ESTIMATING THE FLORA DIVERSITY IN PENGKALAN KUBUR MANGROVE FOR FUTURE SUSTAINABILITY

by

SYAHIRAH ATIQAH BINTI ADNAN

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DECLARATION

I declared that this thesis entitled "Estimating the Flora Diversity in Pengkalan Kubur Mangrove for Future Sustainability" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ________________________

Name : ________________________

Date : ________________________

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LIST OF ABBREVIATIONS

NOAA	National Oceanic and Atmospheric Administration
FAO	Food and Agriculture Organization
UNEP	United Nations Environment Programme
ITTO	International Tropical Timber Organization
SPGME	Soonabai Pirojsha Godrej Marine Ecology Centre
FRIM	Forest Research Institution Malaysia
GPS	Global Positioning System
MMFR	Matang Mangrove Forest Reserve
DBH	Diameter at Breast Height
ha	Hectare

LIST OF SYMBOLS

±	Plus minus
%	Percentage
°C	Temperature (degree Celsius)
ln	Natural logarithm
=	Equal to
Pi	Fraction of the entire population made up of species i
S	Numbers of species encountered
H'	Shannon diversity index
N	The total number of individuals in the sample
R	Margalef diversity index
J'	Pielou's evenness index
$\sum$	Sum of

ESTIMATING THE FLORA DIVERSITY IN PENGKALAN KUBUR MANGROVE AREA FOR FUTURE SUSTAINABILITY

ABSTRACT

A study was conducted in a mixed mangrove forest in Pulau Ubi, Pengkalan Kubur to determine the floristic composition and diversity. A total of 10 rectangle study plots measuring 25 m x 20 m were established which equivalent to 0.5 ha. Based on 122 individuals collected, 29 families were identified. The plant inventory includes the measurement of diameter at breast height of adult trees from 0.05 m. The mangrove species in Pengkalan Kubur showed moderate diversity with a Shannon-Weiner Index, H' value of 2.73. Meanwhile, the Pielou Evenness Index was 0.75 and the Margalef Richness Index 8.12. These findings underscore the significance of mangrove forest and act as baseline for the protection from ongoing and future sustainability.

ANGGARAN KEPELBAGAIAN FLORA DI KAWASAN PAYA BAKAU PENGKALAN KUBUR UNTUK KEMAMPANAN MASA HADAPAN

ABSTRAK

Satu kajian telah dijalankan di kawasan hutan bakau campuran di Pulau Ubi, Pengkalan Kubur untuk menentukan komposisi flora dan kepelbagaian. Sebanyak 10 segi empat tepat plot kajian berukuran 25 m x 20 m telah ditubuhkan yang bersamaan dengan 0.5 ha Berdasarkan 122 individu dikumpulkan, 29 keluarga telah dikenal pasti. Inventori tumbuhan termasuk ukuran ketinggian dan diameter pada paras dada pokok dewasa dari 0.05 m. Spesies bakau di Pengkalan Kubur menunjukkan kepelbagaian sederhana dengan Indeks Shannon-Weiner, nilai H '2.73. Sementara itu, Indeks Pielou adalah 0.75 dan Indeks Margalef 8.12. Penemuan ini menekankan kepentingan hutan bakau dan bertindak sebagai asas untuk perlindungan daripada kemampanan berterusan dan masa hadapan.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The ample of coastal area in Malaysia is determined through the evidence that Malaysia has a long coastline, about a coastline of some 4,800 km sits over a land area of some 330,000 km on the geologically stable Sunda Shelf. The mangrove are one of the part in beach front district that as a rule exist in the intertidal zone (Naidoo, 2009) inside tropical and subtropical waterfront streams, estuaries and straights of the world (Zhou et al., 2010) where they may acquire natural materials from estuarine or marine biological communities (Ellison and Farnsworth, 2000). Tomlinson cited in Food and Agriculture Organization (FAO) state in book 'The World's Mangrove 1980's-2005' where mangrove are characterized as both the biological system and the plant families that have developed particular change in accordance with live in this tidal environment (FAO, 2007).

Kathiresan and Bingham (2001) defined mangroves are woody plants that grow at the interface amongst land and sea in tropical latitudes and sub-tropical. Plants and related microbes, fungi, plants, and animals, made up of mangroves or mangal. The mangal and its related abiotic components constitute the mangrove biological community. The word "*mangrove*" normally alludes to both the plants and the forest communities. To avoid confusion, Macnae (1968) suggested that "*mangal*" ought to indicate to the forest community while "*mangroves*" ought to relegate to the individual plant species. Duke (1992) describe a mangrove as, "a tree, shrub, palm or ground fern, for the most part outperforming one-half meter in tallness, and which usually develops above mean ocean level in the intertidal zone of marine beach front situations, or estuarine edges." This definition is adequate with the exception of that ground ferns should presumably be considered mangrove relates rather than true mangroves.

In addition, these forest ecosystem most of the vital purpose and serve an expansive scope of services for both local and national level. The exploitation of the mangrove forest related with the activity of timber harvesting, despite the fact that mangrove forest are referred for their timber as their marsh dipterocarp forests counterparts, pole extraction is outstanding (Latiff, 2012). According to FAO (1994), besides the wood product that the rural populations depend on, these mangrove forest also provide non-wood forest items; food thatch commonly from nipah palm; fodder, liquor, sugar, medication and nectar (FAO, 1994; Ghasemi, 2010). Apart from that, mangrove additionally often utilize for the tannin production which extremely suitable in leather work and for curing and coloring of angling nets. This manufacturing has reduced sought for this couple of years due to the preface of the nylon angling net and utilization of chrome which act as main agent for healing leather (FAO, 1994).

The protection of biological diversity provided by mangrove as it comprise of broad diversity of aquatic and terrestrial species of various taxonomic groups and mangrove biological communities are broadly perceived as suppliers of an incredible assortment of goods and services to individuals, serve ideal breeding, nourishing and nursery grounds for some environmentally and financially crucial fish and shellfish species (Badola & Hussain, 2001), also as sustaining living space for inhabitant and emigrant water birds. A comparison of gets in different living spaces recommends that several species particularly prefer to live in the mangal.

The mangrove forests can be perfect retreat for nature and wildlife lovers, photojournalists, flying creature watchers or those who needs to unwind and esteem the splendid of the mangrove environment and its assorted verdure. The meandering streams and rivulets add to the serene environment particularly to those escaping the pressure of urban life. In Kampong Kuantan, Selangor, visitors able to watch the fireflies found at waterway estuaries have been a noteworthy ecotourism fascinating (Wan Faridah *et al*., 2007).

1.2 Problem Statement

Previously, there has been less study in the floristic distribution been done in Kelantan area. Thus, this research updates the baseline data information of Pengkalan Kubur. The data for the floristic distribution was essential for both at the local and national levels and in order to have a good preparation for sustainable forest management as the authority rely upon this data, and the inadequate information on the status and distribution of mangroves makes it challenging to provide fruitful arrangement for their conservancy (FAO, 2007). Despite the fact that extra research are expected to define exact details and restriction of this defensive capacity, the various research or studies and workshops attempted on this topic over the recent years have conveyed to light various intriguing elements. Specialists and researchers concur that thick and dense coastal forest belts, if all around formed and handled, can possibly act as bio shields for the assurance of individuals and different resources against a few tidal waves and other waterfront risks.

1.3 Significants of Study

This study will be beneficial for further taxonomical study and future reference on floristic composition in mangrove particularly in Kelantan. If there is an exclusive or rare species, a conservation action can be taken to avoid species extinction. Apart from that, it will assist the local authority to take further action to sustain and conserve the mangrove ecosystem.

1.4 Objectives

Generally, information about Pengkalan Kubur Mangrove Forest is very scanty. The floristic distribution of the forest and additionally the populace status are not well studied and documented. The following are the specific objective:

i. To determine the floristic composition in Pengkalan Kubur mangrove for future sustainability.

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CHAPTER 2

LITERATURE REVIEW

2.1 Mangrove Forest

The word “mangrove” indicate to a group of tropical trees and bushes that develop in the intertidal zone where comprise of about 16 families and approximately 40 to 50 species based on its classification (Feller and Sitnik, 2002). Mangroves are woody plants that develop at the interface amongst land and ocean intropical and sub-tropical latitudes. In addition, they are able to endure in certain specific states such as of high saltiness, intense tides, strong winds, tremendous temperatures and sloppy and anaerobic soils (Kathiresan and B. L. Bingham, 2001).

However, NOAA (n. d.) stated that mangrove forests cannot cope in low temperatures and these can be proven as they spread at tropical and subtropical latitudes nearby the equator. According to Kasawani *et al*., (2007), commonly mangrove breed in loose periodically deluges by tidal streams along protected waterfront, estuarine and riverine ranges in tropical and subtropical latitudes. Mangrove forests might be found as left fixes of miniature trees – prisin very high saltiness and additionally disturbed conditions – or as lush forests with a canopy achieving 30–40 in tallness with proper ecological conditions. In undisturbed and untouched estuaries, mangroves may reach out for a few kilometers inland (FAO, 2007). Besides, the studies on mangrove forest in Kelantan are scanty, see Table 2.1.

Table 2.1 Previous study on mangrove forest in Malaysia

Research Area	Research Title	Source	Year
Kuala Kemaman, Terengganu	Floristic Composition, Structure & Potential Net Primary Production Of Mangrove Forest	Soepadmo & Pandi Mad Zain	1989
Kisap Forest Reserve, Langkawi	Biomass And Species Composition In 1 ha Stand Of Mangrove Forest	Norhayati	1995
Tumpat Kelantan Delta, peninsular Malaysia	Mangrove species distribution and abundance in relation to local environmental settings: a case at Tumpat Kelantan Delta, east coast of peninsular Malaysia	Satyanayana *et al.*	2010
Kisap Forest Reserve, Langkawi	Biomass And Species Composition In 0.25 ha Stand Of Mangrove Forest	Hafizah Seman	2004
Ayer Hangat Forest Reserve, Langkawi	Biomass And Species Composition In 0.25 ha Stand Of Mangrove Forest	Fera Fizani	2004
Semporna Mangrove Forest, Sabah	Diversity Of Mangroves Ecosystem	Wah *et al.*	2011
Peninsular Malaysia	Policy and management of mangrove forests	Dato' Hj. Dahlan Hj. Taha	2007
Semantan Mangrove Forest, Sarawak	Conservation Value Of Mangrove	Ashton & Macintosh	2001
Belungkor Reserve Forest, Johor	Species Composition In 1 ha Stand Of Mangrove Forest	Intan *et al.*	2003
Port Klang	UPM-APSB's AISA airborne hyperspectral imaging for individual mangrove mapping	Kamaruzaman Jusoff	2006
Peninsular Malaysia	Distribution And Rarity Of Rhizophoraceae	Wan Juliana *et al.*	2009
Pulai Reserve Forest, Johor	Mangrove Species Survey	Jamaliah *et al.*	2003
Matang, West Peninsular Malaysia	Floral Diversity And Distribution In The Mangroves, After A Century Of Sustainable Forestry	Arnoud *et al.*	2012
Tok Bali, Kelantan	Biological Diversity Assessment of Tok Bali Mangrove Forest	Kasawani *et al.*	2007
Peninsular Malaysia	Biodiversity and biomass of a natural and degraded mangrove forest	Zhila *et al.*	2014
Malaysia	The Use Of Mangrove In Malaysia	Abd. Shukor	2004

Mangroves are an assemblage of vascular plants that have its personal morphological, physiological and other non-noticable in adjustment with live in a saline intertidal environment influence by low dissolved oxygen or consistently anoxic fine sediments. These plants, together with their commanded of microorganisms and animals, shape the mangrove biological system. The term mangrove thus assign for both to the plants themselves as well as to the ecosystem (Ong and Gong, 2013). No classification system is perfect and Tomlinson (1986) had himself admitted: '*Of course, the groups are not sharply circumscribed and the assessment is somewhat subjective, since there is a continuum of possibilities*.'

NOAA (n. d.) claimed that most of the mangrove forest can be seen through its opaque skein of their prop roots that cause this trees appear to be standing on stilts above the water where this skein of roots permits the trees to handle the daily rise and fall of tides, which implies that most mangroves get overflowed at any rate twice per day. Moreover, the roots also lessen the movement of tidal waters, resulting sediments to settle out of the water and enhance the muddy bottom. McGowan (2006) claimed that present of pneumatophores (exposed breathing roots) to allow gas exchange in what are regularly anaerobic residue, supporting prop roots for backing in what might be shallow and unstable sediment, buoyant and viviparous propagules that permits scattering of the seed in an oceanic environment and salt excretion glands to oversee salt balance within the plant in what is oftentimes a saline environment.

Despite the fact and the literature on mangrove forests are broad and numerous case studies portray their degree and losses over time, global, thorough information on the status and patterns in the extent of mangroves has been deficient. The first attempt to gauge all of the mangrove area worldwide was embraced as a component of the FAO and United Nations Environment Programme (UNEP) Tropical Forest Resources Assessment in 1980. In that study, the world mangrove total was assessed at 15.6 million hectares, while later gauges range from 12 to 20 million hectares. Countries with limited areas of mangroves were excluded from many of the earlier studies, presumably in light of absence of data. The range of mangroves in these nations and regions is, however, relatively poor and therefore did not significantly influence the world total. The world's mangroves 1980–2005 were adapted by FAO in participation with mangrove specialists throughout the world, and was co-funded by the International Tropical Timber Organization (ITTO).

Mangroves are frequently the main forest ecosystem found along the coasts, they provide required resources for local communities and a territory for an extensive variety of wildlife, and are crucial in the management of forest genetic resources. Due to their coastal location mangroves protect coastal water quality (English *et al*., 1997) form a boundary for coastal protection from wave tempest and flood loss (Yoshiro *et al*., 1997). Mangroves are also necessary breeding grounds for juvenile fish that as it can also maintain fisheries through their supplement export (Robertson *et al*., 1991). Besides, they also play an essential role in carbon fixation and stocking, control of the quality and amount of water, and the flux of natural particles to the marine ecosystem (Zhila *et al.*, 2014).

2.2 Mangrove Distribution

Generally in Malaysia, mangrove plant species diversity is equivalent with the worldwide as no less than 70 species from 28 families have been recorded from the 73 species reported by Spalding *et al*., (2010). Mangrove comprises under 2% of the total land area in Malaysia. Abd. Shukor (2004) indicated that there are 641,886 ha of mangrove forest in Malaysia of which for the most part found in Sabah, 57% and 26% in Sarawak and the remaining 17% in Peninsular Malaysia respectively. Of the total, 441,092 ha or 69% of its area have been gazette as forest reserves and managed under Forestry Department. The Matang Mangrove Forest Reserve, Peninsular Malaysia, is another vast forest in the district. The mangrove area commonly known as the mangrove forests of the best-supervised in Malaysia and among the best-oversaw worldwide. The typical characteristics of mangrove that can be found in Malaysia are tall, dense and floristically diverse on which the mangrove distribution actually is constrained by temperature (Selvam & Karunagaran, 2004).

A major range of mangrove forest in Sabah have been gazette as Mangrove Forest Reserve class V, with Sabah have the most broad coverage of mangrove in Malaysia (Wah *et al*., 2011). There are approximately of 15 % of the mangrove forests in Semporna have been injure by encroachment activity, such as conversion of mangrove forest for oil palm plantation, shrimp cultivating, and others that would lead the area to corrupt (Sabah Forestry Department, 2007). From Table 2.2 and 2.3, mangroves are largely distribution in Sabah whereas in the Table 2.2, the area of mangrove was downturn of 7.3% from the earlier year. Sabah and Sarawak make up to 82% of the nation's mangrove (Table 2.3).

Table 2.2 The distribution of mangrove forest reserves and stateland mangroves in Malaysia.

State	Forest Reserve (ha)	Stateland Mangroves (ha)	Total
Johore	17,029	8,050	25,079
Kedah	7,949	-	7,949
Malaca	-	-	-
Kelantan	338	100	438
Negeri Sembilan	540	727	1,267
Pahang	2,483	8,990	11,473
Penang	451	-	451
Perak	43,502	-	43,502
Perlis	-	-	-
Selangor	15,090	-	15,090
Terengganu	1,295	-	1,295
Sabah	317,423	49,927	367,350
Sarawak	34,992	133,000	167,992
Total	**441,092**	**200,794**	**641,886**

Note: ha = hectares (Source: Abd. Shukor, 2004)

Malaysia lost about 110 000 ha of mangroves from 1980 to 2005. During the first decade (1980–1990), mangrove damage was basically due to change of land for horticulture, shrimp ponds or urban growth (FAO, 2007). Shrimp cultivating spread rapidly in the country, especially in Peninsular Malaysia, leading to the clearing of huge areas of forest. The presences of fireflies at stream estuaries have been a major ecotourism appeal, such as in Kampong Kuantan, Selangor where these activities also contribute to the losses of the mangroves.

FAO (2007) listed Asian nations with a significant degree of mangroves are Malaysia, Myanmar, Bangladesh and India, which, together with Indonesia, represent more than 80 percent of total Asian mangrove area. Thus, the mangroves of these five nations also serve a high percentage of worldwide mangrove extent and this demonstrates all of them are included in the ten nations with the biggest degree of mangrove area around the world.

Table 2.3 The distribution of mangrove forest reserves in Peninsular Malaysia.

State	Total Area (ha)	Note
Johor	17,185	In 1994, 16,659 ha were left. Lately more mangrove were felled in Kukup, Sungai Pulai, Sungai Santi areas for development
Kedah	8,118	In 1994, only 8,034 ha existed, noew some have been converted to prawn and shrimps ponds; while that at Malut in Langkawi has been totally lost. In other parts of Langkawi they habe been protected
Perlis	13	There are patches of mangrove forest in the area of Kuala Perlis but not economical
Negeri Sembilan	204	In 1994, only 879 ha existed along the Sungai Linggi; much of the mangroves in the vicinity of Port Dickson have been developed
Pahang	2,416	The mangroves are found in the sheltered estuaries and also along the rivers, especially Sungai Kuantan and Sungai Rompin
Perak	41,617	Most are quite intact especially in Matang but those in Majong district and Setiawan had been degraded
Pulau Pinang	279	Both the mangroves in Penang Island and Seberang Prai are affected by water pollution
Selangor	14,897	In 1994, it was reported that only 15,090 ha is left; that of Jugra and Pulau Ketam have been badly affected by development
Kelantan	744	There are patches of mangrove forests at estuaries and their river banks in Tumpat and Bachok districts
Terengganu	1,295	There are mangrove forests at estuaries and their river banks, especially Sungai Kemaman
Melaka	80	There are patches of mangrove forests at estuaries and their river banks especially Sungai Linggi
Total	99,767	Whilst in 1994 it was 105,537
Sabah	340,689	23,266 ha are state lands
Sarawak	126,400	93,200 ha are state lands
Grand Total	**566,856**	

Note: ha = hectares (Source: Latiff, 2012)

2.3 Zonation of Mangrove

Mangrove distributions are basically determined by sea level and its fluctuations. Other auxiliary components are: air temperature, salinity, ocean currents, storms, shores slope and sloppy soil. Most mangroves live on sloppy soils, but they also can develop on sand, peat and coral rock. This attitude is regularly portrayed by zonation mangroves where mangroves show zonation patterns in several of different geographic areas (Smith 1992). Certain species require specific areas, or niches, within the biological community. Some mangrove species occur near to shores, fringing islands, and sheltered bays; others are discovered further inland, in estuaries influenced by tidal activity. According to a book 'Status of Mangrove in Peninsular Malaysia' by Forest Research Institute Malaysia (FRIM) (2012), their editor had categorized mangrove based on previous study conducted by Watson (1928) where five major types of mangrove forest zones in Peninsular Malaysia was classified based on the dominant species which shape almost pure stands from the seafront into the hinterland: (i) the *Avicennia–Sonneratia* species (on pioneer shore), (ii) *Bruguiera cylindrical* species, (iii) *Bruguiera parviflora* species, (iv) *Rhizophora* species and (v) *Bruguiera gymnorhiza* species (on landward edge). According to Japar Sidik (1994), a mangrove forest grew best in Malaysia where the highest number of species occurs and is favored by a humid tropical climate and high rainfall, which are normally lead by silt-laden rivers forming proper mudflats.

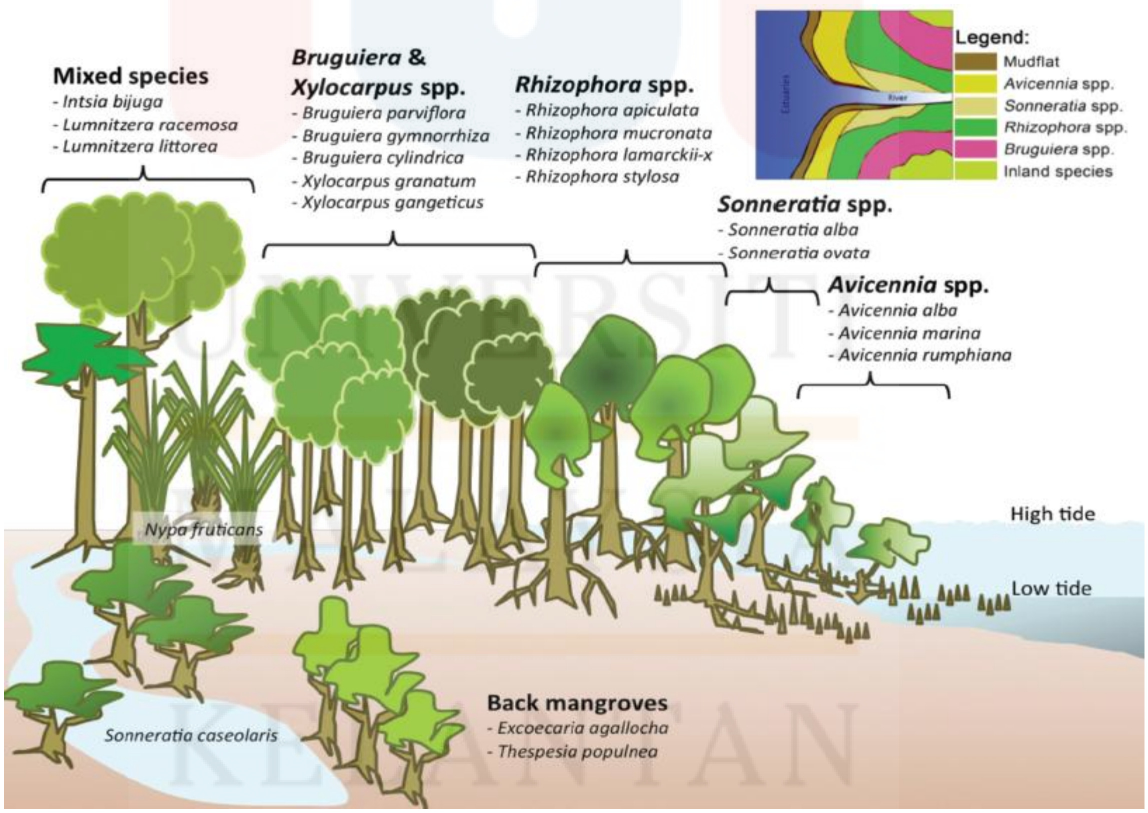

Figure 2.1 Stylized zones of mangrove species typical in Malaysia.

2.4 Anatomy

2.4.1 Root Anatomy

Mangroves are highly adapted to the coastal environment, with exposed breathing roots, extensive support roots and buttresses, salt-excreting leaves, and viviparous water scattered propagules. Normally mangrove plants species have aerial roots, commonly prop roots or stilt roots. These adaptations differ among taxa and with the physical-chemical nature of the habitat (Duke, 1992). The roots of numerous mangroves do not penetrate far into the anaerobic substrata. Instead, the trees produce profuse lateral roots for backing. Selvam and Karunagaran, (2004) expressed in developing *Rhizophora* species roots which are stilt roots diverge from the tree as much as 2 m above ground and pass through the soil some distance away from the main stem and they give the principal physical support of the trunk. Usually aerial roots of neighbouring trees regularly cross, and the outcome is the advancement of an impenetrable mesh of stilt roots.

Ong and Gong (2013) claimed that other species, like *Heritiera littoralis* and *Xylocarpus granatum*, have extremely outstanding sinuous buttress roots which additionally bolster support these plants in the muddy condition which spread out over a substantial area. These broad winding buttresses are probably a reaction to heavy winds and yearly typhoons. However, there are breathing roots that act as lateral branch from a shallow horizontal root (also called cable roots (SPGME, n. d.) that aides in secure the plants in soft substrate and at a specific interval, there are pneumatophores which permit gas exchange. The example of the species is *Avicennia* while *Bruguiera* are known as knee roots since they come out of the mud from cable roots and bend back down and able to in gas exchange.

2.4.2 Wood Anatomy

Tomlinson (1986) has summarized the unique anatomical element of mangrove woods. Development rings are clearly particular as in *Avicennia* totaly null (Das & Ghose, 1998). Thus, these lead to severe constraints on maturing tree. Duke and Pinzon (1992) suggested that leaf scar nodal number is a better approach to evaluate the age of *Rhizophora* seedlings. Mangrove wood has special characteristic that empower the trees to overcome the high osmotic capability of seawater and the transpiration brought by high temperatures. There are different narrow vessel that running through the wood which its extent in density from 32 to 270 per sq.mm. (Das & Ghose, 1998). The limitation of this vessel are diameter ranging from less than 100 μm to 150 μm. (Selvam & Karunagaran, 2004) in which turn out the density of the narrow vessel produce high tension in xylem since slight decline in diameter of the vessel. Most of the wood in mangroves is diffuse porous and help in the moderate movement of water through wood.

Wound repair in mangrove wood has also been well studied. In *Rhizophora* species, a closing layer separates wounded tissue within 17 days as indicated by Wier *et al*., (1996) and it is completely enclosed by periderm by 52 days. Confinement of the wounded site and development of wound periderm may avert spread of pathogens to undamaged tissues.

2.4.3 Leaf Anatomy

Kathiresan and Bingham (2001) explained on this life system where mangrove leaves are almost rugged with obscure leaf veins (there are no vein sheaths). The cuticle of this leaf thick and smooth with small hairs, giving the plant a glossy appearance. It characteristic are moderate in size and arranged in a modified decussate arrangement with a couple at a point less than 180° to the preceding pair. The arrangement gives advantage as it diminish shading produces branch systems with greater diversity that fill space in the most photosynthesis in efficient way (Tomlinson, 1986). There are six stomata presented from mangrove leaves and shift from each species. In general, the leaves lack bundle sheath fibres and bundle sheath extensions, but possess developed tracheids terminating in vein endings. Branched sclereids are plenteous and well developed in *Aegiceras*, *Rhizophora*, *Sonneratia* and *Aegialitis*. The sclereids may give mechanical support to leaves or demoralize herbivores. Both sclereids and tracheids may also be included in water storage (Tomlinson, 1986).

Water is also stored in colorless, non-assimilatory water-storage tissue that is hypodermal in dorsiventral leaves, but is profound situated in the broad mesophyll region of isolateral leaves. In some species, the thick layer of non-assimilatory tissue occurs before the assimilatory cells. Koizumi *et al.*, (1998) point out this back disperse incoming light, creating a gradient that may help the plant capture weak light, increasing photosynthesis productivity.

2.5 Species Diversity

Genarally, species diversity is a measure of the number of component species and their abundance at a defined point in space and time (Rosenzweig, 1995). Species diversity and biodiversity are broadly utilized terms in ecology and natural resource management. Species diversity may influence ecosystem functions, such as the productivity of a framework or the stability of that production. Hooper *et al*., (2005) discussed that species diversity considers species richness in as far as quantities of species as isolated entities, 'functional group diversity' considers species composition where species with similar consequences for a particular ecosystem-level process (i.e., functional traits) are bunched together as functional groups. According to Reich *et al*., (2004), the distinctive levels of diversity can independently affect ecosystem functioning such as the productivity of a system or the stability of that production. These relationships is important to have a clear understanding because if the effect of biodiversity damage are to be predicted, and management of ecosystems to be modified to sustain vital ecological processes (Kelvin, 2009).

The species diversity has been primarily concerned by ecologists as it is normally utilized representation of ecological diversity. Lexerod and Eid (2006) point out tree species diversity and tree size diversity assorted quality of particular importance to forestry. Niche width and habitat diversity are also key component of ecological diversity (Hamilton, 2005). Species diversity is influenced by an assortment of various processes, only some of which operate across spatial scales. At a global scale, change in species diversity is only caused by two processes, extinction and speciation, and the net balance between these two processes determines whether diversity is increasing or reducing on Earth.

The alpha diversity refers to diversity within a stand, the beta diversity to the degree of change in diversity along a complex environmental gradient and the gamma diversity to the level of separation between stands at the landscape level (Whittaker, 1972). Sax and Gaines (2003) claimed that species immigration is also imperative due including of introducing new species that not present previously. Thus, they can expand diversity by becoming settled and contributing to the total number of species present in a territory. However, in small parks or reserves that have been totally separated by encompassing urban improvement, net species diversity has often degraded (Drayton & Primark, 1996).

It is not uncommon for species diversity to be expressed in the form of a species diversity index. Spellerberg (1991) suggested that species diversity could be maintained for use in this context that is as an expression or index of some relation between number of species and number of individuals. Several indices of species diversity are used in the large amount of literature on biological diversity and ecological monitoring. A commonly used index is that referred to as 'Shannon's Index' or 'H'. The theory of species diversity considers three different ecological phenomena (species richness, relative abundance and community evenness). Works by Wilsey *et al*., (2006) early in their experiment, diversity indices weekly reflected contrast in richness however after the competitive effect of *Rudbekia hirta* become more intense, diversity indices more firmly reflected differences in its evenness. Based on the study, it was shown that the species evenness and diversity indices are not often positively cavalry along with richness. Thus, it was suggested that evenness and richness can be affected by different processes, with richness being more influenced by the quantity of emerging seedlings and evenness more by species interaction like competition.

2.6 Species Richness

Species richness is the total number of species present in a given area or sample whereas diversity consider how individuals are assigned between those species, i.e., the species frequency distribution (Aslam, 2009). Species richness (i.e., the amount of species) is the simplest and the most direct concept for characterizing community diversity where it focused on the estimation of species richness based on a sample from a local community. In fact, it turns out that nearly all quantitative measures of diversity are some blend of two components, species richness and evenness, where evenness depicts how equally individuals are conveyed among the species. The quantity of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample.

Species richness as a measure on its own makes no account of the quantity of individuals of each species present. It gives as much weight to those species which have very few individuals as to those which have numerous individuals. It is common for mangrove forests to be made up of very few species, monospecific stands are not uncommon and larger forests may frequently be made up of 3 or 4 species found within distinct zones, with couple of species of associate flora (McGowan, 2006). Smith (1992) found that species richness in an estuary is not a consequence of propagule dispersal properties, concluding that these factors may not affect species richness at a local scale but that it might play an essential role at the biogeographic scale.

2.7 Mangrove Classification

Tomlinson (1986) stated mangroves may be divided into three groups according to their features: major elements (strict or true mangroves), minor elements and mangrove associates. Mangrove exclusive or major mangroves were defined the tree species that are *mainly restricted to the intertidal zone within deep water and high salinity include Avicennia lanata, A. marina, A. officianalis, Bruguiera cylindrical, B. gymnorrhiza, B. parviflora, B. sexangula, Ceriops decandra, C. tagal, Kandelia candel, Lumnitzera littorea, Nypa fruticans, Rhizopohra apiculata, R. sytlosa, Sonneratia alba*, and *S. caseolaris*, etc. (Saengar *et al*., 1983;Tomlinson, 1986; Rotaquio *et al*., 2007; Rajpar & Zakaria, 2014).

Meanwhile, mangrove non-exclusive or minor mangroves was defined as tree species that compromise with low salinity and are restricted to shallow water where salinity fluctuates from the time being and the species listed such as *Acrostichum aureum, A. speciosum, Aegiceras corniculatum, A. floridum, Excoecaria agallocha, Heritiera littoris, Osbornia octodonta, Pemphis acidula, Planchonella obovata, Scyphiphora hydrophyllaceae*, and *Xylocarpus granatum*, etc. (Saengar *et al*., 1983;Tomlinson, 1986; NTG, 2002; Rajpar & Zakaria, 2014). Mangrove associated was classified as plant species that grow with mangrove tree species include grasses, epiphytes, pteridophytes, bryophytes, and parasitic plants. (Tomlinson, 1986; Rotaquio *et al*., 2007; Rajpar & Zakaria, 2014).

2.8 Sustainability

The term of sustainability defined as development which meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Basically, sustainability comprises 3 major pillars; social, environmental and economic. However, sustainability can be described as a process of living within the scarcity of resources urge by the technology and social in order to meet present and future needs. Harris stated that interdisciplinary nature is a must in the theory of sustainable development, and all of the four capitals which is manufactured capital, natural capital, human capital, and social capital are essential over the long term (Harris, 2003). Market mechanisms often do not operate effectively to conserve this natural capital, but tend to deplete and degrade it. Things that need to be concern are the interrelationship between development and environment, seeking to address the extent poverty on a global scale alongside the emerging global environmental agenda for instance pollution, resource exploration, loss of biodiversity and global warming. Global warming in particular was achieving prominence as a new environmental threat.

Table 2.4 Comparison of mangrove forest in other areas the South-East Asia.

Study Site	Exclusive	Non-exclusive	Associates	Total
Selat Kuah (Wan Juliana et al., 2007)	30 + 1(h)	nc	Nc	nc
Kilim-Kisap (Wan Juliana et al., 2005)	28	25	1	54
Kisap Forest Reserve, Langkawi (Norhayati & Latiff, 2001)	17	nr	Nr	17
Merbok, Kedah (Ong, 2003)	23*		34	57
Sepang-Lukut, N. Sembilan (Saberi et al., 1993)	Nr	nr	Nr	0
Pulai Forest Reserve, Johor (Jamliah et al., 2003)	27	1	Nr	28
Santi Forest Reseerve, Johor (Sariah, 2003)	21	nr	Nr	21
Belungkor Forest Reserve, Johor (Intan et al., 2003)	16	nr	Nr	16
Semantan, Sarawak (Ashton & Macintosh, 2002)	18*		10	28
Singapore (Morgany et al., 1999)	34	nr	62	96
Thailand (4 regions) (Japar Sidek)	38	40	17	95
Malaysia (Japar Sidek, 1994)	38	57	9	104

Notes : nr = no record, nc = no complete, and * = the number represents for both exclusive and non-exclusive categories (Source: Latiff, 2012)

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

The study area was conducted at the Kelantan Delta, Pengkalan Kubur in the district of Tumpat, Kelantan. It was located within 06°13’53.1” N and 102°06’05.6” E (Figure 3.1) in the northern-most state on the East Coast of Peninsular Malaysia bordering with Thailand. Kelantan is one of the states in Peninsular Malaysia and covers an area of 14,931 km^2 which is 4.4 percent of the total area of Malaysia. It has an area almost 1493,181 ha of which 894,271 ha or about 60% under forest cover (Dahlan and Abdullah, 2006) (Figure 3.2). Spalding *et al*., (2010) claimed that the mangrove formations in South China Sea are generally small and limited to river mouths, where they normally lay 0.5–1 km inland.

Malaysia Meteorology Central Kelantan (2010-2016) reported the mean annual air temperature is 28.4°C in Jan-July 2016 and 27.3°C for annually (2012-2015) with 82% relative humidity and annual precipitation averages from 2750-3000 mm. In 1999, the precipitation recorded as 340 mm for each year while the daily precipitation is 206 mm. Pengkalan Kubur mangrove forest consist of three mixed area mangrove which 15.8 ha. The soil in Pengkalan Kubur mangrove forest made up of sand, silt and clay. The elevation for this study area ranges from 11 m above the sea.

Figure 3.1 The location of Peninsular Malaysia (Source: Google)

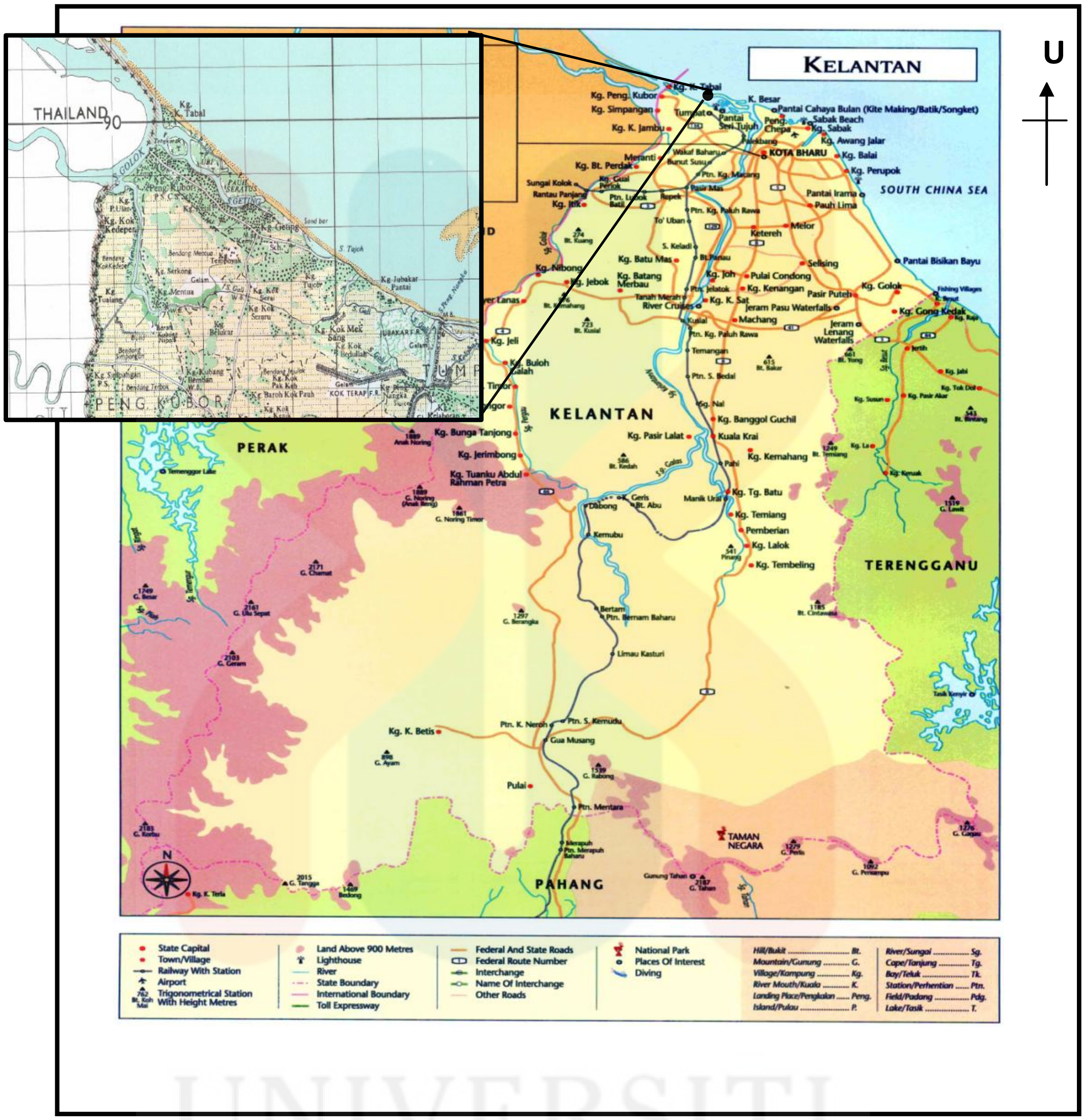

Figure 3.2 The location of Pengkalan Kubur mangrove forest, Tumpat, Kelantan (Source: Google)

3.2 Sampling Location

The vegetation types of the sampling location are Mixed Mangrove Forest area was red mangrove which is *Rhizopora mangle* and back mangrove and located within the low marsh. The forest divided into three according its characteristic; true or exclusive mangroves, non-exclusive species and associated mangrove species. A total number of the species collected were present in chapter 4.

3.3 Plot Establishment

A systematic sampling design was used to gather information on floristic of several growth patterns as it would be unreasonable to measure each tree in the whole mangrove forest to inventory species in the area. The fieldwork for this research was accomplish in mangrove forest measured 25 m x 20 m plot survey as shown in Figure 3.3. 10 replication of 25 m x 20 m subplot of the tree sample was taken randomly at different interval between each plot. The site of the plot was estimated to be 5000 m^2 and equivalent to 0.5 ha are plotted. These 10 replication was design as according to Kevin (2004), it can be extrapolate and provide information about the whole entire forest from the sample plots. Selection of plot are made by concerning the existence of trees inside or outside the plot boundary because to its lower area scale. Thus, square plots were selected over other shapes considering that square plot experience few issues with selection.

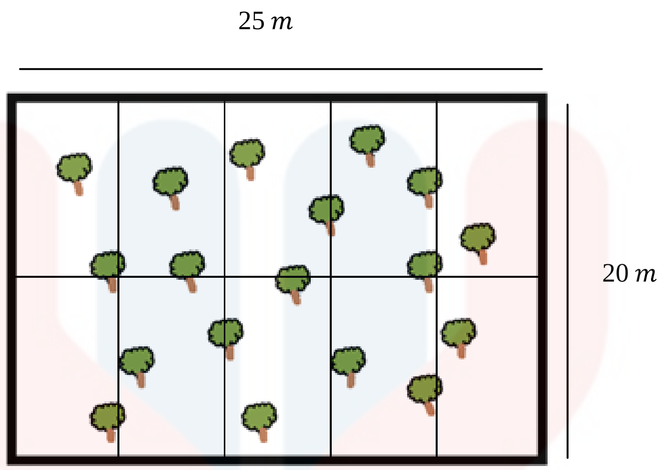

Figure 3.3 The area of plot survey.

3.4 Data Collection

The technique used was specimen collected for further identification species of the trees. Within each plot, trees with a diameter at breast height (DBH) of 5 cm and above were measured and identified. The specimen taken were leaves, flower and bark from each tree. Based on the 10 replicate plot area measured, the locations of trees within the plot were recorded and the trees tagged and labeled with number for future assessment (Figure 3.4).

Figure 3.4: Tree that has been tagged.

Figure 3.5 Garmin GPS model 72H.

Besides, the latitude and longitude of the tree were recorded using Garmin GPS (Figure 3.5) as it is least risky and can overcome the probability of redundancy of data. Thus, the chances the sample from the same tree taken twice was null. However, some of the trees were very tall, the binoculars (Figure 3.6) was used to identify the structure of the leave and the flower, and compared with the identical structure dried leaves that fall down on the ground. Before proceed with the species identification, the specimen were air-dried at room temperature. The identification of specimens was made possible using keys in the book entitled *Mangrove Flora of Langkawi* and by refers to the botanist of Universiti Malaysia Kelantan. All the data collected were recorded in Appendix B.

Figure 3.6: Binocular.

3.5 Data Analysis

The data gathered then have been analyzed to identify the type of species. To express the structure of a plant community, few attributes were taken into consideration including species diversity, species richness and species evenness were calculated for each mangrove trees species found in the study area. Species diversity scutiny both the number of species in a defined sampling unit (species richness) and the distribution of individual among species (species evenness). In this research, species diversity was measured using Shannon-Weiner index. The other types of indices were used namely Margalef's Index, Pielou's Evenness Index and chi-square.

3.5.1. Shannon Wiener Index

Diversity index is a mathematical measure of species diversity in a community and the species itself has two separate components; i) the community composition species richness, and ii) the relative abundances of different species into account. The type of diversity used here is α- diversity which is the diversity of species within a community or habitat. Magurran (2004) stated the Shannon diversity(H') and evenness (E') indices calculated as a measure to incorporate both species richness and species evenness. The advantage of using this index is that individuals are randomly sampled from and indefinitely large population and it assumes that all species are re[resented in the sample (Magurran, 1988). Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. The diversity index was calculated using the Shannon – Wiener diversity index (1949):

$$H' = \sum_{i=1}^{S} Pi \ln Pi$$

Equation (3.1)

where pi is the proportion of individuals found in the i^{th} species

H' = The Shannon diversity index

Pi = Fraction of the entire population made up of species i

S = Numbers of species encountered

$\sum$ = Sum from species 1 to species S

ln = Natural algorithm

Its range is from 0.0 to approximately 4.6. Therefore, the value for Shannon – Wiener Index usually fall between 1.5 to 3.5 and 4.5 indicates only for rarely surpasses (Magurran, 2004). A value of 0.0 means that every organism in the sample is of the same species and 4.6 means the number of individuals are evenly distributed among numerous species.

3.5.2 Margalef Index

The Margalef diversity index (Margalef, 1958) (R') can easily be calculated in a spreadsheet:

$$R' = \frac{(S-1)}{\ln N}$$

Equation (3.2)

Where:

S = The number of species

N = The total number of individuals in the sample

ln = Natural algorithm

3.5.3 Pielou's Index

For calculating the evenness with which individuals were distributed among the species, the Pielou's Evenness Index (J') was used (Pielou, 1966):

$$J' = \frac{H}{\ln S}$$

Equation (3.3)

Where:

S = The number of species

H = Shannon – Wiener Index diversity index

3.5.4 Chi-Square Analysis

In order to assess the relationship between two categorical variables, the chi-square was used. This analysis was calculated using SPSS statistic application. Chi-square test was included to determine if the populations are the same and the result of chi-square test was very definite. A chi square test is a widely-used non-parametric test, which examines if the frequency distribution of the observed data matches that of either the expected data or another known distribution. The resulting output includes the chi-square statistics as shown in the Appendix E.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Taxonomic Composition Density

The diversity of mangrove is excessively low as compared to tropical forest. Different mangrove species share a common morphological characteristic that makes the process of identification was very confusing part. The study recorded a total of 122 individuals representing 40 species from 38 genera and 29 families from the sampling site across all size classes of tree from 5cm dbh and above. Table 4.1 presents the summary of taxonomic composition of trees and plants of the study area. From the chi-square test with significant level 0.05 and chi-square test conducted to determine whether observed sample frequency specified and for strength of the relationship between species and individual. The chi-square calculated is 0.672, since the value >0.05 there is a significant difference between observed and expected frequency.

4.2 Species Richness and Diversity

The total number of mangrove species worldwide is 114 (Tomlinson, 1986) while Malaysia has 104 species (Japar, 1994). Table 4.2 shows the Shannon-Weiner Diversity Index (H') sample area was 2.73. According to Magurran (1988), typically the value of the H' lies between 1.5 and 3.5, and the increment is small due to the logarithmic element in the function although in the exceptional cases, the value can exceed 4.5 and above. A high value of H' indicates a large number of species with comparable abundance yet, a low value express domination by a few species. Since the range is intermediate, the index itself tells moderate about the actual species diversity.

Referring to Table 4.3, the H' value at Pengkalan Kubur mangrove forest was lower compared to Khairil *et al*., (2013) at Redang Island, Terengganu with 3.4. The value showed that Redang Island is more diverse compared to Pengkalan Kubur mangroved area. Meanwhile, these two value were among the highest than other studies such as Rozainah and Mohamad (2006) at Balok river, Pahang with 1.86, Kasawani *et al*., (2007) at Tok Bali, Kelantan with 1.60, Ashton and Macintosh (2002) at Semantan, Sarawak with 1.42, Zhila *et al*., (2014) at Selangor for Sungai Haji Dorani was 0.91 while at Kuala Selangor was 0.55 where the value of the Shannon-Weiner index was 1.65 times greater (0.91/0.55 = 1.65) at Sungai Haji Dorani compared to Kuala Selangor. However, Wah *et al*., (2011) discussed on the H' value for non-disturbed mangrove area was 0.71 and for disturbed mangrove area was 1.73. The undisturbed mangrove forest had lower tree species compared to disturbed mangrove forest. The Shannon index which emphasizes the richness component of diversity ranks Redang Island mangrove area as the most diverse.

Table 4.1 List of the taxonomic composition in Pengkalan Kubur Mangrove Forest, Kelantan.

Num	Family	Genera	Species	Individuals
1	Acanthaceae	1	1	2
2	Apocynaceae	1	1	1
3	Araliaceae	1	1	4
4	Avicenniaceae	1	1	3
5	Bignoniaceae	1	1	6
6	Casuarinaceae	1	1	1
7	Celastraceae	1	1	2
8	Clusiaceae	1	1	1
9	Combretaceae	1	1	1
10	Compositae	1	1	1
11	Elaeocapraceae	1	1	1
12	Fabacea	3	3	12
13	Fagaceae	1	2	4
14	Flagellariaceae	1	1	1
15	Legumminose	2	2	4
16	Malveacea	2	2	34
17	Melastomataceae	1	1	1
18	Meliaceae	2	2	5
19	Moraceae	1	1	1
20	Myrsinaceae	1	1	2
21	Oleaceae	2	2	2
22	Palmae	3	3	10
23	Pandanaceae	1	2	7
24	Pteridaceae	1	1	1
25	Rhizoporaceae	1	1	4
26	Rubiaceae	2	2	2
27	Sonneratiaceae	1	1	1
28	Sterculiaceae	1	1	6
29	Verbenaceae	1	1	1

Table 4.2 Species diversity index values for Pengkalan Kubur mangrove forest.

Indices	Value
Shannon-Weiner Diversity Index, H'	2.73
Pielou Evenness Index, J'	0.75
Margalef Richness Index, R'	8.12

Table 4.3 Biodiversity index values for other studies in Malaysia.

Study site	Area (ha)	Alpha diversity	Evenness	Frequency
Semantan Mangrove Forest	0.1	1.42	0.68	1.50
Redang Island	0.1	3.40	0.88	46.7
Selangor; Kuala Selangor	0.1	0.55	Nr	nr
Sungai Haji Dorani		0.91		
Balok River	0.2	±1.86	Nr	nr
Tok Bali Mangrove Forest	0.2	1.60	0.79	nr
Semporna Mangrove Forest	0.6	0.71, d	Nr	nr
		1.73, nd		
Sibuti Mangrove Forest	1.3	1.18	0.54	1.41

Notes: d = disturbed; nd = non-disturbed; nr = no record

For evenness, values of zero indicate that the community is extremely uneven dominated by one species, whereas a value of one indicates that the community is absolutely even maximum diversity exists, no one species dominates. There were limitations in comparative studies due to differences in method of study such as plot positioning (Table 4.3). The evenness value was determined through the formula from Pielou Evenness Index, J'. The highest diversity index (H'= 3.40) and species evenness index (J' = 0.88) was recorded in Redang Island. The distribution of individuals among various species was uniform, as shown by the high evenness index. The result for evenness in Pengkalan Kubur was 0.75 which means moderately even. For the comparison of J’, Shah *et* al., (2016) reported that Sibuti mangrove forest showed the lowest value with 0.54. Referring to Table 4.3, Tok Bali mangrove forest has greater species evenness than the Pengkalan Kubur mangrove forest, even though the Pengkalan Kubur has greater species richness. Magurran (1988) claimed that J’ value with 1.00 prove all species are equally abundant.

Margalef Richness Index (R’) revealed that the tree species richness at Pengkalan Kubur mangrove forest was 8.19 which is higher compared to Sibuti and Semantan mangrove forest with R’ value were 1.41 and 1.50 respectively. Low diversity index can be resulted due dominance few species. However, Redang Island show the higher value recorded with 46.7 which indicate this area was high diversity, Heip (1974) consider species richness and species evenness as two independent characteristics of biological communities that together constitute its diversity.

4.3 Family Abundance

The family abundance was attributed to nine large or commonest families based on the number of species and individuals (Table 4.4). Palmae and Fabacea each having 3 species or 2.5 % was the highest value followed by Meliaceae, Pandanaceae, Rubiaceae, Fagacea, Legumminose, and Oleaceae with 2 species each or 1.6% respectively in terms of number of species.

Table 4.4 The family dominance of nine large families abundance of species and individuals for the overall Pengkalan Kubur Mangrove Forest (ranked in descending order of abundance). Figures in parentheses are percentage of total.

Based on number of species		**Based on number of individuals**	
Family	**Num of species (%)**	**Family**	**Num of individuals (%)**
Palmae	3 (2.5)	Malvaceae	34 (27.9)
Fabacea	3 (2.5)	Fabaceae	12 (9.8)
Meliaceae	2 (1.6)	Palmae	10 (8.2)
Pandanaceae	2 (1.6)	Pandanaceae	7 (5.7)
Rubiaceae	2 (1.6)	Sterculiaceae	6 (4.9)
Fagacea	2 (1.6)	Bignoniaceae	6 (4.9)
Legumminose	2 (1.6)	Meliaceae	5 (4.1)
Oleaceae	2 (1.6)	Rhizoporaceae	4 (3.3)
Total	18 (14.8)	Total	84 (68.8)

The family of Malvaceae was widely distributed throughout study plot by large number of individuals (34) representing 27.9 % from the total 122 individuals collected, followed by Fabaceae, Palmae, and Pandanaceae with 12, 10, and 7 respectively. Surprisingly, Table 4.4 also highlights that nine dominant families by individual assumed more than half of its species richness (68.8 %).

Table 4.5 Plants species list occurrence at Pengkalan Kubur Mangrove forest

Num	Family	Species	Individuals
1	Acanthaceae	*Acanthus ebracteatus* Vahl.	2
2	Apocynaceae	*Cerbera maghas* L.	1
3	Araliaceae	*Schefflera actinophylla* (Endl.) Harms	4
4	Avicenniaceae	*Avicennia alba* Blume	3
5	Bignoniaceae	*Dolichandrone spathacea* (L.f) K. Schum.	6
6	Casuarinaceae	*Casuarina equisetifolia* L.	1
7	Celastraceae	*Elaeodendron croceum* (Thunb.) DC	2
8	Clusiaceae	*Calophyllum inophylum* L.	1
9	Combretaceae	*Terminalia catappa* L.	1
10	Compositae	*Wollastonia biflora* (L.) DC	1
11	Elaeocapraceae	*Sloanea macbrydei*	1
12	Fabacea	*Acacia auriculiformis*	10
		Adenanthra pavonia	1
		Cynometra ramiflora L.	1
13	Fagaceae	*Lithocarpus curtisii*	3
		Lithocarpus orbicarpus	1
14	Flagellariaceae	*Flagellaria indica* L.	1
15	Legumminose	*Caesalpinia crista* L.	1
		Derris trifoliata Lour	3
16	Malveacea	*Hibiscus tiliaceus* L.	33
		Thespesia populnea (L.) Sol. Ex Corrêa	1
17	Melastomataceae	*Memeceylon edule*	1
18	Meliaceae	*Aglaia* sp.	1
		Xylocarpus rumphii (Kostel.) Mabb.	4

Table 4.5 (continued)

Num	Family	Species	Individuals
19	Moraceae	*Ficus microcarpa* L.f.	1
20	Myrsinaceae	*Ardisia elliptica*Thunb.	2
21	Oleaceae	*Jasminum elongatum (Bergius) Willd*	1
		Olax imbricate	2
22	Palmae	*Cocos nucifera* L.	1
		Nypa fruticans Wurmb	8
		Oncosperma tigillarium (Jack) Ridl.	1
23	Pandanaceae	*Pandanus odoratissimus* L.f.	5
		Pandanus tectorius Parkinson	2
24	Pteridaceae	*Acrostichum aureum* L.	1
25	Rhizoporaceae	*Bruguiera cylindrica* (L.) Blume	4
26	Rubiaceae	*Morinda embellata*	1
		Timonius compressecaulis (Miq.) Boerl.	1
27	Sonneratiaceae	*Sonneratia caseolaris* L.	1
28	Sterculiaceae	*Heritiera littoris* Dryand	7
29	Verbenaceae	*Clerodendrum inerme* (L.) Gaertn	1

A total of 21 mangrove species was recorded out of 40 species found in Pengkalan Kubur Mangrove forest and the distribution of the species was shown (Table 4.5). *Hibiscus tiliaceus* the most common species and was the most present almost at all sampling site with an estimated total 33 individuals (27.05%). The other abundant species were *Acacia auriculiformis* (8.19%) and *Nypa fruticans* (6.56%). This result was different with other studies in the Tumpat district where Satyanarayana et *al*. (2010)

listed out five dominant species in Tumpat i.e, *Avicennia alba*, *Bruguiera gymnorrhiza*, *Nypa fruticans*, *Rhizopora mucronata* and *Sonneratia caseolaris*. However in Pengkalan Kubur mangrove forest, had recorded the similar species but in different number for example *Avicennia alba* (3), *Sonneratia caseolaris* (1), and Nypa *fruticans* (33). In term of comparison with other mangrove forest in Kelantan state, Kasawani et *al*., (2007) found the common species at Tok Bali were *Sonneratia alba* with 1165 trees followed by *Ceriops decandra, Excoecaria agallocha, A. alba, Bruguiera cylindrical, B. sexangula* , *Rhizophora apiculata, Aegiceras corniculatum, N. fruticans* and *D. trifoliate*.

Wan Juliana *et al*., (2014) claimed that the mangrove species composition on the west coast and east coast is different. According to Mohd Lokman Hussain and Sulong Ibrahim (2001), focused on the Terengganu region, 55 species was found where 26 species were non-exclusive and another 29 species classified as mangrove exclusive species. On the west coast, Soepadmo and Pandi Mat Zain (1989) supervised the mangrove of Sementa, Selangor and reported a total of 32 species were found. Latiff (2012) argue on the poorer flora of the east coast mangroves and the zonation is not obvious as they are not protected. These may be resulted from the exposure of east coast mangrove to larger waves of South China Sea.

4.4 Mangrove Species Categories

According to Tomlinson (1986) cited in FAO (2007) classification, mangroves may be divided into three groups according to their features: major elements (strict or true mangroves), minor elements and mangrove associates (Tomlinson, 1986; FAO 2007; Wan Juliana *et al*., 2010). Saenger *et al*., 1983 defined mangrove exclusive as tree species that are mainly restricted to the intertidal zone within deep water and high salinity; mangrove non exclusive is a tree species that tolerate low salinity and are restricted to shallow water where salinity fluctuates from time to time while mangrove associated as plants species that grow with mangrove tree species. Tomlinson's list of true mangrove species has been here modified by adding some species commonly found as exclusive mangrove species (Saenger *et al*., 1983).

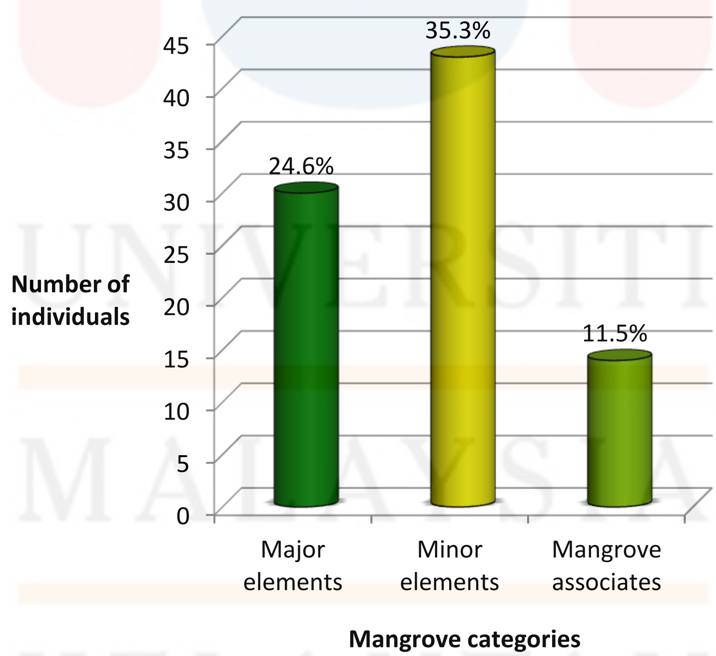

Figure 4.1 Graphical representation of the number of individuals and its mangrove classification.

The histogram indicates the number of individual classified found on each group where the major element is the most abundant with 30 individuals each or 35.3 % followed by minor elements and mangroves associate 43 individuals each or 24.6 % and 14 individuals each or 11.5 % (Figure 4.1)**.** The contribution of various mangrove classifications towards its number of individuals is provided in Table 4.6. A total of 8 individuals of *Nypa frutican* found there, of which these were considered as the largest species among true species followed by *Heritiera littoris* with 6 individuals. On the other hand, *Hibiscus tiliaceus* was dominated by large number of individuals (33) non-exclusive mangrove followed distantly by *Dolichandrone spathaceae* with 6 species.

Table 4.6 The plant species of Pengkalan Kubur mangrove forest according to its mangrove categories.

Mangrove categories	**Species**	**No. of individuals**
Exclusive mangroves	*Acanthus ebracteatus*	2
	Acrostichum aureum	1
	Avicennia alba	3
	Bruguiera cylindrica	4
	Cynometra ramiflora	1
	Heritiera littoris	7
	Soneratia alba	1
	Xyolocarpus rhumphii	1
Non- exclusive mangrove	*Cerbera maghas*	1
	Clerodendrum inerme	1
	Dolichandrone spathacea	6
	Flagellaria indica	1
	Hibiscus tiliaceus	33

Table 4.6 (continued

Mangrove categories	Species	No. of individuals
Mangroves associates	*Ardisia elliptica*	2
	Caesalpinia crista	1
	Callopylum inophylum	1
	Derris trifoliate	3
	Nypa fruticans	8
	Oncosperma tigillarium	1
	Pandanus odoratissimus	5
	Termilia catappa	1

Japar (1994) recorded that Malaysia has 38 exclusive, 57 non-exclusive and more than ten associated mangrove biota. Out of the 40 species found, 9 were exclusive, 5 were non-exclusive and 7 were associated mangrove forest. The exclusive species represented 23.7% and the non-exclusive species represented 8.8% of the Malaysia exclusive and non-exclusive mangrove species respectively. The 9 exclusive mangrove species consist of 30 trees.

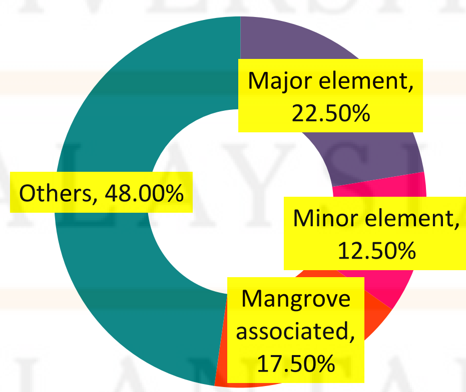

Figure 4.2 The percentage of plant distribution according categories.

Based on the Table 4.6, the highest number of mangrove associate species was *Pandanus odoratissimus* followed by *Derris trifoliate* (3 spp) and *Ardisia elliptica* (2 spp) recorded. Meanwhile, *Oncosperma tiggilarium, Terminalia catappa, Caesalpinia crista,* and *Callopylum inophylum* was reported as singleton. In the previous study, there were an argument on *Clerondrum ineme* as some researchers claimed it as mangrove associated (Thomas and Evans, 2006) while others did not consider it as mangrove species (Santayana *et* al., 2002). A total of 10 study plot have been established as in the sampling plot as a whole, the major element, minor element and mangrove associated species were 22.5%, 12.5% and 17.5%, respectively based on the species identified (Figure 4.2).

4.5 Mangrove Biodiversity Index according to Sampling Site

Table 4.7 Value of mangrove diversity according to diversity indices 10 sampling plot

Sampling site	Shannon-Weiner Index (H')	Pielou Evenness Index (J')	Margalef Index (R')
Plot A	1.78	0.20	2.95
Plot B	1.69	0.15	3.34
Plot C	1.76	0.29	2.01
Plot D	1.04	0.35	1.44
Plot E	2.02	0.22	3.34
Plot F	0.93	0.31	0.81
Plot G	1.76	0.18	3.25
Plot H	0.53	0.27	0.46
Plot I	0.68	0.62	0.34
Plot J	2.72	0.17	5.19

Table 4.7 indicates the value of mangrove diversity according to diversity indices in each sampling plot. Plot J shows the highest Shannon-Weiner Index (H' = 2.72) and Margalef Index (R' = 5.19) while for the Pielou Evenness Index, J' the greater evenness was at plot D with 0.35. Evenness is the distribution of individuals over species. Plot J recorded a larger diversity index since the community that has more species will have a greater diversity index than a community of similar evenness with fewer species. A community with greater evenness will also have a larger diversity index than a community same richness with lower evenness. Since diversity entails both richness and evenness, it is the possible community is richer, whereas the other community is more

even. However, these diversity indices vary due to the total number of species found in the study area and not represent to all area of Pengkalan Kubur mangrove area.

4.6 Distribution of plants species according sampling site

The mass occurrence of plants of each sampling site was recorded and the distribution was shown (Appendix B). From the overall sampling sites, *Acacia aureum* and *Hibiscus tiliaceus* were mostly appeared in almost all sites. It seems that from the overall study plots in study area under back mangrove zone due to the occurrence of the *A.aureum*. In plot F, H and I, these 2 species were presented consistent with the lack of canopy in this site. These species only require a little amount of light to start with, and soon enable to adapt with the surrounding. Based on the observation, this area has a potential to be developed in the future. Regularly, this site will change its soil structure and subsequently its vegetation types towards terrestrial ecosystem. Gradually, several mangrove species will be replaced by associate and terrestrial species, by virtue of hydrology and alteration may lead to the end of mangrove zone in this area.

However, some of the changes that take place following changes in hydrology may cause high increase of associate species that can tolerate disturbance, such as *A. aureum* and *H. tiliaceus* thus result in decreasing in species diversity index and this situation match enough like has been observed in these plots (Wilcox, 1995; Rozainah and Mohamad, 2006). Eradication of *A. aureum* to make way for young mangrove establishment is not easy yet, they can be both laborious and very expensive in term of cost. If this area does not have a seed bank by younger individuals or seedlings or juvenile, the regeneration process will not be able to occur which eventually lead this area in a vulnerable state, easily prey to unsustainable development project like aquaculture ponds (Chan, 1989; Rozainah and Mohamad, 2006). Therefore, the present species composition data is important as part of management of conservation and monitoring in any these changes of valuable ecosystem quality for future sustainability.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Overall the objectives of this study have been accomplished successfully. Based on data obtained and direct observation, the forest generally facing degradation of its diversity due to the status of the forest and anthropogenic activities such as mangrove wood harvesting. Managerial approaches and principle is key to improve the status of degraded mangroves in order conserve and restore this valuable area. Although the environmental correlates of plant species richness have long received attention, research into the genesis of this diversity is in its infancy. In Kelantan the study on the floristic composition was scanty. Meanwhile, overseeing that forest under sustainable management according to the protection and improvement of the present forest level and rehabilitation should be the first priority. Eventhough the study area was small, but the result showed different floristic variation and certain sampling plot had the high diversity and density of tree species. The result for this study can be a preliminary baseline data for other ecological studies or any future action to sustain this Pengkalan Kubur mangrove forest.

There are some limitations that had been scrutinized throughout this study such as the accessibility and weather problem. Pengkalan Kubur mangrove forest was not easy to be accessed except by boat and the time consume was limited for the sampling as only few person doing the sampling. About 2 hour to reach at the sampling site and sometimes the water level was high due the special characteristic of mangrove forest itself. Meanwhile, if the study plot was scattered, the result for biodiversity index will be higher since there will be more exclusive mangrove and non-exclusive mangrove species found.

5.2 Recommendations

As a recommendation, seeing the value of mangrove forest, the authorities should enforce their regulations to protect and conserve the mangrove forests in Pengkalan Kubur since the reductions and conversions of mangrove forest were critically observed. Mangrove should be treated carefully without underestimating their role for local livelihoods and see their long-term benefits for future generation via appropriate conservation and management practices.

Steps should be taken by Forestry Department to conserve some of these degraded mangrove forest as forest reserve. These can be seen in Matang Mangrove Forest Reseve (MMFR) in Perak as it is one of the best managed mangrove forests for wood and charcoal productions. Hence, the challenge of preserving and managing any type of remaining forest still persists. That is to develop a forest-friendly sustainable ecosystem in order to provide food and job while also preserving the environment. Other than that, long-time monitoring is essential to monitor the flora composition in mangroves and more study should be conducted in this area in the future. Awareness programs need to be introduced to local communities in order to establish the importance of mangrove forests and to protect it. Mangroves in Pengkalan Kubur would be an ideal site to support both conservation and soil protection against disasters such as another wave of unexpected strong or tsunami in the future.

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