Malaysia Tropical Forest Conservation Project
Report of the Setiu Wetlands Phase

A collaborative project between the Department of Wildlife and National Parks, Malaysia (PERHILITAN) and Coral Cay Conservation.

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Report Production

This report has been compiled from input of the CCC field staff of the Malaysia Tropical Forests Conservation Project (MTFCP). Their original contributions have been compiled and edited to form this final report. The report has been reviewed and edited by Peter Raines (CCC), Alexia Tamblyn (JFA) and Dr. Craig Turner (JFA).

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Executive Summary

- As part of the Malaysia Tropical Forests Conservation Project (MTFCP), Coral Cay Conservation undertook a Rapid Biodiversity Assessment in the Setiu Wetlands, state of Terennganu, Peninsula Malaysia. The project ran for a period of fifteen months, from November 2004 to February 2006.

- Terrestrial surveys encompassed habitat mapping and two target faunal groups - vertebrates (birds, bats, mammals and herpetofauna) and invertebrates (butterflies).

- Using a Landsat 7ETM+ image (acquired on 06/01/06), GPS co-ordinates from field surveys put into a Geographical Information System (ESRI ArcMap ver.8.3). The maps were referenced to Universal Transverse Mercator Spheriod projection, WGS84 datum. Using this map survey sites were selected across a range of key habitats within the wetland region. The habitat types included: casuarina forest, dry forest, mangrove, peat swamp forest and scrub. A further four habitat types were investigated during surveys these were: Gelam - dry; Gelam - wet; Islet and palm oil plantation.

- Results from faunal group surveys were used to generate species inventories and compare species diversity by survey site and habitat type.

- A total of 80 bird species from 30 families were identified using point counts and mist-netting. The mangrove, lagoon and casuarinas showed the highest levels of species diversity. The Lesser Green Leaf Bird (*Chloropsis cyanopogon)* and the scarlet-breasted flowerpecker (*Prionochilus thoracicus)* are classified as IUCN near threatened. These species' are association with the Sundaic lowland forests (BirdLife, 2006) that are threatened by deforestation and fragmentation.

- A total of 70 bats was caught and attributed to a total of 13 different species with a further 6 identified down to genus. Families represented were: Pteropodidae, Vespertillionidae, Emballonuridae, Rhinolopidae. The dry forest and the peat swamp forest provided the highest numbers of captures. Two species of bat caught during the survey are noteworthy due to their IUCN status of near threatened: the Dyak fruit bat (*Dyacopterus spadiceus*) and Creagh's horseshoe bat (*Rhinolophus Creaghi*).

- Four orders of non-volant mammals were found: Carnivora, Insectivora, Rodentia and Scandentia. Six different species identifications were made, and three of these were rodentia. The most captures were made in the mangrove and the peat swamp forest.

- Twenty-three species of herpetofauna were recorded: 18 reptiles and 5 amphibians. Of these, 78% of the 387 individual observed across all sites were identified as *Leiolepis belliana,* common butterfly lizards. There appeared to be a link between the high dominance of ground dwelling lizards and the absence of small mammals in scrub and coconut scrub habitats. The highest species richness and diversities were found in the mangrove and peat swamp forest sites.

- A total of 38 butterfly species were found across all the survey sites and these belonged to one of the families of Nymphalidae, Lycaenidae, Pieridae or Papilionidae. The greatest number of individuals was caught in plantation habitats, however the more varied species compositions were in the mangrove and peat swamp forest.

- The Setiu Wetlands is a complex of habitat pockets within a wider landscape mosaic. In conclusion, it is the habitats where dense vegetation cover is retained, such as mangroves, peat forest and dry forest that harbour higher levels of biodiversity and should therefore be considered key habitats in the Setiu wetlands. Habitat maps show these habitats are highly fragmented and isolated. Their conservation is of up most importance.

- The findings in this report represent a 'snapshot' of the fauna and flora at Setiu. More detailed and ongoing research is required in order to best understand the spatial and temporal patterns exhibited by the biodiversity of the wetland complex and thus manage the inherent components sustainably.

1. Introduction

1.1 Background

In the past 30 years, Malaysia has undergone dramatic levels of economic growth. Malaysia leads the world in the production of primary commodities such as rubber and is one of the biggest exporters of palm oil, tropical hardwoods, pepper and tin (World Bank, 2005).

Alongside economic development, Malaysia has experienced rapid population growth. In 2005 the population of Malaysia was estimated at 26.1 million with a growth rate of 1.8% per year (Population Reference Bureau, 2005). Whilst living standards are among the highest in Southeast Asia, 10 million people live in rural areas (Population Reference Bureau, 2005). Rural livelihoods are supported by small-scale cultivation of rice crops and rubber plantation and agricultural activities often involve slash and burn cultivation. Natural resources are consequently being put under increasing pressure.

Malaysia is one of the 17 'megadiversity countries' recognised by Conservation International (Mittermeier & Mittermeier, 2005). Malaysia also falls under the Sundaland 'Biodiversity Hotspot' (Conservation International, 2005) and the Peninsula Malaysia Lowland and Montane forest ecoregion of WWF's 'Global 200' (Olson *et al.,* 2001).

The forests found in the region are associated with high levels of floral and faunal diversity. Peninsula Malaysia, Sabaha and Sarawak (Borneo territories) supports over 15,000 species of plants and 185,000 described animal species including over 650 species of birds and almost 1200 species of butterflies (Perumal & Sharma, 2001; Asean Regional Centre for Biodiversity Conservation, 2005). There are 232 endemic animal species across all groups, and 156 of its resident species have been classified as threatened (IUCN, 2004).

The climate of Malaysia is typically humid tropical and is characterised by year round high temperatures and seasonal heavy rain. As a result of these climatic conditions, the predominant natural vegetation is tropical rain forest. Forest cover 20,890 ha^{-1} or just under two thirds of the land in Malaysia (FAO, 2005). Forest types are classified according to substrate and floristic composition and include: lowland and hill dipterocarp forest, peat swamp forest, freshwater swamp forest and mangrove (Whitmore, 1984, 1990; FAO, 2000). Table 1.1 below outlines the extent and distribution of some of these forest types within Malaysia.

Table 1.1 Forest cover statistics by forest type for Malaysia.

Region	Land Area	Dipterocarp	Swamp	Mangrove	Total Forested land	% Total Forested land
Peninsula Malaysia	13.6	5.36	0.30	0.11	5.86	44.2
Sabah						
Sarawak	7.37	3.80	0.19	0.32	4.46	60.5
	12.33	8.84	1.25	0.17	10.28	82.6
Total	32.86	17.99	1.74	0.54	20.56	62.4

(FAO, 2000). All figures (million ha).

The loss of tropical forests is one of the most pressing issues facing the world today. The demand on rainforest resources is leading to their fragmentation, transformation and conversion to other types of land cover. Deforestation is particularly severe in Southeast Asia with grave implications for the region's unique biodiversity (*Sodhi et al.*, 2004). During 2000-2005 the rate of deforestation in Malaysia was about 0.7% per year, meaning an average of 140,000 ha of forest are lost annually (FAO, 2005).

1.2 Wetland Habitats in Malaysia

The diverse and complex series of wetland forest types found in Malaysia is a rare collection of most of the coastal wetland habitat types found in the tropics: ranging from mudflats, mangroves to peat swamps and a diverse range of intermediate ecosystems: back mangrove forests, brackish riverine forests and open brackish scrub habitats (Global Environment Facility, 1999).

Wetlands are critically important ecosystems that provide significant social, economic and ecological benefits (Stuip *et al.*, 2002). Wetlands take-up excess water from river systems and offer a natural flood control mechanism both as a trap and filter for sediment build-up from deforestation upstream (Ramadasen *et al.*, 1999).

Wetlands also support high levels of biological diversity. They are, amongst the richest and most productive ecosystems and provide a number of ecosystem services (Ramsar Convention on Wetlands, 1996). Some key wetland habitats types are described below:

Mangroves

Plant diversity is lower in mangroves than that of a lowland dipterocarp or dry forest. The most common tree species are *Rhizophora, Avicennia, Bruguiera, Sonneratia.* Two types of swamp palm are also found in the forest, Nipah (*Nypa fruticans*) and Nibong (*Oncosperma horrida*).

A large number of animals frequent mangrove habitats, although relatively few live there permanently and even fewer are restricted to mangroves (Christensen, 1983). Several Langurs (Genus *Trachypithecus)* and Macaques (*Macaca fascicularis)* frequent mangroves. Wild pigs (*Sus scrofa),* and mouse deer (*Tragulus sp),* are common in Nipah swamps. Occasionally, small carnivores such as fishing cats (*Felis viverrina)*, and mongooses (*Herpestes sp)*, may visit mangroves or even live there. Otters (*Aonyx cinerea* and *Lutra sp)* are common but highly inconspicuous. Flying foxes are known to roost in mangroves. Monitors (*Varanus salvator)* are common, as are a number of snake species. Christensen (1983) provides the following overview of the avifauna for mangroves in Southeast Asia.

Around 20% of the world's mangrove forests have disappeared during the past 25 years as a result of over-exploitation and conversion to other uses, such as offshore fisheries in the case of Malaysia (FAO, 2005b). Mangroves are harvested for fuelwood, charcoal, timber, poles and fish traps. Nipah is a versatile Non-Timber Forest Product used for housing thatch, cigarette paper, sugar, alcohol, vinegar and salt (FAO, 2005b).

There are an estimated 564, 971 ha of mangroves in Malaysia (Wilkie & Fortuna, 2003) and they are found on all coasts, with the largest areas on the coast of Sabah and the west coast of Peninsula Malaysia.

As of 2004, a reported 128,257ha of mangroves were gazetted as 'State land' (Forestry Department Peninsula Malaysia, 2005). However, few of these areas are protected by national park or reserve designations and threats to mangroves continue to endanger the wealth of biological resources associated with these complex ecosystems.

Dry Forest

Tropical dry forests are not as diverse as those in wetter regions, but they do contain a variety of trees and plants adapted to the effects of seasonal rainfalls. Woody species dominate coastal dry forest areas. Moving away from the coast, dry forests are charaterised by thicket-type vegetation dominated by screw pine (Pandanus utilis) and cycas (Cycadaceae). Dry forests also contain some dipterocarps with a dense undergrowth of shrubs such as tree ferns and chain fern rhizome and epiphytes (WWF, 2001).

Tropical dry forests have been considered one of the most threatened of all major forest types (Miles *et al.,* 2006). Concentrations of dry forest in Asia are found in Thailand, Vietnam, Laos and Cambodia but the percentage protected dry forests in Southeast Asia is relatively low at 14.2% or 4,200ha (Miles *et al.,* 2006) and what remains is highly fragmented.

Peat Swamp Forest

Peat swamps are particularly important wetland habitats and can makes up 75% of wetland areas. Peat forests exist in low-lying areas on clay sediments with high levels of pyrite. The peat is formed by accumulation of decaying plant matter in low oxygen and highly acidic conditions. Peat beds can be very deep (up to 20m) and have characteristic black water produced by tannins released from the decaying plant material (Ramadasan *et al.,* 1999).

The acidity of peat and variability of water levels means the forest canopy is often shorter with more emergents and a thinner layer canopy than dipterocarp forests. As a result peat forests offer difficult conditions for plants and animals and have lower species richness than lowland dipterocarp forests. Peat swamps offer a niche environment to specialised species, for example pitcher plants, which are adapted to living in nutrient poor soils and provide their own nutrients by trapping small animals.

Casuarinas

Casuarinas are a pine like tree species which form open stands in coastal margins. The trees have very shallow roots and produce nitrogen through microbial associations, casuarinas can colonise nutrient-poor soils and other marginal environments such as granite outcrops and lateritic or sandy soils. As a result, most casuarina forests tend to be low in stature, often with a dense shrubby under-storey. The tallest casuarina forests occur in riverine habitats, where they may be over 20 metres tall (Joyce, 2006).

Scrub
Areas of coastal scrub are characterised by short grasses and small to medium sized (2-5m) herbaceous understories. The density and the composition of the shrub cover varies as does the herbaceous understory. In some places shrubs form a dense, almost impenetrable woody plant cover with a sparse understory whilst in other places the shrubby overstory is more open and savannah-like.

In many countries, as in Malaysia, a large proportion of the population live in or close to wetlands rely on natural resources for their livelihoods (Stuip *et al.,* 2002). Wetlands provide for a significant part of the staple diet of Malaysia - rice and fish, with high productivity enabling high levels of commercial farming and development. However, as populations have grown, coastal habitats are now subject to great pressures from demands for agricultural land and from logging (Okubo *et al.,* 2003). Protecting these valuable habitats is critical.

Since 1950 an estimated 50% of all wetlands are thought to have been lost globally (Ramsar Convention on Wetlands, 1996). There are thought to be around 20 million ha in Southeast Asia (Okubo *et al.,* 2003) and 200,000ha in Peninsula Malaysia (Page *et al.,* 2005).

By 2003, Malaysia had designated 30% of the total land area, or 10,000 ha^{-1} as protected areas, i.e. national parks, reserves (World Resources Institute, 2005). Many tracts of forest are protected e.g. the lowland Dipterocarp forest at Taman Negara National Park, Malaysia’s first National Park. However vast gaps are found in the conservation of other forest ecosystems such as heath forests and peat swamps of the south Peninsula Malaysia in areas like Selangor (Gaither, 1994; Lee *et al.,* 2002).

In 1994 Malaysia ratified the Ramsar Convention of Wetlands of International Importance and designated Tasek Bera, a unique freshwater swamp, as it’s first Ramsar site. Ramsar define wetlands as *‘areas of marsh, fen, peat land or water whether a natural or artificial, permanent or temporary, with water that is static, flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres’* (Ramsar Convention on Wetlands, 1996).

To date a total of 82 Ramsar wetland sites have been designated in Peninsula Malaysia. Nationally, the Malaysian Wetland Directory identified 56 wetlands of conservation importance. These comprise both natural and artificial habitats with a total area covering 3.3 million hectares (Yoke Fun,1996). The Setiu basin is one of these sites.

1.3 The Setiu Wetlands

The Setiu Wetlands are located in the northeast of Peninsula Malaysia (Figure 1.1), in the state of Terennganu. For Terengganu, approximately 51.6% or 670,000 ha of the state still remains under forest cover. Of this, 5,168 ha are designated as plantation (Krishnapillay & Ong, 2003).

The wetlands form part of the Setiu river basin and the region features:

- Estuaries and deltas
- Intertidal mudflats, sand flats and mangroves

- Coastal brackish and saline lagoons and marshes
- *Melaleuca* swamp forest (known locally as 'gelam') or freshwater swamp forests with vegetation comprising almost exclusively of *Melaleuca cejeputi*
- Lowland dry forest with characteristic Dipterocarps and Nipah palm (*Nypa fructicans*).

(Global Environment Facility, 1999).

This range of habitats provides a variety of floristic communities, which in turn support animal communities characteristic of tropical wetland ecosystems.

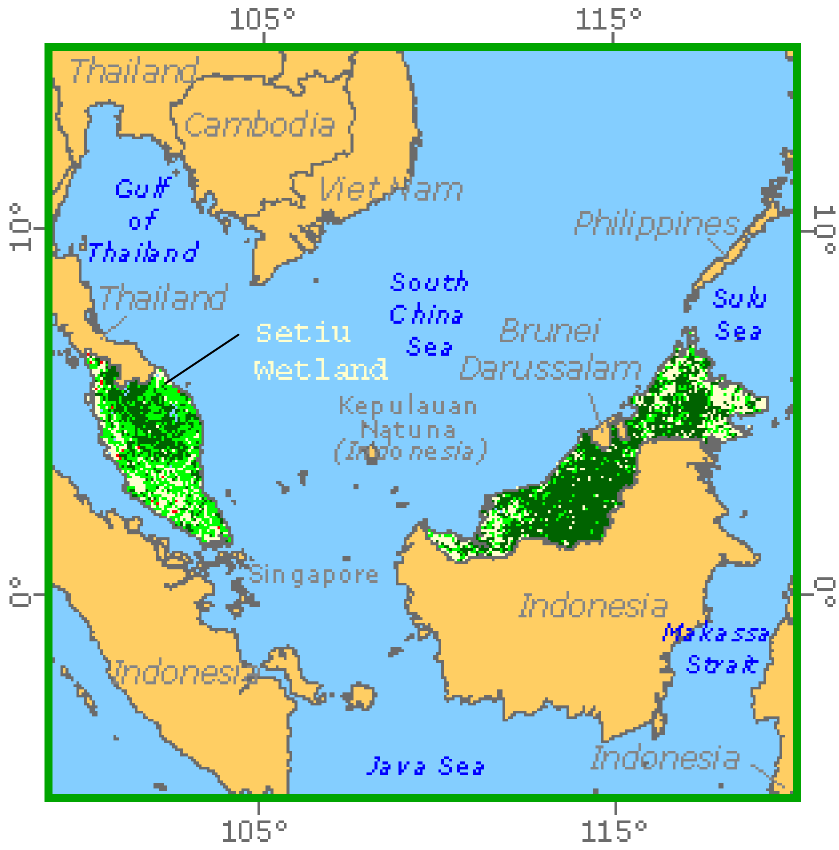


Figure 1.1 Location of the Setiu Wetlands in relation to Peninsula Malaysia.

Previous research in the Setiu Wetlands has included specific and targeted projects such as in-depth studies on certain vegetation types e.g. mangroves (Hussain & Ibrahim, 2001) or specific faunal groups such as the WWF-Malaysia project on Green Turtles (*Chelonia mydas*) and Painted and River Terrapins (*Callagur borneoensis*) nesting along the Setiu river mouth and estuary. Subsequent work documented the riparian vegetation and riverine fauna associated with the habitat (WWF, 2004). In addition, overviews documenting socio-economic activities have been produced (Amin & Abu Hasan 2003) and physio-chemical studies completed, with WWF-Malaysia producing the 'Coastal and estuarine land use management around some major river systems in Peninsular Malaysia. Case study III: Sg. Setiu, Terengganu' report (Salam 1998). It addressed issues such as water pollution, waste management, ecosystem and habitat degradation and infrastructure development around the Setiu River and its associated wetlands.

A lack of systematic research at an ecosystems level in Setiu means little comparative data is available on the biodiversity of these important ecosystems or on the effects of disturbance and development. Hence there is a great need to re-addressing the imbalance and to obtain biodiversity information on the major faunal and floral groups within the wetland areas of Malaysia in order to ensure their survival and sustainable management into the future.

1.4 Malaysia Tropical Forest Conservation Project

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.

In 2004, following the development of a partnership with PERHILITAN (Department of Wildlife and National Parks, Peninsular Malaysia), CCC undertook a terrestrial islands project on Pulau Perhentian supported by PERHILITAN as part of the Malaysia Tropical Forest Conservation Project (MTFCP).

The terrestrial project based on the Perhentian Islands of Pulau Besar and Pulau Kecil, completed base line biodiversity assessments on major floral and faunal groups over a period of seven months during 2004. Project outputs include:

Terrestrial habitat maps with assessments on fauna within defined habitats. A series of biodiversity indicators for main faunal groups (bats, birds, butterflies, herpetofauna and non-volant mammals) were generated to compare species diversity and abundance on the islands, which resulted in a set of recommendations for natural resource management on the islands (Tamblyn *et al.,* 2005).

Following the Perhentians Phase, CCC was invited to continue their work in the Setiu wetlands. The aims of the MTFCP are shown in Table 1.2.

1.5 Report Outline

This report documents the results of the MTFCP Setiu Wetlands Phase. It provides an overall assessment of representative habitat types in the region and of the diversity and distribution of vertebrates (birds, bats, non-volant (non flying) mammals and herpetofauna -amphibians and reptiles) and invertebrates (butterflies).

Rapid Biodiversity Assessments were undertaken at 12 main survey sites over a 12-month period. Descriptions of the survey approach and the habitats covered are provided in the following chapter. The methods used to survey each faunal group and floral communities are then provided. The results are presented for each faunal group, including a discussion of the survey results and conclusions and recommendations.

Table 1.2 Aims, objectives and outputs of the Malaysia Tropical Forest Conservation Project.

Aim	Objectives	Anticipated Outputs
Resource assessment	Undertake an initial scientific survey of target habitats	Initial baseline database
	Conduct detailed inventories and provide quantitative data sets of major faunal groups	Description of forest habitats
	Establish a baseline dataset	Documentation of anthropogenic impact
	Map terrestrial habitat types	
	Provide preliminary management tools and recommendations	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	Quantitative biodiversity assessment and comparison of terrestrial habitats
	Conduct preliminary human impact assessment studies	Data set for comparison with future surveys
	Provide data for the national, regional and global datasets	Preliminary management recommendations
	Provide preliminary management tools and recommendations	
Training and conservation education	Provide scientific training for CCC volunteers and Malaysian nationals	Trained project members
	Heighten awareness of forest resources, their use and protection	Increased forest survey human resource capabilities within Malaysia
	Begin to develop a sense of community awareness and stewardship in managing the forest resources initially the Perhentian Islands and the Setiu Wetlands	Increased awareness amongst local communities

2 Methodology

2.1 Introduction

Baseline biodiversity surveys provide an opportunity to assess ecological changes over space and time, and therefore have a central role in many aspects of tropical forest research, conservation and management (Turner *et al.*, 2002). Habitat mapping can be used in combination with baseline faunal and floral surveys for major habitat types to assess ecological patterns and provide a environmental data sets which form the basis of successful habitat management.

The MTFCP baseline faunal surveys focused on four major vertebrate taxonomic groups: birds, bats, non-volant mammals and herpetiles (reptiles and amphibians) and one invertebrate group, the lepidopterons. All surveys utilised standard rapid biodiversity assessment techniques (Stork & Davies, 1996) using observation and live capture techniques (Sutherland, 1996; Bibby *et al.*, 1998). Habitat mapping was achieved following Phase I habitat surveys, using GPS/GIS and topographic maps. Details of all the survey methodologies are discussed in this chapter.

2.2 CCC Survey Approach

It is acknowledged that conservation biologists have long used "non-professional" volunteers to collect 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. 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 CCC since 1986. At present it is used in collaborative programmes in the Philippines and in Fiji.

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. CCC uses an intensive 7-day training programme designed to provide volunteers the skills to collect useful and reliable data. The programme aims 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 and Science Officer and involves lectures, equipment orientations and practical sessions within the field, with de-briefings and evening audio-visual presentations. Paper based and practical tests conclude the training programme to ensure that the knowledge and techniques learnt can be accurately applied.

The training programme follows the model used on Danjugan Island in the Philippines, (Turner *et al.*, 2002) and also applied many of the methods used during forest resource assessment work elsewhere in the Philippines and Malaysia (Turner *et al.*, 2003).

2.3 Aims of the MTFCP

The aims and objectives of the MTFCP are outlined as follows:

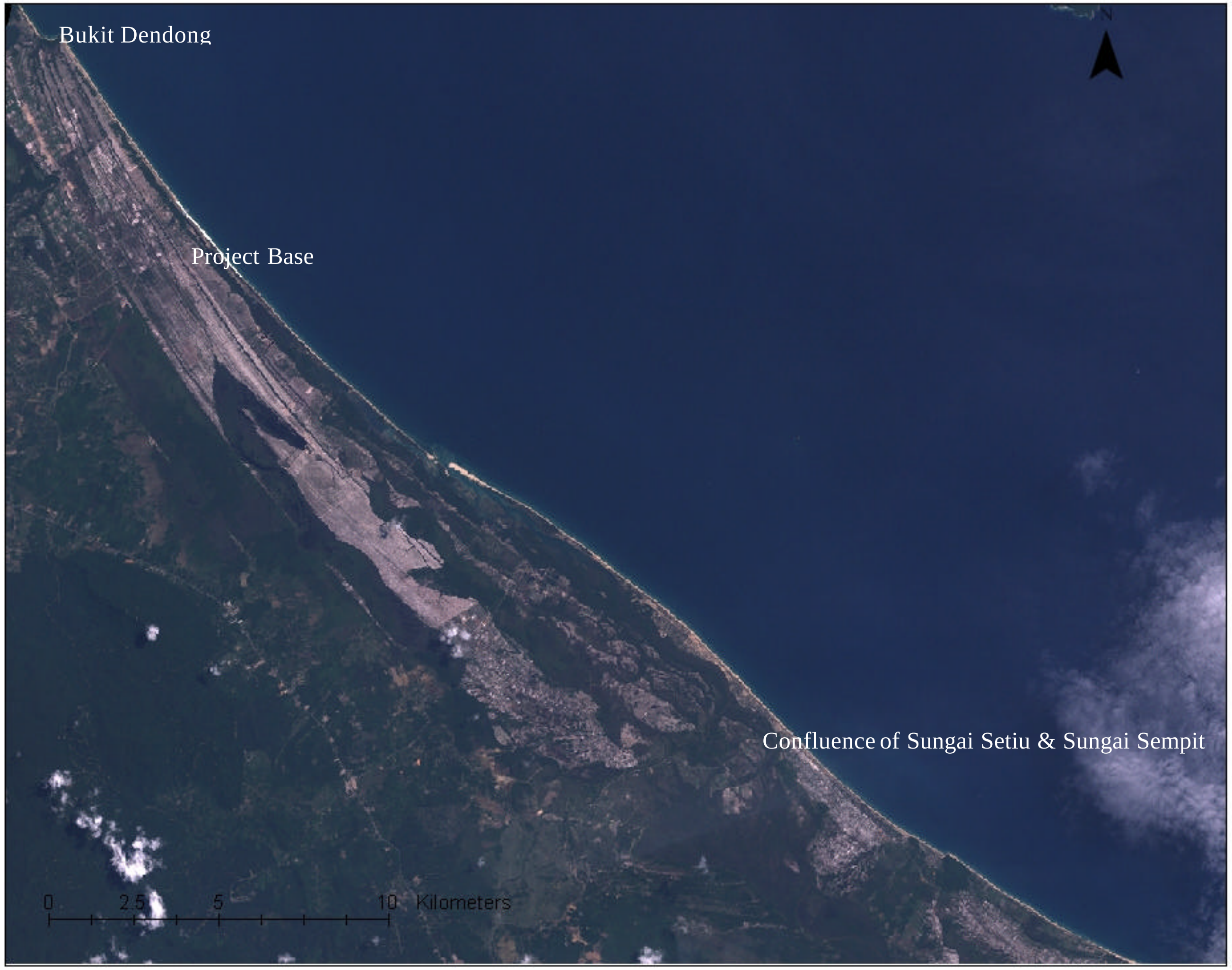
- To obtain base-line quantitative data on the biodiversity of the fauna and flora of the Setiu Wetlands,
- To create resource maps and an environmental database for the region,
- To provide suitable education materials and programmes to improve environmental awareness amongst local communities,
- To offer training opportunities to host country counterparts in biodiversity assessment and management
- To provide an ecological basis to support integrated community-driven management plans for the conservation, restoration and sustainable use of biodiversity in the region.

The results of the baseline survey work will contribute vital information to the development of sustainable management recommendations for this area with the potential to combine the work of the MTFCP with other data sources and develop a management plan for the whole of the wetland region. All results and reports produced by the MTFCP will be submitted to PERHILITAN and will be made available to other conservation and ecological stakeholders when requested, who, in turn, will facilitate their dissemination and outputs to the wider stakeholder arena.

2.4 Survey Location

The project region is shown in Figure 2.1. It is a broad strip, covering approximately 30km of coastline of the northeast corner of Terennganu. It is bounded in the north by Bukit Dendong (Dendong Hill) N 05° 46.53.6 E 102°37.46.0 and in the south at the meeting of the Sungai Setiu and Sungai Sempit (rivers) N 05° 36 22 27 E 102° 48 27 45.

Figure 2.1 Landsat 7ETM+ image of the project region. (Courtesey of University of Maryland, Global Land Coverage Facility data archives. Image acquired 06/01/06).



2.5 Habitat Mapping

Habitat mapping assessments of the study region were undertaken using Phase I Habitat Survey techniques (Cherrill & McClean, 1999). CCC has previously used the Phase I Habitat Survey approach in order to map the terrestrial habitats of Danjugan Island, Philippines and the Perhentian Islands, Malaysia (Turner *et al.*, 2002; Tamblyn *et al.*, 2005). Major habitat boundaries were delineated within the project area and then classified according to major vegetation communities present using vegetation transects and sample quadrat plots (Alder & Synnott, 1992; Sutherland, 1996).

Habitat maps were generated from GPS co-ordinates from field surveys and put into a Geographical Information System (ESRI ArcMap ver.8.3). The co-ordinates were then imposed onto a Landsat 7ETM+ image acquired on 06/01/06 from the Global Land Coverage Facility, University of Maryland data archives (see Figure 2.1). Maps were referenced to Universal Transverse Mercator Spheriod projection, WGS84 datum.

2.6 Bird Point Counts

The point count technique involves an observer recording all individual birds identified from sightings or calls during a set time whilst remaining at one location (Bibby *et al.*, 1998). A compass bearing was chosen at random as the starting point for each point count transect. These transects featured 10 counting stations, 250 m apart. At some survey sites e.g. Mangroves (S9 & S12) transect direction and position of count stations were governed by accessibility (e.g. tidal cycles).

Birds of the same species were only recorded twice if observers were certain they were different individuals. Each point count was fixed at 22 minutes and the time noted for each individual spotted within this time frame. This relatively short period of time allowed more ground to be covered and for more count stations – the recommended approach for habitats with low species diversity. A team of at least 4 individuals was used for each survey to gain as best coverage of the viewing areas as possible.

Point counts are effective in these habitat types as standing in one location for a fixed time period allows observers time to locate and observe birds, even birds that are notoriously hard to spot, small or very fast in flight.

2.7 Mist-netting for Birds

Standard mist netting techniques were employed (Bibby *et al.*, 1998) to survey the less conspicuous species that may not have been detected using the point count method. Nets were established using bamboo poles and ropes tied vertically from tree branches. Mist nets (38mm mesh, Avinet, USA) were attached in different combinations at different locations within the study area. These locations were selected for their accessibility, areas of high bird activity and where species that could not be identified had been sighted.

Nets were opened between 06:00 hours and 07:00 hours and closed at approximately 10:00 hours and between 16:00 hours to 19:00 hours. Occasionally nets could be kept open throughout the day. These times were dependent upon weather conditions i.e. recording in heavy rain was avoided. Nets were checked every 20 minutes. Net records were kept which included: number of nets used, height, duration open, 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.* (2002).

Mist nets are advantageous as they can help avoid biases of visual and audio census observations and also facilitates capture of some inconspicuous, timid and/or rarely vocal species (Remsen & Good, 1996; Bibby *et al.*, 1998). However ground level mist-nets sample a small portion of avifauna, within 2-3m of the ground. Capture numbers do not represent quantitatively species composition of habitats (Jenni & Leuenberger, 1996).

2.8 Mist-netting for Bats

Mist-nets were used at various locations within the designated survey sites. To maximise capture efficiency, nets were established across likely flight-paths such as clearings, along ridges, or by water (Heaney *et al.*, 1989), in a variety of combinations, such as ‘Z’ and ‘T’ formations (Kunz *et al.*, 1996), and at differing heights above the ground. High nets were operated on a pulley system, and when possible were complemented by a low net positioned on the same pulley system (following Ingle, 1993). Nets were opened at approximately 19:00 and closed at 10:00. Netting was halted during rain or strong winds.

Bats captured were identified using Kingston (2004) and were 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. Fore-arm length was measured using dial callipers, and weight using spring balances. When new species were encountered, ear, hind-foot and total length were also recorded.

2.9 Non-volant Mammal Traps

Small mammals were trapped using Sherman live traps (2x2.5x6.5”), and medium-sized mammals trapped using cage traps. Traps were set up in ‘trap lines’ following the approaches of Heideman *et al* (1987) and Heaney *et al* (1989). Traps were stationed in lines of 6 Sherman and 4 cages along 100m transects with 10m spacing between each trap. Three trap lines were established (with at least 15m separation between lines) at each survey site for 3 mornings and 3 nights. Each trap location was marked with a small piece of ribbon/raffia tied to a branch above the trap. All trap lines were established in areas where no other surveys are being undertaken to minimise disturbance and enhance capture probability.

Traps were placed on the ground under suitable cover and alongside natural objects such as fallen trees, logs or branches or under low shrubs. Each trap was baited and dry bedding material placed in the nest box. Traps were checked at least twice a day, re-baited and damp bedding replaced as needed.

On checking a closed or triggered trap, the contents were emptied into a weighing sack. Mammal captures were identified to species using keys available (Francis, 2001; Turner & Turner, 2005), and their age and sex determined where possible. The animals were also measured to determine body and tail lengths, and weight. Animals were then released.

Notes taken for each captured animal included the site, date and trap location, the species, age, sex, biometric measurements, and comments such as breeding condition, health, or recapture. For medium sized species (e.g. Civets) biometrics were not taken due to risk to field personnel, individuals were identified and then released.

2.10 General observations

At some survey sites, observations of large mammal species (e.g. Langurs and Macaques) were undertaken in addition to small mammal trap lines. Although highly conspicuous, large mammals are often extremely timid and highly mobile allowing only their observations to be conducted on an ad hoc basis. During these times, observations such as number of individuals, group activities, feeding routines and behaviour were noted. General observations are of approximate value and therefore provide only supplementary evidence as part of the assessment.

2.11 Herpetofauna Quadrat Visual Encounter Survey (QVES)

The quadrat method has been shown to be one of the most effective herpetofaunal sampling techniques (Jaeger & Inger 1994). Four observers intensively search a quadrat, measuring 10m by 10m. Each observer begins at one of the four corners of each quadrat and moves at the same speed in a clockwise direction. This synchronised movement should prevent most reptiles and amphibians from exiting the quadrat before capture. Each quadrat should be searched thoroughly ensuring that all microhabitats are investigated.

Each individual encountered and captured by hand was identified, measured with callipers, weighed, marked, and immediately released at the point of capture. Substrate and height at which individuals were encountered were also recorded. Where identification could not be determined, dorsal and ventral photographs were taken.

2.12 Herpetofauna Transect Visual Encounter Survey (TVES)

Straight-line transects of 100m were marked out with raffia (following a compass bearing). Observers walk along the transect at 30 minutes per 100m, spaced laterally, with approximately 2-4m between each observer. This slow pace enables thorough examination of the vegetation by each observer. Each transect was walked twice per site visit with 24hrs between each walk. All reptiles and amphibians captured were processed as above, including the distance along the transect, and time of each individual capture.

Both quadrats and transect VES were used in this study as each targets different species. Faster moving lizards, most snakes, and arboreal frogs are more likely to be caught during TVES, while frogs and small lizards that inhabit the leaf litter are more likely to be captured with quadrats (Crump & Scott 1994). Both QVES and TVES allow for standardised survey effort in terms of time, area and personnel, and thus permit comparisons of results between habitat types.

2.13 Pitfall traps with drift fences

Pitfall trapping regimes are used to sample small reptiles in most habitats (Thompson *et al*, 2003). Ten buckets per transect are used, to maximise catch efficiency (Friend *et al*, 1989). Buckets are buried to ground level and along the line of buckets 10m long plastic sheet fence with approximately 35 cm above ground are constructed following Friend *et al*, (1989) and Halliday (1996). Approximately 10cm was buried below ground level to trap burrowing herpetofauna. Leaf litter, to provide cover for the trapped herpetofauna and potentially to attract invertebrates as bait (Bloomberg & Shine, 1996), and drainage holes are added to each bucket. All soil excavated was removed from the immediate vicinity to reduce disturbance that may deter some animals.

Two fences were set at each survey site and left for 3 nights. The temporary nature of the traps should not reduce capture rates (Friend *et al*, 1989). 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.

2.14 Invertebrate Surveys - Butterfly Netting Transects

Terrestrial invertebrate communities were sampled using appropriate indicator groups (e.g. Lepidopterans) and were surveyed using netting. Such techniques have been effectively implemented by CCC in the Philippines (Turner *et al.*, 2002).

The transect walk method with non-random point counts was used to investigate butterfly diversity and abundance at different survey sites. The use of such transects also means that a wide variety of habitats and microclimates (streams, canopy gaps, different aspects, etc) can be surveyed (Hill, 1999).

Straight-line transects of 500m were marked out with count stations every 50m. Butterflies were surveyed along the transects using methods similar to those described for butterflies in temperate regions by Pollard (1977), and used in previous studies of tropical forest butterflies (Hill *et al.*, 1995; Hamer *et al.*, 1997; Hill, 1997; Spitzer *et al.*, 1993; Slade, 2001).

To ensure a constant duration of observation for each transect walk, a constant speed of three minutes per 50m was maintained in between count stations. During the walk butterflies were observed within an imaginary box around the observer (5m each side, 5m ahead and 5m above). At each count station a quadrat 10m x 10m is then observed.

Following this, a 10-minute period of netting was attempted. This method is similar to those used in other tropical butterfly studies (Spitzer *et al*., 1993; Hill *et al.*, 1995; Hamer *et al.*, 1997). Thus, any differences in butterfly diversity between sites is not due to differences in visibility, because recording is restricted to within 10m of the stations and within 5m of transects (Hamer *et al.*, 1997).

Butterflies that could not be identified to species or genus on the wing were caught and photographed for identification out of the field to minimise stress to the captures. High definition digital photographs were used to take dorsal and ventral views of each capture.

Peak butterfly density has been noted to occur around the middle of the day (Hill *et al*, 1995; Pollard, 1977; Pollard, 1988; Walpole, 1999). Transect counts were therefore conducted between 10 00 hours and 15 00 hours, and in good weather as temperature/irradiance differences are known to affect butterfly flight (Pollard & Yates, 1993; Willott *et al.*, 2000).

Walpole & Sheldon (1999) noted low densities of butterflies beneath the canopy, and concluded that to obtain a sizeable sample, repeated counts were needed along the transect. The direction the transects were walked were therefore alternated for each transect to try to minimise any differences due to time of day, and in an attempt to ensure equivalent conditions.

2.15 Report Outline

This report aims to address the diversity and distribution of species within surveyed habitats across the Setiu Wetlands over a fifteen-month period.

The report focuses on birds, bats, non-volant mammals, herpetofauna and butterflies throughout the habitat types, allowing an assessment of species composition and diversity to be made between each habitat. Each faunal group is addressed in separate chapters, where the data is statistically analysed to distinguish differences between survey locations. In the final chapter (discussion and conclusions), all the results are analysed together to suggest future research and recommendations as well as conservation priorities.

3. Habitat Mapping and Vegetation Analysis

Survey locations were identified in 7 different habitat types, with 4 main habitat types (scrub, dry forest, mangrove and coastal Casuarina forest) containing two survey sites within this habitat type. All survey sites are situated within the Setiu Wetlands. Further habitat types were identified throughout the survey period allowing a further 3 main survey site to be established; coconut forest, lagoon and peat forest. Additional sites, with limited survey effort, were established towards the end of the project period.

Table 3.1 Summary Survey locations by habitat type

Survey Location	**Habitat Type**
S1	Scrub
S2	coastal Casuarina forest
S3	Scrub
S4	Dry Forest (disturbed)
S5	Dry Forest (disturbed)
S6	Coconut forest
S7	Dry Forest (disturbed)
S8	Lagoon/mangrove
S9	Mangrove
S10	Peat Forest
S11	coastal Casuarina forest
S12	Mangrove
Additional Sites	
	Gelam - Dry
	Gelam - Wet
	Islet
	Palm Oil Plantation

3.1 Habitat Mapping Results

Using a Landsat 7ETM+ image (acquired on 06/01/06), GPS co-ordinates from field surveys put into a Geographical Information System (ESRI ArcMap ver.8.3). The maps were referenced to Universal Transverse Mercator Spheriod projection, WGS84 datum.

Figure 3.1 Landsat 7ETM+ image of the project region. (Courtesey of University of Maryland, Global Land Coverage Facility data archives. Image acquired 06/01/06).

Figure 3.2 Habitat map showing three sections of the project region (Scale 1:125,000).

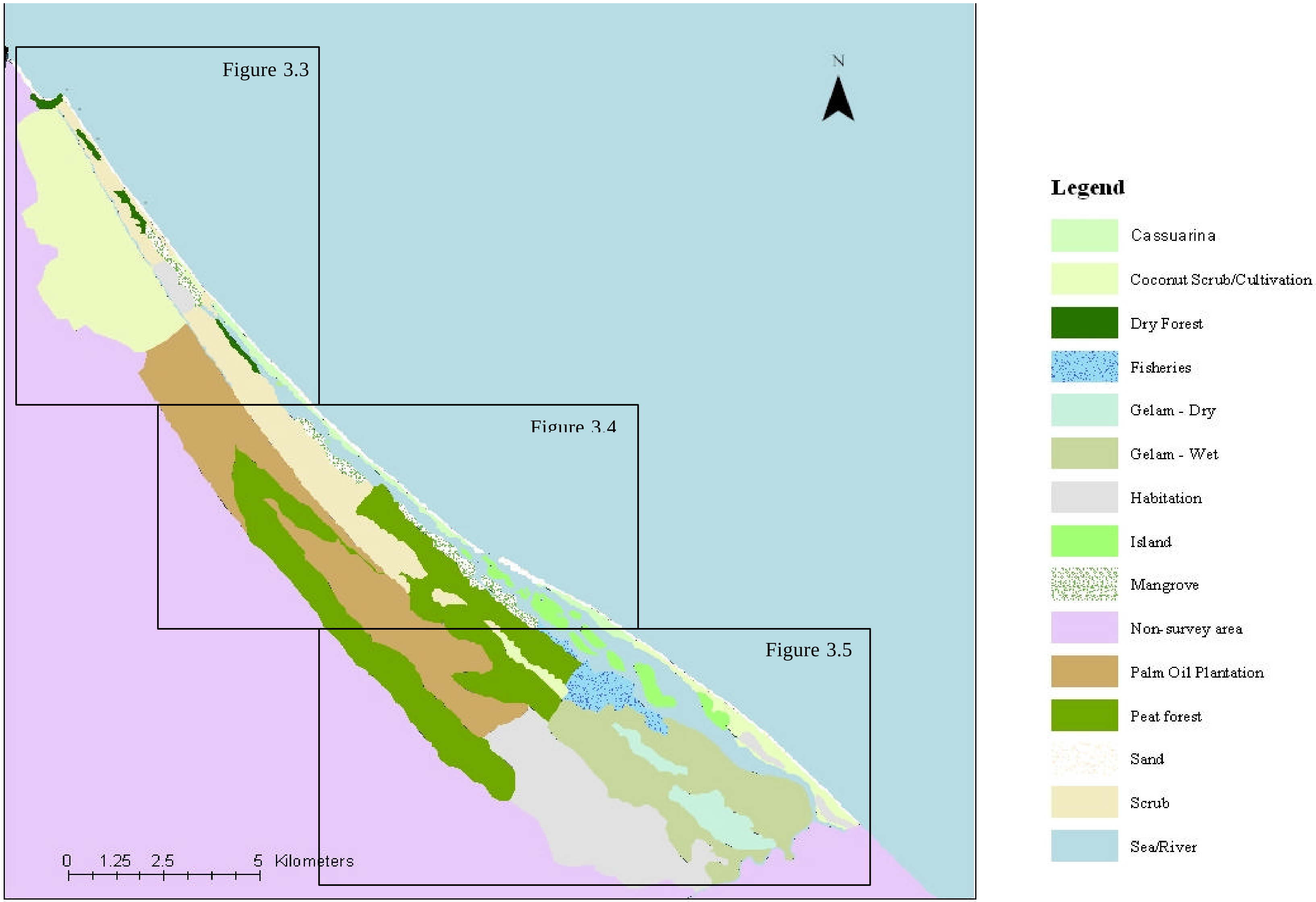


Figure 3.3 Habitat map showing the northern section of the study region and the location of survey sites (scale 1:45,000).

Figure 3.4 Habitat map showing the mid section of the project region and the location of survey sites (scale 1:40,000).

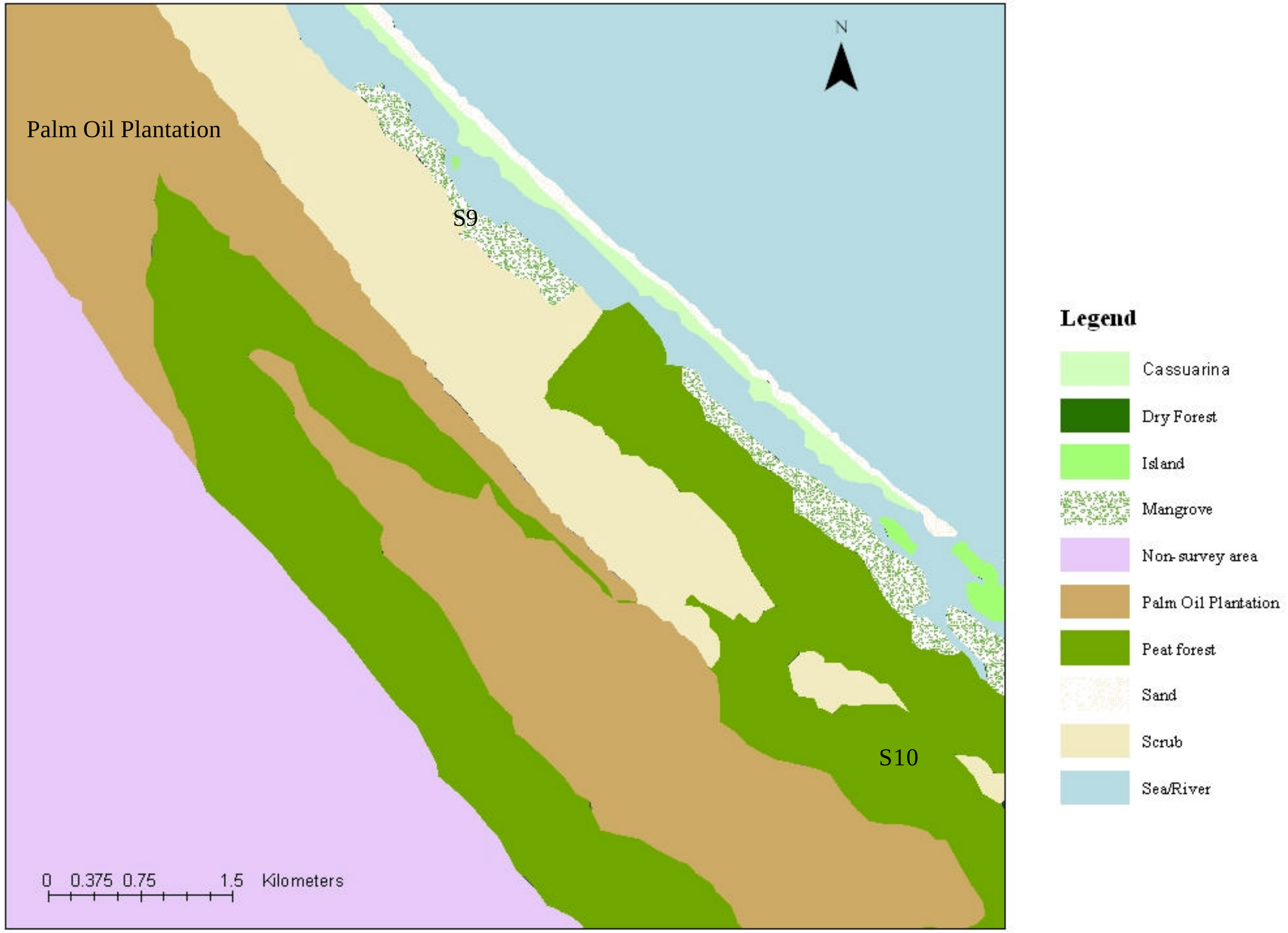
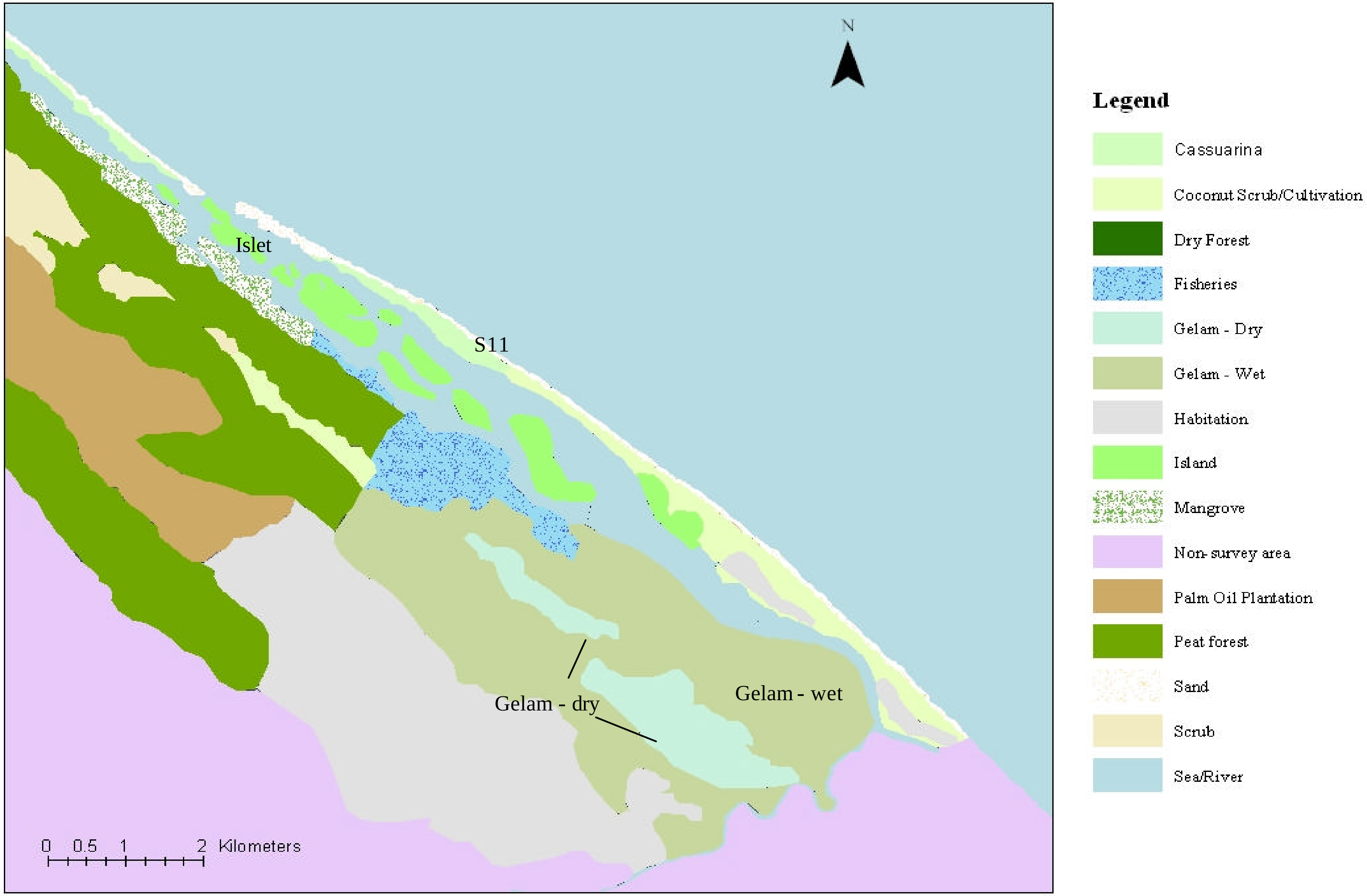


Figure 3.5 Habitat map showing the southern section of the project region and the location of survey sites (scale 1:60,000).



The twelve survey sites were chosen to sample the range of habitats within the wetlands. Detailed habitat descriptions is as follows:

S1 - Scrub

N 05°46.29.2 E 102°38.02.1 – N 05°46.44.0 E 102° 37.45.8. Figure 3.3
This habitat forms the buffer between the coast on the east of the study region and inland mangroves to the west. It is located adjacent to the patch of dry forest at S7. The habitat is mainly dry, although the area is subject to flooding from nearby rivers in the rainy season. Vegetation is low and sparse and consists of xerophilous plants adapted to sandy saline soils. The site receives frequent disturbance from grazing cattle and hence there are few characteristically tall trees. Where trees do occur, typical species include Screw Pine *(*Genus *Pandanus)* and Lontar Palm *(Borassus flabellifer*).

S2 – Casuarina

N 05°43.54.0 E 102°.39.55.2 – N 05°42.42.36 E 102°41.02.77. Figure 3.3
A thin strand of coastal Casuarina forest. Dominant vegetation type is *Casuarina equisetifolia.* The habitat is characterized by a dry sandy substrate. Moving inland, the understorey becomes dominated by a dense herbaceous layer of jasmine (*Jasminium* sp.) and the canopy is open and light and reaches approximately 10-15m. The eastern side of the patch borders the lagoon, and mangrove species integrate with the casuarinas and jasmine. This site is disturbed by vehicle movements and trails, removal of soils for composting and small scale fisheries and coconut plantations. The strip is heavily subjected to weathering and natural erosion from the sea, with sections becoming increasingly thin.

S3 – Scrub

N 05°43.30.7 E 102°39.55.9 – N 05°. Figure 3.3
Situated on the edge of the settlement of Betin Lintang, this site consists of a large patch of open scrubland. As it is located near a main road, the area is frequently used by villagers and is dissected by a main track to the road and village. The area is unfenced and is frequently used by cattle for grazing. Vegetation is sparse. Singular xerophilous trees reaching approximately 1-2m dot the landscape. The site varies little in altitude (approximately 5-10m above sea level) and dried up river-beds form undulations bordered by dense tree growth.

S4 - Dry Forest, disturbed

N 05° 45.58.3 E 102° 38.17.4 –N 05°46.29.2 E 102° 38.02.1. Figure 3.3
S4 and S5, both disturbed patches of dry forest are more or less contiguous and form a narrow strip of regenerating forest between the Project Base and S7 at the northern

limit of the region. The dry forest strip is found between the coast and the scrub interior.

S5 - Dry Forest, disturbed

N 05° 44.52.1 E 102° 38.55.4 – N 05° 45.34.5 E 102° 38.29.4. Figure 3.3
This site is a narrow band of regenerating dry forest just south of S4. The area was once used as a farming settlement but has now been left to re-grow following abandonment. The area is re-colonising rapidly, with canopies approximately reaching 10-15m. The understorey is very dense with climbing plants and tall shrub growth (figure 3.6). There are numerous logging trails leading into the forest patch, and several clearings remaining after logging and burning. To the east of the site there is a drop off to a seasonal stream.

S6 - Coconut scrub

N 05°44.17.7 E 102° 39.37.9. Figure 3.3
A thin intersection of scrub located between the coast and the mangroves near the Project Base. It is comprised of a mixture of land use including failed coconut plantation, local fisheries, disused and small-scale habitation with land earmarked for future development and plots for sale. In addition to living and dead coconut palms, vegetation cover is primarily sparse xerophilous trees 1 to 2 m in height. A well-used tarmac road runs the length of the eastern side of the strip, bordering the beach.

S7 - Dry forest

N 05° 46.53.6 E 102°37.46.0. Figure 3.3
A fragment of dry forest covering Bukit Dendong, a local landmark hill reaching approximately 150m in height at the headland of the beach extending along the study region. Dominant vegetation includes mature Dipterocarps, Shorea sp. and Nipah palm (*Nypa fructicans*). The habitat is subject to logging and evidence of recent disturbance was found during the survey period (e.g. logging trails, disused trapping equipment). The rough terrain offers some protection from disturbance and limits this activity to the base of the hill. The hill consists of steep rock outcrops with hidden forested gullies, caves and steep drop offs. Several of the cave formations were seen to host large bat populations.

S8 - Lagoon

N 05°41.43.06 – E102°40.48.72 – N05°41.56.95 – E102°41.34.48. Figure 3.3
The lagoon is located near the Project Base and is found just south of the village, lying between the casuarinas of S2 and the mangrove fringing the scrub of S3. The Lagoon and its linked rivers have a strong tidal influence with an opening to the sea at the southern end of S2. Two rivers from the nearby mountains here, providing a seasonal influence with ground run-off. To the south of the lagoon there is a high

density of fishery operations. Several uninhabited islets lie in the lagoon, one of which is supplementary survey site Pulau Gemia. To the north of the lagoon a river runs south from Bukit Dendong to the lagoon and feeds out to the sea.

S9 - Mangrove

N05°42.16.91 E102°41.00.72- N05°41.20.93- E102°41.55.85. Figure 3.4
Towards the south of the project region, mangrove swamp forms the inter-tidal zone. There is an aquaculture development adjacent to this habitat, which is beginning to impinge on the site from the southern end. However the interior remains relatively dense and less disturbed compared to the mangroves at S12. Dominant species include: *Rhizophora* sp. (red mangrove), *Avicennia sp.* (black mangrove) and Nipah palm (*Nypah fructicans*). There is a wide strip of habitat included within S9 surveys which has a less muddy ground layer and a smaller tidal influence, but the presence of mangrove stilted roots and Nipah confirm its identification as mangrove. To the east the mangrove was impenetrable for survey work and surveys were confined to less dense mangrove areas to the west. A village lies to the south west of the mangrove but disturbance seems quite limited.

S10 - Peat Forest

N 05°39.29.3 E102°43.12.1 – N 05°39.17.4 E 102°43.40.8. Figure 3.4
The habitat is a lasting remnant of inland peat swamp, which would have extended much further in the past. The majority area around the swamp has been converted to oil palm plantations and is currently subject to a large-scale government drainage scheme, linked to future developments in the Setiu wetland area. Consequently a vast drainage channel divides the allocated survey site, and the residual waters are permanently draining into this. The forest is fairly impenetrable from the exterior and several distinct logging trails provide points of access.

The habitat is permanently water logged with acidic soils. Dead vegetation forms a spongy layer and accumulates up to 20m thick. Due to the moist conditions, very dense understoreys (up to 10-15m) and canopies form (up to and above 20m in places). Dominant tree species include: *Dipterocarps sp., Gonystylus sp., Durio s.p and Shorea sp* which all have great commercial value. As the site contains valuable timber species and is one of the few remaining forested areas in the region, the site is subject to logging and clearings exist in the western part of the forest.

S11 – Casuarina

N 05° 39.47.96 E 102° 44.34.71 – N 05° 40.11.09 E 102° 43 59 33. Figure 3.5
In the far south of the wetlands is a coastal strand of Casuarina forest. It consists of a similar habitat to S2, however S11 is found on the far end of a thin peninsula between the coast and an inland lagoon. As the habitat is fairly isolated, the site is less disturbed than the Casuarinas at S2. The trees form an open canopy but the understorey consists of old fallen Casuarinas, mossy undergrowth and a dense herbaceous layer of Jasmine. The habitat is interspersed with open areas of taller

herbaceous growth (up to 2m) and grassy tidal areas, which are flooded during high rains from the lagoon. As with the other casuarinas patch, the survey site is bordered by the lagoon to the west and the sea to the east.

S12 - Mangrove

N 05° 44.53.82 E 102° 39.00.56 – N 05° 44.18.43 E 102° 39.27.85. Figure 3.3
The mangrove swamps at S12 are an inter-tidal zone between the coast and the lagoon. The site consists of a similar floristic community as S9 mangroves, however S12 is interspersed with coconut plantations. Due to their proximity to the village of Betin Lintang, the mangroves here are disturbed. Locals were frequently observed using trained macaques to harvest coconuts from the mangroves, hand-picking shellfish from the river and extracting other timber and non-timber products. Aquaculture ponds lie at the perimeter of the mangrove near the village and drain directly in and out of the river. Nipah palm is harvested to be traditionally used to line the roofs of local houses. The survey site is effectively divided into quadrants by the river and perpendicular road.

Supplementary Survey Sites

During the course of surveying within the 12 designated sites, it became evident that further habitats were an intrinsic part of the Setiu wetlands ecosystem. In order to ensure that a comprehensive assessment of the biodiversity could be obtained, further surveys were carried out at four supplementary sites. These surveys provided sufficient data to gather an accurate snapshot of species and prevalence in these sites.

Gelam - Dry

N 05°37.39.2. E 102°45.42.8. Figure 3.5
'Gelam' or Melaleuca swamp can be seen to exist as two intrinsically linked sub-habitat types: large sand 'dunes' with limited vegetation (primarily *melaleuca leucadendron*) interspersed with waterlogged forest. The formation is essentially beach ridges/sand plains covered by aeolian sands, underlain by back and fore- shore depositions, originally from weathered granite. Peaty back swamps have then formed between the ridges. The area of Gelam surveyed featured an area of monoculture with man-made irrigation and a small track network. Wet gelam is interspersed with a dryer mix of Gelam dominated by grasses with scattered juvenile Gelam. The soil is sandy. The two sub-habitat types are estimated to exist in an approximate dry to wet ratio of 70:30.

Melaleuca stands are particularly important habitats in low lying coastal zones and form in inter-coastal in depressions on flood plains through water and wind interactions. *Melaleuca leucadendra* form mid-dense canopies between 18-30m (Joyce, 2006). Their coastal locations and floristic compositions make Melaleuca forests important habitat for a range of bird species (Yeoman *et al.,* 2005; Joyce, 2006). There was evidence of a natural and annual pattern of burning and regeneration of the *Melaleuca* plants.

Gelam -Wet

N05°36.63.6 E102°46.23.7 Figure 3.5
A mixed habitat featuring patches of coastal swamp and natural eucalypt stands associated with the underlying alluvial flood plain. This area is surrounded by higher elevated sandy, scrubland. The Gelam forest here are dominanted by *Melaleuca sp*, of the Myrtaceae family but are also associated with a range of floral species including swamp water ferns, orchids, sedge and rushes and other myrtaceous trees.

Larger Gelam is found in wet troughs. Some of the grassland has been cleared for agriculture (mangoes) and palm oil plantations. There is a network of sand roads throughout the site used by local farmers and a few gravel tracks. Villages and fish farms are also in close proximity to the sites. The soil appears to be relatively infertile and costly to manage as a result of which many of the fields are deserted; in these areas young Gelam is reclaiming the land.

Islet – Pulau Gemia

N 05°39.23.0 E 102°44.32.4 – N 05°39.09.07 E 102° 44.54.0. Figure 3.5
The island is 0.84 km in length and 0.18km at its widest point. The habitat is patchy and consists of many different types including: casuarinas, coconut and mango trees, scrub, grassland, reed beds and marsh. The island is a short distance from the spit (see figure 2.5) and mainland and has three other islands adjacent to it, one of which is attached by large mud flats during low tide. As the islands are situated in the lagoon, the water is tidal and thus has a great affect on the islands vegetation and inhabitants, allowing for easy dispersal between the islands and the mainland. The island was deemed as a valuable site for comparisons with other habitats as it is uninhabited and has experienced minimal disturbance.

Palm oil plantation

N05°40.39.3' E102°41.60.5 Figure 3.5
The area was converted to palm oil (*Elaeis guinensis*) around 10 years ago. As well as palm oil, some agricultural crops of grapes and pineapple are grown. The soil is devoid of natural vegetation and hence very sandy, requiring regular irrigation from the nearby lake at Tasek Burumbat. Water is channelled in and stored in an artificial lake nearby. The irrigation channels can act as corridors for wildlife ass they are fringed by native trees and shrubs. However the habitat is dissected by a number of tracks for extracting palm oil.

Conclusion

The Setiu Wetlands is a complex habitat pockets within a wider landscape mosaic. Faunal surveys were structured around the defined habitat pockets in order to give a comparative biodiversity assessment of the major habitats represented within the Setiu Wetlands.

4. Birds

4.1 Introduction

In 2005 BirdLife International identified a total of 1,111 Important Bird Areas (IBAs) that contain wetland areas that should qualify as Ramsar Sites in Asia. Asian governments have so far only designated a total of 144 Ramsar Sites, which protect all or part of 120 IBAs. This equates to 991 or 88% of the potential sites that have been identified by BirdLife International having not yet been afforded protection under the Ramsar Convention (International Wetlands Conference, Uganda, 2005).

BirdLife International currently describes 55 'Important Bird Areas' in Malaysia, 16 of which are in Peninsula Malaysia. There are also seven 'Endemic Bird Areas' identified in the region, including EBA 158 – Sumatra and Peninsula Malaysia (BirdLife, 2005). There are 40 species listed as 'globally threatened' in Malaysia. These include the charismatic Plain pouched hornbill (*Aceros subruficollis)* (Vulnerable, IUCN 2004) and the Lesser adjutant (*Leptoptilos javanicus)* (Vulnerable, IUCN 2004).

The east coast area of Peninsula Malaysia and its offshore islands are particularly significant for bird life as they fall under the East Asian-Australisian Flyway migration route shown in Figure 4.1. Migration routes and flyways are lanes of travel that species make usually from breeding grounds to over wintering grounds. Flyways are considered to be the main arterial highways to which the migration routes are tributaries. Migration and flyway routes are concentrated along coasts, principle rivers and mountain ranges, i.e. closely following major topographic features.

Figure 4.1 Map outlining the East-Asian-Australasian Flyway migration route. Taken from Wetlands International Oceania (2002).

The coastal areas are not only important for feeding and roosting sites for resident species but also provide stopovers, food and shelter for migratory birds (Tamblyn *et al.*, 2005). Understanding and documenting the bird life and diversity of these coastal habitats is vital to provide strategies for conserving these important sites for bird species in the area.

Declining bird populations in the region have been directly linked to deforestation of lowland dipterocarp forest habitats (Peh *et al.*, 2005). However, more recently the decline in bird numbers, especially those of wetland and migratory bird species is linked to the drainage and conversion of wetland areas. This is a major threat for wetland birds reliant on these sites for breeding, nesting and over wintering. Coastal populations are also threatened by large-scale development, including aquaculture and the clearance of mangroves (BirdLife, 2005).

4.2 Aims

- To provide a detail species inventory of the bird species in the Setiu Wetlands.
- To detail bird species diversity in the Setiu Wetland area.
- To assess relative abundance and distribution of bird species in relation to the different habitat types found in the wetlands.
- To detail and assess the conservation importance of bird species and threats to the habitats in the Setiu Wetlands.

4.3 Results

The birds life of the study region were surveyed using point count and mist-netting methods. Below the results are analysed by survey method and a discussion combines the results from each survey method to discuss the implications for bird conservation in the wetlands.

Point counts

The total number of point counts conducted across survey sites during the research period is shown below in Table 4.1

Table 4.1 Point count survey effort by location.

Site	Habitat Type	Point Counts
S1	Scrub	7
S2	Casuarina	5
S3	Scrub	7
S4	Young Dry Forest	6
S5	Young Dry Forest	4
S6	Scrub	3
S7	Dry Forest	4
S8	Lagoon	5
S9	Mangrove	4
S10	Peat Swamp	8
S11	Casuarina	9
S12	Mangrove	11
Sub Total	-	73
Supplementary Survey Sites	Gelam	3
	Dry Gelam	3
	Islet	3
	Palm Oil Plantation	3
Total	-	95

Statistical measures can be used to analyse bird community composition in relation to survey locations and habitat types from point count data. Species diversity indices can be calculated from the original point count datasets. These indices provide information about the structure of the sample communities and provide a basis for comparison of each bird communities between the differing habitat types.

The results of point count observations at each survey location are shown in Table 4.2. A total of 1862 individual birds were observed, representing 76 species from 30 families. Pacific Swallow (*Hirundo tahitica*) was the most commonly recorded species, with 242 sightings. Other common sightings include the Barn Swallow (*Hirundo rustica*), Common Myna (*Acridotheres tristis*) and Ashy Tailorbird (*Orthotomus sepium*).

Less commonly recorded species include: the Black-shouldered Kite (*Elanus caeruleus*), Lineated Barbet (*Megalaima lineate*), Tickell's Blue Flycatcher (*Cyornis tickelliae*), Plain Sunbird (*Anthreptes simplex*), Streak-eared Bulbul (*Pycnonotus blanfordi*), White-breasted Waterhen (*Amaurornis phoenicurus*) and Oriental White-eye (*Zosterops palpebrosa*).

Table 4.2 Point count results – species by location.

			Survey Sites															
Family	Species	Common Name	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	Total	IUCN	CITES	Status
Accipitridae	*Aviceda leuphotes*	Black Baza	0	0	0	0	1	5	0	8	7	9	0	0	*30*	Lc	Appendix II	M
	Elanus caeruleus	Black-shouldered Kite	1	0	0	0	0	0	0	0	0	0	0	0	*1*	Lc	Appendix II	BR
	Haliaster Indus	Brahminy Kite	0	0	2	0	1	5	0	13	0	0	1	1	*23*	Lc	Appendix II	B R
	Haliaeetus leucogaster	White-bellied Sea Eagle	20	1	0	1	1	2	5	1	0	2	1	0	*34*	Lc	Appendix II	R
	Macheiramphus alcinus	Bat Hawk	0	0	0	0	0	0	2	0	0	0	0	0	*2*	Lc	Appendix II	B R
	Milvus migrans	Black Kite	2	0	4	0	0	0	0	0	0	0	0	0	*6*	Lc	Appendix II	M
Alcedinidae	*Alcedo atthis*	Common Kingfisher	0	0	0	0	0	1	0	6	0	0	1	0	*8*	Lc	-	B R M
	Halcyon capensis	Stork-billed Kingfisher	0	0	0	0	0	0	0	1	0	1	0	3	*5*	Lc		B R
	Halcyon smyrnensis	White-throated Kingfisher	0	0	0	1	0	1	0	0	0	0	0	1	*3*	Lc		B R
	Todiramphus chloris	Collared Kingfisher	0	0	0	0	0	1	0	4	0	0	8	15	*28*	Lc		B R
	Halcyon pileata	Black-capped Kingfisher	0	5	0	1	0	5	0	1	0	0	1	3	*16*	Lc		B R
Ardeidae	*Ardeola bacchus*	Chinese Pond Heron	0	0	1	4	0	6	0	3	0	0	5	2	*21*	Lc	-	M
	Butorides striatus	Little Heron	0	0	0	0	0	1	0	16	0	0	1	1	*19*	Lc		R M
	Egretta eulophotes	Great Egret	0	17	0	0	0	1	0	7	0	0	0	1	*26*	Lc	-	R M
	Egretta garzetta	Little Egret	0	0	0	0	0	0	0	0	0	0	0	3	*3*	Lc		R M
	Egretta sacra	Pacific Reef Egret	0	0	0	0	0	1	0	1	0	0	0	0	*2*	Lc	Appendix III	B R M
Campephagidae	*Pericrocotus divaricatus*	Ashy Minivet	0	0	0	0	0	0	0	0	1	10	0	0	*11*	Lc		M
Caprimulgidae	*Caprimulgus macrurus*	Large-tailed Nightjar	0	0	0	0	0	0	0	0	0	0	2	0	*2*	Lc	-	R
Charadridae	*Vanellus indicus*	Red-wattled Lapwing	0	0	3	0	0	0	0	0	0	0	0	0	*3*	Lc		R
Chloropseidae	*Aegithina tiphia*	Common Iora	1	0	2	0	0	0	0	0	0	0	3	38	*44*	Lc		R
	Chloropsis cyanopogon	Lesser Green Leaf Bird	0	0	0	0	0	0	2	0	0	0	0	0	*2*	NT		R
Columbidae	*Geopelia striata*	Peaceful Dove	3	4	2	0	5	24	0	4	0	0	17	7	*66*	Lc	-	R
	Streptopelia chinensis	Spotted Dove	0	0	0	0	0	0	0	3	0	0	1	0	*4*	Lc		R
Coracidae	*Coracias benghalensis*	Indian Roller	0	0	0	0	0	9	0	2	0	0	4	0	*15*	Lc	-	B R
	Eurystomus orientalis	Dollar Bird	0	4	0	0	0	12	0	11	4	2	5	7	*45*	Lc	-	B R M
Corvidae	*Corvus enca*	Slender-billed crow	0	0	0	0	0	0	0	15	0	0	0	5	*20*	Lc		R
	Corvus macrorhynchos	Large-billed Crow	0	6	0	0	0	2	0	5	0	0	1	0	*14*	Lc	-	R
	Copsychus saularis	Oriental Magpie Robin	0	2	0	0	2	0	0	4	0	0	18	4	*30*	Lc	-	R
	Lalage nigra	Pied Triller	0	9	0	2	0	0	0	0	0	1	0	0	*12*	Lc	-	R
	Oriolus chinensis	Black-naped Oriole	0	41	0	0	0	0	0	14	1	0	33	4	*93*	Lc	-	R M

Table 4.2 Continued. Point count results – species by location.

Cuculidae	*Chrysococcyx minutillus*	Little Bronze Cuckoo	0	0	0	0	0	0	0	0	0	0	0	2	*2*	Lc		R
	Eudynamys scolopacea	Common Asian Koel	0	0	0	0	0	0	0	1	3	0	0	0	*4*	Lc	-	R M
	Phaenicophaeus tristis	Green-billed Malkoha	0	2	0	0	0	2	0	4	7	0	0	0	*15*	Lc	-	R
	Phaenicophaeus sumatranus	Chestnut-bellied Malkoha	0	0	0	0	0	0	0	0	0	0	0	3	*3*	Lc	-	R
	Phaenicophaeus chlorophaeus	Raffles Malkoha	0	0	0	0	0	0	0	0	0	0	0	0	*0*	Lc	-	R
Dicaeidae	*Dicaeum cruentatum*	Scarlet-backed Flowerpecker	0	3	1	6	3	1	1	0	9	3	0	0	*27*	Lc	-	R
	Dicaeum trigonostigma	Orange-bellied Flowerpecker	0	2	0	0	0	0	0	0	0	0	0	0	*2*	Lc	-	-
Dicruridae	Dicrurus paradiseus	Greater Racket-tailed Drongo	0	8	0	0	0	0	2	12	2	6	0	0	*30*	Lc	-	R
Hirundidae	*Delichon dasypus*	Asian House Martin	0	0	0	0	0	0	0	0	0	0	18	0	*18*	Lc	-	M
	Hirundo rustica	Barn Swallow	0	0	81	8	2	45	0	0	0	0	0	0	*136*	Lc	-	M
	Hirundo tahitica	Pacific Swallow	10	0	5	0	15	41	15	45	28	42	33	8	*242*	Lc	-	R
Megalamidae	*Megalaima lineate*	Lineated Barbet	0	0	0	0	0	0	0	1	0	0	0	0	*1*	Lc	-	B R
Meropidae	*Merops leschenaultia*	Chestnut-headed Bee eater	0	1	1	0	1	7	0	22	3	9	1	12	*57*	Lc	-	B R
	Merops viridis	Blue throated Bee eater	0	0	0	0	0	0	0	0	0	0	0	6	*6*	Lc	-	B R M
Muscicapidae	*Cyornis rufigaster*	Mangrove blue flycatcher	0	0	0	0	0	0	0	0	2	0	0	3	*5*	Lc	-	R
	Cyornis tickelliae	Tickell's Blue Flycatcher	0	0	0	0	0	0	0	0	0	1	0	0	*1*	Lc	-	R M
	Rhipidura javanica	Pied Fantail	2	1	0	1	0	0	0	2	3	0	34	15	*58*	Lc	-	R
Nectarinidae	*Aethopyga siparaja*	Crimson Sunbird	0	0	0	0	1	0	0	0	4	12	0	0	*17*	Lc	-	B
	Anthreptes malaccensis	Brown-throated Sunbird	0	0	0	0	0	0	0	0	0	0	1	4	*5*	Lc	-	R
	Anthreptes simplex	Plain Sunbird	0	0	0	0	0	0	0	0	0	0	0	1	*1*	Lc	-	R
	Arachnothera longirostra	Little Spider Hunter	0	0	0	0	0	0	0	0	0	0	0	2	*2*	Lc	-	R
	Nectarinia calcostetha	Copper-throated Sunbird	0	0	1	0	0	0	0	13	1	0	1	10	*26*	Lc	-	B R
	Nectarinia jugularis	Olive-backed Sunbird	3	0	7	0	5	13	0	6	8	8	18	9	*77*	Lc	-	B R
	Prionochilus thoracicus	Scarlet-breasted Flowerpecker	0	0	0	0	5	0	1	0	0	1	0	0	*7*	NT	-	R
Pachycephalidae	*Pachycephala grisola*	Mangrove Whistler	0	0	0	0	0	0	0	1	0	0	1	1	*3*	Lc	-	R
Passeridae	*Anthus novaeseelandia*	Richards Pippit	8	0	13	0	4	13	0	0	0	0	6	0	*44*	Lc	-	M

Table 4.2 Continued. Point count results – species by location.

Picidae	*Chrysocolaptes lucidus*	Greater Flameback Woodpecker	0	2	0	0	0	4	0	4	0	0	3	0	*13*	Lc	-	B R
	Dinopium javanense	Common Flameback Woodpecker	0	0	0	0	0	0	0	0	0	0	3	3	*6*	Lc	-	-
Pycnontidae																		
	Pycnonotus finlaysoni	Stripe-throated Bulbul	0	0	0	0	0	0	0	0	2	0	0	0	*2*	Lc		R
	Pycnonotus goiavier	Yellow-vented Bulbul	50	0	26	5	4	0	0	1	0	1	1	7	*95*	Lc		R
	Pycnonotus plumosus	Olive-winged Bulbul	1	9	5	3	0	0	0	0	0	13	2	8	*41*	Lc	-	R
	Pycnonotus blanfordi	Streak-eared Bulbul	0	0	0	0	0	0	0	0	1	0	0	0	*1*	Lc		R
Rallidae	*Amaurornis phoenicurus*	White-breasted Waterhen	0	0	0	0	0	0	0	0	1	0	0	0	*1*	Lc		R M
Scolopacidae	*Tringa hypoleucos*	Common Sandpiper	0	2	0	0	0	18	0	21	1	4	4	0	*50*	Lc	-	M
Sturnidae	*Acridotheres tristis*	Common Myna	0	0	4	0	0	48	0	14	0	0	25	45	*136*	Lc	-	R
Sylvidae	*Orthotomus ruficep*	Ashy Tailorbird	0	0	2	5	1	2	0	2	24	12	26	52	*126*	Lc	-	R
	Orthotomus sutorius	Common Tailorbird	1	0	0	0	0	0	0	0	0	0	1	0	*2*	Lc	-	R
	Orthotomus atrogularis	Dark Necked Tailorbird	0	0	0	0	0	0	0	0	0	0	3	0	*3*	Lc		R
	Phylloscopus borealis	Arctic Warbler	0	0	0	0	0	0	0	0	0	0	0	0	*0*	Lc	-	B R M
Timalidae	*Macronous gularis*	Striped-tit Babbler	0	0	0	0	0	0	0	0	0	0	0	7	*7*	Lc		R
Turdidae	*Copsychus malabaricus*	White-rumped Sharma	0	0	0	0	0	0	0	0	0	1	0	0	*1*	Lc		R
Zosteropidae	*Zosterops palpebrosa*	Oriental White-eye	0	0	0	0	0	0	0	0	0	0	0	1	*1*	Lc		R
		Total	102	119	160	37	51	270	28	268	112	138	283	294	*1862*	-	-	-

N.B Bird Status
B - Breeder
R – Resident
M – Migrant
Notes taken from UNEP WCMC (2006) and MNS (2005). Notes on status of birds incomplete.

Analysis of community composition was assessed using PRIMER (Clarke & Warwick, 2001). Species diversity by location was analysed using five measures: Total number of species; Total number of individuals; Species richness; Pielou's evenness and Shannon-Weiner diversity (Carr, 1996). The results of species diversity analysis are shown in Table 4.3.

Table 4.3 Bird diversity indices for point count results by location

Survey Sites	Total Species[1]	Total Individual[2]	Species Richness[3]	Pielou's Evenness[4]	Shannon-Weiner[5]
S1	11	82	2.26	0.60	1.42
S2	17	118	3.35	0.80	2.25
S3	17	160	3.15	0.63	1.80
S4	10	36	2.51	0.90	2.09
S5	14	50	3.32	0.86	2.27
S6	25	268	4.29	0.80	2.56
S7	6	23	1.59	0.66	1.18
S8	33	267	5.72	0.86	3.02
S9	20	112	4.02	0.80	2.41
S10	18	136	3.46	0.80	2.33
S11	33	282	5.67	0.81	2.83
S12	35	294	5.98	0.81	2.90

[1] Number of Species: the number of species present in a community is a crucial aspect of that community's biodiversity. The number of species varies between locations and can be a useful biodiversity indicator.
[2] Total Number of individuals identified during the survey period.
[3] 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. Species richness of the communities sampled in this study are based on same sample sizes and surveying effort.
[4] Pielou's Evenness: this is an expression of equitability and expressed as J'=H'/H'max =H'/log S where H' max is the maximum possible value of Shannon diversity, if all species were equally abundant.
[5] Shannon-Wiener: represented as H' = Σi pi Log (pi) where pi is the proportion of the total count arising from the ith species. The higher the figure obtained the higher the diversity of the area.

Table 4.3 shows that the mangrove site at S12 yielded highest numbers of species (35) and individuals (294) and therefore ranked highest for species richness (5.98). The Lagoon site at S8 scored highest for species diversity (Shannon-Weiner). The high numbers of species and individuals at S12 and S8 suggests the inter-tidal zone occupied by both these habitats acts as a hub for species from the surrounding habitats and could be utilised by both wetland and forest species in transit and for food and shelter.

The Bray-Curtis similarity measure calculated (from the bird point counts/effort) between permutations of sample pairs (Clarke & Warwick, 1994). The relationship between survey sites was analysed using a hierarchical agglomerate clustering technique (Clarke & Green, 1988) and the results are shown in Figure 4.2. It shows the clustering of three major groups, which are highlighted in red, blue and green.

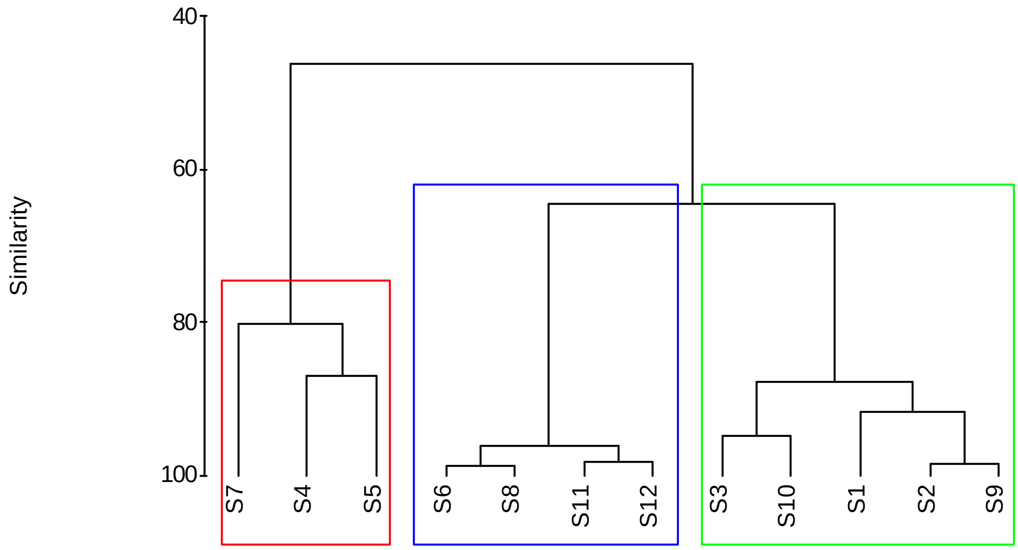


Figure 4.2 Dendrogram showing location similarities (bird point counts/effort). Bray-Curtis 4th root transformation.

The red cluster represents the three dry forest sites of S4, S5 and S7, where species composition to reflect geographical and ecological (e.g. niche availability) similarities of the three sites. However species composition at these sites is relatively dissimilar. S4 yielded wetland generalists species and S5 appears to harbour more forest-dwelling specialist varieties (sunbirds in particular).

Although the Dry forest habitat types are clustered together, there appears to be no distinct correlation between other similar habitat types. Where we might expect a clustering of S9 and S12 (mangroves) and S2 and S11 (casuarinas). No such picture emerges and the blue and green clusters are comprised of a variety of habitat types. However, it must be noted that each of the habitat types would be influenced by their surrounding area due to high edge effect incidence and the relatively small pockets of discrete habitats.

Further analysis was then undertaken to assess which species were responsible for the clusters shown in the dendrogram in Figure 4.3. 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 4.4-4.7 show the results of SIMPER analysis for the red, blue and green site clusters.

Table 4.4 SIMPER results for red cluster (S4, S5, S7 – all Df). Average similarity: 25.57%.

Species	Av Abun[1]	Av Sim[2]	Sim/SD[3]	Contribut%[4]	Cum%[5]
Hirundo tahitica	10	12.66	0.58	49.5	49.5
Dicaeum cruentatum	3.33	4.14	1.78	16.2	65.69
Pycnonotus goiavier	3	3.03	0.58	11.85	77.54
Haliaeetus leucogaster	2.33	2.63	6.4	10.27	87.81
Hirundo rustica	3.33	1.52	0.58	5.92	93.74

Table 4.5 SIMPER results for blue cluster (S6 - Cs, S8 -L, S11-C S12-M). Average similarity: 40.95%.

Species	Av Abun[1]	Av Sim[2]	Sim/SD[3]	Contribut%[4]	Cum%[5]
Acridotheres tristis	33	8.16	1.92	19.91	19.91
Hirundo tahitica	31.75	7.94	1.38	19.38	39.29
Nectarinia jugularis	11.5	2.93	2.95	7.14	46.43
Geopelia striata	13	2.57	1.41	6.27	52.71
Eurystomus orientalis	8.75	2.4	2.68	5.87	58.58
Orthotomus sepium	20.5	2.1	0.62	5.14	63.71
Merops leschenaulti	10.5	1.74	1.06	4.24	67.96
Tringa hypoleucos	10.75	1.6	0.62	3.9	71.86
Oriolus chinensis	12.75	1.32	0.67	3.21	75.07
Todiramphus chloris	7	1.12	1.16	2.74	77.81
Rhipidura javanica	12.75	1.11	0.54	2.7	80.51
Ardeola bacchus	4	1.02	2.36	2.49	83.01
Nectarinia calcostetha	6	0.71	0.51	1.74	84.74
Copsychus saularis	6.5	0.71	0.91	1.73	86.48
Chrysocolaptes lucidus	2.75	0.61	0.89	1.49	87.97
Haliaster indus	5	0.61	0.99	1.48	89.45
Coracias benghalensis	3.75	0.49	0.82	1.19	90.64

Table 4.6 SIMPER results for green cluster (S1 – S, S2 – C, S3 – S, S9 – M, S10 –Ps). Average similarity 19.32%.

Species	Av.Abund[1]	Av.Sim[2]	Sim/SD[3]	Contrib%[4]	Cum.%[5]
Hirundo tahitica	17	5.09	0.73	26.36	26.36
Nectarinia jugularis	5.2	2.38	0.99	12.34	38.7
Pycnonotus goiavier	15.4	2.14	0.34	11.05	49.75
Pycnonotus plumosus	5.6	1.64	0.71	8.51	58.26
Orthotomus sepium	7.6	1.24	0.41	6.42	64.68
Dicaeum cruentatum	3.2	0.95	0.87	4.89	69.58
Dicrurus paradiseus	3.2	0.8	0.52	4.14	73.72
Eurystomus orientalis	2	0.66	0.56	3.43	77.14
Merops leschenaulti	2.8	0.62	0.84	3.19	80.34
Anthus novaeeelandia	4.2	0.61	0.32	3.16	83.5
Geopelia striata	1.8	0.57	0.58	2.94	86.43
Aviceda leuphotes	3.2	0.56	0.32	2.9	89.33
Rhipidura javanica	1.2	0.36	0.56	1.88	91.22

[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

Overall similarity between sites and within each cluster is low. However individual species contributions within clusters does vary. For the red cluster, the dry forest sites of S4, S5, S7, *Hirunda tahitica* (Pacific swallow) accounted for 49.5% of species and the same species was the highest contributor to the green cluster with 26.36% of records at (S3, S10, S1, S2 and S9). For the blue cluster, *Acridotheres tristis* (Common myna) contributed 19.91%. SIMPER results show a predominance of generalist species, such as *A.tristis* for the blue cluster and groups such as bulbuls (genus *Pycnontus*) for the red and green clusters.

Supplementary Site Data

Four supplementary sites were identified during the survey period. It should be noted that the supplementary sites received a reduced survey effort (3 point counts per site).

Table 4.7 shows the results of point counts by location for supplementary sites. A total of 256 birds were recorded. The Olive-backed sunbird (*Nectarinia jugularis*) was the most frequently recorded, comprising 19.55% of species. The Large-billed Crow (*Corvus macrohynchos*) was the second most frequently observed, with 7.45% of recordings.

The supplementary fieldwork also yielded four additional species not identified in point count results from the main survey sites: Crested serpent-eagle (*Spilornis cheeva*), Cattle egret (*Bubulcus ibis*), Racket-tailed treepie (*Crypsirina temia*) and Brown Shrike (*Lanius cristatus*).

The relative abundance of generalists such as the Olive-backed bulbul (see Table 4.4) suggests the supplementary sites have experienced fragmentation and disturbance. Looking at the habitat maps (see Figure 2.1 and Figure 2.4), it is evident, the Gelam complex is the only sizeable patch of that habitat type within the region and therefore it's value as a contiguous habitat can be questioned. It may act as a temporary stop-off point within the coastal flypath.

Four species recorded at the supplementary sites are noted as migrant visitors to Peninsula Malaysia: Black Baza (*Aviceda leuphotes*), Chinese Pond Heron (*Ardeola bacchus*), Brown Shrike (*Lanius cristatus*) and Richard's Pippit (*Anthus novaeseelandia*). A further six species recorded at the supplementary sites are also known migrants (see Table 4.4), although the specific nature of migration through the Setiu Wetlands remains unclear.

Table 4.8 shows a comparison of species richness and individual abundance across all survey sites. Although the supplementary sites received comparatively lower survey effort (3 point counts), the islet, plantation and wet gelam sites produced a higher number of individual birds than some of the main sites where survey effort was comparatively higher such as S4 (6 point counts), S5 (4 point counts) and S7 (4 point counts).

Table 4.7 Point Count bird species by location for supplementary sites.

Family	Species	Common Name	S1-S12 Point Count	Supplementary Survey Sites†					Notes	
				Gelam -Dry	Gelam -Wet	Islet	Plantation	Total	IUCN	Status
Accipitridae	*Aviceda leuphotes*	Black Baza	Y	0	0	0	3	*3*	Lc	M
	Elanus caeruleus	Black-shouldered Kite	Y	1	0	0	0	*1*	Lc	BR
	Haliaster Indus	Brahminy Kite	Y	2	2	0	0	*4*	Lc	BR
	Haliaeetus leucogaster	White-bellied Sea Eagle	Y	0	0	5	0	*5*	Lc	R
	Spilornis cheela	Crested Serpent Eagle	N	1	0	0	0	*1*	Lc	R
	Halcyon smyrnensis	White Throated Kingfisher	Y	7	1	0	5	*13*	Lc	BR
	Todiramphus chloris	Collared Kingfisher	Y	0	0	4	0	*4*	Lc	BR
	Halcyon pileata	Black-capped Kingfisher	Y	0	0	2	2	*4*	Lc	BR
Ardeidae	*Ardeola bacchus*	Chinese Pond Heron	Y	1	1	6	1	*9*	Lc	M
	Bubulcus ibis	Cattle Egret	N	1	1	0	0	*2*	Lc	R M
	Egretta eulophotes	Great Egret	Y	0	0	0	1	*1*	Lc	R M
	Egretta garzetta	Little Egret	Y	0	0	0	9	*9*	Lc	R M
Charadridae	*Vanellus indicus*	Red-wattled Lapwing	Y	2	0	1	0	*3*	Lc	R
Columbidae	*Geopelia striata*	Peaceful Dove	Y	0	0	3	6	*9*	Lc	R
	Streptopelia chinensis	Spotted Dove	Y	9	3	4	0	*16*	Lc	R
Coracidae	*Eurystomus orientalis*	Dollar Bird	Y	0	0	2	1	*3*	Lc	B R M
Corvidae	*Corvus macrorhynchos*	Large-billed Crow	Y	6	3	2	8	*19*	Lc	R
	Copsychus saularis	Oriental Magpie Robin	Y	0	1	6	1	*8*	Lc	R
	Crypsirina temia	Racket-tailed Treepie	N	1	0	0	0	*1*	Lc	R
	Oriolus chinensis	Black-naped Oriole	Y	0	0	8	1	*9*	Lc	R M
Cuclidae	*Phaenicophaeus tristis*	Green Billed Malkoha	Y	0	0	1	0	*1*	Lc	R
	Phaenicophaeus chlorophaeus	Raffles Malkoha	Y	0	1	0	0	*1*	Lc	R
Dicruridae	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	Y	1	0	0	0	*1*	Lc	R
Laniidae	*Lanius cristatus*	Brown Shrike	N	1	0	0	0	*1*	Lc	M
Megalamidae	*Megalaima lineata*	Lineated Barbet	Y	0	2	0	0	*2*	Lc	B R
Meropidae	*Merops leschenaulti*	Chestnut-headed Bee-eater	Y	0	0	0	9	*9*	Lc	B R
	Rhipidura javanica	Pied Fantail	Y	0	0	1	3	*4*	Lc	R
	Nectarinia jugularis	Olive-backed Sunbird	Y	4	0	41	5	*50*	Lc	B R
Passeridae	*Anthus novaeseelandia*	Richards Pippit	Y	17	0	0	0	*17*	Lc	M
	Dinopium javanense	Common Flameback Woodpecker	Y	0	1	1	0	2	Lc	-
	Pycnonotus goiavier	Yellow-vented Bulbul	Y	4	0	0	10	14	Lc	R
	Pycnonotus plumosus	Olive-winged bulbul	Y	0	0	7	0	7	Lc	R
Sturnidae	*Acridotheres tristis*	Common Myna	Y	4	1	0	11	16	Lc	R
Sylvidae	*Orthotomus sepium*	Ashy Tailorbird	Y	0	0	5	0	5	Lc	R
	Orthotomus sutorius	Common Tailorbird	Y	0	0	1	0	1	Lc	R
	Phylloscopus borealis	Arctic Warbler	Y	0	1	0	0	1	Lc	B R M
		Total		*62*	*18*	*100*	*76*	*256*	-	-

NB * - Represents species not recorded at Main 12 survey sites. † Survey effort at each supplementary site was 3 point counts per site.

Table 4.8 Comparative levels of Species richness and individual abundance across all survey sites, with point count survey effort.

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Survey Sites	Total Species[1]	Total Individuals[2]	Point Count Effort
S1	11	82	7
S2	17	118	5
S3	17	160	7
S4	10	36	6
S5	14	50	4
S6	25	268	3
S7	6	23	4
S8	33	267	5
S9	20	112	4
S10	18	136	8
S11	33	282	9
S12	35	294	11
Gelam Dry	16	62	3
Gelam Wet	12	18	3
Islet	18	100	3
Plantation	16	76	3

Bird Mist-net Results

In total, 84 individual birds were captured during mist-net surveys. These captures represent 15 families and 26 species. Table 4.4 shows that the scrub habitat at S6 yielded the most captures, with 16%, but S6 received the second highest net-effort (2274.6 effort). S1 and S11 followed with 10% of captures each. The most frequently netted species was the Olive-winged Bulbul (*Pycnonotus plumosus*) which comprised 16.8% of total nettings. The Pied Fantail (*Rhipidura javanica*) followed with 5.04% of total nettings.

Four species were identified during mist-netting that were not recorded during point count observations: Great Coucal (*Centropus sinensis)*, Black-naped Monarch (*Hypothymis azurea)*, Banded Woodpecker (*Picus mineaceus)* and Abbot's Babbler (*Malacocincla abbotti).*

Table 4.5 shows the mist-net effort for birds. A total of 368 net hours was achieved at the casuarinas forest at S2 and yet the site yielded no captures over the research period. The lack of captures at S2 could be related to the relatively high levels of disturbance at the site compared to the more remote casuarinas forest at S11, where 12 individuals were captured.

Comparing trends in the number of birds observed on point count and those captured in mist-net across the main 12 survey sites, there is some correlation. Sites that yielded the most recordings on point counts (S12 and S11) also produced significant number of captures suggesting abundance of birds is higher in these areas.

Table 4.9 Mist net bird captures by location

Family	Species	Common Name	S1-S12 Point Count ID	S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12	Total
				Survey Sites											
Caprimulgidae	*Caprimulgus macrurus*	Long tailed Nightjar	Y	1	0	2	1	0	1	0	0	0	0	0	*5*
Centropodidae	*Centropus sinensis*	Great Coucal	N	0	0	0	0	0	0	0	0	0	0	1	*1*
Chloropseidae	*Aegithina tiphia*	Common Iora	Y	0	0	1	0	0	1	0	0	0	1	0	*3*
Columbidae	*Geopelia striata*	Peaceful Dove	Y	1	0	0	0	0	3	0	0	0	0	0	*4*
Corvidae	*Hypothymis azurea*	Black-naped Monarch	N	0	0	0	0	0	1	0	0	1	0	0	*2*
	Rhipidura javanica	Pied Fantail	Y	0	0	0	0	0	0	0	0	2	4	0	*6*
Halcyonidae	*Halcyon pileata*	Black-capped Kingfisher	Y	0	0	0	0	0	0	0	0	0	1	0	*1*
	Halcyon smyrnensis	White throated Kingfisher	Y	0	0	1	0	0	1	0	0	0	1	0	*3*
	Todiramphus chloris	Collared Kingfisher	Y	0	0	0	0	0	0	0	0	0	1	2	*3*
Meropidae	*Merops leschenaulti*	Chestnut-headed Bee-eater	Y	0	0	0	0	0	0	0	0	0	0	1	*1*
Muscicapidae	*Cyornis rufigaster*	Mangrove Blue Flycatcher	Y	0	0	0	0	0	0	0	2	0	0	0	*2*
	Cyornis tickelliae	Tickell's Blue Flycatcher	Y	0	0	0	0	0	0	1	0	0	0	2	*3*
Nectarinidae	*Anthreptes malaccensis*	Brown-throated Sunbird	Y	3	0	0	0	0	0	0	0	2	0	0	*5*
	Anthreptes simplex	Plain sunbird	Y	0	0	0	0	0	1	0	0	0	0	0	*1*
	Nectarinia calcostetha	Copper-throated Sunbird	Y	0	0	0	0	0	0	0	0	0	0	2	*2*
	Nectarinia jugularis	Olive-backed sunbird	Y	2	0	0	0	0	0	0	0	0	3	0	*5*
Passeridae	*Anthus novaeseelandia*	Richard's Pippit	Y	1	0	0	0	0	0	0	0	0	0	0	*1*
Picidae	*Picus mineaceus*	Banded Woodpecker	N	0	0	0	0	0	0	0	0	1	0	0	*1*
Pyconontidae	*Pycnonotus finlaysoni*	Stripe-throated Bulbul	Y	0	0	0	1	0	0	2	0	1	0	0	*4*
	Pycnonotus goiavier	Yellow-vented Bulbul	Y	2	0	0	1	0	0	0	0	0	0	0	*3*
	Pycnonotus plumosus	Olive-winged Bulbul	Y	2	0	0	3	1	10	2	0	0	0	2	*20*
Sylvidae	*Orthotomus sutorius*	Common Tailorbird	Y	0	0	0	0	0	1	0	0	0	0	0	*1*
	Malacocincla abbotti	Abbots Babbler	N	0	0	0	0	0	0	0	0	1	0	0	*1*
	Orthotomus ruficep	Ashy Tailorbird	Y	0	0	0	0	1	0	0	0	0	1	0	*2*
Timalidae	*Macronous gularis*	Stripe Tit Babbler	Y	0	0	0	0	0	0	0	0	2	0	1	*3*
Turdidae	*Copsychus malabaricus*	White-rumped Shama	Y	0	0	0	0	0	0	0	0	1	0	0	*1*
		Total		*12*	*0*	*4*	*6*	*2*	*19*	*5*	*2*	*11*	*12*	*11*	*84*

NB * - Represents species not recorded on point counts. No mist-netting was carried out at the Lagoon at S8.

Table 4.10 Mist-net effort for bird captures by location

Family	Species	Common Name	S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12
Effort Per Location*			707.85	368	902.8	462.84	724.2	2274.6	1519	1228.5	2333.25	1656	1419.4
Caprimulgidae	Caprimulgus macrurus	Long-tailed Nightjar	0.00141	0	0.0022	0.0022	0	0.0004	0	0	0	0	0
Centropopidae	*Centropus sinensis*	Great Coucal	0	0	0	0	0	0	0	0	0	0	0.0007
Chloropseidae	*Aegithina tiphia*	Common Iora	0	0	0.0011	0	0	0.0004	0	0	0	0.0006	0
Columbidae	*Geopelia striata*	Peaceful Dove	0.00141	0	0	0	0	0.0013	0	0	0	0	0
Corvidae	*Hypothymis azurea*	Black-naped Monarch	0	0	0	0	0	0.0004	0	0	0.00042	0	0
	Rhipidura javanica	Pied Fantail	0	0	0	0	0	0	0	0	0.00085	0.0024	0
Halcynoidae	*Halcyon pileata*	Black-capped Kingfisher	0	0	0	0	0	0	0	0	0	0.0006	0
	Halcyon smyrnensis	White-throated Kingfisher	0	0	0.0011	0	0	0.0004	0	0	0	0.0006	0
	Todiramphus chloris	Collared Kingfisher	0	0	0	0	0	0	0	0	0	0.0006	0.0014
Meropidae	*Merops leschenaulti*	Chestnut-headed Bee-eater	0	0	0	0	0	0	0	0	0	0	0.0007
Muscicapidae	*Cyornis rufigaster*	Mangrove Blue Flycatcher	0	0	0	0	0	0	0	0.00162	0	0	0
	Cyornis tickelliae	Tickell's Blue Flycatcher	0	0	0	0	0	0	0.00065	0	0	0	0.0014
Nectarinidae	*Anthreptes malaccensis*	Brown-throated Sunbird	0.0042	0	0	0	0	0	0	0	0.00085	0	0
	Anthreptes simplex	Plain sunbird	0	0	0	0	0	0.0004	0	0	0	0	0
	Nectarinia calcostetha	Copper-throated Sunbird	0	0	0	0	0	0	0	0	0	0	0.0014
	Nectarinia jugularis	Olive-backed sunbird	0.00282	0	0	0	0	0	0	0	0	0.00181	0
Passeridae	*Anthus novaelandia*	Richard's Pippit	0.00141	0	0	0	0	0	0	0	0	0	0
Picidae	*Picus mineaceus*	Banded Woodpecker	0	0	0	0	0	0	0	0	0.00042	0	0
Pycnonotidae	*Pycnonotus finlaysoni*	Stripe-throated Bulbul	0	0	0	0.0022	0	0	0.00131	0	0.00042	0	0
	Pycnonotus goiavier	Yellow-vented bulbul	0.0042	0	0	0.0022	0	0	0.00131	0	0	0	0
	Pycnonotus plumosus	Olive-winged Bulbul	0.0042	0	0	0.0065	0.001	0.0044	0.00131	0	0	0	0.0014
Syylvidae	*Orthotomus sutorius*	Common Tailorbird	0	0	0	0	0	0.0004	0	0	0	0	0
	Malacocincla abbotti	Abbots Babbler	0	0	0	0	0	0	0	0	0.00042	0	0
	Orthotomus ruficep	Ashy Tailorbird	0	0	0	0	0.001	0	0	0	0	0.0006	0
Timalidae	*Macronous gularis*	Stripe Tit Babbler	0	0	0	0	0	0	0	0	0.00085	0	0.0007
Turdidae	*Copsychus malabaricus*	White-rumped shama	0	0	0	0	0	0	0	0	0.00042	0	0

*Effort is calculated as the number of mist net hours (average of 19:00-22.00 per night) multiplied by number of nets used.

General Observations
During the course of surveying a number of casual bird observations were made in addition to the methods described. Four additional species of note were observed, which can be added to the species inventory for the survey. These are listed in Table 4.11.

Table 4.11 Casual bird observations and species notes.

Family	Species	Common Name	Location	Habitat	IUCN	Status
Nectariniidae	*Nectarinia sperata*	Purple-throated sunbird	S1 S10	Scrub Peat Swamp Forest	Lc	R
	Prionochilus percuisus	Crimson-breasted flowerpecker	S9	Mangrove	Lc	R
Cuculidae	*Chrysococcyx xanthrhynchus*	Violet Cuckoo	S6	Coconut scrub	Lc	R
Strigidae	*Ninox scutulata*	Brown Hawk Owl	S2	Casuarina	Lc	R M

4.4 Discussion

After the results of point count observations and mist-net captures at the main 12 survey sites were aggregated, a total of 76 bird species from 32 families were recorded. Point counts conducted at the supplementary sites recorded four more species. An extra four species were also recorded on causal observations bringing the overall inventory for the study to 84 species across all survey sites.

Both generalists and specialists were recorded. Typical forest generalists recorded include the Pycnonotidae (bulbuls) family. Most species of bulbul are common in forest edge and areas of secondary growth birds and frequent small, disturbed habitat patches. The success of bulbuls stems from their wide dietary tolerance (fruits, nectar and insects) and their nomadic nature, although they do not migrate. This generalist foraging nature, makes them key seed dispersers for many tropical plants, especially those in small habitat fragments (Cordeiro & Howe, 2003).

Recordings of specialist bird types such as woodpeckers at S2, S6, S8, S11 and on the islet is encouraging. The detection of overall observations were low; a total of 15 individuals in point counts. As many woodpecker species are only residents in mature dense forest stands due to their requirements of tree cavities (trees mover 50cm DBH) and having large home ranges (50-200ha) it makes them vulnerable to changes in forest habitats and are sensitive to forest disturbance (Lammertink, 2001).

In particular, the Banded Woodpecker (*Picus mineaceus*) is a highly inconspicuous species and was only netted once during this survey, at S10. Other species of woodpecker including the Common Flameback and Greater Flameback were noted in the Casuarina and mangrove forest sites at S2, S6, S11 and over the lagoon at S8.

Previous research has found a significant difference in the overall woodpecker community between primary and logged forest types (Styring & Ickes, 2001). Of the most common species: Buff-rumped Woodpecker (*Meiglyptes tristis*) and White-bellied woodpecker (*Dryocopus javensis*) were significantly more common in primary forest. Other studies have also shown that woodpecker species such as the Banded woodpecker (*Picus mineaceus*) exhibit very low relative densities and are dependent on lowland primary forests throughout the Sunda region (Lammertink, 2001).

Woodpeckers, such as the Banded Woodpecker are therefore useful species for indicating the degree of change occurring in habitats (Mikunsinski et al, 2000). In particular for Peninsula Malaysia, 14-15 species of woodpecker are found sympatrically, occupying narrow niches and will therefore be highly sensitive to disturbance (Lammertink, 2001).

Other specialists of note include: the sighting of the Lesser Green Leaf Bird (*Chloropsis cyanopogon)* at S7, the dry forest. The species is classified as Near Threatened. The species' association with the Sundaic lowland forests (BirdLife, 2006) marks it as for concern as primary forests within the region are expected to disappear by 2010. The scarlet-breasted flowerpecker (*Prionochilus thoracicus),* also Near Threatened was also recorded at the Dry forest sites of S5, S7 and at the Peat Swamp at S10. This bird is also a Sundaic lowland specialist.

In parts of Malaysia and Southeast Asia some key wetland habitats have been recognised for birds. Peat swamps in particular have received much attention and are indicated to provide an important habitat for a number of rare and endangered species of birds (Page, 2005). Several species recorded in Peat swamps are of conservation interest, being restricted to only a few localities (e.g. Malaysian Blue Flycatcher) (Yeap et al, 1999) or under pressure from both hunting and habitat loss (e.g. Green Imperial Pigeon) (Yeap et al, 1999).

Studies of Peat swamp forest avifauna have found that the habitat harbours lower species diversity than dry lowland forests (Page, 2005). This relative paucity can be attributed to the greater volume and more complex structure of plant diversity of dry lowland forest compared to Peat swamp forest. Wells (1985) has suggested that an external source of colonists is required to stabilise wetland bird communities and this implies the need for substantial reserves of lowland dry forest contiguous with wetland types such as peat swamp in order to promote healthy bird populations. This has important ramifications for peat swamp bird conservation and buffer zones may be needed to better protect remaining blocks of wetland habitats.

Other sites in Malaysia, such as Tasek Bera, the Ramsar listed Wetland Site have received detailed inventories of avifauna. The fresh-water swamp complex at Tasek Bera has a relatively high diversity and abundance, with about 200 species of birds, including many wetland specialists such as herons, ducks and waders. Two species found at the site are listed as threatened: Crested Fireback (*Lophura ignita*) and Masked Finfoot (*Heliopais personata*). Four others, the Grey-headed Fish Eagle (*Ichthyophaga* *ichthyaetus*), Black Hornbill (*Anthracoceros malayanus*), Crestless Fireback (*Lophura erythropthalma*) and Ferruginous Babbler (*Trichastoma bicolor*) are considered to be Near-threatened (IUCN, 2006).

Little is known of the degree of cross-utilization of the lowland forest, swamp forest and other wetland habitats by birds (Page, 2005). What has been determined in past studies in sub-montane tropical forests in Peninsular Malaysia is that mixed species flocks are affected by even small-scale disturbances, e.g. urbanisation developments. Particularly sensitive species tended to be from the Corvidae, Nectariniidae, and Sylviidae families (related to their restricted altitudinal ranges) (Lee *et al,* 2005). The Black-naped monarch and the Lesser-Green Leaf Bird are such examples of such species that frequent mixed-species flocks (ARCBC, 2005; Kennedy *et al*, 2000). The low-encounter rates of these species across the survey sites may indicate that bird populations in the region have experienced disturbance. However more work would be required to quantify this statement.

In many fragmented areas such as Setiu, wetland habitats represent vital refuges for a wider range of specialists (Sebastian, 2002). Although it may take a century for all the sensitive species to be extirpated from a site following habitat loss, larger species and those foraging on insects, fruits, or both are particularly sensitive to extinction. Larger or heavier-bodied species (e.g. raptors, woodpeckers, malkohas, rollers, dollarbirds etc) will naturally be supported at lower densities, increasing their vulnerability to habitat alterations.

Insectivores are also vulnerable for reasons such as the loss of preferred microhabitats, poor dispersal abilities, and/or ground nesting habits that make them susceptible to predation. The lack of year-round availability of fruits may make survival in deforested or fragmented areas difficult for frugivores. Extirpation of large predators, superior competitors, pollinators, and seed dispersers may have repercussions for tropical ecosystem functioning. (Sodhi *et al*, 2005).

Further work using different bird observation techniques and targeting indicator species such as woodpeckers and/or Black-naped Monarch, using techniques such as call-playback for indicator species like woodpeckers and monarchs could help to gain a greater understanding of the local effects of habitat fragmentation in the wetlands.

In the absence of long-term bird inventories with which to compare the findings here, the health and stability of bird populations in the Setiu Wetlands is unclear. The precautionary principle should be applied to ensure the conservation of these key wetland habitats. In particular, monitoring and protection should be prioritised for the mangrove and lagoon complex at S12 and S8 and the Dry forests (S7, S4 and S5) and Peat Swamp (S10). These sites are isolated examples of their habitat types but yet appear to act as refuges for species of conservation importance such as the Lesser Green Leaf Bird and Scarlet-breasted flowerpecker.

Setiu wetlands must be seen as a whole, a complex matrix formed by several differing habitat types. These habitat pockets are small and therefore liable to significant edge effects. Considering this aspect bird species are likely to overlap habitat types, as shown from the above analysis. However what is clear is that this site still supports specialist species that rely on these habitat fragments and migratory species that rely on the site as feeding or resting grounds. Conservation of the Setiu Wetlands must be considered as a landscape mosaic and not discrete habitat patches and further fragmentation should be prevented.

5. Bats

5.1 Introduction

Southeast Asia is one of the richest areas for bat diversity in the tropics and Malaysia is home to just over 10% of the world's bat species. 132 species of bat have been identified in Malaysia: 21 megachiropteran species and 111 microchiropteran, of which 11 are endemic, the sixth highest number of endemic bat species in the world. The IUCN designates 33 of Malaysia's bat species as Red Listed (IUNC, 2004) and two are Critically Endangered: Malayan Round-nosed bat (*Hipposideros nequam*) and Convexus Horseshoe Bat (*Rhinolophus convexus*).

Although bats constitute the most diverse group of mammals in tropical forests, major gaps exist in our knowledge of forest bat ecology in terms of foraging guilds, flight patterns and the effects of floristic structure on roosting and foraging.

What is known is that tropical forests, both primary and well-regenerated secondary areas, are key bat habitats (Huston *et al.*, 2001). Perennial warm and moist conditions of tropical wetland habitats mean insect reproduction and plant fruiting cycles can be a seasonal and therefore provide a wealth of resources for both Megachiropterans and Microchiropterans. In particular, mangroves and coastal forests are often favoured by bats as they provide both a rich supply of insects and fruiting trees. Bats are known to forage in open scrub areas, but limited numbers can survive in areas cleared for agriculture. The majority of bats are dependent upon some degree of forest cover (Francis *et al.*, 1999).

Bats have been shown to play central roles in pollination and dispersal of seeds in forests (Stoner, 2005). For example, megachiropterans like the Dawn Bat (*Eonycteris spelaea)* and the Lesser Short-Nosed Fruit Bat (*Cynopterus brachyotis*) are important pollinators in mangroves and dry forest habitats. The Dawn Bat is a principle pollinator for the mangrove apple *(Sonneratia alba)* and the Durian *(Durio zibethinus)* (Lim *et al.*, 2001). The Lesser Short-Nosed Fruit Bat has been found to be a very important agent of seed dispersal in Southeast Asian forest habitats (Boon & Corlett, 1989). In particular, on the Malay Penninsula and Singapore, it feeds on the Tiup-Tiup tree (*Aldrinosa dumosa)* within 'Belukar', or secondary forest (Sivasothi, 2002).

Forest bats are an extremely diverse group in Peninsular Malaysia and as a consequence are of intrinsic conservation value and ecological importance (Kingston *et al*, 2003). Bats face many threats, largely due to expanding human populations, including deforestation and conversion of forest habitats to other uses such as agriculture and aquaculture. In particular, fragmentation and associated changes to forest microclimate (Kapos 1989, Saunders *et al.*, 1991) have been found to affect bat diversity by roosting sites, impact insect availability for microchiropterans (Johns, 1997) and by affecting fruit foraging patterns in megachiropterans (Hodgkison *et al.*, 2003; Kingston *et al.*, 2003).

In wetland forest habitats of Malaysia, species found to be at risk include the Flying foxes (Genus: *Pteropus*) who are arboreal roosters and seek refuge in coastal mangroves. The animal's large size, gregarious nature and preference for camp roosting, means they prefer large trees in relatively undisturbed forests. Flying foxes have also traditionally been hunted for food in many areas within the Pacific and overexploitation has caused population decline (Hutson *et al.*, 2001).

The nocturnal and volant nature of bats has limited our understanding of global patterns of species richness (Kingston *et al.*, 2003). Very little is known about the geographic distribution of bats even in relatively well-studied countries such as Malaysia (Hutson *et al*, 2001). Previous studies have focused on the remaining forested regions of Malaysia, 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) and bat research carried-out on Tioman Island as part of a broader biodiversity assessment (Lim *et al.*, 1999). Very little research has been conducted in fragmented forests or mosaic landscapes like the Setiu Wetlands.

5.2 Aims

- To compile a species inventory of bats in the Setiu Wetlands

5.3 Results

A total of 70 bats were caught and attributed to a total of 13 different species with a further 6 identified down to genus. Families represented were: Pteropodidae, Vespertillionidae, Emballonuridae, Rhinolopidae. The highest number of bat captures (18) was made at S7, the site of a bat cave. An additional 9 bats were captured and were identified to family level, belonging to the above families. Table 5.1 shows the species of bat captured by survey location.

Table 5.1 Bat species captures by Location

Sub-Order	Species	Common Names	S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12	Total
Megachiroptera	*Balionycteris maculata*	Spotted Winged Fruit Bat	0	2	0	0	0	0	0	0	3	0	0	5
	Chironax melanocephala	Black-capped Fruit Bat	0	1	1	0	0	0	0	0	0	0	0	2
	Chironax sp.	-	0	1	0	0	0	0	0	0	0	0	0	1
	Cynopterus brachyotis	Lesser Short-nosed Fruit Bat	0	0	9	0	0	0	0	0	0	0	0	9
	Cynopterus sp.	-	0	1	0	0	0	0	0	1	0	0	0	2
	Dyacopterus spadiceus	Dayak Fruit Bat	0	0	0	0	0	0	0	1	0	0	0	1
	Emballonuridae sp.	-	1	0	0	0	0	1	0	0	0	0	0	2
	Eonycteris spelaea	Lesser Dawn Bat/ Dobson's Long-tongued Fruit Bat	0	0	0	0	0	0	1	0	1	0	0	2
	Macroglossus sobrinus	Greater Long-tongued Fruit Bat	1	0	0	0	0	0	0	0	0	0	0	1
	Penthetor lucasi	Lucas' Short-nosed Fruit Bat	0	0	0	0	0	0	1	0	0	0	0	1
	Pteropodidae sp	-	3	0	0	0	0	0	0	3	0	0	2	8
	Rousettus sp.	-	2	0	0	0	0	1	0	0	0	0	1	4
Microchiroptera	*Taphozous saccolaimus*	Sheath-tailed Bat	0	0	0	0	0	0	0	0	0	0	1	1
	Harpiocephalus mordax	Greater Hairy-winged Bat	0	0	0	0	0	0	0	0	0	0	0	0
	Hipposideros cervinus	Fawn-coloured Roundleaf Bat	0	0	0	0	0	0	5	0	0	0	0	5
	Megaderma spasma	False Vampire Bat	0	0	1	0	0	0	0	0	0	0	0	1
	Miniopterus magnater	Bent-winged Bat	0	1	1	0	0	0	0	0	1	0	0	3
	Miniopterus sp.	-	0	2	0	0	0	0	0	0	0	0	0	2
	Rhinolophus Creaghi	Creagh's Horseshoe Bat	0	0	0	0	0	0	6	0	0	0	0	6
	Rhinolophus marshalli	Marshall's Horseshoe Bat	0	0	0	0	0	0	5	0	0	0	0	5
	Scotophilus kuhlii	Lesser Asian Housebat	0	0	0	0	0	0	0	0	1	0	0	1
TOTAL			7	8	12	0	0	2	18	5	6	0	4	69

NB No mist-netting was carried out at S8 - lagoon.

Table 5.2 Bat species net effort by location

Sub-Order	Species	Common Name	Survey Sites S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12
Effort Per Location*													
Megachiroptera	*Balionycteris maculata*	Spotted Winged Fruit Bat	0	0.000594	0	0	0	0	0	0	0.000558	0	0
	Chironax Melanocephala	Black-capped Fruit Bat	0	0.000297	0.000249	0	0	0	0	0	0	0	0
	Chironax sp.	-	0	0.000297	0	0	0	0	0	0	0	0	0
	Cynopterus brachyotis	Lesser Short-nosed Fruit Bat	0	0	0.002241	0	0	0	0	0	0	0	0
	Cynopterus sp.	-	0	0.000297	0	0	0	0	0	0.000321	0	0	0
	Dyacopterus spadiceus	Dayak Fruit Bat	0	0	0	0	0	0	0	0.000321	0	0	0
	Emballonuridae sp.	-	0.000376	0	0	0	0	0.000482	0	0	0	0	0
	Eonycteris Spelaea	Lesser Dawn Bat	0	0	0	0	0	0	0.000295	0	0.000186	0	0
	Macroglossus sobrinus	Greater Long-tongued Fruit Bat	0.000376	0	0	0	0	0	0	0	0	0	0
	Penthetor lucasi	Lucas' Short-nosed Fruit Bat	0	0	0	0	0	0	0.000295	0	0	0	0
	Pteropodidae sp.	-	0.001128	0	0	0	0	0	0	0.000962	0	0	0.000431
	Rousettus sp.	-	0.000752	0	0	0	0	0.000482	0	0	0	0	0.000215
Microchiroptera	*Taphozous saccolaimus*	Sheath-tailed Bat	0	0	0	0	0	0	0	0	0	0	0.000215
	Harpiocephalus mordax	Greater Hairy-winged Bat	0	0	0	0	0	0	0	0	0	0	0
	Hipposideros Cervinus	Fawn-coloured Roundleaf Bat	0	0	0	0	0	0	0.001478	0	0	0	0
	Megaderma Spasma	False Vampire Bat	0	0	0.000249	0	0	0	0	0	0	0	0
	Miniopterus magnater	Bent-winged Bat	0	0.000297	0.000249	0	0	0	0	0	0.000186	0	0
	Miniopterus sp.	-	0	0.000594	0	0	0	0	0	0	0	0	0
	Rhinolophus affinis	Creagh's Horseshoe Bat	0	0	0	0	0	0	0	0	0.000186	0	0
	Rhinolophus creaghi	Marshall's Horseshoe Bat	0	0	0	0	0	0	0.001773	0	0	0	0
	Rhinolophus marshalli	Lesser Asian Housebat	0	0	0	0	0	0	0.001478	0	0	0	0
	Scotophilus kuhlii	[illegible]	0	0	0	0	0	0	0	0	0.000186	0	0

Analysis of diversity was calculated on the bats that could be identified down to the species level. The 6 bat species which were only identified down to Genus were therefore excluded. Therefore 27 of the 70 bats captured during the base survey effort were not identified to sufficient level to be included in this analysis, and consequently S4, S5 and S6 are not included in table 5.3. Additionaly no bats were caught in S11 and therefore this site was not included in the anlaysis.

Therefore the analysis does not give a full picture of the comparative diversity of the different habitat types and consequently only providing a conservative representation of species diversity within the Setiu Wetlands habitat mosaic.

Table 5.3 Bat diversity indices by location.

Location	Total Species1	Total Individuals2	Species Richness3	Pielou's Evenness4	Shannon-Weiner5
S1	1	1	-	-	-
S2	3	4	1.443	0.9464	1.04
S3	4	12	1.207	0.6038	0.837
S7	5	18	1.384	0.8692	1.399
S9	1	1	-	-	-
S10	4	6	1.674	0.8962	1.242
S12	1	1	-	-	-

As shown from the above table that habitat S7, the dry forest, was where the highest number of bats were caught and the site that had the highest diversity, whilst the highest species richness was found at S10.

Results between sites were also graphed simply on a sub-order level to try and identify any trends in make up. This is shown in Figure 5.3 below.

Most sites showed a mixed community of micro- and megachiropteran captures, with the exception of S9, where all megachiroptera.

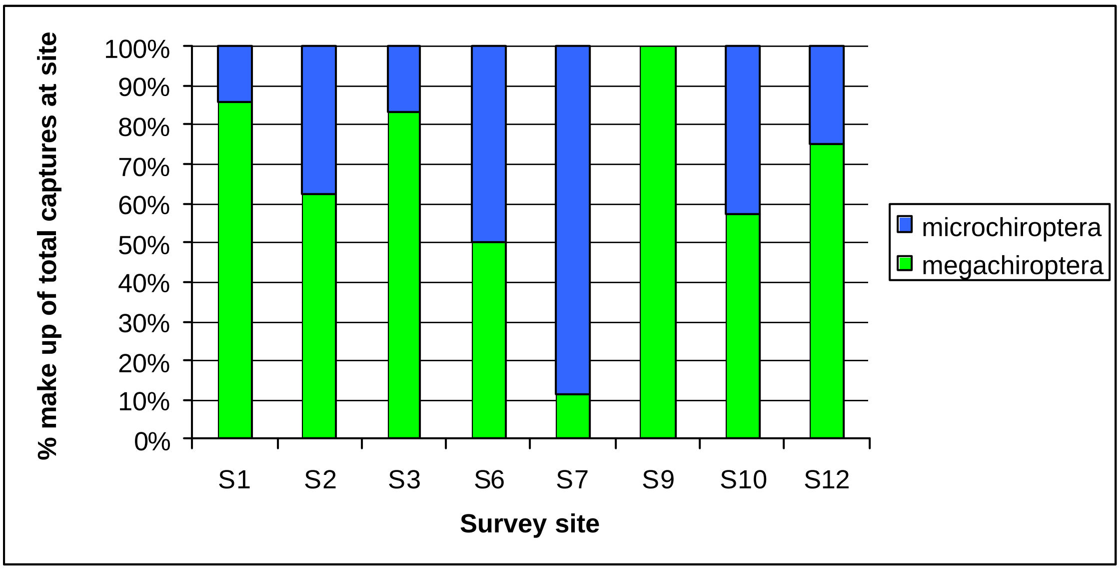

Figure 5.1 Comparative make-up of micro- and mega-chiropteran bat captures across the main survey sites.

Supplementary sites
Capture efficiency was generally higher at the supplementary sites than the main survey sites, with a total of 5 bats being caught within 155 net hours over all sites.

Table 5.4 Bat species caught at supplementary survey sites

Species	Common name	Gelam-dry	Gelam-wet	Islet	Palm plantation
Harpiocephalus mordax	Hairy-winged bat	0	0	1	0
Miniopterus magnater	Western bent-winged bat	0	0	0	3
Chironax sp.	-	1	0	0	0

Morphological data

All bats netted were weighed and measure to help with species identification. The biometrics for each species are included in tables 5.5 – 5.7.

Table 5.5 Bat capture morphological data – Adult Males.

Species	Statistical Measure	Body Mass (g)	Fore-arm (mm)	Ear (mm)	Hindfoot (mm)	Tail (mm)	Bodylength (mm)	Total length (mm)
Chironax sp	mean	38	58.2	12.4	23.7	0	68.4	102
	N	1	1	1		1	1	1
Cynopterus sp	mean	32	64.5	16.8	10.1	7.2	25.5	48.4
	N	1	1	1	1	1	1	1
Pteropodidae sp	Range	19-37	59-66	9-15.6	9-24.6	1.4-6.1	52-68.5	77-105.9
	Mean	29	62.825	12.4	16.55	3.875	59.45	88.25
	St. Dev	14.55	28.21	6.11	10.25	2.51	27.24	40.9
	N	4	4	4	4	4	4	4
Roussetus sp	Range	35-85	62-82.3	13.7-16.2	10.5-19.5	4.8-10.3	49-73.5	93.9-121.2
	Mean	60	71.15	14.95	15	7355	61.25	107.55
	St. Dev	35.36	15.77	1.77	6.36	3.89	17.32	19.3
	N	2	2	2	2	2	2	2

Juvenile		Body Mass (g)	Fore-arm	Ear	Hindfoot	Tail	Bodylength	Total length
Dyacopterus sp	mean	34	70.3	13.9	11.5	0.95	49.3	84.7
	N	1	1	1	1	1	1	1
Roussetus sp	range	29-30	55-55.5	13-13.2	13-14	7.3-8.5	50.5	71.5-92.7
	mean	29.5	5.25	13.1	13.5	7.9	25.25	87.1
	SD	0.071	0.35	0.14	0.71	0.85	35.71	7.92
	N	2	2	2	2	2	1	2

Table 5.6 Bat species captures morphological data - female Megachiropteran

Species		Body Mass (g)	Fore-arm	Ear	Hindfoot	Tail	Body length	Total length
Unidentified Megachiroptera sp.	Mean	47	59.4	16.8	15.1	0	83	-
	N	1	1	1	1	1	1	-

Table 5.7 Morphological data for Microchiropterans (all adult male)

Species		Body Mass (g)	Fore-arm	Ear	Hindfoot	Tail	Bodylength	Total length
Emballonuridae sp	range	43-44	71.2-73.6	12.2-13.1	27.4-28.4	26.7-23.8	61.0-89.4	94.0-126.6
	mean	14.75	25.85	9.05	13.7		12.05	24.4
	SD	19.45	35.14	11.38	17.96	0.71	15.63	33.09
	N	2	2	2	2	2	2	2
Miniopterus sp.	range	86-89	48-54.2	5.7-9.4	8.7-9	15	63.1-64	87.3-88.6
	mean	87.5	51.1	7.5	8.85	45.4	63.55	87.95
	SD	2.12	4.38	2.62	0.21	2.9	0.64	0.92
	N	2	2	2	2	2	2	2
Rhinolophus marshalli	mean	28.5	50.7	17.1	26.4		23.1	47.8
	N	1	1	1	1	1	1	1

5.6 Discussion

Two species of bat caught during the survey are noteworthy due to their IUCN status of near threatened: the Dyak fruit bat (*Dyacopterus spadiceus*) and Creagh's horseshoe bat (*Rhinolophus Creaghi*), further information on these species is given below:

- Dyak Fruit Bat (*Dyacopterus spadiceus*): The males of the species have large, swollen nipples that lactate and it is thought that the Dayak fruit bat is the only known mammalian species where male lactation might be standard. Male nipples are still smaller than those of females and produce only about a tenth as much milk. The cause of this is currently unknown, but it may be a side effect of phytoestrogens in leaves in the bats' diet, or it may be an actual adaptation to feed their young. This species is threatened by human induced habitat loss and degradation.
- Creagh's Horseshoe Bat (*Rhinolophus creaghi*): This species is primarily found in primary lowland forest from sea level to 700 m and is often associated with caves which are the preferred roosting location (Esselstyn *et al.*, 2004). This species is threatened by human induced habitat loss, degradation and fragmentation.

Comparisons between bat sub-orders and numbers of individuals caught demonstrate a bias towards megachiropteran bat captures across all survey sites, with 54% of captures being attributed to fruit bats.

For one site, however, S7 the dry forest 89% of bats caught were micro-chiropterans. Whilst the Old World fruit bats are inclined to roost in trees or tents made from palm leaves, the insectivorous bats have been shown to roost in caves and natural crevices in rock formations. The high number of microchiroptera caught at S7 is indicative of the sheer density of bats exiting from the cave lying in the side of Dendong Hill.

However it is must be noted that echolocating species are known to be able to detect mist nets and bat species do differ in the degree of catchability or detectability. The positioning of nets in habitual flight paths means that bats are less likely to pay attention to the weak echoes off nets or traps. However, foraging bats are searching for weak echoes from insects in the airspace before them and will easily detect and avoid a net (Thomas & West, 1989). This could infer that there is a larger contingent of micro-chiropterans than detected. Tidemann *et al.* (1978) and more recently, Kingston et al (2003) have shown the contrasting success rates of microchiropteran captures using mist nets and harp nets, and paralleled use of both types of net would increase accuracy in comparing the bat communities.

Due to the complex nature of the habitat mosaic species-specific foraging behaviour should be considered. Smaller species (including the echolocators) will feed on resources of high abundance, fruit bats forage for patchy but high energy resources, and some species of nectar-feeding bat have been shown to travel up to 30km to a specific food source. The manner in which insectivorous bats feed may also come into play as some species fly continually foraging whilst others simply move small distances between perches to intersect insects, which could result in patchiness of certain species (Fenton, 1982). Individual megachiropteran species also show high levels of specificity to certain fruits which could account group foraging and patchiness in capture rate (Estrada *et al*, 2001; Heaney *et al*, 1989). However, the mangrove sites, as expected, showed occupation mainly by fruit and nectar-feeding bats. The mixed and dense vegetation in the mangroves provides a variety of fruits for the megachiropterans.

Considering the foraging behaviour and the comparatively small size of each survey site, caution must be taken when attributing a particular species' presence to an individual survey site. The results obtained do not necessarily suggest a lower density of Microchiropterans in the Setiu Wetlands and should only be interpreted as a need for more survey methods and effort for future work in the reserve.

6. Mammals (Non-volant)

6.1 Introduction

Mammals are key components of tropical forest communities. They play important and diverse roles in tropical forest ecosystems, for instance in seed dispersal, pollination, frugivory and food web predation (Cuarón, 2000). Mammals also represent significant economic resources for people living in relation to forests, and they supplement local livelihoods either as sources of food for consumption or sale of animals and artefacts (hide, bone, teeth etc).

Ecologists have emphasized the important role that larger herbivores (e.g. primates and ungulates) play in tropical ecosystems through their influence on forest structure, composition, productivity, nutrient cycling, soil structure and succession (Jathana *et al.*, 2003).

The difficulties in sampling and measuring the structural and biological complexity of tropical forest ecosystems has led researchers to develop mechanisms that can be used to identify ways in which to prioritise conservation efforts. Due to their charismatic nature, mammals have often become the focus of such efforts. As is the case with many top carnivores and predators, mammals such as the Tiger (*Panthera tigris*) are seen as 'keystone' and 'flagship' species, by which inferences about the state of ecosystems can be assessed. Large mammals are particularly vulnerable to habitat disturbance. They exist at lower population densities within forests because of intense competition for food, living space and predation (Whitmore, 1998). Large herbivores are, however, relatively difficult to conserve owing to their large home range needs, inherently low population densities and tendency to come into conflict with humans through crop raiding and predation of stock. Thus, mammals are a significant faunal group for conservation monitoring.

Whilst much attention has been given to large charismatic mammal species, such as the primates and felids, very little is known about the ecology, diversity and distribution of small mammals within tropical forests (Wells *et al.*, 2004). This is due to their cryptic behaviour, size, nocturnal preferences and difficulties for observation in habitats, particularly with arboreal species (Wells *et al.*, 2004). Where work has been conducted, researchers are often surprised by the patterns of small mammal diversity and biogeographical variations, which have great implications for evolution and conservation (Heaney, 2001).

Of the 8414 species of mammal in the world, approximately 233 non-volant species are found in Malaysia (WCMC, 2005). One study at Pasoh, Kuala Lumpur state, found 89 species of mammals (including five species of primate) within an area of $8km^2$ (Whitmore, 1998). There are 93 mammal species classified as threatened by the IUCN (2004) in Malaysia. Of these, 18 species are endemic to Borneo (Malaysian territories of Sabah and Sarawak). Very limited work assessing diversity and distribution of mammal species in coastal habitats has been completed in Peninsular Malaysia.

6.2 Aims

- To document the diversity and distribution of mammal species with Setiu Wetland.
- To identify patterns between mammal communities and other faunal groups, for example reptiles.

6.3 Results

The mammal captures across the main survey sites were represented by a low number of species (Table 6.1). Four orders of mammals were found: Carnivora, Insectivora, Rodentia and Scandentia. Within these orders five families were identified and these were represented by seven species.

The relative capture effort for both cage and sherman traps across survey sites (Table 6.2) and details of the morphological data for all captures (Tables 6.3-6.5) are summarised below.

Table 6.1 Mammal captures by location.

Order	Family	Species	Common Name	S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12	Total
Carnivora	Viverridae	*Paradoxurus hermaphroditus*	Common Palm Civet	0	1	0	0	0	0	2	0	0	0	0	3
Insectivora	Soricidae	*Suncus murinus*	Asian House Shrew	0	0	0	0	0	0	0	0	1	0	0	1
Rodentia	Sciuridae	*Callosciurus notatus*	Plantain Squirrel	0	0	0	1	0	0	0	0	0	0	0	1
Rodentia	Muridae	*Rattus tiomanicus*	Malaysian Field Rat	0	0	0	0	0	0	0	0	7	0	0	7
Rodentia	Muridae	*Rattus argentiventer*	Rice Field Rat	0	0	0	0	1	0	0	1	0	0	1	3
Rodentia	Muridae	*Unidentified Rattus*	Unknown	2	0	0	1	5	0	0	13	24	1	7	53
Rodentia	Muridae	*Unidentified Murinae*	Unknown	0	0	0	0	0	0	1	0	0	0	0	1
Scandentia	Tupiidae	*Tupaia glis*	Common Tree Shrew	0	0	0	1	6	0	7	2	7	0	0	23
Total				2	1	0	3	12	0	10	16	39	1	8	[illegible]

NB. No mammal trapping was conducted at S8 – the lagoon.

Table 6.2 Mammal capture trap (Cage and Sherman combined) effort by location.

Species	Common Name	S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12
Effort per location*		63072	46980	62799	84456	35370	21420	7956	52200	132344	32240	8640
Paradoxurus hermaphroditus	Common Palm Civet	0	0.000212	0	0	0	0	0.000251	0	0	0	0
Suncus murinus	Asian House Shrew	0	0	0	0	0	0	0	0	0.000055	0	0
Callosciurus notatus	Plantain Squirrel	0	0	0	0.000118	0	0	0	0	0	0	0
Rattus tiomanicus	Malaysian Field Rat	0	0	0	0	0	0	0	0	0.000528	0	0
Rattus argentiventer	Rice field rat	0	0	0	0	0.000282	0	0	0.000191	0	0	0.000115
Rattus rattus	House rat	0	0	0	0	0	0	0	0	0	0	0
Unidentified Rattus	Unknown	0.000317	0	0	0.000118	0.000141	0	0	0.000249	0.00181	0.000310	0.000810
Unidentified Murinae	Unknown	0	0	0	0	0	0	0.000126	0	0	0	0
Tupaia glis	Common Tree Shrew	0	0	0	0.000118	0.000169	0	0.000888	0.000383	0.000528	0	0

NB Effort per location* expressed as number of trap hours. Effort per capture expressed as number of traps divided by trap hours.

Table 6.3 Female mammal capture – morphological data.

Species	Statistical Measure	Body Mass (g)	Ear (mm)	Hindfoot (mm)	Tail (mm)	Body Length(mm)
Rattus tiomanicus	Range	53-178	14.85-19.1	14.4-28.9	110.65-158.85	101.3-132.1
	Mean	109.25	16.975	24.3875	133.8833	116.7
	St Dev	52.31555	3.005204	6.762689	24.1467	21.77889
	Total	4	2	4	3	2
Unidentified *rattus*	Range	20-131	15-17.8	24.8-29.7	116.9-163	117.2-177.6
	Mean	91.125	16.61111	27.295	147.142	141.4
	St Dev	36.41208	0.856511	1.77552	15.89271	21.28767
	Total	8	9	10	10	9

Table 6.4 Male mammal captures – morphological data.

Species	Statistical Measure	Body Mass (g)	Ear (mm)	Hindfoot (mm)	Tail (mm)	Body Length (mm)
Rattus tiomanicus	Range	96-119	16.3-21.75	27.8-28.9	144.9-165.5	106.7-164.1
	Mean	108.6667	19.025	28.48333	157.8	138.2667
	St Dev	11.67619	3.853732	0.596518	11.24144	29.12633
	Total	3	2	3	3	3
Tupaia glis	Range	125-201	10-11.4	35.5-42.2	148.1-167.4	140.7-193.2
	Mean	161.5	10.8	38.68	155.25	165.875
	St Dev	33.4016	0.848528	2.408734	8.392258	25.13131
	Total	4	3	5	4	4
Unidentified *rattus*	Range	34-148	11.85-22.3	20.7-30.9	87-167.2	88.6-205.3
	Mean	79.32	15.87083	27.95885	117.2174	128.9
	St Dev	31.97358	1.965513	3.492408	43.55243	26.17231
	Total	25	25	26	23	24

Table 6.5 Unk nown sex mammal captures – morphological data.

Species	Statistical Measure	Body Mass (g)	Ear (mm)	Hindfoot (mm)	Tail (mm)	Body Length (mm)
Paradoxurus hermaphroditus	Range	220-540	-	39.8-41.4	170.6-306	-
	Mean	342.33	-	40.6	219.86	-
	St Dev	172.78	-	1.13137085	74.850874	-
	Total	3	-	2	3	-
Tupaia glis	Range	134-270	8.85-9.75	35-43.6	134-172.9	102-160.75
	Mean	177.44	9.3	38.1875	153.95	136.03
	St Dev	43.38	0.63	3.44	11.56	26.25
	Total	9	2	8	7	4

6.6 Discussion

No mammals were recorded from S3 (scrub) or S6 (coconut scrub). The lack of small mammals at these sites could be their displacement via niche competition at these habitats by herpetofauna, in particular lizards such as the butterfly lizard (*Leiopolis belliana*). Comparing numbers of mammal captures and number of lizard sightings from VES's (see Chapter 6) at S3 and S6 shows that lizards are very common at these sites, but were found to be more abundant at S11 (casuarina). This would require further investigation.

Surveys at the four supplementary sites confirmed the general absence of small mammals across the area. Only one individual *Rattus tiomanicus* was recorded despite a survey effort of 12 cages and 18 sherman traps in 3 transects for 3 nights at each site.

Casual Observations

During the course of surveying, a number of casual observations of large mammal species. Two primate species were recorded: Dusky faced Langurs (Trachypithecus obscurus) and Long-tailed Macaques (*Macaca fascicularis).*

A troop of Dusky faced Langurs were recorded at the dry forest on Dendong Hill at S7. Typically, social groups of Langurs consist of between 5-20 individuals including one or two adult males and one or two adult females. It is thought group territories cover between 5 and 12 ha for Langurs inhabiting the Malay Peninsula. (Nowak, 1999). They prefer to live in closed primary forests, but also inhabit old-growth secondary forests and urban forests (MacKinnon and MacKinnon, 1978 & 1980). The dusky leaf-monkey spends most of its time in the upper canopy levels of the forest (MacKinnon and MacKinnon, 1978, 1980). Langurs are highly mobile and are known to feed from 87 different species of trees, ingesting both leaves and fruit (Nowak, 1999) and are important seed dispersers.

It is probable the troop are residents in the dry forest at S7, as they were sighted and heard regularly during surveys at S7 and S1, the nearby scrub habitat. However remaining fragments of dry forest in the region are highly fragmented (see Figure 2.2 and Figure 2.3). Other larger tracts of dry forest are found towards the interior and to the north of Dendong Hill, but the viability of langur populations in the coastal zone is questionable, considering their foraging needs and habitat size requirements.

Dusky Langurs are classified as Low Risk Least Concern by the IUCN (2004). However there is very little information available on their status. The Langurs observed during this study evidently inhabit one of the last fragments of Dry forest in the region.

Dusky Langurs are sympatric with the other species of primate recorded during surveys, the Long-tailed Macaques (*Macaca fascicularis)*, although the two species were not found sympatrically in the region. There was no evident cross over in their habitats. Langurs were only identified in the Dry forest at S7, and Macaques were recorded at the mangrove sites of S9 and S12.

Long-tailed Macaques are highly adaptable generalists who successfully occupy disturbed habitats and forest edges. They achieve high population densities in mixed mangrove swamps, secondary hill forests, and riverine forests. In Malaysia, they are abundant in coastal lowland forests and cleared land, such as plantation areas, has been colonized by this species. It has been observed that some disturbed habitats have higher troop and population sizes than some pristine forests.

Population densities of Macaques range from 10-400 per km^2. Regardless of the habitat type, studies suggest there should be at least 500 squared kilometers of habitat necessary to support a viable population of 5,000 long-tailed macaques (Supriatna et al, 1996). However Macaques are more mobile than Langurs and are not as restricted to arboreal

Macaques, as generalists are more adaptable and less restricted in terms of habitats than Langurs, which are almost exclusively arboreal. They can be commensural and were observed in and around the settlement of Betin Lintang and the project base. Most sightings were in the early morning (6-8am) or at dusk (6-7pm) and generally on the boundary between mangrove and coconut scrub habitats. Macaques are also caught and trained by locals to retrieve coconuts and other fruits from the mangrove and coconut scrub (Turner pers.comm, 2006).

Table 6.6. Other large mammal species of note recorded in Setiu.

Species	Common Name	Survey Site	Habitat	Status	
				IUCN	CITES
Lutrogale perspicillata	Smooth-coated Otter	S12	Lowland wetlands and coastal areas, including estuaries, river mouths, reservoirs, lakes and streams.	Vulnerable	Appendix II
Manis javanica	Malayan Pangolin	Project base/corpses found on roads in Betin Lintang	Primary, secondary forests and agricultural areas.	Low Risk/Not Threatened	Appendix II
Nycticebus coucang	Slow Loris	S9	Almost exclusively arboreal - prefers primary and secondary forests	Low Risk/Least Concern	Appendix II

7. Herpetofauna

7.1 Introduction

Herpetofauna (reptiles and amphibians) occupy a wide range of habitats and niches within ecosystems. In particular wetlands and the terrestrial areas surrounding wetlands are core habitats for many semi-aquatic species that depend on mesic ecotones to complete their life cycle (Semlitsch *et al.*, 2003).

Forests are known to provide preferential habitats for amphibians in particular (IUCN, 2004). Amphibians and reptiles occupy a number of niches within forests. They are often found near rocks and debris, and in overhanging vegetation. Trees are also favourable environments, with reptiles and amphibians commonly found on trunks, in branches, under bark and in the canopies. Epiphytes such as aerial ferns, pandans, moss mats and orchids are also regular haunts.

Malaysia is home to around 400 species of reptiles (WCMC, 2006). Seventeen species are endemic. There are 202 species of amphibians known from Malaysia (IUCN, 2006) of which 64 are believed to be endemic. An estimated 98 species of frog occur in Peninsula Malaysia, although actual numbers are thought to be higher (Sukumaran, 2004). Most endemic herpetofauna species are found in the Bornean territories of Sabah and Sarawak.

As amphibians and reptiles are cold-blooded and have permeable skin, they are highly sensitive to fluctuations in microclimates (temperature, sunlight, moisture). The effects of habitat disturbance are compounded for small herpetofauna with limited dispersal capabilities (Hampson, 2001). Habitat decline and fragmentation are therefore the most influential global causes of amphibian and reptile decline (Gillespie *et al.*, 2005).

Although endemism on the Peninsula is low, many herpetofaunal species found in Peninsula Malaysia require old-growth forest for their survival. The drainage of wetland habitats and fragmentation has been identified as possible causes of large-scale amphibian decline (Houlahan & Findlay, 2003).

7.2 Aims

- To detail the herpetofauna of the Setiu Wetlands.
- To assess herpetofaunal species diversity and assemblages across different habitat types.

7.3 Results

A range of herpetofauna species were recorded across the survey locations, with twelve species positively identified (Table 7.1). Using records identified to species level, it is clear that one species; the Common butterfly lizard (*Leiolepis belliana*) dominates across the majority of survey sites (except S7, S9 and S12). A particularly high number were recorded at S11, where the lizard accounted for 71% of sightings at the site. Fewer species were detected using pitfall traps (Table 7.2 & 7.3).

Table 7.1 Herpetofaunal species recorded on Visual Encounter Surveys (TVES and QVES) by location.

			Survey Sites												Supplementary Sites				
Family	Species	Common Name	S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12	*Sub Total*	Gelam Dry	Gelam Wet	Islet	Palm Oil Plantation	Total
Agamidae	*Calotes versicolor*	Changeable Lizard	6	1	2	0	3	24	0	0	0	6	0	*42*	0	0	2	5	*49*
	Leiolepis belliana	Common Butterfly Lizard	47	34	17	4	4	24	0	0	1	168	0	*299*	13	0	8	24	*344*
Bufonidae	*Bufo melanostictus*	Asian Toad	0	0	0	0	0	0	0	0	0	0	0	*0*	5	0	0	0	*5*
Colubridae	*Ahaetulla prasina*	Oriental Whip Snake	0	0	0	0	0	2	0	0	0	0	0	*2*	0	0	0	0	*2*
Colubridae	*Dendrelaphis pictus*	Painted Bronzeback	0	0	0	0	0	0	0	0	0	0	1	*1*	2	0	0	0	*3*
Ranidae	*Fejervarya limnocharis*	Paddy Frog	0	0	0	0	0	0	0	0	0	0	0	*0*	0	0	2	4	*6*
Rhacophoridae	*Polypedates leucomystax*	Asian Tree Frog	0	0	0	0	0	0	0	0	2	0	0	*2*	0	0	0	0	*2*
Scincidae	*Lygosoma bowringii*	Common Supple Skink	0	0	0	0	0	0	0	0	1	0	0	*1*	0	0	0	0	*1*
	Mabuya longicaudata	Long-Tailed Skink	0	0	0	0	0	6	0	0	0	0	0	*6*	0	0	0	3	*9*
	Mabuya macularia	Speckled Forest Skink	0	0	0	0	0	0	0	0	0	0	0	*0*	1	0	0	0	*1*
	Mabayu multifasciata	Common Asiatic Skink	0	0	0	0	0	1	0	2	5	0	0	*8*	0	0	0	1	*9*
Varanidae	*Varanus salvator*	Malayan Water Monitor	0	2	0	0	0	0	0	0	0	0	0	*2*	0	0	2	0	*4*
Unknown	Unidentified Frog	Unknown	0	0	0	0	0	0	0	9	8	0	0	*17*	0	2	4	15	*38*
Unknown	Unidentified Gecko	Unknown	0	0	0	0	0	1	0	0	1	0	0	*2*	0	0	0	0	*2*
Unknown	Unidentified Lizard	Unknown	0	0	0	0	0	0	0	0	1	0	0	*1*	0	0	1	3	*5*
Unknown	Unidentified Skink	Unknown	0	0	0	0	0	0	0	0	4	0	0	*4*	0	0	0	0	*4*
		Total	53	37	19	4	7	58	0	11	23	174	1	387	21	2	19	55	*484*

N.B No VESs' were undertaken at S8, the lagoon.

Table 7.2 Herpetofaunal species recorded by pitfall traps by location.

Family	Species	Common Name	Survey Sites S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12	Total
Agamidae	*Leiolepis belliana*	Common Butterfly Lizard	0	0	1	0	0	0	0	0	0	0	0	1
Bufonidae	*Bufo melanostictus*	Asian Toad	2	0	1	1	3	1	0	0	0	2	0	10
Bufonidae	*Bufo quadriporcatus*	Four Ridged Toad	0	0	0	0	0	0	0	0	1	0	0	1
Microhylidae	*Kaloula pulchra*	Banded Bullfrog	0	0	0	0	3	0	1	0	0	0	0	4
Ranidae	*Fejervarya limnocharis*	Paddy Frog	0	0	2	0	0	0	0	0	0	0	0	2
Scincidae	*Lygosoma bowringii*	Common Supple Skink	1	0	2	0	0	0	0	0	1	2	0	6
Scincidae	*Mabuya multifasciata*	Common Asiatic Skink	0	0	0	0	0	0	0	0	5	1	0	6
Scincidae	*Mabuya rugifera*	Rough-Scaled Skink	0	0	0	0	0	0	0	0	1	0	0	1
		Total	3	0	6	1	6	1	1	0	8	5	0	31

Table 7.3 Survey effort for VES by location.

Survey Method	Survey Sites S1	S2	S3	S4	S5	S6	S7	S9	S10	S11	S12	Sub Total	Supplementary Sites Gelam -Dry	Gelam - Wet	Islet	Palm Plantation	Total
TVES Per site	14	15	11	8	14	13	10	13	15	20	15	148	3	3	3	3	*160*
Total Effort - duration minutes	161	130	89	139	195	207	144	254	398	173	364	2254	40	54	56	73	*2477*
Median duration minutes	8	6	8	11	15	11	15	15	23	8	23	-	6	17	15	16	-
QVES Per site	11	15	13	10	13	6	7	16	14	18	14	137	3	3	3	3	*149*
Total Effort - duration minutes	64	98	136	124	138	85	78	312	257	129	274	1695	24	47	43	55	*1864*
Median duration minutes	5	5	9	11	10	5	9	12	14	7	20	-	11	21	24	23	-
Total VES Per site	25	30	24	18	27	19	17	19	29	38	29	454	3	3	3	3	*466*

N.B No pitfall traps were conducted at S8 - the lagoon or at the supplementary survey sites.

Herpetofaunal species composition was assessed using the Bray-Curtis similarity measure between the permutations of sample pairs in Primer (Clarke & Warwick, 2001). The relationship between survey sites was analysed using a hierarchical agglomerate clustering technique (Clarke & Green 1988). The Dendrogram analysis uses VES data that is transformed to incorporate surveying effort i.e. total species and individuals identified/by total VES count at each survey site (effort). The results of this are shown in Figure 7.1.

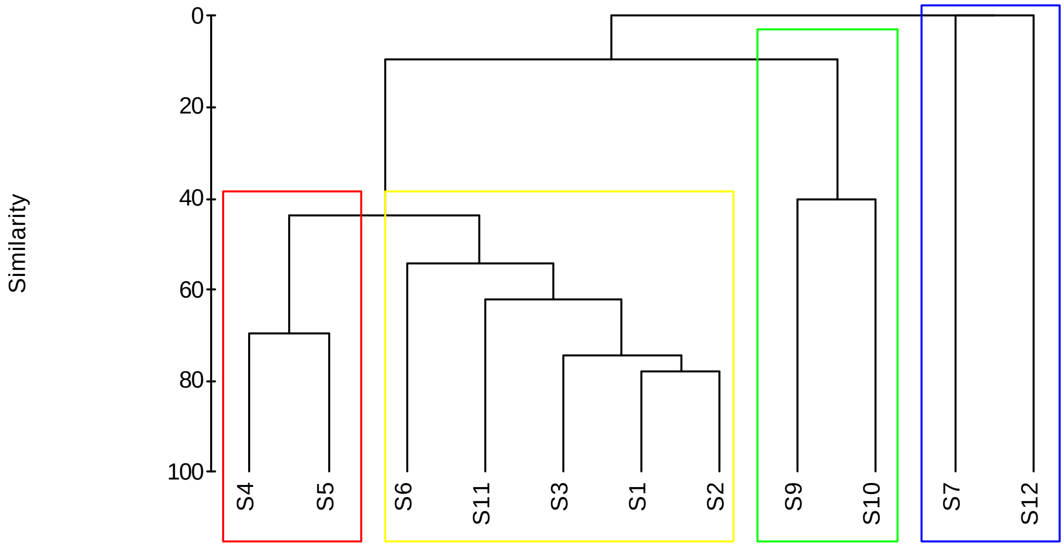

Figure 7.1 Dendrogram showing similarities between survey sites for herpetofaunal species. Bray-Curtis 4th root transformation.

Figure 7.1 shows the groupings of survey sites, highlighted by four colours – red, yellow, green and blue. The red group shows the clustering of the two disturbed dry forest sites at S4 and S5. The similarity at these sites are relatively high (70%). This echoes the analysis of other faunal groups for the dry forest sites. Very few herpetofauna were found at these sites on VES's (four individuals at S4 and seven at S5). This could suggest that these dry forest fragments have been highly disturbed.

The yellow group is less evenly matched and is comprised of a variety of habitat types – coconut scrub (S6), casuarina (S11 and S2) and scrub (S3 and S1). S1 and S2 demonstrate the highest similarity (74%).

The green group highlights a mangrove at S9 and Peat Swamp at S10. The grouping of these two habitats, could suggest a similar assemblage of herpetofauna due to microclimatic conditions at such sites i.e. aquatic refuges, humidity and dense vegetation in the understorey. However the reduced actual number of captures and species richness at these two sites, should be noted. Further work would be needed to make a more accurate assessment of comparisons of herpetofauna of mangroves and peat swamp habitats.

The final grouping, highlighted in green are two outlier sites, where very little herpetofauna were recorded. S7, the dry forest site, which yielded no sightings and the S12 mangrove where only one snake (*Dendrelaphis pictus*) was recorded. The species diversity of survey locations was then analysed further. The results of which are shown in Table 7.4.

Table 7.4 Diversity analysis for herpetofaunal results by survey location. NB – diversity calculations for sites with one or no representative species were not possible. Hence S4, S7 and S12 show 0 values.

Survey Site	Total Species[1]	Total Individuals[2]	Species Richness[3]	Pielou's evenness[4]	Shannon-Weiner[5]
S1	2	53	0.25	0.51	0.35
S2	3	37	0.55	0.30	0.33
S3	2	19	0.34	0.48	0.33
S4	1	4	0	0	0
S5	2	7	0.51	0.98	0.68
S6	6	58	1.23	0.68	1.22
S7	0	0	0	0	0
S9	2	11	0.41	0.68	0.47
S10	8	23	2.23	0.84	1.76
S11	2	174	0.19	0.21	0.15
S12	1	1	0	0	0

Table 7.4 shows that the Peat swamp at S10 yielded the highest number of species (8). There is little correlation between the number of species recorded at sites and the number of individuals. The casuarina at S11 provided a high number of captures, but very low species richness (0.19). Two species were represented by two lizard species, *Calotes versicolor* and *Leiolepis belliana.*

7.4 Discussion

A total of 12 species of herpetofauna were identified following VES and pitfall surveys at the main survey sites. Three species were identified at the supplementary sites: *Bufo melanostictus and Mabuya macularia* from the dry Gelam site and *Fervarya limnocharis* from the palm oil plantation. Casual observations provided a further eight species and these are listed in Table 7.5.

Casual Observations

A number of additional sightings were made of notable herpetofauna species outside of the surveying periods. The species are summarised in Table 7.5.

Table 7.5 Additional sightings of herpetofaunal species within Setiu.

Family	Species	Common name	Location notes
Agamidae	*Draco volans*	Common gliding lizard	S10
Colubridae	*Boida dendrophilia melanota*	Mangrove snake	S12
	Naja kaothia	Monocellate cobra	Project Base
	Homalopsis buccata	Puff-faced water snake	S1
	Rhabdophis chrysargos	Spotted Keelback	S12
	Rhabdophis subminiatus subminiatus	Red-necked Keelback	Project Base
Gekkonidae	*Cosymbotus platyurus*	Flat-tailed Gecko	Project Base
Scincidae	*Lygosoma quadrupes*	Short limbed supple skink	S10
Varanidae	*Varanus salvator*	Malay water monitor	Found at most survey sites. Some impressively large monitors (2-3ft) were observed at S1/S7 and S11.

Aggregating the main herpetofaunal findings from VES and pitfalls with casual observations shows that a total of 23 species of herpetofauna from nine families, were recorded during surveys. These were comprised of 18 species of reptiles and 5 species of amphibians. On VES's 24 individual frogs, geckos, lizards and skinks were unidentified. Table 7.6 provides a summary of the species covered in surveys and their status.

Table 7.6 Summary of herpetofaunal species recorded.

Family	Species	Common name	Survey method	Habitat type	Status notes
Agamidae	*Calotes versicolor*	Changeable lizard	VES	C S Df Cs I Pp	Lc
	Draco volans	Common gliding lizard	Casual observations	Ps	Lc
	Leiolepis belliana	Common butterfly lizard	VES Pitfalls	S C Df Cs Ps Gd I Pp	Lc
Bufonidae	*Bufo melanostictus*	Asian toad	Pitfalls VES	C S Df Cs Gd	Lc
	Bufo quadriporcatus	Four-ridged toad	Pitfalls	Ps	Lc
Colubridae	*Ahaetulla Prasina*	Oriental whip Snake	VES	Cs	Lc
	Boiga dendrophilia melanota	Mangrove snake	Casual observations	M	Lc
	Dendrelaphis pictus	Painted bronzeback	VES	Cs Gd	Lc
	Homalopsis buccata	Puff-faced water snake	Casual observations	S	Lc
	Naja kaothia	Monocellate cobra	Casual observations	S	Lc CITES Appendix II
	Rhabdophis chrysargus	Spotted keelback	Casual observations	S	Lc
	Rhabdophis subminiatus	Red-necked keelback	Casual observations	S	Lc
Gekkonidae	*Cosymbotus platyurus*	Flat-tailed gecko	Casual observations	S	Lc
Microhylidae	*Kaloula pulchra*	Banded bullfrog	Pitfalls	Df	Lc
Ranidae	*Fejervarya limnocharis*	Paddy frog	VES Pitfalls	S I	Lc
Rhacophoridae	*Polypedates leucomystax*	Asian tree frog	VES	Ps	Lc
Scincidae	*Lygosoma bowringii*	Common supple skink	Pitfalls VES	S C Ps	Lc
	Lygosoma quadrupes	Short limbed supple skink	Casual observations	Ps	Lc
	Mabuya longicaudata	Long-tailed skink	VES	Cs Pp	Lc
	Mabuya macularia	Speckled forest skink	VES	Gd	Lc
	Mabuya multifasciata	Common Asiatic skink	VES Pitfalls	Ps C M Pp	Lc
	Mabuya rugifera	Rough-scaled skink	Pitfalls	Ps	Lc
Varanidae	*Varanus salvator*	Malayan water monitor	VES Casual observations	C S I	Lc CITES (Malaysia ratified 2002)

NB – Habitat Key – C –casuarina, Cs Coconut scrub, Df – Dry Forest, Gd – Gelam dry, Gw Gelam wet, Islet, M – Mangrove, Pp – palm oil plantation, Ps – Peat swamp, S – scrub.

None of the herpetofaunal species recorded during surveys were endangered. However, very little research has been carried out on the ecology, local distribution (Peninsular Malaysia and smaller scale) and habitat requirements of the herpetofauna of Malaysia. What is clear is that generalists such as *L.belliana* are dominant. The abundance of generalist lizard species such as *C. versicolor* and to a greater extent *L. belliana*, which are common at the edge or in forest gaps is know to increase after forest disturbance (Azevedo-Ramos *et al.,* 2005) and this may help to explain their presence, especially as the only species represented on VES at S4 and S5, the disturbed Dry forest sites and the nearby patch of scrub at S1.

Relatively few herpetofaunal species were recorded from the wet habitats, such as the mangroves at S9 and S12. As many amphibians are unable to osmoregulate (control levels of salt and minerals in the body), there is likely to be a dearth of amphibians in such environments. However, few reptiles were noted from the mangroves either.

The success rate of captures from pitfalls was low, with only 31 captures in total from all sites. One suggestion for improving the accuracy of species abundance for sensitive (to movement and noise) and evasive species such as *L.belliana* would be to estimate populations from lizard-hole exploration. Estimates of the abundance of burrowing reptiles such as *L.belliana* and *Varanus salvator* can be correlated with hole density within a given area, as generally, only one lizard is found per hole (Milne *et al.,* 2000).

In some cases, where habitat ranges overlap, lizards have been found to occupy small mammal (non-predatory) burrows. Repeated or severe episodes habitat fragmentation can lead to colonization and extinction of species with different resource requirements. If adjacent groups (e.g. reptiles and small mammals) are 'too close' together – e.g. dominance of insectivorous guilds, either of the groups could go extinct, depending on the overlap and the carrying capacity of the environment.

In cases where small mammal burrows provide lizards with key refuges (i.e. where habitat disturbance has led to competition for resources: food, nest sites), territorial lizards out-compete small mammals (Kerr & Bull, 2006). This may well be the case at S3 (scrub) and S6 (coconut scrub), where no mammals were recorded and where butterfly lizards might oust and evict small ground dwelling mammals.

Areas for future research could include assessing the response of herpetofauna to changes in environmental variables and fragmentation. As very little work has been done on even documenting the herpetofaunal species of the Setiu Wetlands. It is important we can continue to identify and document reptiles and amphibians in order to gain a better understanding of the impact of habitat loss and disturbance (Gillespie et al, 2005).

It has been shown that effective conservation management for amphibians and reptiles cannot be restricted to wetland areas alone. Large areas of terrestrial habitat surrounding wetlands are critical for maintaining biodiversity. Core terrestrial habitats have been found to range from 159 to 290 m for amphibians (frogs and salamanders) and 127 to 289 m for reptiles (snakes and turtles) from the edge of the aquatic site (Semlitsch et al, 2003). Terrestrial habitats are also important for herpetofaunal feeding and nesting, and, thus, the biological interdependence between aquatic and terrestrial habitats that is essential for the persistence of populations. (Semlitsch et al, 2003).

8. Invertebrates – Butterflies

8.1 Introduction

There are 1133 recorded species of butterfly in Malaysia, with 117 of these being endemic to the country. The butterfly populations of peninsular Malaysia can be separated into 3 distinct groups depending on their geographic origin – *Indo-Chinese*, *Sundanian* and *Oriental.* (Corbet & Pendlebury, 1992).

Tropical butterfly assemblages in particular are generally diverse, with many habitats having large numbers of endemic species, most of which are dependent to some extent on forest ecosystems (Sutton & Collins, 1991). Butterflies make a suitable group for ecological studies; they are relatively conspicuous to the untrained eye, mostly diurnal, their taxonomy is relatively well known. (Hill *et al.*, 1992; Spitzer *et al*, 1993; Beccaloni & Gaston, 1995) Their geographic distributions are fairly well studied the world over, and there is currently a high level of research being carried out in South East Asia through the National University of Singapore. This is in contrast to other insect groups in the tropics, where the taxonomy is often poorly known, and morpho-species are often used instead.

Butterflies are excellent potential bio-indicators of disturbance and fragmentation in both tropical and temperate regions since they demonstrate the most conspicuous responses to changes in environmental conditions. (Gilbert, 1984; Spitzer *et al.*, 1997; Kremen *et al.*, 1993). There is strong disparity in species distribution across the country, with small numbers of many species in undisturbed primary habitats, and large populations comprising few species in the secondary forests and disturbed areas. Moths, are equally good indicators of the health of an ecosystem, however survey methods applied would not be efficient in light of their nocturnal behaviour. Were traps to be used to a greater extent, then an improvement would be to look at the moth constitution within each surveyed habitat.

The dependence of the larval stages on a specific host plant e.g. *Ypthima* species on Poaecea grasses, and the adults' roles as pollinators for other plants, link butterflies closely to the diversity and health of their habitats (Blau, 1980; Kato, 1996; Ghazoul, 1997). For example host-plant butterfly larvae specificity means that a disturbance-related reduction in hosts will result in a clear reduction in the number of specific species of butterfly, with extinction the worst-case scenario (Koh *et al*, 2004 a&b).

Hammond & Miller (1998) conclude that the biodiversity of butterflies is linked to the ecosystem by influencing nutrient cycling, plant population dynamics, and predator-prey population dynamics. Butterflies are also very sensitive to changes in temperature, humidity, and light levels, parameters often affected by habitat disturbance (Wood & Gillman, 1998). The high temperature and humidity of the Malaysian tropics means that one brood of butterflies rapidly succeeds another throughout the year and the species are continuously on the wing. However, there is pattern of seasonality with previous records showing a naturally greater abundance between April to September across most of the country (Corbett & Pendlebury 1992).

However the value of using butterflies as indicators has also been criticised and questions have been raised due to their complexity (i.e. vulnerability to disturbance at different life cycle stages); bias towards the apparency of adults, the most active stage of life and the difficulties of monitoring such highly mobile taxa (Dennis *et al.,* 2006). In forest habitats particularly, species can often go undetected within dense canopies and sampling becomes non-random (Hardy & Dennis, 2005).

8.2 Results

A total of 38 species was found across all the survey areas and these belonged to one of the families of Nymphalidae, Lycaenidae, Pieridae or Papilionidae. All species found were endemic to Peninsular Malaysia and there we no species found which have been identified as under any kind of threat on the IUCN red list.

Table 8.1. A list of the species found across all sites is listed below:

Family	Sub-family	Species	Habitat
Nymphalidae	Danainae	*Ideopsis* sp	forest and wooded
		Ideopsis similis persimilis	forest and wooded
		Ideopsis vulgaris macrina	forest and wooded
		Ideopsis vulgaris	forest and wooded
		Danaus (salatura) affinis malayanus	coastal, mangrove
		Danaus genutia genutia	forest fringe and wooded
		Danuas sp.	virtually anywhere
		Euploea core gramnifera	virtually anywhere
		Euploea mulciber mulciber	forest and wooded
		Euploea sp.	virtually anywhere
		Parantica agleoides agleoides	primary and secondary forest
Nymphalidae	Satyrinae	*Ypthima pandocus*	forest fringe and wooded, long grass
		Ypthima huebneri	forest fringe and wooded, long grass
		Ypthima baldus newboldi	forest fringe and wooded, long grass
		Ypthima sp.	forest fringe and wooded, long grass
		Elymnias hypermnestra agina	forest fringe, woods, gardens, parks
Nymphalidae	Nymphalinae	*Cupha erymanthis lotis*	forest and wooded
		Lebadea martha parkeri	forest and wooded
		Lexias pardalis dirteana	forests (found on shady paths)
		Pandita sinope sinope	primary forest
		Lasippa heliodore dorelia	primary and secondary forest, scrub
		Rhinopalpa polynice eudoxia	primary forest
Papilionidae		*Papilio polytes*	farms, gardens forest fringes
		Graphium agamemnon spp	primary and secondary forest, scrub
		Papilio memnon agenor	forest fringe and wooded
		Papilionidae sp.	forest fringe and wooded
Lycaenidae		*Hypolycaena thecloides thecloides*	primary and secondary forest
		Hypolycaena erylus teatus	forest, wood, mangrove
		Arhopala sp.	forests
		Deremas Anyx	primary forest
		Zizina otis lampa	roadside and grassland
		Poritia erycinoides phraatica	primary forest

Family	Sub-family	Species	Habitat
Pieridae		*Catopsilla pyranthe pyranthe*	forest fringe and wooded
		Eurema camaralzeman paraclaudina	
		Eurema lacteola lacteola	primary forest (hills)
		Eurema simulatrix tecmessa	primary and secondary forest, scrub
		Eurema andersonii andersonii	primary forest
		Eurema sp.	primary and secondary forest, scrub
		Delias hyparete metarete	Urban and forested areas
		Delias hyparete	Urban and forested areas
		Appias libyhea olferna	primary and secondary forest, scrub
		Pieris canidia malayica/ malayana	farm and scrubland
		Pareronia valeria/ anais	primary and secondary forest, scrub
		Appias paulina distanti	primary forest
		Catopsilia pomona pomona	primary and secondary forest, scrub

Table 8.2 Diversity indices across all sites

Site	S	N	d	J	Fisher	H(Loge)	1-Lamda
S1	**8**	35	1.97	0.67	3.24	1.38	0.65
S2	**9**	27	2.43	0.86	4.73	1.89	0.84
S3	**3**	9	0.91	0.62	1.58	0.68	0.42
S4	**1**	8	0		0.31	0	0
S5	**9**	26	2.46	0.83	4.88	1.82	0.82
S6	**9**	117	1.68	0.48	2.27	1.05	0.57
S7	**9**	18	2.77	0.92	7.16	2.03	0.90
S9	**2**	2	1.44	1		0.69	1
S10	**13**	18	4.15	0.97	21.00	2.48	0.96
S11	**9**	36	2.23	0.89	3.85	1.96	0.86
S12	**14**	54	3.26	0.82	6.13	2.17	0.86

S - Number of Species: the number of species present in a community is a crucial aspect of that community’s biodiversity. The number of species varies between locations and can be a useful biodiversity indicator.
N - Total Number of individuals identified during the survey period.
D - 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. Species richness of the communities sampled in this study are based on same sample sizes and surveying effort.
J - Pielou’s Evenness: this is an expression of equitability and expressed as $J'=H'/H'_{max} =H'/\log S$ where H'_{max} is the maximum possible value of Shannon diversity, if all species were equally abundant.
5 Shannon-Wiener: represented as $H' = -\sum_i p_i \text{Log}(p_i)$ where p_i is the proportion of the total count arising from the ith species. The higher the figure obtained the higher the diversity of the area.

Table 8.3 Bray-Curtis similarity between sites on species level. (Calculated using group averages, standardised and with fourth root transformation).

S1	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S9**	**S10**	**S11**
S2	25.13									
S3	19.678	21.76								
S4	23.854	25.801	60.709							
S5	50.253	15.623	39.384	26.983						
S6	19.24	16.916	0	0	13.933					
S7	39.391	11.63	16.189	19.121	44.044	6.8093				
S9	21.067	23.124	44.544	62.712	24.161	0	36.195			
S10	0	7.5438	13.071	0	9.9736	5.7196	16.486	0		
S11	23.674	19.573	0	0	18.149	32.886	0	0	8.3249	
S12	35.656	28.422	15.463	17.69	34.31	13.999	38.432	25.147	5.5324	21.869

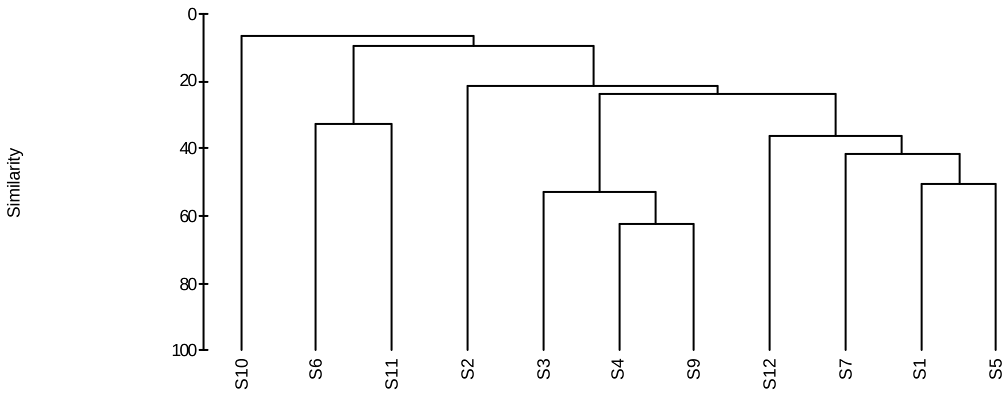

Figure 8.1 Dendrogram illustration of hierarchical agglomeration clustering technique, Clarke & Green 1988)

8.3 Discussion

Whilst large numbers of butterflies were caught across all sites, the numbers of species was relatively low. The species make-up is indicative of fairly high levels of disturbance, with most species identified as being common residents of peninsular Malaysia.

Of notable interest is the presence of the Common Tiger. There are a couple of forms of *Danaus genutia* with distinct distributions: the Langkawi and Malay proper forms. Recent work has shown the Malayan proper form to be increasingly dominant over the Langkawi form on the mainland (Corbett & Pendlebury, 1992), and our findings support this.

Whilst the Painted Jezebel has been shown to naturally inhabit forested and wood areas, it may also been found in large numbers in urbanised areas – the larvae feed on mistletoe, a common parasite of human-introduced plant species (Singapore Science

Centre). It is therefore an excellent example of a generalist butterfly species expected to occupy disturbed habitats.

The Cabbage White finding is interesting – the 2 sub-species, *Pieris canidia malayan* and *P. canidia malayica* are only thought to be resident to Singapore and still recorded absent from Malaysia and Thailand (www.arcbc.org). Recent work suggested that it may have been identified in Johor, and hence crossed the straight into Southern Malaysia. However, this is the first recorded sighting of it in the Northern states of Malaysia. Further investigation to ascertain numbers in the survey area would be a useful research area.

Tropical rainforests and mangroves in particular, are a habitat providing an ecological niche for a high diversity of Lepidopteran species, and support a complex web of dependent orders. The many individuals from a reduced range of species caught by the hand-held nets may will be indicative not only of some species being quicker to escape the swooping net, but also of the high level of specificity of butterflies to the host plants within their lifecycle.

The low diversity captured at "net level" also reflects the exponential co-extinction of species butterflies with host plants (Koh, Sodhi & Brook 2004) highlighting the importance of conservation of entire habitats to preserve the butterfly communities in a given niche. Improvements within the surveying would be the use of baited traps. The hand-netting method is clearly biased towards the weaker and lower flying species such as *Ypthima* species.

Within the context of the localised habitat ecosystem, the reduction in species number will in turn create an overall reduction in number for the butterfly predators.
Would anticipate that the data here represents only a fraction of the picture, and were survey work carried out to include canopy-dwelling species, i.e. use of fruit-bait traps, then would see a more concerning lack of diversity compared to a control ecosystem, i.e. untouched mangrove (Dumbrell &Hill 2005).

9 Conclusions

This report documented the results of the MTFCP, Setiu Phase undertaken by CCC and PERHILITAN during 2004-2006.

During the project, surveys were undertaken in eight habitat types: coconut scrub, casuarina forest, dry forest, lagoon, mangrove, peat forest and scrub. Supplementary surveys were undertaken in areas of Gelam, dry and wet, the Islet of Pulau Gemia and in a Palm oil plantation.

Within these habitats, surveys focused on five faunal groups: birds, bats, non-volant mammals, herpetiles and butterflies. Table 9.1 summarises the main findings for these faunal groups and show the relative value of each site in terms of species diversity and faunal group abundance.

Two sites, the peat forest at S10 and mangrove at S12, emerge as key habitats for both species diversity and group abundance. S10 shows relatively high levels of species diversity and numbers of individuals across all five faunal groups. The peat forest scored the highest levels of diversity for mammal and herpetile species, although species diversity in these two faunal groups is generally low across all survey sites. S12 scored highest for bird and butterfly diversity and also yielded the most individual bird observations.

It is clear the region is home to rich and varied bird life. The median for bird species identification was 20 species per site, although total numbers of species varied from 6 (S7) to 35 (S12) across the sites. The habitats support many generalist bird species, notably bulbuls (*Pycnonotus* sp.). Specialists groups such as woodpeckers (Picus sp.) were also recorded. Two red-listed species were observed: the Scarlet-breasted Flowerpecker (Prionochilus thoracicus) and the Lesser Green Leafbird (Chloropsis cyanopogon) both of which are classified Near Threatened (IUCN, 2004).

The dry forest at S7 is an important habitat for bats in the region and this site scored highest for bat species and individuals. Megachiropterans comprised 54% of all captures, although microchiropterans dominated at S7. Two Red Listed (Near Threatened) species were captured: the Dyak fruit bat (*Dyacopterus spadiceus*) and Creagh's horseshoe bat (*Rhinolophus Creaghi*).

Small mammal diversity and abundance was relatively low across all survey sites and could be linked to out-competition for niches by herpetiles, in particular ground dwelling lizards such as the Common Butterfly Lizard (*Leioplis belliana*). The majority of mammal captures were represented by commensural Muridae species from the *Rattus* genus associated with habitation and agricultural areas. Large mammals were observed, including two primates: Dusky faced Langurs (Trachypithecus obscurus) and Long-tailed Macaques (Macaca jascicularis) and the Smooth-coated Otter (Vulnerable).

Table 9.1 Summary of faunal groups species diversity and group abundance by location.

Faunal Group	Survey Site																									
	S1		S2		S3		S4		S5		S6		S7		S8		S9		S10		S11		S12		Total	
	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I
Birds	12	104	18	119	17	164	10	43	14	53	27	289	6	33	33	268	21	114	22	149	33	295	36	305	84	1942
Bats	1	1	3	4	4	12	-	-	-	-	-	-	5	12	-	-	1	1	4	6	-	-	1	1	15	37
Mammals	-	2	1	1	-	-	2	3	2	12	-	-	2	10	-	-	2	16	3	39	-	1	1	8	6	92
Herpetiles	4	56	3	37	5	25	2	5	4	13	6	59	1	1	-	-	1	11	7	31	4	179	1	1	23	418
Butterflies	8	35	9	27	3	9	1	8	9	26	9	117	9	18	-	-	3	2	13	18	9	36	14	54	38	350
Total	25	198	24	188	29	210	15	59	29	104	42	465	24	74	33	268	27	144	49	243	46	511	53	369	-	

Table 9.2 Summary of faunal goups species diversity and group abundance by location for supplementary sites.

Faunal Group	Supplementary Survey Site									
	Gelam - Dry		Gelam - Wet		Islet		Palm Oil Plantation		Total	
	S	I	S	I	S	I	S	I	S	I
Birds	16	62	12	18	18	100	16	256	36	436
Bats	1	1	-	-	1	1	1	3	3	5
Mammals	-	-	1	1	-	-	-	-	1	1
Herpetiles	3	21	1	2	6	19	7	55	11	97
Butterflies	?	?	?	?	?	?	?	?	?	?
Total	?	?	?	?	?	?	?	?	?	?

NB S - Total number of species. I - Total number of individuals

Recommendations

The results from this study suggest it is generally the habitats that retain dense vegetation and/or tree cover, which provide the best conditions for maintaining biodiversity in the Setiu region. The mangrove at S12, Peat forest at S10 and Dry forest at S7 all harboured highest values for faunal groups. However looking at habitat maps (see chapter 2), these habitat types are highly fragmented and not well represented in the Setiu region. It is interesting to note that the mangroves at S9 did not score as high as S12. One reason for lower levels of diversity here could be the influence on fisheries and aquaculture in the mangroves at S9.

The biggest threats to the region are habitat fragmentation from agricultural expansion and palm oil plantations, aquaculture and from urban development. These pressures are replicated all across southeast Asia and key habitats such as peat swamp forests like S10 have been favoured for agricultural use and conversion to plantations and are now rare (Whitten et al, 2005). Quantifying the effects of fragmentation in areas such as Setiu should be prioritised.

Many wetland habitats in Southeast Asia are also threatened by global climate change and rises in sea level (Watson et al, 1998). Although assessing the impacts of climate change was not within the remit of the MTFCP, the implications of environmental change caused by rising sea levels, in Setiu, a low lying region, are serious. Future work in the region could detail the potential threats and vulnerability of the coastal zone and of the wetland habitats to climate change.

In-depth research using advanced survey techniques would be valid for the region's fauna, in particular for identifying further species within the five faunal groups studied here. For birds, indicator species such as woodpeckers (*Picus* sp.) could benefit from audio-aided techniques such as playback attraction for territorial birds. For bats, harp traps and/or sonar detection for microchiropterans could increase the efficiency of captures for echolocating species inordinately.

Long-term studies of the large mammals found in Setiu, such as the Dusky faced Langurs (*Trachypithecus obscurus*) could help identify the regional status of primates and whether the forest habitats are large enough for population stability.

Once inventories are established, resource managers will be better placed to implement sustainable conservation plans for the biodiversity of the Setiu Wetlands.

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