DIVERSITY OF CICADA (HEMIPTERA: CICADOIDEA) IN HUTAN LIPUR BUKIT BAKAR, MACHANG, KELANTAN

by

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DECLARATION

I declare that this Final Year Project (FYP) report entitled "Diversity of Cicada (Hemiptera: Cicadoidea) in Hutan Lipur Bukit Bakar, Machang, Kelantan" is an original report of my research study. I am aware of and understand the university's policy on plagiarism and I certify that this report is my own work, except where indicated by reference, and the work presented in it has not been submitted in support of another degree or qualification from this or any other university or institute of learning. Except where stated otherwise by reference or acknowledgement, the work presented is entirely my own.

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APPROVAL

"I hereby declare that I have read this thesis and in my 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 Honours"

Signature :…….....
Name of Supervisor :…….....
Date :……..

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Diversity of Cicada (Hemiptera: Cicadoidea) in Hutan Lipur Bukit Bakar, Machang, Kelantan

ABSTRACT

A study on the diversity of cicada was conducted in Hutan Lipur Bukit Bakar, Machang, Kelantan. The objectives were to determine the species richness and also the species abundance of cicadas in Hutan Lipur Bukit Bakar. Sampling was conducted from July 8, 2018 until August 8, 2018, with 26 sampling days. A total of 27 individuals from one family, five genera and seven species were recorded by using light traps and manual collection through nature trail with three sampling points. Genus *Dundubia* (1 species), *Pomponia* (1 species), *Orientopsaltria* (1 species), *Chremistica* (2 species) and *Abroma* (2 species) were identified in this research. The most dominant genera that been recorded are *Chremistica* and *Abroma.* There were three diversity indices that applied for the data analysis and values were obtained; Shannon-Wiener Diversity Index, H'= 1.49 with an H'_{max}= 1.95, Margalef Diversity Index, D_{Mg}= 1.82 and Pielou's Evenness Index, J= 0.77. The values of these diversity indices show that Hutan Lipur Bukit Bakar, Machang, Kelantan has a low diversity of cicadas species. These were because of the several factors that can affect the determination of cicadas' diversity such as conversion of forest area into a recreational area, environmental issues and some of the disturbances by the visitors in the sampling area. This was the first cicadas' research carried out in the study area and contributes to a new record of cicadas.

Kepelbagaian Riang-riang (Hemiptera: Cicadoidea) di Hutan Lipur Bukit Bakar, Machang, Kelantan

ABSTRAK

Satu kajian mengenai kepelbagaian riang-riang telah dijalankan di Hutan Lipur Bukit Bakar, Machang, Kelantan. Objektif kajian ini adalah untuk menentukan kekayaan spesies dan juga kelimpahan spesies riang-riang di Hutan Lipur Bukit Bakar. Penyampelan telah dijalankan dari 8 Julai 2018 sehingga 8 Ogos 2018, dengan penyampelan sebanyak 26 hari. Sebanyak 27 individu daripada satu famili, lima genus dan tujuh spesies direkodkan dengan menggunakan perangkap cahaya dan pengumpulan secara manual melalui denai alam semula jadi dengan tiga penanda sampel. Genus *Dundubia* (1 spesies), *Pomponia* (1 spesies), *Orientopsaltria* (1 spesies), *Chremistica* (2 spesies) dan *Abroma* (2 spesies) telah dikenal pasti dalam kajian ini. Genus paling dominan yang telah direkodkan adalah *Chremistica* dan *Abroma*. Terdapat tiga indeks kepelbagaian yang digunakan untuk analisis data dan beberapa nilai telah diperolehi; Indeks Kepelbagaian Shannon-Wiener, H '= 1.49 dengan H'_{max} = 1.95, Indeks Kepelbagaian Margalef, D_{Mg} = 1.82 dan Indeks Kesamarataan Pielou's, J= 0.77. Nilai-nilai indeks kepelbagaian menunjukkan bahawa Hutan Lipur Bukit Bakar, Machang, Kelantan mempunyai kepelbagaian spesies riang-riang yang rendah. Ini adalah kerana beberapa faktor yang boleh memberi kesan kepada penentuan kepelbagaian riang-riang seperti penukaran kawasan hutan ke kawasan rekreasi, isu-isu alam sekitar dan beberapa gangguan daripada pengunjung di kawasan penyampelan. Ini merupakan penyelidikan riang-riang yang pertama dijalankan di kawasan kajian dan menyumbang kepada rekod baru riang-riang.

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LIST OF ABBREVIATIONS

a.m.	Ante meridiem
p.m.	Post meridiem
GPS	Global Positioning System
JPNK	Jabatan Perhutanan Negeri Kelantan
m.a.s.l.	Metres above sea level
PRF	Permanent Reserved Forest
SAC	Species accumulation curve
UKM	Universiti Kebangsaan Malaysia
UMK	Universiti Malaysia Kelantan
UMS	Universiti Malaysia Sabah

LIST OF SYMBOL

%	Percent
cm	Centimetre
V	Volt
ml	millilitre
H’	Shannon-Wiener diversity index
D_{Mg}	Margalef diversity index
J	Pielou’s evenness index
m	Metre

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Insects, which are classified under the Class Insecta can be discovered in almost every kind of habitat on Earth, in spectacular several forms. Insects, the largest group of animals which constitute 75% of all living animals. There are more than one million living insects' species in the world and still many more yet to be discovered. They are the most successful groups of animals inhabiting every conceivable ecological condition (Hook, 2008). One of the insect order is Hemiptera. The Hemiptera is distributed worldwide, and is the most diverse of the non-endopterygotenorders, with more than 90, 000 species in about 140 families (Gullan & Cranston, 2006).

One of the insects that grouped under order Hemiptera is Cicada. Cicada or in the Malay language, Riang-riang is well known as the insect that produces a sound which is generated by tymbal membrane through snapping their wings. Cicada is classified under the superfamily Cicadoidea. Cicadoidea divided into two families, Cicadidae and Tettigarctidae. They are about 2,500 different species of cicadas worldwide which can be found in a variety of temperate and tropical regions. Some cicadas live on pine trees or near swamps, but majority they live among deciduous trees (Petrus et al., 2011).

Cicadas are insects that play an important role in forest system. Top layers of soil moisture content improved when the excess water from the sap eliminated as a

waste during the cicadas' feed time. Furthermore, the cicada is an important prey to another animal like a bird. Lastly, it helps in facilitates water movement within soil during burrowing activity by nymph which happens before transformation to adult cicada (Allen, 1996).

This study had been conducted in Hutan Lipur Bukit Bakar, Machang, Kelantan. The area rich in natural assets of flora and fauna was given a clue to the cicada species resides in the chosen area and also able to update the cicadas species in the state of Kelantan, Malaysia.

1.2 Problem Statement

Over these years, research about cicadas' studies has been carried out in many countries including at the state of Malaysia. Mostly, the research about cicadas was at Borneo of Malaysia, Sabah. Kinabalu Park and Lohan Village at Ranau, Sabah were an example of selected locations that studied the diversity of cicadas (Petrus et al., 2011). While, cicadas' research at the Peninsular of Malaysia had been carried out at Johor National Park, Mount Ledang, Johor and some research overview survey at Fraser's Hill, Pahang (Tahir & Sulaiman, 2015; Sulaiman et al., 2015). However, diverse population of cicada at Hutan Lipur Bukit Bakar, Machang, Kelantan was not discovered yet before this. Moreover, analysis of population for cicada species are still lacking in Malaysia especially in Kelantan area.

1.3 Objectives

This research mainly focused on the following objectives:

(a) To determine the species richness of cicadas in Hutan Lipur Bukit Bakar, Machang, Kelantan.

(b) To determine the species abundance of cicadas in Hutan Lipur Bukit Bakar, Machang, Kelantan.

1.4 Scope of Study

The research was more focused on the cicadas' superfamily, Cicadoidea and also finding the diversity of cicadas. Collection of data was conducted at Hutan Lipur Bukit Bakar that was located in Machang, Kelantan. The collection during in field work was had done by using light traps and long extendable handle net. The research work was then continuing at the laboratory for specimen's preservation and identification process.

1.5 Significant of Study

This research can contribute to the data and information to Hutan Lipur Bukit Bakar, Machang, Kelantan. Through this research, the species population and diversity of cicadas in Hutan Lipur Bukit Bakar, Machang, Kelantan could be determined. Moreover, Kelantan State Foresty Department or Jabatan Perhutanan Negeri Kelantan (JPNK) would be able to get information about the diversity of cicadas, thus this can able to implement the department to enhance or maintain their conservation and preservation activities of insects such as cicadas.

The diversity of cicadas were identified at the end of the research. Through this final year project, manage to update species list of cicadas especially in Kelantan State

because cicada's research study and data were still lacking in Kelantan. Moreover, this study also able to contribute to the specimens of the cicada at Natural Resources Museum, Universiti Malaysia Kelantan, Jeli Campus, Kelantan.

CHAPTER 2

LITERATURE REVIEW

2.1 Cicada Taxonomic Classification

Generally, in biology, the definition of taxonomy is the describing, naming, and classifying of organisms. The taxonomy was used morphological, behavioural, genetic, as well as biochemical observations to identify organisms. In taxonomy study, there were taxonomic levels which were starting from the species, organisms are classified into large groups of organism. Species, genus, family, order, class, phylum, kingdom, and domain are the ascending order of the taxonomic levels (Panawala, 2017). Cicadas are of the insects in a class of Insecta that classified under the order of Hemiptera.

Hemiptera or true bugs was an insect that had piercing and sucked mouth-parts. Besides cicadas in this order, there were also aphids, bed bugs, leafhoppers and whiteflies. Hemiptera is the largest order because most members of this order undergo incomplete metamorphosis (Ibrahim, 2010).

Hemiptera is divided into two suborders which are Heteroptera and Homoptera (Figure 2.1). Cicadas or in Malay language, riang-riang is under suborder Homoptera. Homoptera is from the Greek language and gives meaning as a similar wing (Petrus *et al*., 2011). In Homoptera is divided into Cicadomorpha, Fulgoromorpha and Sternorrhyncha (Song et al., 2012). Cicadamorpha and Fulgoromorpha are collectively known as an Auchenorrhyncha (Gullan & Craston, 2006).

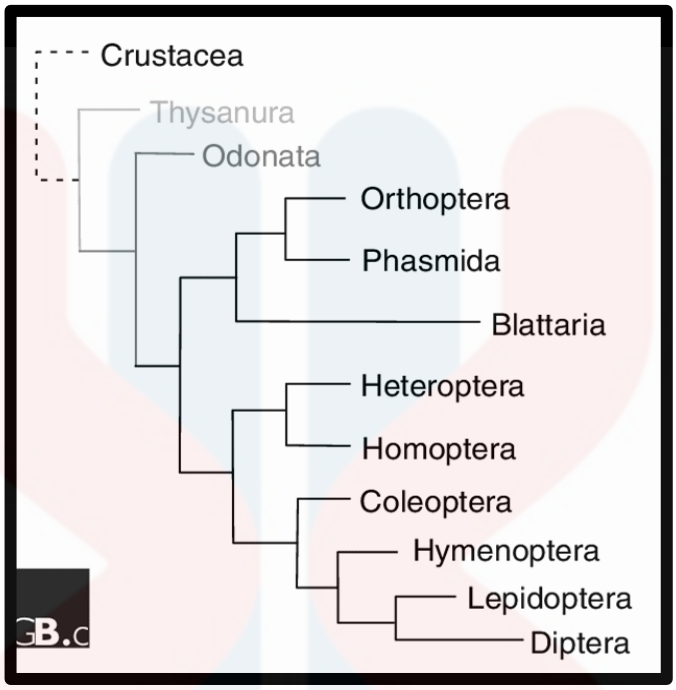

Figure 2.1: Phylogenetic Tree of Insect Orders.

(Source: Evans & Gundersen-Rindal, 2003)

Cicadas belong to the superfamily Cicadoidea and divided into two families, Cicadidae and Tettigarctidae (Petrus et al., 2011). Cicada is an insect that is large and widely distributed species, with a large pair of eyes that wide apart on the head and usually have well-veined wings. Mostly the species members under Hemiptera order are terrestrial and phytophagous (Abdullah & Isa, 2011).

2.2 Cicada Morphology

The insect of the adult body in class Insecta is divisible into three distinct parts which are the head, thorax and abdomen (Roy & Brown, 2004).

Cicadas have a large pair of eyes and three glittering ocelli in the centre. Cicada mouth part has a straw-like structure which will help them to excess sap from food plants as their food. Plus, cicadas are not able to bite as they lack bity mouth structure.

Cicadas also consist of tiny antennae at the frontal of the head. For thorax have three main parts, pronotum, mesonotum and metanotum. The pronotum or frontal part of cicadas has a pronotal collar (Figure 2.2). Cicadas consist of three pairs of legs and two pairs of wings. For the cicadas' abdomen, they consist of eight upper segments, tergite and lower segments, sternite. At the base of the abdomen consists of timbal cavity which makes the male species produce a loud noise. The male species also have a long operculum compared to the female species (Sarkar, 2015).

Furthermore, the adult cicadas are mainly to produce loud sound and this noise could be known as a stridulation (Hook, 2008). Mostly, the previous cicadas study state that the sound generally generated from male cicadas. However, there were still certain of female cicadas' species had an ability to produce sound (Luo & Wei, 2015). The cicadas were produced a different sound from the usual and it could happen when it gets disturbed or in protest. Then, as to approach the female cicada, the male will produce a special song (Triplehorn & Johnson, 2005).

Cicadas are singing insect that quite diverse in behaviours and looks. For adult cicadas, mostly they are in length between of 2 cm to 5 cm. Cicadas are quite diverse in looks and behaviours. The Asian species of the cicada in the genera *Pomponia, Megapomponia,* and *Tagua* have a length measurement of 4.7 cm -7 cm. The largest species, known as an Empress Cicada have a 20 cm wingspan (Simon & Ramel, 2013).

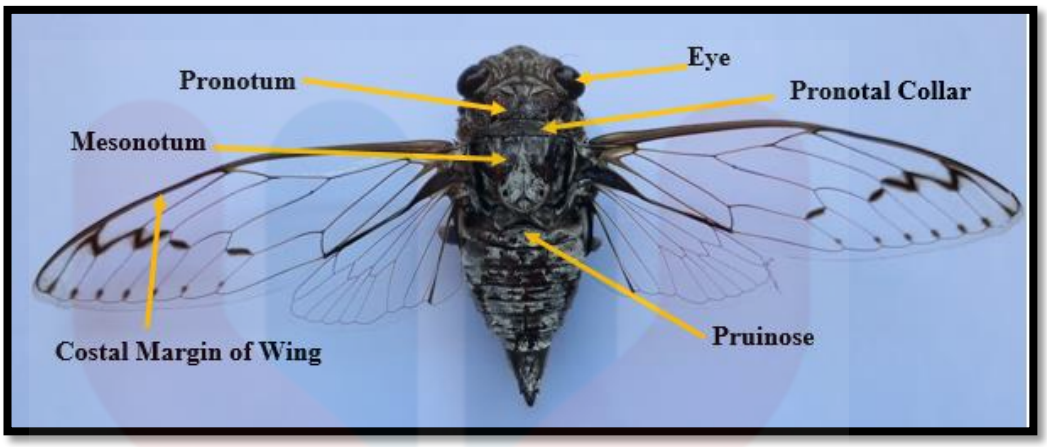

Figure 2.2: Cicada Body Plan.

2.3 Lifecycle of Cicadas

Nymph of the cicada used to live underground. During that phase, they used to feed on the roots of trees and plants species (Hook, 2008). After spending almost one to 17 years live in underground, cicadas will emerge just for few weeks to a couple of months (Sarkar, 2015).

Cicadas will emerge from their underground living at night. Then, will climb any nearby vegetation area and through this phase, they will transform into winged adult cicadas (Figure 2.3). These cicadas will spend their time by hanging on trees to find mates by day, at dawn and dusk (Petrus et al., 2011). Nearby sexually receptive of cicadas females will be attracted and move in closer to calling sound by a flick or snapping their wings as to make a response to an individual chorusing cicada male (Cooley & Marshall, 2001). After male seeks copulation with female breeding, female cicadas will place the eggs under the bark of twigs and branches. Usually, the eggs will hatch right after 70 to 120 days. The pronymph will leave eggs and molt into nymph before they burrow themselves into the underground (Petrus et al, 2011).

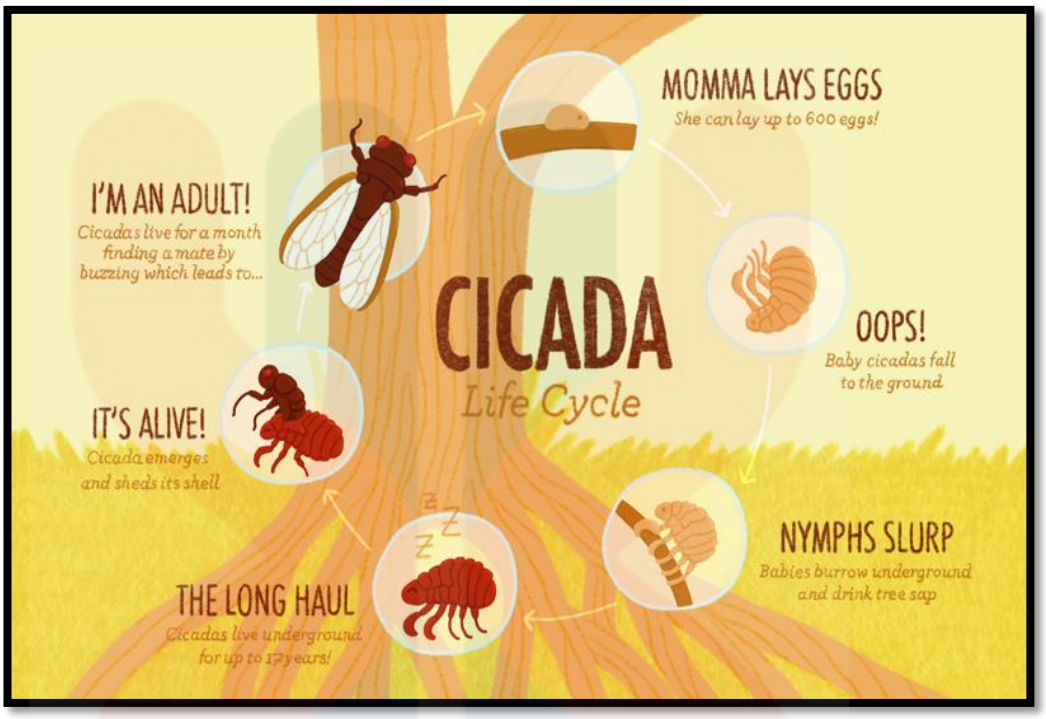

Figure 2.3: Cicada Life Cycle.

(Source: Fleming, 2016)

Overall there are two types of cicadas, annual cicadas and periodical cicadas. Every year, annual cicadas will emerges once in a particular time of a year. While, periodical cicadas will be emerging constantly once after a few years (Sarkar, 2015). It is known as a 'periodical cicada' because they do emerge for every 13 years or 17 years. Periodical cicadas with 1.5 inches long do have clear wings with orange veins that are held roof-like over their bodies. Example species of periodical cicada is *Magicicada* sp. which are the well-known and longest-lived species of insect in North of United States. Unlike the periodical cicada, the annual cicadas are larger than the periodical cicadas. Annual cicada or more familiar to be called as a dog day does have green-brown bodies with black markings on it and a whitish bloom (Shetlar & Andon, 2015).

2.4 Diversity and Distribution of Cicada

Cicadas are the large group of insects from the order Hemiptera that can be known as true bugs. In order Hemiptera, there are around 90,000 species in about 140 families (Gullan & Cranston, 2005).

Insects of order Hemiptera can be found anywhere, but not in frozen or cold areas that near the poles. For cicadas, they were mainly could be found in a diverse tropical and temperate region areas (Hook, 2008). According to the Hook (2008), they were 2, 500 of cicada's species were found in a worldwide.

In Malaysia, 150 species of cicadas had been found (Tan, 2003). At Johor National Park, Mount Ledang, Johor, the study recorded 27 cicadas' species in 11 genera under family Cicadidae (Tahir & Sulaiman, 2015). While in Sabah, the researchers from Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah (UMS) with collaboration Universiti Kebangsaan Malaysia (UKM) recorded 87 species of cicadas with 24 genera and 2 families (Zaidi & Azman, 2003; Azman & Nurulaida, 2007; Petrus et al., 2011). Examples of the area of Sabah that have been determining the population of cicadas species were at Crocker Range Park in Tambunan which nearer Keningau and also at Kinabalu Park and Kampung Lohan in Ranau, Sabah (Zaidi et al., 2002; Petrus et al., 2011).

Furthermore, in Thailand was recorded 142 species in 42 genera of cicadas (Sanborn et al., 2007). Moreover, in Laos, 60 species belonging to 33 genera have been found (Lee, 2014).

Different species of cicada might have different habitat because some cicada species live on the top of the highest leaf and other cicadas tend to settle on the tree trunk. Besides, they are also cicadas used to be in grassland area than to hang on the tree (Sarkar, 2015).

2.5 Importance of Cicada

Every living thing has reasons and purposes include cicadas as one of the important insects to the ecosystem, social and to the others living things. In an ecosystem, the cicada is an important energy source as they act as a food source for birds and the other animals (Figure 2.4). However, cicadas are not an only food source for animals but it also acts as a food source to human, such as to Malawi's people which are located in South-eastern Africa. Examples of cicada's genus that commonly served as dishes are *Loba, Platypleura and Pycna* (Anankware et al., 2015).

Figure 2.4: Gold-whiskered Barbet bird eating a cicada.

(Source: Rahman, 2008)

Moreover, Cicadas' role as a parasite on trees has contributed benefit in biodiversity because cicadas prevent their host tree populations from out to compete with the other tree species (Ezzey, 2015).

Cicadas tend to feed on sap. Because of that, the soil moisture content of the topsoil will improve as the excess water from the xylem will be eliminated as

waste. Cicadas have also helped the flow of water movement within soil due to burrow activity by immature cicadas or nymph (Allen, 1996). Plus, the sound or songs that produced by male cicada can be as a sign of summer and estimate the seasons (Sanborn & Phillips, 2013).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

The research study was conducted at Hutan Lipur Bukit Bakar. Generally, Hutan Lipur Bukit Bakar was located in Machang which at the north-east of the Kelantan State, close to Terengganu (Choong et al., 2017) (Figure 3.1).

From the Hutan Lipur Bukit Bakar, there was Kampung Tembeling at southeast, Bukit Golok at the north and Bukit Akar at the south. Hutan Lipur Bukit Bakar has an elevation of 326 metres, 1,070 feet with a latitude of 5.732538 north and longitude 102.259791 east. The place was first opened in the year 1975 and covers an area of 3.14 hectares within Ulu Sat Forest Reserve (Machang District Council, 2016) (Figure 3.2).

Hutan Lipur Bukit Bakar was one of the Permanent Reserved Forests (PRF) in Peninsular Malaysia. Hutan Lipur Bukit Bakar was then gazetted as the recreational forest (Norashikin et al., 2015).

According to Jabatan Perhutanan Negeri Kelantan (2003), the type of vegetation in Hutan Lipur Bukit Bakar was mainly logged-over hill dipterocarp forests at an elevation between 300 to 800 m.a.s.l. In the late of year 1970s to 1980s, Hutan Lipur Bukit Bakar in Machang, Kelantan was one of reserve forest had been carried out logging by the selective management system (Norashikin et al., 2015).

Hutan Lipur Bukit Bakar was a forested hill that rich with the biodiversity and many unique species of flora and fauna. At there, it was surrounded by a few streams

that make beautiful scenery. Regarding that nature view, that recreational area was suitable destination and place to visit for relaxing purpose. Hutan Lipur Bukit Bakar also has good facilities as it was provided picnic areas, toilet and a place to eat (Hamzah & Ismail, 2008).

The research study was conducted at Hutan Lipur Bukit Bakar which were starting from July 8, 2018 until August 8, 2018, with 26 sampling days. Collection of specimens was done at three sampling points in Hutan Lipur Bukit Bakar. The distances for the first sampling point which also represented as a first trail was 1 kilometre, while the second sampling point or second trail was 700 meter and last but not least, the third sampling point or third trail was 750 meter. The dissimilarity of the distance in sampling point due to the differences of the geographical structure and some of the sampling point unable to set up the longer trail because of the safety factor and absence of the rangers. These factors were beyond the ability of the researchers. The coordinate for every of each sampling point was recorded by using Global Positioning System (GPS) version Garmin 72H.

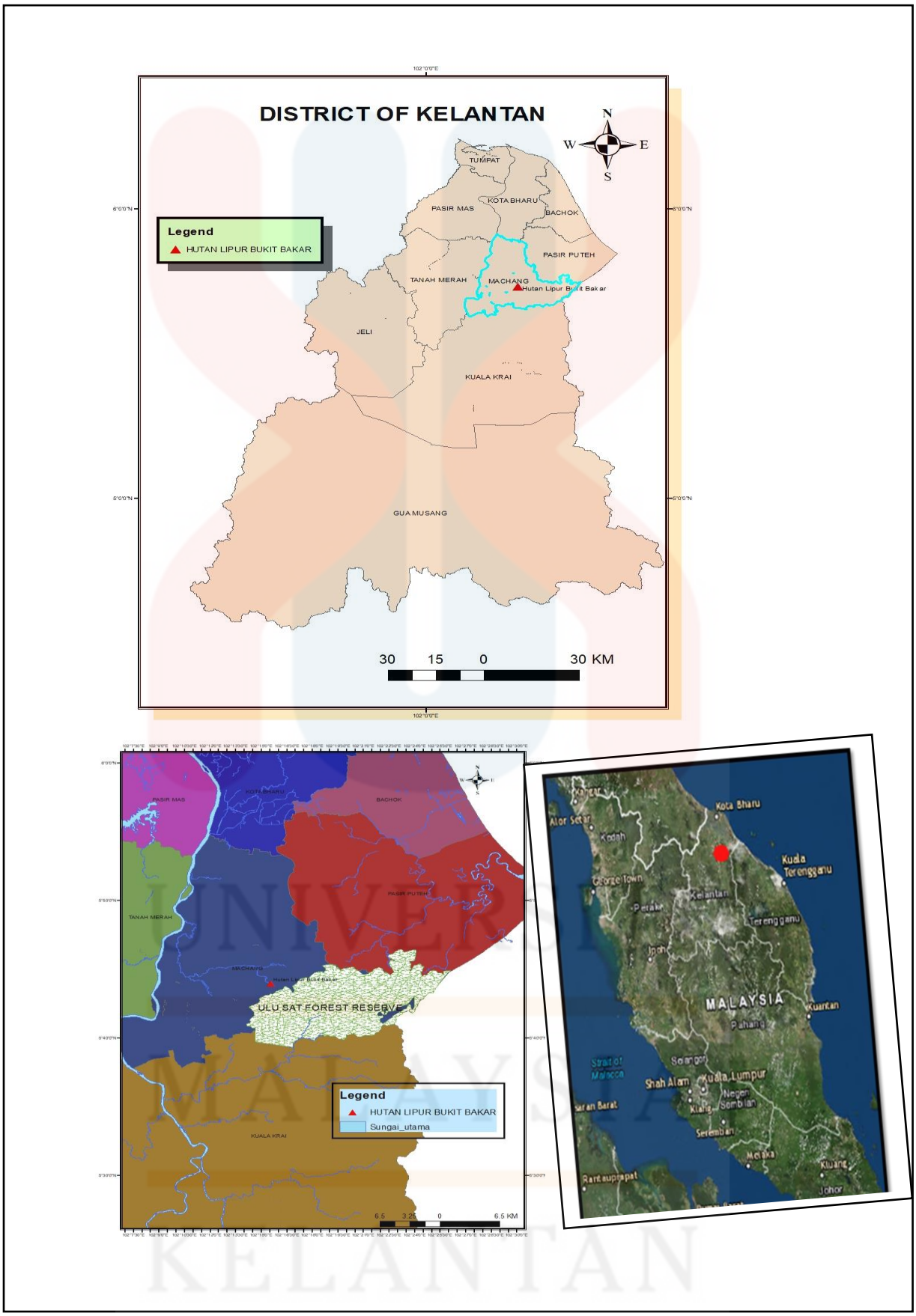

Figure 3.1: Location of Hutan Lipur Bukit Bakar, Machang, Kelantan.

(Source: ArcGIS, 2018)

3.2 Apparatus and Materials

Table 3.1 shows a list of apparatus and materials that were used during conduct the research at fieldwork and lab work. Fieldwork was done at Hutan Lipur Bukit Bakar, Machang and lab work was conducted at Natural Resources Museum, Universiti Malaysia Kelantan, Jeli Campus, Kelantan (Appendix A & Appendix B)

Table 3.1: The apparatus and materials that had been used in fieldwork and lab work.

PROCESS	APPARATUS & MATERIALS	DESCRIPTION
Collecting Process	• Garmin GPS 72H • Long extendable handle net • Light Trap (White sheets,12V 5W DC LED White Bulb, 12V 7.2AH Sealed Lead Acid Battery) • Binocular • Insect killing jar • Chloroform • 5ml of macro centrifuge tubes	Three sampling points were set up for three light traps. Insect killing jar contained chloroform was filled in to collect the specimens.
Dry Preservation Process	• Insect pins (Macro) • Mounting board • Pinning stage	Specimens were been pinned at a setting board to be mounted

3.3 Methods

3.3.1 Sampling of Cicada

Overall, the sampling process was completely done in 26 days. There were two different sampling methods used in this research which were a light trap and manual collection.

A sampling of cicada was done by setting up a light trap at three sampling points that consists of first trail, second trail and third trail. First trail was represented as a T1 while the second trail was represented as a T2 and the third trail was represented as a T3.

Since the cicadas were one of the insects that attracted to the light source, the light trap was used during the fieldwork as a main method collection.

While, the long extendable handle net was also used at along the same trails in Hutan Lipur Bukit Bakar, Machang, Kelantan as a manual collection. All the collected cicadas were killed by using the insect killing jar. Generally, the insect killing jar was contained with a piece of tissue paper that was filled with several drops of chloroform that acted as a killing agent.

A piece of tissue paper was set in the insect killing jar because the soft absorbent layer could help the insect killing jar to remain dry and stay clean (Ibrahim, 2010).

a) Light Trap

A light trap was been set at three sampling points at each point. Light traps were operated simultaneously in the night that was started from 1900 to 0200 hours. Light trap comprises of a LED white bulbs were set in front of a white sheet cloth

screen, with its lighting directed towards the surrounding areas (Appendix A). Cicadas that flight to the light traps were scooped off manually by hand or with the aids of long extendable handle net. An advantage of using this kind type of light trap was allowed to be a more selectable researcher and also caught the insects that were only needed to be made as a sample specimen. Regarding that, these were able to avoid an over-collecting which were can affect the population insects in that study area.

According to Patrick (2016), an effect of light trap depends on two factors which are the direction of the wind and wind speed. The direction of the wind importantly taken for some researcher because many insects are facing hardship during a strong wind, thus they will fly upwind on wind speed.

However, the measurement of the wind direction was not taken during in this research study as it was not required in data analysis.

Besides, the activity of the flying insects was also depended on the weather, temperature range and humidity in that region area. An example can give is when the weather in that area was rain. During in this cases, the insect's activity could be stopped or reduced (Patrick, 2016). Thus, throughout this research study, the sampling collection in a light trap was avoided during on rainy days or full moon as it could bias the result of the data.

b) Insect Net

During field research, cicadas were collected by insects nets as a manual collection. Specifically, it was an insect net with a long extended handle (Appendix A). The net was used especially during the daytime at along the nature trail in fieldwork which was at Hutan Lipur Bukit Bakar, Machang, Kelantan. There were three sampling points had been going through during in 26 days of collections. The

long extendable handle of insect net was used to capture the cicadas more easily because mostly cicadas will spend their time hanging on the trees. Insect nets will also use to collect the cicadas from bushes but mostly had collected manually by hand.

3.3.2 Cicada Preservation Process

Collected specimens went undergoes preservation process by using dry mounting process. When cicadas' specimen was already fully relaxed, they had to start to mount. Insect pins were used during operation of dry mounting. All collected cicada was been pinned to the right side of the midline in the thorax part that was located behind the pronotal collar. This part was known as a mesonotum. The setting board had been set with one pair of each cicada. It was important to place the pin in the suggested part, as to avoid any damaging structure that was necessary for the identification process. As the cicada was already straight on its pin, the spreading board was used to spread it's both sides' wings. After pinning process was done, a specimen of cicadas were oven-dried at 40 degrees Fahrenheit. Then, cicadas had been left five to seven days in a dry place with very little humid. The warm dry air was a help to dry the specimens and keep mold spores away.

3.3.3 Cicada Identification

The cicadas were identified based on their antennae in front of their eyes, wings and thorax. When the identification process had done, all the information obtained was recorded. All specimens of cicada were properly labelled to keep all the collected history and information such as date of collection, location, family, genus, species and collector. Then, the collected specimens were deposited at Natural Resources Science Museum, Universiti Malaysia Kelantan, Jeli Campus. The identification of cicadas

was referred to Duffels & Zaidi (1999), Petrus et al. (2011) and Tahir & Sulaiman (2015).

3.3.4 Data Analysis

Species diversity was determined during in this cicada's research for represent the number of a variety of cicadas' species in a study site area, Hutan Lipur Bukit Bakar. The mathematical measurement of species diversity in Hutan Lipur Bukit Bakar was based on the species richness and also the species abundances. The mathematical measurement was more concise known as a diversity index.

As to determine the species richness and abundances, three mathematical diversity indices had been applied which were the Shannon-Wiener Diversity Index, Margalef Diversity Index and Pielou's Evenness Index. All of these indices were calculated by using the Microsoft Excel software 2013 version. Besides, Species Accumulation Curve (SAC) was also used during analysis of the data.

(a) Species Accumulation Curve (SAC)

Species accumulation curves (SAC) were also be used to graph all the cumulative number of species in a particular environment. SAC is the plot of the expected number of detected species and resulted in a graphical representation of the sampling process (Mao et al., 2005).

SAC also can be called as a species-richness curve, collector's curves or species effort curve. The SAC would be used to estimate the number of species in a particular area and for a purpose to indicate the adequacy of a fauna survey in representing the fauna in a particular area. Typically, SAC would try to stipulate

whether research or studies had been caught 30%, 50% or 90% of species in that particular area (Thompson et al., 2018).

Species accumulation curve was generated in Microsoft Excel 2013 by counting the number of species accumulated that are gathered from the sampling site. The sampling process was stopped once the curve levels show asymptotes.

Microsoft Excel is a common software used by most researchers for statistical data analysis. This software capable of producing basic descriptive statistics, such as averages and frequencies. Microsoft Excel is one of software that is capable of producing high-quality data of tables and graph which is then able to generate the graph curve for species accumulation.

(b) Shannon-Wiener Diversity Index (H')

Shannon-Wiener diversity index (H') was used to measure the species diversity within the community in an ecosystem. It assumes all the species that represented and randomly in a sample (Sagar & Sharma, 2012).

$H' = -\sum \rho i \ln \rho i$ ---------- Equation 3.1

$H'_{max} = \ln S$ ----------Equation 3.2

Based on the Shannon-Wiener Diversity Index' above (Equation 3.1), where, ρi is the proportion of characters belonging to the i type of letter in the string of interest. In ecology, ρi is often the proportion of individuals belonging to the i species in the dataset of interest (Sarma & Das, 2015).

H'_{max} is the maximum Shannon-Wiener Diversity Index of the data within the community in an ecosystem (Equation 3.2).

(c) Margalef Diversity Index

As to determine the species richness, Margalef diversity index was needed as a tool analysis. Many species richness measures suffer from the problem that they are strongly dependent on sampling effort. The greater the sampling effort, potentially the higher the index value. Thus comparing metrics from samples collected with differing levels of sampling effort can be difficult and possibly misleading. Margalef Diversity Index was one of the first attempts to compensate for the effects of sample size by dividing the number of species in a sample by the natural log of the number of organisms collected (Tothmeresz, 2013).

$$D_{Mg} = \frac{(S-1)}{\ln N} \text{----------Equation 3.3}$$

According to the Margalef Diversity Index's above (Equation 3.3), firstly the S showed was the number of species in a sample while the N was represented as the number of organisms in the sample. The use of Margalef Diversity was shown the relationship between the number of species and the number of organisms in a sample. The relationship was shown that as the number of species increased, the Margalef Index also increased (Tothmeresz, 2013).

(d) Pielou's Evenness Index

To determine the species abundances, Pielou's Evenness Index was used. Pielou's Evenness Index was the suitable index to measure the equitability. Moreover, it was also allowed comparison of the Shannon-Wiener Diversity Index with the distribution of individuals in the observed species that would have the maximum diversity (Anand, 2013).

$$J = \frac{H\prime}{\ln S}$$ ----------Equation 3.4

According to the Pielou's Evenness Index's above where the values ranging from zero to one (Equation 3.4), H' was determined as the Shannon-Wiener Index and S was a total number of observed species in the sample. The ln S was represented as the maximum value of Shannon-Wiener Diversity or Maximum H' (Anand, 2013).

CHAPTER 4

RESULT AND DISCUSSION

4.1 Cicada Assemblage

In this research, a total of 27 cicadas' specimens that had been collected in Hutan Lipur Bukit Bakar, Machang, Kelantan representing 4 males and 23 females. Specifically, the specimens that were collected were comprising seven species of cicadas which consists of only one family order (Table 4.1) (Appendix C & Appendix D).

However, in that seven species of cicadas, four species were identified to morphospecies due to the lacking image identification and description of species in past research of Malaysia's cicadas species or in Asia.

Table 4.1: Distribution of cicadas' species encountered according to family in Hutan Lipur Bukit Bakar, Machang, Kelantan.

Family	Scientific name
Cicadidae	*Abroma* sp. 1
	Abroma sp. 2
	Chremistica pontianaka (Distant)
	Chremistica sp. 1
	Dundubia vaginata (Fabricius)
	Orientopsaltria alticola (Distant)
	Pomponia sp. 1

Moreover, according to the data collected, the female individual of cicadas was recorded the highest number of individuals (23 out of 27 individuals) collected (Figure 4.1). *Dundubia vaginata* and *Orientopsaltria alticola* were the only species represented by male specimens (4 out of 27 individuals).

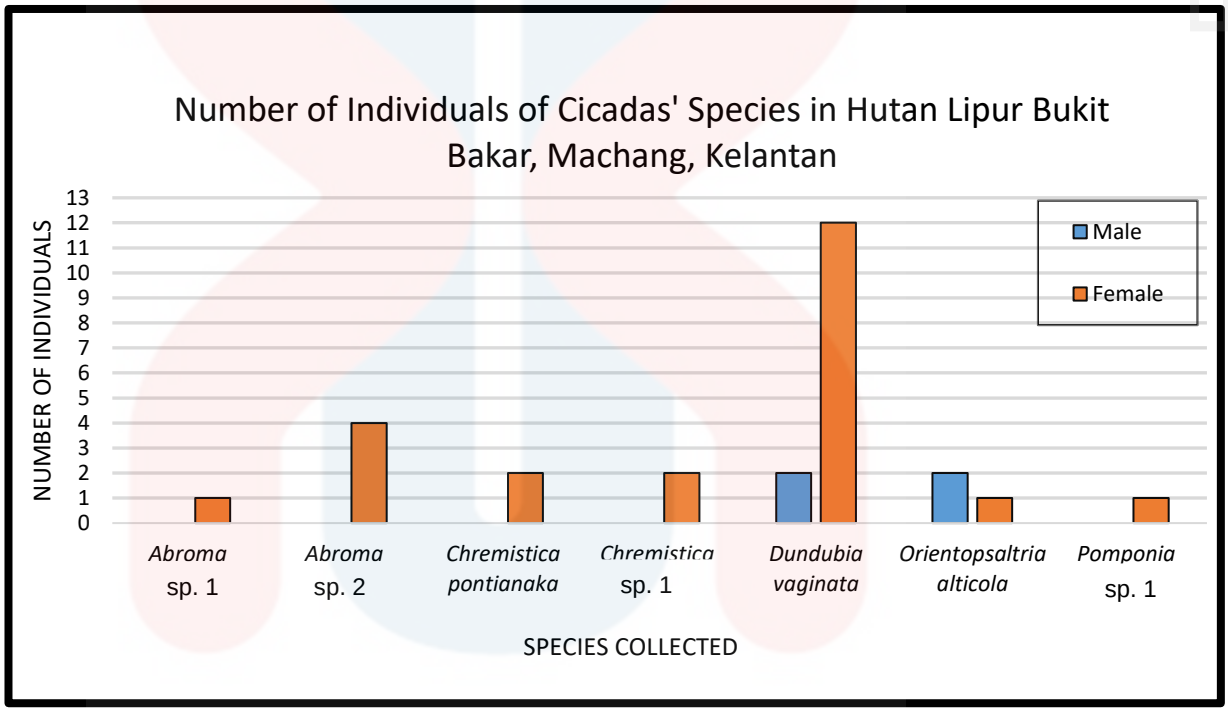

Figure 4.1: Comparison number of individuals between the cicadas' gender.

All the cicadas that had been collected during at Hutan Lipur Bukit Bakar were using two methods for a collection of specimens, light traps and manual collection. Thus, the species accumulation curve (SAC) were used in this research as they were signed to analyse all the data obtained.

In the following research, the three datasets had been utilizing to generate SAC that was analysed by using Microsoft Excel software. All the data were shown sets for a light trap, manual collection and overall collections.

First data was representing species accumulation curved for a light trap method collection (Figure 4.2). In the night, the light trap was set up at three sampling point. The sampling process for light trap method was finished at day 21.

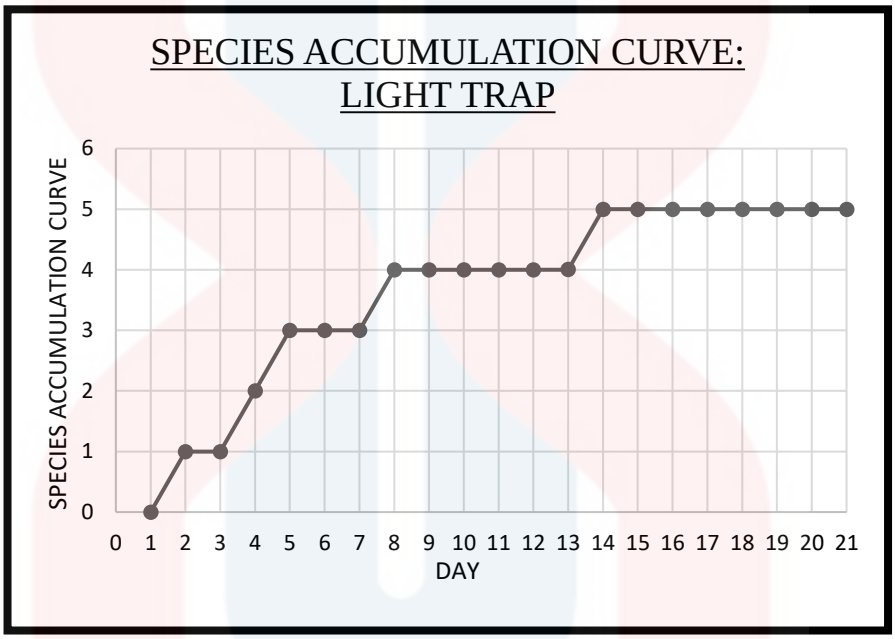

Figure 4.2: Species accumulation curve of light trap's method for cicadas' species collected in Hutan Lipur Bukit Bakar, Machang, Kelantan.

Next, the second data was representing species accumulation curved for a manual sampling collection (Figure 4.3). The manual collection was sampling along the nature trail for 26 days during the day. The long extendable handle net and binoculars were used during sampling in all the three trails which were also represented as a three sampling points.

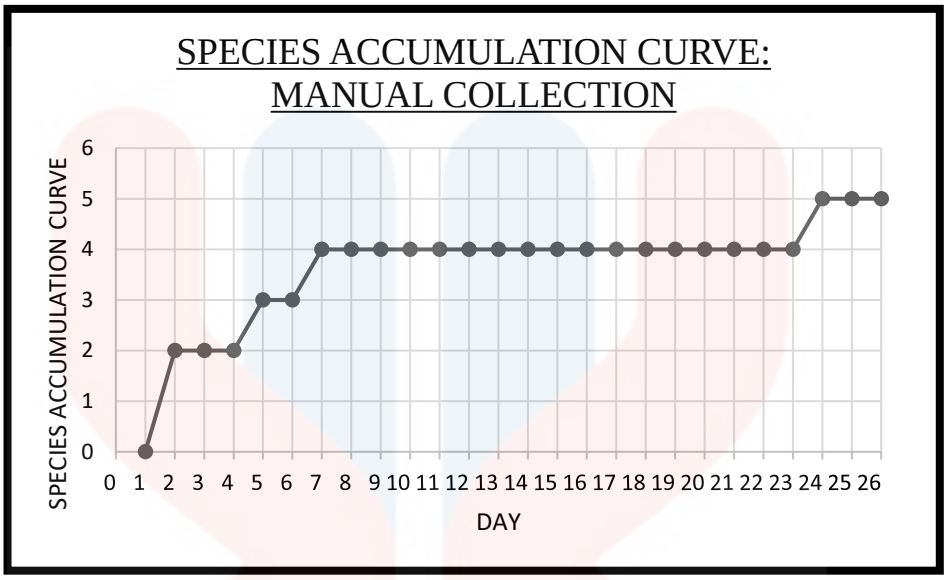

Figure 4.3: Species accumulation curve of manual collection's method for cicadas' species collected in Hutan Lipur Bukit Bakar, Machang, Kelantan.

Overall sampling collections were the sum up for the light trap and manual collections which had been done practically for 26 days in total during at fieldwork. Referring to the graph (Figure 4.4), when the number of individuals that successfully collected increases, the chances for the number of species obtained would be increases.

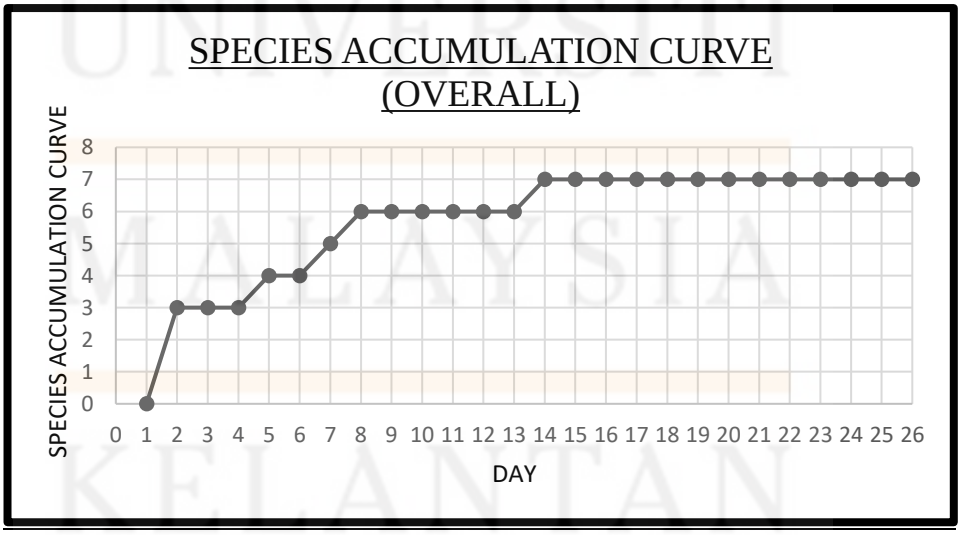

Figure 4.4: Species accumulation curve of overall collection's method for cicadas' species collected in Hutan Lipur Bukit Bakar, Machang, Kelantan.

This ensued as the species accumulation curved that shown were influenced by species richness (total number of species), relative abundance and diversity. Species richness defines the boundary of the horizontal asymptote value for a species accumulation curve, and the shape of the curve is influenced by both relative abundance and diversity. Simulations with a high proportion of rare species and a few abundant species have a species accumulation curve with a low 'shoulder' (Thompson & Withers, 2003).

In this biodiversity sampling, when more and more individuals obtained until there were new species could be collected, the sampling process can be stopped where during at this phase, the species accumulation curves reaches an asymptote. Asymptotes that shown based on a graph above were a straight line that continually approaches a given curve and not going to encounter with any finite distance. Hence that, the species richness was not changed and in a constant amount. Apart from that, enough to present the results and for any specimen sampling. By that, 26 days for cicadas sampling process with seven species collected was adequate in this research which were to determine their species richness and abundance in Hutan Lipur Bukit Bakar, Machang, Kelantan.

4.2 Species Richness

Based an examination on the data obtained through the cicadas' sampling in Hutan Lipur Bukit Bakar, it indicated the results for a species richness or particularly called as a total number of species.

Species richness is the total number of species in an assemblage. Measuring species richness is an essential objective for many community ecologists and conservation biologists. The number of species in a local assemblage is an intuitive

and natural index of community structure, and patterns of species richness have been measured at both small and large spatial scales (Blake & Loiselle, 2000; Rahbek & Graves, 2001; Gotelli & Colwell, 2011).

Furthermore, when based on genera, the genus *Abroma* and genus *Chremistica* were indicated to be the most dominant genera among to the others in the Hutan Lipur Bukit Bakar as it was recorded with two species. The rest of genera, *Dundubia*, *Orientopsaltria* and *Pomponia* only obtained one species for each genus (Figure 4.5)

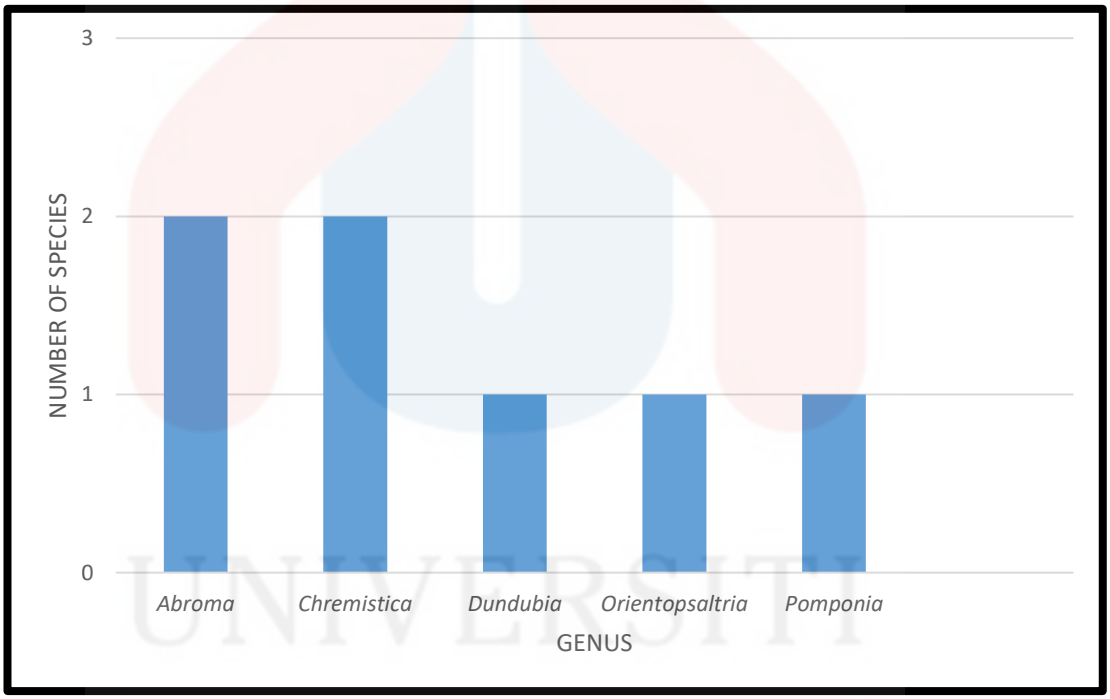

Figure 4.5: Number of species of each genus of the cicadas collected in Hutan Lipur Bukit Bakar, Machang, Kelantan.

In biological communities' studies, Shannon-Wiener diversity index varied from 0 to 5. The 0 was stated as the lowest diversity while 5 was stated as the highest diversity (Stub et al., 1970; Mason, 1988; Shah, 2013).

Based on the data of the Shannon-Wiener diversity index in this research study,

the value of H' = 1.49 and H' $_{max}$ = 1.95 (Table 4.2). Thus, the value considered as a low diversity because of the exploitation natural habitat. The cicadas' habitat was disturbed because of human exploitation to natural resources. Exploitation of natural resources such as trees occurred due an opened the study area into a recreational area. According to the Petrus et al. (2011), cicadas would spend their time on trees and feed on the sap of shrubs. Thus, the disturbance of cicadas' living habitat results in low diversity.

Table 4.2: Shannon-Wiener Diversity Index

Symbol	Value
H'	1.49
H' $_{max}$	1.95

Unlike the Shannon-Wiener diversity index, Margalef diversity index does not have limit value and it shows a variation depends on the number of species (Kocatas, 1992; Shah, 2013). In the data obtained (Table 4.3), the value of Margalef diversity Index was D_{Mg} = 1.82 which was actually was represented the number of species richness in Hutan Lipur Bukit Bakar, Machang, Kelantan.

Table 4.3: Margalef Diversity Index

Symbol	Value
D_{Mg}	1.82

This value can be interpreted in terms of the fact that the study area was not serving a good environment and also exploitation habitat for the cicadas to living on.

4.3 Species Abundance

According to the McGill et al. (2007), a species abundance distribution is a number of individuals observed for each different species encountered within the study area.

The research only came out with one family and regarding on that result, family Cicadidae (5 genera, 7 species and 27 individuals) was proved to be the most dominant family in Hutan Lipur Bukit Bakar. The result obtained was strongly acceptance when been compared with the several previous research studies at Borneo of Malaysia, Sabah such as at Crocker Range Park, Tambunan and some places at Ranau district when it represented the Family Cicadidae as the most dominant family (Zaidi et al., 2002; Azman et al., 2007; Petrus et al., 2011).

When based on the species that successfully collected, *Dundubia vaginata* resulted with the highest number of individuals. Followed with the *Abroma* sp. 2, *Orientopsaltria alticola*, *Chremistica pontianaka* and *Chremistica* sp. 1. Whereas while the lowest number of individuals were *Abroma* sp. 1 and *Pomponia* sp. 2 (Figure 4.6).

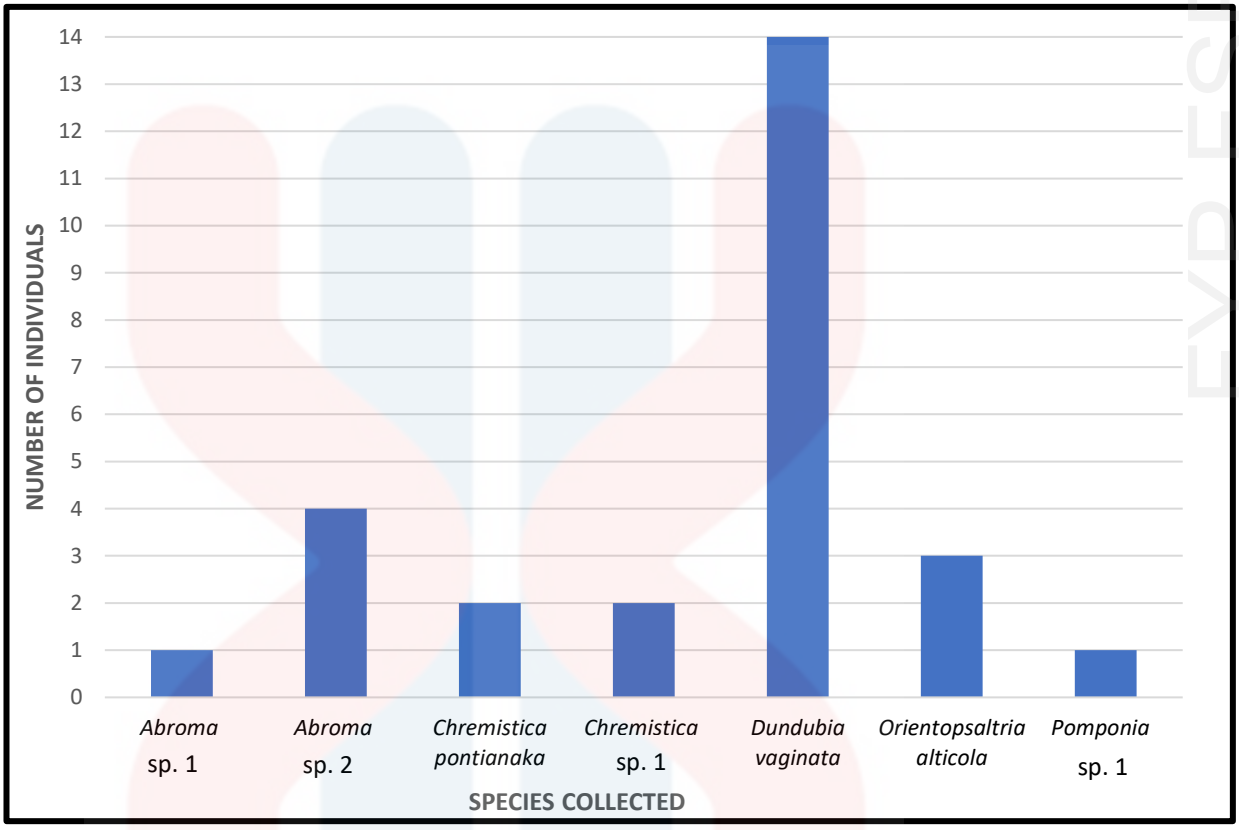

Figure 4.6: Number of individuals of each species of cicadas collected in Hutan Lipur Bukit Bakar, Machang, Kelantan.

Dundubia vaginata (Figure 4.7) is the highest number of individuals obtained in this research that recorded 14 of individuals which consists of 2 males and 12 females. Thus, this indicates that the genus *Dundubia* is the most dominant species. The result obtained was logic enough to be accepted as it was proven by another entomologist over the world. According to the Fabricus (1787), *Dundubia vaginata*, a jade green cicada is one of the most common species of cicada that could be found in tropical rainforests of Malaysia (Presern et al., 2004).

Figure 4.7: Jade Green Cicada, *Dundubia Vaginata*

The second dominant species was followed by *Abroma* sp. 2, resulted in 4 individual. This followed by the *Orientopsaltria alticola* that obtained 3 individuals of 1 species, *Chremistica pontianaka* and *Chremistica* sp. 1 with a 2 female individuals respectively. The least amount individual was *Pomponia* sp. 1 (Figure 4.8) and *Abroma* sp. 1 which only obtained one individual for each.

Figure 4.8: *Pomponia* sp. 1, the largest size of cicadas' collection in Hutan Lipur Bukit Bakar, Machang, Kelantan.

The data recorded that the second sampling point (S2) recorded the highest number of individuals which was 19 individuals out of 27, followed by the first sampling point (S1) that recorded 7 individuals and the third sampling point (S3) that only collected 1 individual (Table 4.4). Thus, it shows that more individuals collected

at S2. This is because the S2 was surrounded with a building that was facilitated with light sources, such as a lamp and also geographic factors such as elevation. S1, which is located at the Astaka were collected less number of individual than S2 because the elevation at S2 (150.7 m) is higher than elevation at S1 (49.5 m). The S3 was only managed to get one individual of one species, even the light trap was carried out at hilly places compared to the others sampling points. These were due to the weather factors on that day and noise pollutions by the worker's vehicles that commute at the sampling route even in the midnight. Thus, this showed that the high level of disturbances in the area could affect the number of individuals in cicada's study. According to the Petrus et al. (2011), low level of disturbance in a particular area is a suitable condition for cicadas to complete their life cycle.

Table 4.4: List of cicadas species collected from the three sampling points; S1, S2 and S3 in Hutan Lipur Bukit Bakar, Machang, Kelantan.

No.	Taxon	Sampling Point			Total Individual
		S1	S2	S3	
	Cicadidae				
1	*Abroma* sp. 1	0	1	0	1
2	*Abroma* sp. 2	2	2	0	4
3	*Chremistica pontianaka* (Distant)	1	1	0	2
4	*Chremistica* sp. 1	0	2	0	2
5	*Dundubia vaginata* (Fabricius)	3	11	0	14
6	*Orientopsaltria alticola* (Distant)	1	1	1	3
7	*Pomponia* sp. 1	0	1	0	1
	Total	7	19	1	27

The common species, *Dundubia vaginata* with the highest number of individual collected more at S1 and S2 compared with the others sampling point. *Orientopsaltria alticola* was the only species that collected at S3 with only 1 individual (Figure 4.9).

Figure 4.9: *Orientopsaltria alticola*, the only species collected at the third sampling point (S3) in Hutan Lipur Bukit Bakar, Machang, Kelantan.

During in this research study, Pielou's Evenness index was applied as to measure the relative abundance of the different species making up the richness of an area. The index varied from 0 to 1. The result showed up that the Pielou's Evenness Index, J = 0.77 (Table 4.5).

Table 4.5: Pielou's Evenness Index

Symbol	Value
J	0.77

Referring to the value of Pielou's Evenness index, it was proved that the individuals of cicadas in the community are evenly distributed over the different species. This indicates that the individuals in the communities of cicadas are evenly distributed diverse over the different species. Moreover, the value of the index indicates that the cicadas were determined to be as a moderate abundance. This was because the individuals collected for each genus was at a moderate amount.

Hutan Lipur Bukit Bakar, Machang, Kelantan was had been classified as a recreational area and had been visited by the most local tourists and also from

international. Thus, this could trigger several environmental problems factors such as sound and water pollutions.

These environmental issues may disturb the biodiversity lives at there like cicadas. According to the Maurice & Bourton (1975), cicadas need trees and shrubs in their life to deposit their eggs, moulting activity, obtained food and also a place for mating (Petrus et al., 2011). Thus, these environmental issues could disturb the cicada's habitat.

Hence, observed from the data could be showing up that the number of species and individual of cicadas was relatively low. The factor such as low richness of flora and fauna may be one of the contributions that can affect the fluctuation of cicadas' population in Hutan Lipur Bukit Bakar. The low richness of flora and fauna because of conversion some part of forests into a recreational area.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As a conclusion, the determination of species richness and abundances of cicadas in Hutan Lipur Bukit Bakar, Machang, Kelantan were achieved. Species richness and relative species abundance were the two factors that should be considered when measuring species diversity.

Species diversity contributes to ecosystem health. If a species disappears, an entire ecosystem can start to decline. Species diversity is the very important key of range in ecosystem health (Nappi, 2018).

This research study managed to record 27 individuals of cicada from the Hutan Lipur Bukit Bakar, Machang, Kelantan consisting 7 species of 5 genera and 1 family under superfamily Cicadoidea. *Dundubia vaginata* recorded the highest number of individuals and also the highest individual collected at the second sampling point (S2) in the study area, whereas the genus *Abroma* and *Chremistica* were recorded the highest species collected.

Moreover, the research study indicates the low diversity of cicadas according to the site area that was opened for recreational park purpose. This shows the negative impact of the environment on insect diversity such as pollution issues. Biodiversity studies on specific insect species present at the Hutan Lipur Bukit Bakar were totally recommended for future entomology research plus increase the data ecological of flora and fauna, especially in Kelantan state.

5.2 Recommendations

The further research study on the diversity of cicada especially in area state of Kelantan as it is still lacking data and information on these insects because mostly the research about the cicadas was carried out in Borneo of Malaysia. By doing the research around the Kelantan State, there could be the high chance to obtain more species of cicadas which could be also found in another neighbouring country such as Thailand as the Kelantan bordered with Thailand.

Moreover, the longest period during sampling is needed in the further study as to obtain the more specimen and several of cicada's species. This was because during in this research study, the period of sampling process was still considered as a short period and only able covered in one season. By making the research in many seasons, the data obtained could capable of making a comparison between one season with another one season and would have a high chance to acquire more species with variation.

Furthermore, advocate the environmental awareness education programme at around research study can give potential positive values among the public or local people to take care of the environment which is the essential treasure for biodiversity life cycles such as insects. This is because when based on observation, local people who stayed nearer to Hutan Lipur Bukit Bakar less practising in concerned of nature. Moreover, as the Hutan Lipur Bukit Bakar already opened for recreational park area purpose, the environmental issues getting worse due to the contribution of waste especially from local people who are lack of environmental education. By advocate this kind of programme, it can help in improving the forest habitat quality which actually effective ways for the biodiversity's life to keep living on. Overexploitation

of forest for the purpose of development into the recreational park resulted in declination of species flora and fauna such as cicada as their habitat was being disturbed. According to the UNESCO (2018), overexploitation is the second largest direct threat to many species after habitat loss. Overexploitation refers to the harvesting of natural resources to a point exceeding the resources' capacity to be renewed. Thus, a low diversity resulted in the number of cicadas were decline due to the overexploitation in a research study.

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APPENDIX A

Image of selected equipment that was used during the sampling process in Hutan Lipur Bukit Bakar, Machang, Kelantan.

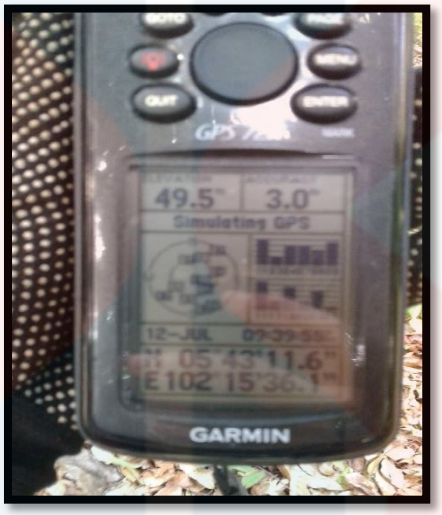

Image 1. Garmin GPS 72H

Image 2. Binocular

Image 3. Long extendable handle net

Image 4: Light Traps (with a white sheet and white bulbs)

APPENDIX B

Image of fieldwork process in Hutan Lipur Bukit Bakar, Machang, Kelantan.

Image 1. Collect the cicadas especially from the top of the tree by using long extendable handle net

Image 2: Observed the cicadas by using binocular

Image 3: Observed and collect the specimens on light trap

Image 4: Took coordinates for every sampling point by using GPS

APPENDIX C

A number of individuals of cicada species that were collected at Hutan Lipur Bukit Bakar in Machang, Kelantan.

Genera	Scientific name	Number of individuals
Abroma	*Abroma* sp. 1	1
	Abroma sp. 2	4
Chremistica	*Chremistica pontianaka* (Distant)	2
	Chremistica sp. 1	2
Dundubia	*Dundubia vaginata* (Fabricius)	14
Orientopsaltria	*Orientopsaltria alticola* (Distant)	3
Pomponia	*Pomponia* sp. 1	1
	TOTAL	27

APPENDIX D

Images of cicada's specimens that were collected from the study area, Hutan Lipur Bukit Bakar, Machang, Kelantan.

Plate 1. *Dundubia vaginata*, female.

Plate 2. *Pomponia* sp. 1, female.

(a)

(b)

Plate 3. (a*) Orientopsaltria alticola*, male; (b) *Orientopsaltria alticola*, female.

(a)

(b)

Plate 4. (a) *Chremistica pontianaka,* female; (b) *Chremistica* sp. 1, female.

(a)

(b)

Plate 5. (a) *Abroma* sp.1, female; (b) *Abroma* sp. 2, female.

APPENDIX E

Final Year Project Planning (FYP 1 & FYP 2)

Date	Activities	Description	Location
April 2018	Submission and presentation of research proposal	FYP 1	UMK Jeli Campus
June 2018	Submission research report – Chapter 1,2,3	Last task of FYP 1	UMK Jeli Campus
July 1, 2018 until July 5,2018	Fieldwork materials & apparatus preparation	• insect killing jar • materials of the light trap • insect pins • chloroform • long extendable insect net • GPS • binocular	UMK Jeli Campus
July 8, 2018 until August 8,2018	<u>Fieldwork:</u> a sampling of cicada at field study	The pinning of cicada was conducted after three to five days the specimen left in insect killing jar (contained chloroform).	Hutan Lipur Bukit Bakar, Machang
August 12, 2018 until August 14, 2018	<u>Laboratory Work:</u> Pinning and oven-	After the pinning process, the specimens were oven-	Natural Resources

	dried the specimens	dried at 40 degrees Fahrenheit.	Museum, UMK Jeli Campus
August 15, 2018 until August 16, 2018	Identification specimens	Identified the family and genus.	Natural Resources Museum
September 2018 until October 2018	Identification specimens and writing research report	Identified the scientific name, do corrections for chapter 1, 2, 3 and start writing for chapter 4 and 5.	UMK Jeli Campus
November 18, 2018	Confirmation of specimens identification	Confirmation with a supervisor.	Microbiology Laboratory, FSB, UMK
November 19, 2018	First draft report	Submission to a supervisor.	UMK Jeli Campus
December 10, 2018	Submission final report	Submission to faculty.	UMK Jeli Campus
December 18, 2018 until December 19, 2018	Presentation of a full research project (VIVA)	Colloquium.	Bilik Kuliah, FSB, UMK
January 7,2019	Submit corrected version to a supervisor	For correction approval.	UMK Jeli Campus
January 10,2019 until January 17, 2019	Submit hardbound	Last task of FYP 2	UMK Jeli Campus