MALAYSIA TROPICAL FOREST CONSERVATION PROJECT
REPORT OF THE PERHENTIAN PHASE
2005

A COLLABORATIVE PROJECT BETWEEN THE DEPARTMENT OF WILDLIFE AND NATIONAL PARKS (PERHILITAN) AND CORAL CAY CONSERVATION



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Executive Summary

Coral Cay Conservation (CCC) has been working in association with the Department of Wildlife and National Parks of Malaysia to develop the terrestrial project based in the Pulau Perhentians from the period of April to October 2004. This succeeds the successful pilot phase of the project completed in July 2003. This project phase consolidates previous work from the pilot project as well as expanding and enhancing the previous data sets.

The terrestrial project survey work focused on major faunal groups: birds, mammals (non volant), reptiles, amphibians, bats, invertebrates (butterflies), and basic vegetation assessment on Pulau Besar and Pulau Kecil. Further surveys were completed on the uninhabited islands of Susu Dara and Rawa, which are situated on the west side of P.Kecil. The main results include:

- A total of 15 species of bat (some still to be confirmed) 3 of which were Megachiropterans (*Pteropus hypomelanus, Cynopterus brachyotis* and *Eonycteris spelaea)* and 12 species of Microchiropterans. A total of 136 bats were caught in 2004 representing 8 families and 2 sub orders.

- A total of 29 species of bird have been recorded representing 16 families. 18 of these species have been listed as IUCN least concern (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN), and 1 species, the Nicobar Pigeon *(Caloenas nicobarica)*, as IUCN as near threatened and CITES Appendix 1.

- A total of 35 species of herpetiles representing 10 families.

- A total of 45 species of butterflies representing 5 families.

- A total of 8 species of non-volant mammals (a further 2 needing confirmation) representing 6 families.

P.Besar has been found to be the more diverse of the two islands and less disturbed. The larger mammals appear now to be extinct on P.Kecil however fruit bats may be more abundant. The northern part of P.Besar is the least disturbed with several species sensitive to human activities caught and seen there.

The P.Perhentians are clearly an important ecological refuge harbouring a variety of habitats, spanning coastal to forested areas, which in turn support a diverse range of species (based on the taxonomic groups that were studied) including species that have been extirpated from other locations due to habitat loss, and that are range restricted and forest dependent.

Conservation indices and values depicting biodiversity 'hotspots' on both of the islands are discussed. Furthermore comparisons between P.Perhentians and other east coast islands are made.

Results from the P.Perhentians have resulted in the following conclusions and suggestions being made:

- More research is required throughout the year on all faunal groups
- In depth vegetation inventory work
- Development of information and awareness tools for local stakeholders and tourists
- Relevant state authorities should further investigate the recognised risks to wildlife (e.g. hunting and collection)
- State authorities should review island development in relation to biodiversity 'hotspots'
- Review levels of disturbance and land change throughout the islands
- Review possibility of P.Perhentian being review for possible designation as a state park
- Explore the potential to market the island's terrestrial biodiversity in addition to that of the marine, thus promoting a more holistic nature tourist destination

List of Tables and Figures

1. Introduction

The rapid growth of tourism, especially that of nature tourism and of unregulated tourist operators over the last few decades has resulted in an increased influx of visitors into natural areas. This has placed an increasing amount of pressure on natural ecosystems' carrying capacity and their wildlife. Managing this is problematic and subject to conflicting ideas, debates and concerns.

Whilst accepting that the development of a tourist industry is seen as not only the most obvious but inevitable way forward for areas to generate income, the effects of multiple users of natural resources create the potential for conflict between the needs of humans and those of wildlife. Within the Perhentian Islands, Malaysia (see Figure 1.1) an increase in demand from tourism has changed the demand on natural resource use. The need for proper management and the use of natural resources in a sustainable way is therefore paramount.

The Malaysian government sees tourism as playing an important role in the socio-economic development of the country and the government is actively promoting domestic and international tourism. The tourism sector itself is currently the third largest foreign exchange earner after the manufacturing industry and oil palm industry and continues to grow (Table 1.1).

Table 1.1 Tourism Growth in Malaysia.

Year	Number of Visitors	Receipt Value (RM)	Receipt Value (US$)
2000	10.22 million	17 billion	4.5 billion
2001	12.78 million	24 billion	6.3 billion
2002	13.29 million	25 billion	6.5 billion
2003	10.58 million	21 billion	5.5 billion

(Source: www.tourism.gov.my 2004)

The Malaysian Government has made a positive start to addressing this issue by setting up Marine Park networks, however, the development of marine and island parks have been promoted and marketed towards mass tourism (e.g. Pulau Payar Marine Park, northwest of Peninsular Malaysia and Redang Marine Park, east coast of Peninsular Malaysia) see Table 1.2.

Table1.2 Visitor Figures for Marine Parks.

Total Number of Visitors to Marine Parks (1999-2002)				
	1999	2000	2001	2002
P.Tioman	184,954	200,527	243,052	213,172
P.Payar	83,203	106,784	125,485	133,775
P.Redang	47,008	52,634	73,580	63,825

(Sources: A.Ahmad, 2002)

However, there are physical limitations of space (lack of areas suitable for island development), limitations to the amount of facilities available and the amount of pressure placed on the ecosystem (including waste disposal, water demand). The need for a long-term management strategy encompassing all aspects of the Marine Park is required and the ecosystem approach to management supported by adaptive management regimes could provide this.

1.1 Malaysian Islands

The small islands that line the coast of Peninsular Malaysia are heavily forested and likely to have a very important ecological role (Cronk 2001). Such islands often provide havens for endemic, endangered and migratory species as previously found on similar forested islands in Southeast Asia (Turner *et al.*, 2002a). Pulau Redang, situated off the north east coast of peninsular Malaysia, has been noted to support a number of unique species, including half the mammalian species identified (Rahman & Ibrahim 1996). The Flying Lizard (*Draco volans*) illustrates the importance of the offshore landmasses, as although rare on mainland Malaysia, this species thrives on the surrounding islands of peninsular Malaysia (see Figure 1.1 for East Coast Island locations).

Despite this, virtually no research has been conducted on the numerous forested islands surrounding peninsular Malaysia. The main focus of the island research has centred on Langkawi off the west coast of peninsular Malaysia, investigating the herpetofauna (Bowles 1997), forest structure (Kohira *et al.*, 2001), land use and cover distribution (Baban & Yusof 2001), and forest recreation (Jussoff & Hassan 1996). Additional research has recently focused on P. Tioman and has included work on Herpetofauna (Grismer *et al.*, 2004), bird inventories (Sodhi *et al.*, 1999), butterflies (Quek *et al.*, 1999) and mammals (Lim *et al.*, 1999), the flora and vegetation of Pulau Tioman (Latiff *et al.*, 1999).

The Perhentian Islands and other east coast islands have seen little research, with limited information on the islands resources. However, the Perhentians 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 & 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 not yet been evaluated.

Due to Malaysia's polices and institutional frameworks, there is a separation of jurisdiction between Federal and State Government. Furthermore, natural resources and areas are under different sectoral management. This is shown by the only Federal body and land management agency, on the Perhentians being the Marine Parks. However, Marine Parks are only allowed to manage the area of the high water mark to 2 nautical miles out to sea with the rest of the islands being further sub divided into different land use departments.

Marine Parks have been managed and marketed as Marine Reserves, where the marine ecosystem is protected and highly valued. However there seems to exist a discrepancy in attitudes towards the terrestrial ecosystems. It should be noted that to

protect the marine ecosystem and the integrity of the marine resources it is important to understand the linkage between land and sea. Successful management of the islands must be a result of interlinking these two resources and managing them as one complete connecting ecosystem.

Figure 1.1 Location of East Coast Islands in relation to Peninsular Malaysia.

1.2 Perhentian Islands

The Perhentian Island Archipelago, located 21 km off the mainland of Peninsular Malaysia, in the state of Terengganu, consists of 11 small islands with the largest being P.Besar (approximately 867 hectares) and P.Kecil (approximately 524 hectares). These are both inhabited and the centre of tourism on the islands. Additional islands take a westerly bearing off Kecil and consist of Susu Dara Besar, Susu Dara Kecil, Rawa and Takong Laut as well as additional smaller islands, which are uninhabited (see Figure 1.2). All these islands and their surrounding waters have been identified and recently established as Marine Parks.

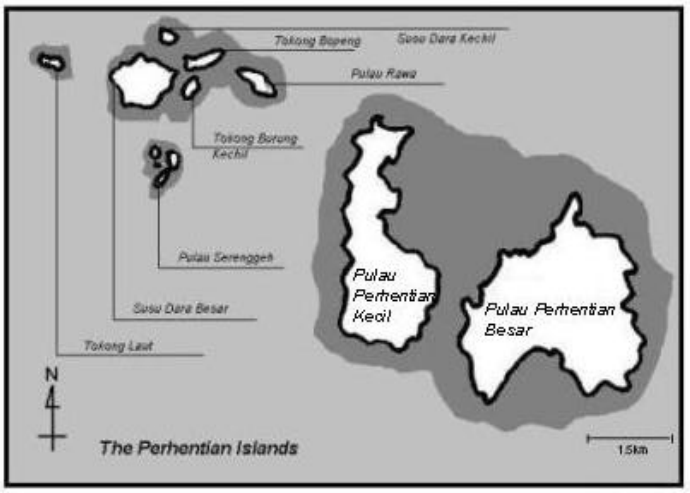

Figure 1.2 Schematic map of Perhentian Islands, Malaysia. (Approximate scale only).

Although tourism started in the 1960s, prior to the early 1980s, the main economic activities on the islands were fishing and small scale agriculture including coconuts, rubber, cloves and fruit trees. In 1991 the population census placed the population of the islands at 1,010 people; estimates today put the population at 1,500 people with the majority of the population being local Malays. The physical infrastructure of the village situated on Perhentian Kecil, consists of a jetty, a primary school, a health clinic, a police station, a post office and several shops and a small market. Electricity became available for limited periods in 1990 and increased to 24 hours in 1994, new generators and infrastructure are currently being built and the whole system modernised. Piped water is now provided to the village from the water treatment plant on Perhentian Besar.

Tourism really started to make an impact after 'Visit Terengganu Year 1992' where the Perhentian Island Resort was developed as the sole international class hotel. Subsequently more and more developments have sprung up on both Kecil and Besar. The main economic activity of the islands now consists of tourism.

The Perhentians do, however, have limited areas for development due to limited availability of flat lands. Most of the islands are hilly and still covered by forest so that development has been restricted to small coastal strips. The biggest concentration of chalets can be found in Pasir Jong and Teluk Dalam on Perhentian Besar and Pasir Panjang on Perhentian Kecil. Many of the resorts are small scale with traditional buildings and cheap accommodation.

However, the islands are themselves small and can only support a certain amount of development and infrastructure. Excessive demands on water and problems of waste disposal are already all too evident on the islands. Shortages of land force developers into direct conflict with conservation initiatives e.g. illegal development on turtle beaches. Development results in dredging of channels, destabilisation of slopes, deforestation and releasing sediment on to coral gardens.

Estimations from the Marine Park staff suggest that Redang has over 60,000 visitors in the 8 months when it is accessible from the mainland. The Perhentians have been estimated to receive up to 69,000 tourists in 8 months (which is the length of the tourist season) (Tamblyn pers.coms).

1.3 Pulau Redang

Redang Island Marine Park has been marketed as a successfully managed Marine Protected Area. Redang Island was valued for its pristine reef and ecosystems but as early as 197 the Malaysian Nature Society (Green 1978) called attention to the noticeable deterioration and its increase in visitor numbers. Consequently after the Fisheries Act of 1985, Pulau Redang Archipelago was the first area to be declared a Marine Park in 1985.

Redang supports a population of over 2,000 people. Initially these people were fishers (81% of the residents in 1989) with additional small-scale enterprises such as turtle egg, birds' nest and shell collection, subsistence agriculture and the tourists trade (MNS 1990). In the 1990s MNS estimated that 2,500 people a year visited the islands and that this had caused concerns and threatened the carrying capacity of the area. Tourism was unfocused, based on camping and small traditional 'a' frames, toilets consisted of pit latrines and rubbish was either burnt or buried. The MNS study of this area (1990) suggested that locals and tourist business alike believed that keeping tourism small scale ensured the atmosphere of the islands was maintained. However, detailed management plans were required to ensure the sustainability of the islands and prevent further ecosystem degradation.

In 2003 Marine Park staff estimated that 60,000 tourists visit Redang in a single year (based on 2002 figures, Tamblyn pers coms). Change has been rapid and construction includes large jetties, 212 room resorts and expansion of the additional 12 resorts, coral dredging and an airstrip site. Many of these developments fail to adhere to the Department of the Environment's rules and EIAs that are mandatory for building in Marine Parks. Blatant violations during construction include burning of rubbish, lack of silt traps used, sullage water left untreated, sewage water discharging untreated and diesel spillages (MNS).

1.4 Pulua Tioman

Pulau Tioman first hit the international spotlight by being the location for the musical 'South Pacific'. Today Tioman's international interest is far more controversial as the development of a RM40 million yachting marina threatens Tioman's ecosystems (Malaysian Nature Society 2004) and defies EIAs and Marine Park policy. Since the 1980s, Tiomans tourist development has been largely based on large-scale resort hotels being built on the coastal area. Although development has been limited to the coastal zone, due to the increase in numbers of tourists visiting the area, a larger number of people are now utilising the forest ecosystem. It has been estimated that over 190,000 tourists arrive annually at P.Tioman, based on tourist arrivals from 1995-2003, according to the Tioman Development Authority.

Pulau Tioman is situated 45 km off the east coast of Peninsular Malaysia and is a pear shaped island 22 km long and 11 km wide. As early as 1972 the island was gazetted as a state wildlife reserve (12,383 ha reserve) however in 1984 over 4,000 ha were excused to aid agricultural development. Today only just over 8,000 ha remains of the wildlife reserve. The island's terrestrial habitat includes primary lowland dipterocarp forest, upper hill cloud forest, secondary successional forest, mangrove and coastal forest, in addition to small farm gardens. In 1985 the waters around the islands become a national marine reserve under the Fisheries Act (1985).

The first major scientific expedition occurred in 1966, with the then National Museum of Singapore (now the Raffles Museum of Biodiversity Research) (Medway & Bullock, 1966) which lead to some major contributions of research on mammals, birds, herptiles and freshwater fish. Recently PERHILITAN (the Department of Wildlife and National Parks Malaysia) and many foreign-based researchers have also visited the islands.

Tioman is thought to have been connected to both Peninsular Malaysia and Borneo during the last ice age, as some of the island's flora and fauna more closely resemble Bornean taxa (Ng *et al.*, 1999).

1.5 Project Background

Coral Cay Conservation (CCC) is a not-for-profit organisation that provides resources for the protection and sustainable use of tropical ecosystems. CCC works closely with local communities and organisations and is funded primarily by volunteers who pay to participate in the research programme as resource surveyors.

Following meetings between Marine Park Section personnel in Malaysia and Peter Raines, CCC Managing Director in May 2002, a collaborative project was planned to be undertaken on the Perhentian Islands between March and June 2003. This would initially be a 3-month pilot phase project with a view to long-term implementation of the Malaysia Reefs and Islands Conservation Project (MRICP). Full details of the project development stages and rationale for the MRICP are given by Raines (2002).

A preliminary literature review revealed that virtually no baseline ecological survey work has been completed on the Perhentians. Thus, whilst the islands are inhabited and support a growing tourist industry, the impacts on the islands natural resources via consumptive and non-consumptive uses is unclear. In 2003 this project was in collaboration with Marine Parks and in 2004 partnership was developed with PERHILITAN as a result of the 2003 pilot phase. Surveys by CCC will provide the data and outputs necessary to provide management recommendations and habitat maps to help the long-term conservation and sustainable management of this area.

1.6 Aims of the Malaysian Tropical Forest Conservation Project

The aim of the research detailed in this document was the collection of further, in-depth baseline information on the health and ecological status of the forests of the Pulau Perhentian Archipelago. In addition, it is one of the stated objectives of the proposed work to instigate a programme of training and conservation education at both the local scale on the Perhentian Archipelago and also at the national level within

Malaysia. The aims, objectives and anticipated outputs are summarised in Table 1.3 below.

Table 1.3 Aims, objectives and outputs of the Malaysian terrestrial project.

AIM	OBJECTIVE	ANTICIPATED OUTPUT
• Resource assessment	• Undertake an initial scientific survey of target forest areas • Conduct detailed inventories and provide quantitative data sets of major faunal groups • Establish a Baseline dataset • Map terrestrial habitat types • Provide preliminary management tools and recommendations	• Initial Baseline database • Description of forest habitats • Documentation of gross anthropogenic impact • Preliminary habitat map using satellite imagery • Preliminary management recommendations
• Habitat based assessment	• Undertake spatially based surveys within the project area to quantitatively assess species distributions by habitat type • Conduct preliminary human impact assessment studies • Provide data for the national, regional and global datasets • Provide preliminary management tools and recommendations	• Quantitative biodiversity assessment and comparison of terrestrial habitats • Data set for comparison with future surveys • Preliminary management recommendations
• Training and conservation education	• Provide scientific training for CCC volunteers and Malaysian Nationals • Heighten awareness of forest resources, their use and protection • Begin to develop a sense of community awareness and stewardship in managing the forest resources of the Perhentian Archipelago	• Trained project members • Increased forest survey human resource capabilities within Malaysia • Increased awareness amongst local communities

1.7 Report Outline

This report provides a detailed view of the biodiversity of both P.Besar and P.Kecil and includes details of outlying islands.

The ecological survey work concentrated on the larger islands of Besar and Kecil; however, over the 8-month project phase additional islands were surveyed.

The report focuses on faunal assessments of the islands including: bats, birds, mammals (non-volant), butterflies and herpetofauna. Species inventories and research conducted on Redang and Tioman are compared to the biodiversity assessment completed on the Perhentians.

Finally, the development of conservation indices and biodiversity indicators are addressed and applied to the Perhentian Islands. These are visually represented on maps to highlight areas of high biodiversity.

2. Survey Approach

Ecologically sound forest management, whether for conservation alone or in conjunction with sustainable resource use, will only become successful if the dynamic behaviour of the systems can be adequately characterised and predicted (Alder & Synnott 1992). Habitat mapping studies used in combination with baseline faunal and floral surveys for all major habitat types provide an opportunity to assess ecological patterns and changes along spatial and temporal dimensions. Therefore, they have a central role in many aspects of tropical forest research, conservation and management (Turner *et al.*, 2001).

It is acknowledged that conservation biologists have long used "non-professional" volunteers to collect much of the information needed to make informed decisions concerning resources they are trying to protect (Bildstein 1998). There is also a growing body of literature supporting the use of trained volunteers in baseline ecological monitoring work, and with appropriate training, non-scientifically trained, self-financing volunteers have been able to provide useful data for natural resource management at little or no cost to the host country (Fore *et al.*, 2001; Mumby *et al.*, 1995; Darwall *et al.*, 1996; McLaren & Cadman 1999). This approach has been pioneered and successfully applied by Coral Cay Conservation (CCC) since 1986. At present it is used in collaborative programs in the Philippines (working with local NGOs and local Government), Fiji (with the Ministry of Tourism) and in Honduras (working with a local Non-Governmental Organisation).

The scope of volunteer participations is thus that any individual with appropriate levels of commitment are permitted to participate on a CCC programme. Traditionally, volunteers are international in their origin with a mix of ethnic backgrounds. In addition to employing the services of international volunteers, CCC offer four fully funded places per monthly program cycle to Malaysian Nationals with a proven interest and commitment to work in an appropriate field. Applicants to this scholarship programme are screened for suitability by senior CCC staff. It is anticipated that scholarship candidates will be from a wide range of backgrounds to include those from academic institutes in Malaysia as well as government and non-Governmental Organisations. The cyclical nature of CCC programmes provides for a high turnover of both international and national volunteers.

Efficient and effective training is a vital component of any volunteer programme in order that participants quickly gain the required identification and survey skills that allow them to collect accurate and useful data. During the research work, CCC uses an intensive 7-day training programme. The programme was designed to provide volunteers, who may have no biological knowledge, with the skills necessary to collect useful and reliable data. The primary aim of the lecture programme is to give volunteers the ability to discern the specific identification characteristics and relevant biological attributes of the target organisms they will encounter during surveys. The training programme is co-ordinated by the Project Scientist (PS) and Science Officer (SO) and involves lectures, equipment orientations and practical sessions within the field, with de-briefings and evening audio-visual presentations. Volunteers are also encouraged to utilise identification guides (and other reference texts) to ensure a thorough understanding of the information provided in the lectures.

An important component of the training schedule is a series of testing procedures to ensure that each volunteer has reached a minimum acceptable standard. Hence the training programme concludes with a series of tests, which ensure that the volunteers have reached an acceptable standard of knowledge. These tests use both paper-based and practical skills tests to assess survey technique knowledge and application. Furthermore, to assess the quality of data collected by CCC volunteers during actual survey work, validation exercises are undertaken.

The terrestrial training and survey programme follows an adapted version of the model recently used on Danjugan Island in the Philippines, where a four-month flora and fauna inventory study was recently completed (Turner *et al.*, 2002a). It will also apply many of the methods used during forest resource assessment work elsewhere in the Philippines (Turner *et al.*, 2003b). All surveys will be co-ordinated by the PS and SO to ensure accurate and efficient data collection.

2.1 Survey Sites

All sites that were surveyed over the period of seven months, on both Besar and Kecil, are illustrated below (Figure 2.1).

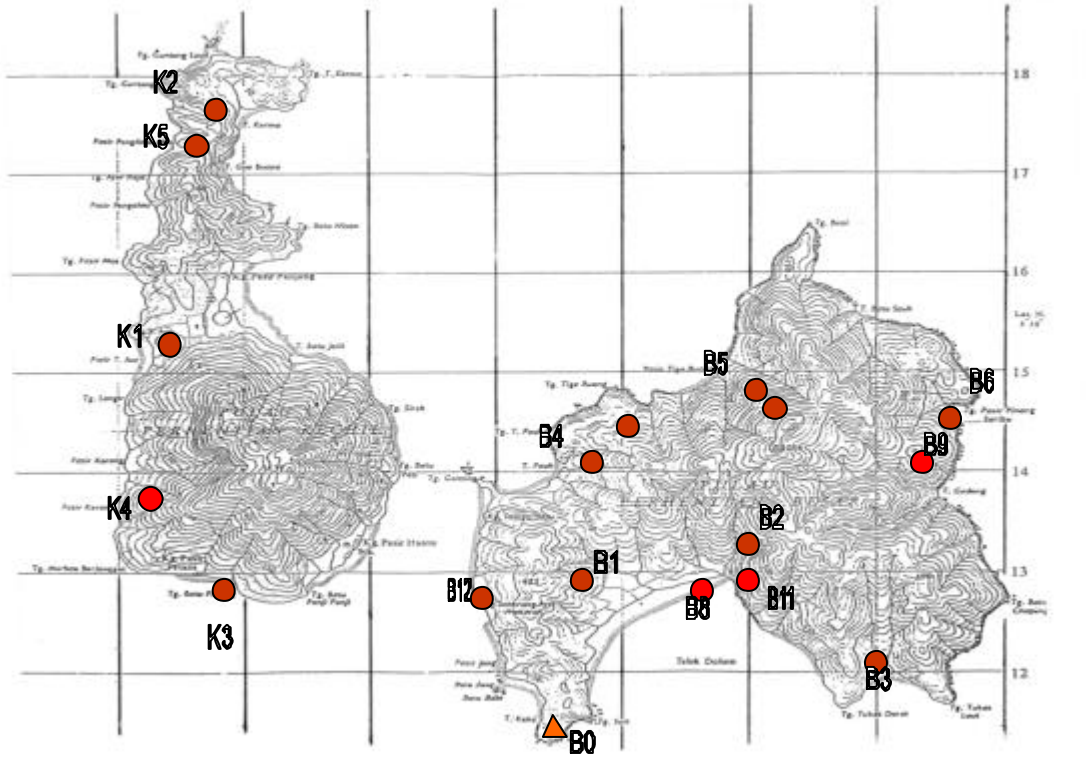

Figure 2.1 Survey Locations are given as sites B0 – B12 and K1 – K5. Base camp (B0) is given as red triangle situated on Besar.

2.2 Vegetation Description of Survey Sites

The Perhentian Island chain consists of continental islands that belong structurally to and represent a submerged part of the mainland. These islands survived the rise in sea level around 20,000 years ago when the sea level rose 120 metres. Thus the islands, originally connected by land bridges, have been isolated for 15 – 20,000 years.

The Perhentians are granite islands, which are characterized by hilly slopes joining the sea and granite tors protruding out forming cliffs and outcrops. The granite bedrock of the islands only permits the development of thin and rocky soil, however, in more sheltered valley areas, deeper soils have been allowed to form.

Most of the island of Besar is virgin forest comprising of mainly Dipterocarp forest, with both *Dipterocarpus* species and *Shorea* species being found. The vegetation on Kecil has been altered and only in largely inaccessible areas such as the steep sided southern region, are there pockets of primary forest, surrounded by secondary rainforest. Details of this are shown in the sateliite image (Figure 2.2).

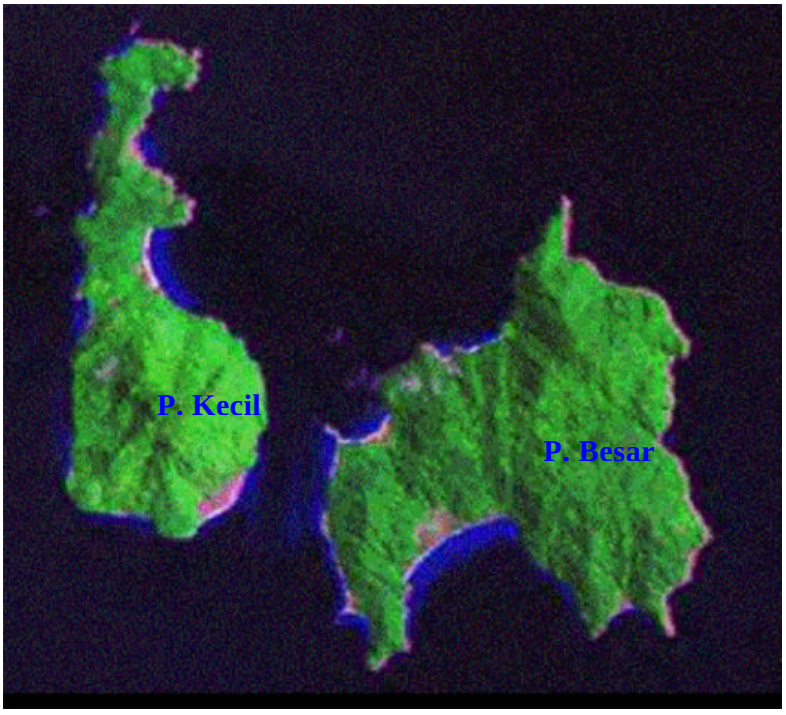

Figure 2.2. Landsat satellite image of the Perhentian islands. Colour Key: Green – extent of vegetation cover (90% forest on P. Besar, 60% forest P. Kecil); Pink – developed areas (particularly Westside of P. Besar and Eastside of P. Kecil); Blue – shallow coastal waters.

Differences in tree sizes between the sites were examined by measuring the girths (using tape measures) at breast height of the 10 largest trees within 20m x 20m sample

plots; the circumference (girth) values were then used to calculate the diameter at breast height (DBH). The plots were centred at alternate Sherman traps along the small mammal trapping lines (see methods for small mammals chapter 7) or at the point count stations (see methods for birds chapter 4). In addition to DBH values for each plot, we recorded the presence of plantation trees, foot trails, and the stumps of logged trees.

Base (B0): The area around base camp is dominated herbaceous shrub layer, interspersed with coconut palms, with cleared areas of grassland. To the north and east of the base camp the old growth forest appears.

B1: The area surveyed was located to the west of the Jungle Trail, which links Flora Bay with the Perhentian Island Resort at T.Pouh, and is the only well used trail through the forest on the island. The trail runs parallel to a permanent stream. The floor of the stream's gorge was found to have primary high canopy dipterocarp forest and trees likely to have been planted by people, mostly banana, along the trail. The height of the canopy decreased towards the ridges. In some areas on the west bank of the stream there are smaller trees and dense bushes.

B2: The survey site was up-stream of a waterfall (occasionally visited by tourists) in an area of primary forest and steep slopes. The stream exits at the far northeastern end of the Flora Bay beach. A stretch of stream below the waterfall has recently been dammed by a resort owner to create a pool to draw water from - a water pipe now leads from the pool through the forest to the resort. The upper reaches of the stream was opened and vegetated with small trees and vines. Large mature trees were found on the slopes giving way to smaller trees on the slopes towards the streams source.

B3: Situated in the south east of Besar, this survey location consisted of primary forest stands inter-dispersed with banana trees planted alongside a small river. Where two streams meet the area has established beds of lilies. The beachfront area has recently been developed, and this development extends slightly into the forest where rubbish pits have been dug and water pipes are drawing water from the stream. (Average DBH 126.10 cm in a sample size of 50 individuals, standard deviation of 35.78 cm).

B4: The survey location was based on a ridge to the northeast of the Perhentian Island Resort (Tg. T. Pauh) in west Besar. Seasonal streams flow under boulders exiting at the small beach north of the resort. A trail runs from this small beach and loops northeast to join with the Jungle Trail. Although it is a clear, well-worn trail, it does not appear to be in regular use. This area is typical of other sites on the island, with tall dipterocarp forest, small dry streams and boulders. Some of the boulders are large enough to create overhangs where bats are roosting.

B5: Situated in northern Besar at the north east corner of the beach, which is now a turtle nesting sanctuary (Pasir Tiga Ruong), this survey site showed evidence of disturbance from tree tapping (plastic rubber collecting cups were commonly found on the floor and many trees were marked (with tape) and had tapping holes) to smaller tree felling along a recently cleared path. The canopy is high and enclosed with small streams, woody vines and rocky outcrops. Moving eastward, there are steep slopes and a change in vegetation: smaller trees, dense bush, and rattan the forest is

undisturbed. (Average DBH 126.67 cm in a sample size of 110, standard deviation of 29.02 cm).

B6: Situated on the east coast of Besar approximately 50m from the beach, next to the northerly stream. The area between the streams is dominated by dense bush and several stands of bamboo forming a low canopy. Either side of the streams the canopy is high, leading up to the ridges where the canopy is lower - an average height of approximately 25 m - containing many palms, pandanas and rattan species. The two streams exit at the beach. Further upstream, and on the slopes, large dipterocarp trees form a high canopy (Average DBH 122.84 cm in a sample size of 70 individuals, standard deviation 28.13 cm).

B7: Situated north of Besar, upstream of survey site B5 - in a southwesterly direction from the beach north of the turtle sanctuary - this survey base was in an area of steep slopes. Terrain is rocky and steep with little ground cover and mature forest cover. (Average DBH 126.60 cm in a sample size of 30 individuals, standard deviation 29.70 cm).

B8: Situated at the southern end of Besar behind Flora Bay. Moving away from the large gravel bed at the back of the beach, a very wet area dominated by Rattan is found. Beyond this the forest was quite open with signs of both natural and unnatural disturbance. Further north from the coast the forest became fuller with less breaks in the canopy with areas of large granite boulders. The site was hemmed in on either side by two streams both of which had a good flow of water in them. Moving north up the hill the terrain became increasingly steep. (Average DBH 114.16 cm in a sample size of 70 individuals, standard deviation 32.02 cm).

B9: Situated north east of Besar. This area is dominated by small saplings and rattan species with patches of dense ground cover and granite boulders. (Average DBH 124.39 cm in a sample size of 100 individuals, standard deviation 30.27 cm).

B10: Situated on the northern coast of Besar, and south west of Pasir Tiga Ruong, behind a beach known as the Blue Lagoon. The topography rose steeply away from the coast to one of the higher points on the island. The area surveyed was enclosed in a valley with steep sides that are likely to protect the forest from most of the storms hitting the island. Streams ran down each side of the survey area dotted with large boulders that acted as a natural break in the forest. At ground level the forest was open with the canopy dominated by larger trees resulting in very little understory. At the top and bottom of the hill there were fewer large trees and the understory was more developed. Huge granite boulders jutted out of the hillside producing natural outcrops on what was a very steep site. (Average DBH 133.81 cm in a sample size of 90 individuals, standard deviation 23.07 cm).

B11: Situated on the south of Besar, east of Flora Bay. The topography rose steeply to the southwest, with low canopy, large boulders and dense ground cover. To the west of this site there was little tree cover and canopy. Instead the areas and was dominated by ground cover and saplings. (Average DBH 125.28cm in a sample size of 100 individuals, standard deviation 22.09 cm).

B12: Situated on the west coast of Besar, facing the island of Kecil. This area is characterised by steep relief, high canopy with few breaks and many large boulders. Areas where there are breaks in the canopy contain many saplings and higher amounts of ground cover. (Average DBH 130.37 cm in a sample size of 60 individuals, standard deviation 23.76 cm).

K1: Situated on the west coast of Kecil. This survey site is off a regularly used pathway across the island that connects Long Beach and the beach on the west side of Kecil at P. Aur. Many of the larger trees within this area had been cut and rubber trees had been planted. North of the rubber plantation, the vegetation changes suddenly to dense low scrub. (Average DBH 79.61 cm in a sample size of 100 individuals, standard deviation 16.87 cm). To the south of the second trail there is a patch of grassland, likely to be abandoned agricultural land. Adjacent to this patch of grassland, the dipterocarp and ficus forest shows signs of disturbance, e.g. tree stumps. It was here that two illegal mist nets were found and confiscated by Perhilitan staff. Moving south, the gradient increases. Several trails were found, along with coconut and bamboo trees.

K2: Situated on the northern tip of Kecil. The area immediately behind D'Lagoon (T.Kerma) has been cleared and is now a small banana plantation with low lying vegetation. This survey site was a relatively flat area containing many logged trees leaving an open canopy (but lianas present) and dense ground cover consisting of rattan and saplings. (Average DBH 96.865 cm in a sample size of 40 individuals, standard deviation 19.50 cm).

K3: Situated on the southern tip of Kecil. This area is situated south of the main village of Kecil and consists of a well-used path into the forest segment. Coconut palms, bananas and rubber trees mixed in with secondary re-growth forest dominate this area. Signs of continued use and of rubber tapping and harvesting are present. Rattan and dense ground cover are dispersed under the plantation type species. (Average DBH 10.78 cm in a sample size of 100 individuals, standard deviation 25.70 cm).

K4: Situated at the southwest end of Kecil this was a fairly undisturbed site, with the forest running uninterrupted to the back of a small beach. About fifty metres into the forest there was a medium size abandoned banana plantation and was slowly being encroached upon by the forest. Heading north up the hill the forest showed signs of natural disturbance only. (Average DBH 106.4 cm in a sample size of 90 individuals, standard deviation 20.11 cm).

K5: Situated on the northern tip of Kecil, behind a west facing beachfront in a relatively flat area. Canopy cover limited with many saplings and ground cover dominating the forest floor. (Average DBH 89.09 cm in sample size 100 with a standard deviation of 15.37 cm).

SusuDara (Susu): One small beach gives access to this island. The south-facing slope has a moderate gradient, where tall dipteropcarp and ficus trees have been able to take hold. The ridge is typical of those found on Besar, with smaller trees and bushes. The north-facing slope has a steeper gradient and consequently was dominated by small trees and bushes. There was no evidence of unnatural disturbance to the vegetation.

Rawa: Access to this small island is via the only beach, where evidence that turtles are nesting was found. The western area of the island is dominated by low canopy forest. Moving eastward the forest opens into an area dominated by ferns before giving way to rock and low canopy forest again. The eastern tip of the island is bare rock and grassland. A colony of black naped terns appears to be resident on these exposed rocks.

3. Bats

3.1 Introduction

The Mammalian order Chiroptera has 1,001 species divided into two sub-orders: the Megachiroptera (Old World fruit bats) with 167 species and the Microchiroptera with 834 species (Mickleburgh *et al.,* 2002); the highest diversity is found in the neotropics, with South-east Asia being one of the richest areas. However, on oceanic islands, bats are often the most diverse group of mammals present. Oceanic island ecosystems are recognised as essential for the future survival of several bat species, most notably some of the larger megachiroptera, e.g. the Island Flying Fox (*Pteropus hypomelanus*), which roosts exclusively on islands. In turn, the ecosystems benefit as many trees, including dominant canopy species, rely on seed dispersal by these large frugivores. In some island systems pteropodids are the only vertebrates capable of dispersing the large-seeded fruits of canopy trees, therefore playing a vital role in structuring the plant community, earning them the title 'keystone species' (Rainey *et al.,* 1995).

Mickleburgh *et al* (2002) states that 112 species of bat are present in Malaysia: 17 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/SSC 2001). Of these listed, 2 are listed as critically endangered which, along with Myanmar and the Democratic Republic of the Congo, is the highest in the world.

Bats face many threats, largely due to expanding human populations: loss of habitat, hunting pressure, disturbance to caves, and persecution. The loss of forest habitats has undoubtedly affected the numbers of bats that rely on forest cover for roosts and food. On small islands, typhoon damage can have a similar if temporary effect. However, an expanding human settlement brings with it other species that can have an impact on native populations. Pteropids have traditionally been hunted for food in many areas within the Pacific and overexploitation has caused many population declines. The micorchiropterans have not suffered from hunting pressure to the same extent, although a few species are collected for food, as souvenirs, or to make traditional medicines. Interference with roosting areas, e.g. caves, and loss of habitat, reducing the numbers of insects the bats feed on, have been the major threats to populations.

In their review of the global status of bats, the Chiroptera Specialist Group of the IUCN's Species Survival Commission state that (in the neotropics) in many cases the numbers of species recorded are underestimates; and the lack of information makes assessing the status of populations difficult, which in turn hampers the development of appropriate conservation measures (Mickleburgh *et al.,* 2002). More research is needed in most areas.

Recent research on Malaysia's bats has focused on the remaining forested regions of the Peninsular, e.g. the long term monitoring of bat populations by the Malaysian Bat Conservation Research Unit in the Krau Wildlife Reserve (Kingston *et al.,* 2003).

Despite this increase in research effort and interest in bat conservation, Peninsular Malaysia's islands have received little research effort; most recent bat research carried-out was on Tioman Island as part of a broader biodiversity assessment (Lim *et al.*, 1999). However, the bat fauna of the Perhentian Islands has previously received little research effort.

3.2 Aims

- To compile an inventory of all the chiropteran species on the Perhentian Islands
- Assess chiropteran roosting sites
- To compare chiropteran species found on the Perhentians with other East Coast Islands
- To assess threats to chiropteran species
- To produce conservation and future research recommendations

3.3 Methods

The bat fauna was sampled at each of the survey sites using mist nets (in fixed positions or on poles for 'flicking'), hand nets, and by direct observation of roosting sites, e.g. from cave entrances. A total of ten 6 m x 2.6 m bat nets, made by Avinet (U.S.A), and supplied by Alana Ecology, were used; a further two 13m nets were made available during the course of the survey. The number of nets erected, and the time they were open, varied between sites due to: the number of volunteers available to put up and monitor the nets; the focus of each site's bat research, e.g. caves, forest, or plantation; weather conditions during a study (for instance work ceased for storms or heavy rain).

Mist nets
Mist nets were erected at a variety of heights to sample the Megachiroptera and Micochiroptera populations. Some nets were positioned in areas that were considered to be likely 'flight paths', e.g. over forest streams and forest trails, while other nets were set at random using poles or where high branches and the required gap (6 m) could be found. Low nets (0 – 5 m) were fixed on poles made from saplings or ropes attached to trees; high nets (6 – 12 m) were attached to loops of rope over branches or onto bamboo poles and raised using pullies (O'Malley *et al.*, 2004). Nets were opened at 18.30 and closed at approximately 22.00. They were checked regularly (every 15 - 20 minutes) to limit stress to entangled bats and the number of escapees, often by chewing their way out of the net.

'Flicking'
This method is used to capture elusive species - those better able to detect mist nets and so avoid capture - and to sample in an area where unmanageable numbers could be caught in a fixed net, e.g. at a cave entrance. Here a 6 m net was attached to two 3 m poles, made from saplings, each held by one researcher; when a bat approached, the poles were flicked-up to scoop the bat into the net. With a fast coordinated action from the two researchers holding the poles, the bats had little chance to swerve and avoid capture. Flick netting began at 18.30 hours and stopped at approximately 20.30 hours.

Hand nets
Hand nets were used to capture bats flying low through the forest, and at cave entrances.

Direct Observation
Other methods used to survey bats included daytime searches for roosts and recording the presence of roosting flying foxes when encountered.

Each captured bat was 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. Biometric data was recorded for each bat using callipers and Pesola Scales (100g, 600g, and 1000g). Forearm length is probably the single most important measurement when identifying bats (Bennett *et al.*, 1988); therefore it was recorded for all captures. Weight was found by weighing the bat in a cloth bag, and then subtracting the weight of the bag. When encountering a new species, or if identification was in doubt, then some or all of the following additional measurements were taken: tail length, ear length, hind foot, and total length.

Using these data, and by examining the bat's characteristic external features, identification was possible with the help of two keys: Kingston (2004), Ingle and Heaney (1992).

3.4 Results

A total of 15 species (some still to be confirmed) were captured during the survey period. Of these, 3 were Megachiropterans (*Pteropus hypomelanus, Cynopterus brachyotis* and *Eonycteris spelaea)* and 12 species of Microchiropterans (see table 2.1). A total of 136 bats were caught representing 8 families and 2 sub orders. Tables of biometrics taken are listed in Tables 3.6 Female Morphological Data, 3.5 Female Morphologcial Data (continued), 3.7 Male Morphological Data, and 3.8 Male Morphological Data (continued).

The most commonly netted species was the *Hipposideros larvatus* with a total of 52 individuals captured *Rhinolophus stheno/affinis* was netted 21 times, closely followed by *Megaderma spasma* netted a total of 19 times and *Cynopterus brachyotis* netted a total of 10 times. Tables 3.4 and 3.5 show surveying effort (with the type of nets used, their times opened and the numbers involved) which show how much effort is required to catch certain chiropteran species.

The location with the most netted species and the highest levels of diversity include Site 0 (base camp), B1, B5, B6 and B7 all on Perhentain Besar (see Figure 2.1 for locations).

Initially a variety of different statistics can be used to measure different attributes of community composition in relation to habitat or locations. This includes measures of total species per survey location, the total number of individuals found at each survey location, and diversity indices that are more informative about structure of the sampled community. This includes species richness, in terms of the number of species for a defined number of individuals; a species dominance index that identifies the way the community composition is divided up among the different species (see table 3.1).

Table 3.1 Diversity Indices for each survey location (for captured species).

Sample	Total Species[1] (S)	Total Individuals[2] (N)	Species Richness [3](d=(S-1)/Log(N))	Simpson's dominance Index[4]	Simpson's evenness index[5]
B0	11	22	3.24	0.12	0.88
B1	8	24	2.20	0.37	0.63
B3	1	1	-	1	0
B4	4	7	1.54	0.27	0.73
B5	4	21	0.99	0.60	0.40
B6	7	25	1.86	0.25	0.75
B7	4	17	1.06	0.38	0.62
B8	3	5	1.24	0.36	0.64
B9	2	6	0.56	0.72	0.28
B10	2	3	0.91	0.56	0.44
B11	1	5	0	1	0
K1	1	3	0	1	0
K2	3	13	0.78	0.46	0.54
K3	2	6	0.56	0.5	0.50
K4	1	1	-	1	0
K5	1	1	-	1	0
Susu	2	4	0.72	0.63	0.38

[1]Total species number.
[2]Total number of individuals.
[3]Species Richness defined by Margalef's Index. This incorporates the total number of individuals and is the measure of the number of species present for a given number of individuals.
[4]Simpsons Dominance Index. The largest values correspond to assemblages whose total abundance is dominated by one, or very few, of the species present within the sample site.
[5]Simpsons Evenness Index. This is used as the total sample size is relatively small. The higher value (of $1\text{-}S^{-1}$) appears when all species have the same abundance within the sample set.

Simpson's index is used here rather than Shannon-Wiener diversity index, as the Simpson's index is less sensitive to the degree of sampling effort (Clarke & Warwick, 2001).

From the above analysis table it can be seen that there are several sites that have low species diversity and high dominance of species. This includes B3, B9, B11, K1, K4 and K5. In each of these sites only one species of bat was identified. The highest site for species diversity is Site 0, where a total of 10 different species were identified, each being represented by few individuals, thus showing evenness. This includes the only confirmed sighting of *Pteropus hypomelanus, Taphozous melanopogon* and *Rhinolophus refulgans*. The island of Besar is shown to have a more diverse bat population than that of Kecil and the outlying island of Susudara.

Further analysis of community composition was assessed using PRIMER (Clarke & Warwick 2001). The Bray-Curtis similarity measure was calculated (from the number of individuals of each species per location surveyed) between the permutations of pairs (Clarke & Warwick 2001).

Table 3.2 Summary of Mega and Microchiropetran Species by location (from captures).

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

Table 3.4 Bat captures by location and Flick net effort.

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	K1	K2	K3	K4	K5	Rawa	Susu
Effort per location*	4	60	0	1.15	12	0	49	113	0	0	0	0	0	22.5	160	0	0	0	0	0
Species																				
Pteropus hypomelanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cynopterus brachyotis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eonycteris spelea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emballonura spp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emballonura monticola	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
Taphozous melanpogon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Megaderma Spasma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhinolophus affinis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhinolophus convexus/refulgens	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhinolophus stheno/affinis	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hipposiderus bicolor	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0.4	0	0	0	0	0
Hipposiderus larvatus	1	0.14	0	0.87	0.17	0	1	0.083	0	0	0	0	0	0	0	0	0	0	0	0
Hipposiderus spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0
Myotis muricola	0.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myotis spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Effort is calculated as number of hours of opened net multipled number of nets used.

Table 3.5 Bat captures by location and Mist netting effort.

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	K1	K2	K3	K4	K5	Rawa	Susu
Effort per location*	24	414	0	0	23	20	490	55	52	12	24	0	0	0	10	90	0	16	0	115
Species																				
Pteropus hypomelanus	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cynopterus brachyotis	0.18	0	0	0	0	0	0	0	0.038	0	0	0	0	0	0	0.1	0	0	0	0.037
Eonycteris spelea	0	0.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emballonura spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emballonura monticola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taphozous melanpogon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Megaderma spasma	0.1	0.33	0	0	0.2	0	0.013	0.036	0	0	0.083	0	0	0	0.2	0.13	0	0.25	0	0.4
Rhinolophus affinis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhinolophus convexus/refulgens	0.2	0.06	0	0	0	0.1	0.1	0	0.067	0	0	0	0	0	0	0	0	0	0	0
Rhinolophus stheno/affinis	0	0.06	0	0	0.2	0.04	0.02	0.015	0	0	0	0	0	0	0.086	0	0	0	0	0
Hipposiderus bicolor	0	0.03	0	0	0.4	0.05	0.033	0	0	0.33	0	0	0	0	0	0	0	0	0	0
Hipposiderus larvatus	0	0.01	0	0	0	0.0060	0.17	0.067	0.049	0.13	0	0	0	0	0	0	0	0	0	0
Hipposiderus spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myotis muricola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myotis spp.	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0

* Effort is calculated by number of hours mist nets (average of opening times of 18.30-21.00) are opened multiplied by number used.

Table 3.6 Female Morphological Data.

Species	Statistical Measures	Mass (g)	Fore-arm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)
C. brachyotis	Mean	44	64.55	14.775	11.875	-
	St.dev	7.34	0.28	0.45	1.89	-
	Range	35-50	64.3-64.8	14.3-15	9.9-14.3	-
	N	4	4	4	4	-
E. spelaea	Mean	27	58.3	15.6	-	-
	St.dev	-	-	-	-	-
	Range	-	-	-	-	-
	N	1	1	1	-	-
H. bicolor	Mean	11	44.9	16.4	5.9	-
	St.dev	-	-	-	-	-
	Range	-	-	-	-	-
	N	1	1	1	1	-
H. larvatus	Mean	15.80	56.68	16.28	8.94	29.1
	St.dev	2.44	0.90	2.68	0.80	-
	Range	11-18	55.1-58.4	10.4-19.2	7.6-10.45	-
	N	13	14	12	12	1

Table 3.7 Female Morphological Data (continued).

Species	Statistical Measure	Mass (g)	Fore-arm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)
R. affinis	Mean	6	17.87	8.34	5.04	-
	St.dev	6.08	27.1	9.05	4.73	-
	Range	11-15	48.5-49.7	15.6-21	9.1-11.3	-
	N	3	4	4	4	-
R. convexus/refulgens	Mean	5.83	38.53	13.86	6.76	-
	St.dev	0.57	0.92	0.32	1.17	-
	Range	5.5-6.5	38-39.6	13.5-14.1	5.9-8.1	-
	N	3	3	3	3	-
R.. stheno/affinis	Mean	12.97	49.8	17.95	10.85	17.8
	St.dev	1.47	0.92	1.49	1.06	-
	Range	11-16	47.6-50.6	16.2-20.2	9.9-12.2	17.8
	N	9	9	6	4	1
T. melanopogon	Mean	23.83	63.18	11.5	11.5	-
	St.dev	7.00	0.80	-	-	-
	Range	16-29.5	62.4-64	11.5	11.5	-
	N	3	3	1	1	-
Unknown Emballonura	Mean	22.5	64.4	13.5	10	25.5
	St.dev	0	0.28	0.70	2.96	0.98
	Range	-	64.2-64.6	13-14	7.9-12.1	24.8-26.2
	N	2	2	2	2	2
M. muricola	Mean	3	31	7.5	5.2	-
	St.dev	-	-	-	-	-
	Range	-	-	-	-	-
	N	1	1	1	1	-
M. spasma	Mean	25	69.3	39.5	13.8	-
	St.dev	-	-	-	-	-

Table 3.8 Male Morphological Data .

Species	Statistical Measures	Mass (g)	Fore0arm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)
C. brachyotis	Mean	38	61.2	15.85	13.95	-
	St.dev	2.82	4.75	1.62	1.34	-
	Range	36-40	56.1-65.5	14.7-17	13-14.9	-
	N	2	3	2	2	-
E. spelaea	Mean	70	70.8	-	15.1	-
	St.dev	-	-	-	-	-
	Range	-	-	-	-	-
	N	1	1	-	1	-
E. monticola	Mean	5	44.1	-	-	-
	St.dev	-	-	-	-	-
	Range	-	-	-	-	-
	N	1	1	-	-	-
M. spasma	Mean	23	56.87	30	15.03	-
	St.dev	2.58	0.45	1.8	2.43	-
	Range	20-26	56.4-56.8	28.2-31.8	12.4-17.2	-
	N	4	4	3	3	-
H.bicolour	Mean	5.92	41.81	15.5	6.11	23.05
	St.dev	1.23	3.23	1.39	0.97	0.77
	Range	4.5-8	35.6-44.6	13.1-17.4	4.8-7.6	22.5-23.6
	N	7	6	7	6	2

Table 3.9 Male Morphological Data (continued).

Species	Statistical Measures	Mass (g)	Fore-arm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)
H. Larvatus	Mean	15	55.90	16.42	8.71	-
	St.dev	1.81	1.22	1.52	0.80	-
	N	23	24	16	18	-
	Range	11-18	52.8-58.5	14.2-18.5	7.7-10.6	-
M. Muricola	Mean	4	34.7	9	6.8	33.9
	St.dev	-	-	-	-	-
	Range	-	-	-	-	-
	N	1	1	1	1	1
R. affinis	Mean	12	49.36	18.46	9.7	16.8
	St.dev	2	0.64	1.76	0.36	
	Range	10-14	48.9-50.1	16.5-19.9	9.4-10.1	16.8
	N	3	3	3	3	1
R. stheno/affinis	Mean	11.66	49.8	17.9	9.73	20.35
	St.dev	1.15	0.2	1.41	0.80	1.62
	Range	11-13	49.6-50	16.4-19.2	8.9-10.5	19.2-21.5
	N	3	3	3	3	2
R.convexus/refulgens	Mean	5.75	38	12.25	6.525	14.5
	St.dev	1.06	1.41	1.90	1.16	-
	Range	5-6.5	37-39	10.9-13.6	5.7-7.35	14.5
	N	2	2	2	2	1
Unknown Myotis	Mean	3	-	7.3	4.9	33.3
	St.dev	-	-	-	-	-
	Range	-	-	-	-	-
	N	1	-	1	1	1

The relationship between survey sites was analysed using a hierarchical agglomerate clustering technique (Clarke & Green 1988) (see figure 3.1).

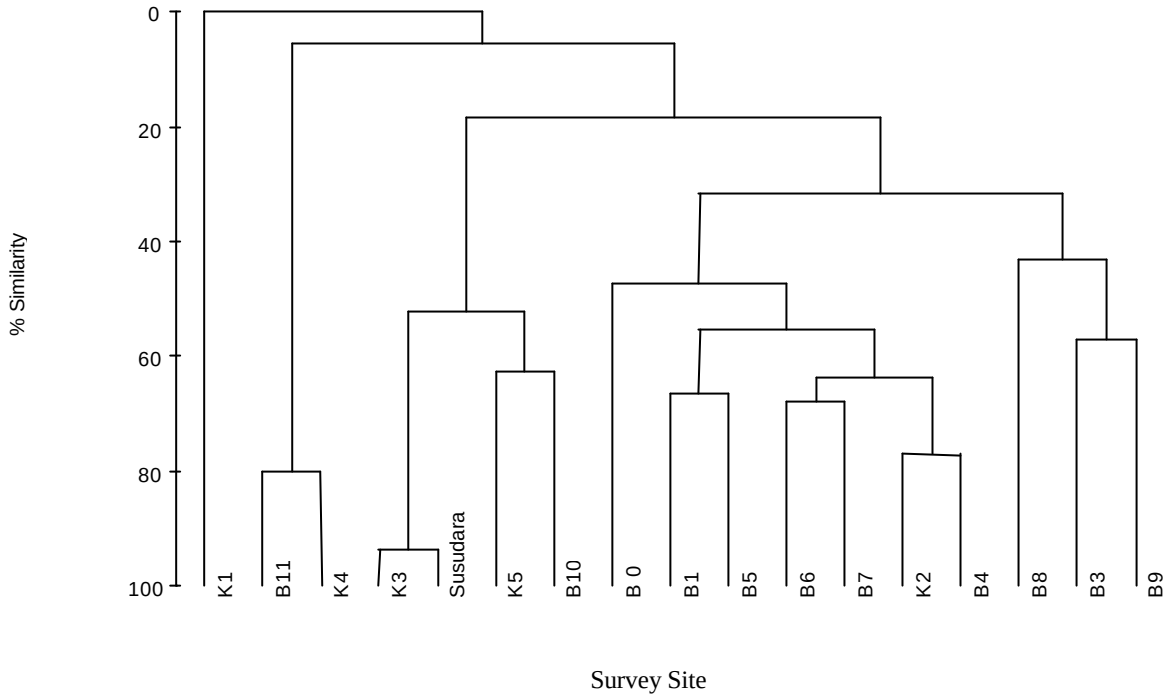

Figure 3.1 Dendrogram showing similarities of bat species composition between survey sites. (Using Bray-Curtis similarity transformation 4th root).

From the dendrogram above it can be seen that the main outlier is survey site K1. The only bat species that have been sampled in this location were unidentified *Hipposideros* species, with no other species being represented. K4 and B11 form a further separated group having only one species represented within the survey location site (*Rhinolophus affinis*). K3, Susudara, K5 and B10 represent the third major group with a total of three species captured at these locations (*Cynopterus brachyotis*, *Megaderma spasma* and *Rhinolophus affinis*) all in relatively low numbers. The fourth major group consists of the majority of survey sites, having a higher percentage in similarity, and sites that are found mostly on Besar. These sites are dominated by four major microchiropteran species *Megaderma spasma*, *Rhinolophus convexus/refulgens*, *Rhinolophus stheno/affinis* and *Hipposideros larvatus* in relatively high numbers. B0 is more distinct from the group by having more species present that have not been surveyed (caught) in any other location including, *Pteropus hypomelanus*, unidentified *Emballonura* species, *Taphozous melanopogon* and *Rhinolophus refulgans*.

Although only captured at one site, flying foxes were present at all sights visited including Rawa and Susu Dara. These flying foxes and other high fliers (for example, *T. melanopogon*) have been observed across the sites, but due to the difficulties in catching such species the data suggests that there are few across the islands. Observations also place *Cynopterus brachyotis* at Rawa Island.

Further research on caves and bat roosts were undertaken over the survey period providing insight into possible numbers of bat communities.

Caves and bat roosts

Tg Pasir Pinang Saribu (east Besar near survey site B6): *Taphozous melanopogon* were roosting amongst boulders along the coastline (Approximately 300m on a bearing of 260-270° from the beach) south of the beach. Identification was made by photography and was based on their roosting position (Emballonuridae are agile and often hold onto rock 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 in this cave.

Approximately 75m east of Tg Pasir Pinang Saribu (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 on June 12th).

T Keke (south Besar near survey site 0): Approximately 250 m on a bearing of 70° from base camp *Taphozous melanopogon* were found roosting on a large rock overhang. Three individuals were captured (female) and identified according to Kingston (2004), and Ingle and Heaney (1992).

Pasir Tiga Ruong (north west Besar near survey site B10-B5): The entrance was approximately 1.5 m high by 4 m wide. *Hipposideros larvatus* was captured emerging at dusk. Individuals were captured, showing two different colour phases.

Caves not surveyed:
There is a cave on western side of Susudara Besar reported to have large numbers of bats but due to access difficulties this was unable to be survyed.

T.Kerma (north Kecil): Approximately 150 m south of T.Kerma is a large opening into a cave exposed to the sea. The cave is guarded to protect the interests of a businessman who has licence to collect birds' nests from the cave. There is a bat colony resident in the cave, however due to difficulties of access no sampling was possible.

Comparisons with other East Coast Islands

Research completed on all three east coast islands shows varying degrees of similarities, with P.Tioman being the most biodiverse in chiropteran fauna, followed by the P.Perhentians and lastly P.Redang. There are several species that may now be extinct in P.Redang as their presence has not been noted since 1911.

Table 3.10 Comparisons of bat species across East Coast Islands

Scientific Name	Common Name	Redang[1]	Perhentian [2]	Tioman[3]
Pteropodidae				
Cynopterus brachyotis	Lesser Dog Faced Fruit Bat	Last recorded 1911	Yes	Yes (endemic subsp)
Cynopterus horsfieldi	Horsefield's Fruit Bat	No	No	Yes (endemic subsp)
Eonycteris spelaea	Cave Fruit Bat	Yes	Yes	Yes
Macroglossus minimus	Common Long-tongued Fruit Bat	No	No	Yes (P.Tulai)
Pteropus hypomelanus lepidus	Island Flying Fox	No	Yes	Yes
Emballonuridae				
Emballonura monticola monticola	Lesser Sheath-tailed Bat	Last recorded 1911	Yes	Last recorded 1962
Taphozous melanopogon	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	Last recorded 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	Last recorded 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	Last recorded 1966
Vespertilionidae				
Myotis muricola	Whiskered Myotis	No	Yes	No

[1]Redang survey completed in 1990 by Malaysian Nature Society.
[2]Perhentian surveys completed by CCC (Turner *et al.*, 2003c & 2004)
[3]Tioman surveys compliled from Lim *et al.*, (1999) Raffles Bulletin of Zoology, supplement 6.

Table 3.10 shows that there are two species which are endemic on Tioman; however, more research has been conducted on this island. 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. Figures 3.2 and 3.3 illustrate Table 3.10.

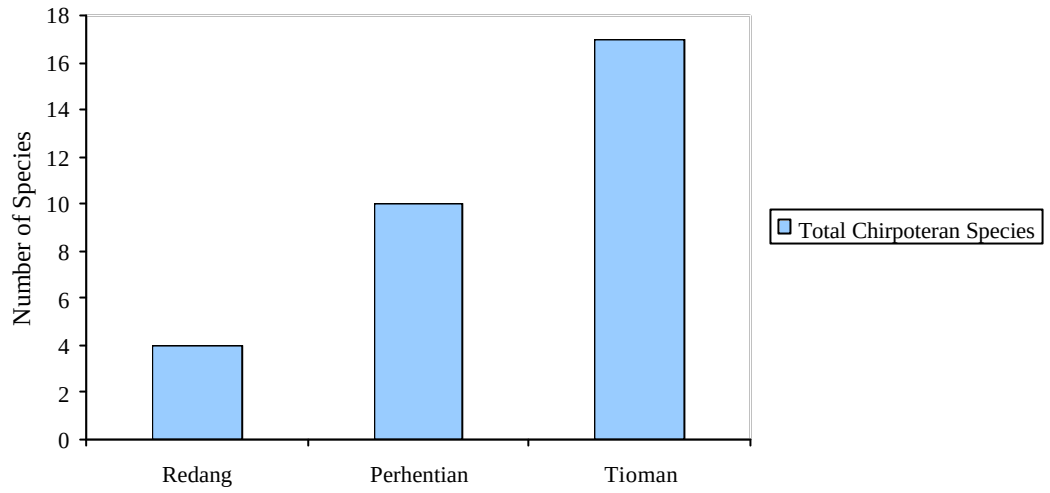

Figure 3.2 Total Chirpoteran species across the East Coast Islands.

Figure 3.2 illustrates that Tioman has the largest species diversity with 17 species being present on the island. The Perhentians follow with 10 species and Redang with a total of 4 species. Species that have not been recorded since the 1960s have been omitted in this analysis.

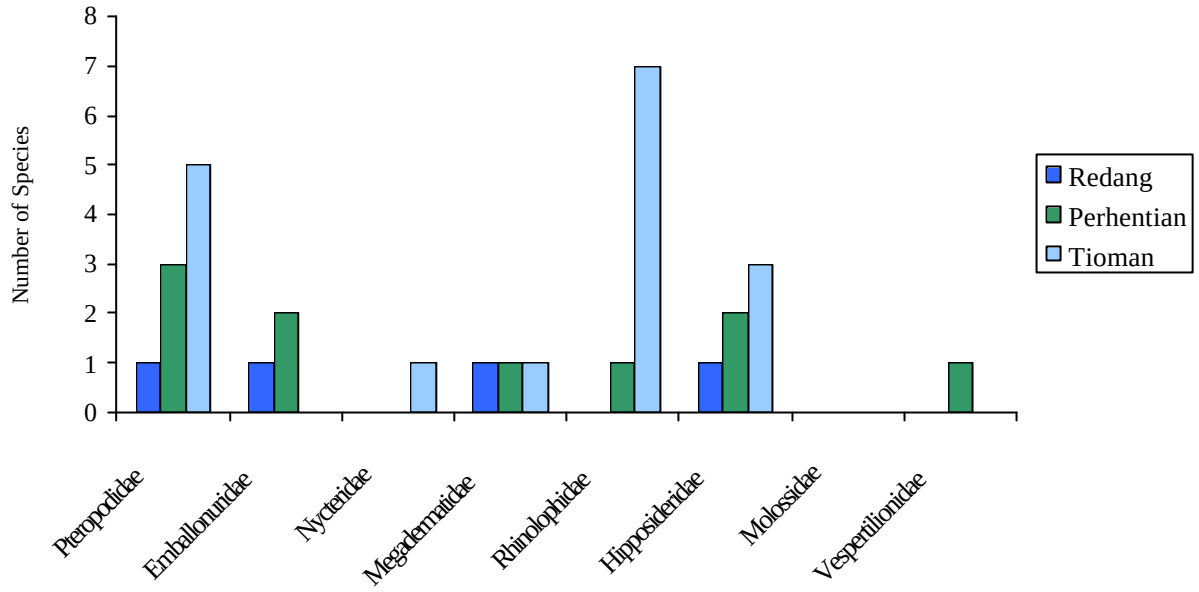

Figure 3.3 Chirpoteran Families represented on the East Coast Islands.

The Rhinolophidae and the Pteropodiae families represent the greatest numbers of species.

3.5 Discussion

All species that have been 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. Further more, 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. P.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.

P.Besar contains more micro and megachiropteran species than P.Kecil. This maybe due to the number of roosting sites available (caves, hollow trees) on Besar, due to the fact that Besar is a larger island and has more undisturbed land 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. Both islands were planted with fruiting trees in the past as part of the islanders' subsistence economies.

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 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 that 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 under storey 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/both P Redang and P Tioman, which could be seen as an indication that Perhentian is, in its present state, less disturbed than the other East Coast islands.

4. Birds

4.1 Introduction

It is estimated that there are 9672 species of bird in the world. Of these, 725 species are found in Malaysia. There are 39 species that are considered to be endemic and 34 species near endemic. There are approximately 430 resident species and 70 species that regularly migrate through the region. Malaysia is ranked 21st among all countries for the diversity of it's avifauna. The Malaysian Nature Society has highlighted 150 sites that have the potential to be Important Bird Areas (IBA) and Malaysia currently has 7 Endemic Bird Areas (EBA) (BirdLife 2004).

The coastal area of Malaysia has a large diversity of habitats ranging from the tropical rainforests that spread down from the hills, to the wetlands that dominate much of the coastline. The coastal area of Malaysia and its offshore islands are significant as they fall under the East Asian Flyway, the Southeast Asia Migration route. Therefore the area is not only important for feeding and roosting sites for resident species but also provides stopover sites, food and shelter for migratory birds. The conservation and understanding of these coastal areas and the interrelation between the coast and offshore islands is vital for the future of bird species in the area.

The fact that the Perhentain islands fall under the East Asian Flyway provides a haven for endemic, endangered, coastal and migratory species. The main island, Perhentian Besar, and the other uninhabited islands have had very little disturbance, the eastern side of Perhentian Besar being almost inaccessible. Perhentian Besar, Susu Dara Besar and sections of Perhentian Kecil are dominated by dipterocarp forest and may have important ecological roles.

Although island habitats can be seen as potential refuges for species, island species are more susceptible to local extinctions. As many as 67% of Globally Threatened Birds on oceanic islands are threatened by invasive species and the total numbers of extinctions associated with invasive species has risen to 65 bird species (BirdLife 2004). Although there are complicated interactions, extinctions and threats to species survival are believed to be mostly caused by the introduction of rats and cats to island habitats.

4.2 Aims

- To assess the bird species diversity on the Perhentian Islands
- To compliment and expand previous species records
- To assess relative abundance and distribution of bird species in relation to habitat type.
- To detail and assess threats to bird species

4.3 Methods

Point Counts
This technique involves an observer recording all individuals identified from sightings or calls, during a set time whilst remaining at one location (Bibby *et al.*, 1998). Point

counts were chosen for several reasons. Standing in one location for a fixed time period allowed observers time to locate and observe rainforest birds. This made it easier to identify birds that are notoriously hard to spot and often small or very fast in flight. The point count was also used as is it means that observers cause minimal disturbance to the area whilst stopped at each count station.

A stratified random method was used at each site. A compass bearing was chosen at random as the starting point for each point count. The point count was then marked out in advance. The point counts were spaced approximately 150 m apart. Locations were selected that provided a good view through the under storey or canopy, such as a well positioned rock. There were 10 stations in total in each point count. The pattern used was two parallel lines of 5 stations 250 m apart. Birds of the same species were only recorded twice if observers were certain they were different individuals.

The aim was to conduct 50 point counts at each site visited. The point count was conducted 5 times at each survey site in both the morning and evening. The start time was recorded at each point count, as was the minute that each individual was spotted. 12 minutes was spent at each point count station. This relatively short period of time allowed more ground to be covered and for more count stations – the recommended approach for habitats with a low species diversity. A team of 4 individuals was used for each survey. In addition to providing a species list, this method allows the density and distribution for each species to be compared between sites and islands.

Flush Walks

Flush walks were carried out in addition to the point counts. The aim of this method was to flush ground dwelling birds that were unlikely to be spotted during point counts, such as the Nicobar Pigeon *(Caloenas nicobarica*), into view. At least 2 flush walks were conducted per survey site. A team of 6 formed a line and walked the point count route, spread out on either side of the line. As the line moved through the forest ground dwelling and under story birds were driven from their hiding place and into view of the observers who recorded all birds that they saw. This approach was used after 50-point counts had been completed.

Mist netting

Standard mist netting techniques (Bibby *et al.*, 1998) can be employed to survey the less conspicuous species that may not have been detected using the point count method. Nets can be established between existing trees or using bamboo poles (or similar) and ropes tied vertically from tree branches. This permits nets to be operated at a range of heights. Six mist nets (38 mm mesh, Avinet, USA) should be deployed at six different locations within a specified survey area. These locations should be selected for their accessibility, areas of high bird activity and where species that could not be identified had been sighted. Different net locations should be used on return visits.

Nets were opened between 05.30 hours and 06.30 hours and closed at approximately 1000 hours. Afternoon opening times were between 16.00 hours to 18.30 hours. Occasionally nets can be kept open throughout the day. These times were dependent upon weather conditions i.e. recording in heavy rain should be avoided. Nets were checked between every 30 minutes to every 2 hours dependent upon previous bird activity. Net records were kept (number used, height, duration open) and also record

species caught, time, date, location and basic morphology data; total length, tarsus length, bill length, wing length, tail length and body weight, following the approach of Turner *et al.* (2002b).

General Bird Observations
At certain sites or locations general bird observations were carried out. This involved a group of observers choosing a location with a vantage point, such as a large granite bolder rising through the canopy, an area of open forest or gully that provided observers with a wide field of vision. Observers then treated this site as a single point count station recording different species that were identified over a certain period of time, ranging from 30 minutes to an hour. Species were only recorded twice if observers were certain that they were sighting a different individual. The advantage with this method was that observers were stationary for long periods of time and therefore caused very little disturbance to the area of forest they were monitoring. This allowed species to be observed that were often scared off by observers moving through the forest on a point count, such as the Nicobar Pigeon *(Caloenas nicobarica*) or Pied Imperial Pigeon *(Ducula bicolor)*.

Coastal Bird Observations
The final method used to survey the bird life of the Perhentian Islands was a coastal observation. A boat was used to travel around Perhentian Besar and Perhentian Kecil conducting a point count from predetermined locations. This proved to be a very successful method, as a large area could be covered in a relatively short period of time. Each point count station was surveyed for 8 minutes under the same guidelines as the forest point counts. From the vantage point of a boat a huge area could be monitored. This method was used two times at the end of the survey period on the Perhentians. The Black Capped Kingfisher *(Halcyon pileata)* and an unidentified raptor were both spotted using this method. This method also allowed for a more accurate count of the number of White Bellied Sea Eagles in the area. In one session seven individuals were sighted at various locations around the two islands.

4.4 Results

Results show that 30 species (an additional one species still requires confirmation) were found to be present on the islands over the survey period. However, it must be noted that species composition of the islands changed over the survey period. For a fuller survey to be achieved bird observations and surveys need to be completed over the monsoon period were it is believed more species are present on the islands.

The total number of surveys completed over the research period is recorded in Table 4.1. These include point count and flush walk methodologies.

Table 4.1 Surveying effort across all survey sites during 2004.

Location	Number of Point Counts	Number of Flush Walks
B0	40	1
B2	9	0
B3	30	1
B4	30	1
B5	30	1
B6	80	4
B7	10	0
B8	50	0
B9	40	2
B10	20	0
B11	50	2
B12	42	0
K1	30	1
K2	40	0
K3	40	1
K4	30	0
K5	30	0
Susu	10	5
Rawa	0	2

It must be noted that mist netting was also used in conjunction with the above surveying methodologies. The results for the mist netting technique have been limited (with very few captures and species which have already been recorded within the island habitat) and therefore have not been used in subsequent analysis.

Initially a variety of different statistics can be used to measure different attributes of community composition in relation to habitat or locations. This includes measures of total species per survey location, the total number of individuals found at each survey location, and diversity indices that are more informative about the structure of the sampled community. This includes species richness, in terms of the number of species for a defined number of individuals; a species dominance index that identifies the way the community composition is divided up among the different species. This is shown in table 4.3.

The total numbers of species recorded at each location by the use of point counts are listed in table 4.2.

Table 4.2 Species by location (point count data).

	BO total	B2 total	B3 total	B4 total	B5 total	B6 total	B7 total	B8 total	B9 total	B10 total	B11 total	B12 total	K1 total	K2 total	K3 total	K4 total	K5 total	Susu total	Rawa total
Purple throated sunbird	16	0	5	8	10	33	0	2	3	4	1	0	7	13	6	2	0	0	0
Nicobar Pigeon	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	11	0
Olive backed sunbird	2	0	0	0	0	1	0	0	0	0	0	2	0	0	0	1	0	0	4
Emerald dove	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	1	0
White Rumped Sharma	7	1	29	13	15	62	4	13	22	14	8	12	22	9	23	15	2	0	0
Pied Imperial Pigeon	15	0	27	15	4	56	3	15	35	152	97	39	88	53	6	35	6	100	3
White Bellied Sea Eagle	3	1	8	0	1	7	0	1	0	1	1	2	3	3	0	1	1	4	5
Pacific Swallow	11	0	0	0	0	7	0	0	2	11	2	57	1	0	0	0	0	2	0
Magpie Robin	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chinese Pond Heron	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Sandpiper	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artic warbler	0	0	3	1	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0
Black Naped Turn	2	0	0	0	0	0	0	47	0	14	0	0	0	12	0	3	0	0	25
Black Naped Oriole	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	3
Barn Swallow	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barn Owl	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Philippine Glossy Starling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
Flycatcher sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Babbler sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Edible Nest Swiflet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Little Spiderhunter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
White collared Kingfisher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0

Table 4.3 Diversity Indices for each survey location (using point count data).

Survey Location	Total Species[1] (S)	Total Individuals[2] (N)	Species Richness[3] (d=(S-1)/Log(N))	Simpson's dominance Index[4]	Simpson's evenness index[5]
B0	12	65	2.64	0.16	0.85
B2	2	2	1.44	0.5	1
B3	5	72	0.94	0.32	0.69
B4	4	37	0.83	0.34	0.68
B5	4	30	0.88	0.38	0.64
B6	8	170	1.36	0.28	0.72
B7	3	8	0.96	0.41	0.68
B8	6	79	1.14	0.42	0.59
B9	4	62	0.73	0.45	0.56
B10	6	196	0.95	0.62	0.39
B11	6	110	1.06	0.78	0.22
B12	5	112	0.85	0.39	0.61
K1	5	121	0.83	0.57	0.44
K2	6	97	1.09	0.35	0.66
K3	3	35	0.56	0.49	0.52
K4	7	59	1.47	0.42	0.59
K5	4	10	1.30	0.42	0.64
Susu	10	126	1.86	0.64	0.36
Rawa	7	46	1.57	0.34	0.68

[1]Total species number.
[2]Total number of individuals.
[3]Species Richness defined by Margalef's Index. This incorporates the total number of individuals and is the measure of the number of species present for a given number of individuals.
[4]Simpsons Dominance Index. The largest values correspond to assemblages whose total abundance is dominated by one, or very few, of the species present within the sample site.
[5]Simpsons Evenness Index. This is used as the total sample size is relatively small. The higher value (of $1\text{-}S^{-1}$) appears when all species have the same abundance within the sample set.

Simpson's index is used here rather than Shannon-Wiener diversity index, as the Simpson's index is less sensitive to the degree of sampling effort (Clarke & Warwick, 2001).

From the above analysis several sites appear to have low species diversity and high dominance of several species (and thus low evenness indices) within the surveyed locations. Susu Dara, B10 and B11. This can be explained by very high numbers of the Pied Imperial Pigeon, and very low numbers of additional species. B2, with absolute evenness, can be explained by very low species numbers (2 species) each being represented by only one individual. B0 (base camp) survey location is where the greatest number of species were found (a total of 12 different species) with the species showing evenness ie. an even representation of each different species present. All other location show similar levels of dominance and evenness, with species such as the Pied Imperial Pigeon, the White-rumped Sharma and the Purple-throated Sunbird contributing most to the number of individuals found at these survey locations.

Analysis of community composition was assessed using PRIMER (Clarke & Warwick, 2001). The Bray-Curtis similarity measure was then calculated (from the bird point counts/effort) between the permutations of sample pairs (Clarke & Warwick 1994a) (Figure 4.1). The relationship between survey sites was analysed using a hierarchical agglomerate clustering technique (Clarke & Green 1988).

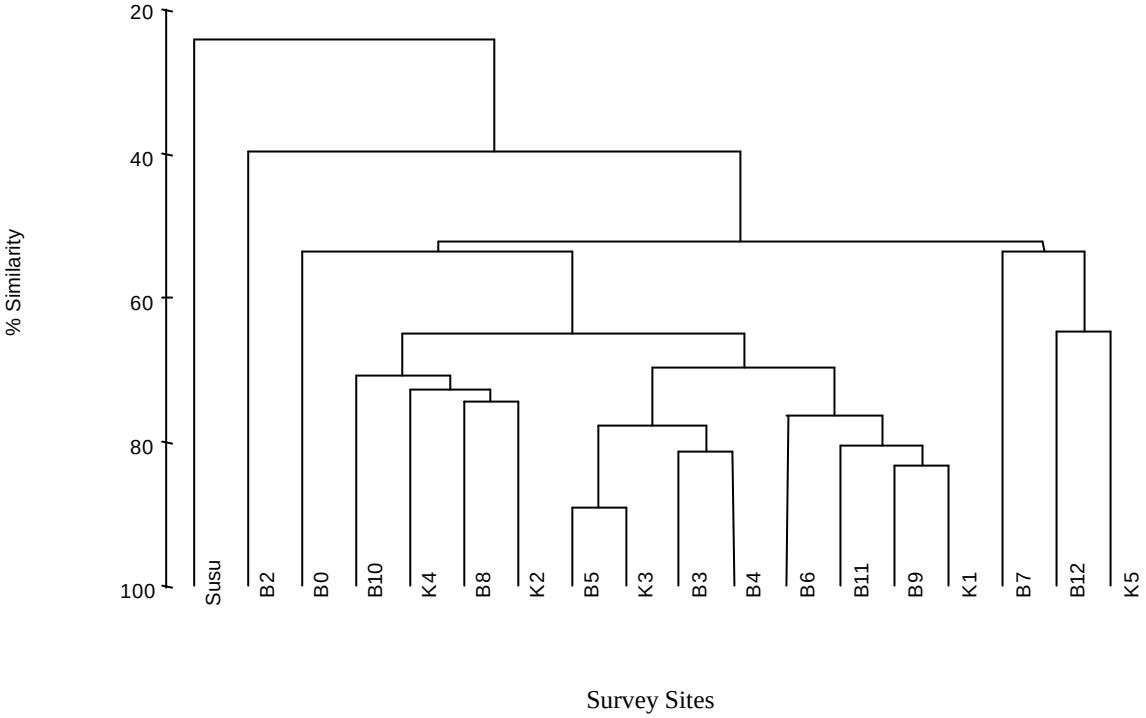

Figure 4.1 Dendrogram showing location similarities (bird point counts/effort). Bray-Curtis 4th root transformation.

The Dendrogram analysis uses point count data that is transformed to incorporate surveying effort i.e. total species and individuals' identified/by total point counts at each sample site (effort). Rawa could not be included within this comparison, as point counts were not completed on this survey location.

Susu Dara is seen to be very different in terms of species composition compared to other sites on the Perhentians. This may be due to the smallness of the island and the fact that it is uninhabited and therefore less disturbed. There were also a large number of Nicobar pigeons found in this location as well as additional species, which were rarely found in other locations including; Black-naped Oriole, the Philippines Glossy Starling, the Emerald Dove and Babbler species, and Flycatcher species that remain unidentified. Additionally, this site was the only location where the White Collared Kingfisher was identified.

B2 is also seen as an outlier due to the poor species numbers (only 2 species recorded). B0 is the final 'non-grouped' survey location. Although this survey site shows over 50% similarities with other survey groups, species which have not been surveyed in any other location have been found to be present within this location, including; the Barn Swallow, the Magpie Robin, the Common Sandpiper and the Chinese Pond Heron. This may be explained by the amount of survey effort that was achieved within this area due to the site being the main project base camp.

Further analysis to find which species were responsible for the observed clustering was also achieved. By looking at the overall percentage contribution each species makes to the average similarity within groups, a species list can be formed showing species in decreasing order of their importance in discriminating the sample sets. This gives species that are typical to the group, in the sense that they are found at constant (high) abundances in most samples. These species can then be used as discriminators between groups. This can be achieved through SIMPER (Clarke & Warwick, 2001) (Tables 4.4, 4.5 and 4.6).

Table 4.4 SIMPER Result for Black Group (B10, K4, B8, K2): Average similarity: 71.95%

Species	Av.Abund[1]	Av.Sim[2]	Sim/SD[3]	Contrib.%[4]	Cum.%[5]
Pied Imperial Pigeon	2.60	19.97	7.30	27.75	27.75
White Rumped Sharma	0.42	16.25	11.15	22.58	50.33
Black Naped Turn	0.51	15.30	4.66	21.26	71.59
Purple throated sunbird	0.16	11.27	8.88	15.66	87.25
White Bellied Sea Eagle	0.04	9.17	15.80	12.75	100.00

[1]Average abundance
[2]Average similarity
[3]Standard deviation of contribution of species to similarity between groups
[4]Percentage contribution of individual species to the overall similarity between groups
[5]Cumualtive contribution of species to overall similarity between groups

Table 4.5 SIMPER Result for Red Group (B5, K3, B3, B4, B6, B11, B9, K1): Average similarity: 73.82%

Species	Av.Abund	Av.Sim	Sim/SD	Contrib.%	Cum.%
White-rumped Sharma	0.54	24.68	4.79	33.44	33.44
Pied Imperial Pigeon	0.95	23.92	6.07	32.40	65.84
Purple Throated Sunbird	0.17	17.50	3.79	23.71	89.55
White-bellied Sea Eagle	0.06	4.29	0.72	5.81	95.36

Table 4.6 SIMPER Results for Blue Group (B7, B12, K5): Average similarity: 57.12%

Species	Av.Abund	Av.Sim	Sim/SD	Contrib.%	Cum.%
Pied Imperial Pigeon	0.23	30.01	14.46	52.53	52.53
White-rumped Sharma	0.17	22.51	12.33	39.41	91.94

These SIMPER results illustrate the distinctions between the groups through species compositions. There is a high degree of similarity between the groups, however individual species percentage contribution changes within the groups and individuals unique to groups can also be highlighted.

Coastal observations further increased the species list. As this process was completed by using the point count system, these species have not been included in the analysis, but are included in the species lists and comparisons between the East Coast Islands. Notable species discovered using this methodology was the Black-capped Kingfisher and the Pacific Reef Egret.

Notable species found on the Perhentians include:

Nicobar Pigeon (*Caloenas nicobarica*): 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Near Threatened. This species is usually found on uninhabited islands as a ground dwelling bird. It may also forage between islands relying on fruiting trees. Trapping for food, the pet trade, gizzard stone as well as clearing islands for plantations, island developments and the increase of invasive species have decreased the species numbers. This species is also listed on CITES appendix 1 (species which are threatened with international trade) and also listed under Section 64 of the Protection of Wildlife Act 76, in Malaysia.

Black–capped Kingfisher (*Halcyon pileata*): IUCN listed as least concern as evaluated by BirdLife 2004, however the global population of this species has not been quantified, but there is belief that the population has declined in recent years.

Barn Owl (*Tyto alba*): 2004 IUCN Red List Category (as evaluated by BirdLife the official Red List Authority for birds for IUCN): Least Concern and CITES Appendix II. Global population trends have yet to be quantified.

Dusky Crag Martin (*Hirundo concolor*): 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Black Naped Oriole (*Oriolus chinensis)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Tiger Shrike (*Lanius tigrinus)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Forest Wagtail (*Dendronanthus indicus*): 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Pacific reef egret (*Egretta sacra)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

White-bellied Fish-eagle (*Haliaeetus leucogaster)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified; there is evidence of a population decline.

Black-naped Tern (*Sterna sumatrana)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Emerald Dove (*Chalcophaps indica)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

House Swift (*Apus affinis)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified, but there is evidence of a population increase.

Barn Swallow (*Hirundo rustica)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Pacific Swallow (*Hirundo tahitica)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Asian Palm-swift (*Cypsiurus balasiensis)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified, but there is evidence of a population increase.

White-rumped Shama (*Copsychus malabaricus)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Asian Glossy Starling (Aplonis panayensis): 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Arctic Warbler (*Phylloscopus borealis)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Olive-backed Sunbird (*Nectarinia jugularis)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Little Spiderhunter (*Arachnothera longirostra)*: 2004 IUCN Red List Category (as evaluated by BirdLife International - the official Red List Authority for birds for IUCN): Least Concern. Global population trends have not been quantified.

Pied Imperial Pigeon *(Ducula bicolour)*: although not categorized in CITIES or IUCN, this species has been subject to high levels of hunting pressure. Their reliance on island habitats, mangrove forests and coastal zones has also caused further pressure on survival due to habitat loss.

Comparisons with other East Coast Islands

Surveys conducted on the East Coast Islands of P.Redang, P.Perhentians and P.Tioman have been collated and compared as shown in Table 4.7.

Table 4.7 Comparisons of bird species across the East Coast Islands.

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Procellariidae				
Bulweria bulwerii	Bulwer's Petrel	No	No	Yes
Fregatidae				
Fregata ariel	Lesser frigate bird	No	No	Yes
Fregata andrewsi	Christmas island frigate bird	No	No	Yes
Ardeidae				
Ardea sumatrana	Great-billed Heron	Yes	No	Yes
Egretta alba/Casmerodius albus	Great egret	No	No	Yes
Egretta sacra	Pacific reef egret	Yes	Yes*	Yes
Butorides striatus	Little Heron	Yes	No	Yes
Ardeola bacchus	Chinese Pond Heron	No	Yes	Yes
Egretta garzetta	Little egret	No	No	Yes
Bubulcus ibis	Cattle egret	No	No	Yes
Ixobrychus sinensis	Yellow bittern	No	No	Yes
Ixobrychus cinnamomeus	Cinnamon bittern	No	No	Yes
Accipitridae				
Elanus caeruleus	Black shouldered kite	No	No	Yes
Haliastur Indus	Brahminy Kite	Yes	No	Yes
Haliaeetus leucogaster	White-bellied Sea Eagle	Yes	Yes	Yes
Icthyophaga icthyyaetus	Grey-headed Fishing Eagle	Yes	No	No
Pernis ptilorlynchus	Oriental Honey Buzzard	Yes	No	No
Spilornis cheela	Crested serpent eagle	No	No	Yes
Spizaetus cirrhatus	Changeable hawk eagle	No	No	Yes
Accipiter gularis	Japanese sparrowhawk	No	No	Yes

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Spizaetus alboniger	Blyth's hawk eagle	No	No	Yes (but not recorded since 1997)
Falconidae				
Falco peregrinus	Peregrine falcon	No	No	Yes (but not recorded since 1997)
Rallidae				
Amaurornis phoenicurus	White-breasted waterhen	Yes	Yes*	Yes
Gallicrex cinerea	Watercock	No	No	Yes
Jacanidae				
Hydrophasianus chirurgu	Pheasant-tailed Jacana	Yes (migrant)	No	No
Charadriidae				
Charadrius mongolus	Mongolian Plover	Yes (migrant)	No	No
Pluvialis squatarola	Grey plover	No	No	Yes
Charadrius peronii	Malaysian plover	No	No	Yes
Charadrius dubius	Little ringed plover	No	No	Yes
Charadrius leschenaultii	Greater sand plover	No	No	Yes
Glareolidae				
Glareola maldivarum	Oriental pratincole	No	No	Yes
Scolopacidae				
Calidris temminckii	Temmick's stint	No	No	Yes
Heteroscelus brevipes	Grey-tailed tattler	No	No	Yes
Numenius phaeopus	Whimbrel	Yes (migrant)	No	No
Actitis hypoleucos	Common Sandpiper	Yes (migrant)	Yes	Yes
Gallinago species	Common or Pintail Snipe	No	Yes (needs confirmation)	No
Tringa nebularia	Common Greenshank	No	No	Yes (not recorded since 1997)
Sternidae				
Sterna sumatrana	Black-naped Tern	Yes	Yes	Yes
Sturna anaethetus	Bridled Tern	Yes	No	Yes
Sterna hirundo	Common Tern	Yes	No	No
Sterna bergii	Crested Tern	Yes (migrant)	No	Yes
Columbidae				
Ducula bicolor	Pied Imperial Pigeon	Yes	Yes	Yes
Chalcophaps indica	Emerald Dove	Yes	Yes	Yes
Caloenas nicobarica	Nicobar Pigeon	Yes	Yes	Yes (not recorded since 1997)
Ducula aenea	Green Imperial Pigeon	Yes	No	Yes
Treron vernans	Pink-necked Pigeon	Yes	No	Yes
Treron olax	Little green pigeon	No	No	Yes
Treron capellei	Large green pigeon	No	No	Yes
Treron fulvicollis	Cinnamon headed green pigeon	No	No	Yes
Ducula badia	Mountain imperial pigeon	No	No	Yes

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Columba livia	Rock pigeon	No	No	Yes
Streptopelia chinensis	Spotted dove	No	No	Yes
Ptilinopus jambu	Jambu fruit dove	No	No	Yes
Cuculidae				
Cacomantis merulinus	Plaintive cuckoo	No	No	Yes (not recorded since 1997)
Cacomantis sepulcralis	Rusty Breasted Cuckoo	No	No	Yes (not recorded since 1997)
Cuculus fugax	Hodgson's Hawk Cuckoo	Yes (migrant)	No	Yes (not recorded since 1997)
Phaenicophaeus curvirostris	Chestnut-Breasted Malkoha	No	No	Yes
Centropus sinensis	Greater Coucal	No	No	Yes
Eudynamys scolopacea	Asian Koel	No	No	Yes
Tytonidae				
Tyto alba	Barn Owl	No	Yes*	No
Strigidae				
Otus bakkamoena	Collared Scops Owl	No	No	Yes
Otus scops	Eurasian Scops Owl	No	No	Yes
Caprimulgidse				
Caprimulgus indicus	Grey Nightjar	No	No	Yes (not recorded since 1997)
Caprimulgus macrurus	Large Tailed Nightjar	No	No	Yes (not recorded since 1997)
Apodidae				
Apus affinis	House Swift	Yes	Yes	Yes
Collocalia maxima	Black-nest Swiftlet	Yes	No	Yes
Collocalia fuciphaga	Edible-nest Swiftlet	Yes	Yes*	Yes
Collocalia esculenta	Glossy Swiftlet	No	Yes	No
Cypsiurus balasiensis	Asian Palm Swift	No	Yes	No
Apus pacificus	Pacific Swift	Yes (migrant)	No	Yes (not recorded since 1997)
Rhaphidura leucopygiallis	Silver Rumped Spinetail	No	No	Yes (not recorded since 1997)
Hirundapus cochinchinensis	Silver Necked Needletail	No	No	Yes (not recorded since 1997)
Coraciidae				
Eurystomus orientalis	Dollarbird	No	No	Yes
Alcedinidae				
Alcedo atthis	Common Kingfisher	Yes	No	Yes
Halcyon chloris	White-collared Kingfisher	Yes	Yes*	No
Ceyx erithacus	Blacked-backed Kingfisher	Yes (migrant)	No	No
Halcyon pileata	Black Capped Kingfisher	No	Yes*	Yes
Todirhamphus chloris	Collared Kingfisher	No	No	Yes
Halycon coromanda	Ruddy Kingfisher	No	No	Yes (not recorded since 1997)

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Halcyon smyrnensis	White Throated Kingfisher	No	No	Yes (not recorded since 1997)
Picidae				
Dinopium javanense	Common Flameback	No	No	Yes
Hirundinidae				
Hirundo rustica	Barn Swallow	Yes	Yes	Yes
Hirundo tahitica	Pacific Swallow	Yes	Yes	Yes
Hirundo concolor	Dusky Crag Martin	No	Yes*	No
Hirundo daurica	Red Rumped Swallow	No	No	Yes
Campephagidae				
Coracina striata	Bar Bellied Cuckoo-Shrike	No	No	Yes
Pericrocotus divaricatus	Ashy Minivet	No	No	Yes
Pericrocotus flammeus	Scarlet Minivet	No	No	Yes
Hempius hirundinaceus	Black Winged Flycatcher Shrike	No	No	Yes
Chloropseidae				
Aegithina viridissima	Green Iora	No	No	Yes
Aegithina tiphia	Common Iora	No	No	Yes
Pycnonotidae				
Pycnonotus finlaysoni	Striped Throated Bulbul	No	No	Yes
Pycnonotus plumosus	Olive Winged Bulbul	No	No	Yes
Pycnonotus brunneus	Red Eyed Bulbul	No	No	Yes
Pycnonotus erythropthalmos	Spectacled bulbul	No	No	Yes
Tricholestes criniger	Hairy backed bulbul	No	No	Yes
Hemixos flavala	Ashy bulbul	No	No	Yes
Pycnonotus atriceps	Black Headed Bulbul	No	No	Yes (not recorded since 1997)
Dicruridae				
Dicrurus leucophaeus	Ashy Drongo	No	No	Yes (not recorded since 1997)
Dicrurus macrocerus	Black Drongo	No	No	Yes
Dicrurus paradiseus	Greater Racket Tailed Drongo	No	No	Yes
Oriolidae				
Oriolus chinensis	Black Naped Oriole	No	Yes*	Yes
Irena puella	Asian Fairy Bluebird	No	No	Yes
Muscicapidae				
Cyanoptila cyanomelana	Blue And White Flycatcher	Yes	No	No
Ficedula parva	Red-throated Flycatcher	Yes (migrant)	No	No
Pachycephalidae				
Pachycephala grisola	Mangrove Whistler	Yes	No	No
Corvidae				
Corvus splendens	House Crow	No	No	Yes
Corvus macrorhynchos	Large Billed Crow	No	No	Yes

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Timaliidae				
Trichastoma rostratum	White chested babbler	No	No	Yes
Trichastoma bicolor	Ferruginous babbler	No	No	Yes
Timaliidae				
Trichastoma abbotti	Abbott's babbler	No	No	Yes
Malacocincla malaccensis	Short tailed babbler	No	No	Yes
Malacopteron magnirostre	Moustached babbler	No	No	Yes
Napothera brevicaudata	Streaked wren babbler	No	No	Yes
Stachyris nigriceps	Grey throated babbler	No	No	Yes
Macronous gularis	Striped tit babbler	No	No	Yes
Stachyris erythroptera	Chestnut Winged Babbler	No	No	Yes (not recorded since 1997)
Turdidae				
Erithacus cyane	Siberian Blue Robin	Yes (migrant)	No	No
Copsychus saularis	Oriental Magpie Robin	No	Yes	Yes
Copsychus malabaricus	White Rumped Sharma	No	Yes	Yes
Sylviidae				
Phylloscopus borealis	Artic Warbler	Yes	Yes	Yes (not recorded since 1997)
Locustella lanceolata	Lanceolated Warbler	Yes (migrant)	No	No
Acrocephalus orientalis	Oriental Reed Warbler	No	No	Yes
Orthotomus atrogularis	Dark necked tailorbird	No	No	Yes
Orthotomus sericeus	Rufous tailed tailorbird	No	No	Yes
Alcippe brunneicauda	Brown Fulvetta	No	No	Yes
Orthotomus ruficeps	Ashy tailorbird	No	No	Yes
Muscicapidae				
Ficedula mugimaki	Mugimaki Flycatcher	No	No	Yes (not recorded since 1997)
Rhipidura javanica	Pied Fantail	No	No	Yes
Hypothymis azurea	Black Naped Monarch	No	No	Yes
Pardalotidae				
Gerygone sulphurea	Golden Bellied Gerygone	No	No	Yes
Motacillidae				
Motacilla flava	Yellow Wagtail	Yes (migrant)	Yes	Yes
Dendronanthus indicus	Forest Wagtail	Yes (migrant)	Yes*	Yes (not recorded since 1997)
Motacilla cinerea	Grey Wagtail	No	No	Yes (not recorded since 1997)
Anthus cervinus	Red Throated Pipit	No	No	Yes
Anthus rufulus	Paddyfield Pipit	No	No	Yes
Laniidae				
Lanius tgrinus	Tiger Shrike	No	Yes*	No
Lanius cristatus	Brown Shrike	Yes (migrant)	No	Yes

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Sturnidae				
Aplonis panayensis	Philippine Glossy Starling	Yes	Yes	Yes
Sturnus sturninus	Daurian Starling	Yes (migrant)	No	No
Sturnus sinensis	White Shouldered Starling	No	No	Yes (not record since 1997)
Sturnidae				
Acridotheres tristis	Common myna	No	No	Yes
Gracula religiosa	Hill myna	No	No	Yes
Sylviidae				
Alcippe brunneicauda	Brown Fulvetta	No	No	Yes
Nectariniidae				
Nectarinia jugularis	Olive-backed Sunbird	Yes	Yes	Yes
Nectarinia sperata	Purple-throated Sunbird	Yes	Yes	Yes
Anthreptes malacensis	Brown-throated Sunbird	Yes	No	Yes
Anthreptes simplex	Plain Sunbird	No	No	Yes
Nectarinia sperata	Copper Throated Sunbird	No	No	Yes
Arachnothera longirostra	Little Spiderhunter	No	Yes*	Yes
Dicaeidae				
Dicaeum trigonostigma	Orange bellied flowerpecker	No	No	Yes
Dicaeum cruentatum	Scarlet backed flowerpecker	No	No	Yes
Prionochilus maculatus	Yellow breasted flowerpecker	No	No	Yes
Prionochilus percussus	Crimson breasted flowerpecker	No	No	Yes
Zosteropidae				
Zosterops palpebrosus	Oriental White Eye	No	No	Yes
Ploceidae				
Passer montanus	Eurasian Tree Sparrow	No	No	Yes (not record since 1997)
Estrildae				
Lonchura striata	White-rumped Munia	Yes	No	Yes
Lonchura leucogastra	White Bellied Munia	No	No	Yes

[1]Redang survey completed in 1990 by Malaysian Nature Society.
[2]Perhentians surveys completed by CCC in 2003 and 2004.
[3]Tioman survey complied from surveys between 1986 – 1998, Sodhi *et al* 1999.
*Species are recorded by CCC 2004 by observation outside that of point count system.

The figures below illustrate table 4.7 and compare the species number and the family representations across the East Coast Islands.

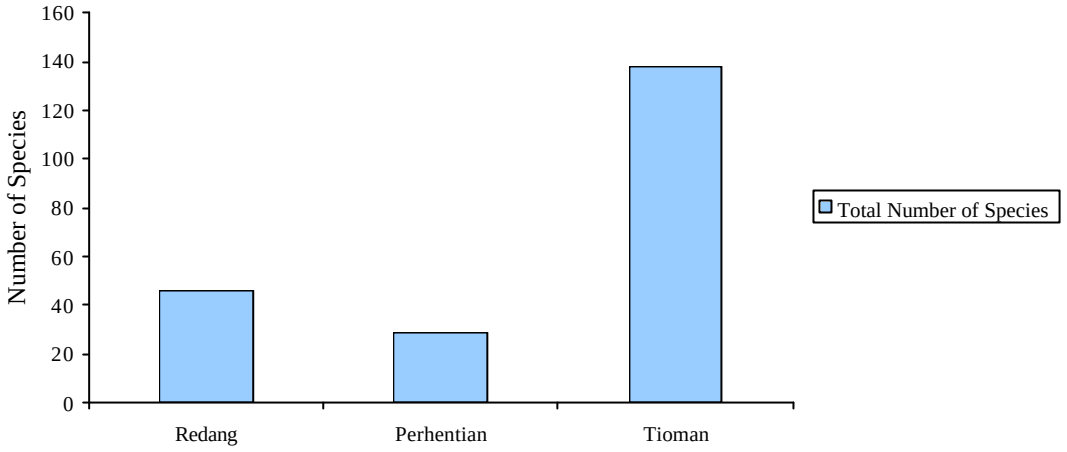

Figure 4.2 Birds species numbers compared across East Coast Islands.

It can be seen that P.Tioman has the most bird species compared to the other East Coast Islands, with 148 species being represented. P.Perhentians has only 30 species (one still requires confirmation) represented on the island, and P.Redang a total of 46 species. This can be further analysed by assessing bird family representation across the islands.

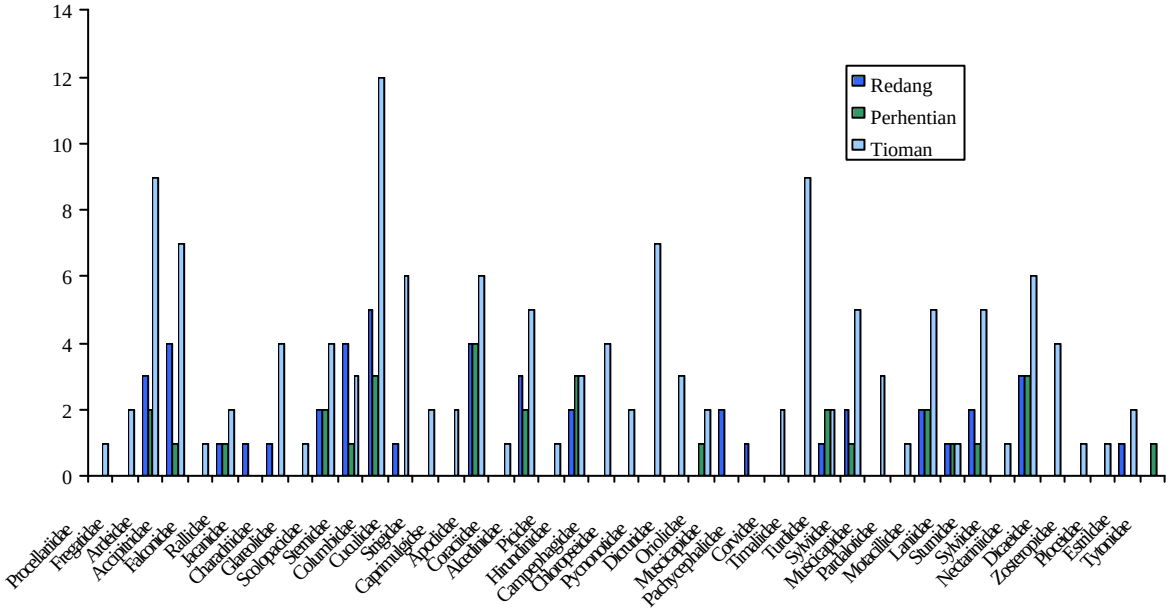

Figure 4.4 Bird Families represented on the East Coast Islands.

Across the East Coast Islands, 43 families of birds are represented. On P.Tioman a total of 39 families are represented, P.Redang has 21 and the P.Perhentians have a total of 16 families present on the islands.

4.5 Discussion

The IUCN listed Nicobar Pigeon has been found on P.Besar, P.Kecil and Susu Dara, which raises the importance of the islands. Positive sightings of the Nicobar Pigeon have been made in the north-east corner of Besar, close to Pasir Saribu, on the east of the island near Pasir Tiga Ruong, in the south of the island to the east of Flora Bay and on the jungle trail. There also appears to be a number of individuals on Susu Dara. It is possible that the individual seen on Kecil had come from either Besar or Susu Dara to feed.

The presence of the Nicobar pigeon on the island is very exciting, especially given the relatively recent discovery by researchers at Oxford University that the Nicobar Pigeon is related to the Dodo. "Their analysis shows the dodo and the solitaire to be close relatives, with their nearest living relative the Nicobar pigeon (*Caloenas nicobarica)* from the Nicobar Islands and nearby south-east Asia" (Shapiro *et al.*, 2002).

Singh (2004) recently reported on the state of the Nicobar pigeon in Kuala Terengganu. Bird populations are present in the Perhentians, Redang and Pulau Yu between May and November. However, it seems that the numbers of these birds has decreased over the years reported by PERHILITAN. Clearing of vegetation and development has effected populations in Redang; hunting is also putting pressure on the remaining populations. The meat of the Nicobar pigeon is said to have medicinal properties and is frequently found on the menu in Thailand.

At the end of the surveying period several birds failed to receive positive identifications. A raptor was seen in the last few days and a woodpecker, possibly the Maroon woodpecker *(Blyhipicus rubiginosus)*, was seen on two occasions but is yet to have its identity confirmed. The birds on the island were also clearly changing as the monsoon drew closer. It would be very interesting to stay on the islands during this period to see what species arrive and the changes that occur in bird behaviour. Further work also needs to be done on the relationship between the Perhentian islands and the coastal areas of Peninsular Malaysia.

The Pied Imperial Pigeon *(Ducula bicolour)*, although common on the islands they inhabit, are very susceptible to habitat destruction and human encroachment as they are frugivores. There is wide spread evidence of hunting with guns on the islands. Shotgun shells have been found on Besar, Kecil, Susu Dara and Rawa and gunfire is often heard, coming from the south east of Besar. From discussions with locals it would seem that one of the main targets is The Pied Imperial Pigeon *(Ducula bicolor)*, which is hunted for its meat.

Illegal mist netting is a problem on the islands, most notably on Kecil. Long mist nets have been found on 3 occasions, all on Kecil. Birds like the White Rumped Sharma *(Capsicums malabaricus)* are being caught and taken to the mainland to be kept as pets in cages.

The islands are a refuge for species, with 20 species that have been listed by BirdLife as IUCN least concern, although global populations are yet to be established. Conservation initiatives are needed as threats from bird collection and hunting for meat may seriously damage bird populations. Invasive and exotic species, such as rats and domesticated cats, may also pose a significant threat to bird populations, especially species that are ground dwelling (e.g. Nicobar Pigeon). Areas which have high conservation values (see chapter 11) should be noted and disturbance kept to a minimum.

5. Herpetofauna

5.1 Introduction

According to the IUCN Red List of Threatened Species (2004), at least 1,856 amphibian species are threatened with extinction, representing 32% of all species. 43% of all species are in population decline; fewer than 1% are increasing, 27% are stable, and the rest are unknown. 427 species are considered Critically Endangered (CR), 761 are Endangered (EN), and 668 are Vulnerable (VU).

Peninsular Malaysia harbours more than 199 amphibian species and is ranked sixteenth in the world in terms of levels of amphibian biodiversity. Many of these amphibians are believed to be under serious threat of extinction with an estimated 71% of the Malaysian anurofauna endangered by the destruction of lowland forests (Kiew 1984). Furthermore, many species are associated with a vast array of habitats and little is known about ecological niches of various species. Many of the species found in Malaysia are reported by the IUCN 2004 Red List as Data Deficient.

Amphibians are good bioindicators or indictors of environmental health because of their unprotected, permeable skin, and a lack of long-range dispersal capability making them sensitive to a wide range of contaminants (Lannoo 1998). They inhabit both aquatic (the egg stage is extremely susceptible to chemical pollutants) and terrestrial habitats, which means that they are exposed to both aquatic and terrestrial pollutants, as well as being higher invertebrate carnivores.

This is similarly true of reptiles, which although not wholly dependent on water have similar need to that of amphibians. The abundance and diversity of herpetofauna fluctuate directly with changes in the composition and amount of microhabitats and are therefore a further sign on ecosystem health. Peninsular Malaysia harbours 69 endemic species of reptile and a total of 268 species (Earthtrends.wri.org). However, similarly to amphibians little research has been conducted and only specific species or areas have been researched (e.g. P.Tioman).

5.2 Aims

- To create species lists and inventories of the amphibians of the island
- To create species lists and inventories of the reptiles of the island
- To assess relative abundance of the species found

5.3 Methods

Drift Net Fences
These traps have a 10-meter long plastic sheet fence with approximately 35 cm above ground as recommended by Friend *et al* (1989) and Halliday (1996) respectively. Approximately 10 cm was buried below ground level to trap burrowing herpetofauna. There were four buckets along the fence, one at each end to increase catch efficiency (Friend *et al*, 1989), and two in between with an approximate spacing of 3 m. Each bucket had small drainage holes and a small amount of leaf litter, to provide cover for the trapped herpetofauna and potentially to attract invertebrates as bait (Bloomberg

and Shine, 1996). All soil excavated was removed from the immediate vicinity of the trap to reduce disturbance that may deter some animals.

Two fences were set at each survey site and left for four nights. The temporary nature of the traps should not have reduced capture rates (Friend *et al*, 1989). The traps were checked twice daily at approximately 08:00 and 17:00. All individuals captured had diagnostic features recorded and their snout-vent length and tail length recorded using callipers. Where possible the herpetofauna were identified to species level.

Visual Encounter Surveys (VES)
Visual encounter surveys are intensive, systematic searches. The surveyors walked at a slow steady pace searching the forest at all levels from the canopy to under stones. Rudimentary night-time VES were performed but due to concerns about safety, only at sites where well-established paths existed.

Daytime VES commenced at approximately 11:00, midmorning being the best time to encounter diurnal herpetofauna (Bloomberg and Shine, 1996) and were performed by four surveyors (three volunteers and one staff member). Daytime VES combined transect and quadrant search techniques and covered a different area daily. Each VES consisted of three quadrant searches 50 m apart.

Each observer begins at one of the four corners of each quadrant and each individual moves at the same velocity in a clockwise direction. They then spiral inwards, searching the area thoroughly, till meeting in the middle of the quadrant. This synchronised movement prevented most of the reptiles and amphibians from exiting the quadrant before being observed or captured.

In transect searches 3 surveyors walked in a line 5 meters apart. The central person controlled the direction of travel and distance surveyed (using paces). An addition surveyor followed 5 meters behind the front three to recheck the area covered and to record sightings called out by the 3 forward surveyors. This aided the observation of species that 'squirreled' around trees to avoid detection by the three surveyors in front.

5.4 Results

Analysis concentrated on diversity indices at each location that was surveyed during the research programme 2004. This includes species richness, dominance and evenness indices using Simpson's indices (see Table 5.1).

Survey locations B8, K5 and Susu dara survey results give rise to a single species representation, which in turn results in a high dominance index (i.e. 1) and a low evenness index. Survey location B0 is the most species rich of the survey sites (this maybe linked to surveying effort), with the greatest number of species identified and with a relative even representation of individuals. Survey locations B1, B3, B7 and K4 also show high levels of species diversity with even representation of individuals.

Table 5.1 Diversity Indices for survey locations.

Survey Location	Total Species[1] (S)	Total Individuals[2] (N)	Species Richness[3] (d=(S-1)/Log(N))	Simpson's dominance Index[4]	Simpson's evenness index[5]
B0	14	24	4.09	0.10	0.90
B1	6	14	1.90	0.19	0.81
B2	3	5	1.24	0.36	0.64
B3	8	18	2.42	0.16	0.84
B5	4	11	1.25	0.55	0.45
B6	8	29	2.08	0.42	0.59
B7	6	8	2.40	0.19	0.81
B8	1	7	0	1	0
B9	3	4	1.44	0.38	0.63
B10	3	8	0.96	0.41	0.59
B11	6	18	1.73	0.36	0.64
K4	9	20	2.67	0.15	0.85
K5	1	2	0	1	0
Susu	1	1	-	1	0

[1]Total number of species.
[2]Total number of individuals.
[3]Species Richness defined by Margalef's Index. This incorporates the total number of individuals and is the measure of the number of species present for a given number of individuals.
[4]Simpsons Dominance Index. The highest values correspond to assemblages whose total abundance is dominated by one, or very few, of the species present within the sample site.
[5]Simpsons Evenness Index. This index is used as the total sample size is relatively small. The higher value (of $1\text{-}S^{-1}$) appears when all species have the same abundance within the sample set.

From the initial analysis it can be seen that several sites have higher levels of diversity. These include Base camp (B0), sites B6, B7 and K4. Survey locations B8, K5 and Susu dara show particularly poor species diversity with only one species being recorded form these sites. (This gives rise to high dominance figures, of 1, and low evenness, of 0, values).

Further research is needed in all survey sites to identify additional species and clarify existing species that could not be identified to species level at the time of the survey.

Table 5.2 Species Lists by Location 2004 surveys.

Sub-Order	Family	Species	B0	B1	B2	B3	B5	B6	B7	B8	B9	B10	B11	K4	K5	Susu
Anura	Rhacophoridae	*Polypedates leucomystax*	2	2	1	0	0	0	1	0	0	0	0	1	0	0
Archaeobatrachia	Microhylidae	*Kaloula pulchra*	2	0	0	2	0	0	0	0	0	0	0	1	0	0
Autoarchoglossa	Scincidae	*Lygosoma quadrupes*	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Autoarchoglossa	Scincidae	*Mabuya multifasciata*	1	2	0	5	8	18	1	7	1	3	10	3	0	0
Autoarchoglossa	Scincidae	*Scinella reevesii*	0	1	0	0	0	0	0	0	2	4	0	0	0	0
Autoarchoglossa	Autoarchoglossa	*Dasia olivacea*	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Autoarchoglossa	Varanidae	*Varanus bengalensis*	1	0	0	0	0	1	0	0	0	0	0	0	2	0
Autoarchoglossa	Varanidae	*Varanus salvator*	1	0	0	1	0	0	0	0	0	0	0	0	0	1
Autoarchoglossa	Varanidae	*Varanus sp.*	1	0	0	2	0	0	1	0	0	0	0	0	0	0
Sauria	Agamidae	*Bronchocela cristatella*	0	0	0	2	1	0	0	0	0	0	0	2	0	0
Sauria	Agamidae	*Draco volans*	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Sauria	Agamidae	*Acanthosaura armata*	1	4	0	2	1	1	2	0	0	1	0	0	0	0
Sauria	Gekkonidae	*Ptychozoon spp.*	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Sauria	Gekkonidae	*Unknown Gecko*	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sauria	Gekkonidae	*Cyrtodactylus quadrivirgatus*	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Sauria	Gekkonidae	*Cyrtodactylus spp*	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Sauria	Gekkonidae	*Gekko gecko*	0	0	0	3	0	0	2	0	0	0	0	5	0	0
Sauria	Gekkonidae	*Gekko monarchus*	3	0	0	0	0	0	0	0	0	0	1	3	0	0
Sauria	Gekkonidae	*Gekko smithi*	5	2	0	0	1	4	0	0	1	0	3	0	0	0
Sauria	Gekkonidae	*Hemidactylus frenatus*	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Sauria	Gekkonidae	*Ptychozoon kuhli*	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Serpentes	Colubridae	*Lycodon capucinus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Serpentes	Colubridae	*Ahaetulla prasina*	0	0	2	0	0	0	0	0	0	0	2	0	0	0
Serpentes	Colubridae	*Chrysopelea ornata*	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Serpentes	Viperidae	*Tropidolaemus wagleri*	1	3	2	0	0	0	0	0	0	0	1	0	0	0

Comparisons with other East Coast Islands

Herpetological research has been heavily focused on P.Tioman over the last decade, with Dr Grismer heading much of the research. This has given rise to high levels of endemic species being discovered on the island. Table 5.3 gives a species comparison across the three major east coast islands.

Table 5.3 Herpetile Species comparisons across East Coast Islands.

Family	Scientific Name	Redang[1]	Perhentian[2]	Tioman[3]
Megophryidae	*Leptolalax kajangensis*	No	No	Endemic
Megophryidae	*Megophrys nasuta*	No	No	Yes
Rhacophoridae	*Nyctixalus pictus*	No	No	Yes
Rhacophoridae	*Philautus petersi*	No	No	Yes
Rhacophoridae	*Theloderma horridum*	No	No	Yes
Rhacophoridae	*Polypedates leucomystax*	No	Yes	Yes
Bufonidae	*Bufo parvus*	No	Yes	Yes
Bufonidae	*Ansonia tiomanica*	No	No	Endemic
Bufonidae	*Bufo asper*	No	No	Yes
Bufonidae	*Bufo melanostictus*	No	No	Yes
Bufonidae	*Pelophryne brevipes*	No	No	Yes
Microhylidae	*Chaperina fusca*	No	No	Yes
Microhylidae	*Kalophrynus pleurostigma*	No	No	Yes
Microhylidae	*Kaloula baleata*	No	No	Yes
Microhylidae	*Kaloula pulchra*	No	Yes	Yes
Ranidae	*Fejervarya cancrivora*	No	No	Yes
Ranidae	*Limnonectes blythii*	No	No	Yes
Ranidae	*Limnonectes hascheanus*	No	No	Yes
Ranidae	*Rana chalconota*	No	No	Yes
Ranidae	*Rana erthraea*	No	No	Yes
Ranidae	*Rana hosii*	No	No	Yes
Ranidae	*Rana picturata*	No	No	Yes
Scincidae	*Lygosoma quadrupes*	No	Yes	No
Scincidae	*Lygosoma bowringii*	No	Yes	Yes
Scincidae	*Mabuya multifasciata*	Yes	Yes	No
Scincidae	*Mabuya longicaudata*	No	Yes	No
Scincidae	*Scinella reevesii*	No	Yes	No
Scincidae	*Dasia olivacea*	No	Yes	Yes
Scincidae	*Emoia atrocostata*	No	No	Yes
Scincidae	*Eutropis longicaudata*	No	No	Yes
Scincidae	*Eutropis multifasciata*	No	No	Yes
Scincidae	*Larutia seribuatensis*	No	No	Endemic
Scincidae	*Lipinia surda*	No	No	Yes
Scincidae	*Lipinia vittigera*	No	No	Yes

Family	Scientific Name	Redang[1]	Perhentian[2]	Tioman[3]
Scincidae	*Sphenomorphus scotophilus*	No	No	Yes
Scincidae	*Sphenomorphus sp.*	No	No	Endemic
Ichthyophiidae	*Ichthyophis sp*	No	No	Yes
Trionychidae	*Dogania subplana*	No	No	Yes
Varanidae	*Varanus bengalensis*	No	Yes	No
Varanidae	*Varanus salvator*	Yes	Yes	Yes
Varanidae	*Varanus nebulosus*	No	No	Yes
Varanidae	*Varanus sp.*	No	Yes	No
Dibamidae	*Dibamus tiomanensis*	No	No	Endemic
Typhlopidae	*Ramphotyphlops albiceps*	No	No	Yes
Typhlopidae	*Ramphotyphlops braminus*	No	No	Yes
Agamidae	*Bronchocela cristatella*	No	Yes	Yes
Agamidae	*Draco volans*	Yes	Yes	No
Agamidae	*Acanthosaura armata*	Yes	Yes	Yes
Agamidae	*Aphaniotis fusca*	No	No	Yes
Agamidae	*Drace fimbriatus*	No	No	Yes
Agamidae	*Draco haematopogon*	No	No	Yes
Agamidae	*Draco melanopogon*	No	No	Yes
Agamidae	*Draco sumatranus*	No	No	Yes
Agamidae	*Gonocephalus chamaeleontinus*	No	No	Yes
Agamidae	*Gonocephalus grandis*	No	No	Yes
Gekkonidae	*Cnemaspis kendallii*	No	No	Yes
Gekkonidae	*Cnemaspis limi*	No	No	Yes
Gekkonidae	*Cosymbotus craspedotus*	No	No	Yes
Gekkonidae	*Cosymbotus platyurus*	No	Yes*	Yes
Gekkonidae	*Lepidodactylus lugubris*	No	No	Yes
Gekkonidae	*Gehyra mutilata*	No	No	Yes
Gekkonidae	*Cyrtodactylus tiomanensis*	No	No	Endemic
Gekkonidae	*Cyrtodactylus consobrinus*	No	Yes*	No
Gekkonidae	*Cyrtodactylus quadrivirgatus*	No	Yes	Yes
Gekkonidae	*Cyrtodactylus spp*	No	Yes	No
Gekkonidae	*Gekko gecko*	No	Yes	No
Gekkonidae	*Gekko monarchus*	No	Yes	Yes
Gekkonidae	*Gekko smithi*	No	Yes	Yes
Gekkonidae	*Unknown Gecko*	No	Yes	No
Gekkonidae	*Hemidactylus frenatus*	No	Yes	Yes
Gekkonidae	*Ptychozoon spp.*	No	No	No
Gekkonidae	*Ptychozoon lionotum*	No	Yes*	No
Gekkonidae	*Ptychozoon kuhli*	No	Yes	Yes
Boidae	*Python reticulatus*	No	Yes	Yes
Colubridae	*Ahaetulla prasina*	No	Yes	Yes
Colubridae	*Boiga cynodon*	No	No	Yes

Family	Scientific Name	Redang[1]	Perhentian[2]	Tioman[3]
Colubridae	*Boiga drapiezii*	No	No	Yes
Colubridae	*Bioga nigriceps*	No	No	Yes
Colubridae	*Boiga dendrophila*	No	Yes*	No
Colubridae	*Calamaria ingeri*	No	No	Endemic
Colubridae	*Calamaria lumbricoidea*	No	No	Yes
Colubridae	*Calamaria pavimentata*	No	No	Yes
Colubridae	*Cerberus rynchops*	No	No	Yes
Colubridae	*Chrysopelea pelias*	No	No	Yes
Colubridae	*Chrysopelea ornata*	No	Yes	No
Colubridae	*Dendrelaphis caudolineatus*	No	No	Yes
Colubridae	*Dendrelaphis cyanochloris*	No	No	Yes
Colubridae	*Dendrelaphis striatus*	No	No	Yes
Colubridae	*Dendrelaphis pictus*	No	Yes	Yes
Colubridae	*Dryocalamus subannulatus*	No	No	Yes
Colubridae	*Dryocalamus davisoni*	No	Yes*	No
Colubridae	*Dryophiops rubescens*	No	No	Yes
Colubridae	*Elaphae flavolineata*	No	No	Yes
Colubridae	*Elaphae taeniura*	No	No	Yes
Colubridae	*Enhydris enhydris*	No	No	Yes
Colubridae	*Enhydris plumbea*	No	No	Yes
Colubridae	*Fordonia leucobalia*	No	No	Yes
Colubridae	*Gongylosoma muketense*	No	No	Endemic
Colubridae	*Gonyosoma oxycephalum*	No	Yes*	Yes
Colubridae	*Lepturophis albofuscus*	No	No	Yes
Colubridae	*Liopeltis tricolor*	No	No	Yes
Colubridae	*Lycodon capucinus*	No	Yes	No
Colubridae	*Oligodon purpurascens*	No	No	Yes
Colubridae	*Oligodon booliati*	No	No	Endemic
Colubridae	*Pareas vertebralis*	No	No	Yes
Colubridae	*Psammodynastes pulverulentus*	No	No	Yes
Colubridae	*Ptyas carinatus*	No	No	Yes
Colubridae	*Rhadbophis chrysargos*	No	No	Yes
Colubridae	*Sibynophis melanocephalus*	No	No	Yes
Viperidae	*Tropidolaemus wagleri*	No	Yes	No
Viperidae	*Trimeresurus sp*	No	No	Yes
Elapidae	*Bungarus flaviceps*	No	No	Yes
Elapidae	*Calliophis intestinalis*	No	No	Yes
Elapidae	*Ophiophagus hannah*	No	No	Yes

[1] Species list from Pulau Redang. Data derived from MNS 1990.
[2]Perhentian species list from CCC surveys 2003 and 2004
[3] Species checklist from Pulau Tioman. Data Derived from Grismer, 2004.
*Species are recorded outside surveying time through observations by CCC 2004.

The figures below illustrate the East Coast Island comparison table (Table 5.3). Which illustrates the total number of species observed across the islands and their representative family groups.

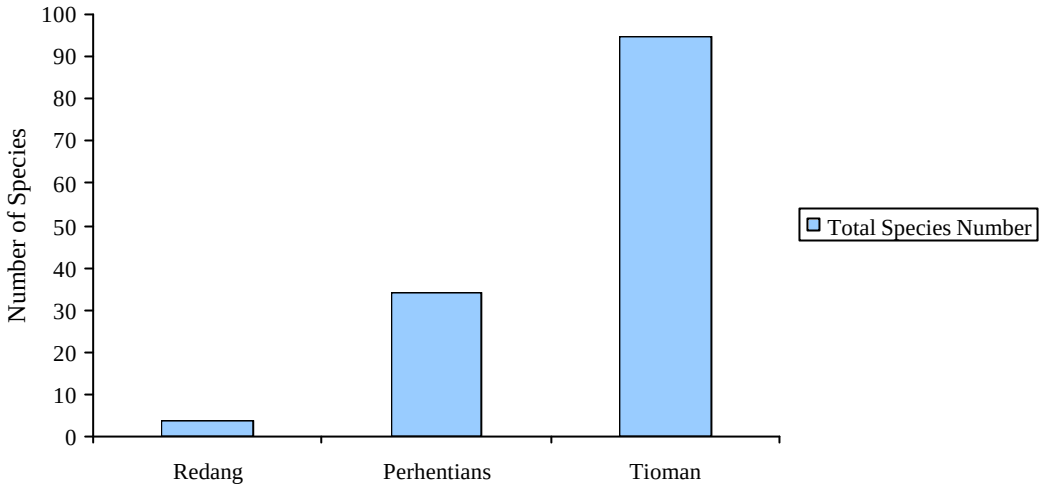

Figure 5.1 Herpetile Species represented across East Coast Islands.

P. Redang shows the lowest levels of species diversity with only four species being represented on this island. This is probably due to low surveying effort and lack of specific research expeditions to study the herpetofauna of the island. The Perhentians have 35 species present on the islands, and P.Tioman a grand total of 95 species. P.Tioman has received a great level of interest in herpetile research over the years.

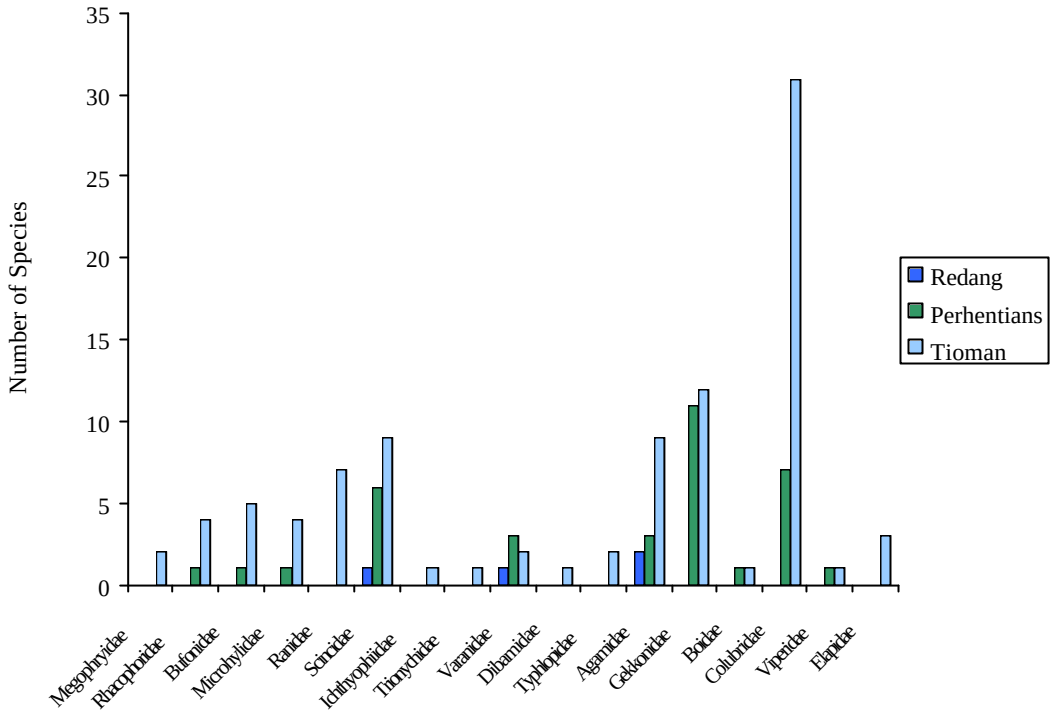

Figure 5.2 Herpetile families represented on East Coast Islands.

17 families are represented across the East Coast Islands. The Colubridae family have the highest species representation with 33 species present. This graph does not take into account high levels of endemic species that have been found to be present in P. Tioman. Gekkonidae represent the next largest family present on the islands with 16 species.

5.5 Discussion

The Malaysian islands of P. Redang and the P. Perhentians have received little attention on the research of their herpetiles. Species numbers and populations are bound to increase with an increase of specific research. P. Tioman has received high levels of interest. The frequent expeditions led by Dr L. Lee Grismer: Department of Biology, La Sierra University and this has provided much insight in to species diversity and endemism on the island.

Monitoring hunting pressure, the introduction of invasive and exotic species and habitat destruction is needed to prevent a decline in the species and populations found on all of the East Coast Islands.

6. Butterflies

6.1 Introduction

Recent work on the tropical island of Singapore examining the relationship between the loss of butterflies and their specific host plants (Tillberg & Breed 2004) show that butterfly extinctions are likely to rise exponentially with that of extinction rates of the host plants. This underpins the urgent need to preserve habitats in order to prevent extinction rates increasing and possible 'knock-on' effects within a defined ecosystem.

The Lepidoptera play an important role in many ecosystems and their specificity to host plants is just one of many complex interactions within them. Additionally they are sensitive to other changes in their environment such as light, humidity, wind speed and temperature; parameters often affected by habitat disturbance (Wood & Gillman, 1998). They also have high reproductive rates (with dependence of the larval stages on a specific host plant) and are at a low trophic level that allows them to quickly respond to environmental stress. They are therefore considered good indicators of environmental change, diversity and ecosystem health (Beccaloni *et al.*, 1995; Ghazoul, 1997)

Southeast Asia has the highest Lepidopteran biodiversity in the world. Over 1,200 species of butterfly have so far been recorded in Malaysia, among the highest of any country in the world relative to the small land mass and many of these are endemic (Malaysia's National Policy on Biological Diversity, 1998). Prior to this work no research had been conducted on the butterflies of the Perhentian Islands.

The primary threat to butterfly species today comes from the destruction and fragmentation of their natural habitat and the long-term negative effects of this increased habitat fragmentation on meta-population stability. Due to their importance in ecosystem functioning (as pollinators and as food sources), intrinsic value and sensitivity to environmental change, it is crucial that more research on this group is undertaken.

6.2 Aims

- To create species lists and inventories
- To create digital imagery of species
- Develop photographic guide or key
- Assessment of species diversity within survey area

6.3 Methods

Sweep Nets
Butterflies were sampled opportunistically using sweep nets. The time of day, location, and amount of time taken were recorded. This allowed for inter-site comparisons for number of individuals and number of species, against effort. The use of such a methodology also meant that a wide variety of habitats and microclimates (streams, canopy gaps, different aspects, etc.) could be surveyed (Hill 1999).

The majority of sampling was done during the middle of the day (11.00 – 14.00 hours) when butterflies were most active (Hill *et al.*, 1995; Pollard, 1977; Pollard 1988; Walpole 1999) counts are therefore conducted between 10.00hrs and 15.00hrs, and only when the weather was good (i.e. sunny, and no rain), as temperature/irradiance differences are known to affect butterfly flight (Pollard & Yates, 1993; Willott *et al.*, 2000). Some sampling was also done outside this time, allowing for the observation of species most active earlier and later in the day such as *Melanitis leda*, the Common Evening Brown.

If more detailed observation was required for identification the individual was carefully transferred from the net or trap into a clear plastic bag. Here wingspan was measured and recorded and they could be more easily identified. Photographs were also taken where the individual could not be identified or where confirmation by a specialist was thought necessary.

6.4 Results

Analysis concentrated on diversity indices at each location that was surveyed during the research programme. This includes species richness, dominance and evenness indices using Simpson's indices (see Table 6.1). Each analysis is based on species caught in the survey period.

Table 6.1 Diversity Indices for butterfly species by location

Survey Location	Total Species[1] (S)	Total Individuals[2] (N)	Species Richness[3] (d=(S-1)/Log(N))	Simpson's dominance Index[4]	Simpson's evenness index[5]
B0	40	140	7.89	0.0052	0.95
B3	2	2	1.44	0.5	0.5
B4	2	3	0.91	0.56	0.44
B5	8	11	2.92	0.14	0.86
B6	3	3	1.82	0.33	0.67
K1	9	11	3.34	0.12	0.88
K2	6	9	2.28	0.26	0.74

[1]Total number of species.
[2]Total number of individuals.
[3]Species Richness defined by Margalef's Index. This incorporates the total number of individuals and is the measure of the number of species present for a given number of individuals.
[4]Simpsons Dominance Index. The highest values correspond to assemblages whose total abundance is dominated by one, or very few, of the species present within the sample site.
[5]Simpsons Evenness Index. This index is used as the total sample size is relatively small. The higher value (of $1\text{-}S^{-1}$) appears when all species have the same abundance within the sample set.

The most diverse location surveyed was B0 (base camp). This is mostly due to the increased survey effort at this particular location. Sites B4 and B7 show high levels of species numbers and a rather even distribution of species.

Table 6.2 documents all the species that were identified by location throughout the surveying period.

Table 6.2 Butterfly species by survey location

Species	B0	B3	B4	B5	B6	K1	K2
Abisara saturata	1	0	0	0	0	0	0
Anthene emolus	2	0	0	0	0	0	0
Arhopala athada	10	0	0	2	0	0	4
Athyma nefte	6	0	0	0	0	0	1
Athymia perius	1	0	0	0	0	0	0
Chilades pandava	3	0	0	0	0	0	0
Cirrochroa orissa	1	0	0	0	0	0	0
Cyrestis spp	3	0	0	0	0	0	0
Cyrestis themire	19	0	0	0	1	1	1
Danaus crisipus	0	0	0	1	0	0	0
Danaus genutia	2	1	0	1	0	0	0
Drupadia ravindra	2	0	0	0	0	0	0
Elymnias hypermnestra	5	0	0	1	0	0	0
Euploea crameri	5	0	0	0	0	0	0
Euploea mulciber	1	0	0	0	0	1	0
Eurema hecabe	4	0	0	0	0	0	0
Eurema sari	0	0	0	0	1	0	0
Eurema spp	4	0	0	0	0	1	0
Faunis canens	1	0	2	0	1	1	0
Graphium agamemnon	2	0	0	0	0	0	0
Graphium eurypylus	3	0	0	0	0	0	0
Graphium sarpedon	1	0	0	0	0	0	0
Graphium spp.	2	0	0	0	0	0	0
Hesperidae spp	1	0	0	0	0	0	0
Hypolimas spp.	1	0	0	0	0	0	0
Hypolycaena erylus	5	0	0	0	0	0	0
Jamides celeno	3	0	0	0	0	0	0
Lycaenidae spp	8	0	0	0	0	0	1
Lycaenidae spp1.	1	0	0	0	0	0	0
Melanatis leda	1	0	0	0	0	0	0
Nacaduba beroe	0	0	0	0	0	1	0
Nacaduba spp	0	0	0	0	0	1	0
Neptis hylas	7	0	0	1	0	2	0
Neptis spp.	6	0	0	0	0	0	0
Orsotriaena medus	3	0	0	0	0	0	0
Papilio polytes	4	0	0	1	0	2	1
Papilo memnon	0	1	0	2	0	0	1
Cirrochroa orissa	1	0	0	0	0	0	0
Ideopsis vulgaris	1	0	0	0	0	0	0
Rhinopalpa polynice	2	0	0	0	0	0	0
Salanoemia similis	1	0	0	0	0	0	0
Tanaecia iapis	13	0	1	2	0	1	0
Ypithma baldus	1	0	0	0	0	0	0
Ypithma ceylonica	1	0	0	0	0	0	0
Ypithma savara	2	0	0	0	0	0	0

Comparisons with other East Coast Islands

Surveys that have been conducted on the East Coast Islands of P. Redang, P. Perhentians and P. Tioman, have been collated and compared in Table 6.3.

Table 6.3 Comparison of butterfly species across East Coast Islands

Scientific name	Redang[1]	Perhentian[2]	Tioman[3]
Papiliondae Family			
Troides amphrysus ruficollis	No	No	Yes
Pachliopta aristolochiae asteris	No	No	Yes
Papilio polytes romulus	Yes	Yes (*Papilio polytes*)	Yes
Papilio memnon agenor	Yes	Yes (*Papilio memnon*)	No
Papilo demolion demolion	No	No	Yes
Graphium sarpedon luctatius	Yes	Yes (*Graphium sarpedon*)	Yes
Graphium doson evemonides	Yes	No	Yes (*Graphium doson kajanga*)
Graphium agamemnon agamemnon	Yes	Yes	Yes
Graphium eurypylus	No	Yes	No
Meandrusa payeni ciminius	Yes	No	No
Pieridae Family			
Delias hyparete metarete	No	No	Yes
Leptosia nina nina	Yes	No	Yes (*Leptosia nina malayana*)
Cepora iudith malaya	Yes	No	No
Phrissura aegis cynis	Yes	No	Yes
Appias albina albina	Yes	No	No
Appias libythea	No	Yes	Yes (*Appias libythea olferna)*
Appias nero	No	Yes	No
Saletara liberia distanti	No	No	Yes
Hebombia glaucippe aturia	No	No	Yes
Pareronia valeria lutescens	Yes	No	Yes
Catopsilia pyranthe pyranthe	Yes	No	Yes
Catopsilia pomona pomona	Yes	Yes (*Catopsilia pomona*)	Yes
Catopsilia scylla cornelia	No	No	Yes
Eurema hecaba cuntubernalis	Yes	Yes (*Eurema hecaba*)	Yes
Eurema lacteola lacteola	No	Yes (*Eurema lacteola*)	Yes
Eurema blanca snelleni	Yes	No	Yes
Eurema sari sodalis	Yes	Yes (*Eurema sari*)	Yes
Eurema tilaha	No	No	Yes
Eurema ada	No	Yes	No
Gandaca harina distanti	Yes	Yes (*Gandaca harina*)	Yes
Gandaca harina aora	No	No	Yes

Scientific name	Redang[1]	Perhentian[2]	Tioman[3]
Nymphalidae Family			
Danaus melanippus hegesippus	Yes	No	No
Tirumala septentrionis septenrionis	Yes	No	No
Radena similes persimilis	Yes	No	No
Radena juventa sitah	Yes	No	No
Euploea crameri bremeri	Yes	Yes	No
Euploea mulciber mulciber	Yes	Yes	No
Euploea diocletianus diocletianus	Yes	No	No
Ideopsis vulgaris	No	Yes	No
Danaus genutia	No	Yes	No
Danaus chrysippus	No	Yes	No
Elymnias panthera panthera	Yes	No	No
Elymnias hypermnestra agina	Yes	Yes (*Elymnias hypermnestra*)	No
Mycalesis fusca fusca	Yes	No	No
Orsotriaena medus cinerea	Yes	Yes (*Orsotriaena medus*)	No
Ypthima baldus newboldi	Yes	Yes (*Ypthima baldus*)	No
Ypthima pandocus	No	Yes	No
Faunis canens arcesilas	Yes	Yes (*Faunis canens*)	No
Amathusia phidippus phidippus	Yes	No	No
Melanitis leda	No	Yes	No
Danaus melanippus hegesippus	No	No	Yes
Parantica luzonensis aurensis	No	No	Yes
Ideopsis juventa	No	Yes (*Ideopsis juventa*)	Yes *(Ideopsis juventa sitah*)
Ideopsis similis	No	Yes	No
Euploea crameri	No	Yes	Yes
Euploea tulliolus	No	No	Yes
Elymnias hypermnestra agina	No	Yes (*Elymnias hypermnestra*)	Yes
Elymnias panthera panthera	No	Yes	No
Mycalsis janardana sagittigera	No	No	Yes
Mycalesis perseus cepheus	No	No	Yes
Orsotriaena medus	No	Yes (*Orsotriaena medus*)	Yes (*Orsotriaena medus cinerea*)
Melanocyma faunula faunula	No	No	Yes
Taenaris horsfieldii birchi	No	No	Yes
Cupha erymanthis lotis	Yes	Yes (*Cupha erymanthis*)	Yes
Précis atlites atlites	Yes	No	No
Hypolimnas bolina jacintha	Yes	Yes (*Hypolimnas bolina*)	Yes

Scientific name	Redang[1]	Perhentian[2]	Tioman[3]
Cyrestis themire themire	Yes	Yes (*Cyrestis themire*)	Yes
Neptis hylas papaja	Yes	Yes (*Neptis hylas*)	No
Neptis ilira	No	No	Yes
Phaedyma columella singa	Yes	No	No
Moduza procris milonia	Yes	Yes (*Moduza procris*)	No
Parthenos sylvia lilacinus	Yes	No	No
Tanaecia julii	Yes (*Tanaecia julii bougaibvillei*)	Yes	No
Euthalia aconthea gurda	Yes	Yes (*Euthalia aconthea*)	No
Phalanta phalantha phalantha	No	No	Yes
Phalanta alicippe tiomana	No	No	Yes
Cirrochroa orissa	No	Yes	No
Cirrochroa emalea emalea	No	No	Yes
Chersonesia rahia tiomania	No	No	Yes
Vindula dejone tiomana	No	No	Yes
Cethosia biblis perakana	No	No	Yes
Cethosia hypsea	No	No	Yes
Junonia hedonia	No	No	Yes
Junonia orithya wallacei	No	Yes	Yes
Hypolimnas anomala anomala	No	No	Yes
Junonia iphita	No	Yes	No
Athyma nefte	No	Yes	No
Athyma perius	No	Yes	No
Abisara kausambi	No	Yes	No
Tanaecia iapis	No	Yes	No
Rhinopalpa polynice	No	Yes	No
Lycaenidae Family			
Abisara geza niya	Yes	No	No
Abisara saturata kausambioides	Yes	Yes (*Abisara saturata*)	No
Taxila haquinus haquinus	Yes	No	No
Miletus chinesis learchus	Yes	No	No
Discolampa ethion thalimar	Yes	No	No
Abisara savitri savitri	No	No	Yes
Allotinus unicolor unicolor	No	No	Yes
Caleta elna epeus	No	No	Yes
Everes lacturnus rileyi	No	No	Yes
Acytolepis puspa	No	Yes (*Acytolepis puspa*)	Yes (*cytolepis puspa volumina*)
Neopithecops zalmora horsfieldi	Yes	No	No
Zizina otis lampa	Yes	No	Yes
Zizula hylax pypmaea	No	No	Yes

Scientific name	Redang[1]	Perhentian[2]	Tioman[3]
Chilades pandava pandava	Yes	Yes (*Chilades pandava*)	Yes
Chilades lajus	No	Yes	No
Euchrysops cnejus cnejus	Yes	No	Yes
Catochrysops strabo strabo	No	No	Yes
Catochrysops panormus exigus	No	No	Yes
Lampides boeticus	No	No	Yes
Jamides celeno aelianus	No	Yes (*Jamides celeno*)	Yes
Jamides aratus adana	No	No	Yes
Jamides philatus subditus	Yes	No	Yes
Nacaduba subpersuia lysa	Yes	No	No
Nacaduba beroe	No	Yes	No
Nacaduba berenica icena	Yes	No	No
Ionolyce helicon merguiana	Yes	No	No
Prosotas nora superdates	Yes	No	No
Anthene emolus goberus	Yes	Yes *(Anthene emolus)*	Yes *(Anthene emolus)*
Anthene lycaenina miya	Yes	No	No
Arhopala athada	No	Yes	No
Arhopala psuedocentaurus	Yes	No	No
Arhopala aedias agnis	Yes	No	No
Arhopala aida aida	Yes	No	No
Arhopala phaenops sandakani	Yes	No	No
Arhopala sublustris ridleyi	Yes	No	No
Arhopala corinda acestes	Yes	No	No
Cheritra freja frigga	No	No	Yes
Loxura atymnus	No	No	Yes
Thamala marciana marciana	Yes	No	No
Drupadia ravindra moorei	No	Yes (*Drupadia ravindra)*	Yes
Drupadia theda thesmia	Yes	Yes (*Drupadia theda*)	Yes
Hypolycaena thecloides thecloides	Yes	No	Yes
Hypolycaena erylus teatus	Yes	Yes *(Hypolycaena erylus)*	Yes *(Hypolycaena erylus)*
Bindahara phocides phocides	Yes	No	No
Curetis santana malayica	Yes	No	No
Curetis saronis sumatrana	Yes	Yes (needs confirmation)	No
Curetis tagalica labuana	No	No	Yes
Nacabuda beroe	No	Yes	No
Nacabuda berenice	No	No	Yes
Sinthusa malika amata	No	No	Yes
Cebrella pellecebra	No	Yes	No
Hesperiidae Family			
Hasora badra badra	Yes	No	No

Scientific name	Redang[1]	Perhentian[2]	Tioman[3]
Tapena thwaitesi bornea	Yes	No	No
Tagiades jepetus atticus	Yes	No	No
Tagiades gana gana	Yes	No	No
Suastus gremius gremius	Yes	No	No
Hyarotis adrastus praba	Yes	No	No
Salanoemia tavoyana	Yes	No	No
Salanoemia similis	No	Yes	No
Matapa druna	Yes	No	No
Pirdana distanti distanti	Yes	No	No
Telicota colon stinga	Yes	No	No
Parnara naso bada	Yes	No	No
Pelopidas mathias mathias	Yes	No	No
Polytremis lubricans lubricans	Yes	No	No
Caltoris philippina philippina	Yes	No	No
Calaenorrhinus ficulnea queda	No	No	Yes
Iambrix stellifer	No	No	Yes

[1] P. Redang species inventory complied by Malaysian Nature Society 1990.
[2] P. Perhentian Island surveys complied by CCC in 2003 and 2004.
[3] P. Tioman survey compiled by Sodhi *et al*, 1999, Raffles Bulletin of Zoology, 1999, supplement 6.

Graphs below illustrate the above table depicting the species and families of butterflies across the East Coast Islands.

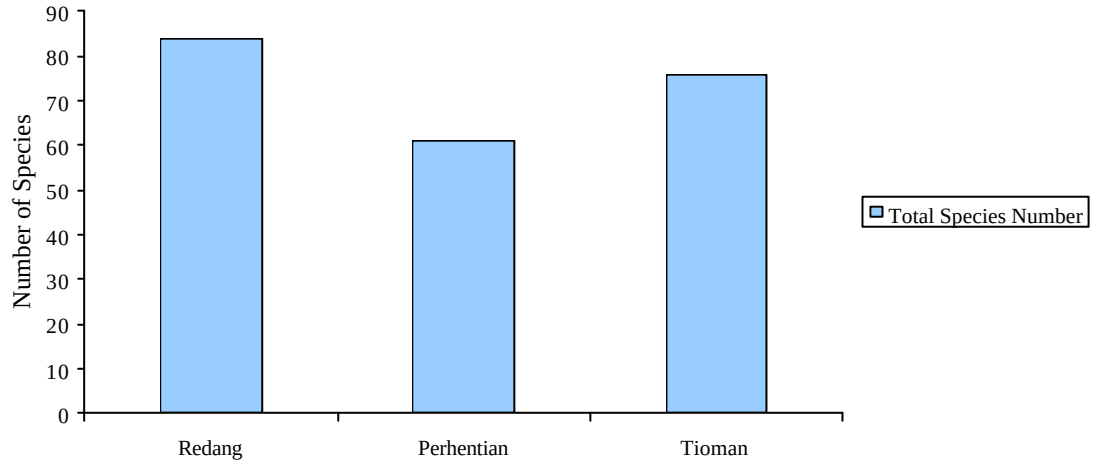

Figure 6.1 Butterfly species representation across East Coast Islands.

P. Redang is shown to have the highest number of species (84 species) compared to P. Perhentians (61 species) and P. Tioman (76 species).

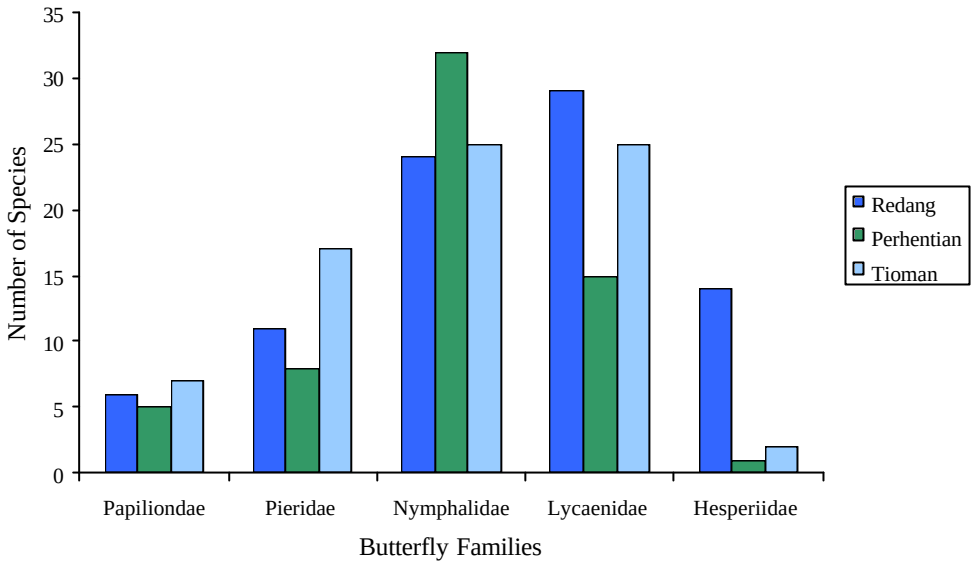

Figure 6.2 Butterfly families represented on East Coast Islands

The largest number of species is represented in the family Nymphalidae, followed by the family Lycaenidae. The Papiliondae family represents the lowest number of species across all the East Coast Islands.

6.5 Discussion

Human habitation may account for the increase in species richness in the forest edge and locations near and around chalets and hotels. It has been found (Spitzer *et al.* 1993) that an increase in butterfly diversity and species richness near villages occurs due to fruit trees and another plantation species being planted around pockets of populations. Planting of these will increase those species attracted to these plants. For example, many species of the Papilionidae family are sun loving, and are attracted to citrus plants and flowers. Moreover, the larvae of many Papilionidae species are also attracted to citrus species (Baltazar, 1991).

There were also significantly more species of Nymphalidae, another sun-loving family, in disturbed areas. Many species in this family of butterflies are attracted to overripe or rotting fruit and animal excreta (D'Abrera 1982; 1985), both of which are more common around the highly disturbed forest, due to its closer proximity to nearby villages.

More research is needed in the more forested areas of P.Besar and P.Kecil, as species numbers are likely to increase. The main priority is that the island habitats remain as undisturbed as possible as fragmentation and development may have serious implications to butterfly populations.

7. Mammals (non-volant)

7.1 Introduction

Although a great deal is known about mammalian biology, systematics, distribution patterns and conservation status, this knowledge is neither uniform nor complete. Of the 5,000 mammal species known worldwide, the threat status (IUCN RedList 2004) of more than 2,500 is insufficiently known or inadequately documented.

Non-volant species represent five of the families consisting of Insectivora, Primates, Rodentia, Carniviora and Artiodactyla. Many of these species are mainly forest dependent and the threat posed by deforestation and the introduction of many non-native species known to be present has yet to be quantified.

Malaysia has over 200 species of mammals. However, a total of 45 species of non-volant mammals are listed in the IUCN 2004 Red List as Critically Endangered, Endangered, Vulnerable or Data Deficient, this includes 12 endemic species.

Little data has been published on the habitat selection, relative abundance, or life histories of the small mammals. The number of threatened species is proportional to the degree of deforestation of the region and most species require primary forest for survival (Heaney 1993). What is known is that over 216 species of mammals are entirely dependent on habitat below 600 m, and this native vegetation (and what is found on the Perhentians) has experienced the most dramatic conversion into other forms of land use (Department of Wildlife and National Parks, Economic Planning Unit, Danish Cooperation for Environment and Development, 1996). The remarkable depauperate level of information available on these species in conjunction with the pressures on their habitat and populations, presents an extreme threat to the mammalian species the Indo-Malayan region.

7.2 Aims

- To assess the species diversity on the islands
- To compile an inventory of all the non-volant mammal species on the Perhentian Islands.
- To assess threats to species
- To produce conservation and research recommendations

7.3 Methods

Small mammals were trapped using Sherman live traps (2x2, 5x6.5”), and medium-sized mammal trapped using cage traps that were locally produced (6x4x10”). Traps were set up in ‘trap lines’ following the approaches of Heideman *et al.* (1987) and Heaney *et al.* (1989). Traps are stationed in three lines - each consisting of upward of 10 Sherman and 3 cages along transects with at least 10 m spacing between each trap. The trap lines were established (with at least 25 m separation between lines) at each survey site.

It was ensured that the traps were within the habitat type being surveyed. Each trap location is marked with a small piece of ribbon/raffia (or similar) tied to a branch (1

m) above the trap. Traps were placed on the ground close to any visible runways or alongside natural objects such as fallen trees, logs or branches and under low shrubs. Each trap was baited with carrot, and a mixture of porridge oats and peanut butter.

Traps were set for four nights, and closed after being checked in the morning - a small animal trapped in a metal box during the heat of the day would quickly succumb to dehydration and therefore trapping did not take place during daylight hours. Traps were checked from 07.00, and re-baited and set from 16.30.

All trap lines are established in areas where no other surveys were being undertaken to minimize disturbance and enhance capture probability. On checking a closed or triggered trap, the contents were emptied into cloth animal holding bags (supplied by Alana Ecology) from where the animals could then be held and examined.

Measurements were taken with dial callipers (Alana Ecology) and included: tail length, head and body length, and hind foot length. The animals fur was described – colour and absence/presence of prominent guard hairs – and, if female, the number and position of the teats.

7.4 Results

Observations

Scat from an unknown omnivore was identified, implying a population of animals undetected by the survey. The distribution and variable age of samples suggests frequent visitation to the open rock outcrop and possible territorial behaviour. The contents of the scat revealed numerous plant species and both marine and terrestrial arthropods to be dietary items. Short fur was also present but no confirmation can be made as to its inclusion as traces of mammalian prey or, as possible fur groomed from the individual in question. Known omnivores from the Malay Peninsular include the Long-Tailed (or Crab-Eating) Macaque and a few species of Civet. Numerous unconfirmed reports have been made for both cases.

Capture Data

Analysis concentrated on diversity indices at each location that was surveyed during the research programme. This includes species richness, dominance and evenness indices using Simpson's indices (see Table 7.1). Each analysis is based on species caught in the survey period.

Table 7.1 Diversity Indices at survey locations.

Survey Location	Total Species[1] (S)	Total Individuals[2] (N)	Species Richness[3] (d=(S-1)/Log(N))	Simpson's dominance Index[4]	Simpson's evenness index[5]
Base 0	2	7	0.51	0.76	0.25
B1	5	24	1.26	0.36	0.64
B3	3	8	0.96	0.41	0.59
B4	6	23	1.60	0.20	0.80
B5	2	16	0.36	0.63	0.38
B6	3	29	0.59	0.49	0.51
B7	6	11	2.085	0.19	0.81
B8	2	6	0.56	0.72	0.28
B9	2	17	0.35	0.71	0.29
B10	2	6	0.56	0.72	0.28
B11	2	14	0.38	0.87	0.13
B12	2	20	0.33	0.63	0.38
K1	3	8	0.96	0.41	0.59
K2	4	33	0.86	0.56	0.44
K3	4	13	1.17	0.30	0.70
K4	3	4	1.44	0.38	0.63
K5	2	31	0.29	0.62	0.38
D1	3	3	1.82	0.33	0.67
Susu	1	3	0	1	0
Rawa	1	3	0	1	0

[1]Total nmber of species.
[2]Total number of individuals.
[3]Species Richness defined by Margalef's Index. This incorporates the total number of individuals and is the measure of the number of species present for a given number of individuals.
[4]Simpsons Dominance Index. The highest values correspond to assemblages whose total abundance is dominated by one, or very few, of the species present within the sample site.
[5]Simpsons Evenness Index. This index is used as the total sample size is relatively small. The higher value (of $1\text{-}S^{-1}$) appears when all species have the same abundance within the sample set.

The highest number of species surveyed are found within location B4 and B7, with a total of 6 species found. However, across the survey locations generally there was found to be low species diversity, but with high amounts of individuals present. Thus dominance at each survey location is fairly low of any particular species.

From Table 7.2 (species by location), it can be seen that a total of 279 indivdulas were caught over the 8-month period. Of this over 48% was of an unidentified *Muridae* species, nearly 28% of catches were of *Tupaia glis* and nearly 19% were *Rattus* species.

Survey effort was calculated for each of the survey locations and morphological data from captured mammals have been listed.

Table 7.2 Mammal Species Numbers by Location.

Sub order	Family	Species	Total	B0	B1	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	K1	K2	K3	K4	K5	D1	Susu	Rawa
Myomorpha	Muridae	*Maxomys rajah*	8	0	2	0	4	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Myomorpha	Muridae	*Rattus argentiventer*	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Myomorpha	Muridae	*Rattus spp 1*	30	6	3	3	7	0	0	2	0	0	0	0	0	4	4	0	0	0	1	0	0
Myomorpha	Muridae	*Rattus spp 2*	14	0	1	4	4	0	0	2	0	0	0	0	0	1	1	0	0	0	1	0	0
Myomorpha	Muridae	*Rattus spp 3*	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
Myomorpha	Muridae	*Unidentified Muridae*	136	1	13	0	3	12	17	3	1	14	1	13	5	0	24	3	0	23	0	3	0
Scandentia	Tupaiidae	*Tupaia glis*	78	0	5	1	4	4	11	2	5	3	5	1	15	3	4	4	2	8	1	0	0
Sciuromorpha	Sciuridae	*Callosciurus notatus*	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Soricomorpha	Soricidae	*Crocidura spp*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Soricomorpha	Soricidae	*Unidentified Soricidae*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Total			279	7	24	8	23	16	29	11	6	17	6	14	20	8	33	13	4	31	3	3	3

Table 7.3 Female Mammal Morphological Data

Species	Statistical Measures	Mass (g)	Fore-arm (mm)	Ear (mm)	Hindfoot (mm)	Tail (mm)	Head & Body Length (mm)
Crocidura spp	Mean	15	-	7.1	13.9	63.2	84.9
	St.dev	-	-	-	-	-	-
	Range	-	-	-	-	-	-
	N	1	-	1	1	1	1
M. rajah	Mean	-	-	22.5	40.4	181.6	192.6
	St.dev	-	-	-	0.4	0.8	6.2
	Range	-	-	-	40.1-40.7	181-182.2	188.2-196.9
	N	-	-	1	2	2	2
R. argentiventer	Mean	137.5	-	-	31.8	173.2	-
	St.dev	38.9	-	-	1.8	28.28	-
	Range	110-165	-	-	30.5-33.1	153.2-193.2	-
	N	2	-	-	2	2	-
Rattus spp 1	Mean	71.5	-	18.6	32.2	145.4	136
	St.dev	36.1	-	-	5.3	24.1	136
	Range	46-97	-	-	26.5-37.1	117.9-163.2	115.5-147.1
	N	2	-	1	3	3	3
Rattus spp 3	Mean	-	-	-	32.5	187.2	155.6
	St.dev	-	-	-	-	-	-
	Range	-	-	-	-	-	-
	N	-	-	-	1	1	1
Muridae spp	Mean	124.6	-	17.3	32.4	171	157.9
	St.dev	42.6	-	1.9	1.7	34.5	22.7
	Range	73-205	-	12.9-21	27.7-35.7	18-220	92.3-201.2
	N	34	-	27	45	44	46

Table 7.4 Male Mammal Morphological Data

Species	Statistical Measure	Mass (g)	Fore-arm (mm)	Ear (mm)	Hindfoot (mm)	Tail (mm)	Head & Body Length (mm)
M. rajah	Mean	159.5	-	20.6	39.1	165.8	174.7
	St.dev	91.2	-	1.9	5.2	26.6	39.7
	Range	95-224	-	19.4-22.8	34.1-45.2	147.3-191.9	140-220.2
	N	2	-	3	4	4	4
R. argentiventer	Mean	175	-	18.2	34.1	183.2	190.3
	St.dev	-	-	-	1.4	10.20	13.25
	Range	-	-	-	32.5-35.3	171.4-189.5	175-198
	N	1	-	1	3	3	3
Rattus spp 1	Mean	76.3	-	18.4	33	126.9	146.8
	St.dev	47.2	-	1.4	2.67	55.9	19.0
	Range	41-130	-	17.5-20	29.4-36.8	16.8-157.5	120-169.6
	N	3	-	3	6	6	5
R*attus* spp 2	Mean	56	-	17.7	32	131.3	124.9
	St.dev	-	-	2.45	-	19.5	12.51
	Range	-	-	15.6-20.4	-	109.6-147.4	116-133.7
	N	1	-	3	1	3	2
Rattus spp 3	Mean	-	-	-	34.2	190.5	164.6
	St.dev	-	-	-	-	-	-
	Range	-	-	-	-	-	-
	N	1	-	-	-	-	-

Table 7.5 Male Morphological Data Contiued

Species	Statistical Measures	Mass (g)	Fore-arm (mm)	Ear (mm)	Hindfoot (mm)	Tail (mm)	Head & Body Length (mm)
T. glis	Mean	139.86	-	10.0	39.8	178.6	162.5
	St.dev	41.61	-	2.6	2.6	13.6	22.2
	Range	60-198.6	-	7.4-13.1	33.6-43.5	161-208.9	124.5-214.6
	N	10	-	5	22	21	20
Muridae spp	Mean	104.34	-	18.0	32.1	159.2	146
	St.dev	38.78	-	2.05	2.85	22.2	31.9
	Range	40-195	-	13.4-21.4	23.4-36.6	109.1-194.9	94.2-217.8
	N	32	-	33	50	52	52

	O	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	D1	K1	K2	K3	K4	K5	Rawa	Susu
Effort per location*	591.5	7302.5	0	224	4080	135	3768	714	528	3262	132	710.5	1174	56	700	3744	1815	139.5	4698	57	130.5
Callosciurus notatus	0	0	0	0	0.063	0	0	0	0	0	0	0	0	0	0	0	0	0.057	0	0	0
Maxomyus rajah	0	0.0769	0	0	0.071	0	0.069	0.067	0	0	0	0	0	0	0	0	0	0	0	0	0
Rattus Argentiventer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.067	0	0	0	0
Rattus spp.1	0.071	0.071		0.071	0.071	0	0	0.071	0	0	0	0	0	0.071	0.070	0.071	0	0	0	0	0
Rattus spp.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.07017	0
Tupaia glis	0	0.071	0	0.071	0.071	0.067	0.068	0.069	0.068	0.069	0.069	0.069	0.069	0.071	0.070	0.068	0.067	0.069	0.070	0	0
Unidentified Muridae	0	0.073	0	0	0.071	0.067	0.068	0.067	0.070	0.069	0.069	0.069	0.069	0	0	0.068	0.067	0	0.070	0	0.0689

Table 7.6 Mammal captures by location and cage trap effort.

* Number of cages x the number of hours the cages are kept opened i.e. cage hours.

Table 7.7 Mammal captures by location and Sherman trap effort.

	O	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	D1	K1	K2	K3	K4	K5	Rawa	Susu
Effort per location	0	14	0	224	224	60	234	228	0	58	0	710.5	232	14	14	2148	60	12	2450.5	0	0
Callosciurus notatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocidura spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.083	0	0	0
Maxomyus rajah	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rattus Argentiventer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.067	0	0	0	0
Rattus spp.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rattus spp.2	0	0.071	0	0.071	0.071	0	0	0.071	0	0	0	0	0	0.071	0.071	0.071	0	0	0	0	0
Rattus spp.3	0	0	0	0	0	0	0	0.071	0	0	0	0	0	0	0	0	0	0	0	0	0
Tupaia glis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified Muridae	0	0	0	0	0	0.067	0.068	0.067	0	0.069	0	0.069	0.069	0	0	0.067	0	0	0.069	0	0
Unidentified Soricidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.067	0	0	0	0

* Number of Sherman traps x the number of hours the traps are kept opened

Comparisons with other East Coast Islands

Surveys conducted on the East Coast Islands of P.Redang, P.Perhentians and P.Tioman, were collated and compared in Table 7.8.

Table 7.8 Comparisons of non-volant mammals across the East Coast Islands

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Soricidae				
Crocidura fuliginosa	Southeast Asian White-toothed Shrew	Yes	Needs confirmation	No
Tupaiidae				
Tupaia glis	Common Tree-shrew	Yes	Yes	Endemic (*Tupaia glis sordida*)
Sciuridae				
Callosciurus notatus	Plantain Squirrel	Yes	Yes	Endemic (*Callosciurus notatus tenuirostris)*
Sundasciurus tenuis	Slender Squirrel	Yes	No	Endemic (*Sundasciurus tenuis tenuirostris)*
Callosciurus nigrovittatus	Black-banded Squirrel	No	No	Endemic (*Callosciurus nigrovittatus microrhynchus)*
Lariscus insignis	Three-striped Ground Squirrel	No	No	Endemic subspecies (*Lariscus insignis fornicatus)*
Ratufa bicolor	Black Giant Squirrel	No	No	Endemic subspecies (*Ratufa bicolor tiomanensis)*
Rhinosciurus laticaudatus	Shrew-faced Ground Squirrel	No	No	Endemic subspecies (*Rhinosciurus laticaudatus robinsoni)*
Pteromyidae				
Iomys horsfieldii	Horsfield's Flying Squirrel	No	No	Yes
Petaurista petaurista melanotus	Red Giant Flying Squirrel	No	No	Yes
Tragulidae				
Tragulus javanicus	Lesser Mouse-deer	Yes	No	No
Tragulus napu rufulus	Large Mouse Deer	No	No	Yes
Lorisidae				
Nycticebus coucang insularis	Slow Loris	No	No	Endemic sub species not recorded since 1958
Cercopithecidae				
Macacca fascicularis	Long-tailed Macaque	Yes	Extirpated	Yes
Trachypithecus obscurus	Dusky Langur	No	Yes (Besar)	No
Cynocephalidae				
Cynocephalus variegates	Colugo/Flying Lemur	No	Yes (Besar)	Endemic (*Cynocephalus variegates taylori*)
Muridae				
Rattus tiomanicus	Malayan wood rat	Yes	No	Endemic (*Rattus tiomanicus tiomanicus)*
Maxomys surifer	Red spiny rat	No	Yes	Endemic (*Maxomys surifer binominatus)*
Maxomys rajah	Brown spiny rat	No	Yes	No
Rattus tanezumi	Oriental house rat	No	Yes	No

Scientific Name	Common Name	Redang[1]	Perhentian[2]	Tioman[3]
Rattus argentiventer	Ricefield Rat	No	Yes	No
Leopoldamys sabanus	Long-tailed Giant Rat	No	No	Endemic (*Leopoldamys sabanus stridens)*
Niviventer cremoriventer	Dark-tailed Tree Rat	No	No	Endemic *Niviventer cremoriventer cremoriventer* (?) not recorded since 1966
Rattus exulans concolor	Polynesian rat	No	No	Not recorded since 1966
Hystricidae				
Atherurus macrourus	Brush-tailed Porcupine	No	No	Endemic (*Atherurus macrourus tionis)*
Viverridae				
Paradoxurus hermaphroditus milleri	Common Palm Civet	No	Needs confirmation	Yes

[1]Redang survey compiled by Malaysian Nature Society, 1990.
[2]Perhentian surveys compiled by CCC in 2003 and 2004.
[3]Tioman surveys compiled by Lim *et al*, 1999. Raffles Bulletin of Zoology, supplement 6, 1999.

The figures below depict the East Coast Islands comparisons. Species that have not been confirmed, or species that have not been recorded since the 1960s are not included in this analysis.

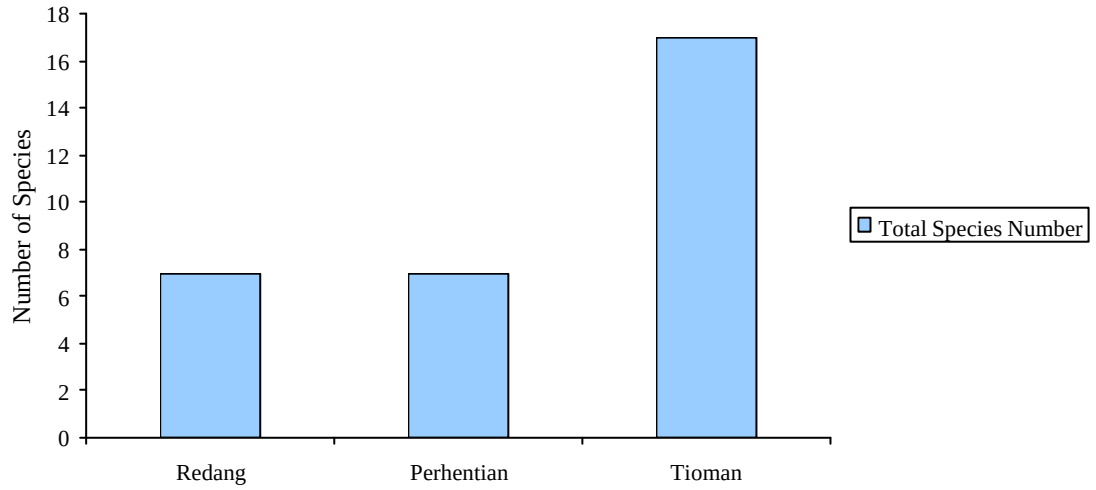

Figure 7.1 Non-volant mammal species representation across East Coast Islands.

The figure shows that both P. Redang and the P. Perhentians show the same total number of non-volant mammal species (seven are represented), compared with P.Tioman that has a total of 17 species.

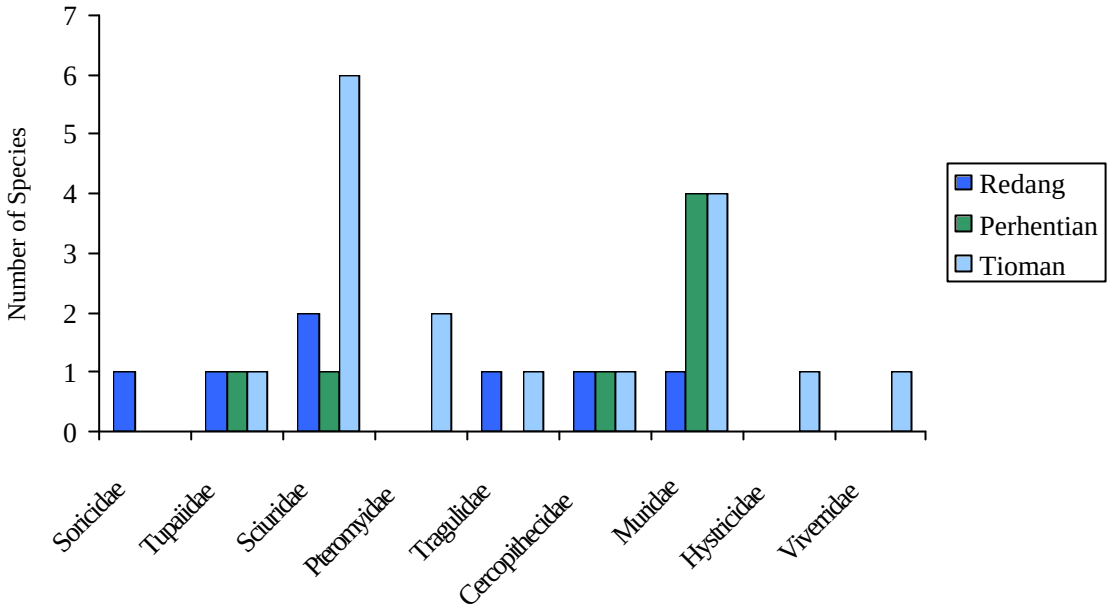

Figure 7.2 Non-volant mammal families represented on East Coast Islands.

The highest numbers of species are represented by the Sciuridae (six species) and Muridae families (seven species). There is equal representation of species numbers on all East Coast Islands by the families Tupaiidae and Cercopithecidae.

7.5 Discussion

There is a difficulty in studying the smaller mammals such as the Muridae species. Many of the species are difficult to identify and specimens may need to be taken. Some species are also highly adaptive and may vary greatly within populations.

Furthermore, many of the trapping techniques used only gives positive results to the terrestrial mammals and the traps can be further selective depending on the bait that is used. Due to the complex nature of rainforests, their vertical stratification and the associated increase in habitat types and complexity, further trapping methods need to be used to capture mammals that are arboreal in nature. This has been demonstrated in Malaysia where trapping of species 10 m within the canopy has given rise to distinctive mammal communities (Wells *et al.*, 2004) within the forest ecosystem. Additional research in this area could further results and enhance knowledge on the species assemblages within Malaysian rainforests.

The Dusky Langur (*Trachypithecus obscurus*) was reportedly present on P.Kecil but none were heard or seen during the course of this survey and therefore are considered to be locally extinct. They are, however, widespread across P.Besar as there were sightings at all survey sites. Likewise, the Colugo (*Cynocephalus variegates*) was not found on P.Kecil, but was observed at all sites on P.Besar. Both species are commonly spotted close to the tourist resorts.

The spiny rats were also only found on P.Besar, and in relatively undisturbed locations. This apparent restriction in their range could be a result of predation pressure from introduced cats that tended to be found close to the tourist resorts. The cat population is probably larger and more widespread on P.Kecil, which may explain the absence of spiny rats there.

Additional research is needed to assess the possibility of the presence of civet cats on the islands, the threat of invasive species (such as rats and domesticated cats) and also on the further identification of some of the *Rattus* and *Muridae* species that could not be identified in this project.

8. Threats to Wildlife

The Wildlife Conservation Society (WCS) stated in Kuala Lumpur at the 7th Conference of the Parties for the Convention on Biological Diversity (COP-7, 2004), that the trade in wildlife in Southeast Asia (includes small songbirds sold as pets, reptiles sold for their skins and meat and animal parts for medicinal use) is causing massive decline in species and continually threatening the long-term survival of others. Even species that are thought of as common are decreasing in numbers throughout the region, as they are being trapped, shot, snared and sold.

Although it was beyond the scope of this survey to thoroughly investigate activities that could potentially threaten the future survival of the islands' wildlife, any evidence of such activities was noted, when encountered, and summarised below:

- The unauthorised use of mist nets to capture bird species.
- The shooting of bird species.
- The hunting of wildlife for food during the monsoon months.
- Collection of bats.
- The introduction of predators such as rats and domesticated cats.
- The killing of snakes.
- The collection of birds' nests.
- The unauthorised collection of turtle eggs.
- Mortality of adults due to collision with speeding boats.

8.1 Threats to Birds

The bird fauna of P.Perhentian is not diverse, but does contain the protected species, the near threatened, Nicobar pigeon (*Caloenas nicobarica*). The Nicobar pigeon has been hunted in the past for its gizzard stone (Birdlife 2004). Surveys did not come across any evidence to suggest Nicobar pigeons were targeted for their stone, however reports from Kuala Besut (O'Malley, pers.coms) confirmed that this was the case in previous years and may still be continuing. Local people were found to be aware of the value of the 'stone' but believed that the Nicobar was now not present on the islands.

Evidence was found that hunting with shotguns is taking place, especially on the uninhabited islands of Rawa and Susudara. Shotgun shells were found across the island of Susudara, which was also found to have the highest density of Nicobar pigeons. The hunting of birds on these islands was common knowledge amongst the people living on P.Perhentian; the most common explanation given was that birds were hunted for sport during the winter months, when migratory birds are moving through the area. Of the birds found on Susudara, none may be hunted under licence (game birds) and all but one is totally protected under Malaysian law (Strange and Jeyarajasingam, 1999).

Some species, most notably the White-rumped Sharma (*Copsychus malabaricus*), are highly sought-after for the pet trade, and can sell for several hundred ringitt (PERHILITAN wildlife officers, pers comm). During the course of the survey period three illegal mist nets were found and removed on P.Kecil and one was removed from

P.Besar. The use of a mist nets to trap White-rumped Sharmas on Besar was reported to the survey team. Nets discovered (aprox 13 m by 2.5 m) did not appear to be checked regularly as each net contained the remains of dead birds and bats. Clearly these nets pose a threat to the intended target, likely to be the white rumped sharma, but also other birds and bats that could get entangled. Fortunately this does not appear to be a widespread problem; more likely, opportunists are putting up one or two nets close to forest trails to catch birds, however, if nets were erected in the more remote areas of P.Besar or on Susudara, then they would pose a serious threat to ground dwelling birds like the Nicobar pigeon.

Bird nests are collected, under licence, from a cave in the north east of P.Kecil where the young birds are allowed to fledge before the nests are taken. However, there are reported to be more nesting areas in caves on Susudara and northern P.Kecil, where unlicensed collection is occurring.

8.2 Threats to Herpetofauna

Perhentian residents reported that hunting of monitor lizards for food takes place in the monsoon period, when fishing boats moor-up around the islands (Tamblyn pers.coms; O'Malley pers.coms). The impact this is having on the monitor population is unclear, but monitor lizards are widespread across the islands and it is common to see large adults.

Many species of snake appear to be routinely killed when encountered by some fishermen and residents of the islands. The remains of snakes, which had been decapitated, were found on several occasions. The snakes are most likely killed out of fear and the belief that most snakes are dangerous. Based on reports from villagers and resort owners, reticulated pythons did not appear to be feared and so are quite numerous, even in developed areas and around the resorts.

8.3 Threats to Mammals

Several roosts of the black bearded tomb bat were found around the island. In one of these roosting sites a ladder was discovered. Whether for collection of bats or birds nests it is unclear (although birds are not reported to be nesting at that site) and needs to be closely monitored.

The introduction of species onto small islands can lead to the decline of native fauna. Cats were seen in the forest in the southern area of P.Besar, and their scats found on the coastline on P.Kecil. Cats are known to be kept on the island by resort owners. This could pose a serious problem for the native fauna.

8.4 Turtles

Although not researched as part of this survey, it was noted that the plight of the turtles is probably the most pressing issue to be tackled. Of the once numerous beaches used for nesting by Leatherback (*Dermochelys Coriacea*), Green (*Chelonia Mydas*), and Hawkesbill (*Eretmochelys Imbricata*) turtles only one major beach remains available. Leatherback turtles have not nested for 20 years on the islands and this year only three female Hawkesbill turtles came ashore (Turtle Protection Ranger

Unit, Perhentian pers com). Green turtle numbers are higher but have reduced compared to previous years.

Green turtles are one of the major attractions for the tourists who flock to the islands to snorkel and dive. However, as of August only 30 females had been tagged for this year (when coming ashore), a figure down on previous years. During his short stay of eight days on Long Beach, P.Kecil, the Expedition Leader saw or heard of four turtles dying, two at least of unnatural causes – upon examination they were found to have injuries consisitent those expected in collisions with boats.

Speeding boats between the two islands appear to pose a serious threat to the future survival of, what now appears to be, the last remaining turtle species with a foothold on the islands. If Green Turtles were to disappear from the Perhentians, not only would it be blow to the species` future survival in Malaysia but could also affect the tourist industry on Perhentian - as one of the major attractions will have gone.

8.5 Recommendations for further work

- Further investigation is needed over the monsoon months to ascertain the threat from hunting on monitors and other wildlife.
- Detailed observations of Nicobar pigeons on Susudara and its satellite islands are needed to determine the size of the population and to learn about their breeding habits.
- Take measures to limit disturbance on the islands used by the Nicobar, especially any breeding areas, and ensure cats and rats are not present or introduced.
- Further develop the education programme at the school to teach the children about the wildlife on their island. This could be extended to include information for the community as a whole.
- Investigate the unlicensed collection of bird nests.
- Discourage resort owners and their staff from leaving cats behind on P.Besar when they leave for the mainland at the end of the tourist season.
- Enforce speeding restrictions and continue to tackle illegal fishing operations between and around the islands.
- Increase in assistance for Turtle Protection Unit in their work with the collection and protection of turtle eggs.

9. Collaborations and Community Programmes

9.1 Introduction

The MRICP provides as unique situation in which to work based in a prime location on Perhentian Besar, this provides ample opportunity to explore and conduct training and information exchange with both tourists and local people alike. Throughout the project duration numbers of interested parties increased, including, local schools, chalet and hotel owners, tourists and local inhabitants.

9.2 Community Education

Education of both the local community and the tourism stakeholder community should be seen as a long-term goal. Through interest developed in the Pilot Phase the stakeholders of the islands developed further interest in CCC's research and many people became actively involved.

Many of the chalet owner's became increasingly aware of the presence of CCC. On several occasions CCC staff were taken to chalets and restaurants to remove snakes and other creatures without harming them. Many local people would come to the project base in order to learn more about the aims of the CCC project and how research was achieved and undertaken. Additionally people often came with information about animals that they had seen on the islands and on several occasions brought captured animals to the site for the staff and volunteers to identify.

Tourists also became actively interested. Many tourists were unaware of what could be found within the forest and were very interested to discover more about the islands they had come to visit. As a result of this interest a simple leaflet was constructed depicting some of the animals that could be more easily seen on the islands. These leaflets were then given to chalet owners and some of the more popular tourist sites. These proved to be very popular and this project will be further developed as a result of this.

9.3 Schools Education Programme

Education is seen as an important part of CCC's activities, especially the education of the younger generation.

As part of this education programme the project visited the local Primary School, Sekolah Kebangsaan, for the Perhentian Islands, located in the small fishing village on the Island of Kecil. The aim of the programme was to educate the children between 11-12 years of age about the animals they would see on the islands and in the forest. The project visited the school on six occasions, presenting posters on birds, mammals (including bats), snakes, lizards and forest dynamics. The most popular animals for the children were, 'White Bellied Sea Eagle', the 'Tockay Gecko' and the 'Common Tree Shrew'. All lessons were conducted with the help of the science teacher Mr. Ayub.

On the final visit, the project presented the school with a laminated poster on the most common animals found on the Perhentian Islands. The aim of this was to present material to the school that would be available for use in future lessons and on occasions for all the children in the school to see. The school, in appreciation of the lesson, presented the project with the school banner and emblem.

9.4 Scholarship/Partnership Programmes

CCC has implemented a Scholarship Awards Scheme on the MRICP which is open to Malaysian citizens who are full-time students undertaking education in a relevant subject at a recognized educational establishment within Malaysia or who are employees of related and recognised organisation or establishment that want to share skills and technology. Four interns (studying at the University of Kuala Lumpur) and four full time staff of PERHILITAN joined the CCC expedition over the course of the project.

10. Conservation Indices, values and recommendations

10.1 An Introduction to Conservation Indices

A recent study (Sodhi *et al.,* 2004) identified the root causes of biodiversity loss in South East Asia. Satellite images have shown that 0.7% of forests are destroyed each year; extrapolation predicts that this will reach over 74% by 2100. Through this destruction between 13 and 42% of plant and animal species will become extinct in Southeast Asia over the next 100 years.

Biodiversity conservation requires constant monitoring, evaluation and baseline assessment in quantifiable terms. However, in order to produce decision support tools a simple, but effective, conservation index or biodiversity indicators are needed. These ultimately give conservation managers a fast and effective tool to use in land or habitat based conservation management by indicating which areas are more biodiverse (i.e. habitat hotspots) than others.

The development of conservation indices or biodiversity indicators in conservation management is still much in its infancy and the development of these using robust, universal methodologies is still being debated. The use of indices such as Simpson's, Shannon-Weiner, Pielou and indices relating to dominance and evenness can be used to inform decision makers. However it is acknowledged that these do not cover the comprehensive viewpoints of biodiversity. For example this does not include taxonomic spectrums, life forms, genetic diversity, structure and the nature of the community in itself (Roy *et al.,* 2004).

However, for landscape management, or an ecosystem approach, assessments into species richness, evenness, diversity of species and communities are seen to be the most appropriate assessment for diversity at certain habitat types (Wilson *et al* 1996). It is not possible to capture all aspects that define a functioning ecosystem and the varying differences in habitat type. This in itself would need to include variables such as temperature, rainfall, soil type, structure and additional factors of biotic differences. Studying biodiversity as comprehensively as the pre mentioned factors is not seen as a feasible or cost effective option. However, value systems looking at aspects of conservation (i.e. threatened species, endemic species) and ecosystem functionability (i.e. based on species diversity) is seen as a major step in conservation management.

10.2 CCC's Conservation Indices Development

The conservation indices designed and used in this report are based on several factors. Each of the indices will be discussed and evaluated separately.

Number of Species: this figure is a component of biodiversity.

Species Richness: Species Richness is defined by Margalef's Index ((d=(S-1)/Log (N)). This incorporates the total number of individuals and is the measure of the number of species present for a given number of individuals.

Simpsons Evenness Index. This index is used as the total sample size is relatively small. The higher value of $1\text{-}S^{-1}$ appears when all species have the same abundance within the sample set. Species evenness is used as communities which are dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance, i.e. communities which are shown to be more even. Thus a higher value for eveness suggests a more diverse area.

Diversity indices also assessed whether species present in the habitat types had any additional significant value. Whether species present were endemic to the area or whether species found in certain habitat types were listed in the IUCN Red List (2004) for Malaysia. If such species were present in particular habitat types then these habitat types were 'weighted'.

Endemic Species: Species that are endemic to Malaysia only. Currently there is limited data to state whether species are endemic to the Perhentian Islands (as has been achieved in Tioman). Weighting involves a simple method of either absence or presence data (calculated as either '0' or '1').

IUCN Red List (2004): All species that are currently listed in any of the categories of the IUCN Red List (this includes, data deficient, least concern, near threatened, threatened, endangered and critically endangered). Species that are present in the habitat areas that have a position on the list will be weighted. This in kept simply to presence or absence on the list (equal weighting of all categories calculated as either '0' or '1').

Method

For each surveyed faunal group (bats, birds, herpetiles, butterflies and non-volant mammals) diversity indices were calculated using PRIMER. Indices such as species richness, Simpson's evenness and dominance indices and number of species and total number of individuals were calculated for each individual surveyed habitat type.

Species numbers, species richness and Simpson's dominance indices were then taken for each faunal group and habitat type. The average was then calculated for each faunal group by habitat type by indices. If the habitat type had above average score, this habitat is then awarded '1', if below average score then the habitat type is awarded '0'. This is completed for each of the three indices and the total (out of the maximum score of 3) is then calculated.

Additionally weighting of habitat types by species listed as endemic to Malaysia on the IUCN Red List is achieved. Absence and presence of species is weighted by '0' or '1', but additionally the number of species that are present in these areas is weighted proportionally, i.e. if there are 3 endemic species in the same habitat type then the weighting will be 3.

Results

For each major faunal group (birds, bats, herpetiles, butterflies and mammals) and at each survey location the conservation indices were established. This used the following biodiversity indices; species number, species richness and Simpson's dominance index. These indices were established for each survey site and then assessed for values that were either above or below average and totalled.

Table 10.1 Bat conservation values by location.

Sites	Species Number	Species Richness	Simpson's Evenness	Above Average	Above Average	Above Average	Total
B0	11	3.24	0.88	TRUE	TRUE	TRUE	3
B1	8	2.20	0.63	TRUE	TRUE	TRUE	3
B3	1	0	0	FALSE	FALSE	FALSE	0
B4	4	1.54	0.73	TRUE	TRUE	TRUE	3
B5	4	0.99	0.4	TRUE	TRUE	TRUE	3
B6	7	1.86	0.75	TRUE	TRUE	TRUE	3
B7	4	1.06	0.62	TRUE	TRUE	TRUE	3
B8	3	1.24	0.64	FALSE	TRUE	TRUE	2
B9	2	0.56	0.28	FALSE	FALSE	FALSE	0
B10	2	0.91	0.44	FALSE	FALSE	TRUE	1
B11	1	0	0	FALSE	FALSE	FALSE	0
K1	1	0	0	FALSE	FALSE	FALSE	0
K2	3	0.78	0.54	FALSE	FALSE	TRUE	1
K3	2	0.56	0.5	FALSE	FALSE	TRUE	1
K4	1	0	0	FALSE	FALSE	FALSE	0
K5	1	0	0	FALSE	FALSE	FALSE	0
Susu	2	0.72	0.38	FALSE	FALSE	FALSE	0
Average	3.4	0.92	0.40				

No additional weighting of sites was needed, as there are no species that are listed as endemic to Malaysia or IUCN Red List.

Table 10.2 Bird conservation indices by location.

Sites	Species Numbers	Species Richness	Simpson's Evenness	Above Average	Above Average	Above Average	IUCN Weight	Total
B0	12	2.64	0.85	TRUE	TRUE	TRUE	5	8
B2	2	1.44	1	FALSE	TRUE	TRUE	3	5
B3	5	0.94	0.69	FALSE	FALSE	TRUE	3	4
B4	4	0.83	0.68	FALSE	FALSE	TRUE	2	3
B5	4	0.88	0.64	FALSE	FALSE	TRUE	2	3
B6	8	1.36	0.72	TRUE	TRUE	TRUE	6	9
B7	3	0.96	0.68	FALSE	FALSE	TRUE	2	3
B8	6	1.14	0.59	TRUE	FALSE	FALSE	4	5
B9	4	0.73	0.56	FALSE	FALSE	FALSE	2	2
B10	6	0.95	0.39	TRUE	FALSE	FALSE	4	5
B11	6	1.06	0.22	TRUE	FALSE	FALSE	5	6
B12	5	0.85	0.61	FALSE	FALSE	TRUE	4	5
K1	5	0.83	0.44	FALSE	FALSE	FALSE	3	3
K2	6	1.09	0.66	TRUE	FALSE	TRUE	4	5
K3	3	0.56	0.52	FALSE	FALSE	FALSE	1	1
K4	7	1.47	0.59	TRUE	TRUE	FALSE	5	7
K5	4	1.30	0.64	FALSE	TRUE	TRUE	2	4
Susu	10	1.86	0.36	TRUE	TRUE	FALSE	6	8
Rawa	7	1.57	0.68	TRUE	TRUE	TRUE	5	8
Average	5.63	1.18	0.61					

There is no weighting of endemic species as there have been no reports of endemic bird species on this island. IUCN weighting does occur for many species present on the islands (details of IUCN listed species can be found in Chapter 4).

Table 10.3 Herpetile conservation indices by location.

Sites	Species Numbers	Species Richness	Simpson's Evenness	Above average	Above average	Above Average	IUCN weighting	Total
B0	14	4.09	0.9	TRUE	TRUE	TRUE	1	4
B1	6	1.90	0.81	TRUE	TRUE	TRUE	0	3
B2	3	1.24	0.64	FALSE	FALSE	TRUE	0	1
B3	8	2.42	0.84	TRUE	TRUE	TRUE	1	4
B5	4	1.25	0.45	FALSE	FALSE	FALSE	0	0
B6	8	2.08	0.59	TRUE	TRUE	TRUE	0	3
B7	6	2.40	0.81	TRUE	TRUE	TRUE	0	3
B8	1	0	0	FALSE	FALSE	FALSE	0	0
B9	3	1.44	0.63	FALSE	FALSE	TRUE	0	1
B10	3	0.96	0.59	FALSE	FALSE	TRUE	0	1
B11	6	1.73	0.64	TRUE	TRUE	TRUE	0	3
K4	9	2.67	0.85	TRUE	TRUE	TRUE	1	3
K5	1	0	0	FALSE	FALSE	FALSE	0	0
Susu	1	0	0	FALSE	FALSE	FALSE	0	0
Average	5.21	1.50	0.45					

IUCN weighting has been given to the species *Bufo parvus* which is listed as IUCN least concern. There are no endemic species present on the island to date.

Table 10.4 Butterfly conservation indices by location

Sites	Species Numbers	Species Richness	Simpson's Evenness	Above Average	Above Average	Above Average	Total
B0	40	7.89	0.95	TRUE	TRUE	TRUE	3
B3	2	1.44	0.5	FALSE	FALSE	FALSE	0
B4	2	0.91	0.44	FALSE	FALSE	FALSE	0
B5	8	2.92	0.86	FALSE	FALSE	TRUE	1
B6	3	1.82	0.67	FALSE	FALSE	FALSE	0
K1	9	3.34	0.88	FALSE	TRUE	TRUE	2
K2	6	2.28	0.74	FALSE	FALSE	TRUE	1
Average	10	2.94	0.27				

There has been no weighting of any of the species associated with the habitat groups, as there are no endemic or IUCN Red Listed species present on the islands.

Table 10.5 Mammal (non-volant) conservation indices by location.

Sites	Species Number	Species Richness	Simpson's Evenness	Above Average	Above Average	Above Average	Total
B0	2	0.51	0.25	FALSE	FALSE	FALSE	0
B1	5	1.26	0.64	TRUE	TRUE	TRUE	3
B3	3	0.96	0.59	TRUE	TRUE	TRUE	3
B4	6	1.60	0.8	TRUE	TRUE	TRUE	3
B5	2	0.36	0.38	FALSE	FALSE	FALSE	0
B6	3	0.59	0.51	TRUE	FALSE	TRUE	2
B7	6	2.09	0.81	TRUE	TRUE	TRUE	3
B8	2	0.56	0.28	FALSE	FALSE	FALSE	0
B9	2	0.35	0.29	FALSE	FALSE	FALSE	0
B10	2	0.56	0.28	FALSE	FALSE	FALSE	0
B11	2	0.38	0.13	FALSE	FALSE	FALSE	0
B12	2	0.33	0.38	FALSE	FALSE	FALSE	0
K1	3	0.96	0.59	TRUE	TRUE	TRUE	3
K2	4	0.86	0.44	TRUE	TRUE	TRUE	3
K3	4	1.17	0.7	TRUE	TRUE	TRUE	3
K4	3	1.44	0.63	TRUE	TRUE	TRUE	3
K5	2	0.29	0.38	FALSE	FALSE	FALSE	0
D1	3	1.82	0.67	TRUE	TRUE	TRUE	3
Susu	1	0	0	FALSE	FALSE	FALSE	0
Rawa	1	0	0	FALSE	FALSE	FALSE	0
Average	2.9	0.81	0.44				

There has been no additional weighting as none of the species recorded are Malaysian endemics or listed on the IUCN Red List.

Table 10. 6 Conservation indices of the Perhentians at each survey location (all faunal groups)

Sites	Bat CI	Bird CI	Herp CI	Butterfly CI	Mammal CI	**Total**
B0	3	8	4	3	0	**18**
B1	3	0	3	0	3	**9**
B2*	0	5	1	0	0	**6**
B3	0	4	4	0	3	**11**
B4	3	3	0	0	3	**9**
B5	3	3	0	1	0	**7**
B6	3	9	3	0	2	**17**
B7	3	3	3	0	3	**12**
B8	2	5	0	0	0	**7**
B9	0	2	1	0	0	**3**
B10	1	5	1	0	0	**7**
B11	0	6	3	0	0	**9**
B12	0	5	0	0	0	**5**
K1	0	3	0	2	3	**8**
K2	1	5	0	1	3	**10**
K3	1	1	0	0	3	**5**
K4	0	7	3	0	3	**13**
K5	0	4	0	0	0	**4**
Susu	0	8	0	0	0	**8**
Rawa	0	8	0	0	0	**8**

*B2 Has biodiversity indices measured in the bird faunal group only. This total therefore does not reflect the true conservation value of the site.

The totals (comprised of all the totals from the faunal groups by location) illustrate areas that have higher values than others. These areas can be interpreted as biodiversity 'hotspots' or areas where the conservation value is high. These values can then be plotted on a map of the P.Perhentians to give a visual representation of biodiversity hotspots on the islands (see figure 10.1).

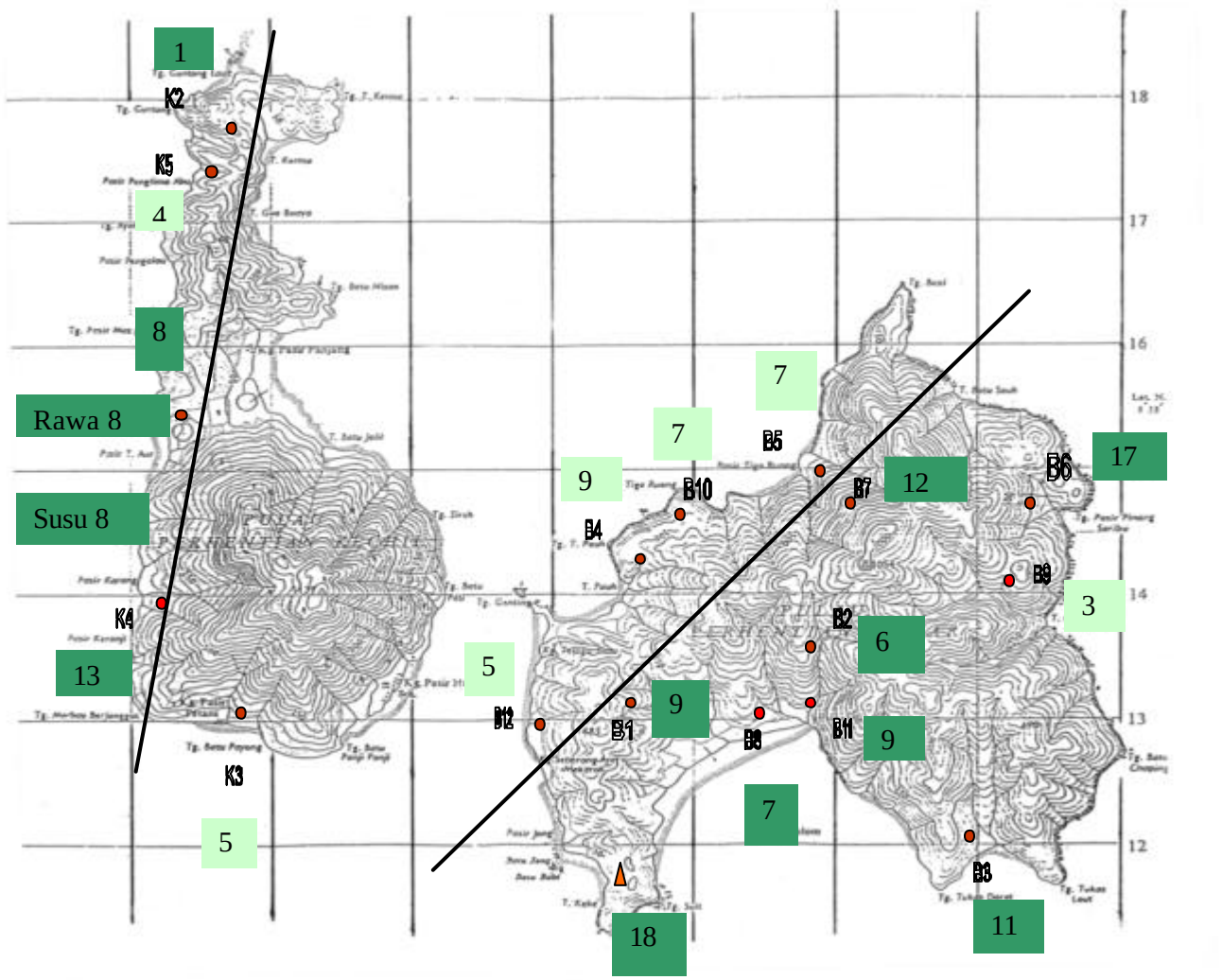

Figure 10.1 Conservation indices plotted on the Perhentians

It can be seen from figure 10.1 that there is a distinct pattern of areas of high biodiversity values and regions of relatively lower biodiversity values. This is depicted by regions of high marked in dark green and low in light green, with a clear dissection across the islands of both P.Besar and P.Kecil.

On P.Besar this indicates that the regions of high biodiversity and therefore conservation importance occur in the northeast side of the island. This region has had little or no development and hence little disturbance. This area is also relatively inaccessible to people, with no used paths or areas of plantation. The west coast of

Besar is the region that has been developed for tourism, with the majority of hotel resorts based along this coast. The forest behind this area has been susceptible to disturbance through increased use by tourists, dumping of rubbish and deforestation due to development.

P.Kecil is shown to be less diverse than P.Besar, with many areas surveyed receiving low conservation indices. Survey locations K4, K2 Rawa and Susudara scored the highest points, suggesting the west coast of P.Kecil and the outlying islands are less disturbed. The majority of P.Kecil has been developed, the south of the island is dominated by the fishing village and its surrounding plantations, the east coast (Long Beach) is a large tourist centre, and pockets of development on the north east and west coast. There are few areas that have been left undisturbed, with large areas of plantations, footpaths, areas of deforestation and rubbish dumping.

The outlying islands of Rawa and Susudara are a strong hold for many bird species, including the Nicobar Pigeon, Pied Imperial Pigeon, White Bellied Sea Eagle and the Black Naped Oriole. Although these islands are not inhabited, signs of hunting are found on these islands, which pose a serious threat to the bird populations.

10.3 Discussion

The rapid speed at which tourism has been developed in many of the Malaysian Islands warrants serious attention to be made to tourism developments, infrastructure and ecological and social impacts. What must be taken in to account is the need for the sustainable development of these areas in which economic gain is not achieved at the expense of the environment. This process must include the equitable sharing of benefits that accrue from successful Marine Park management.

Tourism management, which includes the management of infrastructure and the management of people's activities, must be incorporated in island conservation planning and strategies and should not be produced in isolation of the environment that is supporting the tourist industry.

The distinction of areas of high levels of biodiversity and those of low levels of biodiversity made through the use of conservation indices, accentuates the need for holistic management of areas that need to encompass environmental, social and economic conditions. Ecosystems are complex and non-linear with outcomes often showing time lags and complicated interconnectedness, with both process and function not fully understood. The interconnectivity of the environment also promotes further complications. Land based activities usually affect areas down stream or seaward; water uses could well affect the water table and ability to support the natural environment. Sewage impacts are different from recreational impacts again with each showing their different thresholds of sustainability (Manning & Douherty 1995). All these need to be carefully monitored to ensure long term sustainability of Marine Procted Areas, incorportating both the forested islands and the coral reef ecosystems.

Conservation indices can be incorporated into Marine Park management by defining areas of high levels of biodiversity and depicting areas where diversity is less. This can be used to refine development plans on the island whilst maintaining areas that are rich in biodiversity and limiting any disturbance in these areas.

10.4 Conclusion and Recommendations

Malaysia has joined and ratified the Convention on Biological Diversity, 1992, and with this hold responsibility to ensure it is implementing various aspects of the treaty.

In the Master Plan (Capacity Building and Strengthening of the Protected Areas System in Peninsular Malaysia, 1996) the framework for managing biodiversity include such issues as defining the basic biological resources of an area, its ecological information, development of management plans, zoning methods, research, participation and education. Each of these areas require understanding and research in order to maintain and deliver a socially acceptable, economically viable and an ecologically sustainable method of managing protected areas.

In terms of relating these to Marine Protected Areas, recognition that tourism related development will affect the natural resources (including land development, pollutions, deforestation and illegal activities) and that strategies are needed to be put in place in order to mitigate some of these related problems. Education and public involvement is paramount to build levels of understanding and support.

The use of the information in this report and the final analysis and development of conservation indices is an important step to managing the terrestrial ecosystems within the Marine Protected Area. Further research and monitoring is needed to ensure ecological changes are documented and species evaluated. What this report does provide is an awareness of the diversity of the islands and the link between development of tourist sites and resulting levels of biodiversity. Areas which are shown to contain high levels of diversity within island 'hotspots' need to be protected from any future disturbance to maintain the integrity of the islands ecosystem and species that live on it.

Specific Recommendations

- More research is required throughout the year on all faunal groups
- In depth vegetation inventory work
- Development of information and awareness tools for local stakeholders and tourists
- Relevant state authorities should further investigate the recognised risks to wildlife (e.g. hunting and collection)
- State authorities should review island development in relation to biodiversity 'hotspots'
- Review levels of disturbance and land change throughout the islands
- Review possibility of P.Perhentian being review for possible designation as a state park
- Explore the potential to market the island's terrestrial biodiversity in addition to that of the marine, thus promoting a more holistic nature tourist destination

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