LAPORAN AKHIR PROJEK PENYELIDIKAN JANGKA *PENDEK*

FINAL REPORT OF SHORT TERM RESEARCH PROJECT

Sila kemukakan laporan akhir ini melalui Jawatankuasa Penyelidikan di Pusat Pengajian dan Dekan/Pengarah/Ketua Jabatan kepada Pejabat Pelantar Penyelidikan

1. **Nama Ketua Penyelidik:** DR NURUL SALMI ABDUL LATIP
   Name of Research Leader

   ☐ Profesor Madya/ *Assoc. Prof.* ☒ Dr./ *Dr* ☐ Encik/Puan/Cik *Mr/Mrs/Ms*

2. **Pusat Tanggungjawab (PTJ):**
   School/Department

   PUSAT PENGAJIAN SAINS KAJIHAYAT

3. **Nama Penyelidik Bersama:**
   Name of Co-Researcher

   DR. KHAIRUN YAHYA

4. **Tajuk Projek:**
   Title of Project

   Phytosociology of mangrove forests and fisheries production

5. **Ringkasan Penilaian**/*Summary of Assessment:*	Tidak Mencukupi *Inadequate* 1	2	Boleh Diterima *Acceptable* 3	Sangat Baik *Very Good* 4	5
i) **Pencapaian objektif projek:** *Achievement of project objectives*	☐	☐	☒	☐	☐
ii) **Kualiti output:** *Quality of outputs*	☐	☐	☒	☐	☐
iii) **Kualiti impak:** *Quality of impacts*	☐	☐	☒	☐	☐
iv) **Pemindahan teknologi/potensi pengkomersialan:** *Technology transfer/commercialization potential*	☐	☐	☒	☐	☐
v) **Kualiti dan usahasama :** *Quality and intensity of collaboration*	☐	☒	☐	☐	☐
vi) **Penilaian kepentingan secara keseluruhan:** *Overall assessment of benefits*	☐	☐	☒	☐	☐

6. Abstrak Penyelidikan
(Perlu disediakan di antara 100 - 200 perkataan di dalam **Bahasa Malaysia dan juga Bahasa Inggeris**. Abstrak ini akan dimuatkan dalam Laporan Tahunan Bahagian Penyelidikan & Inovasi sebagai satu cara untuk menyampaikan dapatan projek tuan/puan kepada pihak Universiti & masyarakat luar).

Abstract of Research
(An abstract of between 100 and 200 words must be prepared in Bahasa Malaysia and in English). This abstract will be included in the Annual Report of the Research and Innovation Section at a later date as a means of presenting the project findings of the researcher/s to the University and the community at large)

See attached abstract

7. Sila sediakan laporan teknikal lengkap yang menerangkan keseluruhan projek ini.
[Sila gunakan kertas berasingan]
Applicant are required to prepare a Comprehensive Technical Report explaining the project.
(This report must be appended separately)

LAPORAN DILAMPIRKAN

Senaraikan kata kunci yang mencerminkan penyelidikan anda:
List the key words that reflects your research:

Bahasa Malaysia	*Bahasa Inggeris*
ekosistem Bakau	mangrove ecosystem
diversiti dan kelimpahan spesies	species diversity and abundance
lembangan Sg. Kilim	Sg. Kilim catchment

8. Output dan Faedah Projek
Output and Benefits of Project

(a) * **Penerbitan Jurnal**
Publication of Journals
(Sila nyatakan jenis, tajuk, pengarang/editor, tahun terbitan dan di mana telah diterbit/diserahkan)
(State type, title, author/editor, publication year and where it has been published/submitted)

Tiada. Persembahan projek dibuat dalam bentuk poster di dua program Jabatan Perhutanan tetapi tiada buku abstrak dikeluarkan untuk kedua-duanya.

(1) Abdul Latip, N.S dan Yahya, K. (2006) Manfaat daripada bakau: Adakah anda berbaloh? Seminar Hutan Persisiran Pantai Negara: Peranan Agensi Kerajaan dan masyarakat tempatan. 23-25 November 2006, Kuala Perlis, Perlis.

(2) Abdul latip, Tahir, R. dan Yahya K. (2007) The status of mangrove in Sg. Kilim basin, Langkawi. Seminar Hutan Persisiran Pantai Negara. 5-7 November 2007, Paka, Terengganu.

(b) **Faedah-faedah lain seperti perkembangan produk, pengkomersialan produk/pendaftaran paten atau impak kepada dasar dan masyarakat.**
State other benefits such as product development, product commercialisation/patent registration or impact on source and society.

Hasil daripada projek ialah inventori species paya bakau, koleksi herbarium untuk pusat pengajian dan koleksi gambar species yang terpenting bakau. Koleksi ini telah digunakan untuk pengajaran pelajar pusat pengajian "outreach" program bersama pelajar-pelajar sekolah rendah dan menengah dan untuk program International Tropical Field School bersama pelajar-pelajar University of Victoria, Canada

* Sila berikan salinan/*Kindly provide copies*

(c) **Latihan Sumber Manusia**
Training in Human Resources

i) Pelajar Sarjana:
Graduates Students
(Perincikan nama, ijazah dan status)
(Provide names, degrees and status)

Tiada

ii) Lain-lain: Latihan di lapangan pelajar-pelajar siswazah dan sekolah di sepanjang program berlangsung dan selepas projek tamat
Others

9. Peralatan yang Telah Dibeli:
Equipment that has been purchased

Tiada

Tandatangan Penyelidik
Signature of Researcher

19 APRIL 2012
Tarikh
Date

Komen Jawatankuasa Penyelidikan Pusat Pengajian/Pusat
Comments by the Research Committees of Schools/Centres

Penyelidik telah menghasilkan dokumen inventori spesies paya bakau, koleksi spesimen voucer dan gambar.

25/4/12

TANDATANGAN PENGERUSI JAWATANKUASA PENYELIDIKAN PUSAT PENGAJIAN/PUSAT
Signature of Chairman [Research Committee of School/Centre]

PROFESOR SITI AZIZAH MOHD NOR
Timbalan Dekan
(Pengajian Siswazah dan Penyelidikan)
Pusat Pengajian Sains Kajihayat
Universiti Sains Malaysia

Tarikh
Date

Lampiran

ABSTRACT

Mangrove composition, abundance and diversity in the Sungai Kilim basin, Langkawi, was analysed during a number of fieldworks carried out between 2006 and 2007. Field sampling and treatment of specimen and herbarium collection followed standard procedures. A total of 1915 individual trees were enumerated comprising a total of 7 families with 15 species of true mangrove and 10 species of minor and associate mangrove found from the study site. At all sampling stations Rhizophoraceae was the most dominant family with 65.74% found followed by Avicenniaceae (23.76%) and Meliaceae (8.93%). The number of individuals of mangrove trees showed that *Ceriops tagal* (Rhizophoraceae) (27.10%) is the most common species found at the sampling stations, followed by *Rhizophora apiculata* (Rhizophoraceae) (22.35%) and *Bruguiera cylindrica* (Rhizophoraceae) (12.11%). Cluster analysis showed that two groups of vegetation can be identified based on their similarity, Avicenniaceae and Rhizophoraceae. Patterns of zonation from the seaward to landward margin vary between sites depending on site location but not clearly designated. This could be due to past and present human activities, such as, cutting of *Ceriops* trees by villagers or fishermen. No other serious threats for mangrove were observed in the basin except for local consumption of the vegetation.

(200 words)

ABSTRAK

Komposisi, kelimpahan dan kepelbagaian vegetasi bakau telah dianalisa di lembangan Sungai Kilim, Langkawi dengan menjalankan beberapa kerja lapangan antara tahun 2006 dan 2007. Kerja lapangan dan pengendalian spesimen serta koleksi herbarium dijalankan mengikut prosedur standard. Sejumlah 1915 individu pokok telah dikaji dengan hasil 7 famili bersama 15 spesies bakau tulen dan 10 spesies bakau minor dan "associate" di tapak kajian. Di semua stesen penyampelan Rhizophoraceae adalah family paling dominan iaitu 65.74% diikuti oleh Avicenniaceae (23.76%) dan Meliaceae (8.93%). Daripada bilangan individu pokok *Ceriops tagal* (Rhizophoraceae) (27.10%) ialah spesies yang paling tinggi bilangannya di semua stesen penyampelan, diikuti *Rhizophora apiculata* (Rhizophoraceae) (22.35%) dan *Bruguiera cylindrica* (Rhizophoraceae) (12.11%). Analisa kluster mengenalpasti dua kumpulan vegetasi daripada aspek kesamaan, iaitu yang berkait dengan Avicenniaceae and Rhizophoraceae. Corak zonasi bervariasi daripada laut ke daratan bergantung kepada lokasi tapak tetapi tidak dapat dibezakan dengan jelas. Ini mungkin disebabkan aktiviti manusia yang lepas, seperti, penebangan pokok *Ceriops* oleh penduduk setempat atau nelayan. Tiada ancaman serius lain kepada hutan bakau yang diperhatikan di sekitar lembangan kecuali penggunaan vegetasi ini oleh penduduk setempat untuk kegunaan sendiri.

(177 perkataan)

FINAL REPORT FOR SHORT TERM GRANT

PHYTOSOCIOLOGY OF MANGROVE FORESTS & FISHERIES PRODUCTION

ACCOUNT: 304 PBIOLOGI 637006

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1. INTRODUCTION

1.1 INTRODUCTION

Mangrove forests form one of the major wetland types in Peninsular Malaysia. The importance of mangrove forest goes beyond their status as a habitat of many endangered flora and fauna species. Mangroves in Peninsular Malaysia are found mainly on the sheltered west coast that borders the Straits of Malacca in the states of Kedah, Perak, Selangor and Johor. At the end of 2006, their total estimated cover is 107,802 ha, of which 82,091 ha has been gazetted as Permanent Forest Reserve (PFR). Perak has the largest mangrove reserves, followed by Johor and Selangor (Jabatan Perhutanan Semenanjung Malaysia, 2005). Forestry Department of Peninsular Malaysia (2010) stated that, the total of mangrove forests in Malaysia is 0.1 million ha in 2009. Malaysia's mangroves are more diverse than those in tropical Australia, the Red Sea, tropical Africa and the Americas. About 50% of fish landings on the west coast of Peninsular Malaysia are associated with mangroves (Sasekumar et al., 1990). Prior to 1990 Malaysia had lost almost 30% of her mangroves and the rate is expected to continue at a rate of 1% a year (Gong and Ong, 1990).

Mangroves on the west coast of Peninsula Malaysia are more widespread than the east coast. This may be due to the different wave patterns of water bodies bordering the east and west coasts of the peninsula. The eastern side of Peninsula Malaysia is bordered by the South China Sea that has larger and more energetic waves while the west coast is bordered by the Straits of Malacca that has a limited wind fetch and is thus relatively calmer (Mohd Lokman and Yaakob, 1995). This accounts for the more widespread and rapid deposition of fine sediments and mangroves on the west coast of the Peninsula. The east coast mangroves totalled less than 12 000 ha compared to over 91 000 ha found along the west coast (Shaharudin et al., 2001).

The east coast mangroves are found almost entirely inside the estuaries, while the west coast mangrove are found fringing the coastline fronting the

Straits of Malacca and also inside river estuaries. The east coast mangroves are normally found inside the estuaries, lining the banks up to the tidal limit, which may reach up to 20 km upstream. They are normally fragmented and found in small pockets. As mangroves have thus far been known for their ecological links to nearshore fisheries, the small and fragmented patterns of the east coast mangrove has rendered them to be viewed as unimportant. Many areas of mangroves have been removed to make way for development, particularly at the shores of the estuaries as these areas are considered as prime real estate. The physical role of mangroves, particularly, in protecting the riverbanks has failed to receive attention. Mangrove removal coupled with increasing water traffic has resulted in severe bank erosion in estuaries (Mohd Lokman and Sulong, 2001).

Mangrove are woody plants that can be found at the interface between and sea in tropical and sub-tropical altitudes with high salinity, extreme ides, strong winds, high temperatures, muddy and anaerobic soils. Mangroves are defined as plants, shrubs, palms and ferns that are growing within the inter-tidal region of coastal and estuarine environments in the tropics and subtropics.Perhaps, no other group of plants that occur with such highly developed morphological and physiological adaptations to extreme conditions (Kathiresan & Qasim, 2005). In addition, mangrove forest is an edaphic community which is influenced by physical locations, soil properties, salinity, tidal action and water conditions and exposure to strong winds and currents (Alongi, 2002). Mangrove forests are among the world's most productive ecosystems and they have functions in enriching coastal waters, yield commercial forest products, protect coastlines area and support fisheries (Kathiresan & Qasim, 2005).

Mangrove forests play important roles to ecosystem such as protect coastlines, prevent salt water from intruding into rivers, retain, concentrate and recycle nutrients, provide resources. A mangrove forest is a very dynamic and highly productive ecosystem. It not only plays multiple ecological functions essential to its surrounding habitats, but is also an important resource for coastal communities. They are important by trapping debris in soil formation (Kathiresan & Qasim, 2005). They also serve as sieve for rich organic soil washed down through river systems into sea. Mangroves play a role both on land and in the water which this plant species is a terrestrial tool is by stabilizing shorelines. They create a wall between the land and the sea protects the shoreline from erosion and minimizes destruction from powerful waves. Due to mangroves being a naturally flexible plant, they are able to withstand severe damage of winds, waves, and changing tides for thousands of years (Kathiresan & Qasim, 2005). Mangroves live in shallow water areas and gather sediments that support the root structures. Mangrove forests help to build up soil along tropical coastlines, buffer from storms.

Mangrove areas in Langkawi cover approximately 3142 ha (Jabatan Perhutanan Semenanjung Malaysia, 2003) and the largest area is at the Kisap Forest Reserve with 1336 ha of mangrove forest. Mangroves of Langkawi are considered as uniq ue and rare occurrence, in the sense that they are found on shallow limestone substratum areas. The mangrove vegetation in this area is quite diverse and includes many important species; some with medicinal properties. The limestone hills of the area have a rich diversity of species of ornamental plants such as the cycads and orchids,the limestone rocks also support many bryophytic flora, lichens and macro fungi (Wan Juliana et al., 2008). Japar (1994) reported that Malaysia has 38 exclusive, 57 non-exclusive and more than 10 associated mangrove biota. Thus, this data proved Malaysia as one of the diverse mangrove population in the world.

Malaysia mangroves serve a home for many different organisms that are found in the mangrove areas are all labelled as being euryhaline-able to withstand wide variations of salinity. Mangrove provides a habitat for many popular marine organisms such as crabs, shrimps, and oysters, coral fish (Sasekumar et al., 1990). They also provide habitats for wildlife, including several commercially important species of fish and crustacean and in at least some cases export of carbon fixed in mangroves is important in coastal food webs. Mangrove plantations are grown in coastal regions for the benefits they provide to coastal fisheries and other uses. Other animals that find shelter in the branches and are adapted to mangroves include bats, Proboscis monkeys, snakes, otters, the fishing cat, and fireflies.

Since the mangrove forests of Langkawi especially at Kilim Geoforest Park areas are facing impacts from increasing of boat traffic, coastal development such as reclamation, erosion, accretion and sedimentation, which are mostly for ecotourism activities. Hence, the objective of this study is to assess floristic composition and diversity of Kilim Geoforest Park. This study is necessary to begin conservation assessment that will provide baseline ecological data for sustainable management of the mangrove forest in Malaysia.

1.1 FOREST RESOURCES

Along the northeast coast of Langkawi, behind Tanjung Rhu beach is a large tract of intact mangrove forest. Mangrove forests are important link in maintaining the dedicate balance of the eco-systems particularly with its unique root systems which prevent soil erosion and clean the waters. The mangrove forest of Langkawi ,the only ones in Malaysia which grow on limestones bed, and is a sanctuary for birdlife , insects, reptiles, primates and other wildlife. Forestry Department of Kedah has gazetted a total of 346,343 million hectares or 99.2% of forested area as permanent forest reserve to be managed in a sustainable approach to ensure a balanced use of forested areas especially for economic development. There are several types of forest that can be found in Kedah which are land forest (336,140 ha), mangrove forest (7,949 ha) and plantation forest (2,254 ha). At the end of 2002, it was noted that for about 26,902 ha or 7.5% of the total forested area in Kedah stated as permanent forest reserve in Pulau

Langkawi which were 23,760 ha (87.3%) is forested land while the remainder of 3,142 ha (12.7%) is mangrove forest (Shaharudin et al., 2001).

Most of the Kilim basin, Langkawi is forested areas and it has been divided into several numbers of permanent forest reserves such as Gua Cherita Permanent Forest Reserve, Pulau Langgun, Kuala Kisap, Tanjung Dagu, Selat Panchur and Pulau Timun. All the forest reserve within Kilim basin has been classified as protected forest by Forestry Department of Kedah to ensure the optimum used of forest resources (Shaharudin et al., 2001). Kilim basin has a unique ecosystem consisting of limestone ecosystems and mangroves which provides important habitat for several species of birds and birds as well as aquatic species (Shaharudin et al., 2001).

Besides that, a lot of mangrove trees can be found in Kilim basin area. A total of 230 individual trees with 5 families with 7 species at the Ayer Hangat Forest Reserve while at the Kisap Forest Reserve, 218 individual trees with 4 families and 6 species were recorded with *Rhizophora mucronata* (Bakau kurap) from Rhizophoraceae as the highest species found for both sites. It is followed by other species such as *Avicennia marina* (Api-api merah), *Lumnitzera littorea* (Teruntum merah), *Xylocarpus moluccensis* (Nyireh batu), *Ceriops tagal* (Tengar samak) and *Sonneratia alba* (Perepat) were recorded (Wan Juliana et al., 2008).

Mangrove species such as *Rhizophora mucronata* (Bakau kurap) and *Rhizophora apiculata* (Bakau minyak) are the most preferred species for making firewood because this type of wood is heavy, hard and ignites easily even when partially dry. Beside firewood product, mangrove tree species are utilized as poles, raw material for charcoal production and the minor uses of mangrove trees include production of scaffold poles, fishing stakes and tannin. However, only a few of mangrove species are found to be utilizable such as *Bruguiera parviflora* (Lenggadai), *Bruguiera gymnorrhiza* (Tumu), *Bruguiera cylindrica* (Berus), *Ceriops tagal* (Tengar) and *Xylocarpus moluccensis* (Nyireh batu). For example, mangrove species such as *X. moluccensis* (Nyireh batu) is an attractive timber and useful as excellent furniture and cabinet works.

Other than mangrove forest Langkawi is also occupied by rainforest is rich in varieties of flora that lends itself to medicinal cures, fragrances, lotions and pigments while flowers, fruits, sap, bark, leaves and roots that are utilized by locals for their traditional medicinal properties.

1.2 STUDY SITE

Langkawi, situated off the Northwestern coast of Peninsular Malaysia, comprises a group of 104 tropical islands during low tides and 99 Island during high tide. The main island Langkawi is 47,848 hectare in size (Figure 1). Situated at latitudes 6°10°N to 6°30°N and longitudes 99°35°E to 100°E, Langkawi has a tropical monsoon climate with a high annual temperature of between 24°C to 33°C. The islands are 30 km from the coast of the Malaysian state of Kedah, of which they are administratively a part, near the Malay–Thai border. The study area was divided into three study sites i.e. River Kisap, River Kilim and River Ayer Hangat of Kilim Geoforest Park. These three riverine were rich with mangrove forest, flourished on limestone formation, which is a rare occurrence. The topography varies from flat coastal plains, hilly areas to rugged mountains.

The study site, Kilim basin, is located in the north-eastern of Langkawi Island and the main source of water supply is from Gunung Raya and low hills in the east. The basin is bounded by the Gunung Ayer Hangat basin in the north and Kisap basin in the south. Kilim basin area has undulating topography of low hills in the western part of the bottom of Gunung Raya, while the eastern part is formed by hills and karst island with formation of extensive mangroves (Wan Juliana et al., 2008). There are several permanent forest reserves within Kilim basin such as Gua Cherita Forest Reserve, Pulau Langgun, Kuala Kisap, Tanjung Dagu, Selat Panchur and Pulau Timun. On 1st June 2007 Langkawi was declared as the world's 52nd Geopark and the first in Southeast Asia, by UNESCO Global Network of Geoparks. Langkawi geological history dates back over 500 million years such as the Machinchang Cambrian Geoforest Park and Dayang Bunting Marble Geoforest Park. The islands contain unique rock formations including numerous caves. Kilim Geoforest Park experiences dry season lasting two to three months between December and March, which may influences the flora to have an affinity to those happened in Burma and Thailand. The ecosystems of the old limestone rock formation, the caves, the mudflats and the seas that surround it have three main types of vegetation i.e. the mangroves, the vegetation of the limestone hills and the flora of the mudflats and beaches.

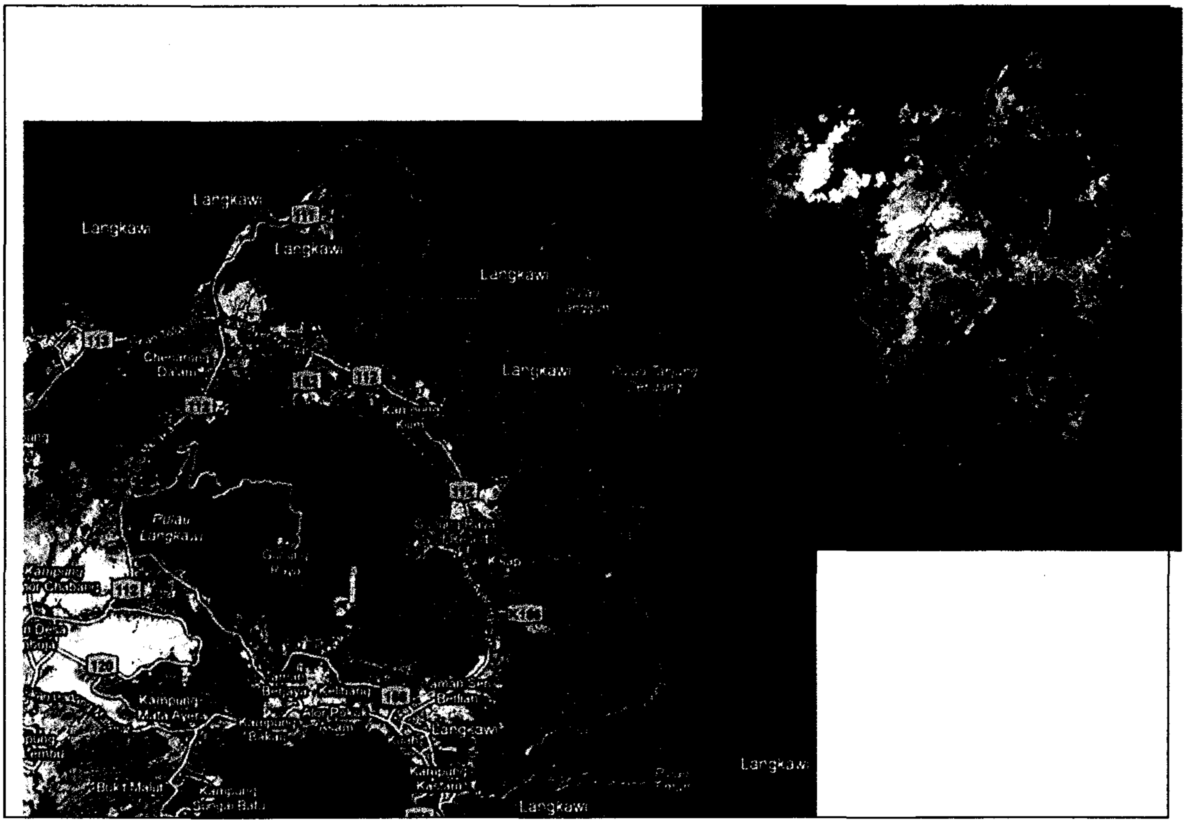


Figure 1. Pulau Langkawi (inset) with red box indicating the study site.

A variety of attractions can be found in this basin such as caves, karsts landscape of the islands and hills, a variety of rock types, fossils and geomorphology, mangrove forests, habitat of flora and fauna and others. All the features have the special intrinsic values such as the history of rock formations, ancient life, landscapes and development of modern life that are part of the elements of tourism attraction and educational materials as well as continued research. In addition, the geology and biology resources with unique landscape are a legacy that should be preserved and conserved in line with the concept of Geoforest Park (Fatheen Nabila et al., 2012).

2. METHODOLOGY & DATA ANALYSIS

2.1 METHODOLOGY

Several fieldwork were conducted to obtain species composition inventory in other parts of the Ayer Hangat mangrove forest reserve. The inventory took place in November-December 2006 and involved a team of 12 people. The inventory covered Sg. Padang Lalang, Sg. Ayer Hangat, Sg. Tok Kassim, Sg. Itau, Sg. Batu Gajah and Sg. Keluang (Figure 2). These rivers are tributaries of the Sg Ayer Hangat and all were vegetated by various mangrove stands from the river mouth to the innermost tributary, Sg. Batu Gajah.

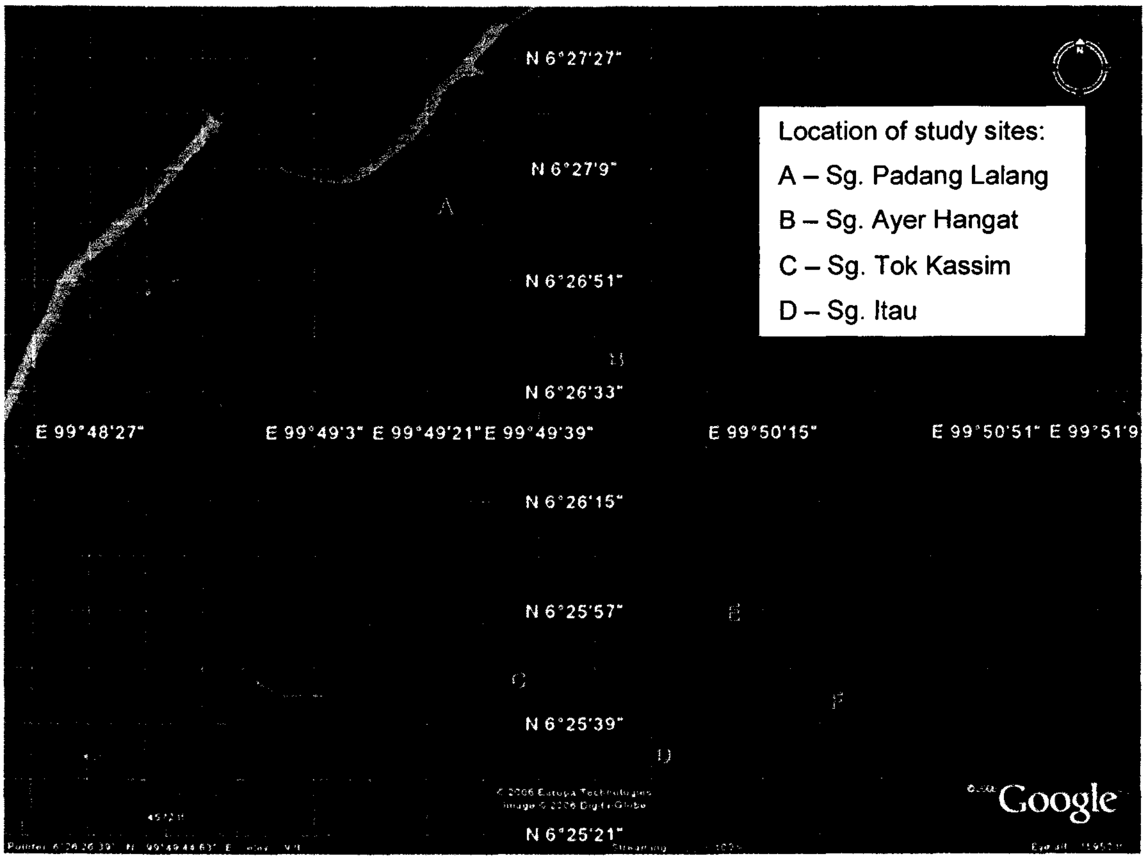


Figure 2. Location of study site, Ayer Hangat mangrove forest reserve. Coloured alphabets indicate the rivers visited for species inventory.

All sampling stations establishment and field surveys on tree species composition at mangrove area in Sungai Ayer Hangat (Figure 1) and other measurements were conducted in December 2006. The sampling stations consisted of 13 plots of 20 m x 20 m plot arranged along Sungai Ayer Hangat area.

In terms of salinity, all rivers were found to be affected by salt water and experience tidal influence. Thus, the distribution of true mangrove stands was found as far as 6-7 km inland. Due to lack of freshwater input low salinity tolerants such as *Sonneratia caseolaris* and *Nypa fruticans* were not present. However, a few individuals of the latter were found in freshwater pools fed by rainwater.

The inventory aimed to produce a mini-monograph of mangrove species as well as a collection of herbarium specimens. The mini-monograph will be used to assist in species identification in the detailed sampling procedures to be collected in other fieldwork exercises.

2.1SAMPLING DESIGN

Quadrat sampling method was used to record all plants (Maurice, 1969). At least three (3) sampling points were identified based upon two main criteria; accessibility and safety, within each sampling site. From each sampling point, two 20 x 20 m quadrats were constructed inland from the water edge of Sungai Kilim area.

Figure 3 shows the sampling design which was used. All plant species in the quadrat were recorded and specimens with flowers and/or fruits were collected. Habitat condition were described based upon plant niche, such as whether the plant grows in sun or shade; woods, field, marsh and water. Observations on plant condition include flower colour, condition or any other observation for identification such as flower, twig, leaf odour, leaf arrangement and leaf venation will be recorded (MacFarlane, 1985).

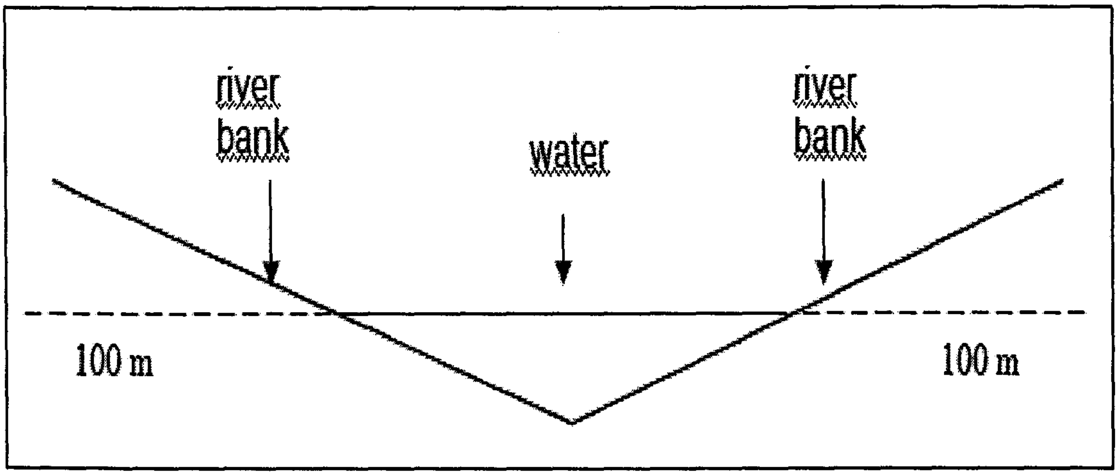


Figure 3. Standard sampling design for riparian vegetation sampling for lakes and rivers.

Whenever possible, a disease-free, intact fresh specimen of plant species was collected. Important plant parts such as flower and fruit, if available was collected to assist in species identification. Specimens were brought back to the laboratory for further identification (if possible up to species level) and made into herbarium voucher. Every species in the quadrat was counted and recorded. Small plants such as grasses, sedges and herbs were to be visually counted using a PVC quadrat ($1m^2$). Forest resources (e.g. rattan and fruiting trees) and environmental factors of the sampling area such as humidity, temperature, and light density were also recorded. The environmental factors were recorded to study their correlation with the growth of vegetation at wetland areas. Besides that, tree's height and diameter at breast height (DBH) were also measured to determine the total above ground biomass.

Table 1 indicate materials used for fieldwork, specimen collection and preservation.

Table 1 Materials used in the study.

	Material	
1	Ropes	To construct sampling plots
2	Bottles	To place sample (e.g. leaves and fruits) for preservation
3	Plastics	to store all specimens from collected sites
4	Newspapers	to wrap specimens after cleaning with alcohol
5	Alcohol	To clean all specimens collected for herbarium process
6	FAA (formalin + acitic acid + alcohol)	For specimen preservation (e.g. leaves and fruits)

2.2 LABORATORY ANALYSIS – HERBARIUM

In the laboratory, plant specimens were cleaned from dirt such as soil at the roots and then soaked into 70% alcohol before arranging it on several newspaper. Two leaves were turned over to show the underside. Carefully, the flowers were spread, so that every petal lies smoothly. Every leaf and petal must be neatly spread and unwrinkled (MacFarlane, 1985). Then, the plant was sandwiched between the newspapers. The herbarium then was laid on the plant press and strapped as tight as possible. After that, the plant was dried in the oven at 60^{o} C for 3 or 4 days.

After drying, the plant was sewed onto herbarium paper. Parts of the plant such as seeds and fruits were put into a transparent small bag. The bag then was glued at the left side of the plant on the herbarium sheet. Lastly, the herbarium was labelled. Each label has a title and the name of the herbarium where the collection is housed. The labels contain species, genus and family; date, altitude (if in the mountain), locality, and habitat, notes, collector and number and also name of person identifying the plant (MacFarlane, 1985).

2.3 DATA ANALYSIS

2.3.1 Shannon-Wiener Diversity Index and Evenness Index

These indices were applied to plant diversity study of Sungai Kilim and were computed for each sampling station. The indices were calculated by using Multi-Variate Statistical Package (MVSP) version 3.1.

Shannon-Wiener Diversity Index:

$$H' = -\sum \frac{ni}{n} \ln \frac{ni}{n}$$

Where:

H'= Shannon-Weiner diversity index

ni = number of individuals in each species

n = total number of individuals obtained

Evenness Index:

$$E = \frac{H'}{\ln(S)}$$

Where:

H' = Shannon's index

S = total number of species in a sample

2.3.2 Cluster Analysis

This analysis was applied to plant diversity study and it was used to measure vegetation similarity between the sampling sites (Krebs, 1989). It is also used to describe a set of numerical techniques in which the main purpose is to divide the objects of study into discrete groups. The clustering was done by using Multi-Variate Statistical Package (MVSP) version 3.1.

3.0 RESULTS

3.1 VEGETATION COMPOSITION, DISTRIBUTION AND DIVERSITY

A total of 15 species and 9 genera from 7 families of mangrove trees (timber tree) have been recorded at 13 sampling stations in Sungai Ayer Hangat area (Table 2 and Table 3). In terms of individual counts, a total of 1915 trees have been recorded. The first three main families which dominated the stations at Sungai Kilim area were Rhizophoraceae (65.74%), Avicenniaceae (23.76%) and Meliaceae (8.93%) based on individual counts. Another 12 families only found less than 1% in the sampling stations (Table 1).

Rhizophoraceae was recorded the highest number of individual counts which was 1259 of mangrove tree. Besides that, this family was dominant in terms of the number of genus and species recorded in the stations and random survey conducted in the study. Overall, Rhizophoraceae family can be classified as the most common and dominant family in Sungai Kilim (3 genera and 6 species) if compared with others which recorded only one genus. Occurrence of *Acanthus* sp. which is non-timber species has been found in Sungai Kilim mangrove area. Coverage percentages of this species recorded at three stations which were station 6 (20% to 30%), station 7 (50%) and station 10 (2% to 3%).

Table 3 shows the number of all species of mangrove trees found in Sungai Kilim area while Figure 4 shows their percentages. *Ceriops tagal* (Rhizophoraceae) has the highest number of trees recorded throughout sampling. There was a total of 519 trees enumerated followed by *Rhizophora apiculata* (Rhizophoraceae), 428 trees; *Avicennia officinalis* (Avicceniaceae), 277 trees; *Bruguiera cylindrica* (Rhizophoraceae), 232 trees; *Xylocarpus granatum* (Meliaceae), 138 trees; *Avicennia alba* (Avicceniaceae), 103 trees; *Avicennia marina* (Avicceniaceae), 75 trees; *Rhizophora mucronata* (Rhizophoraceae), 50 trees; *Xylocarpus moluccensis* (Meliaceae), 33 trees; *Bruguiera parviflora* (Rhizophoraceae), 29 trees; *Excoecaria agallocha* (Euphorbiaceae), 12 trees;

Sonneratia alba (Sonneratiaceae), 9 trees; *Derris trifoliata* (Leguminosae), 5 trees; *Thespesia* sp. (Malvaceae), 4 trees and *Bruguiera gymnorrhiza* (Rhizophoraceae) only a tree. Percentage of all mangrove species was in the range of 0.1% to 27.1% (Figure 4). The percentage for the most dominant species was *Ceriops tagal* at 27.10% followed by *Rhizophora apiculata* (22.35%), *Aviccenia officinalis* (14.46%) and *Bruguiera cylindrical* (12.11%). The rest of the species were covered below than 10% of the sampling stations.

Table 2. Number of genus and species of mangrove tree for each family found in all plots constructed at Sungai Ayer Hangat-Kilim area.

No.	Family	Genus	Species	Number	Percentage %
1	Rhizophoraceae	3	6	1259	65.74
2	Avicenniaceae	1	3	455	23.76
3	Meliaceae	1	2	171	8.93
4	Sonneratiaceae	1	1	9	0.47
5	Euphorbiaceae	1	1	12	0.63
6	Malvaceae	1	1	4	0.21
7	Leguminosae	1	1	5	0.26
Total		9	15	1915	100.00

Table 3 The individual number of species recorded in Sungai Ayer Hangat-Kilim.

Family	Species	Number
Rhizophoraceae	*Ceriops tagal*	519
Rhizophoraceae	*Rhizophora apiculata*	428
Avicenniaceae	*Aviccenia officinalis*	277
Rhizophoraceae	*Bruguiera cylindrica*	232
Meliaceae	*Xylocarpus granatum*	138
Avicenniaceae	*Aviccenia alba*	103
Avicenniaceae	*Aviccenia marina*	75
Rhizophoraceae	*Rhizophora mucronata*	50
Meliaceae	*Xylocarpus moluccensis*	33
Rhizophoraceae	*Bruguiera parviflora*	29
Euphorbiaceae	*Excoecaria agallocha*	12
Sonneratiaceae	*Sonneratia alba*	9
Leguminosae	*Derris trifoliata*	5
Malvaceae	*Thespesia* sp.	4
Rhizophoraceae	*Bruguiera gymnorrhiza*	1
Total		1915

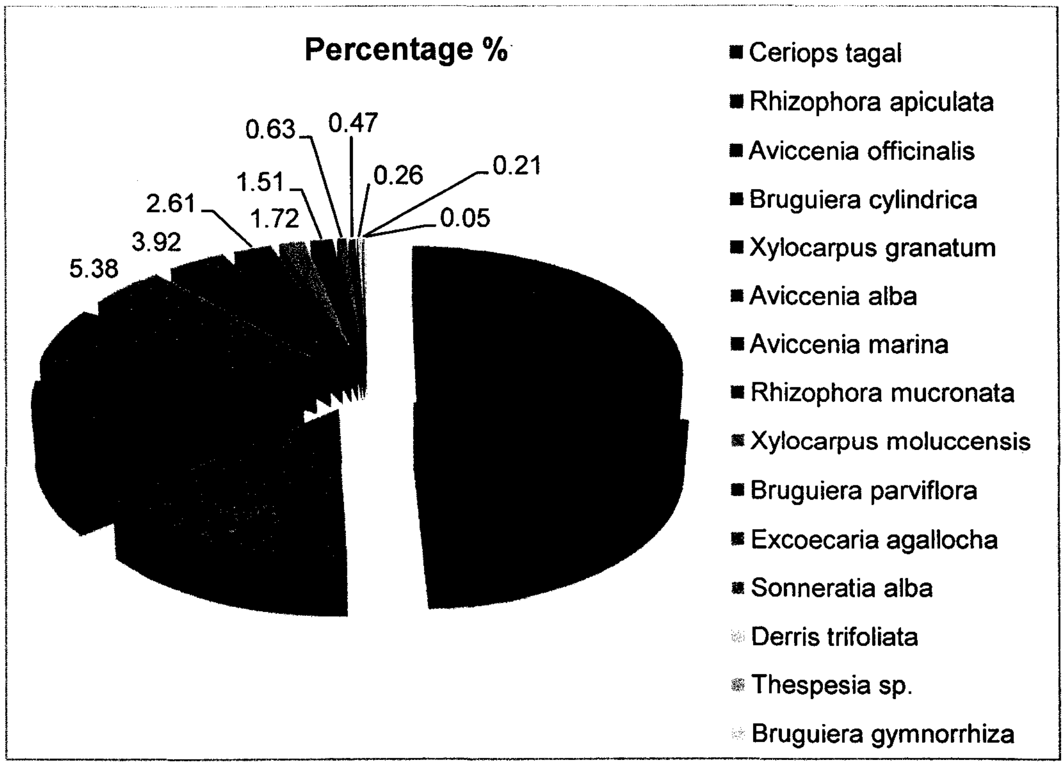


Figure 4. Percentage of mangrove species recorded in Sungai Ayer Hangat-Kilim area.

Table 4 shows the occurrence of mangrove species at all sampling stations in Sungai Kilim area. There were 15 mangrove trees species found in sampling stations. *Rhizophora apiculata* (Rhizophoraceae) was the most frequent species found at all sampling stations in Sungai Kilim. It was followed by *Ceriops tagal* (Rhizophoraceae) that was found at 12 sampling stations. *Xylocarpus granatum* (Meliaceae) was found at 9 sampling stations; *Bruguiera parviflora* (Rhizophoraceae), 8 sampling stations; *Avicennia officinalis* (Avicenniaceae), 7 sampling stations; *Rhizophora mucronata* (Rhizophoraceae), 5 sampling stations; *Xylocarpus moluccensis* (Meliaceae), 4 sampling stations and *Bruguiera cylindrica* (Rhizophoraceae) at 3 sampling stations. There were three species found at 2 sampling stations which were *Aviccenia alba* (Avicenniaceae), *Avicennia marina* (Avicenniaceae) and *Sonneratia alba*

(Sonneratiaceae). Another 4 species were found occurring at only one sampling station.

Table 4. Occurrence of mangrove species at different sampling stations.

No	Species	Number of Plants													Frequency
		St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	St 11	St 12	St 13	
1	*Rhizophora apiculata*	√	√	√	√	√	√	√	√	√	√	√	√	√	13
2	*Ceriops tagal*	√	√	√	√	√	√	√	√	√	√	√		√	12
3	*Xylocarpus granatum*	√			√	√	√	√	√		√	√		√	9
4	*Bruguiera parviflora*		√	√				√	√	√	√	√		√	8
5	*Avicennia officinalis*	√					√	√		√	√		√	√	7
6	*Rhizophora mucronata*	√				√			√	√			√		5
7	*Xylocarpus moluccensis*							√		√	√	√			4
8	*Bruguiera cylindrica*								√	√				√	3
9	*Avicennia alba*												√	√	2
10	*Avicennia marina*												√	√	2
11	*Sonneratia alba*												√	√	2
12	*Bruguiera gymnorrhiza*	√													1

No	Species	Number of Plants													Frequency
		St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10	St 11	St 12	St 13	
13	*Excoecaria agallocha*													√	1
14	*Thespesia* sp.													√	1
15	*Derris trifoliata*													√	1

3.2 CLUSTER ANALYSIS

Figure 5 shows the division of stations according to plant species distribution for mangrove trees at Sungai Kilim. This cluster analysis was done by using Jaccard's Coefficient, the statistic used to compare the similarity and diversity which has been showed between the stations. The stations could be divided into two distinct groups. Group A consists of station 12 and station 13 while group B consists of station 1 to station 10. Group A which consists of station 12 and 13 were placed in the same group because all have almost similar species. This is because all the sampling stations were done in the same area. Both of the stations were dominated by Avicceniaceae species such as *Aviccenia alba* and *Aviccenia marina* made these two stations were placed in the same group.

Group B was larger than group A based on the number of sampling stations that could be divided into two separate clusters. Station 1, 4, 5 and 6 could be grouped into one cluster while station 2, 3, 7, 8,9,10 and 11 were the other cluster. Group B have the obvious similarity in term of species that have come from the same family which is Rhizophoraceae. All stations of first cluster of group B mostly dominated by *Ceriops tagal* and *Rhizophora apiculata* while the second cluster of group B dominated by the same species as the first cluster together with occurrence of *Bruguiera* sp. Station 2 and station 3 were shared the same species which were *Rhizophora apiculata*, *Bruguiera parviflora* and *Ceriops tagal*. Likewise with station 7 and station 10 which consists almost the same species.

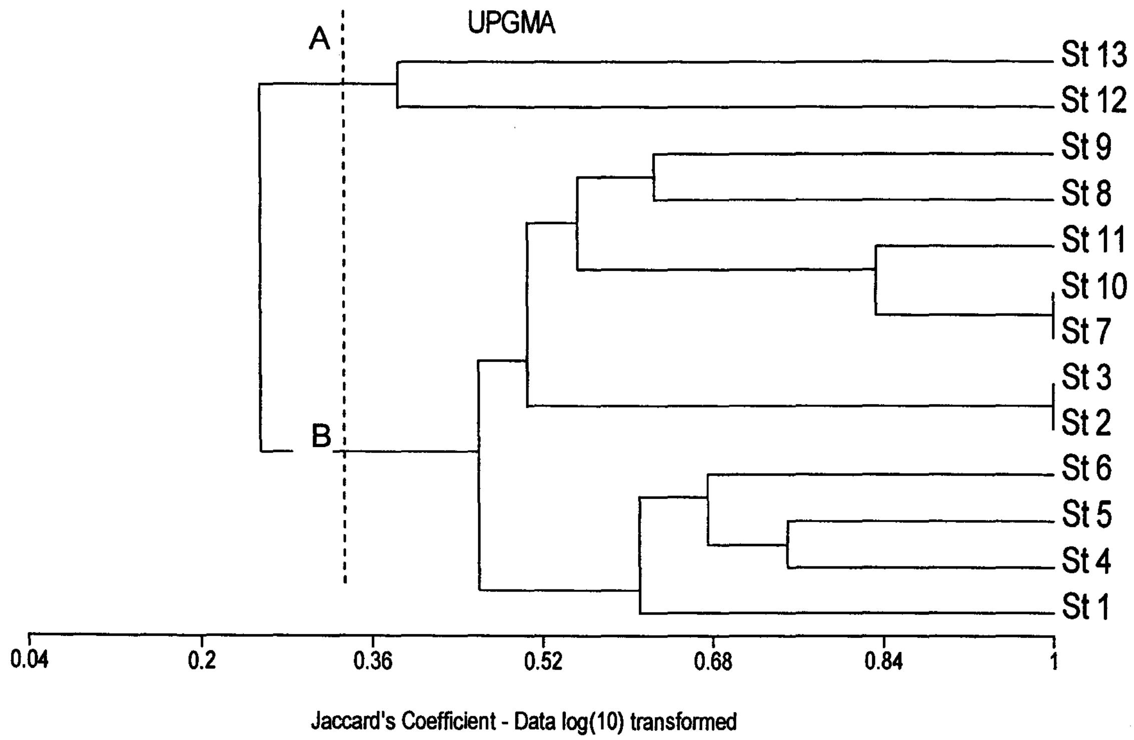


Figure 5. Mangrove plant species distribution according to stations at Sungai Kilim.

Note:

St 1 – Station 1
St 2 – Station 2
St 3 – Station 3
St 4 – Station 4
St 5 – Station 5
St 6 – Station 6
St 7 – Station 7
St 8 – Station 8
St 9 – Station 9
St 10 – Station 10
St 11 – Station 11
St 12 – Station 12
St 13 – Station 13
St 14 – Station 14

3.3 DIVERSITY INDEX

Result of Shannon-Wiener diversity index for each station is shown in Table 5. Value of Shannon-Wiener diversity index for station 2 was the lowest (0.73) while the highest value was at station 12 (1.40). This shows that the diversity of plants in station 2 was lower compared to station 12. For evidence, the number of species in station 2 was 3 species while station 12 contained 12 plant species. For Evenness value, station 12 has the highest value which is 0.78 compare to the other stations.

Although station 12 has the highest value of evenness, the values of the other stations is almost similar and the values for all stations are approximately 1 (1=similar, 0= dissimilar).

Table 5. Shannon-Wiener diversity and Eveness index

Station	Index	Evenness	No. of Species
St 1	1.03	0.58	6
St 2	0.73	0.67	3
St 3	0.80	0.73	3
St 4	0.88	0.80	3
St 5	0.74	0.54	4
St 6	1.04	0.75	4
St 7	1.14	0.64	6
St 8	1.19	0.66	6
St 9	1.18	0.61	7
St 10	1.17	0.66	6
St 11	1.00	0.62	5
St 12	1.40	0.78	6
St 13	1.31	0.53	12

3.4 VEGETATION COMMUNITY

In total 25 species of trees from 13 families were found in the forest reserve (Table 6). Overall the most common species were *Rhizophora apiculata, Rhizophora mucronata, Ceriops tagal, Bruguiera cylindrica, Bruguiera parviflora, Xylocarpus granatum*, and *Avicennia marina.* The species composition is similar to those found in the Pulau Kukup mangrove park, Johor (Table 6). Some of the species can also be found in other mangrove inhabited sites in other parts of Malaysia, for example, Sarawak, Merbok and Pantai Merdeka, Kedah.

Patterns of zonation from the seaward to landward margin vary between sites depending on its location. Based on the Importance Value (Ni), which is indicative of the dominant species, the sequence of zones from seaward to landward is:

Study Site 1: *Sonneratia* community, *Rhizophora* community, *Rhizophora-Bruguiera* community, *Rhizophora* community

Study site 2: *Ceriops tagal* community, *Bruguiera* community, *Bruguiera-Rhizophora* community, *Rhizophora* community, *Bruguiera* community

Study site 3: *Avicennia* community, *Rhizophora* community, *Rhizophora-Bruguiera* community, *Bruguiera* community

Study site 4: *Bruguiera* community, *Bruguiera-Rhizophora* community, *Rhizophora* community, *Bruguiera* community

Study site 5: *Rhizophora* community, *Bruguiera-Rhizophora* community, *Bruguiera* community

Clear zonation patterns were not evident at any of the study sites, which could be due to past and present human activities, such as, cutting of *Ceriops* trees by villagers or fishermen for their own consumption.

Table 6. List of mangrove species found in the Ayer Hangat mangrove reserve as compared to other locations in Peninsular Malaysia.

	Species	MBK	PMDK	MTG	KKP	AHGT
1	*Acanthus ebracteatus*				X	
2	*Acanthus ilicifolis*				X	X
3	*Acanthus volubilis*				X	
4	*Acrostichum aurem*			X		
5	*Acrostichum speciosum*			X		X
6	*Aegialites rotundifolia*					
7	*Aegiceras corniculatum*				X	X
8	*Amyema gravis*					
9	*Avicennia alba*			X	X	X
10	*Avicennia lanata*					
11	*Avicennia marina*					X
12	*Avicennia officinalis*	X	X	X	X	X
13	*Avicennia rumphiana*				X	X
14	*Bruguiera cylindrica*			X	X	X
15	*Bruguiera hainseii*	X				
16	*Bruguiera gymnorrhiza*	X			X	
17	*Bruguiera parviflora*	X	X	X	X	X
18	*Bruguiera sexangula*	X		X	X	
19	*Bulbophyllum xylocarpi*					
20	*Cerbera odollam*					
21	*Cerbera manghas*					
22	*Ceriops decandra*				X	
23	*Ceriops tagal*	X		X	X	X
24	*Clerodencron inerme*					
25	*Dendrobium rhizophoreti*					
26	*Derris trifoliata*				X	X
27	*Dolochandrone spathacea*					
28	*Excoecaria agallocha*	X	X	X	X	X
29	*Heritiera littoralis*				X	X
30	*Hibiscus tiliaceus*				X	X
31	*Intsia bijuga*					
32	*Kandelia candel*					
33	*Loranthus quinquenervis*					

34	*Lumnitzera littorea*					X
35	*Lumnitzera racemosa*				X	X
36	*Nypa fruticans*				X	X
37	*Oncosperma filamentosa*					
38	*Rhizophora apiculata*	X	X	X	X	X
39	*Rhizophora mucronata*	X	X	X	X	X
40	*Rhizophora stylosa*					
41	*Scyphiphora hydrophyllacea*				X	
42	*Sonneratia alba*	X		X	X	X
43	*Sonneratia caseolaris*					
44	*Sonneratia griffithii*					
45	*Sonneratia ovata*			X	X	X
46	*Suaeda australis*					X
47	*Thespesia populnea*				x	X
48	*Xylocarpus granatum*	X			X	X
49	*Xylocarpus mekongensis*					
50	*Xylocarpus moluccensis*				X	X

Note:

- MBK – Merbok
- PMDK – Pantai Merdeka
- MTG – Matang
- KKP – Kukup
- AHGT – Ayer Hangat

In Malaysia, the mangrove forests are divided into 4 different types (UNEP, 2004) (Figure 6). The first type is the *Avicennia-Sonneratia* forest, second type is the *Rhizophora-Bruguiera* forests. The third type is the dry land mangroves that denote the final stage of forest succession and represent the transition into inland forest. The species here is more diverse. Common tree species in this forest type include *Bruguiera gymnorrhiza*, *Rhizophora apiculata*, *Xylocarpus moluccensis*, *Intsia bijuga* and *Oncosperma tigillarium*. The Nypa forests is the fourth type of forest and commonly occur along the banks of tidal rivers where there is greater freshwater influence.

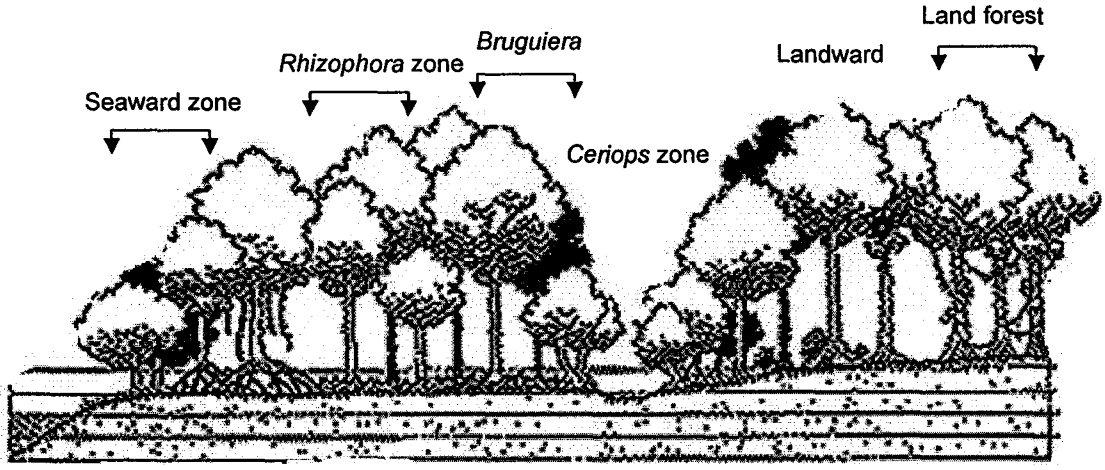


Figure 6: Mangroves forest types in Malaysia

3.5 DESCRIPTION OF MANGROVE SPECIES

The following gives description of species found in the Ayer Hangat forest reserve.

Species Description:

[redacted]

Family : Acanthaceae

Photo:

Biology: Erect, shrubby herbs up to 1.5 m tall, with many spiny, usually green stems; leaves like those of holly, leaf blade dark green, stiff, deeply lobed with sharp spines at each lobe's tip and curved in full sun, flatter in shade; with neatly organised spikes; flowers in spikes at branch tips; petals white turning brownish when older; capsules squarish and slightly flattened, exploding when ripe to send their whitish, flat seeds flying up to 2 m from the parent plant.

Medicinal use: The pounded seeds are used to cure boils and to prevent the condition for as many years as there are pounded seeds in the draught, the juice of leaves is reputed to prevent hair loss.

[redacted]

Family : Pteridaceae

Photo:

Biology: Rhizomes covered with scales up to 8 mm long; leaves to about 1.5m long, brownish-green when young; lower surface of fertile leaflets completely covered with dark brown sporangia, blades of sterile leaflets gradually tapering to a narrow tip

Medicinal use: Rhizomes are pounded into a paste and used to treat wounds and boils (Malay). Leaves are used to stop bleeding.

[redacted]

Family : Avicenniaceae

Photo:

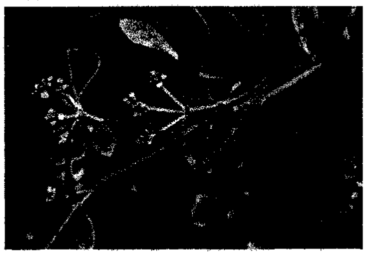

Biology: Shrub or tree up to 10-20m tall. Bark somewhat brown, may be smooth or slightly rough but not fissured. Pneumatophores pencil-like, not very tall (about 20cm). May have stilt roots.
Leaves: Shiny green above, underneath white and waxy.
Flowers: Small, yellow, several together , forming a cross-shaped inflorescence.
Fruits: Flat capsule containing one seed.

Medicinal use: The heartwood is used to make tonics. The bark and seeds are used as a fish poison and resin used in birth control.

[redacted]

Family: Avicenniaceae

Photo:

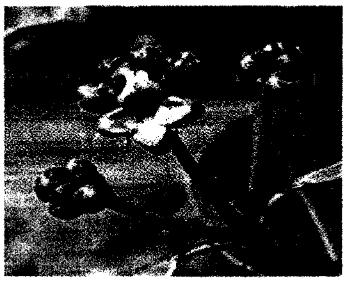



Biology: Bark chalky white when dry, smooth and flaky; pneumatophores 10-15 cm tall; twigs square in cross-section, unlike the rounded twigs in the other *Avicennia* species. Leaf blades shiny yellowish green above and dull pale below; flowers in tight bunches at the ends of a cross-iike inflorescence; petals yellow, about 4 mm across; fruit pale grey-green, compressed, broadly angular egg-shaped.

[redacted]

Family: Avicenniaceae

Photo:

Biology: Tree or shrub, to 20 m tall; trunk commonly with low aerial roots. Bark reddish brown and smooth when young and grey-brown when older; pneumatophores about 20-30 cm tall. Leaf blades bright shiny green above and pale and finely hairy below, egg-shaped to elliptic, tip rounded. Flowers in tight bunches at the ends of a cross-like inflorescence; petals yellow, about 7 mm across; fruit pale grey-green, velvety, compressed, elongate ellipsoid, with seedlings germinating within

Medicinal use: Fruits used as astringent, bark and roots as aphrodisiac, seeds and roots as poultice to treat ulcers.

[redacted]

Family: Rhizophoraceae

Photo:

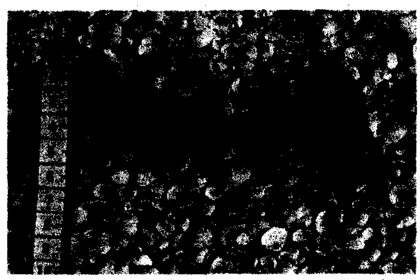
Biology: Tree up to 20 m tall with buttresses and kneed pneumatophores; bark grey, smooth; leaves opposite, blades light green, thin, elliptic; stipules pale yellow or greenish. Flowers 2-5 per leaf angle, sepals light green and sticking out at right angles to the fruit; seed germinates in fruit, their hypocotyl up to 15 cm long, like a green or purplish cigarette and often slighly curved.

Medicinal use: The scrapped skin of the fruit is used to stop bleeding. The leaves are used to control blood pressure (India).

[redacted]

Family: Rhizophoraceae

Photo:



Biology: With buttresses and kneed roots; bark brown to almost black; leaves opposite, blades elliptic-oblong, leathery; stipules often reddish. Flower 1 per leaf angle, sepals shiny red in full sun, yellowish in the shade; seed germinates in fruit, seedling hypocotyl up to 20 cm long and 3 cm wide, cigar-shaped, slightly angular with a blunt narrow tip.

Medicinal use: The bark is astringent and used to treat malaria (Cambodia), cure fish poisoning (Marshall Islands), treat diarrhoea and fever (Indonesia). Elsewhere the fruit is used to treat eye problems, and scrapped skin of the fruit to stop bleeding. The fruit may also be chewed as a betel nut substitute. The leaves are used to control blood pressure (India).

[redacted]

Family: Rhizophoraceae

Photo:

Biology: Grows up to 15 m tall; bark grey, smooth; leaves opposite, blades yellowish green, elliptic; stipules light yellow; flowers 2-5 per leaf angle, sepals yellow-green and remain pointing parallel to the long axis of the fruit fruit; seed germinates in fruit, hypocotyl cylindrical, up to 13 cm long, thinly pencil-like, smooth. Found on the inner side of the mangrove and noted to be a slow grower and has the shortest lifespan. It does not appear to grow well in Singapore with only few individuals and less than the 24 m maximum height found elsewhere.

Family : Rhizophoraceae

Photo:

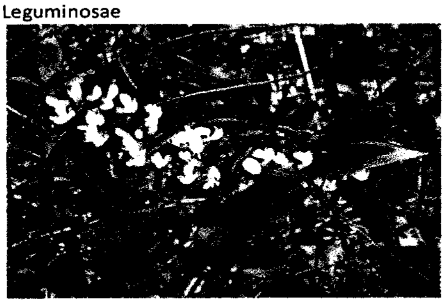
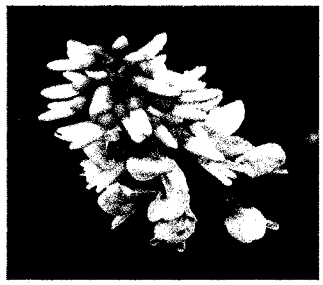
 

Biology: Shrub or rarely tree, to 7 m tall; shortly buttressed; bark light grey, fairly smooth; twig tips flat, formed from the stipules. Leaves opposite, blades dark green in shade, shiny, bright greenish yellow in full sun,upside down egg-shaped, oblong to elliptic, tip rounded or notched, stipules flattened at branched tips. Seed germinating in fruit, hypocotyl narrowly club-shaped, sharply angular.

Medicinal use: Bark to treat hemorrhages and ulcers

Family : Leguminosae

Photo:

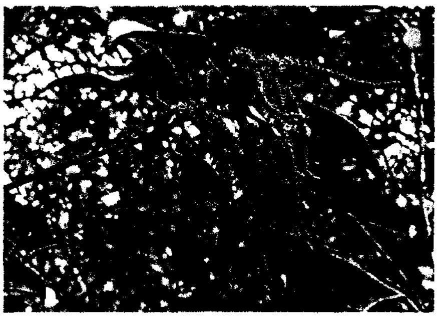
 

Biology: A usually slender, woody climber with pinnate leaves of 3, 5 or 7 leaflets. The inflorescence is slender with few to numerous, 1 cm long, light pink, pea-like flowers.
The slightly wrinkled fruits are disc-like, 3-4 cm by 2 cm, with 2-3 seeds.

Medicinal use: *D. trifoliata* is used in local medicine in India as a stimulant, antispasmodic and counter-irritant, and against rheumatism, chronic paralysis and dysmenorrhoea, and in Papua New Guinea a decoction of the roots is used externally against fever and internally against sores. Thai traditional doctors use roots or stems as a laxative, carminative and anti-arthritis treatment. Poison: It serves as a fish poison. Fodder: The leaves are sometimes used as fodder.

Family : Euphorbiaceae

Photo:

Biology: Young leaves pink and old leaves withering scarlet, blades elliptic, with upcurled sides. Male inflorescences hanging, narrow, 5-10 cm long; female inflorescences shorter, 1-4-cm long.

Medicinal use: The plant is used to treat sores and stings from marine creatures. Smoke from the bark is used to treat leprosy. The plant is being tested for modern medical uses. Modern clinical trials show that the plant may have anti-HIV, anti-cancer, anti-bacterial and anti-viral properties.

Family : Sterculiaceae

Photo:

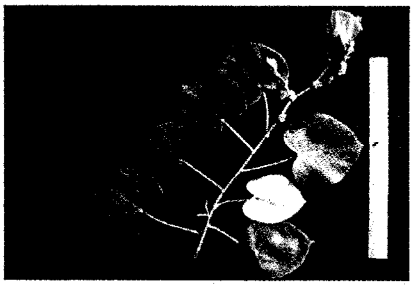
 

Biology: Low, much branched, evergreen tree, to 15 m tall; bark pinkish gray, smooth becoming flaky when older; leaf blades dark green above and silvery white below, withering dull orange-yellow, oblong to elliptic, leathery; flowers in hanging yellowish tassels; fruits purple-brown, woody, shiny with a stiff keel on one side.

Medicinal use: An extract of the seed can be used to treat diarrhoea and dysentery.

Family : Malvaceae

Photo:

Biology:

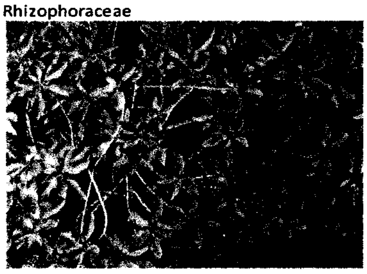
Tree up to 15 m tall. Leaves spirally arranged, blades heart-shaped with pointed tip, slightly 'toothed, dark green above, whitish and short-hairy below. Flowers are few inflorescences, at branch tips or leaf angles, bright yellow fading to dull orange petal with a maroon eye. Filaments of stamens joined together into a light yellow tube, stigmas deep crimson purple. Capsules spherical, topped by persistent sepals. Flowers open at 9 am and close at 4 pm.

Medicinal use:

Leaves are used to cool fevers, soothe coughs and remove phlegm (Malaysia, Indonesia); fresh bark soaked in water is used to treat dysentery (Philippines), for chest congestion and during birth (Polynesians); fresh flowers boiled with milk is used to treat ear infections; the crushed flowers are applied to abscesses (Guam); buds chewed and swallowed for dry throat.. Slimy sap of the bark, branches and flower buds used as a mild laxative or as a lubricant in childbirth.

Family : Rhizophoraceae

Photo:

Biology:

Tree up to 20 m tall with prop roots. Rough, grayish to brown bark, DBH 10-40 cm. Leaves are simple, opposite arrangement, blade shape elliptic, smooth margin, apex apiculate, smooth, dark green, tiny black-spotted below, 9-19 cm long and 4-7 cm wide, stalks and stipules often tinged red. Flowers are stalkless, cream coloured, in pairs, cyme, axillary inflorescence, 4 petals, 4 sepals yellow to red outside, 12 brown stamen. Flowers 1.2-1.4 cm long. Fruits are brown, upside-down pear-shaped, crowned by persistent sepals. seedling viviparous, hypocotyl 30 cm long, smooth and rounded tip.

Medicinal use: Occasionally medicinally in cases of haematuria.

[redacted]

Family : Rhizophoraceae

Photo:

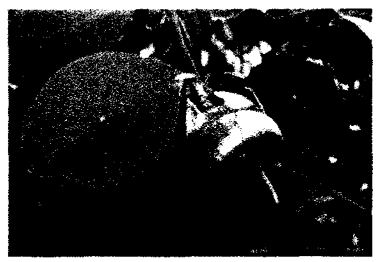

Biology: Tree up to 15 m tall, rarely over 3 m. Leaves opposite, blades oblong, tiny black-spotted below, leaf stalks and stipules often yellowish; stalked flowers, 2-14 per inflorescence on a long, slender, yellow stalk; seedling viviparous, hypocotyl about 60 cm long or more, warty, with pointed tip.

Medicinal use: It is used as an astringent and to treat angina, haemorrhaging (extracts from the seedlings in Indochina); diarrhoea (China, Japan): diabetes, dysentery, hematuria. A poultice of the leaves are used to relief armoured fish stings. Old leaves and roots are used during childbirth (Malay). Bark is used to treat blood in the urine (Burma).

[redacted]

Family : Sonneratiaceae

Photo:

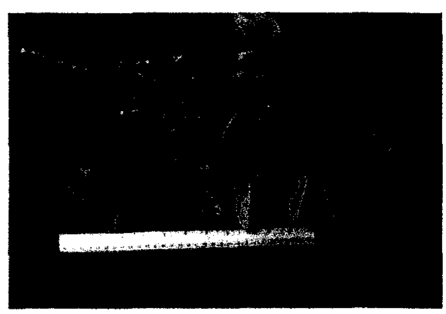
Biology: Large tree to 20 m tall; bark light grey, fissured. Leaves opposite, blade dull light green, broadly drop-shaped. Flowers with numerous white stamens and tiny, white petals. Fruit somewhat pear-shaped, crowned by the persistent sepals whose tips bend back to the stalk. Seeds white, flattened, tiny, buoyant.

Medicinal use: *Sonneratia caseolaris* is used in poultices for cuts, bruises (Burma) and sprains and swellings. Ripe fruit are used to expel intestinal parasites (Malay) and half-ripe fruit for coughs.

[redacted]

Family : Meliaceae

Photo:

Biology: Tree 5-20m tall. Compound leaf comprising 2-3 pairs of leaflets (4-12cm long) that are oblong with more pointed tips, thin and leathery. The compound leaves are arranged in a spiral and wither to a vivid yellow. Flowers tiny white to pinkish in clusters on an inflorescence. Fruit elliptical (8-12cm in diameter) containing 5-10 seeds. Bark with longitudinal fissures, small or no buttress roots, many peg-shaped (blunt-tipped, nearly cylindrical) pneumatophores.

Medicinal use: Traditional medicinal uses include the seeds for treating stomachaches, fruits to increase appetite, ba

4. DISCUSSION

4.0 DISCUSSION

4.1 TAXONOMIC COMPOSITION

Overall a total of 1915 individual trees were enumerated at Sungai Kilim area which comprising a total of 7 families with 15 species of mangrove trees can be found at all sampling stations. Based on the result, Rhizophoraceae is the most dominant family with 65.74% found in all sampling stations constructed in Sungai Kilim area followed by Avicenniaceae (23.76%) and Meliaceae (8.93%). Another 12 families only covered below 1% for individual number of plants occurred for the whole plots. From previous study at Kilim basin area by Nizam, et al. (2005) was recorded a total of 230 individual trees with 5 families with 7 species at the Ayer Hangat Forest Reserve while at the Kisap Forest Reserve, 218 individual trees with 4 families and 6 species. Rhizophoraceae is one largest family found at both sampling sites.

The number of individuals of mangrove trees has shown that *Ceriops tagal* (Rhizophoraceae) (27.10%) is the most common species found in the sampling stations. It is followed by *Rhizophora apiculata* (Rhizophoraceae) (22.35%) and *Bruguiera cylindrica* (Rhizophoraceae) (12.11%). All these trees were the main species recorded at every station. A similar study by Nizam et al. (2005) conducted at Ayer Hangat Forest Reserve and Kisap Forest Reserve recorded that *Rhizophora mucronata* from Rhizophoraceae as the highest species found for both sites. This study findings are also parallel with the previous study conducted by Wan Juliana et al. (2008) in the Kisap Forest Reserve. Their study revealed that *Rhizophora apiculata* is the most dominant species together with other nine mangrove species.Other species were rarely found in the study plots and if present the numbers of individuals that exist were considerably low. The differences in soil physical factor and micro weather condition of certain areas are expected to be the reason for this condition, as these factors can influence the presence or absence of species in certain forest and also can affect the richness of the species (Duivenvoorden, 1996).

There are non-timber species which was *Acanthus* sp. dominated at certain sampling stations in Sungai Kilim area. Occurrence of this species mostly abundant at station 7 with percentage coverage of 50% followed by station 6 (20% to 30%) and station 10 (2% to 3%).

4.2 DIVERSITY INDEX, EVENNESS INDEX AND CLUSTER ANALYSIS

Diversity in an ecosystem was determined through the total number of species in a community often known as species richness and species abundance (Krebbs, 998). Diversity index is the common parameter used to compare the data of plant community. The value of diversity index in this study, the Shannon-Wiener, shows the evaluation of species richness at every sampling site. From the value of diversity index, the influence of disturbance and the stabilization of plant community can be studied. By referring to the diversity index formula, the highest species diversity is found at the forest with the lowest level of disturbance.

Based on the result, it shows that the values of Shannon-Wiener diversity index for all stations are in the range of 0.73 to 1.40. Among all stations, station 12 has the highest value (1.40) with 6 species recorded compared to others while station 2 has the lowest value (0.73) with 3 species was recorded. Evenness index for all plots showed that the distribution of species at every station did not differ much. Among all stations, station 13 has the lowest value (0.53) although consist the highest number of species which is 12 species while station 4 has the highest value (0.80) of Evenness index but with the lowest species number recorded which is 3 species. This showed that the distribution of species in plot 13 is random while in station 4, the distribution is regular. If the entire species were spreading uniformly, consequently Evenness index become maximum.

There are two representative groups of cluster analysis based on plants species that occurred at all sampling stations which are group A and group B. This analysis was applied to plant diversity study and it was used to measure the similarity between the sampling sites (Krebbs, 1989). Group A which consists of station 12 and 13 were placed in the same group because all have almost similar species and all the sampling stations were done in the same area. Besides that, both of the stations were dominated by Avicenniaceae species such as *Avicennia alba* and *Avicennia marina* made these two stations were placed in the same group.

Meanwhile, group B which consist of station 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 were divided into another two separate clusters. Station 1, 4, 5 and 6 could be grouped into one cluster while station 2, 3, 7, 8, 9, 10 and 11 were the other cluster. Group B have the obvious similarity in term of species that have come from the same family which is Rhizophoraceae such as *Ceriops tagal*, *Rhizophora* sp. and *Bruguiera* sp.

4.3 IMPORTANCE OF MANGROVE IN THE WORLD HERITAGE SITE GEOFOREST PARK

At first sight, the scope for recreational use of mangrove ecosystems may appear to be limited, but it is in fact an important aspect of the management of mangroves in Australia (boating and recreational angling). There are also some developing country examples. In Thailand there is considerable value attached to the mangroves in Phangna Bay as a component of the bay's environment which tourists from Phuket can visit in pleasure boats. In some of the Caribbean islands, fringing mangroves are regarded as important indirectly to tourism as they act as sediment traps, thereby protecting the adjacent coral reefs from siltation - the tourist economy of these islands being strongly dependent on the attractiveness of their reef environments.

It is also probable that mangroves will feature in future as one of the tropical environments attractive to the growing developments in ecotourism. Boat trips through mangrove ecosystems are easy to organise and elevated walkways can be built for easy access to the forest environment. Walkways constructed by the Royal Thai Forest Department in a forest reserve area within the Ranong mangrove ecosystem have proved to be highly successful for research and educational activities involving large groups of people (Macintosh, et al, 1992). In suitable areas, this concept is readily adaptable to make it attractive to a wider audience through ecotourism; consequently the latter should be included as part of coastal zone planning where it is considered to have potential. However, ecotourism must be clearly distinguished from tourism in its general context, the latter having had a history usually associated with negative impacts on mangroves.

Kilim basin in the northeast of Pulau Langkawi is predominantly made of Ordovician limestone of Setul Formation. Beside that, the prolonged erosion on limestone has formed isolated hills and ridges separated by narrow and incised basin on which a unique mangrove ecosystem is developed. The limestone peaks were impressed into highly variable shapes, controlled by the nature and attitude of the bedding planes. In addition, the peaks that are directly facing the easterly wind are actually not as much of vegetated and thus form more dramatic pinnacles than those are protected against the seasonal monsoon. The combination of a scenic island karst landscape and a rare limestone-hosted mangrove ecosystem merited the Kilim basin to be adopted as one of the geoforest parks by the Forestry Department of Kedah. Furthermore, Kilim Karst Geoforest Park became one of the most important geoheritage conservation components of the Langkawi Global Geopark (Mohd Shafeea Leman et al. 2007). Because of these features, Kilim Karst Geoforest Park has been chosen as Malaysian heritage and a global geopark by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in June 2007 together with the Machinchang Cambarian Geoforest Park and Dayang Bunting Marble Geoforest Park (Rahimah, 2009).

The focus on forest development in the Kilim basin mostly is development of biological resources, geological heritage, archaeological, historical and cultural, landscapes, natural resources and recreational landscape of geological recreational which is related to water sports recreation. For recreation, the tourist can enjoy the uniqueness of natural landscape directly over the appreciation of aesthetic and recreational activities participated by them. Whereas, for education and research tourism, the educational kiosk is provided beside scientific expedition by Forestry Department of Peninsular Malaysia to collect basis data particularly in biological and geological data has been done. Research results then will be presented in the seminar and published as a scientific research paper (Shaharudin & Azman, 2008). All the efforts should be continuously manage and sustain in order to establish and develop the Kilim Geoforest Park as one of sustainable ecotourism in Malaysia.

5. CONCLUSION

5.0 CONCLUSION

Overall, there are 15 species and 9 genera from 7 families of mangrove trees (timber tree) have been recorded at 13 sampling stations in Sungai Kilim area. The distribution of plants in Sungai Kilim area shows high diversity of plant species. From the data obtained, Rhizophoraceae has the highest diversity of plant species compared to other families recorded in Sungai Kilim area. In addition, Rhizophoraceae also has the highest number of individual plant for the most part of Sungai Kilim area. For non-timber species, *Acanthus* sp. has the highest diversity that can be found at several sampling stations which at station 6, 7 and 10.

In term of species, *Rhizophora apiculata* (Rhizophoraceae) has recorded as highest diversity of mangrove tree species present at Sungai Kilim area which can be found at all 13 stations followed by *Ceriops tagal* (Rhizophoraceae), *Xylocarpus granatum* (Meliaceae), *Bruguiera parviflora* (Rhizophoraceae) and *Aviccenia officinalis* (Avicceniaceae) while the rest of the species were found below than five stations. Yet again, Rhizophoraceae species were found highly distributed at mangrove area in Sungai Kilim.

Evenness index shows the highest value at station 4 in Sungai Kilim area which is 0.80 while the lowest is at station 13 with the value of 0.53. From the range of Evenness index which has been acquired, it shows that the level of species similarity between all plots do not differ much due to the index value of all plots being approximately 1.

The reduction of mangrove forests have been observed in most states in the Peninsular of Malaysia (Latiff, 2004). Inspite of their immense role in protecting human resource and biodiversity, these unique mangrove forest have been facing tremendous threats such as exploitation of mangrove resources for multiple uses such as fodder, fuel wood, timber for building material, alcohol, paper, charcoal and medicine (Upadhyay et al. 2002). Apart from those, conversion of forest areas to aquaculture and agriculture sites, construction of port and harbour, extension of human inhabitation, over-grazing, urbanization, industrialization and pollution are major common occurrences that dwindle mangrove forest in the world (Blasco et al, 1998; Naskar 2004; Upadhyay et al. 2002). In Langkawi itself, uncontrolled land development activities such as development of Langkawi mangrove as well as tourism arrivals to Langkawi up to 1.88 million people every year may threaten natural environment of the study areas in the long run. Steps have been taken by Forestry Department to conserve some of mangrove forests as forest reserve area such as Kisap Forest Reserve.

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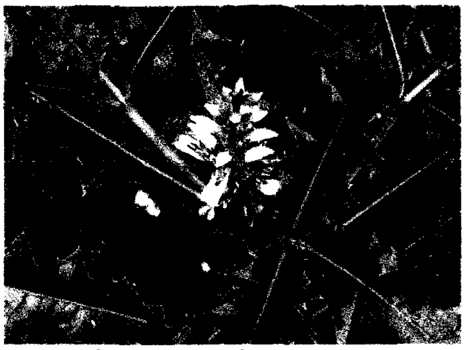
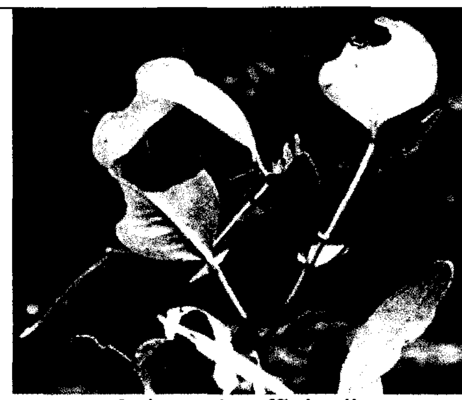
APPENDIX

APPENDIX 1 – Samples of specimen collected from the study sites

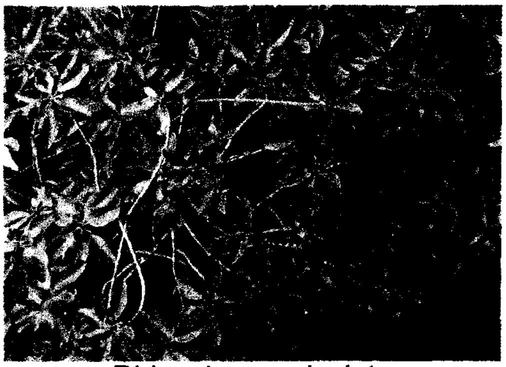
Species obtained from Sungai Kilim and Sungai Ayer Hangat study site.

 *Acanthus ebracteatus*	 *Acrostichum speciosum*
 *Avicennia marina*	 *Avicennia officinalis*
 *Bruguiera cylindrica*	 *Bruguiera parviflora*

Ceriops tagal

Derris trifoliata

Heritiera littoralis



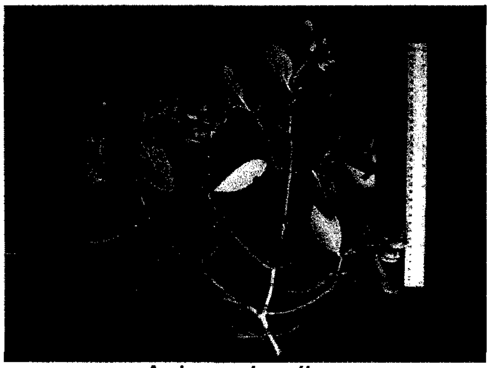
Rhizophora apiculata

Xylocarpus granatum

Xylocarpus moluccensis

Species obtained from Sungai Padang Lalang study site.

Aegiceras corniculatum



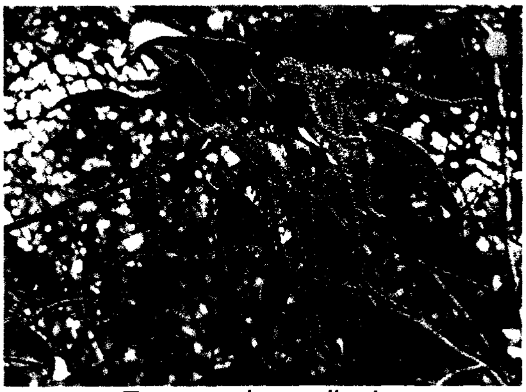
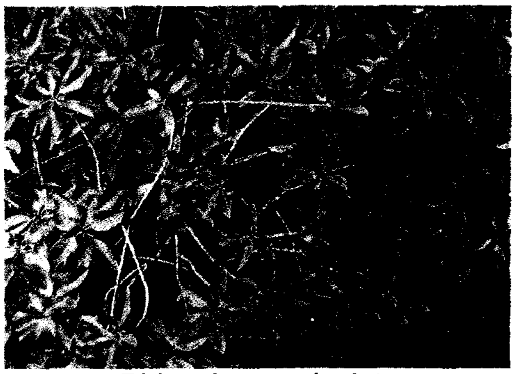
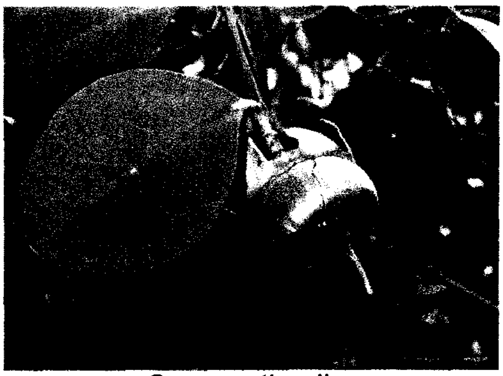
Avicennia alba.

Avicennia marina

Avicennia officinalis

Bruguiera cylindrica

Bruguiera parviflora

 Ceriops tagal	 Excoecaria agallocha
 Lumnitzera littorea	 Rhizophora apiculata
 Rhizophora mucronata	 Sonneratia alba

Sonneratia ovata

Suaeda australis

Avicennia sp. tree

Xylocarpus granatum

Appendix 2 - Study site at Sungai Ayer Hangat, Langkawi.

Plate 2.1 Mangrove area at Sungai Ayer Hangat area.

Plate 2.2 *Rhizophora* sp. found at sampling station.

Plate 2.3 Mangrove forest at Sungai Ayer Hangat.

Plate 2.4 Mangrove at Sungai Ayer Hangat basin.

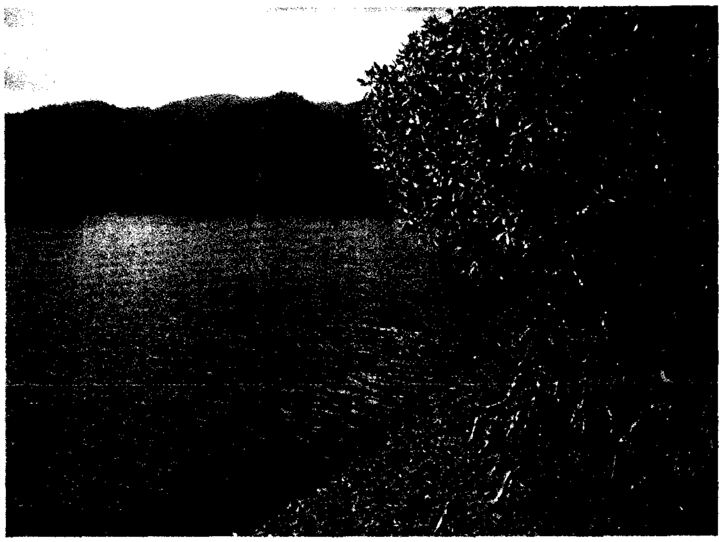


Plate 2.5 *Ceriops tagal* knee roots exposed during low tide.

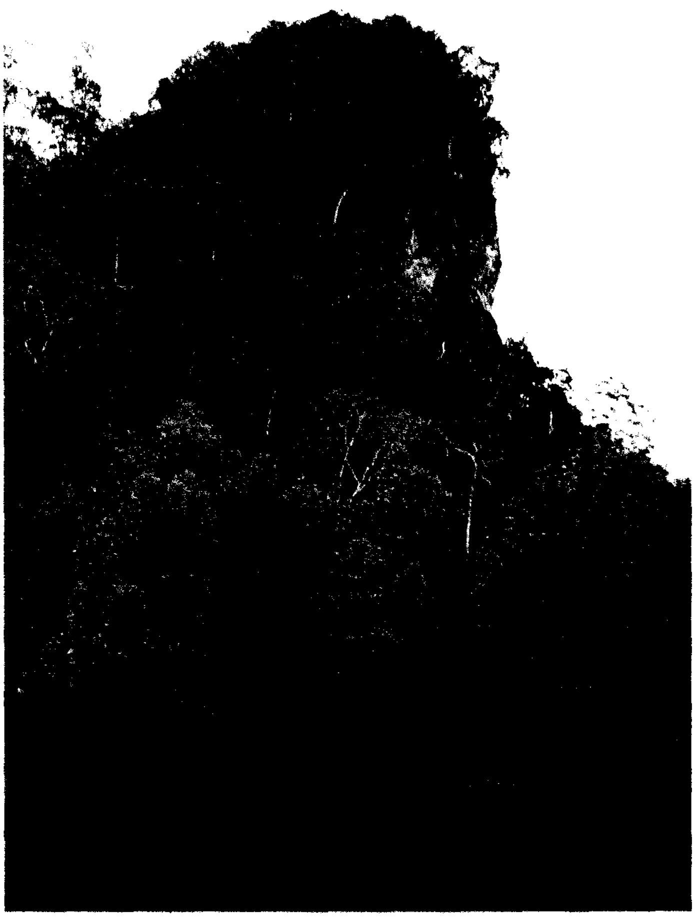


Plate 2.6 Mangrove occurring beside limestone formation is a common sight.

Appendix 3 – Some procedures carried out during the specimen preservation.

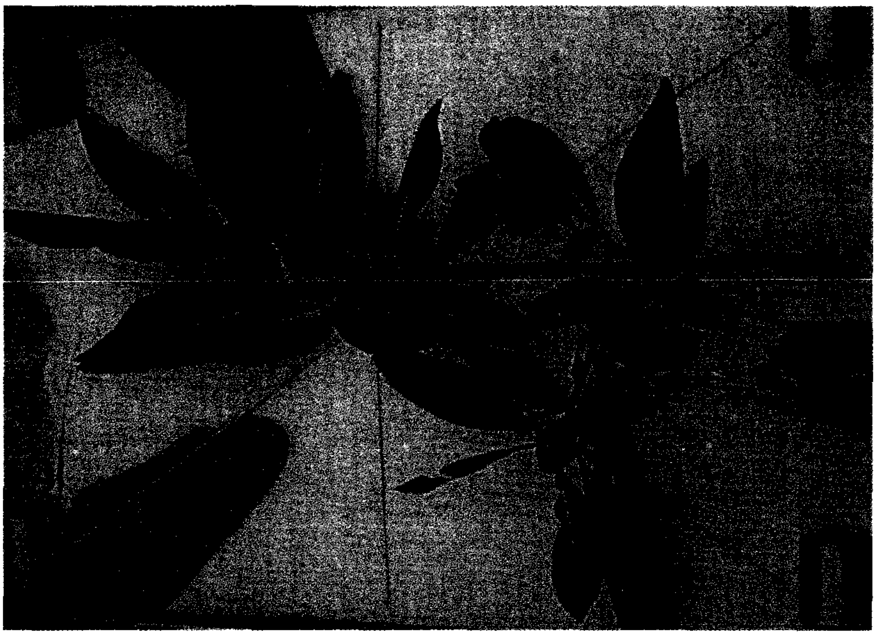


Plate 3.1 Collection of plants specimen for herbarium.

Plate 3.2 Sorting all plant specimen from the field.

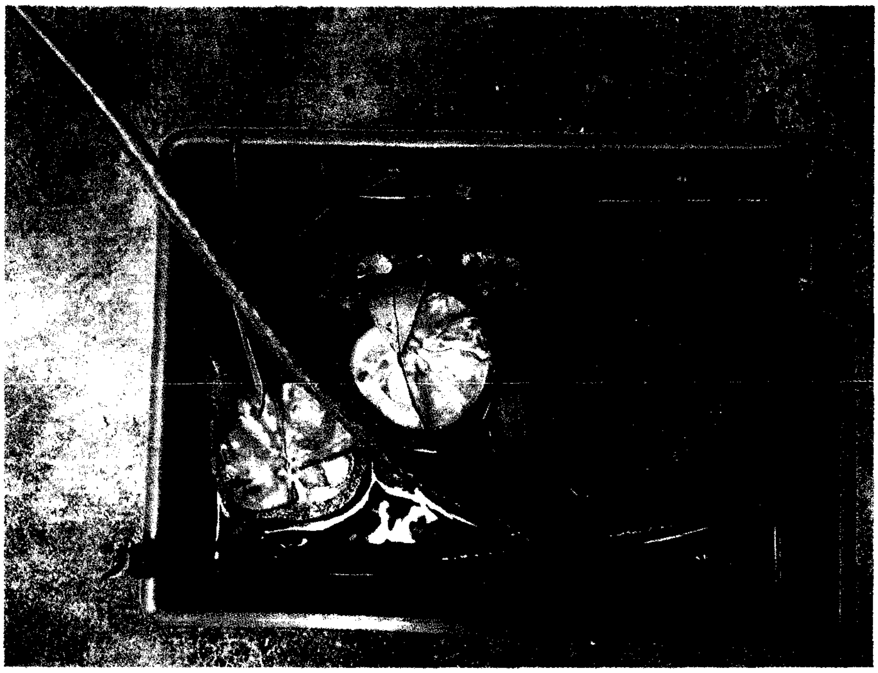


Plate 3.3 Plant samples soaked in alchohol for preservation.

Plate 3.4 Preparing specimen for herbarium.