MACROFUNGAL DIVERSITY AT HUTAN LIPUR BUKIT BAKAR, MACHANG, KELANTAN

by

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A report submitted in fulfilment of the requirements for the degree of Bachelor of applied science (Natural Resources Science) with Honours

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DECLARATION

I declare that this thesis entitled "Macrofungal Diversity at Hutan Lipur Bukit Bakar, Machang, Kelantan" 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.

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APPROVAL

"I/We hereby declare that I/We have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources) with Honours"

Signature : …….

Name of Supervisor : …….

Date : …….

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Macrofungal Diversity at Hutan Lipur Bukit Bakar, Machang, Kelantan

ABSTRACT

The present study deals with the macrofungal diversity and its distribution pattern in Bukit Bakar Recreational Forest, Machang, Kelantan. The macrofungal survey was done at three different trails of Bukit Bakar Recreational Forest, Machang, Kelantan. A total of 52 species of macrofungal species, from 38 genera in 24 families were collected and recorded. Polyporales was found to be the dominant order which representing 20 species. Distribution of macrofungal species in three different trails was also evaluated on the basis of Shannon diversity index, Shannon evenness index and Margalef's index. Highest Shannon diversity index, Shannon evenness index and Margalef's index were found to be 3.63, 0.86 and 11.57 respectively in Bukit Bakar Recreational Forest, Machang, Kelantan. The results indicate a very high species diversity and species richness of the study site.

Kepelbagaian Makrofungal di Hutan Lipur Bukit Bakar, Machang, Kelantan

ABSTRAK

Kajian ini berkaitan dengan kepelbagaian makrofungal dan pola pengedarannya di Hutan Lipur Bukit Bakar, Machang, Kelantan. Survei makrofungal dilakukan di tiga laluan yang berlainan di Hutan Lipur Bukit Bakar, Machang, Kelantan. Sebanyak 52 spesies makrofungal, daripada 38 genera dalam 24 keluarga telah dikumpulkan dan direkodkan. Polyporales didapati sebagai perintah dominan yang mewakili 20 spesies. Pengagihan spesies makrofungal di tiga laluan berbeza juga dinilai berdasarkan indeks kepelbagaian Shannon, indeks keterlaluan Shannon dan indeks Margalef. Indeks kepelbagaian Shannon, indeks keanjalan Shannon dan indeks Margalef didapati masing-masing di 3.63, 0.86 dan 11.57 di Hutan Lipur Bukit Bakar, Machang, Kelantan. Hasilnya menunjukkan kepelbagaian spesis yang sangat tinggi dan kekayaan spesies tapak kajian.

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m	Meters
a.s.l	Above sea level
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Fungi are the various group of microorganisms and organisms that classified among their kingdom as they neither animal nor plant (Hagen, 2012). Not all fungi are mushrooms, but all mushrooms are fungi which have fruiting bodies that are visible to the naked eye (Zainuddin et.al. 2010). Fungi are the organisms that reproduce by both asexual and sexual means and have no chlorophyll. The fungi cell walls have chitin and are usually filamentous. The fungal diseases are called mycoses and the study of fungi is called mycology (Hagen, 2012).

Most of the fungi cannot easily be seen clearly because the color is dull and there are small in size. But there are some fungal that was bright colors and attractive. In Malaysia, there are more than 4000 species of fungi that can be found whether in Sabah, Sarawak or at Peninsular Malaysia. Mushroom has many variations which are apparent characters that important for mushrooms identifications such as their texture, stalk, color, size, and the shape of the cap (Chang & Miles, 1987).

The mycelium is usually unseen or hidden whether inside the wood, below the soil or in other organic substrates is the main body of the fungus, which consists of

threads called hyphae that form a branching web collectively which known as the mycelium. The mycelium spread growth throughout the chosen substrate and absorbing nutrients. It can continue to grow for many years within the substrate but when the environmental conditions are right and suitable for the macrofungal growth, fruitbodies are likely to appear on the surface. Each fruitbody contains thousands of spores and it will germinate and grow to form a new mycelium if one lands in a suitable site (Laessoe, 2013). The fruiting body contains several parts. Pileus is the umbrella-like structure that protects growing basidiospore. Stipe gives support for pileus. An annulus is the structure formed when pileus separates from stipe as mushroom grows up. A gill is a place where basidiocarp grows.

Fungi make their nutrition from organic matter or from animals and living plants but they need to find the host or they need to digest dead, organic matter on other organisms because they cannot produce their own energy. Fungi have an important role as decomposers in the natural cycle and returned the nutrient to the soil. (El Araby, 2002; Laessoe, 2013)

Macrofungal can be classified into three ecological groups that are basic which are parasitic, saprophytic and mycorrhizal fungi. Some of the mushrooms are edible and some of the mushrooms are poisonous (Smith & Weber, 1996). Most are considered saprophytes and macrofungal did not have chlorophyll. Saprophyte is an organism that gets their nutrition from metabolizing non-living organic matter which means they break down and eat dead plants. The body of macrofungal keeps the nutrients and the other important compounds, and they start to fruit - produce when the conditions are suitable and enough material is stored. It is an invisible kingdom. The part of the macrofungal that we can only see the fruiting body of the organism.

1.2 Problem Statement

The diversity of macrofungal in Malaysia is poorly known and there is no accurate figure and data for the fungal diversity for Malaysia. Similarly happen in Hutan Lipur Bukit Bakar, Machang, Kelantan where there is no accurate figure and data for the fungal diversity in that area. Therefore, studies on macrofungal in this area are important for sufficient and accurate documentation on their diversity.

1.3 Objectives

1. To determine the diversity and richness of macrofungal at Hutan Lipur Bukit Bakar, Machang, Kelantan.

2. To study the distribution pattern of macrofungal at Hutan Lipur Bukit Bakar, Machang, Kelantan.

1.4 Scope of Study

This study will focus on the nature trails with 5 meters to the left and 5 meters to the right. Macrofungal specimens will be collected if macrofungal are found below the height of one meter from the tree trunk.

1.5 Significance of Study

This study is important to be conducted because there are no published research that has been done before about the diversity and richness of macrofungal in Bukit Bakar Machang, Kelantan and at the same time to study the distribution pattern of macrofungal within the area.

Other than that, this study has the probability to provide new data for the diversity of macrofungal in the area. With this study, it also has the probability to find a new alternative food sources for local people to consume.

CHAPTER 2

LITERATURE REVIEW

2.1 History and Discovery

Mycology, derived from Greek work, Mykes which means mushroom and logos means discourse. Etymologically, it is the study of mushroom. And indeed that was how mycology began in the dim past. With the invention of the microscope by Antonio Van Leeuwenhoek in the 17th century the systematic study of fungi began (Alexopoulos, 1996). The man who deserves the honor of being called the founder of the science of Mycology is Pier' Antonio Michelli, the Italian botanist who in 1729 published Nova Plantarum Genera in which his researches on fungi were included (Alexopoulos, 1996).

Nowadays, there are many scientists, botanist, and biologist studying the fungi. Many new discoveries are repeated every day. Many people have a very negative concept of fungi as they are disease-causing organisms. Although this impression is not entirely wrong, fungi are so much more than that. They are also beneficial organisms. A number of useful antibiotics are produced by them, including the wonder drug "penicillin". Without fungi, we would not have leavened bread, cheeses, beer, wine and other alcoholic beverages (Deák, 1991).

2.2 Classification of Macrofungal

Fungi can be divided into two groups which are Myxomycota and Eumycota. Eumycota is true fungi that are divided into five divisions which are Mastigomycota, Zygomycota, Ascomycota, Basidiomycota, and Deuteromycota. Mushrooms are fungi and the general term of mushroom is macrofungal which commonly found under the phylum Ascomycota and Basidiomycota.

2.2.1 Basidiomycetes

There are three subphyla that were most recently classification adopted by a coalition of 67 mycologists which are Pucciniomycotina, Ustilaginomycotina, Agaricomycotina and the other two are class level taxa which are Entorrhizomycetes, Wallemiomycetes outside of these, among the Basidiomycota. As a classified now, the subphyla was combined and also covers various taxonomic groups that commonly have been used previously to describe Basidiomycota (Hibbett et.al. 2007). Before this, the whole Basidiomycota were called as Basidiomycetes, this invalid class level name was been given in 1959 as a peer to the Ascomycetes when these taxa are recognized as divisions (Kirk, Cannon & Stalpers, 2008). The class of the Basidiomycetes includes the groups of toadstools, rusts, mushrooms, and smuts. Genus *Amanita* was mushrooms that the only pathogen in this class that can sometimes cause death when eaten or causes serious systemic poisoning.

2.2.2 Ascomycetes

There are three subphyla and the largest subphylum is Pezizomycotina which consists of all Ascomycetes that produce ascocarps, excluding one genus which is *Neolecta*. It is roughly similar to a previous taxon, Euascomycetes. According to (Cavalier-Smith, 1998) the Pezizomycotina includes most macroscopic "ascos" like truffles, Discomycetes, Pyrenomycetes, ergot, lorchels, ascolichens, and caterpillar fungus. It also consists of microscopic fungi like dermatophytic fungi, powdery mildews, and Laboulbeniales. Next is Saccharomycotina consists of most of the true yeasts, like baker's yeast and Candida, which are single-celled fungi that reproduce vegetatively by budding. Previously this species mostly were classified in a taxon called Hemiascomycetes. Third is Taphrinomycotina involving a different and basal group within the Ascomycota that was recognized following molecular DNA analyses. The taxon was originally named as Archaeascomycetes or Archiascomycetes and it includes both hyphal fungi which are *Neolecta*, *Taphrina*, Archaeorhizomyces, fission yeasts which are Schizosaccharomyces, and the mammalian lung parasite, Pneumocystis.

2.3 Morphological Character

Basidiomycetes also called club fungi because the basidia cells that contain the sexual spores that looks like the small club. Basidiomycetes are important plant pathogens, decomposers, and symbiosis with plants mycorrhizal. Basidiomycetes were good in breaking down the large plant cell wall polymers like lignin found in decaying wood. Morphologically, it includes in the complexity from microscopic single cells to fruiting bodies called basidiocarps.

The morphological character of the phylum Ascomycota is the production of four to eight sexual spores in a microscopic sac-like cell that been called an ascus (Bridson, 1998). Ascomycetes were able of producing great amounts of asexual spores called conidia that allow them to propagate without needed to undergo sexual recombination. This feature can be particularly destructive because these plant pathogenic fungi can cause devastating epidemics via repeated rounds of asexual reproduction with the dissemination of billions of conidia in a short period of time. Prior to sexual reproduction, compatible haploid mating-type hyphae fuse to form a dikaryotic hypha. In contrast to the basidiomycetes, ascomycetes have a more limited dikaryotic stage. The dikaryotic stage eventually gives rise to an ascocarp and sexual ascospores.

2.4 Lifecycle of Macrofungal

The macrofungal life cycle simplified. It all starts with the spore dispersal when the spores of this fleshy fruitbody sit in tubes that hang from the underside of the cap. The ripe spores drop out of the tubes and carried away by air currents. If they land in favorable site, they germinate to produce an underground branched web called a mycelium. The types of the spore's dispersal were depended on the type of macrofungal. Next was the germination process, in many fungi, two mycelia of opposite mating types have to fuse before they can produce sexual spores. The fused mycelia continue absorbing nutrients for the fungus, but when conditions are just right in terms of temperature and humidity, a sexual process occurs in special organs within emerging fruitbodies (Laessoe, 2013). This mycelium eventually forms what is known as a hyphal

knot which grows and develops into a pinhead which in turn grows and develops into a macrofungal and then it all starts again.

2.5 Utilization of Macrofungal

Macrofungal are a group of organisms which include species with fruiting bodies that were able to be seen. They have a stalk and a cap and are often seen in forests and fields. The amounts of poisonous species are relatively small while those that are fatal belong to a tiny minority. Macrofungal have various shapes and appearances. The wild edible fungus is used to distinguish their origin and the fact that they include a variety of forms.

Macrofungal plays an important role in mediated processes in the ecosystems for the nutrient cycle. Macrofungal act as the decomposer and play their role to regulate the soil fertility. Macrofungal are only organisms which extensively known can degrade the lignin which is a major component of the wood. Macrofungal has been used as a source of food by Indians, Chinese, and Malays at Malaysia. But for indigenous people, they used it not only as a food but also for other purposes such as medicine and spiritual reason (Lee, Chang & Noraswati, 2009).

2.6 Nutritional and Nutraceutical Value of Macrofungal

Since ancient times mushrooms have been consumed as food by man. Initially, it was probably due to the pleasing flavor and texture that was so attractive. Besides that, in some societies, their use was limited to royalty only and for well over two thousand years, some species of mushroom had also been used as medicinal and tonics. In modern times the cultivation of mushroom has steadily increased with the annual production where 4.27 million merits of mushrooms were consumed in an era in which people have become more concerned about human nutrition (Philip & Shu, 1997).

Macrofungal have been used as nutritional foods by many people and scientists around the world. They have realized that macrofungal are delicious food with great aroma, exotic tasteful appeal, and high nutritional traits because they contain good quality proteins, unsaturated fatty acids, minerals, and vitamins. Some edible macrofungal species are sources of bioactive compounds for medicinal applications, cardiovascular, antiviral, antibacterial, possessing antitumor and other activities.

Agaricus bisporus (Figure 2.1a) or know as white button mushroom are used as medicinal purpose because it contains high levels of dietary fibers and antioxidants including vitamin C, D, and B12, folates, and polyphenols that may provide beneficial effects on cardiovascular and diabetic diseases (Jeong et.al. 2010).

Flammulina velutipes (Figure 2.1b) or enoki is frequently utilized in Asian herbal remedies for cancer patients in addition to overall health boosters. Lower in calories and high in nutritional content, Enoki mushroom has always been included in daily meals in Asia (Balunas, Su, Brueggemeier & Kinghorn, 2008).

Some species of mushrooms have been used as medicine for thousands of years, particularly in China and Japan. Some of the immune- enhancing and anti-cancer effects of traditional species such as *Ganoderma lucidum* (Figure 2.1c) have been demonstrated scientifically (Boh, Berovic, Zhang & Zhi-Bin, 2007)

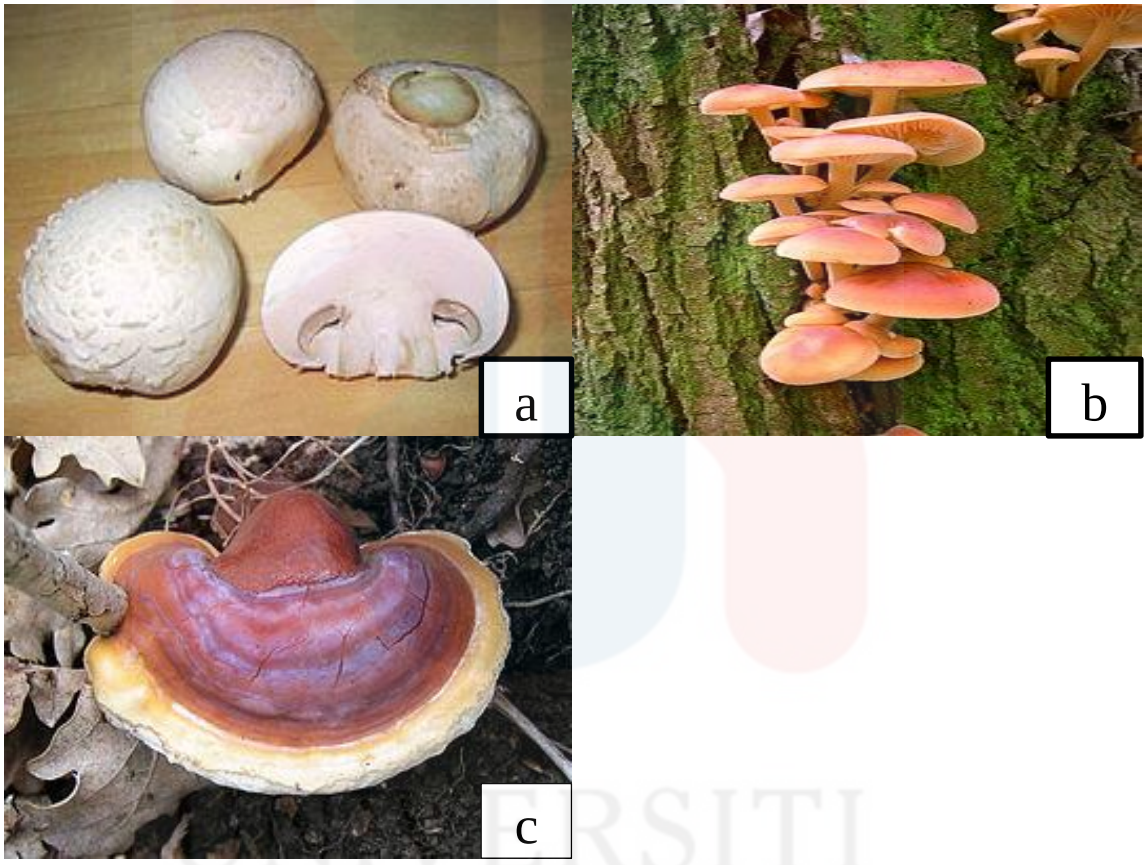

Figure 2.1 : The photographs of macrofungal the most used as medicinal a. *Agaricus bisporus* b. *Flammulina velutipes c*. *Ganoderma lucidum* (Google Image, 2018)

CHAPTER 3

METHODOLOGY

3.1 Study Area

The diversity of macrofungal was carried out at Hutan Lipur Bukit Bakar, Machang, Kelantan. Bukit Bakar Recreational Forest or Hutan Lipur Bukit Bakar and covered an area of 3.14 hectares, within the Ulu Sat Forest Reserve as shown in (Figure 3.1). The latitude and longitude of Bukit Bakar Machang, Kelantan Malaysia are 5° 43' 27.9516" N and 102° 15' 35.0676" E respectively (Lim, Yong & Wong, 2010).

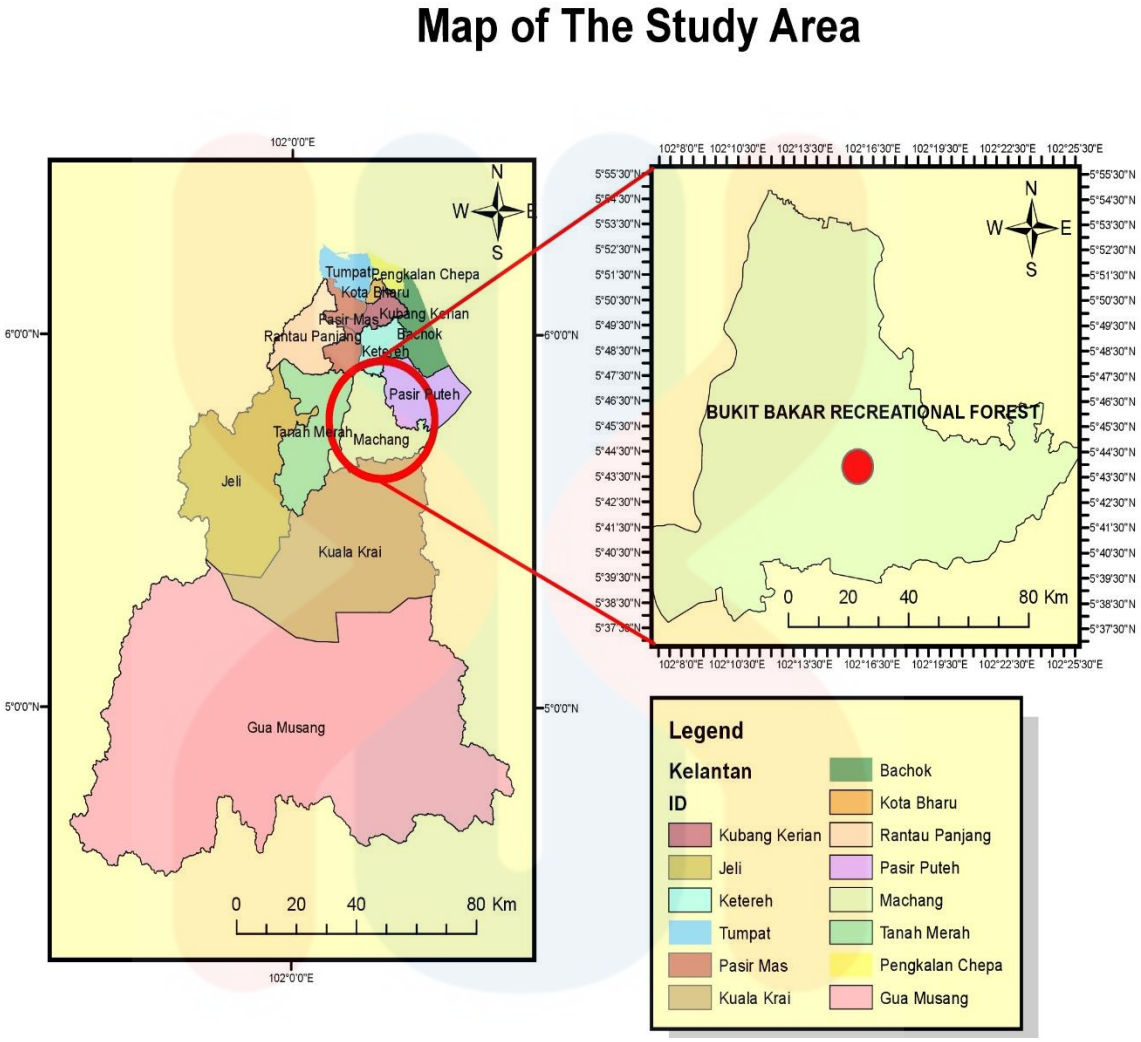

Figure 3.1 : Maps of the study area at Bukit Bakar Recreational Forest Machang, Kelantan (Google Map, 2018)

3.2 Materials

The protection equipment such as mask and gloves were used to prevent poisonous macrofungal. Samples of macrofungal were collected using knife and trowel for digging up the fruit bodies or to cut woody substrate of the macrofungal and secateurs were used for cutting. Then, a covered box was used to store the specimens for each specimen. GPS was used to get the data of the locations and tags to label for each specimen. For the photograph, the blackboard was used as a background, a ruler was used for scale and a camera was used to take the picture. The spore print was collected using a sheet of paper and glass jar was used to cover the macrofungal. For the wet preservation, the glass jar was used to fill the macrofungal and the preservation solutions of the mixture of ethanol, glycerol, and water were used (Lodge, Ammirati, O'Dell & Mueller, 2004).

3.3 Methods

3.3.1 Samples collection

The specimen collection was collected along the three nature trails of Hutan Lipur Bukit Bakar, Machang, Kelantan. The sample was collected along the trails by 5 meters on the left and 5 meters on the right. The reading of the GPS at every point the macrofungal was found was recorded. The photograph for each of macrofungal was taken in situ to see their fruiting body. Morphological characteristic features such as shape, size, color, and texture of the sporocarp were noted as these characteristics were changed when drying up and the descriptive notes were made when the macrofungal was still fresh. After that, all the macrofungal collections were handled with care to avoid loss of delicate surface structures. The trowel was used to remove the whole macrofungal from their substrate without damaging the tissues.

Then the specimens were placed into a covered box or wrapped in zipped plastic bags that fill in with air to avoid the specimens from damaged. Then the specimens were brought to the laboratory. Next, the spore prints for larger macrofungal from the specimen of each collection was prepared. The fruiting body of the macrofungal with the hymenial surface downwards was placed onto a sheet of paper and covered the specimens with a glass jar to prevent drying up then left overnight. Specimens and spore prints tagging number was similar to avoid mixed up.

3.3.2 Preservation

Dry preservation was made as soon as possible to retain the colour, form and to prevent the macrofungal from decay. The specimen was dried for the temperature of 40°C by using the drying oven at the laboratory. The specimen was dried for three days and continuous observation was done to maintain the temperature and macrofungal texture. The specimen was not pressed because macrofungal was fragile. After that, the specimens were bring out from the oven. Then, all the specimens based on their species and was sealed in the zipped plastic bag with the tagged to avoid mixing. Next, the specimens were brought to the natural resources museum to be stored.

Wet preservation also called as spirit or alcohol collections. These terms refer to the preservation of specimens to maintain their structure. To preserve the specimens, the specimens were soaked in the mixture of 70% ethanol, 29% of water and 1% glycerol (Bridson, 1998). Glycerol was added to stop the specimens becoming fragile. Next, the specimens were filled in the glass jar that contained 5% of glycerol solutions. Each of the glass jar were labelled. Then, the specimens was stored in the herbarium museums for the collections.

3.3.3 Identification

For identification of macrofungal, the sporocarp colour was important. The colour changes that were caused when handling the specimens were recorded. The habitat and the morphological characteristics of the macrofungal that was collected were noted, as the loss of moisture from the pileus has occurred rapidly. The colour changes of the species were rapid and, if undetected, it causes incorrect identifications. The features that are small or fragile that may have fine structure veil material that damaged or was lost on handling were noted at the field. The identification of the macrofungal was based on the book of Mushrooms & Toadstools the Illustrated Guide to Fungi (Thomas, 2013) and A Guidebook to the Macrofungi of Tasik Bera (Zainuddin et.al. 2010).

3.3.4 Data Analysis

a. Diversity Index

i. **Shannon Diversity Index** (Spellberg & Fedor, 2003) was used to characterize the total number of macrofungal species in a community by using the formula:

$$H' = -\sum_{i=1}^{s} (P_i)\,(ln\ P_i) \qquad (3.1)$$

H' represents the diversity index, P_i represent the proportion of the population made up of species i and s represents the number of species in samples.

ii. **Shannon Evenness Index** (Lloyd, 1964) also known as Shannon's equitability (EH). Shannon Evenness Index was used to compares the evenness component of species diversity in a community with the maximum amount of evenness possible given the same species richness.

$$E = \frac{H'}{H\ max} \tag{3.2}$$

E represents Shannon Evenness Index, H' represents calculated Shannon Diversity Index and $H\ max$ represents *In* (s) the species diversity under maximum equitability.

b. Richness Index

Margalef's Index was used as a simple measure of species richness (Hammer, Harper & Ryan, 2001).

$$Dg = \frac{(S - 1)}{\ln N} \tag{3.3}$$

S represents the total number of species, N represents the total number of individuals in the sample and *In* represents the natural logarithm

c. Distribution pattern

The Geographic Information System (GIS) application was used to generate the distribution patterns of macrofungal diversity at the area by using the ArcGIS software.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Floristic Composition

Macrofungal is one of the most vital components for the forest ecosystem. The mycologist needs to face the challenge to determine the pattern and magnitude of macrofungal diversity (Hawksworth, 1991, 2001, 2004; Hawksworth & Rossman, 1997). Macrofungal were poorly known, and often temporary and obscure (Mueller et. al. 2004).

The diversity of macrofungal were varied because of different ecological habitats, decaying wood, humid soil, sandy soil, and leaf litters. Mushrooms are seasonal fungi which occupy diverse niches in nature in the forest ecosystem (Pushpa & Purushothama, 2012). The abundance of macrofungi on different substrate greatly depends upon the organic and nitrogenous content of the soil and also on the other nutrients factors which play the key role in the growth of fungi (Kumar et.al. 2013).

The species diversity of macrofungal was related to their specific habitats. The diversity of macrofungal that occurred in an area was not a consistent pattern for every year because it depends on environmental conditions such as rainfall, soil humidity, air humidity and temperature (Lopez-Quintero et.al. 2012; Kutszegi et.al. 2015). The other

factor that influenced the development and the growth of macrofungal were the light, diversity of flora and geographical location elevation (Tapwal, Rajesh & Pandey, 2013).

Hutan Lipur Bukit Bakar, Machang, Kelantan or Bukit Bakar Forest Reserved was classified as hill dipterocarp forest. The total of 52 macrofungal species, from 38 genera in 24 families were collected and recorded from different trails of the study area.

Figure 4.1 shows the families of the macrofungal species recorded in the study area the most number of species that have been identified was belonged to Polyporaceae with seven genera, Agaricaceae with three genera, while Marasmiaceae, Omphalotaceae, Hymenochaetaceae, Ganodermataceae, and Xylariaceae represented with two genera for each families, and the other family represented only by single genus.

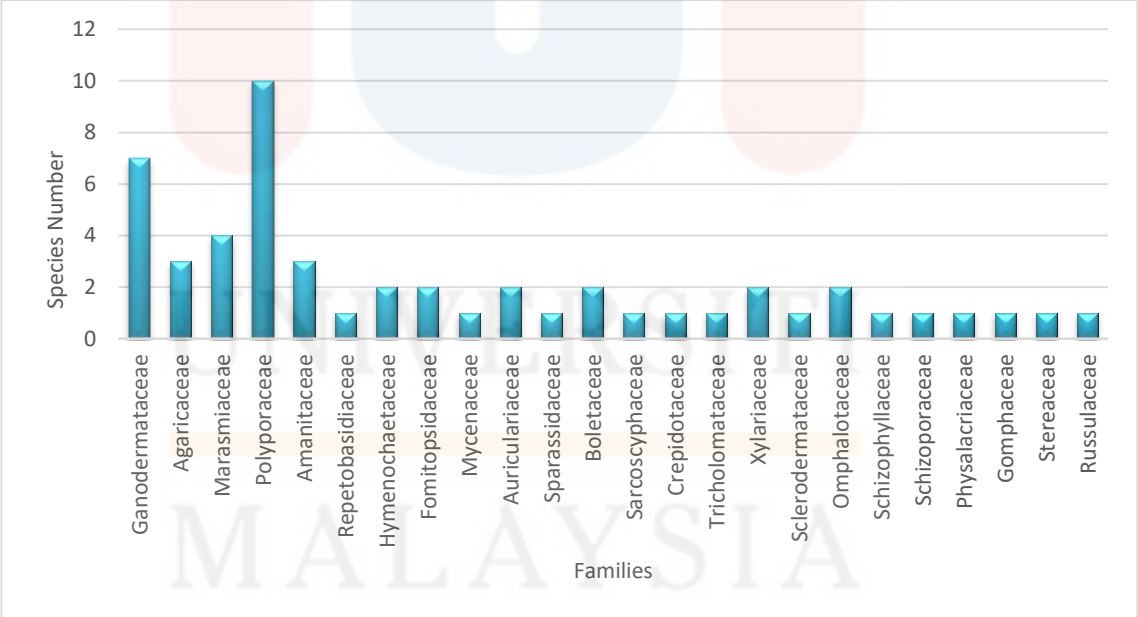

Figure 4.1 : Species richness of macrofungal families of Bukit Bakar Recreational Forest, Machang, Kelantan

Figure 4.2 shows that most of the macrofungal species according to the order in the taxonomic study that has been identified was belonged to Polyporales order (38%) and followed by Agaricales order (35%). Our result shows that the species richness was dominance by the macrofungal that growth from the woody substrates such as tree trunks and stump.

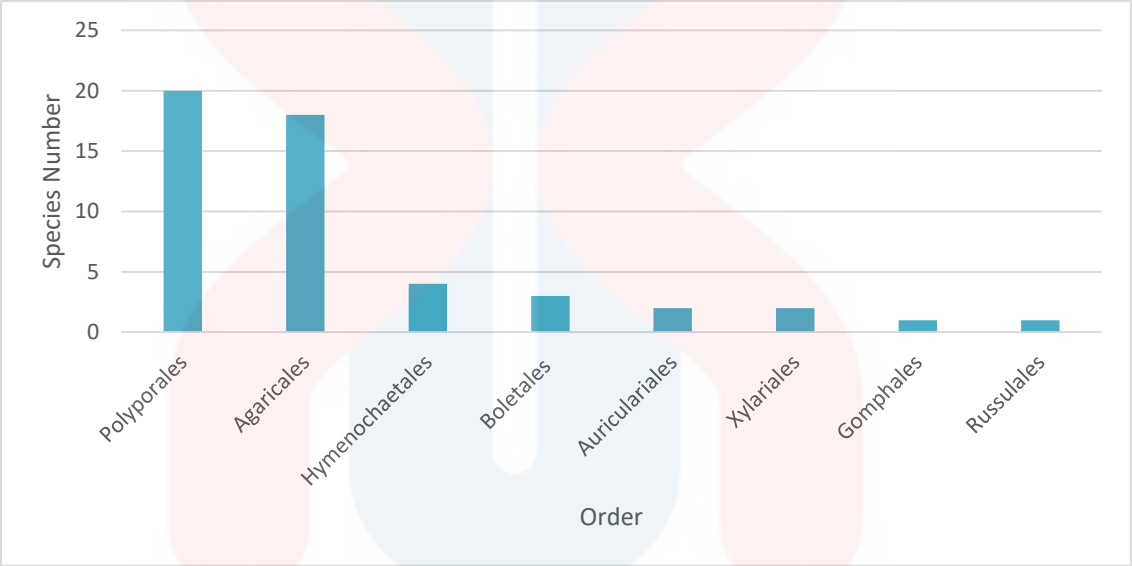

Figure 4.2 : Species richness of macrofungal order of Bukit Bakar Recreational Forest, Machang, Kelantan

The common species that were collected were *Microporus xanthopus* and *Amauroderma rugosum* of the Polyporales order because the species were collected repeatedly from the trails of the study sites. Beyond, the other 46 species were collected only once along the collections period as showed in the Table 4.1 that dominated by order of Polyporales and followed by Agaricales.

Table 4.1 : List of macrofungal species that found once in the study site

No	Name of species	Order	No of Species
1	*Amanita caesaea*	Agaricales	1
2	*Amanita phalloides*	Agaricales	1
3	*Amanita* sp.	Agaricales	1
4	*Amauroderma rugosum*	Polyporales	6
5	*Auricularia auricula-judae*	Auriculariales	1
6	*Boletellus emodensis*	Boletales	1
7	*Cookeina tricholoma*	Pezizales	1
8	*Coriolopsis* sp.	Polyporales	1
9	*Cotylidia* sp.	Hymenochaetales	1
10	*Crepidotus variabilis*	Agaricales	1
11	*Cyathus striatus*	Agaricales	1
12	*Earliella scabrosa*	Polyporales	1
13	*Filoboletus manipularis*	Agaricales	1
14	*Fomitopsis dochmia*	Polyporales	1
15	*Fomitopsis pinicola*	Polyporales	1
16	*Ganoderma applanatum*	Polyporales	1
17	*Ganoderma australe*	Polyporales	1
18	*Ganoderma brownii*	Polyporales	1
19	*Ganoderma curtisii*	Polyporales	1
20	*Ganoderma sichuanense*	Polyporales	1
21	*Ganoderma* sp.	Polyporales	1
22	*Gymnopus foetidus*	Agaricales	1
23	*Hymenochaete rubiginosa*	Hymenochaetales	1
24	*Lentinus strigosus*	Polyporales	1
25	*Lepiota* sp.	Agaricales	1
26	*Leucocoprinus fragilissimus*	Agaricales	1
27	*Marasmius abundans*	Agaricales	2
28	*Marasmius guyane*	Agaricales	1

Table 4.1 Continue…

29	*Marasmius pellicdus*	Agaricales	1
30	*Microporus* sp.	Polyporales	22
31	*Microporus vernicipes*	Polyporales	1
32	*Microporus xanthopus*	Polyporales	1
33	*Mycetinis opacus*	Agaricales	2
34	*Oudemansiella canarii*	Agaricales	1
35	*Panus giganteus*	Polyporales	1
36	*Phellinus igniarius*	Hymenochaetales	1
37	*Pleurocybella porrigens*	Agaricales	1
38	*Pycnoporus sanguineus*	Polyporales	1
39	*Schizophyllum commune*	Agaricales	1
40	*Schizopora paradoxa*	Hymenochaetales	1
41	*Scleroderma* sp.	Boletales	1
42	*Sparassis* sp.	Polyporales	1
43	*Trametes pubescens*	Polyporales	1
44	*Trametes versicolor*	Polyporales	1
45	*Tricholoma myomyces*	Agaricales	1
46	*Xylaria* sp.*1*	Xylariales	1

Saprophytic macrofungal was the largest group of fungi which grow on the dead organic matter including fallen leaves and dead wood. Among the collections, wood-inhabiting species of the order Polyporales were dominant from each trail. Most of the collections from these order were made from decaying plant materials such as roots, trunks, branches, and twigs. The most important wood-inhabiting species belonged to the Basidiomycota, including fruiting bodies of polypore fungi or bracket fungi (Jogeir, Juha & Bengt, 2012). The polypores have been suggested as species-rich in Malaysia (Hattori, Noraswati & Salmiah, 2007).

The study of biodiversity inventory of macrofungal that has been done at Sungkai Wildlife Reserve, Perak, Malaysia recorded that most of the macrofungal species were from dead trees (42.6%), and only 8.2% of the species occurred in leaf litters (Brown et. al. 2006). Based on Table 4.2 there were the percentages of the species and the highest percentages was obtained by the *Microporus xanthopus* with 27.5%. The *Microporus xanthopus* was growth on the dead branches.

Table 4.2 : Total numbers of family, genus and species in Bukit Bakar Recreational Forest, Machang, Kelantan.

Family	**Genera**	**Species**	**No Species**	**Percentages (%)**
Agaricaceae	*Cyathus*	*Cyathus striatus*	1	1.25
	Leucocoprinus	*Leucocoprinus fragilissimus*	1	1.25
	Lepiota	*Lepiota* sp.	1	1.25
Amanitaceae	*Amanita*	*Amanita caesaea*	1	1.25
		A.phalloides	1	1.25
		Amanita sp.	1	1.25
Auriculariaceae	*Auricularia*	*Auricularia auricula-judae*	1	1.25
		A.delicata	1	1.25
Boletaceae	*Boletellus*	*Boletellus emodensis*	1	1.25
	Boletus	*Boletus edulis*	1	1.25
Crepidotaceae	*Crepidotus*	*Crepidotus variabilis*	1	1.25
Fomitopsidaceae	*Fomitopsis*	*Fomitopsis dochmia*	1	1.25
		F.pinicola	1	1.25
Ganodermataceae	*Ganoderma*	*Ganoderma applanatum*	1	1.25
		G.australe	1	1.25
		G.brownii	1	1.25
		G.curtisii	1	1.25
		G.sichuanense	1	1.25
		Ganoderma sp.	1	1.25
	Amauroderma	*Amauroderma rugosum*	6	7.5
Gomphaceae	*Ramaria*	*Ramaria* sp.	1	1.25

Table 4.2 Continue…

Hymenochaetaceae	*Hymenochaete*	*Hymenochaete rubiginosa*	1	1.25
	Phellinus	*Phellinus igniarius*	1	1.25
Marasmiaceae	*Marasmius*	*Marasmius abundans*	2	2.5
		M.guyane	1	1.25
		M.pellicdus	1	1.25
	Pleurocybella	*Pleurocybella porrigens*	1	1.25
Mycenaceae	*Filoboletus*	*Filoboletus manipularis*	1	1.25
Omphalotaceae	*Gymnopus*	*Gymnopus foetidus*	1	1.25
	Mycetinis	*Mycetinis opacus*	2	2.5
Physalacriaceae	*Oudemansiella*	*Oudemansiella canarii*	1	1.25
Polyporaceae	*Trametes*	*Trametes versicolor*	1	1.25
		T.pubescens	1	1.25
	Microporus	*Microporus vernicipes*	1	1.25
		M.xanthopus	1	1.25
		Microporus sp.	22	27.5
	Coriolopsis	*Coriolopsis* sp.	1	1.25
Polyporaceae	*Earliella*	*Earliella scabrosa*	1	1.25
	Lentinus	*Lentinus strigosus*	1	1.25
	Panus	*Panus giganteus*	1	1.25
	Pycnoporus	*Pycnoporus sanguineus*	1	1.25
Repetobasidiaceae	*Cotylidia*	*Cotylidia* sp.	1	1.25
Tricholomataceae	*Tricholoma*	*Tricholoma myomyces*	1	1.25
Schizophyllaceae	*Schizophyllum*	*Schizophyllum commune*	1	1.25
Sclerodermataceae	*Scleroderma*	*Scleroderma* sp.	1	1.25
Russulaceae	*Russula*	*Russula* cf *aeruginea*	1	1.25
Sarcoscyphaceae	*Cookeina*	*Cookeina tricholoma*	1	1.25
Schizoporaceae	*Schizopora*	*Schizopora paradoxa*	1	1.25
Sparassidaceae	*Sparassis*	*Sparassis* sp.	1	1.25
Stereaceae	*Stereum*	*Stereum ostrea*	1	1.25
Xylariaceae	*Xylaria*	*Xylaria hypoxylon*	1	1.25
		Xylaria sp. *1*	1	1.25
			80	100

4.2 Species Diversity

4.2.1 Shannon Diversity Index and Shannon Evenness Index

Shannon diversity index (H') is a common method that was used to characterize species diversity in a community. High values of H' would be representative of more diverse communities. A community with only one species would have an H' value of 0 because Pi would equal 1 and be multiplied by *ln* Pi which would equal zero. If the species are evenly distributed then the H' value would be high. So, the H' value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community.

Macrofungal were collected from three different trails of Bukit Bakar Recreational Forest, Machang, Kelantan to evaluate the macrofungal diversity. The area wise sampling for macrofungal shows that trail A contains the highest number of species (24), followed by trail B which contains 13 species and trail C contains 10 species. Table 4.3 shows the diversity index of macrofungal species at Bukit Bakar Recreational Forest, Machang, Kelantan. The diversity was high as justified by Shannon diversity index (H') was obtained (3.36) and with high Shannon evenness index (E) obtained was (0.86).

Table 4.4 shows that Shannon diversity index at trail A was higher as compared to trail B and C because as we can see in Figure 4.3 which is the macrofungal mostly can be found near the river which is the wet area that suitable for macrofungal growth and also the other factor was the rain because a week before we go to the study site the rainy seasons was started. Trail B and C indicated the lowest value because there is not a rainy day.

Table 4.3 : Shannon Diversity Index and Shannon Evenness Index of macrofungal species at Bukit Bakar Recreational Forest, Machang, Kelantan

Indices	Study site	Values
Shannon Diversity Index (*H'*)	Bukit Bakar	3.20
	Trail A	2.76
	Trail B	2.51
	Trail C	2.34
Shannon Evenness Index (E)	Bukit Bakar	3.83
	Trail A	3.66
	Trail B	2.83
	Trail C	2.64

4.2.2 Species Richness

The data of macrofungal species recorded 80 individuals in Bukit Bakar Recreational Forest, Machang, Kelantan. Table 4.4 shows the Margalef's index of Bukit Bakar was higher with 11.57 and Margalef's index at trail A was higher as compared to trail B and C because the collections of macrofungal species in trail A were higher.

Table 4.4 : Species Richness of macrofungal species at Bukit Bakar Recreational Forest, Machang, Kelantan

Indices	Study site	Values
Margalef's index (D)	Bukit Bakar	11.57
	Trail A	6.55
	Trail B	4.59
	Trail C	3.79

4.3 Distribution Pattern

Figure 4.3 shows the map that was cropped to points the locations, the map shows the distribution position of the macrofungal representative species that were chosen. During the collections period, the places were divided into three trails which have different elevation. The lowest altitude was at Trail A with 57.9 m a.s.l, while Trail C was the higher altitude the macrofungal was collected with 548.2 m a.s.l.

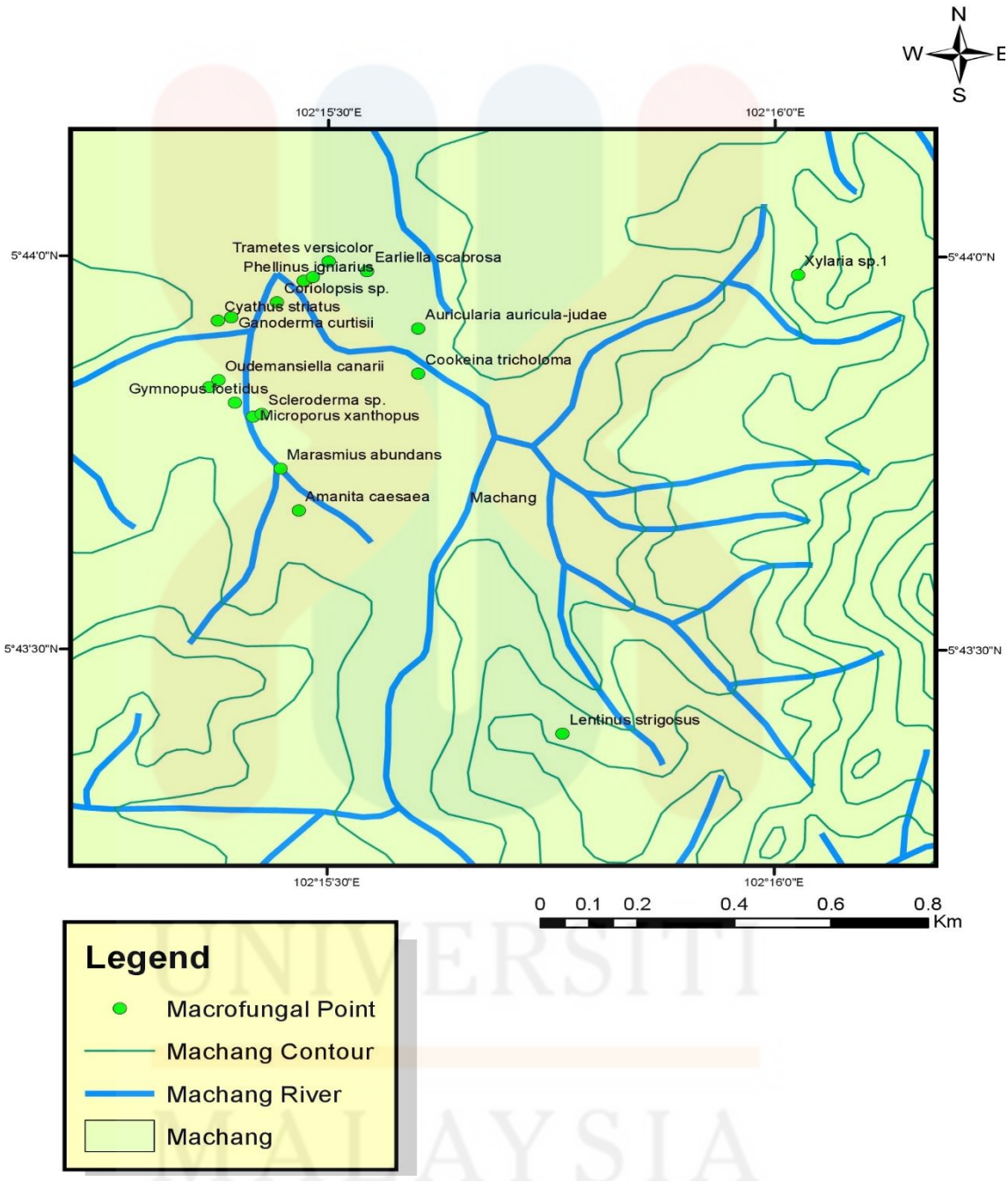

Figure 4.3 : Map of the macrofungal species representative at Hutan Lipur Bukit Bakar, Machang Kelantan

Figure 4.4 shows the distribution of macrofungal species in trail A. The distribution pattern was random at the trail A and there was no specific factor that affecting the distribution pattern of macrofungal.

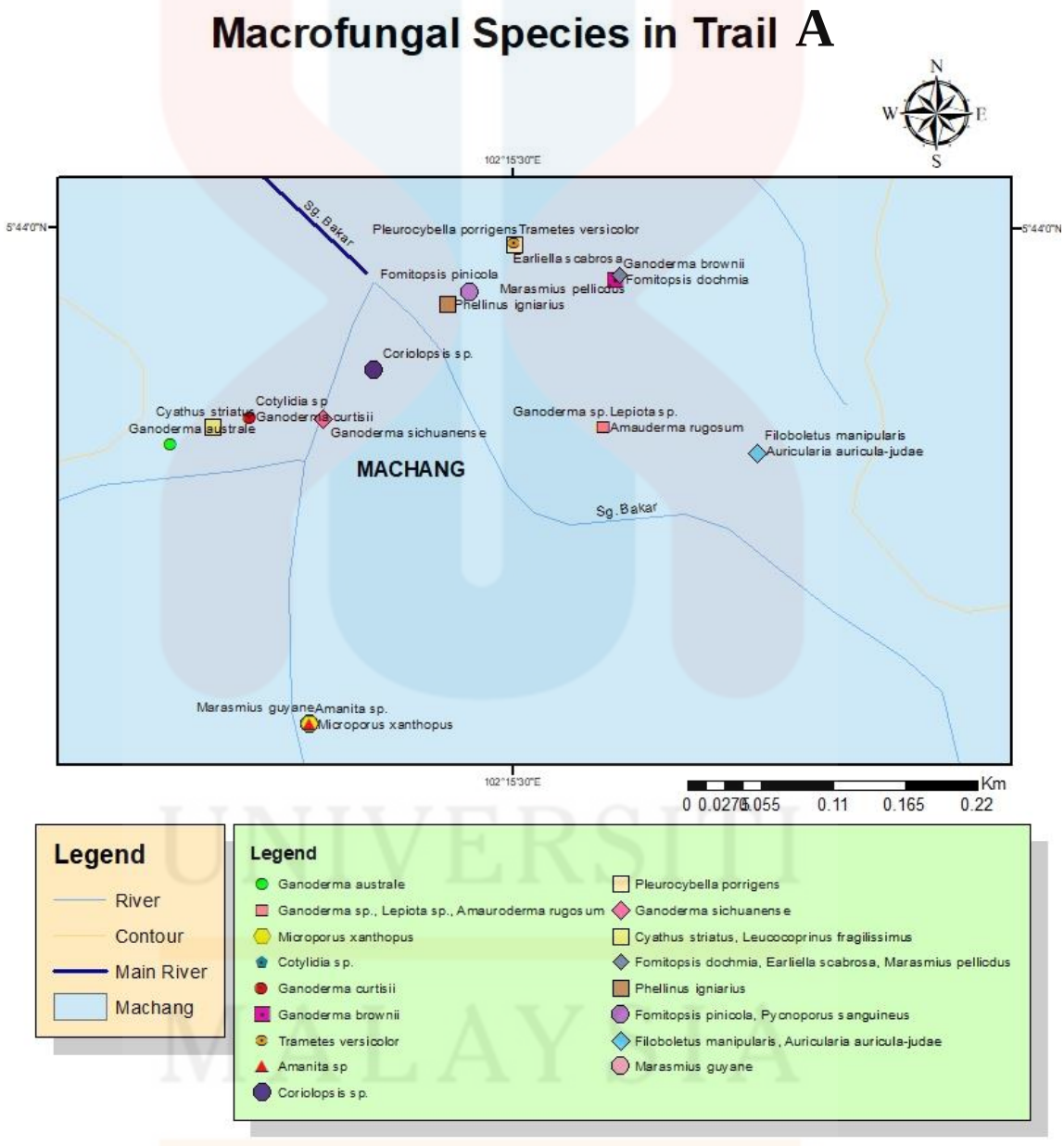

Figure 4.4 : Map of the macrofungal species in Trail A at Hutan Lipur Bukit Bakar, Machang Kelantan

Figure 4.5 shows the distribution of macrofungal species in trail B. In trail B the distribution pattern mostly was near the river and the macrofungal at these trail was growth at the wet environment.

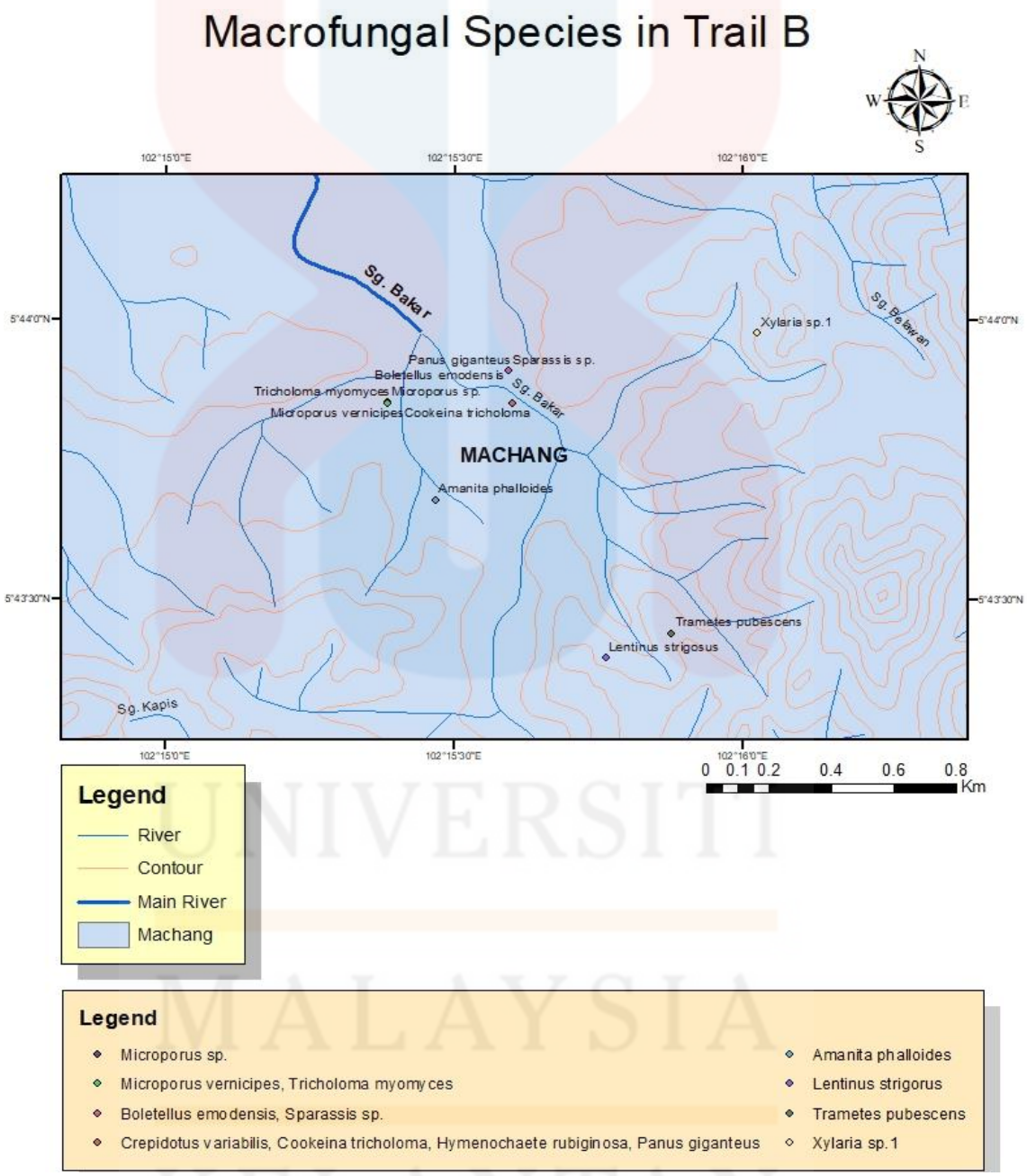

Figure 4.5 : Map of the macrofungal species in Trail B at Hutan Lipur Bukit Bakar, Machang Kelantan

Figure 4.6 shows the distribution of macrofungal species in trail C. In trail C the distribution pattern mostly was near the river and the macrofungal at these trail was growth at the wet environment.

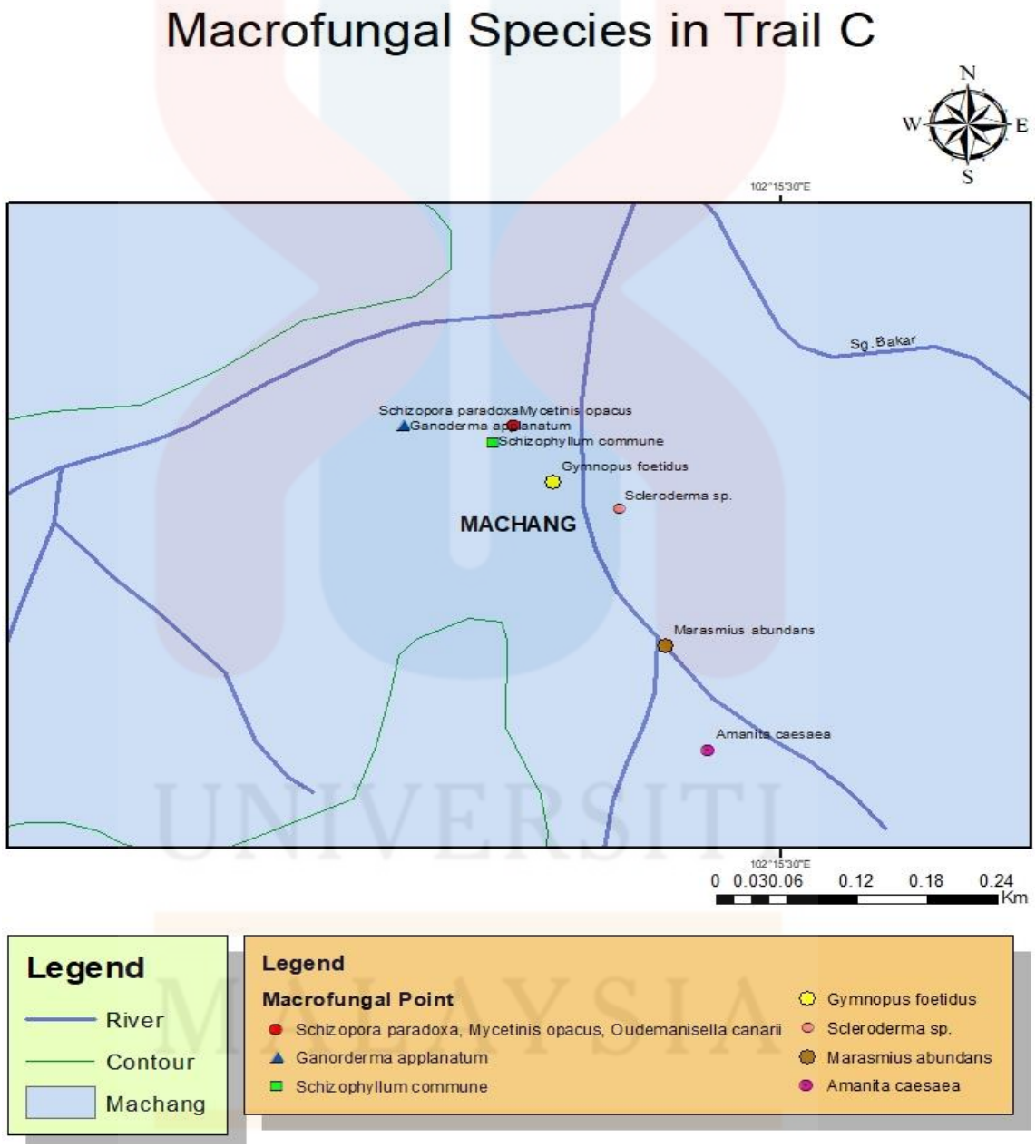

Figure 4.6 : Map of the macrofungal species in Trail C at Hutan Lipur Bukit Bakar, Machang Kelantan

We have observed that at the higher altitudes, the lowest the macrofungal diversity were collected, these shows that the macrofungal species diversity negatively corresponds to elevations. This supports the previous reports on the decreasing of macrofungal diversity when there is increased in the altitude (Kernaghan & Harper, 2001; Jang & Hur, 2014).

The old or rotting and immature specimens were not collected during the collections because these were not inadequate or not suitable for the identification. Besides, the macrofungal collected were not represented the exact number of fungal species of the area.

Based on Table 4.5 there were three species that were found repeatedly which are *Amauroderma rugosum*, *Microporus xanthopus*, and *Marasmius abundans*. *Microporus xanthopus* were the higher number of individuals of species that were found along the three different trails because these species were easily growth on the dead wood or branch.

Table 4.5 : The presence of the macrofungal species for the three trails

Name of species	Trails A	Trails B	Trails C
Amanita sp.	✓		
Amauroderma rugosum	✓		✓
Auricularia auricula-judae	✓		
Coriolopsis sp.	✓		
Cotylidia sp	✓		
Cyathus striatus	✓		
Earliella scabrosa	✓		
Filoboletus manipularis	✓		
Fomitopsis dochmia	✓		
Fomitopsis pinicola	✓		
Ganoderma austral	✓		
Ganoderma brownie	✓		
Ganoderma curtisii	✓		
Ganoderma sichuanense	✓		
Ganoderma sp.	✓		
Lepiota sp	✓		
Leucocoprinus fragilissimus	✓		
Marasmius guyane	✓		
Marasmius pellicdus	✓		
Microporus xanthopus	✓	✓	✓
Phellinus igniarius	✓		
Pleurocybella porrigens	✓		
Pycnoporus sanguineus	✓		
Trametes versicolor	✓		
Amanita phalloides		✓	
Boletellus emodensis		✓	
Cookeina tricholoma		✓	
Crepidotus variabilis		✓	
Hymenochaete rubiginosa		✓	
Lentinus strigosus		✓	
Microporus sp.		✓	
Microporus vernicipes		✓	
Panus giganteus		✓	
Sparassis sp.		✓	
Trametes pubescens		✓	
Tricholoma myomyces		✓	
Xylaria sp.*1*		✓	
Amanita caesaea			✓
Ganoderma applanatum			✓

Table 4.5 Continue…

Gymnopus foetidus			✓
Marasmius abundans	✓		✓
Mycetinis opacus			✓
Oudemansiella canarii			✓
Schizophyllum commune			✓
Schizopora paradoxa			✓
Scleroderma sp.			✓

4.4 Usage of macrofungal species in Malaysia

Several studies (Boa, 2014; Fernando et.al. 2015) reported that *Ganoderma* species are the most valuable medicinal fungi worldwide. Even in modern medicine, these taxa are considered genuinely interesting (Fernando et.al. 2015). The reported medicinal use of *Pycnoporus sanguineus* to treat ear inflammation, corresponds with the findings of numerous scientists (Chang & Lee, 2004) who found that *P. sanguineus* is used to treat sores in Malaysia.

Microporus xanthopus (Figure 4.7a) was used to stop a child from breastfeeding. The *Microporus xanthopus* is a type of wood-inhabiting fungus which the indigenous people use for birth control and as a mosquito repellent. While *Amauroderma rugosum* (Figure 4.7b) has been used as the epileptic child mushroom or 'cendawan budak sawan' in the Malay language, is worn around the neck by the indigenous people in Malaysia to prevent fits and incessant crying by babies (Chang & Lee, 2014; Azliza et.al. 2012). Fits or epilepsy has been linked with inflammation and its development is termed epileptogenesis (Walker & Sills, 2012).

Figure 4.7 : The photograph of the usage common macrofungal species that found in the study area a. *Microporus xanthopus* b. *Amauroderma rugosum*

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

While more sampling is needed to obtain a complete macrofungal inventory of Bukit Bakar Recreational Forest, Machang, Kelantan, we conclude that the survey carried out has demonstrated that Bukit Bakar Recreational Forest, Machang, Kelantan provide a habitat for diverse macrofungal species. Species richness and species diversity fluctuates over latitude, which is likely related to climatic conditions and woody plant species diversity. The information obtained can be used as a baseline to discern future trends associated with climate change to interpret trends resulting from mushroom harvesting and management and is therefore important for management and conservation strategies and the conservation policy.

5.2 Recommendations

The knowledge on identification of edible mushrooms is limited in terms of records and there is no systematic documentation available for Peninsular Malaysia and there are a few ethnomycological studies of macrofungal in Peninsular Malaysia.

Malaysia still needs more mycologists to discover the macrofungal species diversity in Malaysia in order to collect the data because Malaysia only has minimum information about macrofungal diversity, especially in Kelantan. So, this study would be better if the long term research was done to observe the species growth in the area for different month and season.

Next, rainfall and temperature are the two major factors for macrofungal production. So, to analyze the distribution pattern of macrofungal the analysis of relationship between the rainfall for several years and the species density need to be observed to get the most accurate distribution pattern of the macrofungal. Because some of the macrofungal species can be found throughout the year even though there were not a rainy season while some of the species only can be found at a specific time.

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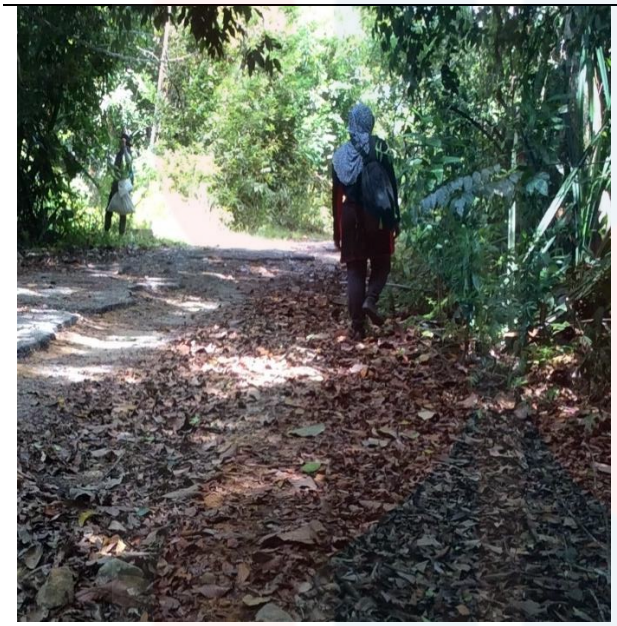
APPENDIX A

During The Data Collections

FIGURE	DESCRIPTION
	Walk slowly and thorough to find the macrofungal species especially the smaller in size.
	The GPS reading was taken at the placed that the macrofungal were found.

APPENDIX B

Macrofungal Species

FIGURE	DESCRIPTION
	The picture was taken in-situ to see the places of the macrofungal growth (substrate).
	The pictures of macrofungal with the scale were taken.