

BAT SPECIES IN THE FORESTS RESERVES OF PENANG ISLAND AFTER 2010: WITH TWO MORE NEW RECORDS FILED

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Abstract: Bat communities in Old World tropical rainforests serve various ecological roles to sustain their habitats, yet may be vulnerable to the loss of their natural habitats. Moreover, the exact biological and ecological roles of the majority of the bats in Penang Island are still understudied. Therefore, we conducted surveys at four selected primary forest reserves (Bukit Genting, Penang National Park, Relau and Teluk Bahang) on Penang Island to determine the forest bat species currently living on the island. This study was conducted using harp traps and mist nets from February 2015 to August 2016. A total of 135 individuals, four families and 11 species of bats were caught with an average capture rate of 2.7 bats per harp-trap night and 4.05×10^{-3} bats per mist-net metre square hour. *Cynopterus brachyotis* was the only Pteropodids species recorded and *Rhinolophus affinis* has the highest capture number in our surveys. Along with *Coelops frithii* reported earlier, two new species, namely *Myotis muricola* and *Phoniscus jagorii*, were documented for the first time in Penang Island, indicating that the forest bat community here is still undersurveyed. Our survey results suggested that the primary forests on Penang Island are valuable for bat conservation in terms of hosting uncommon forest species.

Keywords: Chiroptera, primary forests, tropical rainforests, insular bats, bat conservation.

Introduction

Penang Island is an island that is approximately 285 km² in size and located off the northwest coast of Peninsular Malaysia (Pradhan *et al.*, 2012). It is the most developed and populated island of Malaysia (Tan *et al.*, 2010). Therefore, just like other parts of Southeast Asia (Sodhi *et al.*, 2004), Penang Island is also undergoing massive deforestation. The forest cover on Penang Island has decreased from around 125 km² to 104 km² within an eight-year period from 1999 to 2007 (Tan *et al.*, 2010).

Deforestation in Southeast Asia causes habitat loss and degradation as many species depends on forests, including bats. This region is also well known for its rich diversity of bats (Kingston, 2013), as about one third of the total mammal species found here are bat species (Francis *et al.*, 2010; Kingston, 2010). The common bat families in the region,

namely Hipposideridae, Rhinolophidae, Vespertilionidae (especially the subfamilies Murininae and Kerivoulinae), have adapted to and are known to depend on tropical rainforests (Kingston *et al.*, 2003).

While these bat species are very dependent on tropical rainforests, they nevertheless contribute to forest regeneration and conservation in several ways (Muscarella & Fleming, 2007; Jones *et al.*, 2009; Francis, 2017). Bats that feed on fruits and nectar become pollinators of its target tree species (Hodgkison *et al.*, 2003; Nor-Zalipah *et al.*, 2016). Frugivorous bats disperse seeds while consuming fruits away from the tree or through their faeces, while nectarivorous bats disperse pollen while feeding on nectar (Muscarella & Fleming, 2007; Preciado-Benítez *et al.*, 2015). In fact, frugivorous and nectarivorous bat species that have a big home range can sustain more than one forest fragments and prevent inbreeding of

plant species within the forest islands (Law & Lean, 1999; Acharya *et al.*, 2015). In addition, insectivorous bats suppress the population size of their prey and maintain a balance of the forest ecosystem (Kalka *et al.*, 2008).

In order to prevent total forest clearing on the island, numerous patches of primary forests on Penang Island were gazetted as forest reserves. These include the Penang National Park, Teluk Bahang Forest Reserve, Bukit Kerajaan Forest Reserve, Relau Forest Reserve, Bukit Genting Forest Reserve and Balik Pulau Forest Reserve. The Penang National Park was the first protected area gazetted under the National Park Act of 1980. There has been no logging in all of these forest reserves, except the Penang National Park, which stopped only in 1996 (Hong, 2009). The Teluk Bahang Forest Reserve and Penang National Park are open for recreational purposes, and the Relau Forest Reserve and Bukit Genting Forest Reserve are restricted to the public.

Although the bats on Penang Island, which hosts diverse of modified landscapes, were the most studied in comparison to those on the other islands along Peninsular Malaysia's coastline (Azuan *et al.*, 2016; Nur-Izzati, 2018; William-Dee *et al.*, 2019), previous records were scarcely distributed between the last century till now (e.g. Anon, 1900; Hill, 1974; Langham & Ho, 1977; Medway, 1978; Francis, 2008). No detail revisions on bats from various habitats on the island, including the depleting primary forests, have been conducted or filed to date.

While we are planning to further study or monitor bats in the forests of Penang Island, it is essential to conduct surveys to obtain a more comprehensive checklist on the bat species in these forests. Therefore, in this study, we aim to determine the bat species in four forest reserves on Penang Island. The selected forest reserve sites represent the primary forests in the northwest, central and southern part of Penang Island.

Research Methodology

Field Sites

We surveyed four primary tropical lowland evergreen rainforest sites located in the northwestern, the centre and the southwestern parts of Penang Island between February 2015 and August 2016 (Figure 1, Table 1). All of the sites are below 1,000 m above sea level (Symington, 1943) and hilly. They serve as water catchment areas, and have research, education and recreational purposes for local residents. However, the Penang National Park is a tourism spot visited by both local residents and foreign tourists (Hong & Chan, 2010).

Bat Trapping

The bat trapping as conducted during nights with good weather. Three to four trap nights per session were conducted at each location. Two to four four-bank harp traps were set across trails before 7.00 pm and checked hourly until 11.00 pm. The harp traps were then left overnight at the location and rechecked the next morning at approximately 6.00 am, right before they were closed. Meanwhile, two to four mist nets (9 m × 4 m, 2.5 mm mesh size) were set simultaneously to target non-echolocating bats and were checked every 15 to 20 minutes before being closed at 11.00 pm. The mist nets were placed randomly along the trails at the edge of the forests or natural tree gaps.

Bat Identification

The captured bats were held individually in cloth bags before they were examined. During the process of identification, the body mass, measurements of external body parts (e.g. forearm, ear and tibia lengths), age (Nagorsen & Brigham, 1993), reproductive stages and sex of each captured individual were recorded. Each captured individual was identified based on the external features and measurements following the methods by Kingston *et al.* (2006) and Francis (2008). The captured bats were released as soon as possible after all the required information was obtained.

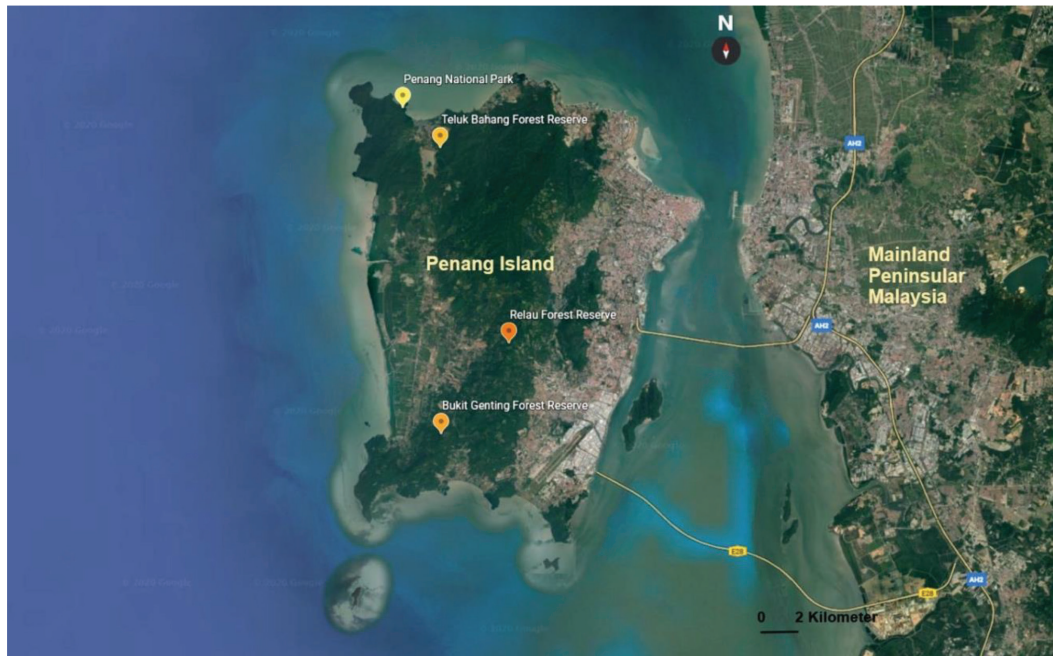


Figure 1: The locations of the four forest sites (marked with 📍) on Penang Island surveyed in this study. The colour of the 📍 indicates the altitude level of the site, with light yellow representing the lowest site from sea level, to orange representing the highest from sea level among the four sites

Data Analysis

The harp-trapping and mist-netting efforts at each site were calculated by either multiplying the total number of harp traps of all the trapping nights at the site or by the total area of mist nets opened and the total hours of spread during all the netting nights at the site. Nonetheless, the capture rate (the total number of bats captured from one site divided by the trapping or netting efforts at the site) for each site were also quantified.

Results and Discussion

Each site was visited for three continuous days, which resulted in a total of 11 to 12 harp trap nights and at least 432 m²h of mist nets being set up at each surveyed forest site (Table 1). A total of 135 bats were caught at all four sites, with an average capture rate of 2.7 bat per harp trap night for all harp traps across the sites, as well as an average capture rate of 4.05×10^{-3} bat per metre square hour for the mist nets. Forested

areas may have a lower capture rate (Khan *et al.*, 2007; Fukuda *et al.*, 2009), but support a variety of bat species due to the abundance of food choices, especially insects, which can cater to many bats preferences (Threlfall *et al.*, 2012). However, some bat species, like *Balionycteris maculata*, *Penthetor lucasi* and *Hipposideros cervinus*, are more abundant in the primary forest sites (Fukuda *et al.*, 2009).

The captured bats were identified and grouped into four families, Pteropodidae, Hipposideridae, Rhinolophidae and Vespertilionidae. A total of 11 bat species were recorded in the forested areas in Penang Island (Table 2). Besides *Cynopterus brachyotis*, all of the species captured in this study were recorded in the occurrence dataset for Biodiversity Information Fund for Asia (BIFA) project (Nur-Izzati *et al.*, 2020). *Cynopterus brachyotis* is the only frugivorous bat species that was captured. There were eight species of frugivorous and nectarivorous bat species found on the whole Penang Island, which included the

aforementioned *Cynopterus brachyotis*, along with *Cynopterus sphinx*, *Cynopterus horsfieldii*, *Eonycteris spelaea*, *Macroglossus minimus*, *Macroglossus sobrinus*, *Dyacopterus spadiceus* and *Penthetor lucasi* (Nur-Juliani, 2016). The other 10 bat species found during this study were all insectivores. The Vespertilionid bats caught during our surveys were from the Vespertilionid genera *Myotis* and *Kerivoula* (Table 2). *Rhinolophus affinis* was the most abundant understory bat species found in Penang Island's primary forests during our survey, followed by *Rhinolophus lepidus*.

Only one individual each of the bat species *Hipposideros galeritus*, *Myotis muricola* and *Phoniscus jagorii* were captured in the survey. These single individual captures reflect the capture rarity of the species and indicate the highly uneven species distribution (Robinson et al., 2000; Kingston, 2001). Capture rarity may reflect the low population density, as well as the possibility of definite roosting selection, which leads to wider distributions and may appear as patchy distributions in some cases (Kingston, 2001). It is also worth to mention here that Penang is also the type locality for *H. galeritus* (Cantor, 1846; Tate, 1941). In fact, two of our singletons, which are *M. muricola* and *P. jagorii* have never been reported from Penang Island, making the singletons reported here the first record of the two species on Penang Island.

According to the Red List of Mammals for Peninsular Malaysia by the Department of Wildlife and National Parks (PERHILITAN), Peninsular Malaysia, the records for and status of *Hipposideros kunzi* are not available, *Rhinolophus pusillus* are data deficient, and *Phoniscus jagorii* fall under Criteria D2 vulnerable. There is no record of *Hipposideros kunzi* in the list due to the recent update on the species taxonomy, which we can assume has not yet been evaluated by PERHILITAN. The data deficient status for *Rhinolophus pusillus* may be due to the limited amount of information available on this particular bat species and not much study has been conducted to assess the species to date. *Phoniscus jagorii* was classed

as vulnerable because the species currently occupies an area of less than 2,000 km² and has continued to be in decline, or had declined by more than 30%, over the past 10 years, with an assumption that the species experienced a proportional decline with the population that was supported and was gravely affected by habitat loss (PERHILITAN, 2017). More research should be conducted in the near future to update the list regularly so that any conservation effort can be carried out to preserve these bats species in Peninsular Malaysia.

All the species detected in our survey were categorised as Least Concern in the IUCN Red List of Threatened Species (Table 2). *Hipposideros atrox* was previously named *Hipposideros bicolor-142* and *Hipposideros bicolor* reported in this study was previously known as *Hipposideros bicolor-131* (Kingston et al., 2001). The *H. bicolor* complex was reviewed and *H. atrox* was filed in 2010 (Douangboubpha et al., 2010) and to date, *Hipposideros bicolor-142* has been described as *Hipposideros kunzi*, with a completely new description by Murray et al. (2018). *Hipposideros atrox* was classified in the IUCN Red List as a Least Concern (LC) species (Douangboubpha, 2019) and *H. kunzi* is not yet listed, but Murray et al. (2018) suggested that *H. kunzi* should be evaluated as a Least Concern species.

Cynopterus brachyotis, *Rhinolophus affinis* and *Rhinolophus lepidus* are the species with a bigger home range and able to travel among nearby forest fragments (Bumrungsri, 2002; Struebig et al., 2009). Therefore, it is estimated that these three species, which have the highest capture frequencies in our study, will not be severely affected by deforestation on the island, but by the complexity of the vegetation structure (Huang et al., 2019). The other species found in our surveys, especially *H. galeritus* and *P. jagorii* are very dependent on the forests and travel within a small home range with low vagility (Furey & Racey, 2016), thus may not survive loss of forest habitat.

All the four forest sites were visited only one time for three continuous days. Thus, the bat

species captured in this study represented only a part of the bat fauna of the forest reserves. Our survey results were also affected by other factors, such as season and survey spots at the sites (Cisneros *et al.*, 2015). The Penang National Park, for instance, was surveyed in 2011 and 16 bat species were found (Khan *et al.*, unpublished data), but it was conducted at the site that yielded only three captured individuals from two species (refer to the species captured in the Penang National Park in Table 2) in this survey (Nur-Izzati, 2018). The compilation of surveys in 2011 and 2016 for the Penang National Park did not add any bat species to the list (Table 3). This may be due to the fact

that our trapping sessions were conducted during the dry season in April 2016, and there was no rain in Penang Island since February 2016. Furthermore, the field methods we used could target only bats that fly and forage in the understorey of the forest. Canopy nets and acoustic surveys are needed to survey bats that fly in open spaces and at the canopy level. For the *Coelops frithii* that was recorded on Penang Island (Huang *et al.*, 2019) but was not captured in the primary forest reserves, this shows that the use of mist nets and harp traps to trap bats can still lead to a new locality of uncommon bat species on this island being recorded.

Table 1: Trapping efforts and capture rates of the four surveyed forest reserve sites on Penang Island

Forest Site	Coordinates	Area (km ²)*	Altitude Range (m)	Date of Survey	Trapping Effort ^a (harp traps)	Netting Effort ^b (mist nets) (m ² h)	Capture Rate ^c (harp traps)	Capture Rate ^c (mist nets)
Teluk Bahang Forest Reserve	05°26.732'N 100°13.166'E	8.30	28-114	26-28 February 2015	12	648	5.5	9.26×10 ⁻³
Penang National Park	05°27.876'N 100°12.075'E	12.13	14-67	15-17 April 2016	12	648	0.17	1.54×10 ⁻³
Relau Forest Reserve	05°21.121'N 100°15.144'E	0.67	351-381	19-21 July 2016	12	NA	2.50	NA
Bukit Genting Forest Reserve	05°18.517'N 100°13.200'E	0.09	291-319	16-18 August 2016	11	432	2.73	0

*information obtained from PERHILITAN (2020) and Penang State Forestry Department (2020)

^aTrapping effort (harp traps) = total number of harp traps set in the survey

^bNetting effort (mist nets) = total area multiplied by total hour of spread of the mist nets in the survey

^cCapture rate = number of bats captured per trapping/netting effort

NA = not available

Table 2: The Red List of mammals for Peninsular Malaysia by the Department of Wildlife and National Parks (PERHILITAN), Peninsular Malaysia and the International Union for Conservation of Nature (IUCN) Red List and the number of bats captured for each species in all four forest sites (Teluk Bahang Forest Reserve, Penang National Park, Relau Forest Reserve and Bukit Genting Forest Reserve) on Penang Island

Family Species	Red List of Mammals for Peninsular Malaysia (2017)	IUCN Red List Category (2020)	Numbers of Captured Individuals				
			Teluk Bahang Forest Reserve	Penang National Park	Relau Forest Reserve	Bukit Genting Forest Reserve	
Pteropodidae							
<i>Cynopterus brachyotis</i>	Least Concern	Least Concern	6	1	-	-	
Hipposideridae							
<i>Hipposideros kunzi</i>	Not Available	Not Available	2	-	1	1	
<i>Hipposideros bicolor</i>	Least Concern	Least Concern	3	-	-	-	
<i>Hipposideros galeritus</i>	Least Concern	Least Concern	1	-	-	-	
Rhinolophidae							
<i>Rhinolophus affinis</i>	Least Concern	Least Concern	46	-	8	18	
<i>Rhinolophus lepidus</i>	Least Concern	Least Concern	11	-	13	3	
<i>Rhinolophus pusillus</i>	Data Deficient	Least Concern	-	-	-	3	
<i>Rhinolophus stheno</i>	Least Concern	Least Concern	3	-	5	2	
Vespertilionidae							
<i>Myotis muricola</i>	Least Concern	Least Concern	-	-	-	1	
<i>Phoniscus jagorii</i>	Vulnerable (Criteria D2)	Least Concern	-	-	-	1	
<i>Kerivoula hardwickii</i>	Least Concern	Least Concern	-	2	3	1	
Total number of individuals			72	3	30	30	
Total number of species			7	2	5	8	

- = absent/not available

Table 3: Bats surveyed in the Penang National Park from 2011 until 2016
(Khan *et al.*, unpublished data; Nur-Izzati, 2018)

Family Species	Numbers of Individual Bat Captured in Penang National Park
Pteropodidae	
<i>Cynopterus brachyotis</i>	22
<i>Cynopterus sphinx</i>	4
Hipposideridae	
<i>Hipposideros armiger</i>	2
<i>Hipposideros kunzi</i>	9
<i>Hipposideros cineraceus</i>	9
<i>Hipposideros galeritus</i>	1
<i>Hipposideros larvatus</i>	2
Rhinolophidae	
<i>Rhinolophus affinis</i>	9
<i>Rhinolophus lepidus</i>	2
Megadermatidae	
<i>Megaderma spasma</i>	2
Miniopteridae	
<i>Miniopterus magnater</i>	1
Vespertilionidae	
<i>Myotis adversus</i>	7
<i>Pipistrellus tenuis</i>	10
<i>Tylonycteris pachypus</i>	1
<i>Tylonycteris malayana</i>	3
<i>Kerivoula hardwickii</i>	4
Total number of individuals	88
Total number of species	16

Conclusion

A survey on the primary forest reserves on Penang Island between 2015 and 2016 lead to the recording of 11 species of bats from four families. Among the species recorded in this study, *Phoniscus jagorii* and *Myotis muricola* were recorded for the first time. These new records suggested that the forest bat communities on Penang Island are still under surveyed. Although the abundance of bats may not be high in these primary forest reserves, the primary forests on the island are still valuable for the conservation of bats, since these natural habitats may harbour uncommon species. In turn, the bat species that are highly dependent

on the primary forests, such as *H. galeritus* and *P. jagorii*, can become potential bioindicators to monitor the quality of the primary forests on Penang Island.

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