NON-VOLANT SMALL MAMMAL DIVERSITY ASSESSMENT IN LATA BIJIH AND LATA JANGGUT USING CAGE TRAP TECHNIQUE

by

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DECLARATION

I declare that this thesis entitled "Non-Volant Small Mammal Diversity Assessment in Lata Bijih and Lata Janggut Using Cage Trap 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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Non-Volant Small Mammal Diversity Assessment in Lata Bijih and Lata Janggut Using Cage Trap Technique

ABSTRACT

A survey on the diversity of non-volant small mammal was conducted at two sites which are Lata Janggut and Lata Bijih, Kelantan. The main objective of this study was to determine the diversity and abundance of non-volant small mammal in both sites. 50 cage traps were used baited with banana (*Musa acuminata*). These traps were placed for seven days for both sites respectively. In total, 43 individuals of non-volant small mammal were recorded comprising from 10 species, three Orders and four Families namely: Muridae, Erinaceidae, Sciuridae, and Tupaiidae. The Moon rat (*Echinosorex gymnura*) captured was a new locality record for the Kelantan state. Continued surveys are needed because there is a need to record more data on the diversity small mammal in Kelantan.

Penilaian Kepelbagaian Diversiti Mamalia Kecil Tidak Terbang di Lata Bijih dan Lata Janggut Menggunakan Perangkap Sangkar

ABSTRAK

Tinjauan terhadap kepelbagaian mamalia kecil tidak terbang telah dijalankan di dua lokasi iaitu di Lata Janggut dan Lata Bijih, Kelantan. Objektif utama kajian ini adalah untuk menentukan kepelbagaian diversiti dan jumlah bilangan mamalia kecil tidak terbang di kedua-dua lokasi. 50 perangkap sangkar telah digunakan dan diumpan menggunakan pisang (*Musa acuminata*). Kesemua perangkap telah diletakkan selama tujuh hari di setiap lokasi. Secara keseluruhan, 43 individu mamalia kecil tidak terbang telah direkodkan yang terdiri daripada 10 spesies, tiga order dan empat keluarga iaitu: Muridae, Erinaceidae, Sciuridae dan Tupaiidae. Tikus bulan (*Echinosorex gymnura*) telah ditangkap dan merupakan satu rekod baru bagi negeri Kelantan. Kaji selidik yang berterusan amat diperlukan kerana terdapat keperluan untuk merekod lebih banyak data berkenaan kepelbagaian diversiti mamalia kecil di Kelantan.

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LIST OF ABBREVIATIONS AND SYMBOLS

a.s.l	Above sea level
E	East
ha	Hectare
IUCN	International Union for Concervation of Nature
Kg.	Kampung
km	Kilometre
LC	Least Concern
m	Metre
N	North
sp.	Species
VU	Vulnerable
%	Percent
>	More than

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The variety of live forms on Earth or in a specific area is the definition of biodiversity (Maczulak, 2010). Life forms including plants, animals and microorganisms and the ecosystem itself are the components of biodiversity. It is very important to understanding the pattern of biodiversity distribution for planning conservation strategies (Gaston, 2000). Biodiversity assessment is important in understanding the pattern of species diversity for conservation purposes.

Mammals can be differentiated from other animals by several characteristics. Mammals can be classified into three which are small, medium and large mammals. Small mammals can be referred as any mammal species which has weight of less than five kilogram for an adult (Hayward & Phillipson, 1979). The examples for small mammals are rats, tree shrews, shrews, moles, porcupines, gyrnnures and bamboo rats. Order Insectivora has families which are Erinaceidae (gymnures), Talpidae (moles), and Soricidae (shrews). Order Scandentia consist of Ptilocercidae (pentail treeshrews) and Tupaiidae (treeshrews). Meanwhile Rodentia is larger order with four families which are Sciuridae (squirrels), Spalacidae (bamboo rats), Muridae (rats and mice), and Hystricidae (porcupines).

The diversity of small mammals can be influenced by several factors such as climate, food availability, elevational gradient, anthropogenic activities and vegetation (Njaka *et al.*, 2014). Small mammals have the unique ability to adapt in various type of environment which makes them so diverse between regions (Joseph, 2010). In this study, two different locations will be used in order to determine the diversity and abundance of small mammals by using cage trap.

1.2 Problem Statement

Threats such as extinction caused by anthropogenic activities are one of the reasons for the loss of species richness in biodiversity. Nowadays, urbanization keeps expanding in Malaysia which involved deforestation and land conversions. Besides urbanization, eco-tourism activities also give the impact on diversity of small mammals. These issues are some of the reason why the diversity of small mammals is getting lesser. Small mammals can be found widely in Malaysian forest. In the end of this study, the estimation on species richness of non-volant small mammals can be done and in the meantime, it can help in conservation activity. This study also can help the future generation to do further research on small mammals. It will also help conservation planning by providing the baseline data of the studied sites.

1.3 Objective

The objective of this study is to determine the diversity and abundance of non-volant small mammals in Lata Janggut and Lata Bijih, Kelantan.

CHAPTER 2

LITERATURE REVIEW

2.1 Diversity of Non-Volant Small Mammals in Certain States in Malaysia

2.1.1 Kelantan, Malaysia

Gunung Stong State Park, Kelantan with area of 21,950ha located in the district of Kuala Krai, north-west of Kelantan (Maseri & Mohd-Ros, 2005; Jayaraj *et al.*, 2012). This state park is strategically located as part of Titiwangsa Range, the Belum Temenggor and the Ulu Muda forests or known as large forest block, which connects with the stretch of forests in Hala Bala Wildlife Sanctuary and the Bang Lang National Park in southern Thailand (Maseri & Mohd-Ros, 2005; Jayaraj *et al.*, 2012). Gunung Stong State Park has most suitable condition for conservation of fauna which consist variety of large mammals such as tigers, elephants, deer and leopards that found there (Zafir *et al*., 2005).

Small mammals have adult weight ranging from two to five kilogram (Bourliere, 1975). For non-volant small mammals, the majority of species can be found in high diversity orders of Rodentia, Lagomorpha, Insectivora and Scandentia. In Gunung Stong State Park, a survey on diversity of non-volant small mammal has been done by using cage traps. This survey has recorded six distributional of non-volant small mammals which have been dominated by *Leopoldamys sabanus* (Jayaraj *et al.*, 2012). This state park also has *Maxomys rajah, Maxomys whiteheadi*

and *Niviventer cremoriventer* which are listed as Vulnerable in the IUCN Red List of Threatened Species (Aplin *et al.,* 2008 a,b). This survey is very important in order to conduct the monitoring and management programme in protected area (Jayaraj *et al.,* 2012).

2.1.2 Sarawak, Malaysia

The diversity and distribution of small mammals in Sarawak tropical forest have been well studied (Tisen & Lading, 1997; Payne *et al.,* 1985; Han, 2000; Dagang, 2006). Bintulu, the central of Sarawak, is one of the location that has been choose for conducting this study. In Bintulu, there are some areas that have been choosen for this study including natural forest, sylvicultural habitats, and tree plantation especially in plantations with a mixed mosaic of natural forest (Stuebing, 2005).

Based on previous study by Roslina and Andrew (2006), found a total of 33 individuals representing 13 species of small mammals from family Tupaiidae (4 species), Sciuridae (3 species) and Muridae (6 species) in planted forest zone, Bintulu, Sarawak. They compared the diversity of non-volant small mammals between two different places which are acacia plantation and natural forest. Based on their finding, they caught more samples in acacia plantation than in the forest. In contrast, when comparing the virgin, logged, fragmented and plantation forests in Peninsular Malaysia, it should be more species found in forest area than plantation area (Laidlaw, 1996; Roslina & Andrew, 2006). They indicated that it might be the factor of trapping effort which can lead to discover more species if they put long-term trapping effort. The patterns of species diversity can be affected by ecological

factor which seen so far still remain to be worked out and further studies are planned in other areas (Roslina & Andrew, 2006).

2.2 Procedures and Methods

2.2.1 Sample Size

Once in a while, maximum number of animals to be caught is not the priority in designing a field research. When this happens, the number of animals to be trapped can be estimated by the researcher and lead them in selecting research efforts that needed to test the hypothesis in order to meet the objective. The sample size that required for the statistical purposes can be estimated by the researcher with enough data from the literature, pilot data, or both.

Almost all research need to be applied by the multiple treatement or replication (Ratti & Garton, 1994; Powell & Proulx, 2003). A reasearch that aim for individual animals, need to be replicated as individuals while if the research is question on a group of species or population, then those units need to be replicated (Powell & Proulx, 2003). If the individuals were replicated in order to answer population-level, it can be refer to the term of pseudoreplication (Hurlbert, 1984) which can lead to misdirect conclusion. In this case, if the variation among individuals is low among all group or population, then it can be used to estimate the variation among group or among population.

McConway (1992) has proposed some ways which can often maximized the sample size which consist of different level which are individual, group or population. For examples, factorial design can be used to determine the impact of several variables in one experiment; a research can be design in order to yield the data that appropriate for statistical test involving small mammals which this way might be parametric, nonparametric, or Bayesian; use sequential and multivariate statistical methods; or use repeated measures design.

2.2.2 Handling the Sample

Impact on individual while handling them can be minimized by using proper steps. Most of the researcher will use anesthesia which can reduce the stress faced by the captured individual through the handling process (ASM/ACUC, 1998). The small mammals can quickly release into their habitat without danger of predation if they are handled without using the anesthesia. Handling with anesthesia can lead to abnormal behavior on the animals which can reduce the recapture success.

Before using anesthesia, the researcher need to reffer to wildlife veterinarian or gain experience from administration or monitoring. For handling a small mammals, body and appendages should be restrained to allow easy breathing (ASM/ACUC, 1998). Cloth, mesh, or heavy plastic bags can be used to restrain the small mammals and it must be labelled to administer anesthesia.

2.3 Trapping Methods

2.3.1 Cage Traps

Cage traps which is one of live-traps that used for trapping the non-volant small mammals without harming them or kill them (Askins, 1999). The trap actually is a cage which made of metal mesh and have door which held open by a trigger mechanism. Bait will be inserted inside the trap and aim for the animals lured into the trap. Usually, cage traps will be deployed on the ground in order to catch terrestrial small mammals or sometime the arboreal small mammals too. Actually cage traps and Sherman Traps are quite same of their mechanism. But both of the traps can be differentiate through their size which both of them can catch different size of sample. Cage trap is larger than Sherman trap. Its mean cage trap has large opportunity to catch small mammals which have large sized (adult). Besides, cage traps can catch variety species of small mammals which the Sherman traps cannot.

2.3.2 Sherman Traps

Sherman trap is a box-style small mammal's trap which has two different sizes, (7.6 x 9.5 x 30.5 cm) and extra-large (10.2 x 11.4 x 38 cm). This trap has been designed to catch range of small mammals including members of the families soricidae (shrews), muridae (mice, voles, rats), heteromyidae (kangaroo rats), and small-bodied sciurids such as chipmunks, ground squirrels, and tree squirrels (Manley *et al.*, 2005). It means that Sherman trap is used to trap small size of small mammals. Not like cage trap which able to trap large size of small mammals. Mixture of rolled

oats and mixed bird seed which contain sunflower seeds and millet are used as bait in Sherman traps. Oats provide carbohydrates, and sunflower seeds are a high protein and fat food (Powell & Proulx, 2003). Other bait can be used depends on the Region.

2.3.3 Pitfall Traps

A pitfall trap is a hole which has less than 40 cm deep and 20 to 40 cm of diameter (Jones *et al.*, 1996). It has smooth vertical walls and always placed in the ground. Pitfall trap is used for capturing the smallest terrestrial mammals which have weight of less than 10 g such as shrew (Spencer & Pettus, 1966; Powell & Proulx, 2003). In order to prevent the target mammals from escape, the pitfall trap need to be deep enough. Animals will be attracted to the bait in the pitfall and then fall in because the trap is placed along the travel-ways. Besides, the trap will be equipped with the drift fences to direct the animals into the trap (Bury & Corn, 1987; Handley & Kalko, 1993; Powell & Proulx, 2003). The mammals can maintain trapped in the pitfall trap for several hours if the trap was set with enough bait or food (Powell & Proulx, 2003). This make the pitfall trap is the effective device for trapping the smallest terrestrial mammals. However, the trapped small mammals will be easily exposed to predation by larger mammalian predator (Powell & Proulx, 2003). On the other hand, multiple shrew that fall into the same trap can lead them to kill and consumes each other. In order to get the maximum survival of trapped mammals, the pitfall trap need to be checked multiple times in a day.

2.4 Diversity Indices

2.4.1 Species Richness

Species richness is actually the number of species which caught in a sample, community, or taxonomic group (McGinley, 2014a). It also can be defined as the count of the different species in a given ecosystem, region, or particular area. The level of species richness can vary depending on a few variables which are sample size and type of data needed. Species richness is different from species diversity. Species diversity is a measure of the diversity within an ecological community that include both species richness and the evenness of species abundances (McGinley, 2014b). Species richness is an important index when thinking about conservation of a given habitat. Area of habitat with rare species should be in conservation priority. An accurate species richness index can help determine what conservation measure needed to be taken in order to provide a better habitat for the species to survive.

2.4.2 Shannon-Wiener Diversity Index

Shannon-Wiener diversity index is one of the most popular measures of species diversity which based on information theory (Heip *et al.*, 1998). It is a measure that we will use to try to draw information from samples in the field. There are four types of information need to be collected regarding order in the community which are the number of species, the number of individuals in each species, the places occupied by individuals of each species, and the places occupied by individuals as separate individuals (Krebs, 2014). Diversity characteristics, that is, evenness and richness

can be determined by using this index (Melo, 2008). The Shannon-Wiener measure of information content should be used only on random samples drawn from a large community in which the total number of species is known (Pielou, 1966).

Based on Shannon and Weaver (1948), Shannon-Wiener diversity index can be presented as H, can be calculated as:

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

where p_i is the number of individuals of a species over the total number of individuals overall. Since the p_i value will be between zero and one, the natural log makes all of the terms of the summation negative, which is why the sum needs to be inversed.

2.4.3 Evenness

Evenness is the distribution of individuals over species (Heip *et al.,* 1998). Several equations have been proposed to calculate the evenness of a diversity which the most popular used for large samples are:

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

where H is the diversity index and H_{max} is the possible maximum diversity. When the range of evenness indicess is near to 0, it means that most individuals belong to a few species, while when it is near to 1, it means that the species are nearly equally abundant (Smith & Wilson, 1996). In the end, it will tell us how balance the distribution of the species between two different location in term of frequency.

2.5 Role of International Union for the Conservation of Nature (IUCN) Red List

IUCN Red List is the most effective tool in order to do the conservation activity. The IUCN Red List Categories and Criteria are commonly used by many researchers from all over the world as the most objective and authoritative system in order to assess the global risk of extinction for many species (Lamoreux *et al.*, 2003; De Grammont & Cuarón, 2006; Rodrigues *et al.*, 2006; Mace *et al.*, 2008). People have the free access to the IUCN Red List where it provide data which encompasses the status of species all over the world. IUCN Red List is very important in order to do the conservation activities where many researcher do their study on the abundance or diversity of animals. There are sort of list on the category which are not avaluated; data deficient; least concern; near threatened; vulnerable; endangered; critically endangered; extinct in the wild; and extinct (IUCN, 2015).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

This study was conducted at Lata Janggut and Lata Bijih. Figure 3.1a and 3.1b shows the maps of Lata Janggut and Lata Bijih where the sampling occurred.

Lata Janggut located at 12 km south-west of Jeli, Kelantan while Lata Bijih located at Kg. Ayer Merbo, Tanah Merah, Kelantan. Both of these sites are becoming the attraction to the people around the district of Tanah Merah and Jeli for recreational activities. But in Lata Bijih, the area is actually covered up by rubber plantation (*Hevea brasiliensis*). The GPS reading from the camp in Lata Janggut is 05°40'8"N, 101°46'11"E and the sampling site is situated >100m a.s.l. For Lata Bijih, the GPS reading from the camp is 05°46'8"N, 101°56'56"E and the sampling site is situated >50m a.s.l. Until now, there is still no data recorded on both locations about the diversity of non-volant small mammal species.

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

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

3.2 Materials

Material and apparatus were divided into two categories which are for capturing the small mammal and for the species identification.

In capturing small mammal, cage traps were used and baited with banana variety *Musa acuminata* or its common name 'Pisang emas'. Cloth bag was used to keep the sample for temporary after the sample been taken out from the cage trap. In order to euthanize the sample, chloroform has been used and then put into the ethanol solution for preservation purpose. Before the sample being preserved, the sample was dissected using the dissecting kit to remove the organs.

Species identification was done by using the key from Francis (2008) and all the information and measurement from each sample were recorded.

3.3 Methods

3.3.1 Sampling

This study was conducted at two different locations which are Lata Janggut (20^{th} July until 26^{th} July 2016) and Lata Bijih (29^{th} July until 5^{th} August 2016). 50 cage traps were deployed at each location with 5m spacing from each trap for capturing the non-volant small mammals. Local banana variety *M. acuminata* was used as bait and changed periodically for a week of sampling periods. The traps were installed for seven consecutive days in order to get the maximum species captured and to accumulate the species number.

3.3.2 Measurement and Species Identification

Standard measurement is very important in order to determine the species (Francis, 2008). This action was done after the sample have been transfer from the cage traps into the cloth bag. This standard measurement includes body weight and body measurement. The measurement of the small mammal's body was taken which includes the measure of head-body length (HB); tail (T); hind foot (HF); and ear length (E) (Figure 3.3.2). After these measurements were taken, the sample was identified using key from Francis (2008).

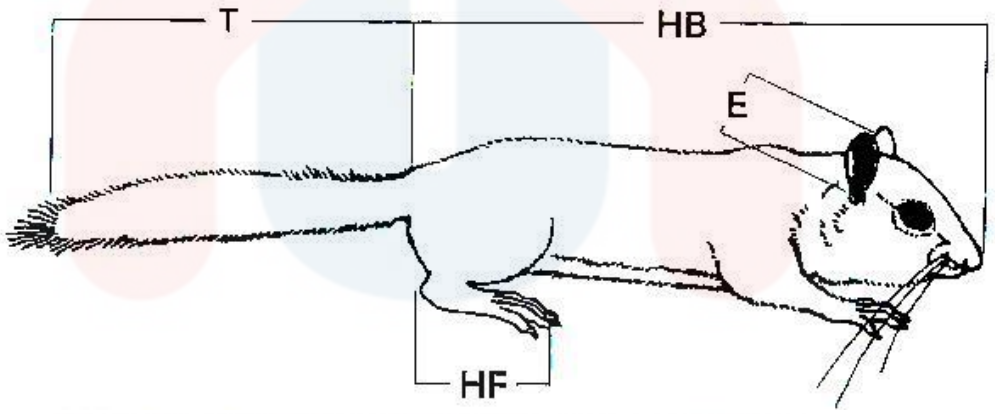

Figure 3.3.2: Measurements of typical small mammal (Source: Francis, C.M. 2008).

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.

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

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

Shannon-Wiener Diversity Index (equation iii) and Evenness Index (equation iv) were calculated for taking account equal number of sampling effort.

Shannon-Wiener Diversity Index (H) = -sum (p_i lnp_i) ……..…….....(equation iii)

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

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

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

(s = total number of species)

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result

Overall, 10 species of non-volant small mammal were recorded which classified under three orders (Insectivora, Scandentia and Rodentia) and four families (Muridae, Erinaceidae, Sciuridae, and Tupaiidae) from 43 individuals with one new locality record for Kelantan (Table 4.1.1)

Table 4.1.1: Species diversity and abundance of non-volant small mammals in Lata Janggut and Lata Bijih, Kelantan.

Species	Lata Bijih	Lata Janggut	Total	IUCN Status
Insectivora				
Erinaceidae				
*Echinosorex gymnura**	1	0	1	LC
Scandentia				
Tupaiidae				
Tupaiia glis	5	2	7	LC
Rodentia				
Muridae				
Rattus rattus	6	3	9	LC
Rattus tiomanicus	4	12	16	LC
Rattus exulans	0	1	1	LC
Maxomys rajah	0	1	1	VU
Maxomys surifer	1	1	2	LC
Sundamys muelleri	0	2	2	LC

Sciuridae				
Callosciurus notatus	0	3	3	LC
Sundasciurus tenuis	1	0	1	LC
Total number of individual	18	25	43	
Number of species	6	8	10	
Number of families	4	3	4	
Trap-days	50	50	100	
Capture rates	36%	50%	43%	

* = new record for Kelantan based on Jayaraj *et al.*, (2016)

Table 4.1.1 clearly shows that Lata Janggut is more diverse in term of number of species (8 species) and total number of individual (25 individuals) compared to Lata Bijih which has 6 species from 18 individuals. Muridae is the most diverse family of non-volant small mammal recorded in this survey with 6 species. The most abundance of non-volant small mammal in this study was *Rattus tiomanicus* (16 individuals) followed by *Rattus rattus* (9 individuals) and *Tupaiia glis* (7 individuals).

Figure 4.1.1 shows the rarefaction curve of species diversity in Lata Janggut and Lata Bijih, Kelantan. Lata Janggut shows the steepest curve compared to Lata Bijih which also proved that the species in Lata Janggut is more diverse that Lata Bijih.

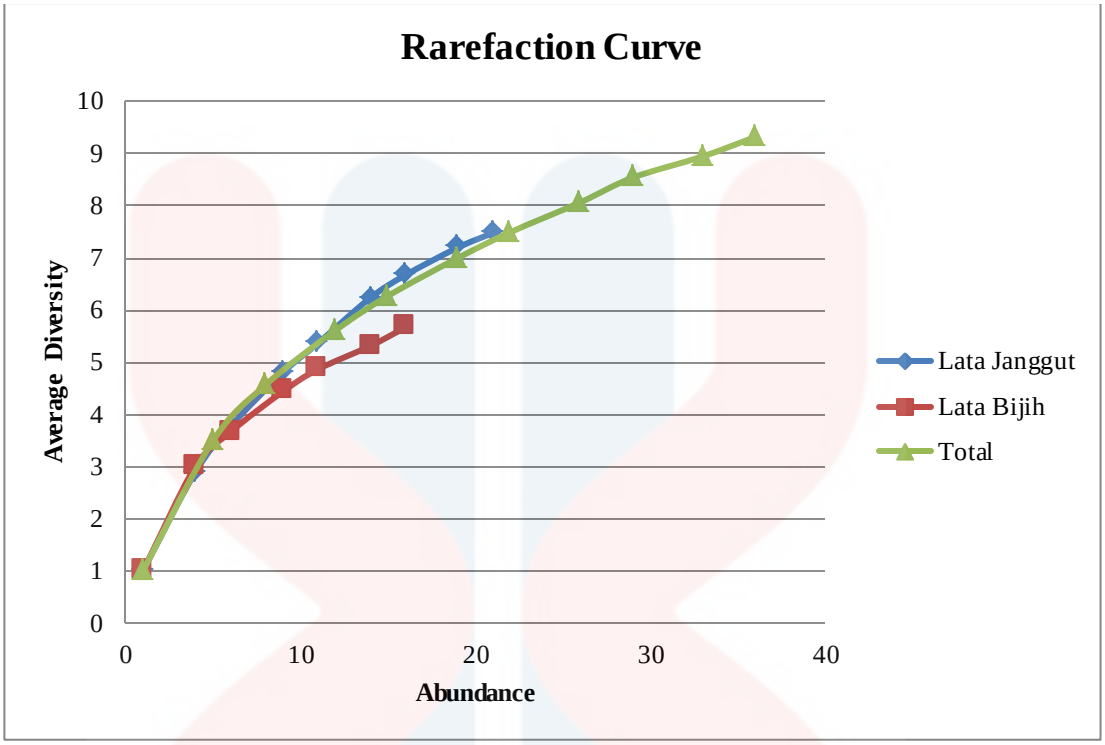

Figure 4.1.1: Rarefaction curve for species diversity in Lata Janggut and Lata Bijih, Kelantan.

The difference of species diversity between Lata Janggut and Lata Bijih also can be shown by Shannon-Wiener diversity index (Table 4.1.2 and Table 4.1.3). The Shannon-Wiener diversity index for Lata Janggut is higher than Lata Bijih (1.652>1.538) which means that Lata Janggut is more diverse.

Table 4.1.2: Shannon-Wiener Diversity and Evenness index for Lata Janggut

Species	**No. of individual**	**(p_1)**	**[ln(p_1)]**	**(p_1)[ln(p_1)]**	**Evenness**
R. rattus	3	0.12	-2.120	-0.254	
R. tiomanicus	12	0.48	-0.734	-0.352	
R. exulans	1	0.04	-3.219	-0.129	
M. rajah	1	0.04	-3.219	-0.129	
M. surifer	1	0.04	-3.219	-0.129	
S. muelleri	2	0.08	-2.526	-0.202	
E. gimnurus	0	0	-		
C. notatus	3	0.12	-2.120	-0.254	
S. tenuis	0	0	-		
T. glis	2	0.08	-2.526	-0.202	
Total	**25**	**1.00**		**1.652**	**0.513**

Table 4.1.3: Shannon-Wiener Diversity and Evenness index for Lata Bijih

Species	**No. of individual**	**(p_1)**	**[ln(p_1)]**	**(p_1)[ln(p_1)]**	**Evenness**
R. rattus	6	0.33	-1.099	-0.366	
R. tiomanicus	4	0.22	-1.504	-0.334	
R. exulans	0	0.00	-	-	
M. rajah	0	0.00	-	-	
M. surifer	1	0.06	-2.890	-0.161	
S. muelleri	0	0.00	-	-	
E. gymnura	1	0.06	-2.890	-0.161	
C. notatus	0	0.00	-	-	
S. tenuis	1	0.06	-2.890	-0.161	
T. glis	5	0.28	-1.281	-0.356	
Total	**18**	**1.00**		**1.538**	**0.532**

Based on Figure 4.1, the curve for both sites are not plateau which indicate that the samples captured still not covered the total species that should be at Lata Janggut and Lata Bijih. Its mean that there are still more species in both sites that still not be captured. These also can be proved from the cumulative frequency graph (Figure 4.1.2) for both sites. The graph reached an asymptotic level on the 3rd day – 4th day but the number of species trapped increased on 5th day of sampling indicate that the total tapping effort was not enough to document all the species of non-volant small mammals that available in both sites.

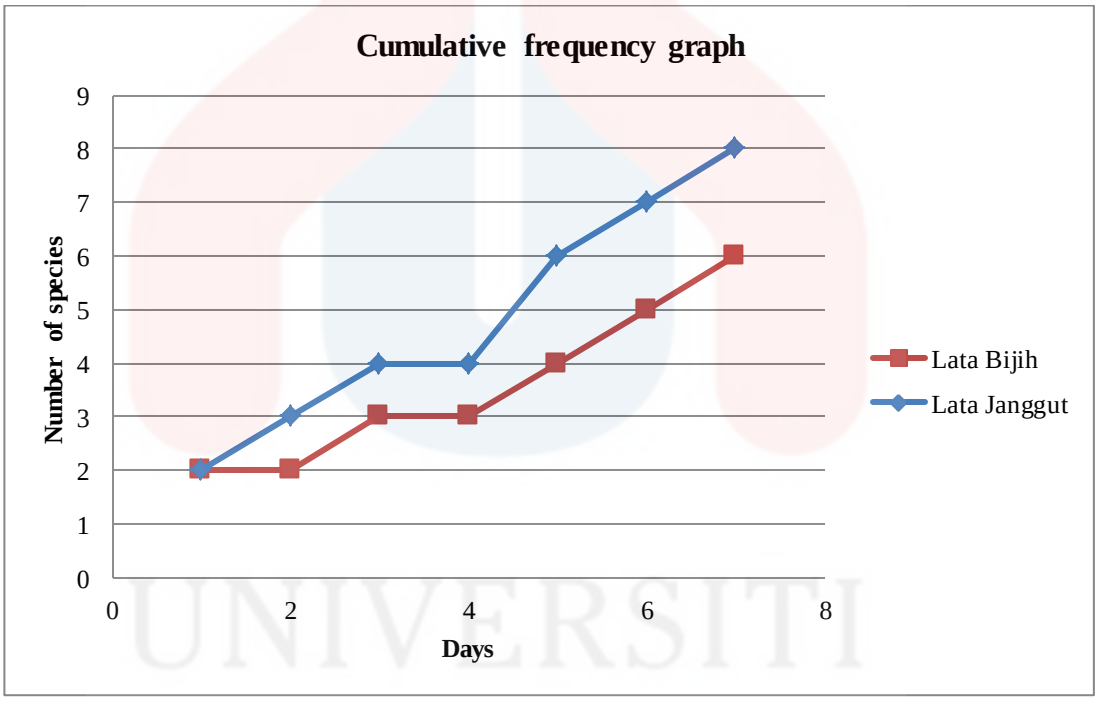

Figure 4.1.2: Cumulative frequency graph of non-volant small mammal in Lata Janggut and Lata Bijih, Kelantan

4.2 Species Account

4.2.1 Moon rat (*Echinosorex gymnura*)

This large insectivore has been caught near the river in Lata Bijih, Kelantan. Moon rat can be identified by its large size, long muzzle, and has very strong pungent odour with strong ammonia content (Francis, 2008). This species can be found around the damp or wet area which has been their preferred area (Lekagul & McNeely, 1977). This species is actually been a new locality species that recorded in Kelantan state (Shukor *et al.*, 2005; Jayaraj *et al.*, 2012; Jayaraj *et al.*, 2016). Other than Kelantan, this species has been recorded at Wang Kelian State Park, Perlis as much as three individuals (Jayaraj *et al.*, 2013). This species also has been reported caught in limestone forest area at Jambusan Cave, Bau, Sarawak (Ida Nivina *et al.*, 2004). This species is listed as Least Concern in the IUCN Red List of Threatened Species (Cassola *et al.*, 2016).

4.2.2 Common Treeshrew (*Tupaiia glis*)

This species is commonly found in forests as well as in gardens or plantations near forest (Francis, 2008). Lata Bijih recorded five individuals which is more than Lata Janggut with only two individuals. Shahfiz *et al.*, (2007) trapped this species in high elevational forest at Cameron Highland, Pahang. This species has been recorded in Mount Nuang, Hulu Langat, Selangor up to 500m a.s.l (Shukor *et al.*, 2001). This species is listed as Least Concern in the IUCN Red List of Threatened Species (Cassola, 2016).

4.2.3 House Rat (*Rattus rattus*)

This medium-sized rat is the most common species that can be found in any forest, but largely confined to human settlements, plantation and gardens (Francis, 2008). Both Lata Janggut and Lata Bijih have recorded this species as it is the second most abundance species after *Rattus tiomanicus*. Jayaraj *et al*., (2016) also have recorded this species in Gunung Reng, Gua Musang, and Pasir Mas, Kelantan. Amori *et al*., (2015) assigned the status Least Concern for this species in the IUCN Red List of Threatened Species as this species is a widespread and abundant species which labelled as a pest.

4.2.4 Malaysian Wood Rat (*Rattus tiomanicus*)

This is the most abundant species that had been captured especially in Lata Janggut. This species is quite similar to *Rattus rattus* which has longer dark guard hairs on lower back and usually has darker base to fur on underside differ to *Rattus tiomanicus* (Francis, 2008). Jayaraj *et al*., (2016) also recorded this species at Pasir Mas, Kelantan. This species also was caught by Mariana *et al*., (2005) at Gunung Stong State Park, Kelantan. This species can be found in secondary forest, plantation, garden, scrub and grassland, but rarely in house settlement or tall dipterocarp forest (Francis, 2008). This species is listed as Least Concern in the IUCN Red List of Threatened Species (Aplin, 2016a).

4.2.5 Pacific Rat (*Rattus exulans*)

This species which is the smallest *Rattus* has been caught only one individual in Lata Janggut. Barbehenn *et al*., (1973) and Rabor *et al*., (1986) stated that this species can be occurs in agricultural areas at any elevation across the country. In South-East Asia, it can be found secondary areas around human settlement, gardens, and also sometimes in rice fields area (Francis, 2008). Jayaraj *et al*., (2016) has caught this species in banana plantation at Gunung Reng, Kelantan. Ruedas *et al*., (2008) assigned the status Least Concern for this species in the IUCN Red List of Threatened Species.

4.2.6 Rajah Sundaic Maxomys (*Maxomys rajah*)

This species commonly can be found in tall and secondary lowland forest (Francis, 2008). Only one individual of this species has been captured in small scale rubber plantation near the secondary forest at Lata Janggut. This species also was captured by Jayaraj *et al*., (2016) at Gunung Chamah and Gua Musang, Kelantan. Shukor *et al*., (2001) also recorded 34 individuals between 500m and 1100m a.s.l on Mount Nuang, Hulu Langat, Selangor. This species is listed as Vulnerable in the IUCN Red List of Threatened Species (Ruedas, 2016) due to population declined almost more than 30% over the last 10 years, effected by the extensive loss and degradation of its lowland forest habitat.

4.2.7 Red Spiny maxomys (*Maxomys surifer*)

This species was caught in both Lata Janggut and Lata Bijih with one individual each sites. Jayaraj *et al.*, (2012) trapped this species in the vicinity of the forest ecotone in Gunung Stong State Park, Kelantan. In Huai Kha Khaeng Wildlife Sanctuary, central Thailand, this species is the most abundant non-volant small mammal that captured by Walker and Rabinowitz (1992). According to Francis (2008), *M. surifer* and *M. rajah* have rarely been caught in the same location, but based on this study, both species were caught at the same area in Lata Janggut. This indicate that both species might be occured in the same area but further study need to be done to confirm this situation. Aplin *et al.*, (2016) assigned this species as Least Concern in the IUCN Red List of Threatened Species.

4.2.8 Müller's Rat (*Sundamys muelleri*)

Normally this species can be found in lowland tropical forests and near the river (Francis, 2008). Incidentally, this large rat was caught near the river area of Lata Janggut. Previously, this species was caught in Sungai Durian Forest Reserve by Lim (1970) and Jayaraj *et al.*, (2012) in Gunung Stong State Park. In Borneo, Roslina and Andrew (2006) caught this species in acacia plantation mixed with secondary forest. This species was assigned as Least Concern in the IUCN Red List of Threatened Species (Aplin, 2016b).

4.2.9 Plantain Squirrel (*Callosciurus notatus*)

Only three individuals of this species were caught in this survey at Lata Janggut. This species commonly can be found in gardens, secondary forest, and monoculture plantation (Francis, 2008). Saiful and Nordin (2004) found this species as the most abundant species that found in Weng River Sub-catchment, Ulu Muda Forest Reserve, Kedah. This species also was caught at 500m to 1100m a.s.l on Mount Nuang, Hulu Langat, Selangor (Shukor *et al.*, 2001). Jayaraj *et al.*, (2013) captured one individual of this species at Wang Kelian State Park, Perlis. Duckworth *et al.*, (2008) assigned the status Least Concern for this species in IUCN Red List of Threatened Species.

4.2.10 Slender Squirrel (*Sundasciurus tenuis*)

This species has wide distribution including tall and secondary forest as well as scrub and gardens (Francis, 2008). Only one individual of this species was caught in Lata Bijih. Previously, Langham (1983) found this species up to 1000m a.s.l on Mount Jerai, Kedah. Jayaraj *et al.*, (2013) also caught 2 individuals of this species and recorded as new record for Wang Kelian State Park, Perlis. This species is listed as Least Concern in the IUCN Red List of Threatened Species (Meijaard, 2016).

4.3 Factor That Differ the Species Diversity between Lata Janggut and Lata Bijih, Kelantan

This survey recorded 10 species of non-volant small mammal with one new locality species for Kelantan (*Echinosorex gymnura*). Based on Table 4.1.1, it is obviously showed that the diversity of non-volant small mammal in Lata Janggut is higher that Lata Bijih. Lata Janggut recorded eight species with 25 individuals while Lata Bijih recorded six species with 18 individuals. The rarefaction graph (Figure 4.1.1) and Shannon-Wiener diversity index (Table 4.1.2 and 4.1.3) also indicated the same assumption for the difference on diversity distribution for both sites. Several factors that differ the diversity distribution of non-volant small mammal in Lata Janggut and Lata Bijih were assessed which included the human involvement in forest exploitation and habitat fragmentation.

4.3.1 Human Involvement in Forest Exploitation

Based on the sites in this study, the types of forest for both sites is totally different. Lata Janggut still has the primary forest and secondary forest. Some of the area had changed into small scale rubber plantation with partially recreational area. There are some people that come to Lata Janggut to have their leisure time which has low risk on environmental depletion. Most of the primary and secondary forest is still in its original condition with low human exploitation. This condition has made a better habitat for non-volant small mammal and other animals too.

In contrast to Lata Bijih, the lowland forest has completely turned into large scale of rubber plantation. The original forest that should be the nature habitat for

non-volant small mammal and other animals has destroyed which made some of the species migrated to other places.

4.3.2 Habitat Fragmentation

According to Andrén (1994), habitat fragmentation lead to habitat loss, patch size reduction and increasing the distance between patch. The biodiversity of a forest can be threatened by forest fragmentation especially in the tropics (Bierregaard, 2001). This condition can be seen obviously happened at Lata Bijih where the secondary forest was cut down and turned into rubber plantation. Some of the area around Lata Bijih was turn into agricultural activity. Habitat fragmentation that created by human has isolate the species diversity in Lata Bijih from other areas of habitat.

In contrast, Lata Janggut has low risk of habitat fragmentation which it has low involvement of human in term of plantation and agriculture activity compared to Lata Bijih. Based on the statement above, it clearly proved that habitat fragmentation has impact the diversity of non-volant small mammal in both sites.

4.4 Factor That Influencing the Capturing Rate

There are several factors that can influence the capturing rate of non-volant small mammal which are; sampling effort; bait selection; fruit season; and weather.

4.4.1 Sampling Effort

The sampling effort for this survey was not adequate in order to record the total non-volant small mammal population at Lata Janggut and Lata Bijih as the cumulative frequency (Figure 4.1.2) is yet to reach and asymptotic level. In Mount Jerai, Kedah, 6,000-7,200 trap-days were required in order to document the diversity of non-volant small mammal (Rayan & Shahrul Anuar, 2006; Shahrul Anuar, *et al.*, 2006). The sampling effort that have been done for both sites is as much as 50 cage traps per day with total 43% of capture rate which is not enough to document total non-volant small mammal at both sites. Further study need to be done in order to complete the inadequacy of this survey.

4.4.2 Bait Selection

The capture rate of non-volant small mammal can be influenced by the choice of bait used. Previous study by Bernard (2003) indicated that the local banana variety 'pisang emas' (*Musa acuminata*) is the preferred bait in order to get the best capture rate on non-volant small mammal. In this study, *M. acuminata* has been choosen as bait and it give almost good result.

4.4.3 Fruit Season

Fruit season can give impact on capture rate of non-volant small mammal. In this study, it occurs that Lata Bijih was having fruit season during the sampling period. This situation has made the non-volant small mammal loss their attention to the bait

that have been prepared, and preferred to the fruit either on the tree or fall to the ground.

4.4.4 Weather

Weather like rain is actually can affect the rate of capture of non-volant small mammal (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 non-volant small mammal not very active and preffered to be in their nest or hole.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As conclusion, this study gives new information on diversity of non-volant small mammal in Lata Janggut and Lata Bijih, Kelantan as a new baseline data. These include their habitat, species account, and the factor that influence the capture rate. This survey also recorded a new locality species for Kelantan that not recorded by previous survey on small mammal of Kelantan. Most of the species that have been recorded in this research were listed as Least Concern in the IUCN Red List of Threatened Species except for one species, *Maxomys rajah* which was listed as Vulnerable. These indicate that either Lata Janggut or Lata Bijih should be well preserve in order to maintain its diversity of flora and fauna.

The comparison of two sites shows the different in species diversity which caused by several factor; socio-ecology; and forest fragmentation. Based on this research, Lata Janggut is more diverse in term of species richness of non-volant small mammal compared to Lata Bijih which has more anthropogenic activity by human. The anthropogenic activity that happened comes from rubber plantation and recreational activity. Otherwise, the primary forest in Lata Janggut still well preserved which lead to higher species richness.

5.2 Recommendation

This research focuses on the diversity of non-volant small mammal in Lata Janggut and Lata Bijih, Kelantan 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. In the same time, this data is very useful for planning the conservation activity for both sites. Further study need to be done at both locations because more species would be there.

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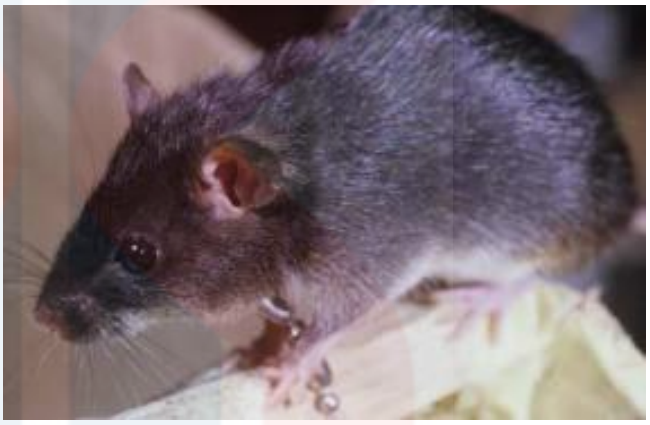
APPENDIX A

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

Moon Rat	*Echinosorex gymnura*	
Common Treeshrew	*Tupaia glis*	
House Rat	*Rattus rattus*	

Malaysian Wood Rat	*Rattus tiomanicus*	
Pacific Rat	*Rattus exulans*	
Rajah Sundaic Maxomys	*Maxomys rajah*	

Red Spiny maxomys	*Maxomys surifer*	
Müller's Rat	*Sundamys muelleri*	
Plantain Squirrel	*Callosciurus notatus*	

Slender Squirrel	*Sundasciurus tenuis*	

Sources: Google Image (2016)

APPENDIX B

Rarefaction curve analysis for Lata Janggut.

Abundance	Average Diversity	Median Diversity	Variance Diversity	95%Conf.Low	95%Conf.High
25(Obs.)	8	8	0	8	8
1	1	1	0	1	1
4	2.892	3	0.62296	1	4
6	3.765	4	0.88066	2	5
9	4.799	5	0.97157	3	7
11	5.36	5	0.99339	3	7
14	6.231	6	0.85049	4	8
16	6.667	7	0.74085	5	8
19	7.196	7	0.56815	6	8
21	7.475	8	0.38376	6	8

Rarefaction curve analysis for Lata Bijih.

Abundance	Average Diversity	Median Diversity	Variance Diversity	95%Conf.Low	95%Conf.High
18(Obs.)	6	6	0	6	6
1	1	1	0	1	1
4	2.998	3	0.42242	2	4
6	3.662	4	0.62438	2	5
9	4.437	4	0.68472	3	6
11	4.864	5	0.62413	3	6
14	5.312	5	0.45912	4	6
16	5.664	6	0.25736	5	6

Rarefaction curve analysis for total Lata Janggut and Lata Bijih.

Abundance	Average Diversity	Median Diversity	Variance Diversity	95%Conf.Low	95%Conf.High
43(Obs.)	10	10	0	10	10
1	1	1	0	1	1
5	3.489	3	0.69457	2	5
8	4.561	5	1.07736	3	7
12	5.607	6	1.20776	4	8
15	6.268	6	1.33952	4	8
19	6.996	7	1.30729	5	9
22	7.49	8	1.32923	5	9
26	8.062	8	1.05922	6	10
29	8.536	9	0.9977	6	10
33	8.943	9	0.72047	7	10
36	9.313	9	0.54157	8	10