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The bat fauna (Mammalia Chiroptera) of Pulau Perhentian, Peninsular Malaysia

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Abstract: The bat fauna of the Perhentian Islands has received no research to date. In 2003 and 2004 as part of the Malaysian Tropical Forests Conservation Project, Coral Cay Conservation undertook the first inventory and species checklist of the bat fauna of the major islands of the Pulau Perhentian archipelago. Species work resulted in a total of 15 species from 8 families being discovered in 17 locations, accounting for 13% of Malaysia's bat fauna. Species identified include *Pteropus hypomelanus, Eonycteris spelaea, Hipposideros larvatus* and *Myotis muricola.* This initial undertaking is no means complete, but it is hoped that this research will be a precursor to additional studies. Recommendations for further work and conservation measures are discussed.

Keywords: Pulau Perhentian, Malaysia, bat fauna, checklist, biometrics.

INTRODUCTION

Bats (Order Chiroptera) often make up a large proportion of the mammalian fauna on small islands. Over half of the 1,111 bat species on our planet are classified as threatened or near threatened with extinction (IUCN 2002). Many of the threatened or endangered bats in the world live on islands. Bats inhabiting islands are more endangered than other bats, with six species thought to have become extinct in the last few decades (IUCN 2002). These island ecosystems are therefore becoming increasingly recognised as essential for the future survival of many bat species, most notably some of the larger megachiroptera, e.g. the Island Flying Fox (*Pteropus hypomelanus*), which roosts exclusively on islands. These island ecosystems also benefit as many trees, including dominant canopy species, rely on many bat species for pollination and seed dispersal. These bat species thus play a vital role in structuring the plant community, acting as keystone species (Hodgkison et al. 2003, Rainey et al. 1995).

Mickleburgh et al (2002) identified 112 species of bat in Malaysia: 17

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megachiropteran species and 95 microchiropteran, of which 11 are endemic - the sixth highest number of endemic bat species in the world. The International Union for Conservation and Nature (IUCN) records 31 of Malaysia's bat species as Red Listed; i.e. 27 % of Malaysian bats are considered to be threatened (IUCN 2001). The Chiroptera Specialist Group of the IUCN's Species Survival Commission state that in many cases the numbers of species recorded are underestimates; and the lack of basic survey information makes assessing the status of populations difficult (O'Malley et al. 2006), which in turn hampers the development of appropriate conservation measures (Mickleburgh et al. 002).

Bats face many threats, largely due to expanding human populations: loss of habitat, hunting pressure, disturbance in caves, invasive species and persecution. The loss of forest habitats has undoubtedly affected the numbers of bats that rely on forest cover for roosts and food, but the level of this impact in Malaysia is not fully known. Malaysia has a strong history of bat research, summarised elsewhere (Liat 2001). However, recent research on Malaysia's bats has focused on the remaining forested regions of the Peninsular, such as Krau Wildlife Reserve (Kingston et al. 2003; Hodgkison et al. 2003). Despite the increasing research effort and interest in bat conservation, Peninsular Malaysia's coastal islands have received very little research focus. Most recent bat research carried out was on Tioman Island as part of a broader biodiversity assessment (Lim et al. 1999) and two previous studies (Csorba et al. 1997, Medway and Bullock 1966). However, the bat fauna of the Perhentian Islands has previously received no research effort.

Prior to the studies undertaken by Coral Cay Conservation (CCC), no research on the bat fauna of the Perhentians had been documented. CCC conducted a biodiversity assessment of the bat fauna of the islands as part of a biodiversity assessment on the whole islands (Turner et al. 2003, Tamblyn et al. 2005). Distributions of species and habitat requirements were not the key focus of this research, as priority was set at species discovery and documentation.

Our aims were;

1) To compile an initial inventory of the chiropteran species on Pulau Perhentian.
2) To gather basic distributional and ecological data on each species.
3) To compare chiropteran species found on the Perhentians with other Malaysian East Coast Islands.
4) To identify key areas of conservation concern for the bat fauna of the island.
5) To produce conservation and future research recommendations.

MATERIALS AND METHODS

Study Area

The Perhentian Island Archipelago, located 21 km off the mainland east coast of Peninsular Malaysia, in the state of Terengganu, consists of 11 small islands with

the largest being P. Kecil (~524 ha) and P. Besar (~867 ha). Additional uninhabited islands take a westerly bearing off P. Kecil and consist of Susu Dara Besar, Susu Dara Kecil, Rawa and Takong Laut as well as additional smaller islands (Figure 1). All these islands and their surrounding waters have been identified and established as a Marine Park (Aikanathan and Hung 1994).

Pulau Besar remains largely forested, with development limited to small coastal stripes. The interior of the island is covered in lowland dipterocarp forest, with granite outcrops and ridges running westerly through the centre of the island. Pulau Kecil is more developed and the forest has undergone more intensive change. Areas have been clear felled in the south of the island for rubber plantations and smaller subsistence plots of fruiting trees such as jackfruit, mangoes and coconuts are present in the north. Although smaller, this island is largely the centre of tourism and is the location for the fishing village and resident community. More detailed descriptions are given by Turner et al. (2003) and Tamblyn et al. (2005).

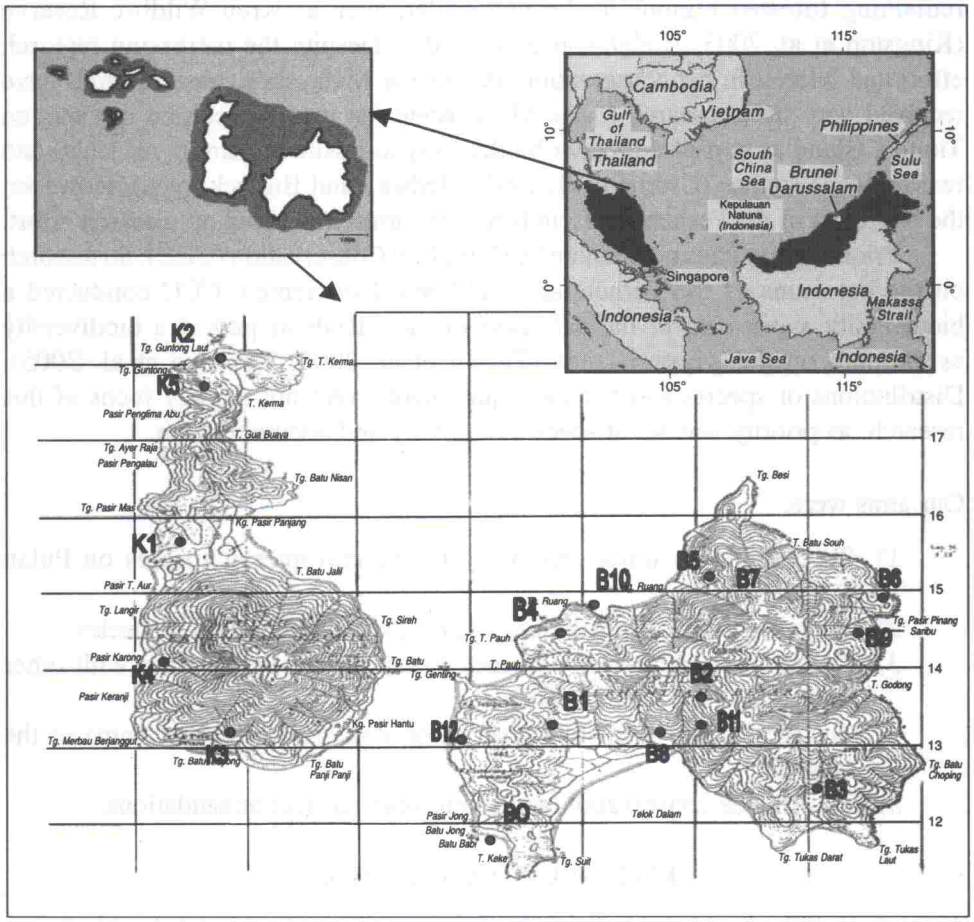

Figure 1. Location of Pulau Perhentian archipelago in relation to Peninsular Malaysia, with approximate locations of surveys sites on P. Kecil (K1-5) and P. Besar (B 1-12) indicated.

Mist net survey

Netting was carried out for 60 nights between June and October 2004. Mist nets (two 10 m x 2.6 m and six 6 m x 2 m, 38 mm mesh) were used at 17 locations within several different habitat types present on the two main islands (Besar and Kecil) and Susu Dara (Figure 1; Table 1). To maximise capture efficiency, nets were established across likely flight-paths such as clearings, along ridges or by water (Heaney et al. 1989), in a variety of combinations, such as 'Z' and 'T' formations (Kunz et al. 1996), and heights ranging from 1 to 10 m above the ground.

Table 1. Brief descriptions of the major habitat types on the P. Perhentian Archipelago (as indicated in Figure 1).

Habitat Type	Description	Survey Location
Herbaceous shrub	Shrub, grassland, coconut palms on forest edge	B0
High dipterocarp forest, medium disturbance level	Small paths, with some plantation species e.g. bananas. Medium level of usage. Streams present	B1, B5
High dipterocarp forest, low disturbance level	High dipterocarp forest, streams present, low level signs of usage.	B2, B3, B4, B7, B10, B12
Rattan & pandanas	Rattan and pandanas species dominant. Palms present.	B6
Wetlands	Wetland grass area, with rattan, pandanas and palm species.	B8
Low forest	Saplings	B9, B11
Plantation forest	Rubber and fruit plantations missed with secondary regrowth forest. Dense understorey. High levels of disturbance.	K1, K2, K3
Secondary forest	Secondary regrowth, isolated pockets of fruit trees. Medium levels of disturbance.	K4
Shrub forest	Small saplings with medium levels of disturbance.	K5
Outer Islands	Medium to high dipterocarp forest in sheltered areas, with shrub dominating slopes. Uninhabited with low levels of disturbance.	Susu Dara, Rawa

High nets were operated on a pulley system, and when possible complemented by a low net positioned on the same pulley (Ingle 1993). Generally, nets were open just before dusk and closed before midnight or when captures ceased, dependent on personnel and weather. These methods follow those used by other studies of bat fauna on small coastal islands (e.g. O'Malley et al. 2006).

Flicking

Flicking was carried out for 20 nights between June and October 2004, and used in conjunction with mist netting. This method is used to capture more elusive species - those better able to detect mist nets and so avoid capture - and to sample in areas where unmanageable numbers could be caught in a fixed net, e.g. at a cave entrance. A 6 m net attached to two 3 m poles, made from saplings, each held by one researcher, was used; when a bat approached, the poles were flicked-up to scoop the bat into the net (Jones et al. 1996).

Direct Observation

Daytime searches for roosts (including caves) and recording the presence of roosting flying foxes when encountered was also included. Roosts were located by exploration on foot, and by touring the perimeter of the islands by boat. Each potential roost location was surveyed for evidence (visual or audible) of bat presence. Species present at roosts were confirmed either by observation (where possible for some megachiropteran species) or by trapping with a hoop-net. This followed the approach of Clyde et al. (1996) where only roosting individuals were caught, and then released once identification had been confirmed. Where it was not possible to safely employ this approach, a single mist-net was opened just outside the mouth of the cave. Where the cave was believed to contain a large number of individuals, the capture of unmanageable numbers of bats in the net was avoided by setting the mist-net outside the times of peak activity (determined by prior observation) and the net was set on bamboo poles held by two researchers, and lowered each time a bat was caught. Each bat captured was dealt with as for the general mist-net survey.

Bats captured were identified using Kingston (2004), Corbett and Hill (1992) and Ingle and Heaney (1992), sexed by observation of genitalia and nipples, and aged (to adult or juvenile) by assessment of the ossification of the joints of the digits of the wing. Forearm length is probably the single most important measurement when identifying bats (Bennett et al. 1988); therefore it was recorded for all captures. Forearm length was measured using a dial calliper, and body mass using a spring balance. When new species were encountered, ear, hind-foot and total length were also recorded. All bats that were captured were subsequently released once biometric data had been recorded. No voucher specimens were taken. For each survey night, the location, weather conditions and time the nets were operational was noted.

RESULTS

A total of 15 species were identified during the survey period. Of these, 3 were Megachiropterans (*Pteropus hypomelanus, Cynopterus brachyotis* and *Eonycteris spelaea)* and 12 species of Microchiropterans (see Table 2). A total of 136 bats were caught representing 8 families and 2 sub orders. Table 3 includes the biometrics taken from the bats caught.

The most commonly netted species was *Hipposideros larvatus* with a total of 52 individuals captured. *Rhinolophus stheno/affinis* was netted 21 times, *Megaderma spasma* netted 19 times and *Cynopterus brachyotis* netted 10 times. It must be noted that although *Pteropus hypomelanus* was only netted on one occasion it was seen at all the survey locations.

Initial findings suggest that P. Besar has more diverse bat fauna, with 14 species being caught compared to only 6 species on P. Kecil. The dipterocarp forest and the forest edge seem to support a large number of species and individuals. Areas of rubber plantations and coconut plantations supported lower numbers of species and individuals.

Across all sites greater numbers and more species of microchirpoterans were caught compared to the number of megachiropterans (Table 4). Although only captured at one site, flying foxes were present at all sites visited including the islands Rawa and Susu Dara. These flying foxes and other high fliers (for example, *T. melanopogon*) have been observed across the majority of the sites, but due to the

Table 2. Inventory of all species identified during the survey period, across all islands.

Sub Order	Family	Species
Megachiropteran	Pteropus	*Pteropus hypomelanus*
	Cynopterus	*Cynopterus brachyotis*
	Eonycteris	*Eonycteris spelaea*
Microchirpoteran	Emballonuridae	*Emballonura species*
	Emballonuridae	*Emballonura monticola*
	Emballonuridae	*Taphozous melanopogon*
	Megadermatidae	*Megaderma spasma*
	Rhinolophidae	*Rhinolophus affinis*
	Rhinolophidae	*Rhinolophus refulgans*
	Rhinolophidae	*Rhinolophus stheno/affinis*
	Hipposideridae	*Hipposideros larvatus*
	Hipposideridae	*Hipposideros bicolor*
	Hipposideridae	*Hipposideros species*
	Myotis	*Myotis species*

Table 4. Summary of Megachiropteran and Microchiropetran species captures by survey location on Pulau Perhentian.

Species	B0	B1	B3	B4	B5	B6	B7	B8	B9	B10	B11	K1	K2	K3	K4	K5	Susu
Pteropus hypomelanus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cynopterus brachyotis	2	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	3
Eonycteris spelaea	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emballonura species	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emballonura monticola	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Taphozous melanopogon	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Megaderma spasma	1	1	0	2	0	4	2	0	0	2	0	0	2	3	0	1	1
Rhinolophus affinis	0	1	0	0	0	0	0	0	0	1	5	0	0	0	1	0	0
Rhinolophus refulgans	4	1	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0
Rhinolophus stheno/affinis	2	1	0	2	2	6	5	0	0	0	0	0	3	0	0	0	0
Hipposideros larvatus	1	14	1	2	16	2	9	2	5	0	0	0	0	0	0	0	0
Hipposideros bicolor	5	2	0	1	1	10	0	0	1	0	0	0	8	0	0	0	0
Hipposideros species	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Myotis muricola	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

difficulties in catching such species the data suggests that there are limited numbers on the islands. Observations also place *Cynopterus brachyotis* at Rawa Island.

Caves and bat roosts

Surveys on caves and bat roosts undertaken included the following site locations:

1) East Besar near survey site B6 (Figure 1): *Taphozous melanopogon* were roosting amongst boulders along the coastline south of the beach. Identification was made by photography and was based on their roosting position (Emballonuridae are agile and often hold onto rocks by the wrist), head shape, size, and white patches on the wings noticeable during flight. *Megaderma spasma* was caught heading in the direction of the cave, but could well have been hunting the emerging bats, and not roosting.
2) Approximately 75m east of the above location (east Besar) is an area of large boulders. *Emballonura monticola* was found roosting in the many small caves and overhangs (based on the capture of one individual).

3) South Besar near survey site B0 (Figure 1): *Taphozous melanopogon* were found roosting on a large rock overhang. Three individuals (female) were captured and identified.
4) North West Besar near survey site B10-B5 (Figure 1): The entrance was approximately 1.5 m high by 4 m wide. *Hipposideros larvatus* was captured emerging at dusk.

Comparisons with other East Coast Islands

Research completed on all three east coast island archipelagos shows varying degrees of similarities, with P. Tioman being the most biodiverse in chiropteran fauna, followed by the P. Perhentians and lastly P. Redang (Table 5). There are several species that may now be extinct in P. Redang as their presence has not been noted since 1911. What must be taken into consideration are the levels of survey effort on each island. Tioman has been the most heavily surveyed, with Redang and the Perhentians receiving relatively low survey interest.

Table 5 shows that there are two species that are endemic on Tioman; additionally there are some species that may have become locally extinct on the island, as they have not been recorded since the 1960s. A further two species seem to be locally extinct on the island of Redang.

DISCUSSION

The brief survey period has recorded a total of 15 bat species, accounting for 13% of the Malaysian bat fauna. This study has provided the first species recordings and biometric data for these species at this location. Whilst this preliminary inventory has not documented any species of particular conservation concern, it has demonstrated the importance of the islands' habitats for bats.

The rapid growth of tourism over the last few decades has resulted in an increased influx of visitors into natural areas. This is certainly true of Malaysia's island ecosystems with, for example, over 200,000 people visiting P. Tioman in 2002 (Ahmad 2002). This has placed an increasing amount of pressure on the natural ecosystems' carrying capacity and their wildlife.

Malaysia's island habitats are heavily forested and likely to have a very important ecological role (Cronk 2001) and such islands often provide havens for endemic, endangered and migratory species as previously found on similar forested islands in Southeast Asia (Turner et al. 2002). The Perhentian Islands are protected by a series of Marine Protected Areas, and are one of twelve island groups off Peninsular Malaysia that have been gazetted as Fisheries Protected Areas under the Fisheries Act 1985 (Aikanathan and Hung, 1994). Such designations do not cover the terrestrial resources of the island, and thus with most of the island groups, including the Perhentians, the ecological and economical importance of the forests have yet to be evaluated.

The initial research conducted by CCC provides a basic ecological evaluation of the Perhentian islands (Tamblyn et al. 2005).

Table 5. Comparison of bat species records among the East Coast Islands of Peninsular Malaysia. (Malaysian Nature Society 1990, Turner et al. 2003, Tamblyn et al. 2005, Lim et al. 1999). Year of last record used for older records.

Scientific Name	Common Name	Redang	Per-hentian	Tioman
Pteropodidae				
*Cynopterus brachyotis**	Lesser Dog Faced Fruit Bat	1911	Yes	Yes
*Cynopterus horsfieldi**	Horsefield's Fruit Bat	No	No	Yes
Eonycteris spelaea	Cave Fruit Bat	Yes	Yes	Yes
Macroglossus minimus	Common Long-tongued Fruit Bat	No	No	Yes
Pteropus hypomelanus lepidus	Island Flying Fox	No	Yes	Yes
Emballonuridae				
Emballonura monticola monticola	Lesser Sheath-tailed Bat	1911	Yes	1962
Taphozous melanopgon	Black Bearded Tomb Bat	Yes	Yes	No
Nycteridae				
Nycteris javanica tragata	Hollow-faced Bat	No	No	Yes
Megadermatidae				
Megaderma spasma	Malayan False Vampire	Yes	Yes	Yes
Rhinolophidae				
Rhinolophus affinis superans	Intermediate Horseshoe Bat	1911	Yes	Yes
Rhinolophus borneensis	Bornean Horseshoe Bat	No	No	Yes
Rhinolophus lepidus refulgens	Glossy Horseshoe Bat	No	No	Yes
Rhinolophus luctus morio	Woolly Horseshoe Bat	No	No	Yes
Rhinolophus macrotis	Big-eared Horseshoe Bat	No	No	Yes
Rhinolophus megaphyllus klossi	Peninsular Horseshoe Bat	No	No	1966
Rhinolophus pusillus pusillus	Least Horseshoe Bat	No	No	Yes
Rhinolophus stheno	Lesser Brown Horseshoe Bat	No	No	Yes
Hipposideridae				
Aselliscus stoliczkanus	Stoliczka's Trident Bat	No	No	Yes
Hipposideros bicolor atrox	Bicoloured Leaf-nose Bat	No	Yes	Yes
Hipposideros larvatus barbensis	Large Leaf-nosed Bat	No	Yes	Yes
Hipposideros cineraceus	Least Roundleaf Horseshoe Bat	Yes	No	No
Molossidae				
Cheiromeles torquatus torquatus	Hairless Bat	No	No	1966
Vespertilionidae				
Myotis muricola	Whiskered Myotis	No	Yes	No

* Denotes endemic subspecies.

The bat species which were recorded on the Perhentians are in the lower risk categories of the IUCN Red List (2004). However, few bat species have been studied across their range and many assessments have been based on the trends of similar researched species (Mickleburgh et al. 2002). Only one species, the Island Flying Fox (*Pteropus hypomelanus*), is listed as CITES Appendix II. The lack of research in bat taxonomy limits assessments of endemic sub-species that may play important ecological roles in many locations – this is especially true of island habitats. Pulau Tioman, for example, has had a significant amount of research on many of its species allowing for sub species and endemic species to be identified and named. This level of research has not occurred on many forested islands off the coast of Malaysia and within the Indo-Malayan realm.

Pulau Besar contains more micro and megachiropteran species than P. Kecil. This maybe due to the number of roosting sites available (caves, hollow trees); Besar is larger and has more undisturbed forested areas. This is especially true of the north and east of the island where the terrain is difficult and the forest is relatively inaccessible. Fruit bats captured on both islands were found in areas where there have been small fruit tree plantations around tourist zones and in areas where *Ficus* species have been plentiful.

Further research that could provide more information on species and species numbers would require the use of Harp Traps or tunnel traps. For example, recent research with harp traps resulted in a further 22 species of insectivorous bats caught that had not been previously caught in mist nets (Kingston et al. 2003), and tunnel traps added 11 species to Polillo Island, Philippines, which had been surveyed extensively previously with mist nets (Sedlock 2001). Small changes in habitat can change the species that are caught with harp traps and are usually species which are more difficult to sample in mist nets (variations over water, streams and in clearings, see Kingston et al. 2003).

Vertical stratification of species is known to occur within old world forest ecosystems (Francis 1994). Sampling of species has mainly occurred within the understorey of these forest ecosystems and thus results may not fully represent species present and abundance.

This survey found several species - *E. monticola, C.brachyotis, and R. affinis* – that are no longer believed to be present on either P. Redang or P. Tioman, which could be seen as an indication that Perhentian is, in its present state, less disturbed than the other East Coast islands.

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