

A final report

**Species Diversity of Bats (Mammalia: Chiroptera)
in Tarutao National Park, Satun Province,
Thailand**

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Abstract

Bats in Tarutao National Park were surveyed between 2008-2009 by harp trapping and mistnetting. The surveys were carried out throughout three major islands (Tarutao, Adang and Rawi). Sixteen sites on Tarutao Island, six on Adang Island, and two on Rawi Island were visited. As a result, a total of 24 species was found, 19 on Taratao island, 18 on Adang Island and 10 on Rawi Island. After compiling with results from previous surveys there are 34 species of bat recorded in this marine national park. The present study is the first bat survey on the most remote islands like Adang and Rawi Island. Half of our species list (12) was found for the first time in this national park. The most species rich on Tarutao Island is Ao Makam while Ao Hin Ngam on Andang Island and Had Sai Kao on Rawi Island are the ones. Geographic variation in echolocation calls of some bat species was recognised. Species description of 26 bat species was described.

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Introduction

Tropical rainforests are known as the most species rich terrestrial ecosystems on earth, they are home of the majority of existing biodiversity. These biodiversity are ecological and economical valuable, and provide environmental services to local, regional and global level. Unfortunately, biodiversity loss is the common phenomena in tropical countries. Many taxa has been experienced extinction crisis or become threatened, due to an expanding and uncontrolled demand on rainforest resources, and from forest disturbance including fragmentation, alternation, and conversion of forest. Currently, most of lowland tropical forest (up to 300m asl.) in Thailand, which is suggested to be the richest biodiversity hotspot, is largely exploited and largely disturbed. Although large proportion of forest in Thailand has been declared as protected areas (national park or wildlife sanctuary) (Trisurat, 2007), they represent biodiversity of ecosystem of higher elevation which can be different from lowland tropical forest. Fortunately, Tarutao Island is the largest island (151 km²) with elevation ranges from sea level to 800 m asl where the ecosystem is still pristine, and lowland tropical forest is mostly undisturbed. Hence, it represents the relict of lowland tropical forest which is expected to be biodiversity rich. However, intensive investigation is anecdotal (Congdon, 1982, Watanasit, *et al.* 2003; Watanasit and Jantarit, 2006). Bats contribute about 40% of species of mammals in Thailand, while the available information indicated that studies on bat diversity on these islands is limited, although the earliest study was taken about a century ago. It is appear that no study has been carried out in the most isolated islands, Adang and Rawi. It is expect that bat diversity is rich on these islands, since the lowland tropical forest is still pristine, and many unknown caves which is the normal day-roosts of most bats which normally found in limestone area. In addition, the existing of the relict population of species that once widely distributed over lowland tropical forest, and the endemic species which resulted from speciation is possible.

Although it has long been studied on the flora of Tarutao (review by Congdon 1982), faunal survey on Tarutao is quite limited. Robinson (1917) undertook bird survey in Langawi and included Tarutao. The first published records of bat on Tarutao is Thomas (1916) who record *Chiromeles torquatus* from specimens deposited in the Federated Museum of Malaya. Tarutao also a type locality of *Taphozous melanopogon fretensis*

(Thomas 1916). Chasen (1940) in his 'Handlist of the mammals found in Malaysian peninsula' listed *Hipposideros cineraceus* from Tarutao Island. Yenbutra and Felten (1986) recorded bat specimens kept in Thailand Institute of Scientific and Technological Research and Senckenberg Museum, and included 11 species of bat from Tarutao Island. Corbet and Hill (1992) listed subspecies of *Megaderam spasma* which found on Tarutao as *M. s. medius*. Bumrungsri (1997) surveyed caves on Tarutao Island and listed 7 species, one of them are fruit bat. Students of Biology Department carried out bat survey from 2003-2007 and tentatively listed 19 species of bat (Bumrungsri, 2003; Piboonphol *et al.* 2004; Thanirat, *et al.* 2005; Thongthamachart *et al.* 2006). However, species identification of these surveys are tentative, and these surveys were carried out only in the small fractions of Tarutao Island, over short period (16 nights in total). No surveys have been done on Adang and Rawi Islands yet. The objectives of the present study is to investigate species diversity of bats in pristine islands of Tarutao Islands National Park

MATERIAL AND METHODOLOGY

1. Study Areas

Tarutao Islands is declared as national park in 1974. It locate in the Andaman Sea off the west coast of peninsular Thailand between 6 30'-6 44' N, and 99 44'-99 90' E. It has been designated by UNESCO as an ASEAN Heritage site. Park boundaries encompass about 1500 km² of land and sea. There are 51 islands in this national park, which 3 of them have areas larger than 10 km²: Tarutao, Adang and Rawi. Tarutao lies approximately about 26 km off the mainland. It is 26km long and 11 km across at the widest point. Mountain ranges running north to south dominate the topography of the island. On this island, elevation range from sea level to 708m asl. Between mountain ranges, permanent and temporary stream are present through out the island. The west coast is characterised by long sandy beaches, mangrove forest, and dense forest. The main road runs from north (headquater) to the west of island (Talo Wow). The limestone (Thung Song Formation) covers the north and eastern parts (30%) where the sandstone and siltstones (Tarutao Formation) are the major rock on this island (65%).

Adang and Rawi, located about 45km west of Tarutao. They are steep, rugged island composed of Triassic granite. On Adang, there are very little flat land, usually the rocky hillside slope directly into the sea. The highest point is 703m asl. On Rawi, it is less rugged and flat land occur (Congdon, 1982).

The climate in this national is characterized by a tropical monsoons climate. The highest rainfall are from April to November, which the average annual rainfall is 2,663 mm. From January to March, it is very dry period, rain is rare during this period. The flora of Tarutao has been studied for long time since 1900, by the British botanists based in Malaysia and Singapore (Congdon, 1982). Congdon (1982) listed 10 vegetation types in the park. On Tarutao, the major vegetation types are semi-evergreen forest, limestone vegetation, mangrove forest whereas on Adang and Rawi mostly covered by semi-evergreen forest. He listed 601 plant species on Tarutao, and 464 species from Adang-Rawi Islands.

During the present study, survey works were conducted in 24 areas in Tarutao and Adang-Rawi Islands. In order to provide information for further research, brief descriptions of these sites are given below.

1/. Tarutao Island

Field surveys were conducted in 17 localities in Tarutao Island. In order to provide information for further research, brief descriptions of these sites are given below.

1). Large pipe under road, between km2-3 road from Punte-Malacca to Talowao (6°40.981'N, 99°38.752'E) was surveyed on 18 December 2008. It is a large pipe, about 0.5 meters in wide, which is surrounded by lowland evergreen forest. This pipe is near to viewpoint, about 100 meters in far. An individual of *Megaderma spasma* was found hinging in the hole.

2). Natural trail between km4-5 road from Punte-Malacca to Talowao (6°40.205'N, 99°38.949'E) was surveyed on 13 December 2008. It is surrounded by lowland evergreen forest. A harp trap was set across a natural trail under canopy beside the road. The trap was set before 6.00 pm until 8.30 pm. Bat detector was also set automatic record beside of the trail. Two species of bats were captured: *Rhinolophus affinis* and *R. malayanus*.

3). Bridge between km5-6 road from Punte-Malacca to Talowao (6°39.577'N, 99°39.335'E) was surveyed on 17 December 2008. It is a small stream, about 7 meters in wide, which is surrounded by lowland evergreen forest and near to the outcrop. The stream is across the road. A harp trap and a mist-net were set over the stream under canopy and under storey, respectively, and a swipe net was used along the road. Harp trap and mist-net were set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. Four species were captured: *Cynopterus brachyotis*, *Hipposideros bicolor*, *Rhinolophus affinis* and *R. coelophyllus*.

4). Km7 road from Punte-Malacca to Talowao (6°38.651'N, 99°39.993'E) was surveyed on 22 December 2008. It is surrounded by lowland evergreen forest. A harp trap was beside the road without canopy. The colonies of bats were found flying out from the forest across the road to other side of forest. The trap was set before 6.30 pm until 8.00 pm. Bat detector was also set automatic record beside the road. No individual of bat was captured.

5). Stream, km8 road from Punte-Malacca to Talowao (6°38.732'N, 99°39.980'E) was surveyed on 22 December 2008. It is a small stream, about 2 meters in wide, which is surrounded by lowland evergreen forest. A harp trap and a mist-net were set over the stream under canopy and across the road under storey, respectively, and a swipe net was used along the road. The trap and mist-net were set before 6.00 pm until 9.00 pm. Three species were captured: *Rhinolophus malayanus*, *Hipposideros bicolor*, and *Myotis siligorensis*.

6). Stream between km8-9 road from Punte-Malacca to Talowao (6°39.013'N, 99°39.579'E) was surveyed on 16 December 2008. It is a small stream, about 3 meters in wide, which is surrounded by hill and lowland evergreen forest. The stream is on beside and parallel with the road. A harp trap and a mist-net were set over the stream under canopy and beside the road under storey, respectively, and a swipe net was used along the road. The trap and mist-net were set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. A species was captured: *Hipposideros larvatus*.

7). Stream between km10-11 road from Punte-Malacca to Talowao (6°38.204'N, 99°40.195'E) was surveyed on 15 December 2008. It is a small stream, about 4 meters in wide, which is surrounded by lowland evergreen forest. The stream is across the road. A harp trap was set over the stream and a swipe net was used along the road. The trap was set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. Two species of bats were captured: *Myotis siligorensis* and *Kerivoula hardwickii*.

8). Talowao Ranger Station (6°37.171'N, 99°40.784'E) was surveyed on 14 December 2008. It is surrounded by lowland evergreen forest and near to the sea. A harp trap was set across the road to historical site under canopy, about 200 meters far from the station. The trap was set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record beside the road. Three species of bats were captured: *Hipposideros larvatus*, *Myotis siligorensis*, and *Miniopterus medius*.

9). Tarun Cave (6°40.587'N, 99°38.581'E) was surveyed on 18 December 2008. The cave is nearby to Moh Lae Ranger Station, and about 100 meters far from the road. It is situated in a large limestone outcrop with a small stream, about 1 meter in wide, belong the cave, which is covered by hill evergreen forest and surrounded by lowland evergreen forest at the front. The cave was surveyed on the day time and large colonies of *Hipposideros bicolor* were found and twenty-five individuals were captured using swipe net.

10). Stream between km3-4 road from Punte-Malacca to Ao Son (6°39.442'N, 99°37.737'E) was surveyed on 18 December 2008. It is a mall stream, about 2 meters in wide, which is surrounded by lowland evergreen forest. Five large pipes under road were surveyed and a small colony of *Megaderma spasma*, about 6-8 individuals was found hanging in all of the pipes. An individual was captured using swipe net. A harp trap and a mist-net were set across the stream and the road, respectively, and a swipe net was used along the road. The trap and mist-net were set before 6.30 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. Four species of bats were captured: *Cynopterus brachyotis*, *Hipposideros bicolor*, *H. larvatus*, and *H. armiger*.

11). Bridge, km5 road from Punte-Malacca to Ao Son (6°38.827'N, 99°37.425'E) was surveyed on 19 December 2008. It is a small stream, about 5 meters in wide, which is surrounded by lowland. The stream is across the road. A harp trap was set over the stream under canopy, at the edge of forest near by the road. A mist-net was set across the road. Both trap and mist-net were set before 6.30 pm until 9.00 pm. A swipe net was used along the road. Bat detector was also set automatic record at the bank of the stream. Five species of bats were captured: *Cynopterus brachyotis*, *Rhinolophus coelophyllus*, *Hipposideros armiger*, *Myotis siligorensis*, and *Myotis hasseltii*.

12). Loh Poh Waterfall (6°37.345'N, 99°37.583'E) was surveyed on 20 December 2008. It is a small stream, about 7 meters in wide, which surrounded by lowland evergreen forest near to swamp forest. Two harp traps and a mist-net were set over the stream under canopy and without canopy. The traps were set before 6.30 pm and were set over night and mist-net was set before 6.30 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. Five species of bats were captured: *Cynopterus brachyotis*, *Rhinolophus affinis*, *Hipposideros larvatus*, *Myotis siligorensis*, and *Miniopterus pusillus*.

13). Bridge No.11 between km7-8 road from Talowao to Talo Udang (6°34.288'N, 99°40.781'E) was surveyed on 26 February 2009. It is a small seasonal stream, about 5 meters in wide, which is surrounded by lowland evergreen forest. Two harp traps and a mist-net were set across a natural trail and the road under canopy and storey. The traps and mist-net were set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record beside the bridge. Eight species were captured: *Rousettus amplexicaudatus*, *Rhinolophus affinis*, *R. malayanus*, *R. lepidus*, *R. coelophyllus*, *Hipposideros bicolor*, *Murina suilla*, and *Kerivoula hardwickii*.

14). Bridge No.15 between km9-10 road from Talowao to Talo Udang (6°33.890'N, 99°40.857'E) was surveyed on 25 February 2009. It is a small stream, about 3 meters in wide, which is surrounded by lowland evergreen forest. Two harp traps were set over the stream and across the road and a mist-net was set along the road. The traps and mist-net were set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record beside the road. Four species were captured: *Rhinolophus malayanus*, *Hipposideros bicolor*, *Myotis siligorensis*, and *Kerivoula hardwickii*.

15). Km11 road from Talowao to Talo Udang (6°33.028'N, 99°40.808'E) was surveyed on 21 December 2008. It is surrounded by lowland evergreen forest. A harp trap and a mist-net were set across and along the road under storey, respectively, under storey. The trap was set before 6.30 pm and was set over night, and the mist-net was set before 6.30 pm until 9.00 pm. Bat detector was also set automatic record beside the road. Seven species were capture: *Rhinolophus affinis*, *R. malayanus*, *R. lepidus*, *R. coelophyllus*, *Hipposideros bicolor*, *Murina suilla* and *Kerivoula hardwickii*.

16). Talo Udang Ranger Station (6°32.572'N, 99°40.384'N) was surveyed on 21 December 2008. It is surrounded by lowland evergreen, mangrove and swamp forests. A harp traps was set across the road under canopy, about 200 meters far from the station. The trap was set before 6.30 pm and was set over night. Seven species were captured: *Rhinolophus affinis*, *R. malayanus*, *R. coelophyllus*, *Myotis siligorensis*, *Murina cyclotis*, *Murina suilla*, and *Kerivoula hardwickii*.

17). Ao Makham Ranger Station (6°33.949'N, 99°37.554'E) was surveyed between 23-24 February 2009. It is surrounded by lowland evergreen forest, near to the sea. Two harp traps were set across the natural trail and over a small seasonal stream under canopy, nearby the station in the first night, and in the second night, both of them were set over the same stream, but on other side of the station. The stream is about 5 meters in wide. The traps were set before 6.00 pm and were set over night. A

mist-net was set at the front of head quarter office under storey. The mist-net was set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record beside the trail in the first night and at the bank of the stream in second night. An individual of *Pteropus hypomelanus* was found foraging around the station. Nine species of bats were captured: *Megaderma spasma*, *Rhinolophus affinis*, *R. coelophyllus*, *Hipposideros bicolor*, *H. cineraceus*, *H. larvatus*, *H. diadema*, *Myotis siligorensis* and *Kerivoula hardwickii*.

2/. Adang-Rawi Islands

Field surveys were conducted in six localities in Adang Island and two localities in Rawi Island. In order to provide information for further research, brief descriptions of these sites are given below.

18.) Stream nearby Adang Ranger Station, Adang Island (6°30.878'N, 99°19.069'E) was surveyed on 7 January 2009. It is a small seasonal stream, about 3 meters in wide, which is without water at bellow and has a little at above. This stream is situated in lowland evergreen forest. Two harp traps were set over the stream under canopy before 6.00 pm and were set over night. Bat detector was also set automatic record at the bank of the stream. At least two individuals of *Pteropus hypomelanus* were found foraging around the site. Six species of bats were captured: *Cynopterus brachyotis*, *Rhinolophus affinis*, *Hipposideros larvatus*, *Myotis hasseltii*, *Murina suilla*, and *Kerivoula hardwickii*.

19.) Pirat Waterfall, Adang Island (6°30.676'N, 99°18.014'E) was surveyed on 8 January 2009. It is a large stream, about 10 meters in wide, with small waterfalls, which is surrounded by hill evergreen forest. A small colony of *Emballonura moticola*, at least 10 individuals, was found in the hole between a large sand stone and ground, which is made from the water. Two individuals of *Emballonura monticola* were captured using swipe net.

20.) Ao Tapien, Adang Island (6°33.144'N, 99°18.990'E) was surveyed on 8 January 2009. It is situated in lowland evergreen forest nearby to swamp forest and coconut plantation. Three harp traps were set across the natural trail under canopy before 6.00 pm and were set over night. Six species were captured: *Rhinolophus affinis*, *R. lepidus*, *R. coelophyllus*, *Hipposideros bicolor*, *H. cineraceus*, and *Kerivoula hardwickii*.

21.) Ao Hin Ngam, Adang Island (6°33.796'N, 99°16.484'E) was surveyed on 9 January 2009. It is a small stream, about 4 meters in wide, which is surrounded by hill

evergreen forest. Two harp traps were set over the stream under canopy before 6.00 pm and were set over night. Bat detector was also set automatic record at the beach nearby to the sea. Twelve species were captured: *Cynopterus brachyotis*, *Rhinolophus affinis*, *R. lepidus*, *R. coelophyllus*, *Hipposideros bicolor*, *H. larvatus*, *H. diadema*, *Myotis siligorensis*, *Myo. moricola*, *Miniopterus medius*, *Min. pusillus*, and *Kerivoula hardwickii*.

22.) Ao Reu Bai, Adang Island (6°32.629'N, 99°16.951'E) was surveyed on 10 January 2009. It is a small stream, about 3 meters in wide, which is surrounded by lowland evergreen and swamp forests. Two harp traps were set over the stream under canopy and without canopy. The traps were set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. Five species were captured: *Rhinolophus affinis*, *R. lepidus*, *R. coelophyllus*, *Hipposideros larvatus*, and *Myotis hasseltii*.

23.) Ao Hin, Adang Island (6°30.816'N, 99°17.111'E) was surveyed on 13 January 2009. It is a small stream, about 1 meter in wide, which is surrounded by lowland evergreen forest. Two harp traps were set across natural trails under storey between small trees and large sand stones beside the stream, both nearby to the sea. The traps were set before 6.00 pm until 9.30 pm. Five species of bats were captured: *Rhinolophus affinis*, *R. lepidus*, *R. coelophyllus*, *Hipposideros bicolor* and *Hipposideros larvatus*.

24.) Had Sai Khao Ranger Station, Rawi Island (6°33.335'N, 99°14.975'E) was surveyed on 11 January 2009. It is surrounded by lowland evergreen forest. Two harp traps were set over an old stream and across a natural trail, about 300 meters far from the station and a harp trap was set across a natural trail near the edge of forest, nearby the station. A mist-net was set over stream in open space and other one set at the edge of forest under storey, both nearby station and the sea. The stream is about 7 meters in wide. The traps were set before 6.00 pm and were set over night, the mist-nets were set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. Eight species were captured: *Cynopterus brachyotis*, *Megaderma spasma*, *Rhinolophus affinis*, *R. coelophyllus*, *Hipposideros bicolor*, *H. larvatus*, *Murina suill*, and *Kerivoula hardwickii*.

25.) Ao Racha, Rawi Island (6°33.123'N, 99°14.133'E) was surveyed on 12 January 2009. It is a small stream, about 4 meters in wide, which is surrounded by lowland evergreen forest. Two harp traps were set over the stream and across a natural trail,

both were set under canopy, and a mist-net was set over the stream under storey, nearby the sea. The traps were set before 6.00 pm and were set over night and the mist-nets were set before 6.00 pm until 9.00 pm. Bat detector was also set automatic record at the bank of the stream. Seven species were captured: *Megaderma spasma*, *Rhinolophus affinis*, *R. coelophyllus*, *Hipposideros bicolor*, *H. larvatus*, *Myotis hasseltii*, and *Tylonicteris pachypus*.

2. Methods

The bats were captured using four-bank harp traps (Francis, 1989), mist-nets, swipe net and hand net. The harp traps were set on the trails, across paths in the forest, over streams, usually in relatively concealed positions. The traps were set before 6.00 pm until 9.00 pm or sometimes overnight. The mist-nets were set across the roads, over stream or across the trail at various heights from ground level up to the canopy as high as 10 meters. The swipe net was used to capture bat along the road and at the bank of stream. The hand net can be used for capturing bats in caves, hollow trees, trees, buttresses and foliage.

For each bats, species (species were identified base upon available reference material – Payne *et al.* 1985; Lekagul and McNeely, 1988; Corbet and Hill, 1992; Bates and Harrison, 1997; Franics, 2008); sex, age (juvenile or adult, juveniles were identified by the presence of unfused epiphyses of the phalanx of metacarpal joints – Anthony, 1988) and the reproductive condition (in females: size of nipples, and palpably pregnant, lactating, or otherwise – Racey, 1988) of bats were determined in the field. The echolocation calls were recorded using a Pettersson Ultrasound Detector D 240x when bats were held in hand or inside a cloth bag. Calls were digitized and recorded into a MP3 Recorder (Multicodec Jukebox) or iHP-120 Recorder (Multicodec Jukebox).

Bats taken for voucher specimens were euthanized in a jar using chloroform. Body mass and some external characters were measured using a Pesola Spring Balance and a digital calliper, respectively. The bodies were fixed in 95% ethanol for 24-48 hours and transferred into 70% ethanol.

RESULTS

Twenty four bat species were found in the 23 nights survey and diurnal cave and water tunnel survey in the current study. Among these, 19 found on Taratao island, 18 on Adang Island and 10 found on Rawi Island. After compiling with results from previous surveys there are 34 species of bat recorded in this marine national park (Table 1). Previously, there is no

survey on the most remote islands like Adang and Rawi, this study is the first one. Half of our species list (12) was found for the first time (table 2). The most species rich on Tarutao Island is Ao Makam while Ao Hin Ngam on Andang Island and Had Sai Kao on Rawi Island are the ones. The more important discriminating characters of 26 species were discussed in systematic section below, together with information on the distribution and conservation status.

Table 1 : List bat species found in the each locality in Tarutao National Park. √ : found

No.	Species	Tarutao Island																	Adang Island					Rawi Island		
		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25
1	<i>Pteropus hypomelanus</i>																√	√								
2	<i>Rousettus amplexicaudatus</i>												√													
3	<i>Cynopterus brachyotis</i>									√	√	√						√			√				√	
4	<i>Emballonura monticola</i>																		√							
5	<i>Taphozous melanopogon</i>																									
6	<i>Megaderma spasma</i>	+								+								+							+	+
7	<i>Rhinolophus coelophyllus</i>			+							+		+		+	+	+			+	+	+	+	+	+	
8	<i>Rhinolophus affinis</i>		+	+								+	+		+	+	+	+			+	+	+	+	+	+
9	<i>Rhinolophus malayanus</i>		+			+								+	+	+	+									
1	<i>Rhinolophus lepidus</i>													+	+						+	+	+	+		
11	<i>Hipposideros bicolor</i>			+		+				+	+			+	+	+		+			+	+		+	+	+
12	<i>Hipposideros cineraceus</i>																	+			+					
13	<i>Hipposideros armiger</i>										+	+														
14	<i>Hipposideros larvatus</i>						+		+		+		+					+	+			+	+	+	+	+
15	<i>Hipposideros diadema</i>																	+					+			
16	<i>Myotis siligorensis</i>					+		+	+			+	+	+	+		+	+					+			
17	<i>Myotis moricola</i>																						+			
18	<i>Myotis hasseltii</i>												+						+				+			+
19	<i>Miniopterus cf. medius</i>									+													+			
20	<i>Miniopterus pusillus</i>											+											+			
21	<i>Murina cyclotis</i>																+									
22	<i>Murina suilla</i>													+		+	+		+						+	
23	<i>Tylonicteris pachypus</i>																									+
24	<i>Kerivoula hardwickii</i>							+							+	+	+	+	+		+	+			+	
	total	1	2	3	0	3	1	2	3	1	5	5	5	8	4	7	7	10	7	1	6	12	5	5	8	6

Locality referred in study area

Table 2. species list from the present and previous surveys carried out on Tarutao Islands National Park

No.	Species	locality	Found in the present study	Found in previous studies
1	<i>Pteropus hypomelanus</i>	Adang	+	
2	<i>Rousettus amplexicaudatus</i>	Tarutao	+	
3	<i>Cynopterus sphinx</i>	Tarutao		3, 4, 5
4	<i>Cynopterus brachyotis</i>	Tarutao	+	3, 6, 7,8
5	<i>Taphozous malanopogon</i>	Tarutao	+	1,3
6	<i>Emballonura monticola</i>	Adang	+	
7	<i>Megaderma spasma</i>	Tarutao, Rawi	+	4, 7
8	<i>Rhinolophus affinis</i>	Tarutao, Adang, Rawi	+	3,4,5,6,7,8
9	<i>R. lepidus*</i>	Tarutao, Adang	+	3, 4, 6,8
10	<i>R. coelophyllus</i>	Tarutao, Adang, Rawi	+	4,5,6,7,8
11	<i>R. malayanus</i>	Tarutao	+	5,7,8
12	<i>R. stheno</i>	Tarutao		6,8
13	<i>R. cf. yunanensis</i>	Tarutao		5
14	<i>R. pearsoni</i>	Tarutao		3
15	<i>Hipposideros larvatus</i>	Tarutao, Adang, Rawi	+	3,4, 5, 6, 8
16	<i>H. armiger</i>	Tarutao	+	4, 6, 8
17	<i>H. bicolor</i>	Tarutao, Adang, Rawi	+	3,4, 5, 6, 7, 8
18	<i>H. cineraceus</i>	Tarutao, Adang	+	2, 8
19	<i>H. diadema</i>	Tarutao, Adang	+	3,6,7,8
20	<i>H. galeritus</i>	Tarutao		5
21	<i>Myotis</i> sp.	Tarutao		6,7,8
22	<i>Myotis siligorensis</i>	Tarutao, Adang	+	
23	<i>Myotis muricola</i>	Adang	+	
24	<i>Myotis hasselti</i>	Tarutao, Adang, Rawi	+	
25	<i>Miniopterus medius</i>	Tarutao, Adang	+	
26	<i>Miniopterus pusillus</i>	Tarutao, Adang	+	

27	<i>Miniopterus</i> sp.	Tarutao		5,6,8
28	<i>Murina suilla</i>	Tarutao, Adang, Rawi	+	
29	<i>Murina cyclotis</i>	Tarutao	+	8
30	<i>Murina</i> sp.	Tarutao		7
31	<i>Tylonycteris pachypus</i>	Rawi	+	
32	<i>Kerivoula hardwicki</i>	Tarutao, Adang, Rawi	+	
33	<i>Hesperoptenus blanfordi</i>	Tarutao		8
34	<i>Cheiromeles torquatus</i>	Tarutao		1,3

References 1. Thomas (1916), 2: Chasen (1940), 3: Yenbutra and Felten (1986), 4: Bumrungsri (1997), 5: Bumrungsri (2003, unpublished data), 6: Piboonphol *et al.* (2004), 7: Thanirat, *et al.* (2005), 8: Thongthamachart *et al.* (2006)

list as *R. pusillus* in Bumrungsri (1997) and Yenbutra and Felten (1986)

SYSTEMATIC DESCRIPTIONS

FAMILY PTEROPODIDAE

Pteropus hypomelanus Temminck

Small Flying Fox

Pteropus hypomlanus Timminck, 1853; Ternate Island, northern Molucca Islands

Diagnosis Characters

According to Lekagul and McNeely (1988), *Pteropus hypomelanus* has a forearm length of 130-144 mm. The ears are short and broad with the tips more broadly rounded off. The forehead, cheeks and chin are dark brown; the crown of the head is fawn and the mantle a deeper russet brown. It is paler in the mid-dorsal region, with grey and black hairs intermixed in differing proportions (Bates and Harrison, 1997).

Distributions and Conservation Status

Pteropus hypomelanus is known from Andaman and Maldive Islands, small islands off coastal Myanmar, Thailand, Vietnam, Cambodia, Malaysia and sometimes adjacent mainland, Indonesia, Philippines, New Guinea and the Solomons (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Pteropus hypomelanus was included as ‘Lower Risk, least concern’ in Simmons (2005), Boitani *et al.* (2006) and IUCN (2008).

Notes: *Pteropus hypomelanus* was found when they were foraging during field surveyed in the study areas (Ao Makham Ranger Station, Tarutao Island and a small stream nearby Adang Ranger Station, Adang Island).

Cynopterus brachyotis Müller

Lesser Short-nosed Fruit Bat

Pachysoma brachyotis Müller, 1838; Dewei (=Dawai) River, Borneo

Diagnosis Characters

Cynopterus brachyotis has a forearm length of 58.5-66.6 mm ($n = 15$). Ears are oval in shape with rounded tip and white edge on outer part. Eyes are large. The muzzle is short or relatively long and broad with relatively long nostril. The tail is very short, enclosed within the interfemoral membrane, except the extreme tip. The fifth metacarpal exceeds the fourth in length, but sometimes is shorter than the fourth, and also shorter the third. The first phalanx of third digit is between 61.8-68.0% the length of the relatively long third metacarpal.

Distributions and Conservation Status

Cynopterus brachyotis ranges from Sri Lanka, India, including Andaman and Nicobar Islands, Nepal, southern China, Myanmar, Thailand, Vietnam, Lao PDR, Cambodia to Malaysia, Sumatra, Java, Borneo, Sulawesi, Philippines, and Lesser Sunda Island (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Cynopterus brachyotis was included as ‘Lower Risk, least concern’ in Simmons (2005), Boitani *et al.* (2006), IUCN (2008).

Notes: There are two taxa in study areas, a taxon is larger (FA: 64.2-66.2 mm and CBL: 25.6-27.8 mm) with long rostrum and high postorbital constriction, and other is smaller (FA: 58.5 mm, CBL: 25.3 mm) with shorter rostrum and sloping postorbital constriction.

Rousettus amplexicaudatus Geoffroy

Geoffroy’s Rousette

Rousettus amplexicaudatus Geoffroy, 1810; Timor Island, Lesser Sunda Islands, Indonesia

Diagnosis Characters

Rousettus amplexicaudatus has forearm length of 79.7-85.4 mm ($n = 3$). Ears are small, oval in shape with rounded tip. There is a pair of nipple in both sexes. Eyes are large. Muzzle is long and elongate. The tail is very short, not enclosed by interfemoral membrane. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 60.2-61.8% the length of the relatively long third metacarpal.

Distributions and Conservation Status

Rousettus amplexicaudatus is known from Myanmar, Thailand, Lao PDR, Vietnam, Cambodia to peninsular Malaysia through Indonesia, Java, Bali, Philippines, New Guinea, Bismarck Archipelago, Solomon Islands (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Rousettus amplexicaudatus is included as 'Lower Risk, least concern' in Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

FAMILY EMBALLONURIDAE

Emballonura monticola Temminck

Lesser Sheath-tailed Bat

Emballonura monticola Temminck, 1838; Mount Murana, Java

Diagnosis Characters

Emballonura monticola has forearm length of 42.5-43.7 mm ($n = 2$). Ears are small, broad, and rounded tip; tragus is small, parallel-side with rounded tip. Eyes are relatively large. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 29.8-33.6% the length of the relatively long third metacarpal. The tail is short and protrudes from the middle of the interfemoral membrane.

Echolocations

Emballonura monticola use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 49.7-52.8 kHz ($n = 2$) for females.

Distributions and Conservation Status

Emballonura monticola is known from Myanmar, Thailand, peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi and other Indonesia islands (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Emballonura monticola was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Taphozous melanopogon* Temminck**

Black-bearded Tomb Bat

Taphozous melanopogon Temminck, 1841; Bantam Western Java, Indonesia

Diagnosis Characters

Taphozous melanopogon has a forearm length of 64.1-64.2 mm ($n = 2$). The ears are small, with wide base, slender and narrower near tip, bluntly tip; the tragus is small and round. The eyes are large. The muzzle is long and elongate. There is a black beard in males. There is a small bag at the base of the metacarpal, between forearm and fifth metacarpal.

Echolocation

Taphozous melanopogon use a narrow-band of frequency-modulated (FM) sweeps echolocation calls with highest energy of 28.9 kHz.

Distributions and Conservation Status

Taphozous melanopogon is known from Sri Lanka, India, southern China to Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, peninsular and adjacent islands of Malaysia, Sumatra, Borneo, Java, Lombok, Moyo, Alor, Timor, Sulawesi and Philippines (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

It was included as 'Lower Risk, least concern' in Hutson (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

FAMILY MEGADERMATIDAE

***Megaderma spasma* Linnaeus**

Lesser False Vampire Bat

Vespertilio spasma Linnaeus, 1758; Ternate Island, Molucca Islands

Diagnosis Characters

Megaderma spasma has forearm length of 56.4-60.8 mm ($n = 4$). Ears are very large and joined on top of head. The tragus is long and triangular with pointed tip. The noseleaf is relatively small, lacks supplementary lateral leaflets. Anterior leaf is rounded. Intermediate leaf is heart-shaped. Posterior leaf is long and convex with rounded on the top. The fourth metacarpal exceeds the third in length, but shorter than the fifth. The first phalanx of third metacarpal is between 48.9-52.7% the length of the relatively long third metacarpal. There is no tail.

Echolocations

Megaderma spasma use a broad-band of frequency-modulated (FM) sweeps echolocation calls with highest energy of 47.5-58.8 kHz ($n = 2$). Although, a specimen from Ra Wi Island has highest energy of 83.2 kHz.

Distributions and Conservation Status

Megaderma spasma is known from Sri Lanka and India through Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, peninsular Malaysia to Lesser Sundas, Sumatra, Java, Borneo, Sulawesi, Maluku, and other Indonesia, the Philippines and Molucca Islands, various adjacent islands (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Megaderma spasma was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006) and IUCN (2008).

FAMILY RHINOLOPHIDAE

Rhinolophus coelophyllus Peters, 1867

Crosler Horseshoe Bat

Rhinolophus coelophyllus Peters, 1867; Salween (= Salween) River, Myanmar

Diagnosis Characters

Rhinolophus coelophyllus has forearm length of 40.9-44.1 mm ($n = 34$ – Table. 1). The noseleaf is relatively large, with a pair of supplementary lateral leaflets. The lancet is heart-like shape and covered by long hair. In ventral view, the sella is parallel-side with rounded tip; in lateral view, the connecting process is rounded. The fourth metacarpal exceeds the third in length, and also exceeds or equals to or shorter than the fifth. The first phalanx of third digit is between 37.8-41.2% the length of the relatively long third metacarpal.

Echolocations

Rhinolophus coelophyllus use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 80.0-82.5 kHz ($n = 26$).

Distributions and Conservation Status

Rhinolophus coelophyllus ranges from central Myanmar, Thailand, Lao PDR to western Malaysia (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Rhinolophus coelophyllus was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Rhinolophus yunanensis* Dobson**

Dobson's Horseshoe Bat

Rhinolophus yunanensis Dobson, 1872; Hotha, Yunnan, China

Diagnosis Characters

Rhinolophus yunanensis has a forearm length of 55.2 mm ($n = 1$). The noseleaf is broad which cover the muzzle, it lacks supplementary lateral leaflets. The sella expand at the base, parallel in the middle and the tip, the tip is round. Connecting process is round. The lancet is triangular with bluntly pointed tip. The fourth metacarpal exceeds the third in length, but shorter than the fifth. The first phalanx of third digit is between 48.4% the length of the relatively long third metacarpal.

Echolocations

Rhinolophus yunanensis use narrowed-band of constant frequency (CF) echolocation call, with highest energy of 55.0 kHz.

Distributions and Conservation Status

Rhinolophus yunanensis is known from northeastern and eastern India, southern China, Myanmar, Thailand (Corbet and Hill, 1992; Simmins, 2005; Francis, 2008).

Rhinolophus yunanensis is included as 'Lower Risk, least concern' as Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006) and IUCN (2008).

***Rhinolophus lepidus* Blyth**

Blyth's Horseshoe Bat

Diagnosis Characters

Rhinolophus lepidus has a forearm length of 35.5-38.9 mm ($n = 19$). The noseleaf is small with a pair of supplementary lateral leaflets. The lancet is triangular in shape with pointed tip. In ventral view, the sella is slightly triangular with rounded tip; in lateral view, the connecting processes are pointed. The third metacarpal exceeds or shorter than the fourth in length, and also the fifth. The first phalanx of third digit is between 36.4-39.5% the length of the relatively long third metacarpal.

Echolocations

Rhinolophus lepidus use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 101.4-107.4 kHz.

Distributions

Rhinolophus lepidus ranges from Afghanistan, Pakistan, northern India, Nepal, China, Myanmar, Thailand, Cambodia, Vietnam, peninsular Malaysia, Sumatra (Indonesia) (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008; Dejtaradol, 2009).

Rhinolophus lepidus was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Rhinolophus malayanus* Bonhote**

Malayan Horseshoe Bat

Rhinolophus malayanus Bonhote, 1903; Biserat, Jalor, Southern Thailand

Diagnosis Characters

Rhinolophus malayanus has forearm length of 39.3-42.3 mm ($n = 13$). Noseleaf is relatively large, with a pair of supplementary lateral leaflets. The lancet is triangular in shape with pointed tip. In ventral view, the sella is parallel-side with rounded tip. In lateral view, the connecting process is rounded.

Echolocations

Rhinolophus malayanus use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 81.4-84.1 kHz ($n = 7$).

Distributions and Conservation Status

Rhinolophus malayanus is known from southern Myanmar, Thailand, Lao PDR, Cambodia, Vietnam, and Peninsular Malaysia (Simmons, 2005; Francis, 2008; Soisook, 2008; Soisook *et al.* 2008).

Rhinolophus malayanus was included as ‘Lower Risk, least concern’ in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Rhinolophus affinis* Horsfield**

Intermediate Horseshoe Bat

Rhinolophus affinis Horsfield, 1823; Java

Diagnosis Characters

Rhinolophus affinis has a forearm length of 48.0-52.6 mm ($n = 51$). The noseleaf is large, lacks supplementary lateral leaflets. The lancet is triangular in shape with pointed tip. In ventral view, the sella is parallel-side with rounded tip; in lateral view, the connecting process is rounded. The fourth metacarpal exceeds the third in length, but shorter than the fifth. The first phalanx of third digit is between 38.0-40.8% the length of the relatively long third metacarpal.

Echolocation

Rhinolophus affinis use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 63.1-67.1 kHz.

Distributions

Rhinolophus affinis is known from India and Nepal to southern China and Vietnam, throughout Malaysia to Borneo and Lesser Sunda Islands, Andaman Islands; perhaps Sri Lanka (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Rhinolophus affinis was included as ‘Lower Risk, least concern’ in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

FAMILY HIPPOSIDERIDAE

***Hipposideros bicolor* Andersen**

Lesser Bicoloured Leaf-nosed Bat

Hipposideros gentilis atrox Andersen, 1918; Semangko Gap, Selangor, Federation of Malaya,
2800 feet

Diagnosis Characters

Hipposideros bicolor has a forearm length of 40.7-43.7 mm ($n = 82$). The ears are relatively large with broad base and bluntly pointed tip. The noseleaf is small, lacks lateral supplementary leaflet. The internarial septum is triangular in shape with bluntly pointed tip. Anterior leaf is lightly straight on each side of its anterior part. The third metacarpal exceeds or shorter than the fifth in length, and shorter than the fourth. The first phalanx of the third digit is between 48.1-54.9% the length of the relatively long third metacarpal.

Echolocation

Hipposideros bicolor use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 133.3-143.1 kHz.

Distributions

It ranges from southern Thailand, Malaysia, Borneo, Sumatra, Java, Philippines, Sulawesi, and adjacent small islands (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Hipposideros bicolor was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

Hipposideros cineraceus Blyth

Least Leaf-nosed Bat

Hipposideros cineraceus Blyth, 1853; Near Pind Dadan Khan, Salt range, Punjab

Diagnosis Characters

Hipposideros cineraceus has forearm length of 33.9-35.5 mm ($n = 4$). The ears are relatively small with rounded base and bluntly pointed tip. The noseleaf is small, lacks lateral supplementary leaflets. The internarial septum is parallel-side with bluntly pointed tip. Anterior leaf is rounded. The fifth metacarpal exceeds the third in length, but shorter than the fourth. The first phalanx of the third digit is between 56.8-65.1% the length of the relatively long third metacarpal.

Echolocation

Hipposideros cineraceus use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 146.2-152.7 kHz.

Distributions and Conservation Status

Hipposideros cineraceus ranges from northeastern Pakistan, northern India, Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, Malaysia, Sumatra, Krakatau Island, Borneo, and probably Philippines (Corbet and Hill, 1992; Matveev, 2005; Simmons, 2005, Douangboubpha, 2008).

Hipposideros cineraceus was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Hipposideros galeritus* Cantor**

Cantor's Leaf nosed Bat

Hipposideros galeritus Cantor, 1846; Penang Island, Malaysia

Diagnosis Characters

Hipposideros galeritus has a forearm length of 47.4-47.7 mm ($n = 2$). The ears are relatively small with broad base and ill-pointed tip. The noseleaf is relatively large with two pairs of lateral supplementary leaflets. The internarial septum is inflated with blunt tip. Anterior leaf is rounded on its anterior part, intermediate leaf exceeds posterior leaf. The third metacarpal exceeds the fifth in length, but shorter or exceeds the fourth. The first phalanx of the third digit is between 42.1-43.0% the length of the relatively long third metacarpal.

Echolocations

Hipposideros galeritus use a short narrow-band of constant frequency (CF) echolocation calls with highest energy of 87.8-90.0 kHz.

Distributions and Conservation Status

Hipposideros galeritus is known from Sri Lanka, India, Myanmar, southern Lao PDR, Cambodia, Thailand, Malaysia to Borneo, Java, Sanana Island (Sula Group, Moluccas Islands), and Bali (Corbet and Hill, 1992; Francis *et al.* 1999; Bates *et al.* 2000; Matveev, 2005; Simmons, 2005; Francis, 2008).

Hipposideros galeritus was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Hipposideros armiger* Hodgson**

Himalayan Leaf-nosed Bat

Hipposideros armiger Hodgson, 1836; Nepal

Diagnosis Characters

Hipposideros armiger has forearm length of 90.0-94.4 mm ($n = 4$). The ears are large and triangular in shape with rounded base and bluntly pointed tip. The noseleaf is relative large; it has four lateral supplementary leaflets, with outer pair is very small. The internarial septum is small, inflated in the middle and bluntly pointed tip. Anterior leaf is rounded; intermediate leaf is inflated with a median eminence; and posterior leaf is narrower than its anterior, it is trilobite and supported by a prominent median septum and two less evident lateral septa. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is 45.9% the length of the relatively long third metacarpal.

Echolocations

Hipposideros armiger use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 66.2-68.7 kHz.

Distributions and Conservation Status

Hipposideros armiger distributes from northern India, Nepal, southern and southeastern China, Taiwan, Vietnam, Lao PDR, Cambodia, Myanmar, Thailand, peninsular Malaysia (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Hipposideros armiger was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Hipposideros larvatus* Horsfield**

Intermediate Leaf-nosed Bat

Rhinolophus larvatus Horsfield, 1823; Java

Diagnosis Characters

Hipposideros larvatus has forearm length of 53.9-59.8 mm ($n = 40$). The ears are relatively large with triangular in shape, rounded base and bluntly pointed tip. The noseleaf is relatively large with three lateral supplementary leaflets. The internarial septum is very small

with triangular in shape. Anterior leaf is rounded. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 44.4-47.9% the length of relatively long third metacarpal.

Echolocations

Hipposideros larvatus use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 92.7-99.8 kHz.

Distributions and Conservation Status

Hipposideros larvatus ranges from northern and eastern India and Bangladesh, southern China, Myanmar, Vietnam, Lao PDR, Cambodia, Thailand, peninsular Malaysia to Sumatra, Java, Borneo, Sumba and adjacent small islands including Kangean Islands (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Hipposideros larvatus was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Hipposideros diadema* Geoffroy**

Diadem Leaf-nosed Bat

Rhinolophus diadema Geoffroy, 1813; Timor Island

Diagnosis Characters

Hipposideros diadema has forearm length of 85.0-87.3 mm ($n = 4$). The ears are large with triangular in shape, rounded base and bluntly pointed tip. The noseleaf is large with four lateral supplementary leaflets, the fourth is very small. The internarial septum is very small with triangular in shape. Anterior leaf is rounded and posterior is supported by a median septum and two weak lateral septa. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 42.6-46.3% the length of the relatively long third metacarpal.

Echolocations

Hipposideros diadema use a narrowed-band of constant frequency (CF) echolocation calls with highest energy of 54.6-55.3 kHz.

Distributions and Conservation Status

Hipposideros diadema ranges from Nicobar Islands, Myanmar, Vietnam, Lao PDR, Cambodia through Thailand, western Malaysia, Sumatra, Borneo, Bali, Philippines to New Guinea, Bismarck Arch, Solomon Islands and northeastern Australia (Corbet and Hill, 1999; Simmons, 2005; Francis, 2008).

Hipposideros diadema was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

FAMILY VESPERTILIONIDAE

Myotis siligorensis Horsfield

Himalayan Whiskered Myotis

Vespertilio siligorensis Horsfield, 1855; Siligori, Nepal

Diagnosis Characters

Myotis siligorensis has forearm length of 29.0-31.3 kHz ($n = 44$). Upperpart is dark or dark brown and underpart is paler. The ears are small, narrow and long, with blunt tip; the tragus is small and slender with blunt pointed tip. The feet are small, with wing membrane attached at the base of toe. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 32.9-36.0% the length of the relatively long third metacarpal.

Echolocation

Myotis siligorensis use a broad-band of frequency-modulated (FM) echolocation calls with highest energy of 52.0-84.9 kHz ($n = 47$).

Distributions and Conservation Status

Myotis siligorensis ranges from northern India to southern China, Myanmar, Thailand, Lao PDR, Vietnam, western Malaysia and Borneo (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Myotis siligorensis was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

Myotis muricola Timminck

Nepalese Whiskered Myotis

Vespertilio tralatitius Timminck, 1840; Java

Diagnosis Characters

Myotis muricola has forearm length of 33.8-34.6 mm ($n = 2$). It is similar to *M. siligorensis*, but is larger forearm length. Upperparts are dark or dark brown; underparts are paler or greyish. Ears are small and long, slender in shape; tragus is small, slender, with bluntly pointed tip. The fourth metacarpal equals to or exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 45.2-48.6% the length of the relatively long third metacarpal. Feet are small, with wing membranes attached at the base of toes.

Echolocations

Myotis muricola use a broad-band of frequency-modulated (FM) echolocation calls with highest energy of 64.2-76.5 kHz ($n = 2$).

Distributions and Conservation Status

Myotis muricola ranges from Afghanistan through northern India and Nepal to Taiwan, Vietnam, possibly Lao PDR, Cambodia, Malaysia, Indonesia, the Philippines, New Guinea (Corbet and Hill, 1992; Francis *et al.* 1999; Matveev, 2005; Simmons, 2005; Francis, 2008).

Myotis muricola was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

Myotis hasseltii Temminck

Horsfield's Myotis

Vespertilio hasseltii Temminck, 1840; Bantam, Java

Diagnosis Characters

Myotis hasseltii has forearm length of 39.9-42.0 mm ($n = 6$). Upperparts are brown or brownish or grey; underparts are pale at under part of body and brownish at its upper part. Ears are long and slender, with bluntly pointed tip; tragus is small and short, triangular in shape, with rounded tip. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 40.5-42.4% the length of the relatively long third metacarpal. Feet are large, with wing membranes attached at the ankle.

Echolocations

Myotis hasseltii use a broad-band of frequency-modulated (FM) echolocation calls with highest energy of 32.1-45.3 kHz ($n = 6$) for males.

Distributions and conservation status

Myotis horsfieldii is known from India (including Andaman Islands), southeast China, Thailand, Myanmar, Lao PDR, Vietnam, western Malaysia, Java, Bali, Sulawesi, Borneo, and Philippines (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Myotis hasseltii was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Tylonycteris pachypus* Timminck**

Lesser Bamboo Bat

Vespertilio pachypus Timminck, 1840; Bantam, western Java

Diagnosis Characters

Tylonycteris pachypus has forearm length of 25.4 kHz ($n = 1$). Upperparts and underparts are dark brown. Ears are small, triangular in shape, with bluntly pointed tip; tragus is very small, rounded shape. Head is flat. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 44.4% the length of the relatively long third metacarpal.

Echolocation

Tylonycteris pachypus use a broad-band of frequency-modulated (FM) echolocation calls with highest energy of 48.2 kHz ($n = 1$).

Distributions and Conservation Status

Tylonycteris pachypus ranges from Bangladesh, India, including Andaman Islands, southern China, Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, to peninsular Malaysia, Philippines, Sumatra, Java, Borneo, and Bali (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Tylonycteris pachypus was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Hesperoptenus blanfordi* Dobson**

Blanford's Bat

Vesperugo (H.) blanfordi Dobson, 1877; Tenasserim, east of Moulmein, Southern Myanmar

Diagnosis Characters

Hesperoptenus blanfordi has forearm length of 26.4 mm ($n = 1$). Upperpart is glossy dark brown and underpart is glossy brownish. The ears are small and broad, with rounded tip; tragus is small, slender and curve, with bluntly pointed tip. The thumb and foot have a thickened dark pad. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 53.7% the length of the relatively long third metacarpal.

Echolocations

Hesperoptenus blanfordi use a broad-band of frequency-modulated (FM) echolocation calls with highest energy of 72.4 kHz ($n = 1$).

Distributions

Hesperoptenus blanfordi ranges from Myanmar, Thailand, Lao PDR, Vietnam, Cambodia to peninsular Malaysia, Borneo (Corbet and Hill, 1992; Borissenko and Kruskop, 2003; Simmoms, 2005; Francis, 2008).

Hesperoptenus blanfordi was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

Miniopterus medius Thomas

Intermediate Long-fingered Bat

Miniopterus medius Thomas and Wroughton, 1909; Kalipoetjang, Tji-Tandoei River, western Java

Diagnosis Characters

Miniopterus medius has forearm length of 40.1-43.3 mm ($n = 30$). Upperparts are dark; underparts are slightly paler. Ears are small, round at the base, with rounded tip; tragus is short and small, parallel-side, with pointed tip. The face is brownish. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 23.4-26.8% the length of the relatively long third metacarpal; it is about three times shorter than the second phalanx ($3D1Px100/3D2P = 32.2-36.4\%$).

Echolocations

Miniopterus medius use a broad-band of frequency-modulated (FM) sweeps echolocation calls with highest of 48.2-63.1 kHz.

Distributions and conservation status

Miniopterus medius is known from south-eastern China, Thailand, western Malaysia, Borneo, Java, Sulawesi, Philippines, New Guinea, possibly the Solomon Islands (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Miniopterus medius was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Miniopterus pusillus* Dobson**

Small Long-fingered Bat

Miniopterus pusillus Dobson, 1876; Nicobar Islands

Diagnosis Characters

Miniopterus pusillus has forearm length of 40.1-41.1 mm ($n = 6$). Upperparts are dark or dark brown; uuderparts are paler or grey; some individuals are dark at the upper part of the body and dark brown at its under part. Ears are round at the base, with rounded tip; tragus is short and small, parallel-side, with rounded tip. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 26.3-26.9% the length of the relatively long third metacarpal; it is about three time shorter than the second phalanx ($3D1Px100/3D2P = 35.4-37.0\%$).

Echolocations

Miniopterus pusillus use a broad-band of frequency-modulated (FM) sweeps echolocation calls with highest energy of 62.7-72.2 kHz.

Distributions and conservation status

Miniopterus pusillus ranges from India (including Nicobar Islands), Nepal to Hong Kong, Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, Sumatra, Java, Sulawesi, Timor, Philippines and Moluccas (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Miniopterus pusillus was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Murina suilla* Temminck**

Brown Tube-nosed Bat

Vespertilio suilla Temminck, 1840; Tapos, Java

Diagnosis Characters

Murina suilla has forearm length of 30.1-32.8 mm ($n = 6$). Upperpart is brown or orange, with greyish at the base, and underpart is white. Ears are small, with blunt tip; tragus is small, slightly triangular, with bluntly pointed tip. Nostril is tube. The fourth metacarpal equals or slightly exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 43.0-44.5% the length of the relatively long third metacarpal. It is haired on the interfemoral membrane.

Echolocation

Murina suilla use a broad-band of frequency-modulated (FM) sweeps echolocation calls with highest energy of 86.9-111.0 kHz.

Distributions and conservation status

Murina suilla ranges from peninsular Thailand, western Malaysia, Java, Sumatra, Borneo, Sulawesi, Peleng Island, New Guinea (Corbet and Hill, 1992; Simmons, 2005; Bumrungsri *et al.* 2006; Francis, 2008).

Murina suilla was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

***Murina cyclotis* Dobson**

Round-eared Tube-nosed Bat

Murina cyclotis Dobson, 1872; Darjeeling, Northeastern India

Diagnosis Characters

It is larger than *Murina suilla*, with forearm length of 33.1-34.8 mm ($n = 3$). Upperparts are dark brown or orange, with dark grey at the base; underparts are brownish and grey. Ears are small with rounded tip; tragus is small, slender in shape with pointed tip. Nostrils are tube. The fifth metacarpal exceeds the fourth in length, but shorter than the third. The first phalanx of third digit is between 46.4% the length of the relatively long third metacarpal. It is haired on the interfemoral membrane.

Echolocations

Murina cyclotis use a broad-band of frequency-modulated (FM) echolocation calls with highest energy of 106.5-113.5 kHz.

Distributions

Murina cyclotis is known from Sri Lanka and India to China, Myanmar, Thailand, Lao PDR, Vietnam, western Malaysia, Borneo, Sumatra, Philippines and Lesser Sunda Islands (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Murina cyclotis was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

Kerivoula hardwickii Horsfield

Hardwicke's Woolly Bat

Vespertilio hardwickii Horsfield, 1824; Java

Diagnosis Characters

Kerivoula hardwickii has forearm length of 32.1-35.5 mm ($n = 12$). It varies in colour; upperparts are dark grey or dark brown; underparts are paler than its upperparts. Ears are small, slender in shape, with bluntly pointed tip; tragus is long, with bluntly pointed tip. The fourth metacarpal exceeds the fifth in length, but shorter than the third. The first phalanx of third digit is between 44.5-48.8% the length of the relatively long third metacarpal.

Echolocations

Kerivoula hardwickii use a broad-band of frequency-modulated (FM) echolocation calls with highest energy of 104.5-124.1 kHz.

Distributions

Kerivoula hardwickii is known from India and Sri Lanka, southern China, Myanmar, Thailand, Lao PDR, Vietnam, Cambodia, peninsular Malaysia, Borneo, Java, Sumatra, Nusa Penida, Mentawai Islands, Sulawesi, Bali, Lesser Sundas, Kangean and Talaud Islands (Indonesia), and Philippines (Corbet and Hill, 1992; Simmons, 2005; Francis, 2008).

Kerivoula hardwickii was included as 'Lower Risk, least concern' in Hutson *et al.* (2001), Simmons (2005), Boitani *et al.* (2006), and IUCN (2008).

DISCUSSION

It is nearly a century since the first record of bat, *Chiromeles torquatus* from specimens deposited in the Federated Museum of Malaya by Thomas (1916), in these Islands. The known species of bat gradually increase (Chasen 1940, Yenbutra and Felten 1986, Bumrungsri 1997). The most intensive survey, although tentatively, were by students of Biology Department, Prince of Songkhla University that carried out between 2003-2007. 19 species were listed (Bumrungsri, 2003; Piboonphol *et al.* 2004; Thanirat, *et al.* 2005; Thongthamachart *et al.* 2006). Currently, at least 34 species of bat recorded on this national park. The new record of 12 species in these islands suggest the actual species richness may be reached after the intensive survey was carried out in many sites as possible. From the increment of species versus number of night trapping, it seem that the actual species richness is nearly reached (Figure 1). However, with the limit in accessibility of a marine national park, it is suggested the future survey should be focus on those sites that never been study especially the south-west forest of Tarutao Island, and Racha Island.

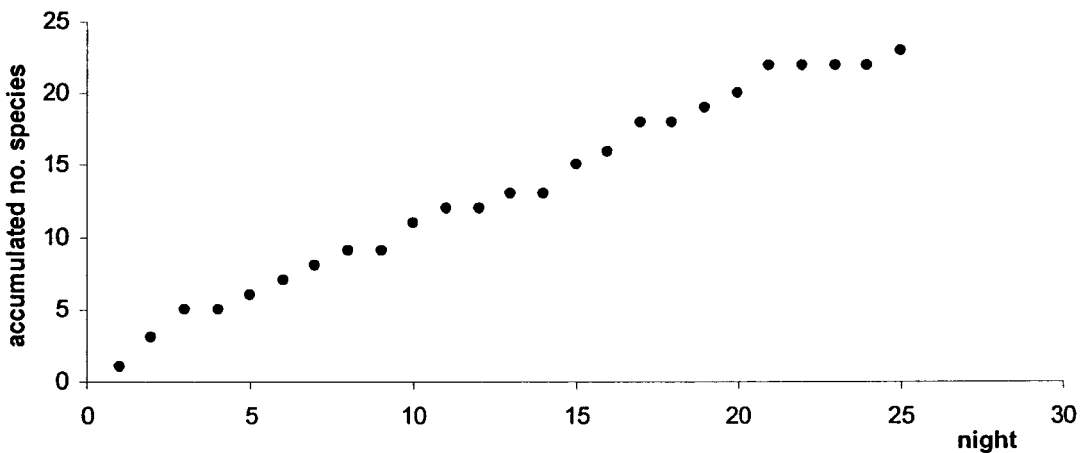


Figure 1 species accumulation curve of bat surveying in Tarutao National Park during the present study.

From all recorded species of bat, of these which are similar to *R. yunnanensis* are probably *Rhinolophus chiewkweeae* which recently described from peninsular Malaysia (Yoshiyuki and Liat 2005). If it is the case, this is a new recorded bat to Thailand. The closest reported distribution of *R. yunnanensis* is Karnchanaburi, which >1000 km from this island. Another intriguing bat is the specimen of *Murina* resemble *M. turbinaris* but differ in coloration, a character that eligible to differentiate between species of *Murina*. In Thailand, *M. turbinaris* found only on the mountain top of northern Thailand (Bumrungsri,

pers. observ.). Unfortunately, only one specimen was collected ever. Future study should be concerned of this unrecognised species. For *Cynopterus brachyotis* which recently found to be a complex species, both the smaller form and larger form were found in this island.

From echolocation, which is mostly species-specific, it is found that some of them are 5 KHz different from mainland including *Rhinolophus lepidus* and *R. affinis*. It is still unknown whether this is a geographical variation or it is a speciation process going on in these species since the distance of 20 km between Tarutao and mainland is further than normal bat foraging range. In addition, it is of interest to have a further study on biogeography of species recorded in these oceanic islands and in other oceanic islands including Surin and Similan Islands. Previously, some taxa were described from Tarutao island including bats and other mammals (Thomas 1916, Corbet and Hill 1992).

In summary, Tarutao islands is one of the most speciose area of bat fauna in oceanic islands of Thailand. Bats is everywhere and probably in high density. Some unknown caves are indicated especially in the limestone areas. This is probably the most pristine cave in Thailand where most of the caves are for tourism. Together with its un-discovered natural history, these islands are thus the jewel for bat diversity as well as biodiversity in general.

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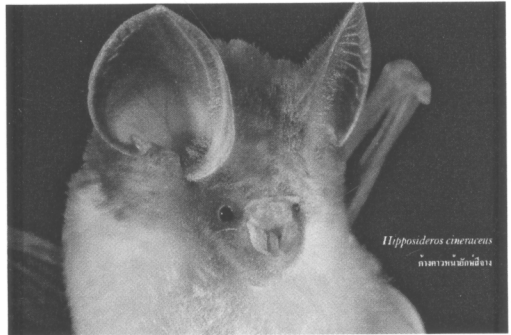
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APPENDIX



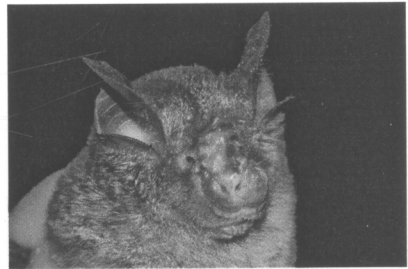
Pteropus hypomelanus (ค้างคาวแม่ไก่เกาะ)



Hipposideros cineraceus (ค้างคาวหน้ายักษ์สีจาง)



Hipposideros bicolor (ค้างคาวหน้ายักษ์เล็กสองสี)



Rhinolophus lepidus (ค้างคาวมงกุฎจุกแหลมใต้)



Kerivoula hardwickii (ค้างคาวขอดคิ้วปีกโต)



Miniopterus pusillus (ค้างคาวปีกพับเล็ก)