Department of Zoology, National University of Singapore. Pp. 1–23.