DIVERSITY ASSESSMENT OF CHIROPTERA AT LATA BIJIH AND LATA JANGGUT USING MIST NETTING TECHNIQUE

by

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DECLARATION

I declare that this thesis entitled “Diversity Assessment of Chiroptera at Lata Bijih and Lata Janggut Using Mist Netting Technique” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Name : _____

Date : _____

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Diversity Assessment of Chiroptera at Lata Bijih and Lata Janggut Using Mist Netting Technique

ABSTRACT

Previously, there was no data on bats diversity assessment at Lata Bijih and Lata Janggut. This research was mainly conducted to assess the diversity of bats at the selected study areas. 10 sets of mist net were deployed on each site for a week. Selected point of deployment had been choosing according to its probability of getting good sampling results. All nets were daily changed its coordinate to increase sampling effort. A total of 34 individuals of bats had been recorded from 13 different species. The overall result shows the diversity at Lata Bijih is higher (0.574 index of species evenness) than Lata Janggut (0.457 index of species evenness). *Rousettus leschenaulti* had been recorded as a new record of bat species at Lata Janggut. Factors that influenced the sampling result have been discussed to improve the next research. All the samples were properly preserved in containers by adding 70% of alcohol solution. The data was interpreted by rarefaction curve and diversity indexes (species richness, species evenness, Shannon-wiener index) while species accumulative curve was constructed to show the effectiveness of sampling period towards sampling results.

Penilaian Kepelbagaian Kelawar di Lata bijih dan Lata Janggut Menggunakan Perangkap Jaring

ABSTRAK

Sebelum ini, tiada data yang direkod mengenai penilaian kepelbagaian kelawar di Lata bijih dan Lata Janggut. Kajian ini dijalankan khusus untuk menilai kepelbagaian kelawar di kawasan kajian yang dipilih. 10 set jaring telah ditempatkan di setiap kawasan sasaran selama seminggu. Titik sasaran telah dipilih mengikut tahap kebarangkalian untuk mendapat hasil tangkapan yang tinggi. Semua jaring telah diubah setiap hari untuk meningkatkan usaha tangkapan. Sebanyak 34 ekor kelawar dari 13 spesies yg berbeza telah direkodkan. Keputusan keseluruhan menunjukkan tahap kepelbagaian di Lata Bijih lebih tinggi (0.574 indeks kepelbagaian spesies) daripada Lata Janggut (0.457 indeks kepelbagaian spesies). *Rousettus leschenaulti* telah direkodkan sebagai rekod baru untuk spesies kelawar di Lata Janggut. Faktor-faktor yang mempengaruhi hasil tangkapan telah dibincang untuk peningkatan kualiti kajian yang akan datang. Semua sampel telah diawet dengan baik di dalam bekas dengan menggunakan 70% larutan alkohol. Data yang diperolehi telah ditafsirkan melalui lengkung penjernihan dan indeks kepelbagaian (kekayaan spesies, kekerapan spesies, indeks Shannon-wiener) manakala lengkung spesies terkumpul telah dibina untuk menunjukkan keberkesanan tempoh tangkapan terhadap keputusan yang diperolehi.

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LIST OF ABBREVIATIONS AND SYMBOLS

LC	Least Concern
>	Higher than
IUCN	International Union for Conservation of Nature
*	New record
%	Percentage
km	Kilometres

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Biodiversity can be defined as regional areas on earth that consist various species of organisms forming an ecological system (Maczulak, 2010). Bat is one of living organisms among mammals that has high diversity (Hill & Smith, 1984; Nowak, 1999) and divided according its ecological factors (Teeling *et al.*, 2002; Van Den Bussche & Hoofer, 2004; Teeling *et al.*, 2005)

1.1.1 Chiroptera

Chiroptera is commonly known as bat, classified as small flying mammals. Hayward & Phillipson (1979) defined that small mammals have less than 5 kilograms of weight. Bats are usually found in the tropical forest areas (Limpens *et al.*, 1989). Order chiroptera is divided into 2 suborders; Megachiroptera (fruit bats) and Microchiroptera (insect bats). Megachiroptera presents of 186 species bats from Family Pteropodidae while Suborders Microchiroptera consist 930 species of bats that come from 17 different families; Craseonycteridae, Emballonuridae, Furipteridae, Hipposideridae, Megadermatidae, Molossidae, Mormoopidae, Mystacinidae, Myzopodidae, Natalidae, Noctilionidae, Nycteridae, Phyllostomidae, Rhinolophidae, Rhinopomatidae, Thyropteridae, and Vespetilionidae (Wilson & Reeder, 2005).

1.1.2 Species Diversity and Abundance

In studying diversity, species richness and evenness of species have been highlighted as the important aspects that need to be discussed (McGinley & Duffy, 2007). Species richness is the measurement of maximum number of species caught in a specific area where the higher number of species is the result of high richness level. On the other side, the evenness of species is the comparison of frequency between 2 or more different sites or it explained by analysing how even the species can be found in each site. It has been stated that the important of assessing the diversity is to study the distribution pattern of species in certain areas (Gaston, 2000).

Species abundance is the observation towards various diversity of organisms within specific area (Patrick, 1968; Patrick *et al.* 1954) where rarefaction curve is used to represent the observed species and compare the average diversity of species between study areas. The reasonable approach of understanding the species abundance is to relate the reflection of limiting resources amount that control the populations of community (May, 1975; Whittaker, 1977; Sugihara, 1980).

There are some aspects that always affect the diversity of organisms as what have been studied by Njaka *et al.* (2014) such as anthropogenic activities, availability of foods, change in climates, elevation level, and vegetation factors. These aspects have to be concerned in doing diversity research. However, it might not totally influence all the living organisms because mammals have a unique ability to adapt in multiple kinds of environment conditions that make them continuously diverse between the regions on earth (Joseph, 2010).

1.2 Problem Statement

Majority of the community in selected study areas depend on agricultural sources. At the same time, conducting the anthropogenic activities and small-scale urbanization have caused deforestation and land degradations (Lambin *et al.*, 2003). They haven't notices that bat has its own roles in seed dispersal and pollination (Kunz *et al.*, 2011).

The issue that need to be highlighted in this study is people are not concern towards diversity of bats and there is no data recorded before. It is important to concern about bats as it play a specific role towards environment in order to control and optimizing a part of the ecological system (Hodgkison *et al.*, 2004). This data might be useful for further research on bats for future generation and to conduct the conservation population of small mammals.

1.3 Objective

The objective of this study is to determine the diversity and abundance of bats in Lata Bijih and Lata Janggut by using mist netting technique.

CHAPTER 2

LITERATURE REVIEW

2.1 Diversity of Bats

Pteropodidae feed on fruits (Fujita & Tuttle, 1991) while some of them feed on nectar and pollen (Singaravelan & Marimuthu, 2004). Genus *Nyctimene* is one of Pteropodidae Families which are insectivorous (McNab, 1971). These types of bats have large measurement of body size. It can reach up to 1.5 kilograms of weight and 1.2 meters' wing. Pteropodidae can be physically identified by their face since it has the fox-like faces, size, weight, eyes (large eyes and produced dull red eye shine when light hit on it), a dog-like muzzle, short tail, and small ears with lacking tragus shorter than Family Microchiroptera (Schutt & Simmons 1998). In addition, there are subfamilies of Pteropodidae; Pteropodinae (feed on fruits) and Macroglossinae (feed on nectars) (Kirsch *et al.*, 1995).

Figure 2.1(a): Picture of fruit bat, *Eonycteris spelaea* (Sources: Google Image)

Microchiroptera suborder is smaller in size compared to fruit bats. It is commonly called insect bat because it feeds on insects. The total weight can be measured within the range of 2 to 80 grams (McNab, 1971). The other physical appearances that can be observed is the nose pads which have various kind of shapes and also its lower lips (Schmidt, 1985). The eyes are usually small and have tragus near the entrance of its ear. Besides, the second digit does not have claw (Norberg, 1969). The research on species diversity is important to ensure that the monitoring and management programme in protected areas are properly managed (Jayaraj *et al.*, 2012).

Figure 2.1(b): Picture of insect bat, *Rhinolophus affinis* (Sources: Google Image)

2.2 Role of Bats in Environment

Bats play important roles toward the environment in optimizing and controlling the main ecological services (provisioning and regulating services). In provisioning services, it is important to produce various kind of fruits as bats act as a dispersal agent of fruits (Ingle, 2003). Furthermore, bats act as pollinators in tropical and subtropical forest that produced fruits and flowers varieties at the same time it improves the economic quality of environment (Kunz *et al.*, 2011). A part of regulating services is also controlled by bats where several viruses among animals such as leptospirosis virus is carried by bats (Babudieri, 1958).

2.3 Trapping and Capturing Bats

There are several methods to capture bats during flight or roost. But, each of methods used will gives different results depend on how do the methods being conducted. In order to get the maximum capture of bats, some aspects have to be focused such as the surrounding climates (avoid catching bats in rainy season), period time (catch during night), trapping points (set up the traps at the suitable point or at their pathway sites or at their niche), roosting habits (identify the their favorite point of roosting), and foraging habits (food resources) (Bradbury & Emmons, 1974; Kunz, 1982; Kunz *et al.*, 1983). Based on previous studies, there is no "best" time to capture bats as long as we know when and where do bats forage and roost (Barbour *et al.*, 1969). Bats are actively foraged at night, so it is a suitable time to do trapping at that time. Bats roost at day in dark places especially for young flightless bats.

2.4 Hand Capture

Hand capture method does not require any special devices. Most of bats are successfully captured by using this method. Bats are gasped using hand covered with gloves while roosting on leave and it should be bended downward to prevent from bite (Brosset, 1976; LaVal & LaVal, 1977). The bats should not be squeezed or prodded because bats are fragile (Baker & Genoways, 1978). In other cases, if the bats are roosting in a crevice site, a long tissue forceps is recommended to be used to take them out (Griffin, 1940; Barbour *et al.*, 1969). Extreme care is needed when catching the bats at the entrance of caves of buildings to avoid injuries (on wing bones and membranes) by covering the surrounding area by net.

2.5 Mist Net

For capturing flying bats, mist net is commonly used and required low cost. It is lightweight, compact and easy to carry. The net needs to be tied straightly at two different poles within the diameter of 4 to 5 cm (Tuttle, 1976). Mist net is the most recommended trapping technique for ecological study that has been further explore by previous researcher (Handley, 1968). It has low risk of injuries towards bats. There are 2 types of mist nets; braided nylon and terylene nylon. Terylene nylon is softer, stronger, and more durability compare to braided nylon. It is commonly used for capturing bats.

Selecting suitable area when deploy the traps is important to get the highest result of samples trapped. Examples of some suitable deployment points that can be selected are roost sites is at water holes, attic of building, cave entrance, over a pond, over a stream, edge of lake, and forest trail. In addition, an audio of echolocation (sound made from falling fruits) can be used to attract bats more effectively (Kuenzi & Morrison, 1998).

There is no standard "rules" or universally accepted methods of removing bats from the net (Jones *et al.*, 1996). Bats that cross the net will usually drop into a pocket formed by the net. It need to be removed safely from the part that the bat entered to ensure that the wing bones will not get any injuries. Avoid direct contact with the bats because it has potential of spreading the rabies disease (Hankins & Rosekrans, 2004). The most preferred ways is let the bat bite a cloth bag or loose part of glove rather than it bite our hand and chewing the net.

2.6 Species Richness

Species richness measured the total quantity in each individual (species) present at a certain area, community, landscape, and region (Levin *et al.*, 2009). It is important to know the species richness in the study areas because from the data, we can analyze the conservation status and factors that influence the species richness.

2.7 Species Evenness

The frequency of individual in each species represented the level of evenness (Heip *et al*., 1998). To calculate the species evenness, an equation has been created:

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

where H' is Shannon-Wiener Diversity Index and H'_{max} is the possible maximum diversity. From this calculation, it will show how frequent (in number) does each species found in an area.

2.8 Shannon-Wiener Diversity Index

Most of researcher used Shannon-Wiener Diversity Index as diversity indices. Although there were another indexes that used for it, this index used the simplest way in term of calculations (Krebs, 2014). The equation used for the calculation is:

$$H' = -\text{sum}\ (p_i \ln p_i)$$

where p_i is the number of individuals of a species over the total number of individuals overall.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

This study has been conducted at Lata Bijih and Lata Janggut. Figure 3.1(a) and 3.1(b) show the maps of the study areas.

Generally, Lata Bijih is a developed forest because there is a rubber plantation area. It located in Tanah Merah district and takes about 35 minutes to reach there from University Malaysia Kelantan (UMK) Jeli Campus. Lata Janggut is a recreational forest area which located 19 kilometers from UMK Jeli Campus. At both areas, there are waterfalls parts, camping site, and jungle trekking track (include the rubber plantation area).

Lata Bijih and Lata Janggut are two of the common plantation and recreational places in Kelantan. From the observation, both areas have good geographical and ecological factors and considered to have various types of flora and fauna. The study areas located not too far from UMK Jeli Campus. It takes less than 1 hour to reach at each site.

Figure 3.1(a): Map of Lata Bijih indicates the sampling site of this study (Source: Google Earth, 2016)

Figure 3.1(b): Map of Lata Janggut indicates the sampling site of this study (Source: Google Earth, 2016)

3.2 Materials

Materials used in conducting this study are divided into 3 section; sampling, measuring & identification and preservation.

Table 3.2: List of the materials used in this study

Sampling	-Mist nets and poles -Straps -Leather gloves -Cloth bags -Headlamp -GPS navigator
Measuring & Identification	-Electronic beam balance -Ruler -Headlamp -Reference books
Preservation	-Chloroform -Chemical-resistant plastic bags -Dissecting kit -70% Ethanol

3.3 Methods for Sampling

For the field sampling, 10 sets of mist nets have been deployed during sampling at different points. The coordinate of each point was recorded by using GPS navigator. Area of bat's foraging and roosting are the main target points. Strap is used to tie each pole for supporting the net and to make it stretch. Sampling session started at late evening (about 6.30 pm) until night (about 10.30 pm) and early morning (about 5.30 am until 6.30 am). Deployment of mist net during day need to be stopped to avoid the net traps the other flying species like birds.

The nets were checked often (at least every 1 hour) to prevent bats from seriously knotted in the net. In order to have a good vision at night, headlamp can be used to help supplying the light (Tuttle, 1979). The trapped bats then removed from the net by using leather glove to protect our hand from being bite by the bats and keep in cloth bags. There is only 1 individuals for each species need to be preserve. The same repeating species caught will be released back.

3.3.1 Measurement and Identification

Each bat was weighted by using electronic beam balance. An external vernier caliper were used to measure the head-body length, tail, forearm, hint foot, and tragus. For gender identification, the bats that had mammary gland were female while male bats absent of mammary gland and it need to be pinched to see whether it produce lactates or not. If there is present of lactates, the bats are expected to pregnant. Status of bats classified into 2 (juvenile or adult). In this case, headlamp has been used to check the present of epiphyseal and diaphyseal fusion on their long bone structure (arm) in those bats. Bat with epiphyseal fusion is juvenile while diaphyseal fusion shows that the bats are already adult. Further species identification was done by referring the key from Francis (2008).

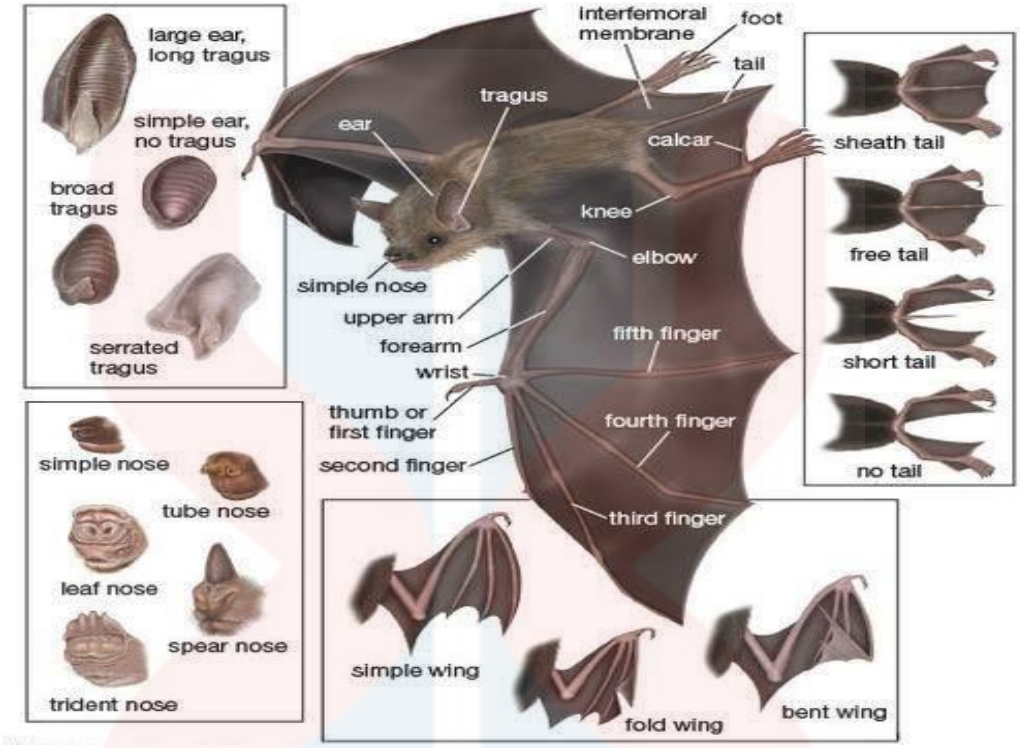

Figure 3.3.2 shows the diagram of bat.

(Source: Google Image)

3.3.2 Preservation

Chloroform were 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 (small intestine, large intestine, and stomach). The purpose of using chemical-resistant plastic bag is to prevent us from inhale that emitted gases produced by chloroform. Once the dissection finished, the samples are cleaned by tap water. Then, the bats were preserved in ethanol and kept in Natural Resources Museum.

3.4 Data Analysis

The species richness in each area was assessed by calculating the total number of species caught (equation i). The relative abundance was calculated by dividing total number of individuals per species with total number of individuals (equation ii). The comparison of species evenness between the study areas are calculated by using evenness formula (equation iii) which consist Shannon-Wiener Diversity Index (equation iv).

Species Richness = Total number of species caught …… (equation i)

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

Shannon-Wiener Diversity Index (H) = -sum ($p_i \ln p_i$) …… (equation iii)

$$p_i = \frac{\text{Individuals of a species}}{\text{Total number of individuals' overall}}$$

$$\text{Evenness; } E = \frac{H}{H_{max}} \quad \text{…… (equation iv)}$$

$$\text{Maximum diversity possible; } H_{max} = \ln\left(\frac{1}{s}\right)$$

(s = total number of species)

CHAPTER 4

RESULT AND DISCUSSION

4.1 Results

Overall samples of bats caught are 13 species as recorded in Table 4.1. The bats are classified according to 3 subfamilies (Pteropodidae, Rhinolophidae and Vespetilionidae). 2 out of 34 individuals are recorded as new locality record for Kelantan.

Table 4.1: Species diversity and abundance of bats in Lata Bijih and Lata Janggut

Species	**Lata Bijih**	**Lata Janggut**	**Total**	**IUCN Status**
Pteropodidae				
Megaerops ecaudatus	0	1	1	LC
Balionycteris maculata	0	1	1	LC
Cynopterus sphinx	6	0	6	LC
Cynopterus horsfieldi	4	0	4	LC
Cynopterus brachyotis	0	1	1	LC
*Rousettus leschenaulti**	0	2	2	LC
Eonycteris spelaea	1	0	1	LC
Macroglossus sobrinus	5	0	5	LC
Macroglossus minimus	3	0	3	LC

Rhinolophidae				
Rhinolophus acuminatus	3	0	3	LC
Rhinolophus affinis	0	2	2	LC
Vespetilionidae				
Myotis muricola	3	1	4	LC
Scotophilus kuhlii	0	1	1	LC
Total number of individual	25	9	34	
Number of species	7	7	13	
Number of families	3	3	3	
Trap-days	10	10	20	
Capture rates	50%	20%	70%	

* = New record of Kelantan

4.1.1 Species Richness

As this research is conducted at 2 different areas, the environmental factors that influenced the sampling results were different. Table 4.1 shows Lata Bijih is more diverse than Lata Janggut in terms of species richness. This result has showed that capture rates at Lata Bijih is 50% more higher compared to Lata Janggut (calculated only 20% of capture rates) as there are 25 individuals from 7 species were successfully caught at Lata Bijih while at the other site, 9 individuals from 7 species of bats were recorded at Lata Janggut.

4.1.2. Relative Abundance

C. sphinx was recorded 6 individuals out of 25 that made its relative abundance 24% higher than *E. spelaea* (1 individual) which only covered 4% of the abundance in Lata Bijih. The most abundance species in Lata Janggut was *R. leschenaulti* (2 individuals) and *R. affinis* (2 individuals) out of 9 total individuals caught followed by *M. ecaudatus, B. maculata, C. brachyotis, M. muricola* and *S. kuhlii* which has 1 individual recorded for each species.

4.1.3 Rarefaction Curve

Figure 4.1.3 shows the rarefaction curve of species diversity in Lata Bijih and Lata Janggut, Kelantan. Lata Bijih shows the steepest curve compared to Lata Janggut which also proved that the species in Lata Bijih is more diverse that Lata Janggut.

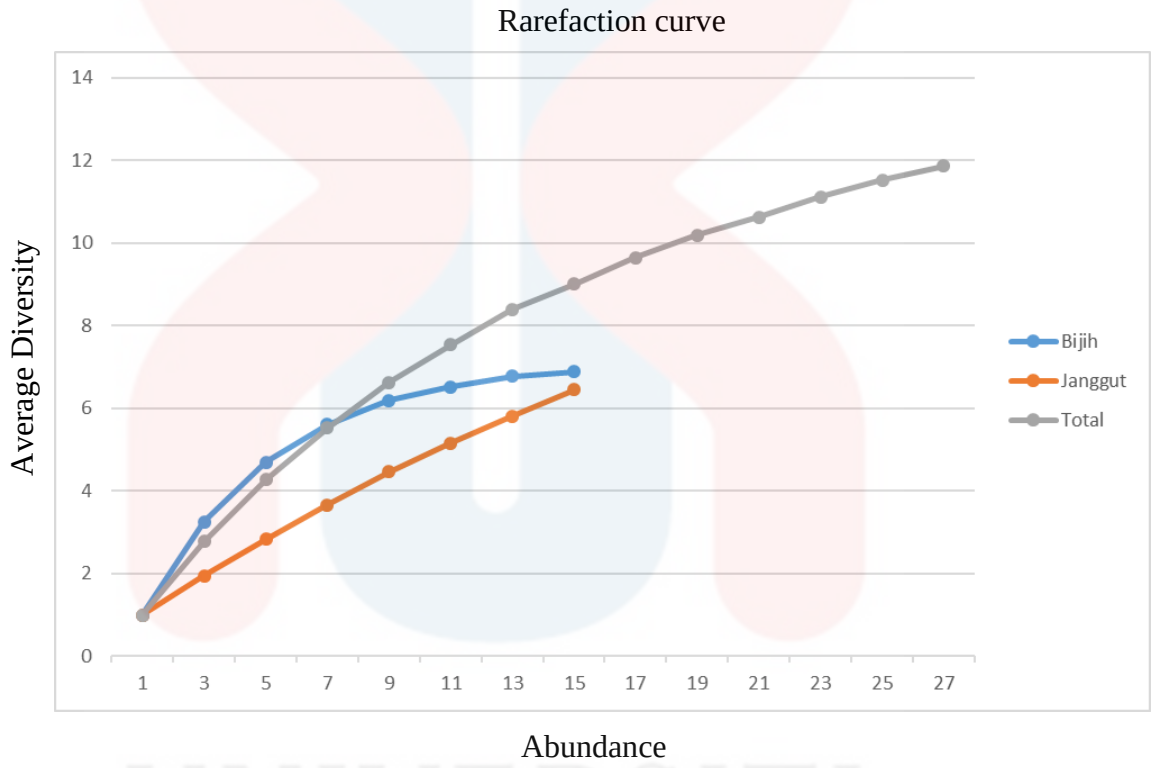

Figure 4.1.3: Rarefaction curve for species diversity in Lata Bijih and Lata Janggut, Kelantan.

Average diversity of bats in Lata Bijih moving towards the horizontal line which shows that sampling duration in that site was nearly complete. Result in Lata Janggut is not adequate enough since the curve needs more time for sampling to growth parallel with the horizontal line as the other site. Although the different abundance for both sites closed each other, Lata Janggut still has the potential in getting more species if the sampling duration drags for a longer period of time.

4.1.4 Shannon-Wiener Diversity and Evenness Index

Based on Table 4.1.4 (a) and Table 4.1.4 (b), Shannon-Wiener Diversity Index at Lata Bijih had been calculated 1.848 which means that area was more diverse than Lata Janggut with the result of 1.005. Since Lata Bijih had the higher diversity, the evenness also higher (0.574>0.457) where bats that had been found were more frequent than the other site

Table 4.1.4(a): Shannon-Wiener Diversity and Evenness index for Lata Bijih

Species	**No. of individual**	**(p_1)**	**[ln(p_1)]**	**(p_1)[ln(p_1)]**	**Evenness**
C.sphinx	6	0.24	-1.427	-0.342	
C.horsfieldi	4	0.16	-1.833	-0.293	
E.spelaea	1	0.04	-3.219	-0.129	
M.sobrinus	5	0.20	-1.609	-0.322	
M.minimus	3	0.12	-2.120	-0.254	
R.acuminatus	3	0.12	-2.120	-0.254	
M.muricola	3	0.12	-2.120	-0.254	
Total	**25**	**1.00**		**1.848**	**0.574**

Table 4.1.4(b): Shannon-Wiener Diversity and Evenness index for Lata Janggut

Species	**No. of individual**	**(p_1)**	**[ln(p_1)]**	**(p_1)[ln(p_1)]**	**Evenness**
M.ecaudatus	1	0.04	-3.219	-0.129	
B.maculata	1	0.04	-3.219	-0.129	
C.brachyotis	1	0.04	-3.219	-0.129	
*R.leschenaultii**	2	0.08	-2.256	-0.180	
R.affinis	2	0.08	-2.256	-0.180	
M.muricola	1	0.04	-3.219	-0.129	
S.kuhlii	1	0.04	-3.219	-0.129	
Total	**25**	**1.00**		**1.005**	**0.457**

4.1.5 Species Accumulative Curve

Based on Figure 4.1.3 (the rarefaction curve), the curve for both sites are not plateau enough which mean, it indicated that the samples captured are still not been covered the total species that should be at both study areas. In other words, the curve explained that there are some other species not being captured yet.

The accumulative curve below explained the asymptotic level on the 6th day to 7th of sampling where the number of captured species increase. The increasing in number shows that the capture rate tends to continuously increase at infinity level as the sampling duration continue (Chao *et al.*, 2009).

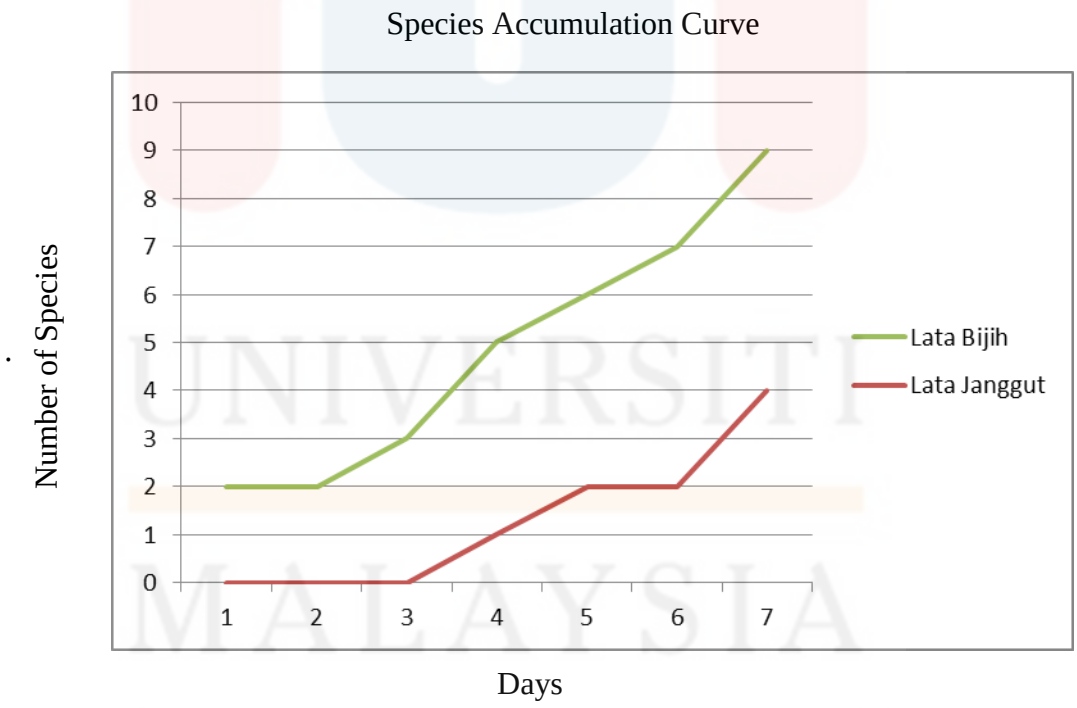

Figure 4.1.5: Species Accumulative Curve of Bats in Lata Bijih and Lata Janggut

4.2 New Record of Kelantan

R. leschenaulti has been recorded as a new local record for bats species in Kelantan based on previously research by Mariana *et al.* (2005), Ean (2011), Jayaraj *et al.* (2012) and Hasan (2012). This bat belongs to Family Pteropodidae. It feeds on nectar and have 90 grams of maximum body weight (Elangovan, 2000). *Leschenaulti* is a tongue-clicking megachiroptera. It able to make a "click" sound using its tongue which give this bats special characteristic (Raghuram *et al.*, 2009).

Figure 4.2: Front view of *Rousettus leschenaulti* (female)

4.3 Factor That Influence the Capture Rate

There are some factors that influence the capture rate of bats which are; sampling effort; change in season; and weather.

4.3.1 Sampling Effort

In this study, the sampling effort for this survey was not adequate in order to record the total of bats population at Lata Bijih and Lata Janggut as the Species Accumulative Curve in Figure 4.1.5 is yet to reach and asymptotic level. Bergallo *et al.* (1996) were stated that minimum night for sampling bats is 70 nights in order to get at least 21 different bats species. The sampling effort that have been done for both sites is as much as 10 mist nets per night with total 70% of capture rate which is not adequate enough to document total bats at both sites. Further study need to be done in order to complete the inadequacy of this research.

4.3.2 Change in Season

Fruit season affected the capture rate of bats. In this study, it occurs that Lata Bijih was having fruit season during the sampling period. This situation has caused the bats more frequent to feed on fruits either on the tree or fall to the ground, at the same time it increases the capture rate in Lata Bijih.

4.3.3 Weather

Weather like rain is actually can affect the rate of capture of bats (Gentry *et al.*, 1966). In this study, the sampling period was held during the rainy season in both Lata Janggut and Lata Bijih, Kelantan. This condition has made the bats not very active and preffered to be in their nest.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Sampling of bats using mist netting technique was successful conducted to assess bats diversity at Lata Bijih and Lata Janggut. Different location of study areas gave the various results in terms of bats species richness level, species accumulative pattern, and species abundance. This is because in each study area, the geographical structure and conditions were limited which affected the deployment points. Since Lata Bijih had a bigger and safer area, more traps managed to be deployed compared to Lata Janggut.

Overall data showed that the number of individuals of each species was in a small scale. Since this is the first research, further research need to be done to improve the result in assessing the bats diversity at Lata Bijih and Lata Janggut. Trapping efforts and sampling duration also have to be increase to maximize the sampling adequacy.

5.2 Recommendation

This research focuses on the diversity of bats in Lata Bijih and Lata Janggut, where it appears both sites still have no record about it. This preliminary study on both sites has created a new baseline data for further study. At the same time, this data is very useful for planning the conservation activity for both sites.

For next research at those areas, it is recommended to use up to 50 sets per area. As the traps effort increase, the probability to get more samples is high. Duration of sampling should be done for a month or more to covered all the surrounding study areas. The use of echolocation device will affect the result because it helps in attracting the bats to fly frequently at selected deployment trap points. Although this may consume a high cost for preparing the devices, the result will be better.

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APPENDIX A

List of species captured in Lata Bijih and Lata Janggut, Kelantan.

Tailless fruit bat
(*Megaerops ecaudatus*)

Greater short-nosed fruit bat or
Short-nosed Indian fruit bat
(*Cynopterus sphinx)*

Spotted-winged fruit bat
(*Balionycteris maculata*)

Lesser dog-faced fruit bat
(*Cynopterus brachyotis*)

Horsfield’s fruit bat
(*Cynopterus horsfieldi*)

Leschenault's rousette bat
(*Rousettus leschenaulti*)

Cave nectar bat
(*Eonycteris spelaea*)

Long-tongued fruit bat
(*Macroglossus minimus*)

Long-tongued nectar bat
(*Macroglossus sobrinus*)

Acuminate horseshoe bat
(*Rhinolophus acuminatus*)

Intermediate horseshoe bat
(Rhinolophus affinis)

Lesser Asiatic yellow bat
(*Scotophilus kuhlii)*

Wall-roosting mouse-eared bat or Nepalese whiskered myotis
(*Myotis muricola*)

APPENDIX B

Rarefaction Data Analysis of Lata Bijih

Abundance	Average Diversity	Median Diversity	Variance Diversity	95%Conf.Low	95%Conf.High
25(Obs.)	7	7	0	7	7
1	1	1	0	1	1
4	3.248	3	0.41891	2	4
7	4.699	5	0.63904	3	6
10	5.611	6	0.64032	4	7
13	6.187	6	0.45849	5	7
16	6.514	7	0.32213	5	7
19	6.774	7	0.1791	6	7
22	6.89	7	0.098	6	7

Rarefaction Data Analysis of Lata Janggut

Abundance	Average Diversity	Median Diversity	Variance Diversity	95%Conf.Low	95%Conf.High
9(Obs.)	7	7	0	7	7
1	1	1	0	1	1
2	1.942	2	0.05469	1	2
3	2.828	3	0.14256	2	3
4	3.663	4	0.24167	3	4
5	4.46	4	0.31071	3	5
6	5.154	5	0.36465	4	6
7	5.814	6	0.36577	5	7
8	6.45	6	0.24775	6	7

Total Rarefaction Data Analysis of Lata Bijih and Lata Janggut

Abundance	Average Diversity	Median Diversity	Variance Diversity	95%Conf.Low	95%Conf.High
34(Obs.)	13	13	0	13	13
1	1	1	0	1	1
3	2.774	3	0.18511	2	3
5	4.279	4	0.50166	3	5
7	5.531	6	0.81185	4	7
9	6.626	7	1.05518	5	9
11	7.541	8	1.15347	6	10
13	8.394	8	1.22399	6	10
15	9.002	9	1.4074	7	11
17	9.645	10	1.33631	7	12
19	10.188	10	1.29595	8	12
21	10.631	11	1.20204	9	13
23	11.118	11	0.98706	9	13
25	11.525	12	0.91029	10	13
27	11.858	12	0.80264	10	13