CHECKLIST OF PIPERACEAE IN BUKIT BAKAR FOREST ECO PARK, MACHANG, KELANTAN

by

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DECLARATION

I declare that this thesis entitled "Checklist of Piperaceae in Bukit Bakar Forest Eco Park, 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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"I hereby declare that I 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 Science) with Honors"

Signature : …….....

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Date : ……..

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CHECKLIST OF *PIPERACEAE* IN BUKIT BAKAR FOREST ECO PARK, MACHANG, KELANTAN

ABSTRACT

This study was conducted to investigate the distribution of Piperaceae in Bukit Bakar Forest Eco Park, Machang, Kelantan. The random sampling methods is carried out in Bukit Bakar Forest Eco Park at different elevations namely lower part (50 – 100m), middle part (100 – 150m) and upper part (150 – 200m) with 100 m interval each which is parallel to the nature trail. About 10 species of Piper has been found from the Bukit Bakar Forest Eco Park with each species consist of several number of species were identified and recorded. Throughout this research, there are one species Near Threatened according to International Union for Conservation of Nature. It was found that one species of Piperaceae was documented as (*Piper porphoryphylum*). The diversity index represented by Shannon evenness index, H' is 3.30 where as the computed evenness index is 0.76 for the overall of Piperaceae family. From the total of Piperaceae recorded, the highest diversity is at the middle part of the area (H'= 2.59) followed by upper part (H'=2.59) and lower part (H'= 1.10). The lowest part of the forest, the species evenness is totally (E_H = 0.69) followed by middle part (E_H= 0.82) and upper part (E_H= 0.73). Based on this study, the checklist of Piperaceae species is provided and the explanation of the species have been made. This species of Piperaceae has it own important and mostly it can be used for medicinal value. The Piperaceae species that has been collected is *Piper nigrum , Piper betle , Piper auritum, Piper aduncum, Peperomia pellucida, Piper sarmentosum, Piper porphyrophyllum, Piper ornatum , and piper serrulatium.*

SENARAI SEMAK *PIPERACEAE* DI HUTAN LIPUR BUKIT BAKAR, MACHANG, KELANTAN

ABSTRAK

Kajian ini dijalankan untuk mengkaji pengedaran spesies *Piper* di Hutan Lipur Bukit Bakar, Machang, Kelantan. Kaedah pensampelan rawak dilakukan di hutan pergunungan di tiga ketinggian yang berbeza iaitu bahagian bawah (50 – 100m) , bahagian tengah (100 – 150m) dan bahagian atas (150m – 200m) dengan jarak 100m yang selari dengan laluan semula jadi. Sekitar 10 bilangan Piper spesies dari hutan lipur bukit bakar yang terdiri daripada beberapa jumlah spesies individu. Sepanjang kajian dijalankan, terdapat satu spesies yang direkodkan sebagai hampir terancam (*Piper porphoryphylum*). Indeks kepelbagaian yang diwakili oleh Shannon index, H ', adalah 3.30 manakala indeks kesamaan yang dikira adalah 0.76 untuk spesis piper secara keseluruhan di kawasan kajian. Dari jumlah spesies yang diperolehi, kepelbagaian tertinggi terdapat di bahagian tengah (H '= 2.59) diikuti oleh bahagian atas (H'=2.59) dan bahagian bawah (H '=1.10) kawasan kajian. Kesamaan spesis untuk kawasan kajian dikeseluruhan yang dicatatkan ialah 0.76. Bahagian bawah hutan, kesamaan spesis adalah (E_H = 0.69) diikuti oleh bahagian tengah (E_H = 0.82) dan bahagian atas (E_H = 0.73). Berdasarkan kajian yang dibuat,senarai semak spesies *Piperaceae* telah dihasilkan dan penerangan mengenai spesies *Piper* telah disediakan. Spesies *Piper* mempunyai kepentingan yang tersendiri dan selalunya digunakan untuk ubat-ubatan. Antara spesies *Piperaceae* yang telah dijumpai adalah *Piper nigrum., Piper betle., Piper auritum, Piper aduncum., Peperomia pellucida, Piper sarmentosum, Piper porphyrophyllum, Piper ornatum.,* dan *piper serrulatium.*

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LIST OF ABBREVIATIONS

GPS	Global Positioning System
IUCN	International Union Conservation of Nation
H’	Shannon – Diversity Index
EH	Shannon – Evenness Index
Cs	Sorenson Similarity Index

LIST OF SYMBOLS

%	Percentage
∑	Summation
=	Equal

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Piperaceae includes more than 1000 species around the world that make itbecome one of the biggestgenus of angiosperms (Kubitzki et al., 1999). Pattern of division of Piperaceae vary from being close by endemic to extensive (Paciencia et al., 2005). In selected Neotropical forests, Piperaceae has been found that it become the most of species of genera compared to the others. In addition, Piperaceae are known to be as the great ecological importance on the base of their connection (Fleming, 1981). Based on vegetation and reproduction characters, the presents of their consistency little flowers, and present of significant challenge, the Piperaceae family is easily to recognise. Based on research made by Kunth (1839), between 7 and 15 genera, it is known as the earliest state Piperaceae family classification based on emphasizing Piperaceae. The carpel number, mainly on number of stamen and place, morphology of flowery bract, leaf venation and inflorescence location of the Piperaceae is the known as the first monograph of Piper.

According to the past and previous study, the tropical plant family of Piperaceae has provided a source of diverse food grade species and medicine used for self antibody (Ian et al., 2006). Meanwhile, the secondary parts or compounds of Piperaceae species can be used as qualities purpose such as defenses from chemical based on certain species of the Piperaceae. Based on previous study, Piperaceae family has shown the effectiveness extract for the using of control of store product pest. Other

than medicine purposes, Piperaceae family also is used for useful source of bio-pesticide material that useful for scheming little-scale pest out-breaks.

In addition, the Piperaceae family also can be used for reducing the probability of confrontation growth such as pyrethrum that can be used among others insecticides botanical that act as synergist (Ian et al., 2006). Based on research made by Arnason et al., (2002), it stated that Piperaceae family is known as one of the family that contain of many promising photochemical with insecticidal activity.

The disperser spectrum and pattern fruit production of Piperaceae similar sturdily among those of "big-bang" flora such as Neotropical leaf. The fauna species such as bats, birds and ants become a limited group of dispersers that harvested the fruit of Piperaceae (Fleming 1981 &1985, O'Donnell, 1989). The individual crop of Piperaceae are little among certain fruits ripen in time intervals predictable over the phase times. According to the Croat (1969), the Neotropical genus Piper occurs in a diversity of habitat. Miyakado et al., (1989) stated that the minor plant compound exist in Piperaceae family recommended used as novel insecticides that can be lead to potential leads. The perception that Piperaceae family are degraded quickly beneath full daylight indicated that the utilization of the extricates to defend store grain or surrounding the domestic and plant are more shows potential than trim the security application (Scott et al., 2003& 2004).

According to the Ian et al., (2008), the family Piperaceae consist of present civilizations and provided more past with a full source of medicine and provide many food grade spice. (Ian et al., 2008). The Piperaceae consist of important value such as medicinal value. According to the botanists, the Piperaceae consist of 1,600 species which is belongs to the top of the estimated 57 total of angiosperms genera which is

consist more than the 500 species. Based on vascular plant species, the species rich are comprise up to 25% based on the genera of Piperaceae family (Ian et al., 2008). According to the angiosperm evolution, the thoughtful of the explosive rapid speciation lead to the high species number for the genera (Frodin, 2004).

In addition, to study the phenomenon such as the personality evolution of Piperaceae might be consist of higher pose taxonomic challenge. Most of Piperaceae are highest in secondary metabolites, include the amides, alkaloids, terpenes and flavonoids which is important in medicinal value and economic importance. Most of the Piperaceae species are usually used as a house plant ornamental (Yuncker, 1958). Meanwhile, according to the Miliken (1997), it stated that mostly, the insects typically act as pollinators to assist increase the fruits spreading.

As reviewed by Brown and Lomolino in 1998, the contribution of increasing of elevation in beginning from the sea level can enhance the raise in Piper species composition, richness and its dominance. It is supposed that the species of Piperaceae diversity will level off after accomplishment the saturated variety sector. The distribution and plenty of the species of Piperaceae are strongly influenced by difference in altitude. The elevation ascent can act as a coordination to evaluate the species of Piperaceae richness (Korner, 2000).

According to the Jaramillo et al., (2004), it stated that the Piper species mostly useful for the medical purposes because it has their own characteristics to help reduce the pain that occurred. The medicinal plants were important because it was mostly sources of pharmaceutical manufacturing around the world. Mostly, the Piperaceae species can be used for herbal remedies and in condition which are naturally for sunburns, hide irritation, burns, and such as inflammation.

Figure 1.1: Fruits of *Piper nigrum* for spices

(Source: Wikimedia Commons, 2013)

1.2 Problem Statement

The evergreen forest of Bukit Bakar Forest Eco Park contains high diversity of plants which is flowering plants and non-flowering plants. Moreover, in Bukit Bakar Forest Eco Park, there are no data recorded and no previous study on Piperaceae from the forest area. This research will be undertaken to collect the data, analyze and identify the various species of Piperaceae family in Bukit Bakar Forest Eco Park, Machang, Kelantan, Peninsular Malaysia.

Commonly, the mountain and forest of Bukit Bakar Forest Eco Park, Machang Kelantan mostly consist of high diversity of plants including Piper which are the vascular plant. In addition, there are no specific scientific data of Piperaceae which exist in Bukit Bakar Forest Eco Park that have been published and recorded. Meanwhile, the main objective of this research to be carried out is to collect the sample of Piperaceae and need to identify them to the species level as it was collected data

information will be useful contribution to the forest inventory of Bukit Bakar Forest Eco Park department. Other than that, it was also inadequate of Piperaceae herbarium collections at Bukit Bakar Forest Eco Park and Museum of Natural Resources in Universiti Malaysia Kelantan, Jeli Campus to easier the student or non-botanists to identify the species of Piperaceae. The herbarium collection of Piperaceae was prepared for the community, students and researcher use for reference purposes.

1.3 Justification

This research is conducted to study the diversity of Piperaceae family which existed in the forest area of Bukit Bakar because there was no previous study and data recorded had been done in that area. This study would be the first one for Piperaceae family in the Bukit Bakar Forest Eco Park, Machang, Kelantan, Peninsular Malaysia. Other than that, the species richness, composition and diversity of the Piperaceae family can be estimated and the total species of Piperaceae in that area can be listed as checklist.

1.4 Objectives

In finishing this research, several objective have been come up. And the objectives are:

I. To identify species of Piperaceae family found at Bukit Bakar Forest Eco Park, Machang, Kelantan.

II. To provide checklist of Piperaceae family found at Bukit Bakar Forest Eco Park, Machang, Kelantan.

1.5 Scope of Study

This research were more focused on vascular plant based on the Piperales order. Thus, this research were be conduct to highlight the study in determining the composition and diversity of flowering vascular plant of Piperaceae family which exist in Bukit Bakar, Machang, Kelantan, Peninsular Malaysia.

1.6 Significance of Study

This study is conducted to determine the species diversity and composition of Piperaceae family which exist in Bukit Bakar. Based on the researches conducted, it can provide knowledge and awareness in order to maintain the evergreen forest in Kelantan as well as record the checklist of Piperaceae family in Bukit Bakar Forest Eco Park, Machang, Kelantan.

From this research, it was expected to provide more data and advantages on the Piperaceae family and can gain the data checklist of the Piperaceae family population. The factor that can change the Piperaceae diversity and population can also be learning and the protection of the species can be completed (Semain et al., 2008).

Figure 1.2: *Peperomia pellucida* used for medicinal use

(Source: Wikimedia Commons,2013)

Figure 1.3:*Piper aduncum* used for medicines and agro-forestry

(Source: Wikimedia Commons, 2013)

CHAPTER 2

LITERATURE REVIEW

2.1 Diversity of Family Piperaceae

From million years ago, within 1000 species distributed pantropically, the Piperaceae family mostly known as the most diverse lineages amongst basal angiosperms (Alejandra and Paul, 2001). The Internal Transcribed Spacers (ITS) of DNA nuclear ribosomal usually based on a universal sample. There are more than 1000 species of the Piperaceae that express to the maingenus of basal angiosperms (Kubitzki et al., 1993). "Paleoherbs" is known as the phylogenetic position of Piperaceae among a diverse group of dicots which is plants that look like monocots in several vegetative features. Among the traditional Magnoliiade, the highest species variety among Piperaceae is unique because it contain an example of noteworthy andenhance in diversification rate at the base of the angiosperms. In the American tropics, it known as the most diversity of thespecies of Piperaceae which is 700 sp. and followed by Southern Asia which is consists of 300 sp. of Piper species. In Southern Asia, it mostly consists of reasonably important species such as *Piper nigrum* which is known as black pepper and *P. bettle* (betel leaf) originated. Piper species usually dispersed pantropically and obtain the form of shrubs, herbs and lianas ordinary in the underneath story of lowland wet forest (Sanderson and Donoghue, 1994).

The Piper species mostly is climbers although some are shrubs and a few are trees. The inflorescence spike develops on the node of branching stem opposites the leaf and is erect or pendulous, monoecious or dioecious. Monoecious is referring to flora that contain of female flowers and male flowers in different structures on the

same plant. Meanwhile, dioecious is known as the species that consist of female and male reproductive structures on different plants. The Piper species consist of very tiny flowers with deficient of petal and sepal, the stalk is connected to the rachis or sessile meanwhile the orbicular bracts is absent. The stigma of species of Piperaceae may be covered with very short hair. Meanwhile, contain of sessile with a short pedicel and the ovary of the Piper species is inferior. The fruit of the Piper species is mostly sessile or with a pedicel, fleshy, and ellipsoid (Cheng et al., 1999). To assist create the comprehension of designs of diversification among Piperaceae family, the dispersion of morphological change or combination of character states need to be examined inside a phylogenetic setting. Bloom structure in Piperaceae family shows up to be impacted by the bundling of blossoms in the inflorescence. Loosely organized blossom contain of an unsteady number of carpels (between three and four of varying) and firmly crowded flowers always contain three. According to the Burger (1971), the flower introduction will be related with difference in fertilization science. A flower on firmly congested the process of flowering often appear a move in anther dehiscence, begin with a lateral slit towards an upwards or apical gap.

2.2 Piperaceae Morphology

Piperaceae family was known as the vascular plant in kingdom plantae. Mostly, Piperaceae species or family habitat is at shrub places, small trees, or lianas which is on bearing essential oil. Piperaceae is known as self-supporting because it climb itself to climb to the other trees. Piperaceae also known as the angiosperms species. Based on the axial of the Piperaceae, which is their stem and wood anatomy, it is present on cork cambium. According to the Cardova et al., (2002) it state that the Piper species

contain its initially superficial. Mostly, the primary vascular tissues of Piperaceae family disposed monocot-like. Meanwhile, for the secondary thickening, it mounting based on the conventional cambial ring to see illustration. Meanwhile, for the vessel of Piperaceae family, it is known as end-wall scalariform.

In addition, the Piperaceae family reproductive type is based on pollination. Meanwhile, for the fertile flowers is known as hermaphrodite although it was unisexual flower not present. Every single part of Piperaceae species have their own specific important because in order to make sure the growth of the species is in good condition (Vasco et al., 2013). In order to determine the different species of Piperaceae,it has their own main criteria or characteristics to differentiate the Piperaceae species.

The leaf anatomy of the Piperaceae is dorsiventral or known as the leaf lamina. The leaves of Piperaceae usually contains pearls glands and certain species also do not have or without pearl glands (Kumar, 1996). Mostly for the Piperaceae family of glandular and eglandular is known as multicellular which is in hair multiseriate conditional. Meanwhile, the present of adaxial hypodermis is important for the secretory cavities. During the present of secretory cavities, it will stimulate the production of mucilage in Piperacea.

2.3 Factors Affecting Piperaceae Family Composition and Diversity

Based on previous research, most of the tropical area, diversity species of Piperaceae family were greatly varies. The main factor is because of the branch of biology and local landscape state such as topography, soil type and sunlight is interruption nin habitat from certain place to another place (Fajardo & Alaback, 2005).

The tropical flora of Piperaceae family has given numerous histories and show civilization with a resource of differing medications and the type of food spice (Ian et al., 2006). Piperaceae family are well known as the Piper species extracts that provide a sole and valuable basis of bio-pesticide material for scheming small-scale insect out-breaks and plummeting the likelihood of resistance maturity when connected as a synergist with differences botanical insecticides. As mentioned by Martin and Gregory (1962), the wind was recorded as the mainly vital important pollen vector in black pepper. Meanwhile, the species of Piperaceae pollination is thought to be carry out from drosophilae flies, bees and beetle (Janzen, 1991; McDade et al., 1994; Kricher, 1997). Environmental factor is known as one of the factor that lead to the decreasing or increasing productivity of Piper species. Temperature lead to the variables impacts that change among the seeds of diverse species where the perfect normal germination temperature is a hereditary characteristic depending on seed morphology and physiology. According to the Ferreira and Borghetti (2004), this factor also give impact straightforwardly on water retention speed and biochemical relation that happen during germination of Piperaceae family.

2.4 Habitat of Piperaceae family

Based on research conducted by Burger, 1971, the Piperaceae family is well known as the mainly old of pan-tropical flower plants. The species of Piperaceae mostly contains of more than thousand species of shrubs, herb, hanging vines and little trees. In spite of the fact that the Piperaceae family is simple to determine by a assortment of asexuale and regenerative characters, the obvious uniformity of their minute blooms present an important challenge to creating an infra-generic

categorization. To advance create the comprehension of design of diversification the species of Piperaceae, the dispersion of morphological change and combination of character states is an important needs to be examined inside a phylo-genetic setting.

As reviewed by Brown and Lomolino (1998), the contribution of increasing of elevation in beginning from the sea level can enhance the raise in Piper species composition, richness and its dominance. It is supposed that the species of Piperaceae diversity will level off after accomplishment the saturated variety sector. The distribution and plenty of the species of Piperaceae are strongly influenced by difference in altitude. The elevation ascent can act as a coordination to evaluate the species of Piperaceae richness (Korner, 2000).

It was stated by Hillerbrand (2004), the variety of latitudinal gradient refereed to the raise of species richness of the species of Piperaceae begin with the poles to the equator and also has been recognised for a variety of dissimilar group of organisms (Hillerbrand, 2004). A developing number of thinks about are recognised by affiliations between territorial species numbers and distinctive climatic and other natural factors (Field et al., 2008).

Other than that, the level of topographic heterogeneity which is describing patterns of vertical relief variation and spatial variability association in climate may cause difference in richness based on local species turnover (Ricklefs, 1987). Based on research made by Kreft et al. (2010), water availability, single variables describing water energy dynamics, on interaction terms between temperature and water-related variables also showed elevated or slightly higher correlations with pteridophytes richness. In general, the species of Piperaceae may be consider of as a mainly being specialist in marginal habitats.

2.5 Economic Importance of Piperaceae Family

Regarding to the Piperaceae life sustaining, the use of Piperaceae known as major source of medicine, food and life necessities. Piperaceae is commonly known as the pepper family. Piperoideae and Peperomioideae is well known as the subfamilies of Piperaceae which is has divided into subfamilies (Semain et al. 2008). Although many of the most common and well-known species are herbs, this Piperaceae family also contain small trees, shrubs and lianas. The distribution of this group is best described as pantropical.

According to Singh in 1993, to make things even more complicated, this variety of form is seen both between and within individual genera which is see genus. This proposal is conducted to identify the diversity of Piperaceae family in Bukit Bakar Forest Eco Park. According to the past and previous study, the tropical plant family of Piperaceae has provided a source of diverse food grade species and medicine used for human antibody (Ian et al., 2006).

Meanwhile, the secondary parts or compounds of Piperaceae family can be used as qualities purpose such as species in Piperaceae family that used for chemical defenses (Zanotti et al., 2012). Based on the previous study, the Piperaceae has shown the effectiveness extract for the use of control from stored product pests (Raut and Bhattacharya, 1999). Other than medicine uses, biopesticede material of Piper species also used for useful source that useful for controlling small-scale insect out-breaks. Based on pungent principle piperine, *Piper nigrum* is considered as the king of spices.

2.6 Significance of Piperaceae Family in Natural and Human Communities

Piperaceae can be used as an indicator regarding to its dissimilar adaptations of different species in environment in ecological niche and it also can be used as indicator of overall species in environment (Semler, 1988). Other than that, it also canbe used as an indicator of whole species diversity and richness because it provides food resources to herbivores. It stated that the Piperaceae family contains approximately of many species, which 10 species have been utilized in drugs conventional or medicine to cancer treatment or cancer-like indications. Based on the studies, the Piperaceae family considers has appeared that extract from species of Piperaceae and compound from Piperaceae plant have several activity such as cytotoxic movement.

The root of Piperaceae is utilised the arrangement of a recreational beverage that involves the unmistakable position in the social, ceremonial and day by day life of island people (Lebot, Merlin, and Lindstorm, 1992).

Figure 2.1: Long Pepper (*Piper longum*) for medicinal uses

(Source: Wikimedia Commons, 2013)

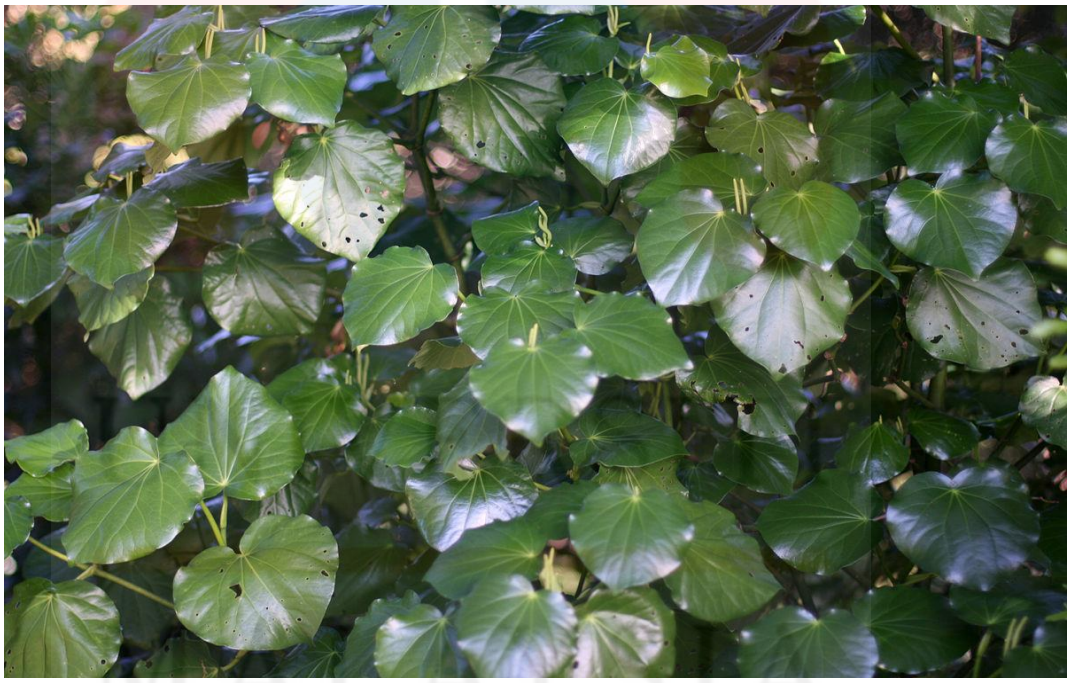

Figure 2.2: *Piper excelsum* for medicinal uses

(Source: Wikimedia Commons, 2013)

2.7 Life Cycle of Piperaceae family

The Piperaceae life cycle is based on piperales which is order of dicot that flowering plants which contains of herbs, small tress and shrub. The small flowers that clustered together shown the characteristics of this order which in cone shaped structures (Watkins et al., 2006). Meanwhile, for the habitat of family Piperaceae which is mostly live in tropical, foliated, warm and places that was shady. In addition, the pepper vines shown the characteristics of the genus of *Piper* plant.

Figure 2.3: Part of Piperaceae species
(Source: Wikimedia Commons, 2013)

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

Piperaceae sample were used in this research were collected from Bukit Bakar Forest Eco Park. Ethanol which is 70% or spirit that were used for preserving the sample. The uses of Global Positioning System (GPS) was used for determining the location of sampling. Meanwhile, the apparatus such as newspaper were used for pressing over the specimen that uses for drying purposes. In addition drying oven was used for remove the moisture from Piper species.

3.2 Methodology

3.2.1 Study Area

Bukit Bakar Forest Eco Park area is around 3.14 hectare with the elevation of 582meters from sea levels. The Forest Eco Park of Bukit Bakar is monitored by Forestry Department of Kelantan state.

From the base site up to the Bukit Bakar itself, there are contain of many floristic and the group of Piperaceae family appears to be at the low levels of threat according to the spore dispersion efficiency (Benniamin et al., 2008). In addition, the evergreen of Bukit Bakar Forest Eco Park covered with variety types of habitat, which play important roles and not only in its biological richness but also in ecological functions.

This study was carried out in Bukit Bakar Forest Eco Park and the site is specifically located in Ulu Sat Forest Reserve, Machang, Kelantan. For this research sampling, the three line transect method were used from starting at base camp of Bukit Bakar Forest Eco Park and finally to the peak of Bukit Bakar Forest Reserve.

The three stages of sampling site which are in lowland, midland, and highland will be determining by using the Global Positioning System (GPS). For the latitude and longitude, to avoid or decrease the nature disruption

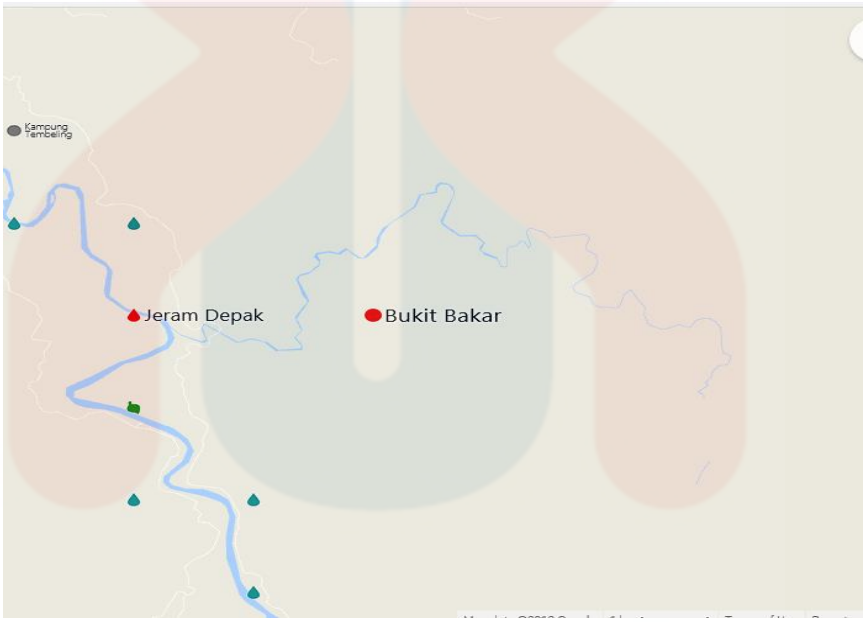

Figure 3.1: Location of Bukit Bakar Forest Eco Park

(Source: Google Maps)

3.2.2 Sampling Methods

A random sampling was conducted during this research at Bukit Bakar Forest Reserve along the way to the top of Bukit Bakar. This method is widely used by the researcher for sampling which will follow alongside the nature trail. Meanwhile, the uses of Global Positioning System (GPS) were used to geo-reference the location of

collected Piperaceae family (Tuomisto et al., 2003). The sampling methods will take a duration of five days to be finished.

The Piperaceae family is frequently irresistible element in the understory of tropical woodlands and it found to be the most species genus in selected Neotropical timberlands (Gentry, 1990). Outwardly, the amiability or the nature of gathering species of Piperaceae in the woodland was categorised as species developing separately, in patch, colonies and intermixed. The species of Piperaceae were moreover classified regarding to the shape of leaf and surface textures of Piperaceae (Shukla and Chakravarthy, 2012).

3.2.3 Sample Preservation and Identification

The specimen that was collected was pushed by using newspaper and the collected species of Piperaceae were tagged for its location. The drying oven was useful during the preservation of the Piperaceae family that was carried out at the lab. The used of drying oven is important to avoid or eliminate the moisture from the sample because it is to prevent the sample from broke. Identification species of Piperaceae process was done promptly in the site and the anonymous specimen will be taken back to identification purposes in laboratory.

Natural Resources Museum in Universiti Malaysia Kelantan, Jeli Campus is place for the identification process of the piper specimen. For the preservation process of Piperaceae family is needed where the sample that was collected was mounted and placed in the Museum of Natural Resources for upcoming reference. The identification process will followed the nomenclature from International Plant Names Index (IPNI)

and by referring the identification key based on books by Paris et al., (2010) in Flora of Peninsular Malaysia.

Figure 3.1: Drying process of samples in drying oven

3.2.4 Data Analysis

a) Species Composition

The data that has been collected will be used to identify the specific family, genus and species which belong to the Piperaceae family.

b) Diversity Index

All the data that has been collected will be analyzed by using Shannon Diversity Index (H), Shannon Evenness Index (E) and Sørenson Similarity Index (Cs).

i.Shannon Diversity Index (H)

It is common utilizedto characterize the species differences in community (Spellerberg & Fedor, 2003). It was broadly utilized used byscientist that more often

than not takes both plenitude and equity of species that display within the community. This contrast of differing qualities measures of arrange inside a specific frameworks is for the most part based on data hypothesis. The species number by this arrangement inside test plot, can be characterized by the number of people in each species. Consequently, it can choose what the degree of vulnerabilities. Regarding to number, it demonstrate the degree of diversity accurately.

$$H = -\sum_{i=1}^{s} (p_i \ln p_i)$$

Where;

p = the number of individuals of one particular species found (n) dividedby the total number of individuals found (N)

ln = the natural log

Σ = the summation of all calculations

ii.Shannon Evenness Index (E)

Species Evenness (E) is known as the degree of the conveyance of individual life forms among species which is been measured by using *H*' and the *log* of risen species (s)

$$E = H / H_{\max} = H / \ln S$$

Where;

S = Species Richness

H = Shannon Diversity Index

iii.Sørenson Similarity Index (Cs)

The Sørenson Similarity Index is utilized for compare the species richness and differing quality of diversity from two locations measurably.

$$\mathrm{Cs} = \frac{2a}{2a + b + c}$$

Where;

a = number of sampling species at lowland

b = number of sampling species at midland

c = number of sampling species at highland

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Floristic Composition Analysis

Based on Ranker and Haufler (2008), the biogeography of Piperaceae species can be deliberated from several points of view with numerous methods. For instance, the composition and diversity of Piper species and its allies can be examined by the species distribution on a single tree (Krömer & Kessler, 2006) or by determining the frequency and abundances of species over regions (Jones, Toumisto, Clark & Olivas, 2005).

The study on Distribution of Piperaceae at diifferent altitudes of Bukit Bakar Forest Eco Park was carried out for total of five days from 11th July until 15th July 2017 resulted in the variety of Piper species collected as shown in Table 4.1. A total of 45 number individuals of Piper species were collected that represent 10 different species of Piper. From the tabulated result, it can be seen that *Piper nigrum.* recorded the highest number of species collected while family meanwhile the *Piper longum* recorded the lowest collected number of species with two species respectively found at the forest of Bukit Bakar Forest Eco Park, Machang, Kelantan.

Table 4.1: A list of Piperaceae species recorded at Bukit Bakar Forest Eco Park, Machang, Kelantan.

No	Family	Scientific Name	Habit
1	Piperaceae	*Piper nigrum.*	T
2		*Piper betle.*	T
3		*Piper auritum*	E
4		*Piper longum*	V
5		*Piper aduncum.*	T
6		*Peperomia pellucida*	v
7		*Piper sarmentosum*	T
8		*Piper porphyrophylum*	T
9		*Piper ornatum*	E
10		*Piper serrulatium*	T
	Family	**10 Species**	

(Notes: E = epiphytic piper; T = tree piper; V = varies)

Table 4.1 above shown the species of Piperaceae found in Bukit Bakar Forest Eco Park, Machang, Kelantan. Epiphytic pipers are known as the plant that sprout on the others plant and did not take the sustenance from these originally plant (Mirbel, 1815). These pipers grow without absorbing the water and nutrient from the soil but it obtain it from tree leaves (leaching). Based on Watkins, Cardelus, Colwell & Moran (2006), the occurrence of epiphytic piper is higher in the hill forest area compared to the lowland area and species of epiphytic piper peaked at 1,000 m above the sea level. Meanwhile, the terrestrial piper are the species of piper which grow from the ground, use up water and nutrient from the soil to ensure the growth which are evenly distributed along increasing elevational gradient. All the collected piper species were considered as new data since there was no previous accessible data have been recorded and published from research conducted at Bukit Bakar Forest Eco Park, Machang, Kelantan. The collected species of piper are from three different altitudes of the forest namely lower part, middle part and upper part of the forest which are ranging from 50 m – 100m, 100 m – 150 m and 150 m – 200 m from the sea level respectively. The

sample of piper species were collected alongside the three different nature trail which exist in Bukit Bakar Forest Eco Park, Machang Kelantan.

Table 4.2: The total number of piperaceae species recorded at Bukit Bakar Forest Eco Park, Machang, Kelantan with percentage of contribution.

No.	Family	Scientific Name	Individual	Percentage (%)
1	Piperaceae	*Piper nigrum.*	8	17.78
2		*Piper betle.*	5	11.11
3		*Piper auritum*	4	8.89
4		*Piper longum*	2	4.44
5		*Piper aduncum.*	5	11.11
6		*Peperomia pellucida*	4	8.89
7		*Piper sarmentosum*	6	13.33
8		*Piper porphyrophylum*	4	8.89
9		*Piper ornatum*	3	6.67
10		*Piper serrulatium*	4	8.89
Total			**45**	**100**

From Table 4.2, *Piper nigrum* contributed the highest number of species with total of 8 species, followed by *Piper sarmentosum* with total of 6 species and *Piper betle* with total of 5 species. According to the variation in species found showing that at the mountain forest of Bukit Bakar Forest Eco Park, there are various diversity of piper species which inhibit there. It was according to the different adaptation of the species to the environment. Based on the tabulated data above, *Piper nigrum* contributed the highest percentage in number of species collected which is 17.78% followed by *Piper sarmentosum* with 13.33%, *Piper betle* and *Piper aduncum* with 11.11%, *Piper auritum, Peperomia pellucida, Piper porphyrophylum* and *Piper serrulatium* with 8.89% each.

Table 4.3: The percentage of species with dominant of Piperaceae species recorded at different altitudes of Bukit Bakar Forest Eco Park, Machang, Kelantan.

Elevation (m)	Scientific Name	Species	Percentage (%)
50 - 100	*Piper betle*	5	11.11
	Piper auritum	4	8.89
	Piper aduncum	5	11.11
100 - 150	*Piper sarmentosum*	6	13.33
	Piper ornatum	3	6.67
	Peperomia pellucida	4	8.89
	Piper serrulatium	4	8.89
150 - 200	*Piper nigrum*	8	17.77
	Piper longum	2	4.44
	Piper porphyrophylum	4	8.89

From the data obtained in Table 4.3, it can be seen that there are only several species of Piperaceae recorded at the lower part of the forest at 50 – 100 m in altitude which are *Piper betle*, *Piper auritum*, and *Piper aduncum* that contribute 11.11%, 8.89% and 11.11% to the total percentage of species recorded. At the midle part of the forest of 100 – 150m recorded a several species of Piperaceae found which is *Piper sarmentosum*, *Piper ornatum*, *Peperomia pellucida* and *Piper serrulatium* with 13.33%, 6.67% and 8.89% respectively. The highest part of the forest of 150 – 200m recorded that Piperaceae species which *Piper nigrum*, *Piper longum* and *Piper porphyrophylum* that dominant that percentage is 17.77%, 4.44% and 8.89%.

From the table 4.3, it can also be interpreted that there are highest diversity of Piperaceae at the middle part of the Bukit Bakar Forest Eco Park followed by the upper part and lower part of the forest.

4.2 Diversity Analysis

Piper nigrum species are recorded to be abundance in Peninsular Malaysia as their existence can be observed as they are commonly to be found from terrestrial to epiphytic habitat or tree habitat. The variation in the number of species collected may due to several factors such as humidity, elevation and management of the forest which may alter the number of species collected.

A total of 45 individuals of Piperaceae were successfully recorded at the forest of Bukit Bakar Forest Eco Park as shown in Figure 4.1. The highest number of species recorded is *Piper nigrum* with total of eight individuals. The Piperaceae which can grow up to maximum of 2 meters in height and favours the open forest area in lowland and also hilly forest up to 200 meters height. This species is widespread in entire Malaysia.

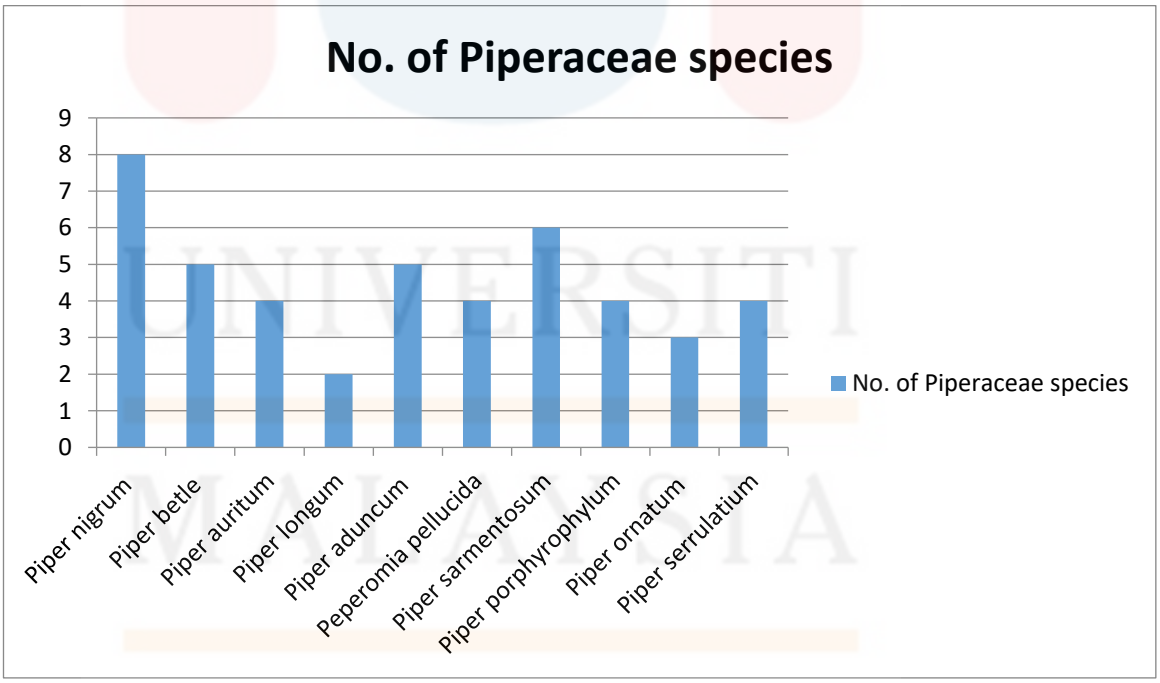

Figure 4.2: Number of Piperaceae species collected at Bukit Bakar Forest Eco Park, Machang, Kelantan.

From the total number of 10 species of Piperaceae recorded, as documented by Turner (1995), they are majorly endemic to Machang and also Kelantan. In this research, there are 45 specimen collected in three different altitude of Bukit Bakar Forest Eco Park, Machang, Kelantan.

In this study, *Piper nigrum* contains of the highest number of individual species that growth in the forest of Bukit Bakar Forest Eco Park. Meanwhile, epiphytic piperaceae followed by *Piper sarmentosum* which is consist total of six individual that collected in Bukit Bakar Forest Eco Park. A total of five individual of Piperaceae is *Piper betle* and *Piper aduncum* that mostly collected at the lower part of the forest of Bukit Bakar Forest Eco Park. Meanwhile, *Piper auritum, Peperomia pellucida, Piper porphyrophylum and Piper Serrulatium* contais of 4 number of total of individuals that been collected at the lower part, middle part and upper part of forest of Bukit Bakar Forest Eco Park, Machang, Kelantan. Meanwhile, for the *Piper ornatum* contains 3 number of total individual species collected. For the lowest number of total of Piperaceae species is *Piper longum* which is contains only two number of total of individual species at Bukit Bakar Forest Eco Park.

From the list, it shown that *Piper nigrum* contains of highest number of individual species that collected at forest of Bukit Bakar. *Piper nigrum* are widely distributed and can be identified with the characteristics of having flowering vine, and contains of single seed like all drupes (Hajesky & Nancy, 2016). *Piper nigrum* is a pantropical distribution, and mostly they are common piper species in all tropical rainforest. *Piper nigrum* also shows a remarkable diversity in term of morphology and habitat that they occupy. Meanwhile, from the list it shown that *Piper longum* has the lowest number of individual species. The morphological characteristics of *Piper longum* is known as the slender, much branched and mostly need support for its proper

growth. For the flower, it mostly unisexual arranged in erect spikes. The distribution of *Piper longum* is native species of the indo-Malaya region but became reduce because of the human activity at Bukit Bakar Forest Eco Park.

4.2.1 Species Composition and Diversity

All the collected species for Piperaceae species were calculated by using Shannon-Diversity index, Shannon-Evenness Index and Sørenson Similarity Index. The uses of Shannon-Diversity Index is to calculate the diversity of Piperaceae species in community (Spellerberg & Fedor, 2003) and the Evenness index will determine the consistency in species distribution at the specified area. The Similaity index was used to determine the similarity among species at different altitudes (Sørenson, 1948) of Bukit Bakar Forest Eco Park, Machang, Kelantan.

a) Shannon-diversity Index

In determining the diversity of Piperaceae family, the diversity calculated was ranging from 0 to Hmax as shown in Table 4.4.

Table 4.4: Shannon-Diversity Index (H') of Piperaceae species recorded at different altitudes of Bukit Bakar Forest Eco Park, Machang, Kelantan.

Location / Site	Shannon-Index (H')	Hmax
Bukit Bakar Forest Eco Park	3.30	3.56
Lower (50 - 100 m)	1.10	1.10
Middle (100 - 150m)	3.18	3.33
Upper (150 - 200 m)	2.59	2.71

Based on the Table 4.4, the value for Shannon-Diversity Index (H') for overall species distribution of Piperaceae species at Bukit Bakar Forest Eco Park is 3.30 and the Hmax value is 3.56. The result tabulated indicates that this forest has relatively high diversity of species among the ferns and lycophytes species as the H' value is approaching the Hmax value. Narrowing down to the diversity of Piperaceae species

at different altitudes showing that at the lower part of the forest, the species diversity is totally diverse; the middle part of the forest is diverse with species of Piperaceae as majority of the family is found in that area and at the upper part of the forest, the diversity of Piperaceae species is moderate.

b) Shannon-Evenness Index

Evenness was used to measure the degree of evenness in abundance of species (Magurran, 2004). The scale of evenness is ranging from 0 to 1 where 0 indicate the least evenness and 1 is the maximum evenness (Smith & Wilson, 1996) that can be seen in Table 4.5.

Table 4.5: Shannon-Evenness Index (E_H) of Piperaceae species recorded at different altitudes of Bukit Bakar forest Eco Park, Machang, Kelantan.

Location / Site	Shannon-Evenness (E_H)
Bukit Bakar Forest Eco Park	**0.76**
Lower (50 - 100 m)	**0.69**
Middle (100 - 150 m)	**0.82**
Upper (150 - 200 m)	**0.73**

From the table 4.5, the value for E_H for overall species distribution at the forest of Bukit Bakar Forest Eco Park, Machang recorded is 0.76 indicating that there are relatively high evenness communities between Piperaceae species. It is also can be said that the species of Piperaceae at the forest area are well distributed. Next, it can be seen that at the lower part of the forest, the species distribution is maximum evenness with value of 0.69. Apart from that, at the middle and upper part of the forest, the evenness index are 0.82 and 0.73 respectively showing that the species distribution of Piperaceae species are high evenness among the species.

c) Sørenson Similarity Index (C_s)

The similarity index was calculated to determine the similarity index between two community (Table 4.6) ranging from 0 to 1 where when approaching to 1, the species are said to be similar between two different location and near to 0 indicates that low similarity of species among the location (Diserud & Odegaard, 2007). The lower part of the forest denoted as Location A whereas the middle and upper part of the forest were denoted as Location B and Location C respectively.

Table 4.6: Sørenson similarity index (C_S) of Piperaceae species recorded at different altitudes of Bukit Bakar Forest Eco Park, Machang, Kelanytan.

Location / Site	Family (C_S)	Genus (C_S)	Species (C_S)
Location A – Location B	0.24	0.17	0.11
Location B – Location C	0.58	0.55	0.31
Location A – Location C	0.31	0.13	0.10

From the table above, it can be seen that among the three location at different elevation showing less similarity among the species of Piperaceae. For location A and location B similarity index calculated was 0.11. There are only several species which is (*Piper sarmentosum* and *Piper ornatum*). For location B and C, there are total of 7 individuals which are *Piper sarmentosum, Piper ornatum, Peperomia pellucida, Piper serrulatium, Piper nigrum. Piper longum* and *Piper Porphyrophylum)* resulting that the similarity index of species is 0.31. The similarity index of species between location A and location C calculated was 0.10 showing that it was least similar to one another as there are only several species which is found in both location.

4.3 Species Distribution

With the aim of to identify the conservation status of the collected ferns Piperaceae species, the International Union for Conservation of Nature (IUCN) Red List (2016) was used to check the current conservation status of the recorded species. From thelist, there is one species which recorded as Near Threatened (NT) which is *Piper porphoryphylum.* There are 5 species of Piperaceae species recorded as Least Concern (LC), one species was Data Deficient (DD) and the remainings are Not Listed (NL). The several species which are not listed in the conservation status as the researchers still do not pay attention to the species as they were focusing on conserving the endangered species of Piperaceae species. Table 4.7 shows the IUCN status and distribution for Piperaceae species.

Table 4.7: IUCN Red List status and distribution of Piperaceae species recorded at Bukit Bakar Forest Eco Park, Machang, Kelantan.

Species	Status	Distribution
Piper nigrum	LC	Hill forest at 200m
Piper betle	LC	Lowland and hill forest
Piper auritum	DD	Widespread
Piper aduncum	NL	Lowlans
Peperomia pellucida	LC	Lowland and hill forest
Piper sarmentosum	LC	Low altitudes
Piper porphyrophylum	NT	Low altitudes
Piper ornatum	LC	Lowland
Piper serrulatium	NL	Lowland areas
Piper longum	NL	Lowland areas

(Notes: NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NL = Not Listed)

4.4 Comparison of Piperaceae with Previous Study

The richness and uniqueness of Piperaceae species were observed a long time ago by many botanists and researchers. Pattern of division of Piperaceae vary from being

close by endemic to extensive. In selected Neotropical forests, Piperaceae has been found that it become the most species of genera compared to the others. In addition, Piperaceae be known as the great ecological importance on the base of their connection (Fleming, 1981).

The total number of species recorded is 10 species while the total number of species of Piperaceae recorded in Bukit Bakar Forest Eco Park is 45 individuals. Throughout this study, it is found that the diversity of Piperaceae species is different at three different altitudes of Bukit Bakar Forest Eco Park, Machang, Kelantan. Thus, the study conducted in Bukit Bakar Forest Eco Park, Machang shown highs density and composition of Piperaceae species where there are only 10 species that been collected and the total of individual species is 45 individual (Table 4.8)

Table 4.8: A summary of Piperaceae species recorded at Bukit Bakar Forest Eco Park, Machang, Kelantan

No.	Family	Scientific Name	Individual
1	Piperaceae	*Piper nigrum*	8
2		*Piper betle*	5
3		*Piper auritum*	4
4		*Piper longum*	2
5		*Piper aduncum*	5
6		*Peperomia pellucida*	4
7		*Piper sarmentosum*	6
8		*Piper porphyrophylum*	4
9		*Piper ornatum*	3
10		*Piper serrulatium*	4
Total	**1 Family**	**10 Species**	**45**

4.5 Checklist of Piperaceae species collected at Bukit Bakar Forest Eco Park

Family Piperaceae (*Piper nigrum)*

Piper nigrum usually can be found at the places like woody vine and mostly in tree condition. *Piper nigrum* known as the flowering vine that produced piper fruits.

Mostly, for the unripe fruits of *Piper nigrum* is used for source of black pepper, meanwhile for the ripened fruit of *Piper nigrum* is be useful for the source of white pepper (Parmar et al., 1997). Mostly, the *Piper nigrum* will be useful for Indian herbs or spices. In certain country such as Kerala, the *Piper nigrum* is known as the native species because the number of the species remain low and meanwhile, according to the Lydon and Duke (1989), it stated that Vietnam is the highest number of producer of *Piper nigrum.*

Family Piperaceae (*Piper betle*)

Piper betle is known as the vine species that from Piperaceae family that consist of kava and pepper. Mostly, the *Piper betle* leaf can be consumed in Asia and also another places in the world. Meanwhile, at the Sri Lanka and India, the betel leaves mostly traditionally used as mark of respect and beginning of auspicious (Guha, 2006). The habitat of the *Piper betle* is it can be found at the places like well-drained fertile soil. Meanwhile, for the places like alkali soils mostly do not suitable for the production of *Piper betle*(Guha, 2006).

Family Piperaceae (*Piper auritum*)

Piper auritum is known as (Hoja Santa) which is can be used for an aromatic herb and the leaf of this Piper auritum is mostly on heart shaped. The genus of this *Piper auritum* is known as *Piper*. For the leaves of the *Piper auritum* is it can be reach usually till 30 centimetres or more in size. The country like America, this *Piper auritum* is known as the native species that their number of population remained decreased because of the factor that occurred.

Family Piperaceae (*Piper aduncum)*

Piper aduncum is known as spiked pepper that is consist of fruits. *Piper aduncum* consist of a diameter of tree that can reach 8metre. Meanwhile, the habitat of *Piper aduncum* is it can grow as individual plants that showing stems. In addition, the habitat of *Piper aduncum* is at the or on logging road because the soil texture at the logging road is suitable for the *Piper aduncum*. Other than that, open landscape also can be habitat of *Piper aduncum.*

Family Piperaceae (*Peperomia pellucida*)

Peperomia pellucida usually can be found at Southeast Asia and until now it is available in most tropical rainforest areas. Usually, *Peperomia pellucida* can be found in a wet and damp area and mostly it habitat is living in a pot, drains or abandoned areas. Meanwhile, mostly the *Peperomia pellucida* cannot withstand the full sun. *Peperomia pellucida* mostly important in medicinal value that can help reduce the sickness occur.

Family Piperaceae (*Piper sarmentosum*)

Piper sarmentosem mostly originating from china. It is now available to grow in Malaysia, Thailand, Indonesia and Indo-china. In addition it mostly grow in a hot and humid tropical climate whether like close to home, roadside or in a damp and shaded agricultural garden (Lim et al., 2009). *Piper sarmentosum* can be planted in the home, open spaces and river banks as well as lakes as coverings, medicinal plants. *Piper sarmentosum* are mostly shrubs and creeping in other trees. According to the Lim et al., (2009), the root of this tree can treat untreated small water, toothache and prolonged cough, while its leaves can treat malaria, colds, sore throat and sore throat.

Family Piperaceae (*Piper porphyrophyllum*)

Piper porphyrophyllum is known as the angiosperms species that is flowering seed plants or dicotyledon. Mostly the growth plant of this Piper species is climber species, and mostly it known as the herbaceous plant. In addition, it is important for the medicinal value. This species can be found at the low altitudes of forest and the species is near threatened (NT) according to the IUCN checklist.

Family Piperaceae (*Piper ornatum*)

Piper ornatum is common names is known as the Red Betel. The plant division of this *Piper ornatum* is flowering seed plants or known as angiosperms (Ranker, 2008). Usually, the growth plant of this species is vine and liana or some are climber towards the other tree. This species well known as the herbaceous climber based on the morphology of this species. According to the Ranker (2008), the habitat of this species are mainly at moist soils places or well-drained soils.

Family Piperaceae (*Piper serrulatium*)

Piper serrulatium is known as the economically and the ecologically important in family Piperaceae (Ranker, 2008). This species is known as the herbaceous climbers and has it important such as medicinal value (Miliken, 1997). *Piper serrulatium* consist of a branch with fruiting spike and female spike that are important for the growth of this *Piper* species.

Family Piperaceae (*Piper longum*)

According to the Parmar (1997), the *Piper longum* is known as the long pepper which is the fruit of this Piperaceae species that consist of a slender, and it have more branched. *Piper longum* needs the support for the proper growth. Usually, the leaves

of the *Piper longum* is long which is 5-9 cm and the wide of the leaves is usually 5 cm. This species usually can be found at the elevation area between 100 to 1000. This species required hot for the proper growth (Parmar, 1997).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the result recorded throughout this research conducted at Bukit Bakar Forest Eco Park, the composition and diversity of Piperaceae species is relatively high. The Shannon-Diversity Index and Shannon-Evenness Index calculated are H' = 3.30 and E_H = 0.76 for the general species collected. At different altitudes of the mountain forest of Bukit Bakar Forest Eco Park the lower part (50-100 m), middle part (100-150m) and upper part (150-200m) of the forest holds different diversity and evenness index. At the lower part of the mountain, H' = 1.10 and E_H = 0.69, middle part of the forest, H' = 3.18 and E_H = 0.82 and at the upper part of the forest, H' = 2.59 and E_H = 0.73. The Sørenson similarity index was calculated resulting in relatively low similarities between species among three different location of different altitudes. The physical characteristics of the forest area could be the factors contributing to the variety of Piperaceae species exists.

Thus, the diversity of Piperaceae species are started to increase in number of species as they will grow and will adapt to the surrounding. The findings shows that the modification of the forest as well as the changes in habitat could be the factors that can affect the species composition and diversity of Piperaceae speciess at the forest of Bukit Bakar Forest Eco Park.

5.2 Recommendations

In order to ensure the conservation of Piperaceae species, there are several suggestions or recommendations that should be highlighted such as increase the number of Piperaceae species conservation centre like establish a herbarium which stores all the families of Piperaceae species specimens that exists in Malaysia as well as overseas. Apart from that, establish a herbarium places (area with living collection of Piper) in campus area which will allows to see the Piperaceae directly. It is also recommended to create a specific field based on Piperaceae species education, entertainment program to the society and taught in curriculum. This action will indirectly increase the awareness among the society about the importance of plants conservation for the use of future generations. On the other hand, increasing the role of Non-governmental Organization (NGOs) in increasing the protection measures of the forest area of Bukit Bakar Forest Eco Park that the forest can be maintained and conserved without any disturbances for future forest regeneration and inventory.

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APPENDIX A

Total Number of Piperaceae species recorded with GPS reading

Family	Species	Altitude	GPS
Piperaceae	*Piper nigrum*	173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
Piperaceae	*Piper betle*	55.4 m	5°43'0.92"N, 102°15'0.59"E
		53.6 m	5°44'8.00"N, 102°15'6.00"E
		55.4 m	5°43'0.92"N, 102°15'0.59"E
		55.4 m	5°43'0.92"N, 102°15'0.59"E
		55.4 m	5°43'0.92"N, 102°15'0.59"E
Piperaceae	*Piper auritum*	86.9 m	5°43'0.20"N, 102°15'0.52"E
		86.9 m	5°43'0.20"N, 102°15'0.52"E
		86.9 m	5°43'0.20"N, 102°15'0.52"E
		86.9 m	5°43'0.20"N, 102°15'0.52"E
Piperaceae	*Piper longum*	173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
Piperaceae	*Piper aduncum L.*	86.9 m	5°43'0.20"N, 102°15'0.52"E
		86.9 m	5°43'0.20"N, 102°15'0.52"E
		86.9 m	5°43'0.20"N,
		92.4 m	102°15'0.52"E
		92.4 m	

			5°43'0.20"N, 102°15'0.63"E
			5°43'0.20"N, 102°15'0.63"E
Piperaaceae	*Peperomia pellucida*	118.4 m	5°31'11.5"N, 102°15'74.0"E
		118.4 m	5°31'11.5"N, 102°15'74.0"E
		140.9 m	5°43'3.31"N, 102°15'8.69"E
		118.4 m	5°31'11.5"N, 102°15'74.0"E
Piperaceae	*Piper sarmentosum*	140.9 m	5°43'3.31"N, 102°15'8.69"E
		140.9 m	5°43'3.31"N, 102°15'8.69"E
		118.4 m	5°31'11.5"N, 102°15'74.0"E
		118.4 m	5°31'11.5"N, 102°15'74.0"E
		118.4 m	5°31'11.5"N, 102°15'74.0"E
		140.9 m	5°43'3.31"N, 102°15'8.69"E
Piperaceae	*Piper porphyrophylum*	173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
		173.2 m	5°43'2.30"N, 102°15'99.4"E
Piperaceae	*Piper ornatum*	140.9 m	5°43'3.31"N, 102°15'8.69"E
		140.9 m	5°43'3.31"N, 102°15'8.69"E
		118.4 m	5°31'11.5"N, 102°15'74.0"E
Piperaceae	*Piper serrulatium*	118.4 m	5°31'11.5"N, 102°15'74.0"E
		118.4 m	5°31'11.5"N, 102°15'74.0"E
		140.9 m	5°43'3.31"N, 102°15'8.69"E
		140.9 m	5°43'3.31"N, 102°15'8.69"E