DIVERSITY AND ABUNDANCE OF BATS AT GUA SETIR COMPLEX

By

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A report submitted in fulfillment of the degree of Bachelor of Applied Science (Natural Resources Science) with Honours

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DECLARATION

I declare that this thesis entitled “Diversity and Abundance of Bats at Gua Setir Complex” 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 the candidature of any other degree.

Signature :.....

Name :.....

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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 Honors"

Signature : …….....

Name of Supervisor :……..

Date :……..

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Diversity and Abundance of Bats at Gua Setir Complex

ABSTRACT

Gua Setir is a limestone hill that covers the length of 1300m, where is located in Kelantan. This study was conducted due to no data recorded at Gua Setir, Kelantan. The main purpose of this study was to record the diversity and abundance of bats at Gua Setir by using mist nets and harp trap that had been set up for about twenty-six nights. The mist nets and harp trap was set up at the placed that had been chosen due to the probability of getting good sampling results. A total of 224 individuals with five different families and 15 different species had been recorded. From the overall data, this results showed the high diversity and abundance of bats (0.674 indexes of species evenness). All the data recorded was interpreted by using diversity indexes (species richness, species evenness, Shannon-wiener index). Species accumulation curve used to show the effectiveness of sampling period towards sampling result. *Megaderma lyra*, *Miniopterus medius*, and *Miniopterus schreibersii* had been recorded as a new record of bats species in Kelantan. The samples collected were properly preserved in containers by adding 70% of alcohol solution. In improving this research for the future there were a few factors that had been discussed.

Kepelbagaian dan Kelimpahan Kelawar di Gua Setir Kompleks

ABSTRAK

Gua Setir adalah kawasan bukit batu kapur yang mempunyai panjang 1300m yang terletak di kelantan. Kajian ini dijalankan kerana tiada data yang direkodkan di Gua Setir. Tujuan utama kajian ini adalah untuk merekodkan kepelbagaian dan kelimpahan kelawar dengan menggunakan set jaring dan perangkap harpa yang telah diletakan selama dua puluh enam malam. Set jaring dan perangkap harpa telah diletakan di kawasan yang dipilih yang berkemungkinan untuk mendapatkan sampel yang baik. Sebanyak 224 ekor kelawar dengan lima famili yang berbeza dan 15 spesis yang berbeza telah direkodkan. Dari keputusan keseluruhan data menunjukkan tahap kepelbagaian dan kelimpahan kelawar adalah tinggi (0.674 indeks kekerapan). Kesemua data yang diperolehi telah ditafsirkan dengan menggunakan indeks kelpelbagaian (kekayaan spesies, kekerapan spesis, indeks Shannon-wiener). Lengkungan spesis terkumpul digunakan untuk menunjukkan keberkesanan tempoh tangkapan terhadap keputusan yang diperolehi. *Megaderma lyra, Miniopterus medius* dan *Miniopterus schreibersii* telah direkodkan sebagai rekod baru untuk spesis kelawar di Kelantan. Semua sampel yang dikutip akan diawetkan dengan baik di dalam bekas dengan menggunakan 70% larutan alkohol. Beberapa faktor penambahbaikan untuk kajian masa hadapan telah dibincangkan.

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LIST OF ABBREVIATIONS AND SYMBOLS

UNEP	United Nation Environment Program
HB	Head and body length
T	Tail
HF	Hind foot
E	Ear
FA	Forearm
M	Meter
IUCN	International Union For Conservation of Nature
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Biodiversity is the variety of living organisms from all source, it consists of terrestrial, marine and other aquatic ecosystem and the ecological complex with their part that includes diversity within species, ecosystem and between species (Wilson, 1998). Biodiversity assessment very important for planning conservation strategies (Lim, & Engstrom, 2001). The 2001 Global Diversity Outlook recognized Malaysia as one of the 12 megadiversity countries in the world and was estimated at more than 170000 species in Malaysia. Typically, biodiversity was measured by the variation of genetic, species, and ecosystem level according to the United Nation Environment Program (UNEP).

Mammals are divided into a few categories, which are small, medium and large mammals. In each group of mammals, they have different characteristics to differentiate. Bats are the one examples of small mammals (Jayaraj, Daud, Azhar, Sah, Mokhtar, & Abdullah, 2013). Bats are known as small mammals because it is warm-blooded, has fur and nurses their babies with milk. Bats is the only mammals that have a powered flight (Thewissen & Babcock, 1992). Their arms are spindly with membranes stretched between the fingers on each hand. Due to this arrangement, it makes their wings quite different

from birds and pterosaurs, and in fact, the bats have evolved flight quite independently. Bats are depended on hearing for navigation and it has differentiated bats with other mammals. Most of the bats are using sonar echos to find their way. Bats are classified in Chiroptera order which means “hand-wing” this is because wings are created by membranes that are attached to four elongated fingers. Bats has a sharp claw that enables them to crawl. Factor that influences the diversity of small mammals is food, vegetation, and climate. Bats play a good role in the ecosystem. For example, they are important in controlling insect’s populations. Besides that, they also act as a pollinator and help to disperse seed (Merritt, 2010).

Bats are commonly found in tropical forest, cave, and agriculture areas (Kunz, & Fenton, 2005). There are 110 species of bats have been recorded in Peninsular Malaysia (Lim, Ramli, Bhassu & Wilson, 2017). Bats basically stay in the cave where there easily can access to water, and also protect their habitat from predators during the day. Cave also have many sources of food. Caves are the ideal environment for these bats because the temperature in the cave is very stable especially in the large caves and therefore the bats have to expend little energy in regulating their body temperature. The cave itself can vary in size from small cracks and crevices, piles of rocks or boulders, to overhangs and extensive limestone caverns.

Limestone karsts are sedimentary rock outcrops that consist primarily of calcium carbonate. Most karsts were formed millions of years ago by calcium-secreting marine organisms before tectonic movements lifted them above sea level (Clements, Sodhi, Schilthuizen, & Ng, 2006). Karst area is important to orchid species habitat.

Many orchid species are ideally adapted to the harsh environment of limestone hills. Besides that, karst area is mainly exploited for limestone it is important for mineral, and production of cement and marble products. Next, karst readily stores rain and other than maintain the hydrological integrity of watershed it also functions as a source of groundwater for consumption and irrigation (Suyanto, & Struebig, 2007). It also important for fauna habitat for example bats, snake, and etc. lastly karst also have huge potential for archaeological and paleontological.

1.2 Problem Statement

The species richness of small mammals declines in response to forest fragmentation (Vargas & Simonetti, 2004). According to the research by Danielsen and Heegaard (1995), the proportion of dominant bat species increased and the overall bat species richness decreased by 38%–50% as the result of logging activities at their study areas. They found that the conversion of forest habitat to the plantation at their study site also caused the species richness of bats to decline between 13%–25% and caused changes in the bat community structure because of the change of environment. The diversity of Chiroptera cannot be determined because of the lack of research and data recorded in Gua Setir, Kelantan, Malaysia. The study had been done to document diversity and abundance of bats at Gua Setir, Kelantan, Malaysia.

1.3 Objective

The objective of this study is to determine the diversity and abundance of bats at Gua Setir complex using mist nets and harp traps method.

1.4 Scope of Study

Karst area is biologically diverse with a unique ecosystem that particularly important for the habitat of bats (Sedlock, Jose, Vogt, Paguntalan & Carino, 2014). According to Kingston (2008), the forest degradation and fragmentation has affected the species richness, bat abundance and assemblage the composition of bats in Malaysia. The aim of this study is to investigate the population of bats in a karst area. This study has been done at Gua Setir Kelantan. Limestone karst landscapes have significant value for biodiversity that is increasingly threatened by development activities such as mining (Struebig et al., 2011). Usually, the karst area has a variety of plant and animal species besides that it also has a unique microbiological habitat. Bats is the one example of small mammals that can be found in the karst area. This is because they typically will reside in a karst area where they have access to water, safe places to hide from predators during the day, and plenty of food. This study has been determined by two method which is mist nets and harp trap. The species of bats were identified using reference books and one of each species will be preserved.

1.5 Significant of Study

This study is important because bats are important for ecological roles as prey and predator, arthropod suppression, seed dispersal, pollination, material, and nutrient distribution, and recycle. Bats also important in the economic sector, which is act as biological pest control, plant pollination, seed dispersal, guano mining, bush meat and medicine, aesthetic and bat watching tourism, and education and research (Mohammed Kasso & Balakrishnan, 2013)

CHAPTER 2

LITERATURE REVIEW

2.1 Chiroptera

Chiroptera commonly known as a bat, classified in small mammals. It categorizes as a small because of usually weight of bats less than five kilograms. Chiroptera is the name of the order of the only mammal capable of true flight, the bat. Bats commonly found in the tropical area. The name is influenced by the hand-like wings of bats, which are formed from four elongated fingers covered by a cutaneous membrane. Chiroptera is one of the most successful orders of mammals that widely distributed in every continent (Gunnel et al., 2012). Chiroptera is divided into two suborders which are Megachiroptera known as fruit bats and Microchiroptera is an insect bat (Mohd Azlan, Neuchlos, & Abdullah, 2005). *Cynopterus brachyotis* which is also known as a lesser dog-faced is the common frugivorous species. According to Hodgkison, Balding, Zubaid & Kunz (1997), this species had fed on 54 plant species. This species is under Megachiroptera suborders.

2.2 Diversity of Bats

In Malaysia, there are more than 125 species of bats had been found (Kingston et al., 2009). The higher species of bats are in Borneo there are 94 species from 8 families were recorded (Payne et al., 1988). One study had been conducted in Gunung Stong State Park, Kelantan there is one new species of bats had been recorded in Kelantan (*Myotis muricola*) and others 11 species have been found in Gunung Stong State Park (Jayaraj et al., 2012).

Pteropodidae is the bats feed on fruit and some of them feed on nectar and pollen (Singaravelan & Marimuthu, 2004). Pteropodidae have a large measurement of body size, it can reach up to 1.5 kilograms of weight and 1.2 meters wing. It can be easily identified by their face since it has the fox-like faces, a dog-like muzzle, short tail and small ears lacking a tragus shorter than Family Microchiroptera (Schutt & Simmons 1998). Long-Tongued bats known as *Eonycteris spelaea* has been found as a good pollinator for durian (Price, 2000). Microchiroptera suborder has a small sized compared to fruit bats. Commonly known as insects bats. The weight of insect bats ranges from 2 to 80 grams (McNab, 1971). This species can be identified by their physical appearance which is the nose pads which have various kind of shapes and also its lower lips (Schmidt, 1985). This species needs to eat at least half its body weight in insects per night (Kingston et al., 2006).

According to Francis (2008), Southeast Asia has a variety species of bats with high species richness compared to other placed. However, the number of bats species are decreasing because affected by human activity which is by fragmentation and

deforestation. Forest disturbance also affect the decreasing numbers of the other mammals in the forest (Shafie, Sah, Latip, Azman & Khairuddin, 2011).

2.3 Morphology of Bats

Usually, the morphology of bats is the best pioneer key used to recognize bats. It can be recognized by their face or muzzle. Fruit bats know as bats that have forward-facing eyes that can see in very dim light compare to insect bats that has a smaller eye with large ears (Heaney, Balete, & Rickart, 2016). The first digit of the bat wing is small and clawed, and bats commonly it uses for a climb or to walk on the ground.

The basic measurements of bats are started from head and body length (HB) which is measured from anus to the front of the nose. Measurement of the tail (T) start from the anus to the tip of the fleshy or bony part of the tail. Hind foot (HF) are measured from the heel to the end of the longest toe. The ear length (E) measured from the bottom of the external opening of the ear to the tip. Forearm (FA) measured from the outside of the elbow to the outside of the wist in the bent wing.

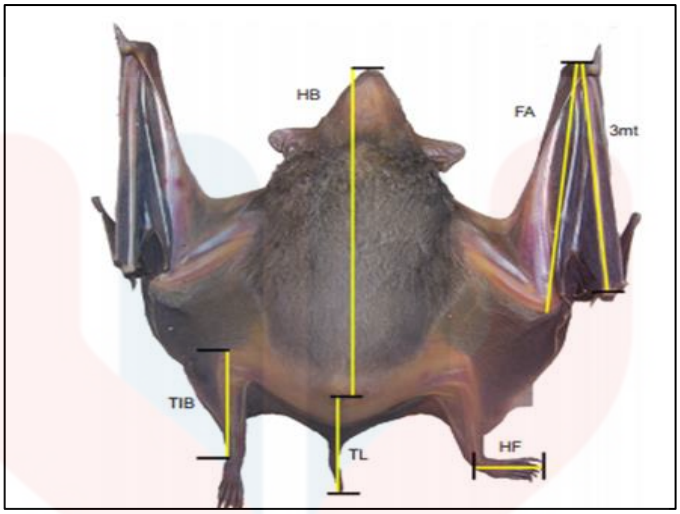

Figure 2.1: Main external measurements and schematic diagram of a bat (Srinivasulu et al., 2010).

2.4 Roles of Bats in Environment

Bats have an important role in the environment. It acts as a pollinator for certain plant and it depends on bats to pollinate their flowers or spread their seed. In the tropical and subtropical forest bats acts as pollinator that produces fruit and flowers and at the same time, it helps to improve the economic quality of the environment (Kunz et al., 2011). Bats also play a role as pest controllers by eating insects. Bats can help to reduce the need for pesticides sprays because it eats insects in some regions (Kasso, & Balakrishnan, 2013).

2.5 Trapping and Capturing Bats

To collect the sample there are several methods that can be used, which is by using mist nets, harp traps, and hand capture. The capture methods employed depend on the species interest, roost or habitat and also the number of bats to catch. Each method will

give different results for this study. According to Karim, Tuen, & Abdullah (2004), the most efficient method is by using harp traps compared to mist nets. Hand capture also one of example capturing method. Harp trap is more effective compared to mist net due to these methods are suitable for catching small to medium-sized Rhinolophidae and Vespertilionidae (Francis, 1989). By using harp trap it can reduce the stressful and injuries for bats compared to mist net. That was a several drawbacks by using mist net which is it needs more time to set up and it also can cause stress and injuries to the bats (Kingston et al., 2006) There are a few things should be considered to get the maximum captured of bats such as choose the suitable site location (Khan, Sazali, Jayaraj, Siali Aban, Zaini, Ketol, & Abdullah, 2007). For example, mist nets or harp trap must deploy near the niche or habitat of bats. Capturing activity should be done in the night because bats are active during the night (Struebig, Kingston, Zubaid, Adnan & Rossiter, 2008). The foraging habitat and roosting habitat also important for capturing bats.

2.5.1 Mist Net

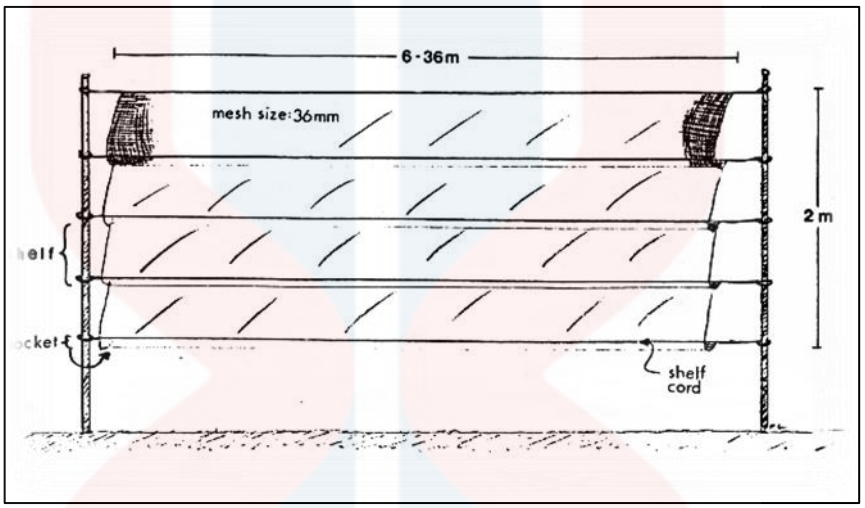

Figure 2.2: Mist net component and dimension (Vonhof et al., 2003).

A mist net is recommended because it is commonly used and required a low cost. It also easier to handle because of lightweight, compact and easy to carry. Besides that, this technique has a low risk of injuries towards bats. It consists of two type which are braided nylon and terylene nylon (Kingston, Francis, Zubaid Akbar, & Kunz, 2003). The trapping method started by selection a strategic site such as near flowering trees, bananas trees and across small streams. The main instrument is strap which use for to tie each pole of the net to make it stretch and supporting from falling to the ground.

2.5.2 Harp Trap

Harp traps can be marvelously effective when used properly. They are particularly good at trapping bats leaving roosts, as the bats have less time to see and avoid the trap than they would if they were free flying (Jayaraj et al., 2013). Harp trap is the most effective methods but the cost is higher rather than a mist net.

2.5.3 Bats Detectors

Bats detectors are one example methods to identify bats species. Bats use high frequency calls normally beyond the range of human hearing to build up a sound picture of their surroundings (Hourigan et al., 2008). This echolocation system enables them to wing their way through the dark night hunting the tiniest of insects. A bat detector makes these echolocation calls audible to humans and because different bat species hunt different prey and are different sizes, they make different calls which can help identify them (Francis, 2008).

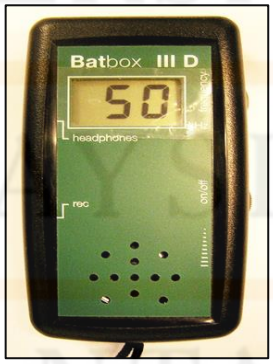

Figure 2.3: An example of a heterodyne detector (Bat Conservation Trust Webpage, 2011)

Bats detectors are used to detect the presence of bats and help to identify the species of bats in the study area. There are a few species that easy to recognize using bat detectors such as Horseshoe bats. Since echolocation calls are frequently one of a kind to a bat species detectors usually make it conceivable to recognize some species from their calls call similarly on ornithologist can distinguish bird species from the song (Nagorsen et al., 1993). There is a major limitation of acoustic bat detectors, which is limited by the absorption of ultrasound in air. A mid-range frequency around 50 kHz, the maximum range is only about 25 to 35 meters in average atmospheric conditions when bats fly. For bat identification during the night, bat detectors can be a very helpful device for echolocation (Hill et al., 2005).

2.6 Diversity Indices

2.6.1 Species Richness

Species richness is the sum of the number of species that present in certain area community and region (Levin et al., 2009). There are three ways to estimate the species richness, which are using the prediction of species accumulation, using the non-parametric estimator and using the shape of species abundance distribution (Maguraan, 2013). Species richness is important in the study area because from the data the conservation status and factors that influence the species can be analyzed.

2.6.2 Species Abundance

Species abundance is the number of individuals per species and relative abundance refers to the evenness of distribution of individuals among species in a community. Usually, the higher the abundant species in a region or ecosystem, the more diverse it is considered. Diversity indices including evenness consolidate quantitative measures of species abundance in connection to the sum of the abundance of all species (Van Dyke, 2008).

CHAPTER 3

MATERIALS AND METHOD

3.1 Study Area

This study was conducted at Gua Setir. Gua Setir is a limestone hill that covers the length of 1300m, mean width of 80m and highest peak of 100m. It located nearby the Kampung Pasir Dusun. This area is covering the alluvium soil, most of the foothills are used for rubber tree plantation. Gua Setir also has high elevation and receive a high amount of rain (Hamdan, 2013). Gua Setir is comprised of limestone, interbedded shale, sandstone, and siltstone. According to locals, there are around 40 caves combined the Setir Cave complex (Adriansyah, Busu, Eva & Muqtada, 2015).

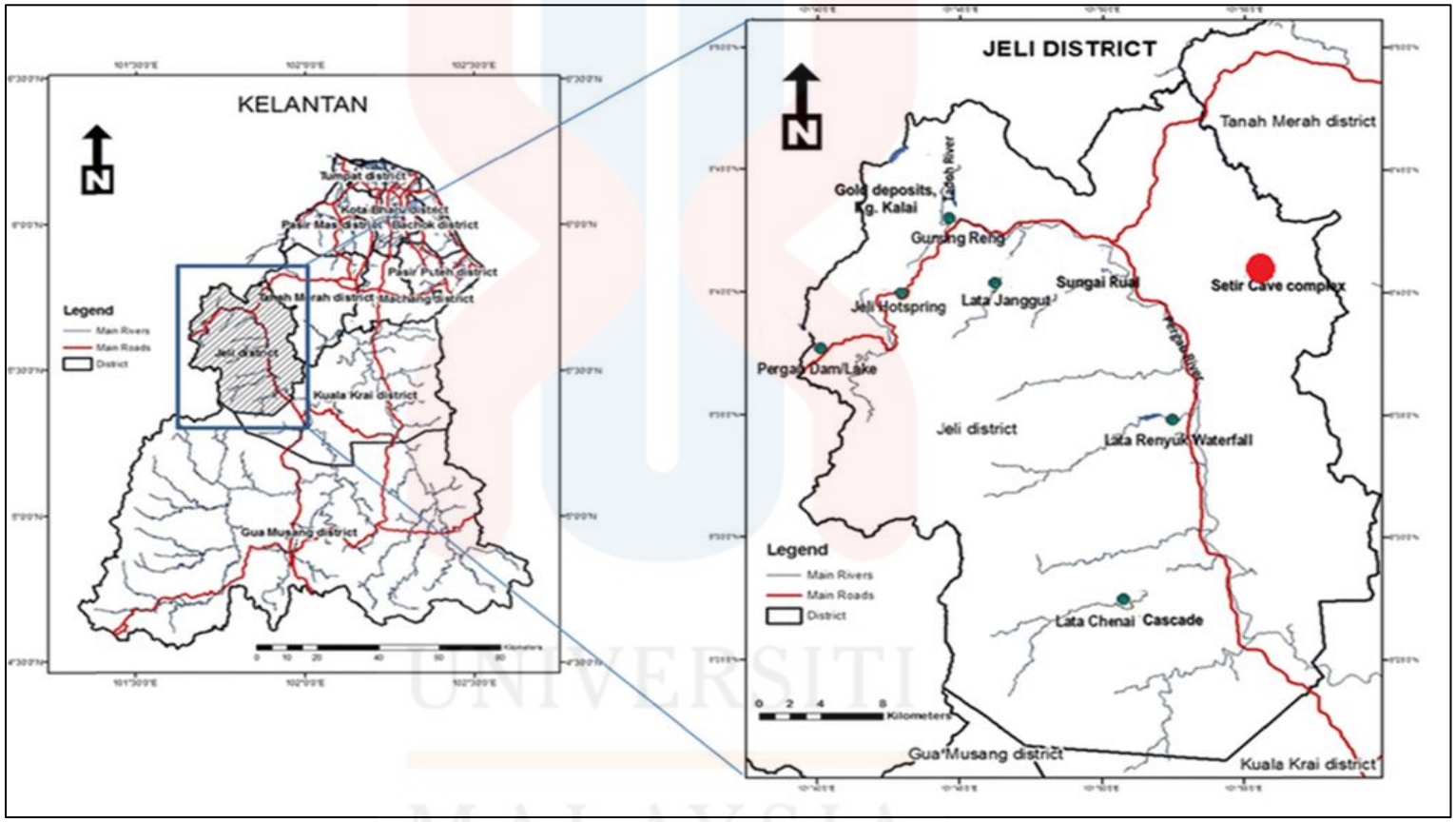

Figure 3.1: Map of Gua Setir (Source: Google Imaginary: CNES, 2018)

3.2 Materials

To conduct this study, three sections of materials have been divided: sampling, measuring and identification and preservation.

Table 3.1 List of materials used in this study.

	Materials
Sampling	-Mist net -Harp trap -Straps -Leather gloves -Cloth bags -Headlamp -Gps Navigator
Measuring and identification	-Electronic beam balance -Ruler -Headlamp -Reference books
Preservation	-Chloroform -Chemical-resistant plastic bag -Dissecting kit -70% Ethanol

3.3 Methods for Sampling

To produce a complete species list there were possible methods that can be used such as mist net and harp trap. During this study 10 mist nets and two-bank harp trap were used. Eight mist nets were deployed near the flowering tree, at the small stream, and at the suitable sites. Two-bank harp trap was placed in front of the cave. Eight mist net was used each night and each mist net will move to a new location until the entire trail system had been trapped twice. The coordinate of each point has been recorded using GPS navigator (Kingston, Lim, & Akbar, 2006). The suitable time for sampling is in the

evening from 6.30 pm until 10.00 pm, and early morning at 5.30 am until 6.30 am. Nets have been checked often at least every one hour to prevent the injury of bats.

3.4 Measurement and Identification

For this method, the electronic beam balance is used to measure the weight of bats. Besides that, the ruler was used to measuring the head-body length, forearm, hint foot, and tragus. For gender identification, the bats that not have mammary gland is considered as male bats. Meanwhile, the bats with mammary glands are female and the mammary gland needs to be pinched to see whether they produce lactates or not (Kingston, Francis, Akbar, & Kunz, 2003). If the lactates present, the bats are expected to pregnant. The standard measurement of the bats like Head-Body Length (HB), Tail Length (TL), Hind Foot (HF), Ear Length (E), Forearm (FA) and Wingspan (WSP) including their weight, sexes and maturity status were recorded using calipers, ruler and data sheet. After measurements were taken, the bats have been a tag with nail varnish and photographed before being released back. Captured bats were identified by using the keys from the book, Bats of Krau Wildlife Reserve (Tigga, Lim, & Zubaid, 2009).

3.5 Preservation

For preservation, only three individual for each species has been preserved. For this method, chloroform is used to euthanize the bats in chemical-resistant plastic bags before those bats can be dissected by using a dissecting kit to remove some organs (Hadi, & Cape, 1995). All the bats were preserved in 70% ethanol and were keep in Natural Resource Museum Universiti Malaysia Kelantan Jeli Campus.

3.6 Data Analysis

The species richness, relative abundance, Shannon diversity index, maximum diversity, species evenness, and Simpson's diversity index were calculated using equation i, ii, iii, iv, v and vi that stated below. The results from the calculation will be a list:

Species Richness, s = The total number of species captured (Equation i)

Relative Abundance = $\frac{\text{Total number of individuals per species}}{\text{Total number of individuals}}$ (Equation ii)

Shannon diversity index, $H' = -\sum p_i(lnp_i)$ (Equation iii)

Maximum diversity, $H_{max} = \ln\left(\frac{1}{s}\right)$ (Equation iv)

Species Evenness, $E = \frac{H'}{H_{max}}$ (Equation v)

3.6.1 Species Accumulation Curve

The collected data have analyzed using a species accumulation curve. Species accumulation curve shows the rate of species that found in the community. It also provides to estimate the species richness and it's also allowed to evaluate and compare the diversity across the population. The species accumulation curve is where the number of species against the days (Thompson & Withers, 2003). There is two type of species accumulation curve which is individual based species accumulation curve and sample-based accumulation curve (Dove & Cribb, 2006). The individual-based on species accumulation curve records the cumulative increase in richness against the number of individuals.

Compared to sample based species accumulation curve is records the accumulation of new species against the quantum that increase the sampling effort.

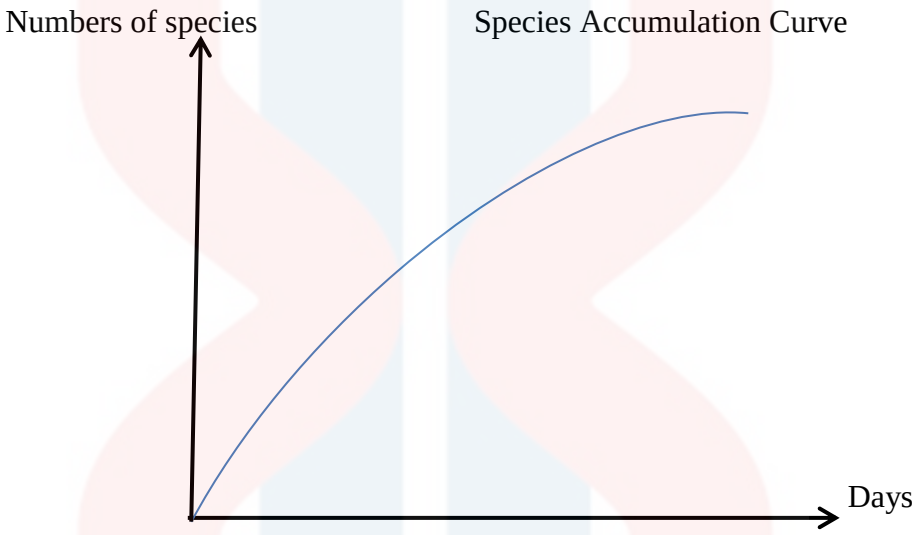

Figure 3.2: Species accumulation curve

3.6.2 Shannon-Wiener Diversity Index

In the sample community, $P_i=n_i/N$ where n_i is the number of individuals in species and N refers to the total number of individuals in the community (Hoare, 2008).

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

Variables:

H	Shannon's diversity index
S	the total number of species in the community (richness)
$\mathbf{p_i}$	the proportion of *S* made up of the *i*th species
$\mathbf{E_H}$	equitability (evenness)

3.6.3 Species Evenness

The species evenness will show how frequent (in number) does each species found in an area. This equation has been created to calculate the species evenness:

$$E = \frac{H'}{H_{\max}}$$

H' refers to the Shannon-Wiener Diversity Index and H_{max} is the possible maximum diversity. The frequency of individuals in each species represented the level of evenness (Krishnamurthy, 2003).

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result

A total of 224 individuals were represented by 15 species from five different families which is, Pteropodidae, Rhinolophidae, Hipposederidae, Vespertilionidae, and Megadermatidae were captured throughout 26 trapping-night at Gua Setir, Kelantan. Three out of 15 species were recorded as a new locality record for Kelantan. Species accumulation curve below (Figure 4.1) illustrates the number of bats species accumulated has achieved the asymptotic level. Due to the location of this study is in the karst area that is the diverse place for the habitat of bats. Besides that, it also has enough time for sampling activity.

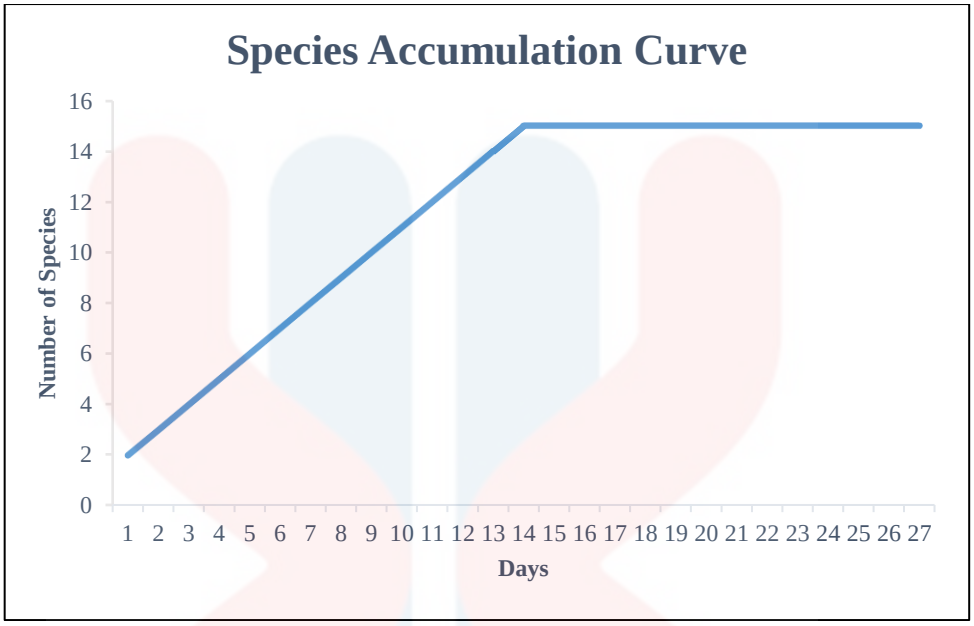

Figure 4.1: Species accumulation curve graph of bats in Gua Setir, Kelantan

All the collected data was obtained by doing manual collection during day by using mist net and harp trap methods. In this study, family Pteropodidae was found to be most dominant family based on species. Mostly, the bats that have found in this study at Gua Setir, Kelantan are from insect bats and majority of the bats is female. Species accumulation curve was plotted every day during the sampling day as it important to record newly found species to indicate the rate of accumulation of collected species in this study area.

Species	Number of individuals	Diet	IUCN status
Pteropodidae			
Eonycteris spelaea	93	Fruit, nectar, pollen and flower	LC
Cynopterus brachyotis	2	Fruit, nectar, pollen and flower	LC
Vespertillionidae			
*Miniopterus schreibersii**	14	Insects and other small arthropods	NT
*Miniopterus medius**	13	Insects and other small arthropods	LC
Tylonycteris pachypus	1	Insects and other small arthropods	LC
Murina suila	1	Insects and other small arthropods	LC
Megadermatidae			
*Megaderma lyra**	1	Large insects, spiders and small vertebrates	LC
Rhinolophidae			
Rhinolophus affinis	52	Insects and other small arthropods	LC
Rhinolophus lepidus	16	Insects and other small arthropods	LC
Rhinolophus stheno	4	Insects and other small arthropods	LC
Rhinolophus acuminatus	3	Insects and other small arthropods	LC
Hipposideridae			
Hipposideros bicolor	8	Insects and other small arthropods	LC
Hipposideros larvatus	13	Insects and other small arthropods	LC
Hipposideros cineraceus	2	Insects and other small arthropods	LC
Hipposideros armiger	1	Insects and other small arthropods	LC
Total Number of Individuals	**224**		
Total Number of Species	**15**		
Number of Families	**5**		

*= New record of Kelantan

4.1.1 Shannon- Wiener Diversity and Evenness Index

According to Macdonald (2003), usually, the Shannon diversity range is between 1.5- 3.5 in most ecological studies. For this study, the Shannon-wiener diversity index calculated is 1.826. The Shannon-Wiener Diversity Index was calculated by referring to the total 224 of the individual that was captured in Gua Setir, Kelantan. Table 4.1.1 shows the total numbers of species evenness is 0.674. The highest evenness in this study represented by *Eonycteris spelaea* which is the evenness 0.135.

Table 4.1.1: Shannon-Wiener diversity and evenness index for Gua Setir

Species	**No. of Individuals**	**Pi**	**H'**	**H_{max}**	**Evenness**
Eonycteris spelaea	93	0.415	0.365	2.708	0.135
Cynopterus brachyotis	2	0.009	0.042	2.708	0.016
*Miniopterus schreibersii**	14	0.063	0.173	2.708	0.064
*Miniopterus medius**	13	0.058	0.165	2.708	0.061
Tylonycteris pachypus	1	0.004	0.024	2.708	0.009
Murina suila	1	0.004	0.024	2.708	0.009
*Megaderma lyra**	1	0.004	0.024	2.708	0.009
Rhinolophus affinis	52	0.232	0.339	2.708	0.125
Rhinolophus lepidus	16	0.071	0.189	2.708	0.070
Rhinolophus stheno	4	0.018	0.072	2.708	0.027
Rhinolophus acuminatus	3	0.013	0.058	2.708	0.021
Hipposideros bicolor	8	0.036	0.119	2.708	0.044
Hipposideros larvatus	13	0.058	0.165	2.708	0.061
Hipposideros cineraceus	2	0.009	0.042	2.708	0.016
Hipposideros armiger	1	0.004	0.024	2.708	0.009
Total	**224**		**1.826**		**0.674**

*= New record of Kelantan

4.2 Species Account

4.2.1 *Megaderma lyra*

Megaderrna lyra, is a common bat throughout South India, roosting in caves, temples, or other dark humid places (Fiedler, 1979). *Megaderma lyra* is under Megadermatidae family, which are medium to large bats with a large erect noseleaf and large ears joined across the top of the head. A large colony was discovered at Aurangabad in India, with 2000 individuals and contained breeding females and males (Bates & Harrison, 1997). The diet of this species has been well studied and mainly consists of insects and small vertebrates, such as fishes, amphibians (frogs and toads), reptiles (lizards), birds (white-eyes, sunbirds, sparrow, and dusky crag martin) and mammals (bats, rats, mice, gerbils). *Megaderma lyra* is a new locality species that recorded in Kelantan state (Jayaraj et al., 2016). This species also has been reported caught at the Kerian River, Perak (Shafie, Sah, Latip, Azman, & Khairuddin, 2011). This species is listed as Least Concern in the IUCN Red List of Threatened Species (Csorba et al., 2008).

Figure 4.2: Front view of *Megaderma lyra* (female)

4.2.2 *Miniopterus schreibersii*

Miniopterus schreibersii is under subfamily of Miniopterinae, which are has a short ear that slightly rounded. Besides that, this species also know bent-winged bats that have a distinctive wing shape. This species commonly can be found in caves, rock clefts, culverts, caverns, and galleries (Crampton & Barclay, 1998). This species feeds on small beetles and insects (Santana, Dumont & Davis, 2010). This species has been caught using by harp trap, in the cave at Gua Setir. This species is actually been a new locality species that recorded in Kelantan State (Jayaraj et al., 2016). This species is listed as Near Threatened in the IUCN Red List of Threatened Species (Hutson et al., 2008).

Figure 4.3: Front view *Miniopterus schreibersii*

4.2.3 *Miniopterus medius*

Miniopterus medius is the intermediate long-fingered bat. This species is under the Vespertilionidae family. This species can be found in the caves and forages over low rivers in the forest. This species generally has a black or dark brown of fur and has short ears. *Mniopterus medius* is the new species (Jayaraj et al., 2016). This species also feeds on beetles and insects. Most of this species has been caught in the cave by using the harp trap. This species is listed as Least Concern in the IUCN Red List of Threatened Species (Bonaccorso et al., 2008)

Figure 4.4: Front view *Miniopterus medius*

4.3 Factor That Influencing Capturing Rate

There are some factors that influence the capture rate of bats which are a sampling effort, sampling location and weather.

4.3.1 Sampling Effort

In this study, the sampling effort for this survey was adequate in order to record the total of the bat's population at Gua Setir as the species accumulative curve in Figure 4.1.1 has to reach asymptotic level. The sampling effort for this study has been done with eight mist net and two bank- harp trap per night with total 26-night sampling. Two species which is *Eonycteris spelaea* and *Cynopterus brachyotis* were captured on mist net and the

other species mostly were captured in harp trap. The minimum night for sampling bats is 70 nights in order to get 21 different species of bats (Froidevaux, 2014).

4.3.2 Sampling Location

This study has been done in karst area which is in Gua Setir Kelantan. The sampling location has affected the species that were captured. During this study, the most captured species is *Eonycteris spelaea* this is because this study has been done at the cave area. According to Maharadatunkamsi et al., (2003) *Eonycteris spelaea* is almost exclusively a cave roosting species. To capture the others species the mist nets should be placed to other location for making sure not captured the same species.

4.3.3 Weather

Raining seasons also one of the factors that affected the capturing rates of bats. During this study, Gua Setir having a raining season for a week these cause the capturing rate decreases when the bat is kept to the ground in their shelter. It was disturbing the sampling rate this is because bats are not active due to the raining seasons. Sensory compulsion may show an extra issue for echolocation bats when flying in rain, yet bats may rather lessen flight movement due to excessively high scavenging costs when pelage and wing films wind up noticeably wet, and not on account of they lose introduction or the capacity to recognize prey (Belwood & Fullard, 1984).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A sampling of bats using mist nets and harp trap technique was successfully conducted to assess the diversity of bats at Gua Setir, Kelantan. The different technique has been using during this study, it gave the various result in terms of bat species richness level, species accumulative pattern and species abundance.

Overall data showed that the number of individuals of each species was enough to cover the diversity of bats at Gua Setir, Kelantan. Most of the species that been recorded in this study were listed as Least Concern in the IUCN Red List of Threatened species except one species, *Miniopterus schreibersii* which was listed as a Near Threatened. This study also recorded three new species for Kelantan that not recorded from the previous study in Kelantan. Gua Setir should be preserved to maintain the diversity of flora and fauna.

5.2 Recommendations

It is important to do further study on bat diversity in order to enhance conservation and management of bats. More survey on bats should be carried out at Gua Setir according to this place is a limestone area.

For the next research in this area, it considers making an extra strategy, such as use the ultrasonic detector (Jayaraj et al., 2006). Besides that, it is recommended to use up to 20 sets per area. The duration of sampling and the time of sampling should be decided properly to make sure it can cover all the study areas.

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APPENDIX A

Table of species captured in Gua Setir, Kelantan

Cave nectar bat	*Eonycteris spelaea*	
Lesser dog-faced fruit bat	*Cynopterus brachyotis*	
Common bent wing bat	*Miniopterus schreibersii*	

Intermediate long-fingered bat	*Miniopterus medius*	
Greater false vampire bat	*Megaderma lyra*	
Intermediate horseshoe bat	*Rhinolophus affinis*	

Intermediate round leaf bat	*Hipposideros larvatus*	
Great round leaf bat	*Hipposideros armiger*	

Source: Google Image (2018)

APPENDIX B

The table below shows the Planning for Final Year Project I and II

Final Year Project I	
2nd March – 15th April 2018	Completing chapter I- introduction
	Completing chapter 2- a literature review
	Competing for chapter 3- material and method
20 April 2018	Preparation for proposal defence
5th July 2018	Submission report for FYP I
Final Year project II	
19th July – 20 July 2018	Preparation material for sampling activity -5-liter ethanol with 70% concentration -Chloroform - Mist net and harp trap
21 July – 15th August	Sampling bats at Gua Setir, Kelantan
	Identification species of bats
1st November – 30 November 2018	Completing chapter 4 – result and discussion
	Completing chapter 5 – conclusion and recommendation
10th December 2018	Submission of final report
18th-19th December 2018	Presentation of FYP II
10th January 2019	Submission of hardbound