

NOTES OF BATS IN PULAU BIDONG AND PULAU PERHENTIAN BESAR, TERENGGANU, MALAYSIA

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Abstract: The study of bats was conducted in Pulau Bidong and Pulau Perhentian Besar from 31st May to 7th July and 13th to 20th August 2015. This study aimed to document the first record of bats and to construct a checklist in for these two off-coast islands in South China Sea. Standard mist nets and harp traps were used throughout the study. A total of 116 individuals comprised of ten species of bats were captured. The most abundant species of chiropterans for both islands was *Cynopterus brachyotis* with 74 individuals whereas the least was *Eonycteris spelaea* with only one individual. Two species; *Rhinolophus lepidus* and *Hipposideros cineraceus* were new records for Pulau Perhentian Besar. A long-term study covering other areas and habitat types within Pulau Perhentian Besar and the surrounding islands will definitely increase the bats records in the future.

Keywords: Bats, Pulau Bidong, Pulau Perhentian Besar, checklist, South China Sea.

Introduction

Bats are the second most diverse group of mammals on earth after rodents with 1,116 species currently have been described (Kunz & Parsons, 2009). Meanwhile, in Malaysia, there are 125 species of bats in Malaysia which accounts for 10% of the world's bat fauna (Kingston *et al.*, 2006). Recently, Abdullah (2016) documented over 100 species including genetic species and morphological species of bats in Malaysia.

Although many types of research on bats have been conducted in Peninsular Malaysia mainland, there is little known on the bats in Peninsular Malaysian forested islands specifically in Malaysian east-coast islands. Malaysian east-coast islands, particularly in Terengganu and Pahang, are well-known tourist destinations for its white sandy beaches, coral reefs, and clear blue seas. Three islands in Malaysian east coast islands, namely, Pulau Perhentian, Pulau Redang, and Pulau Tioman have been listed among the top 10 islands for a holiday in Malaysia by Ostheimer (2012). However, the uncontrolled tourism industry in

Malaysian east-coast islands threatens the bat population here especially the island's specialist flying fox, *Pteropus hypomelanus* (Roslan *et al.*, 2015). The fast-growing tourism industry particularly the unrestrained tourist operators over the last few decades have caused an increasing number of tourist arrivals into the islands' natural areas (Tamblyn *et al.*, 2005).

In view of less published studies being done in Malaysian east-coast islands and the threats of the tourism industry on terrestrial flora and fauna, we conducted a bat survey in Pulau Bidong and Pulau Perhentian Besar. Both islands are located in Terengganu, east-coast state of Malaysia. The aim of this study was to document and update the bat checklist in these two islands and therefore highlighting the needs for sustainability forest management in the future.

Material and Methods

Sampling Sites

The study in Pulau Bidong was done from 31st May to 7th July 2015. The Bidong Archipelago

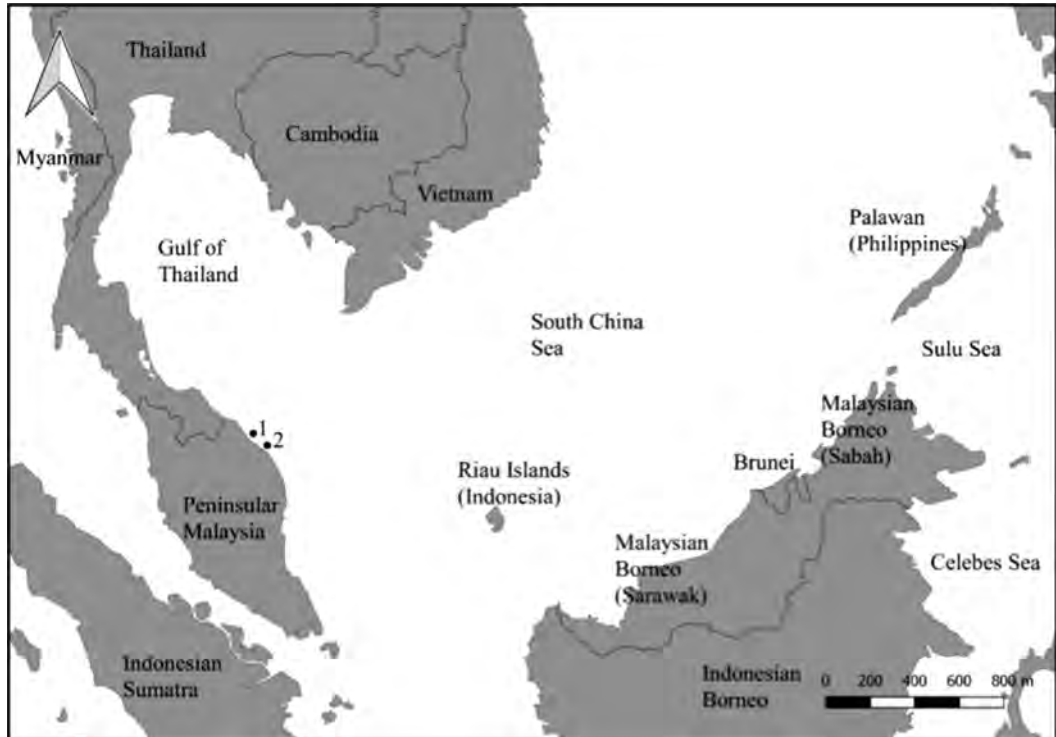


Figure 1: Map showing study sites in Peninsular Malaysia and Southeast Asia, 1= Pulau Perhentian Besar and 2= Pulau Bidong

covers six islands with the largest island of about 260 ha and is located eight nautical miles from the Merang Beach, Terengganu. It was a Vietnamese refugee's settlement area who fled their war-torn country during the 70 s and 80 s. Even though it is a small island, it was once one of the most populated islands in the world when 40,000 refugees inhabited this island in 1979. It was closed in 1991 and now serves as a maritime research centre for Universiti Malaysia Terengganu (UMT) in the western part of the island known as Pantai Pasir Cina. The trees species that can be found here are *Licania splendens*, *Vatica cinerea*, *Calophyllum rupicola*, *Syzygium cinereum* and *Symplocos adenophylla* through 50m x 50m plot. However, only one species, *Diospyros* sp. was observed fruiting (Pesi, 2015). Meanwhile, outside of the plot, it was observed that *Terminalia cattapa*, *Hibiscus tiliaceus*, *C. rupicola* and *Vitex pinnata* were observed to have undergone fruiting (Pesi, 2015).

The study in Pulau Perhentian Besar was done from 13th to 20th August 2015. Perhentian Archipelago consists of 11 small islands and the largest island in this archipelago is Pulau Perhentian Besar (Tamblyn *et al.*, 2005). It is situated 21 km from the mainland of Terengganu. Pulau Perhentian is the most famous island among local and international tourists. Pulau Perhentian Kecil is more developed than Pulau Perhentian Besar because it has Malay village, resulted in more tourism activities and infrastructure concentration there. Our study site was located in Teluk Keke, Pulau Perhentian Besar which is behind the camping site and along the forest trail. Through 50 m x 50 m plot, it was observed that the tree species such as *V. pinnata*, *Morinda elliptica*, *Sindora cochinchinensis*, and *Syzygium* sp. have undergone fruiting whereas *Vatica cinerea*, *Syzygium cinereum*, *Buchanania arborescens*, and *Cratoxylum formosum*, *Chaetocarpus castanocarpus* have not undergone fruiting (Pesi, 2015).

Field Methodology

Our field sampling was conducted using five mist nets that were placed in the understory at the range height of below 5 m while five mist nets were placed at the canopy level at the height of 10 m to 15 m for both islands. Two harp traps (four-banks harp traps) were set up nearby the old cemetery in Pulau Bidong, along the forest trails, and cave opening in Pulau Perhentian Besar. The ground mist nets that were deployed at the areas believed to be in the flyways of bats such as trails, forest edges, above streams, and the cave opening (Khan *et al.*, 2007; Mohd-Azlan *et al.*, 2005). The sub-canopy mist nets were set up by tying the lead fishing weight to a monofilament fishing line and then were shot over tree branches by using a sling shot (Kunz & Parsons, 2009). When the monofilament line has been positioned at the targeted location, it was then used to pull nylon ropes. The same method was then repeated to the second selected branch of tree within the same range of height with the first one. The mist nets were then tied to the rope and pulled to the desired height.

The heights of the traps were taken by using distance finder (Bosch DLM-50M) and through the measurement of the rope. The bats' external morphological measurements were taken by using a digital calliper and weighed by using digital weighing balance (Abdullah, 2003). Adult individuals were determined through the observation epiphyseal-diaphyseal fusion on the third, fourth and fifth metacarpals (Kunz, 1988). Selected bats were also photographed for future references.

Female bats were also observed to determine the breeding status (carrying pups, lactating, or pregnant) (Mohd-Ridwan *et al.*, 2011). The samples captured were marked with nail polisher before being released to the sampling site. Selected voucher specimens were euthanized and preserved in 70% ethanol solution following Abdullah *et al.* (2010). The preserved specimens were then deposited at Museum of Zoology Kenyir (MZK). Species identification followed characterization keys from Francis (2008) and Kingston *et al.* (2006).

Results

A total of three species and 84 individuals were collected in Pulau Bidong whereas in Pulau Perhentian Besar there were 35 individuals comprised of nine species recorded in this study (Table 1). The most abundance species were *Cynopterus brachyotis* with ten individuals in Pulau Perhentian and 64 individuals in Pulau Bidong whereas the least species in this study was *Eonycteris spelaea* with one individual in Pulau Perhentian and one individual of *Megaderma spasma* in Pulau Bidong.

Comparison with previous study in Pulau Perhentian Besar

Our result in Pulau Perhentian Besar was compared with the previous study by Tamblyn *et al.* (2005) (Table 2). The unconfirmed species, *Emballonura* spp., *Rhinolophus affinis/stheno*, *R. convexus/refulgens* and *Myotis* spp. in Tamblyn *et al.* (2005) were not included in this table. From the comparison, the current checklist of bat is increases with the two newly recorded species *R. lepidus* and *H. cineraceus* in our study. Meanwhile, there were no research on terrestrial mammals conducted previously in Pulau Bidong, and our study marked the first record of bats study in this island.

Comparison with other Malaysian east-coast islands

The result of this study was compared with other east-coast islands, Pulau Redang and Pulau Tioman (Table 3) followed Tamblyn *et al.* (2005) with updated new list of species in Pulau Perhentian Besar, Pulau Bidong, net nights and capture rate.

From the Table 3, it was observed that Tamblyn *et al.* (2005) recorded more species in Terengganu coastal islands of Pulau Perhentian Besar with 11 species from 136 individuals compared to this study which recorded only ten species from 35 individuals in Pulau Perhentian Besar and Pulau Bidong with four species from 84 individuals. This is because Tamblyn *et al.* (2005) covered more areas in Pulau Perhentian

Table 1: Total number of species and individuals in Pulau Bidong and Pulau Perhentian Besar

Family	Species	Pulau Bidong		Pulau Perhentian Besar	
		Height (m)	N	Height (m)	N
Pteropodidae	<i>Cynopterus brachyotis</i>	4	6	2	1
		8	1	11	4
	<i>Cynopterus cf. brachyotis</i> Forest	4	33	12	2
		8	24	2	1
				11	1
				12	1
	<i>Eonycteris spelaea</i>	-	-	3.5	1
	<i>Pteropus hypomelanus</i>	8	16	Observation	3
		15	3		
Megadermatidae	<i>Megaderma spasma</i>	4	1	2	2
Rhinolophidae	<i>Rhinolophus affinis</i>	-	-	3	1
				2	1
	<i>Rhinolophus lepidus</i>	-	-	2	2
Hipposideridae	<i>Hipposideros bicolor</i>	-	-	2	7
	<i>Hipposideros cineraceus</i>	-	-	2	2
	<i>Hipposideros larvatus</i>	-	-	2	5
				3	1

*The height were measured from the forest floor to the upper mist nets and harp traps, N=number of individuals.

Table 2: Taxonomic comparison with previous study in Pulau Perhentian Besar

Species name	Tamblyn <i>et al.</i> (2005)	This study
Pteropodidae		
<i>Cynopterus brachyotis</i>	+	+
<i>Cynopterus cf. brachyotis</i> Forest	-	+
<i>Eonycteris spelaea</i>	+	+
<i>Pteropus hypomelanus</i>	+	+
Emballonuridae		
<i>Emballonura monticola</i>	+	-
<i>Taphozous melanopogon</i>	+	-
Megadermatidae		
<i>Megaderma spasma</i>	+	+
Rhinolophidae		
<i>Rhinolophus affinis</i>	+	+
<i>Rhinolophus lepidus</i> *	-	+
Hipposideridae		
<i>Hipposideros bicolor</i>	+	+
<i>Hipposideros larvatus</i>	+	+
<i>Hipposideros cineraceus</i> *	-	+
Vespertilionidae		
<i>Myotis muricola</i>	+	-

*New record from this study , +=Present, -=Absent.

Note that Tamblyn *et al.* (2005) combined *C. brachyotis* Sunda and Forest lineages

Table 3: Taxonomic comparison with other Malaysian east-coast islands

Family	PB	PPB	PPB	PPB	PR	Red List
Species	This study	This study	Turner <i>et al.</i> (2003)	Tamblyn <i>et al.</i> (2005)	MNS (1990)	IUCN (2014)
Pteropodidae						
1 <i>Pteropus hypomelanus</i> Temminck, 1853	+	+		+	-	LC
2 <i>Cynopterus brachyotis</i> (Müller, 1838)	+	+	+	+	Last recorded 1911	LC
3 <i>Cynopterus cf. brachyotis</i> Forest	+	+	-	-	-	
4 <i>Cynopterus horsfieldii</i> Gray, 1843	-	-	-	-	-	LC
5 <i>Eonycteris spelaea</i> (Dobson, 1871)	-	+	-	+	+	LC
Emballonuridae						
6 <i>Emballonura monticola</i> Temminck, 1838	-	-	+	+	Last recorded 1911	LC
7 <i>Taphozous melanopogon</i> Temminck, 1841	-	-	-	+	+	LC
Megadermatidae						
8 <i>Megaderma spasma</i> (Linnaeus, 1758)	+	+	+	+	+	LC
Rhinolophidae						
9 <i>Rhinolophus acuminatus</i> -Peters, 1871	-	-	-	+	-	LC
10 <i>Rhinolophus lepidus</i> Blyth, 1844	-	+	-	-	-	LC
11 <i>Rhinolophus affinis</i> Horsfield, 1823	-	+	-	+	Last recorded 1911	LC
Hipposideridae						
12 <i>Hipposideros bicolor</i> (Temminck, 1834)	-	+	-	+	-	LC
13 <i>Hipposideros cineraceus</i> Blyth, 1853	-	+	-	-	+	LC
14 <i>Hipposideros larvatus</i> (Horsfield, 1823)	-	+	-	+	-	LC
Vespertilionidae						
15 <i>Myotis muricola</i> (Gray, 1864)	-	-	-	+	-	LC
No. of family	2	4	1	6	4	
No. of species	4	10	3	11	7	
No. of individuals	84	35	10	136	Na	
Sampling effort	80	80	Na	Na	Na	
Capture rate	1.05	0.44	Na	Na	Na	

Keys: PB=Pulau Bidong, PPB=Pulau Perhentian Besar, PR=Pulau Redang, PT=Pulau Tioman, PP=Pulau Pangkor, PL=Pulau Langkawi, IUCN=International Union Conservation for the Nature Red List of Threatened Species, LC=Least Concern. Asterix denoted new record in Malaysian east-coast island of Terengganu, + = present, - = absent. Na denoted the number of traps, trapping nights are not specifically mentioned by the previous studies. The capture rate and net nights for Pulau Perhentian Besar information are from the current study.

Besar and more sampling nights. However, we managed to capture Island's flying fox (*P. hypomelanus*) due to better mist-netting technique in sub-canopy level. Most of the study done in Malaysia were conducted in understory level, thus might not a good representation of data in the particular area.

From the comparison with other Malaysian east-coast islands, it was observed that Pulau Tioman had the most number of bats with 19 species compared to other Malaysian east coast islands whereas Pulau Bidong has the least number of bat species with only three species recorded. However, there have been many flora and fauna research conducted in Pulau Tioman for over 100 years and it also has a very high diversity of plants and animals (Ng *et al.*, 1999). Pulau Tioman has been studied extensively since 1899 (Lim *et al.*, 1999), meanwhile, Pulau Bidong recorded least species due to lack of bats study being conducted there and our first study there mark the first bat study on Pulau Bidong.

Species Accounts

Family Pteropodidae

Pteropus hypomelanus, Temminck, 1853
- (Island flying fox)

Nineteen individuals of *P. hypomelanus* were captured at sub canopy and canopy mist nets at Pulau Bidong whereas in Pulau Perhentian Besar there were none. However, it was observed that the fox flying higher nearby the beach in Pulau Perhentian Besar. The previous study was done by Tamblyn *et al.* (2005), however, captured one individual through mist netting in the base camp area in Pulau Perhentian Besar. It was also observed roosting on the tree in the campsite area. This species is known as a habitat specialist and mostly roost in small islands and sometimes fly to the nearby mainland (Bonaccorso, 1998).

Cynopterus brachyotis, Müller, 1838 - (Lesser short nosed fruit bats)

C. brachyotis was the most abundant bat captured at Pulau Bidong with 64 individuals. There were 39 individuals captured at understory, and 25

individuals at sub-canopy level. Meanwhile, in Pulau Perhentian Besar, ten individuals were captured with two individuals at understory level and eight individuals at sub-canopy level. *C. brachyotis* is known to roost typically in the tree (Medway, 1969). It can be found in all types of habitats such as lowland, submontane forest, orchards, plantation, and open country (Kingston *et al.*, 2006). In Pulau Bidong, *C. brachyotis* was recorded mostly from the forest lineages whereas Pulau Perhentian Besar recorded the most *C. brachyotis* from Sunda lineages. Jayaraj *et al.* (2012) developed two models to identify sunda and forest lineages which was first function using cranial, dental and external measurement and a second model using only external morphological characters. For this study, we used the second model to identify sunda and forest lineages of *C. brachyotis*. A molecular study using cytochrome b mitochondrial DNA gene was conducted by Abdullah (2003) to study the cryptic of *C. brachyotis*. The result shows that a major subdivision occurs in the *C. brachyotis* population and there were two distinct forms of *C. brachyotis* which are large form and small form. The variance in size forms might be due to the vegetation types that act as a selective force over time (Abdullah *et al.*, 2000; Abdullah, 2003).

Eonycteris spelaea, Dobson, 1871
- (Common Dawn Bat)

One individual was captured in the understory mist net deployed near the large opening of rock crevices in the jungle trail. This species is known as cave dweller (Khan *et al.*, 2007). *E. spelaea* can be found occupying many areas and vegetation from the lowland dipterocarp forest, *Kerangas* to the upper altitude at the montane forest (Jayaraj *et al.*, 2011). It can be distinguished from other pteropodid bats with no claw on its second digit (Kingston *et al.*, 2006).

Family Megadermatidae

Megaderma spasma, Linnaeus, 1758 - (Lesser False Vampire)

One individual was captured behind the UMT's chalet in Pulau Bidong whereas two individuals have captured at ground mist net nearby the abandoned building in Teluk Keke, Pulau Perhentian Besar. This species can be found in forest, caves, sometimes in large tree hollows, culverts, tunnels, crevices of rock-bolder, and abandoned building (Kingston *et al.*, 2006).

Family Rhinolophidae

Rhinolophus affinis, Horsfield, 1823
- (Intermediate horseshoe bat)

Two individuals were captured at the harp trap deployed nearby the large opening of rock crevices in the jungle trail. This species can be found roosting in caves and forages in the forest's understorey (Francis, 2008).

Rhinolophus lepidus, Blyth, 1844
- (Blyth's Horseshoe Bat)

One individual was captured at harp trap whereas another one individual was captured by using hand-netting when flying around the spotlight at the campsite in Pulau Perhentian Besar. *R. lepidus* (Plate 1) primarily inhabited the lowland forest and they can also be found in hilly forest (Kingston *et al.*, 2006). This species is the new record for Pulau Perhentian Besar.

Family Hipposideridae

Hipposideros bicolor, Temminck, 1834
- (Bicolored Roundleaf Bat)

Seven individuals were captured at harp trap in Pulau Perhentian Besar at large opening of rock crevices nearby the trail behind the old abandoned building. This species is morphologically similar with *H. cineraceus* except with the internarial septum which *H. cinereacus* has distinctly swollen in the middle. This species contain a pair of cryptic species which differed in genetics and echolocation calls with a mean frequency of 131 kHz and 141 kHz (Francis, 2008). Those with a forearm (FA) and tibia (Tb) of less than 43 mm and less than 19 mm are categorised as *H. bicolor* 142 kHz whereas those with FA greater than 45 mm

and Tb greater than 20 mm are categorised as *H. bicolor* 131 kHz (Kingston *et al.*, 2006). Our study, however, unable to differentiated these two cryptic species due to the unavailability of echolocation detector.

Hipposideros cineraceus, Blyth, 1853
- (Least Roundleaf Horseshoe Bat)

Two individuals were captured at harp traps in Pulau Perhentian Besar nearby the jungle trail. This species is the newly recorded in Pulau Perhentian Besar. This species has no lateral leaflets and its internarial septum is swollen in the middle (Yasuma & Andau, 1999). This species is a primary cave dweller and roosting gregariously with other *Hipposideros* bats (Kingston *et al.*, 2006).

Hipposideros larvatus, Horsfield, 1823
- (Intermediate Roundleaf Bat)

Six individuals were captured at harp trap whereas one individual was captured at mist net in Pulau Perhentian Besar. This species can be distinguished with other roundleaf bats with its medium size and has three lateral leaflets on the nose leaf. *H. larvatus* mainly found roosting in caves (Payne *et al.*, 1985).

Conclusion

With two newly recorded bat species in Pulau Perhentian Besar and the first bat's study done in Pulau Bidong, we believed that the flora and fauna of these islands should be protected and the number of tourist arrival should be controlled to ensure the sustainability of the forest habitats remain intact.

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Plate 1: *Rhinolophus lepidus*Plate 2: *Hipposideros cineraceus*



Plate 3: *Pteropus hypomelanus*



Plate 4: Sub-canopy mist net deployment